K.K. Wagh Institute of Engineering Education and Research, Nashik

Curriculum
Final Year B. Tech
(2022 Pattern)

Department of Mechanical Engineering

w.e.f.: AY 2025-2026

K.K.Wagh Institute of Engineering Education and Research, Nashik (Autonomous w.e.f. A.Y.2022-23)
Details of Course Structure: Final Year B.Tech (2022 Pattern) Semester : VII

Board of Studies in Mechanical Engineering

Course Code	Course Type	Title of Course	Teaching Scheme Hrs./week			Evaluation Scheme and Marks								Credits			
			TH	TU	PR	In Sem	End Sem	CCE	TU	TW	PR	OR	Total	TH	TU	PR	Total
MEC224001	DCC*	Engineering System Design and optimization	3	-	-	-	60	40	-	-	-	-	100	3	-	-	3
MEC224002	DEC*	Elective- IV	3	-	-	-	60	40	-	-	-	-	100	3	-	-	3
MEC224003	LHSM*	Principles of Macro Economics	2	-	-	-	-	50	-	-	-	-	50	2	-	-	2
MEC224004	INTERNSHIP	Internship	-	-	24	-	-	-	-	200	-	100	300	-	-	12	12
		Total	8	00	24	-	120	130	-	200	-	100	550	8	-	12	20

* Considering Internship of 6 months, these courses to be offered in online mode.

Elective –	
Course Code	Title of Course
MEC224002A	Total Quality Management
MEC224002B	Smart Materials
MEC224002C	Design of Heat Exchangers

K.K.Wagh Institute of Engineering Education and Research, Nashik (Autonomous w.e.f. A.Y.2022-23)
Details of Course Structure: Final Year B.Tech (2022 Pattern) Semester : VIII

Board of Studies in Mechanical Engineering

Course Code	Course Type	Title of Course	Teaching Scheme Hrs./week			Evaluation Scheme and Marks								Credits			
			TH	TU	PR	In Sem	End Sem	CCE	TU	TW	PR	OR	Total	TH	TU	PR	Total
MEC224011	DCC	Heating Ventilation Air Conditioning & Refrigeration	3	-	-	20	60	20	-	-	-	-	100	3	-	-	3
MEC224012	DCC	Dynamic of Machinery	3	-	-	20	60	20	-	-	-	-	100	3	-	-	3
MEC224013	DCC	Dynamic of Machinery Lab	-	-	2	-	-	-	-	25	-	25	50	-	-	1	1
MEC224014	DCC	Data Analytics Lab	-	-	2	-	-	-	-	25	-	25	50	-	-	1	1
MEC224015	DEC	Elective- V	3	-	-	20	60	20	-	-	-	-	100	3	-	-	3
MEC224016	DEC	Elective-VI	2	-	-	20	30	-	-	-	-	-	50	2	-	-	2
MEC224017	ASM	Robot Kinematics and Dynamics	3	-	-	20	60	20	-	-	-	-	100	3	-	-	3
MEC224018	HSSM –EEM LHSM	Industrial Engineering	2	-	-	-	-	50	-	-	-	-	50	2	-	-	2
MEC224019	PSI	Project Work	-	-	8	-	-	-	-	100	-	50	150	-	-	4	4
			16	00	12	100	270	130	00	150	00	100	750	16	-	6	22

Elective - V		Elective VI	
Course Code	Title of Course	Course Code	Title of Course
MEC224015A	Heat Transfer in Electronic System	MEC224016A	Lubrication, Friction and Wear
MEC224015B	Smart Manufacturing with Industry 4.0	MEC224016B	Unmanned Aerial Vehicles
MEC224015C	Design of Electro- Mechanical System	MEC224016C	Sustainable Futures and Materials
MEC224015D	Supply chain management		

Final Year B. Tech.
Pattern: 2022 Semester: VII (Mechanical Engineering)
MEC224001: Engineering System Design and Optimization*

*** Considering Internship of 6 months, this course to be offered in online mode.**

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Lecture: 03 hr / week	03	ENDSEM : 60 M CCE : 40 M

Prerequisite Courses: - Mechanism and Machines, Mathematics for Mechanical Engineers, Solid Mechanics, Machine Design-I, Machine Design-II.

Course Objectives:

To enable students to apply the statistical considerations in design and analyze the defects and failure modes in components.

To develop competency for system visualization and its design.

To enable student to design machine tool gearbox, I.C. Engine Components etc.

To initiate student to optimum design and apply optimization methods to design mechanical components.

	Course Outcomes	**Bloom's Level**
CO1	**Apply** the statistical considerations in design to find the failure modes in components.	3- Apply
CO2	**Illustrate** the concepts to design machine tool gear box.	3- Apply
CO3	**Apply** the design principles to design I.C. Engine Components.	3- Apply
CO4	**Classify** optimization concepts and **analyze** the reliability of mechanical components	4 - Analyze

COURSE CONTENTS

I	**Statistical Consideration in Design**	(08hrs)	COs Mapped – CO2
Frequency distribution-Histogram and frequency polygon, normal distribution - units of central tendency and dispersion- standard deviation - population combinations - design for natural tolerances - design for assembly - statistical analysis of tolerances, mechanical reliability and factor of safety			
II	**Design of Machine Tool Gear Box**	(07 hrs)	COs Mapped – CO1
Introduction, design and its applications, basic considerations in design of drives, determination of variable speed range, graphical representation of speed and structure diagram, ray diagram, selection of optimum ray diagram, gearing diagram, deviation diagram.			
III	**Design of I.C. Engine Components**	(07 hrs)	COs Mapped – CO2

Introduction to selection of material for I. C. engine components, Design of cylinder and cylinder head, construction of cylinder liners, design of piston and piston-pins, piston rings, design of connecting rod. Design of crank-shaft and crank-pin, (Theoretical treatment only).			
IV	**Introduction to Optimization**	(07hrs)	COs Mapped – CO2, CO3
Introduction, Statement of an optimization problem, Classification of optimization problems, Modern Methods of Optimization- Genetic algorithms, Ant colony optimization, Fuzzy optimization, Neural-network-based methods			
V	**Optimum Design**	(07 hrs)	COs Mapped – CO4
Objectives of optimum design, adequate and optimum design, Johnson's Method of optimum design, primary design equations, subsidiary design equations and limit equations, optimum design with normal specifications of simple machine elements- tension bar, transmission shaft and helical spring.			

Text Books

1. Bhandari V.B. ―Design of Machine Elements‖, Tata McGraw Hill Pub. Co. Ltd.
2. Juvinal R.C, Fundamentals of Machine Components Design, Wiley, India

Reference Books

4. Shigley J. E. and Mischke C.R., ―Mechanical Engineering Design‖, McGraw Hill Pub. Co
5. M. F. Spotts, ―Mechanical Design Analysis‖, Prentice Hall Inc.
6. Black P.H. and O. Eugene Adams, ―Machine Design‖ McGraw Hill Book Co. Inc.
7. Johnson R.C., ―Mechanical Design Synthesis with Optimization Applications‖, Von Nostrand Reynold Pub.
8. S.K. Basu and D. K. Pal, ―Design of Machine Tools, Oxford and IBH Pub Co.
9. P. Kannaiah ,‖Design of Transmission systems‖, SCIETCH Publications Pvt Ltd.
10. Pandy, N. C. and Shah, C. S., Elements of Machine Design, Charotar Publishing House.
11. Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley & Sons.

Codes / Handbooks

1. Design Data- P.S.G. College of Technology, Coimbatore.

Strength of CO-PO/PSO Mapping														
	PO's												PSO	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	3	2	-	-	-	2	-	-	-	-	-	2	-	-

CO 2	3	3	2	-	-	-	-	-	-	-	-	2	2	-
CO 3	3	3	2	-	-	-	-	-	-	-	-	2	2	-
CO 4	3	3	2	-	-	2	-	-	-	-	-	2	-	-
Average	3	3	2	-	-	-	-	-	-	-	-	2		-
Level	3	3	2	-	-	2	-	-	-	-	-	2	2	-

Guidelines for Continuous Comprehensive Evaluation			
Sr. No.	**Component for Continuous Comprehensive Evaluation**	**Marks Allotted**	**Evaluation rubrics**
1	Single Assignment on Unit 1 and 2	15	Evaluated for 30 marks R1- Timely completion-10 marks, R2- Understanding- 10 marks R3- Presentation and Clarity (Converted to 15 marks)
2	Single Assignment on Unit 3, 4 and 5	15	Evaluated for 30 marks R1- Timely completion-10 marks, R2- Understanding- 10 marks R3- Presentation and Clarity (Converted to 15 marks)
3	MCQ Test on Unit 1 to 5	10	A single MCQ Test of 30 marks on all units will be conducted at the end of semester
	Total	**40**	

Final Year B. Tech.
Pattern: 2022 Semester: VII (Mechanical Engineering)
MEC224002A**: Total Quality Management**

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Lecture: 03 hr / week	03	END SEM : 60 M CCE : 40 M

Prerequisite Courses: - Manufacturing Processes, Geometric Modeling and Production Drawing, Instrumentation and Measurement, Financial management etc.

Course Objectives:

1. To facilitate the understanding of Quality Management principles and process.
2. Students should be able to Quality environment of the organization.
3. Student should be able to know the TQM approach for manufacturing/service Organization in length.
4. Student should be able to know various Quality terms like Tolerance and Variability, PDCA cycle, Crosby's 10 points and Deming's 14 Points.
5. Student should be able to know international/national Quality awards

	Course Outcomes	**Bloom's Level**
CO1	**Describe** and summarize the dimensions of product quality or service quality to the customer.	2- Understanding
CO2	**Apply** the philosophies/ contributions in Quality Management and techniques.	3- Apply
CO3	**Examine** potential failure modes and justify the calculation of RPN through 15 steps of FMEA procedure.	3- Apply
CO4	**Classify** and categorize the Quality management system.	4 - Analyze

COURSE CONTENTS

Part A

I	**Introduction of TQM** Introduction - Need for quality - Evolution of quality - Definitions of quality - Dimensions of product and service quality - Basic concepts of TQM - TQM Framework - Contributions of Deming, Juran and Crosby - Barriers to TQM - Customer focus - Customer orientation, Customer satisfaction, Customer complaints, Customer retention.	(8 hrs)	COs Mapped – CO1
II	**TQM Principles** Leadership - Quality Statements, Strategic quality planning, Quality Councils - Employee involvement - Motivation, Empowerment, Team and Teamwork, Recognition and	(7 hrs)	COs Mapped - CO2

	Reward, Performance appraisal - Continuous process improvement - PDCA cycle, 5S, Kaizen - Supplier partnership - Partnering, Supplier selection, Supplier Rating.		
III	**TQM Tools and Techniques** The seven traditional tools of quality - New management tools - Six sigma: Concepts, Methodology, applications to manufacturing, service sector including IT - Bench marking - Reason to bench mark, Bench marking process - FMEA - Stages, Types. Quality Circles - Cost of Quality - Quality Function Deployment (QFD) - Taguchi quality loss function - TPM - Concepts, improvement needs - Performance measures.	(7 hrs)	COs Mapped – CO3
IV	**Quality Management System** Introduction—Benefits of ISO Registration—ISO 9000 Series of Standards—Sector-Specific Standards—AS 9100, TS16949 and TL 9000-- ISO 9001 Requirements—Implementation—Documentation—Internal Audits—Registration—Environmental Management System: Introduction—ISO 14000 Series Standards—Concepts of ISO 14001—Requirements of ISO 14001— Benefits of EMS.	(7hrs)	COs Mapped – CO4

Text Books

1. Dale H.Besterfiled, Carol B.Michna,Glen H. Besterfield,Mary B.Sacre,Hemant Urdhwareshe and Rashmi Urdhwareshe, “Total Quality Management”, Pearson Education Asia, Revised Third Edition, Indian Reprint, Sixth Impression, 2013.

2. Total Quality Management by N.V.R Naidu, G. Rajendra New Age international,

,First Edition,Jan 2006

3. Total Quality Management by R.S Naagarazan ,New Age international,3e, 2015

4. Quality Control & Application by B. L. Hanson & P. M. Ghare, Prentice Hall of India,

2004.

Reference Books

1. James R. Evans and William M. Lindsay, "The Management and Control of Quality", 8th Edition, First Indian Edition, Cengage Learning, 2012.

2. Janakiraman. B and Gopal .R.K., "Total Quality Management - Text and Cases", Prentice Hall (India) Pvt. Ltd., 2006.

3. Suganthi.L and Anand Samuel, "Total Quality Management", Prentice Hall (India) Pvt. Ltd., 2006.

4. Total Quality Management by V.S Bagad Technical Publications, First Edition, Jan 2008

5. Total Quality Management by S. Rajaram Dreamtech Press,First Edition, Jan 2008

Codes / Handbooks

1. Oakland, J.S. (2014). Total Quality Management and Operational Excellence: Text with Cases (4th ed.). Routledge. https://doi.org/10.4324/9781315815725

2. ISO9001-2015 standards

e resources

	Strength of CO-PO/PSO Mapping															
	PO												PSO			
Strength Of CO	1	2	3	4	5	6	7	8	9	10	11	12			1	2
CO 1	3	2	2	-	-	-	-	-	2	2	2	2			2	2
CO 2	3	2	2	-	-	-	-	-	2	2	2	2			2	2
CO 3	3	2	2	-	-	-	-	-	2	2	2	2			2	2
CO 4	3	2	2	-	-	-	-	-	2	2	2	2			2	2
Avg.	3	2	2	-	-	-	-	-	2	2	2	2			2	2

Final Year B. Tech.
Pattern 2022
Semester: VII (Mechanical Engineering)
MEC224002B **: Elective VI - Smart Materials**

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Theory : 03 hrs/week	**03**	**End Sem Exam: 60 Marks** **CCE : 40 Marks**

Prerequisite Courses, if any: -
Basics of Electrical and Electronics Engineering, Engineering Mathematics, Mechatronics, Engineering Mechanics

Course Objectives:

- To study the working principles of various smart materials.
- To understand applicability of various smart materials as actuator and sensor.
- To study advances in smart materials

Course Outcomes: On completion of the course, students will be able to –

	Course Outcomes	Bloom's Level
CO1	**Describe** the role of Smart Materials in developing Intelligent Systems and Adaptive Structures	2- Understand
CO2	**Apply** the concepts of HBLS and LBHS smart materials	3 - Apply
CO3	**Illustrate** special smart materials for emerging applications	3 - Apply
CO4	**Analyze** the applicability of smart materials	4 - Analyze

COURSE CONTENTS

Unit I	Introduction to Smart Materials	(7hrs)	COs Mapped - CO1

What is Intelligence? Artificial intelligence Vs. Embedded Intelligence, Definition of smart material, need for smart materials, classifications of smart systems, components of a smart systems, smart system applications, Concept of Smart Composites, the role of Smart Materials in developing Intelligent Systems and Adaptive Structures, concept of High bandwidth- low strain generating materials (HBLS), and Low Bandwidth High Strain Generating Materials (LBHS)

Unit II	High bandwidth - Low strain generating (HBLS) Smart Materials	(7hrs)	COs Mapped – CO2

Piezoelectric Materials - constitutive relationship, electromechanical coupling coefficients, piezoelectric constants, piezoceramic materials, variation of coupling coefficients in hard and soft piezoceramics, polycrystalline vs single crystal piezoelectric materials, polyvinyldene fluoride, piezoelectric composites.
Magnetostrictive Materials - constitutive relationship, magneto-mechanical coupling coefficients, Joule Effect, Villari Effect, Matteuci Effect, Wiedemann effect, Giant magnetostriction in Terfenol-D, Terfenol-D particulate composites, Galfenol and Metglas materials.

Unit III	Low bandwidth - High strain generating (LBHS) materials	(7hrs)	COs Mapped – CO2

Shape Memory Alloys (SMA) - Introduction, Phenomenology, Influence of stress on characteristic temperatures, Modelling of shape memory effect. Vibration control through shape memory alloys. Design considerations, multiplexing embedded NiTiNOL actuators.
Electro-active Polymers (EAP) - Introduction, Phenomenology, Influence of stress on characteristic temperatures

Unit IV	Special Smart Materials	(7hrs)	COs Mapped –CO3

Overview of the following materials with focus on synthesis, strengths and weaknesses, and applications -
Ferrofluids and Magneto rheological Fluids and applications in dampers
Carbon Nanotubes and Carbon nanostructures and its applications
Thermoelectric Materials, Peltier devices and its applications

Unit V	**Applications of Smart Materials**	**(7hrs)**	**COs Mapped – CO4**

artificial skins, artificial muscles, biomimetic materials, materials with tuneable responses, self-healing materials, adaptive structures, self-replicating materials/structures, self-assembly, inch worm devices, Unimorph and Bimorph Actuators, Magnetostrictive Mini Actuators, Piezo Composites, Manetostrictive Composites, Smart Materials for Energy Applications: Materials used for energy storage, Hydrogen Storage Materials, Energy harvesting, Energy scavenging from vibrations

Text Books

Text Books:

- M.V. Gandhi, B.D. Thompson" Smart Materials and Structures" Springer Science & Business Media, 31-May-1992.
- Brian Culshaw, Smart Structures and Materials, Artech House, 2000.
- Gauenzi, P., Smart Structures, Wiley, 2009.
- Cady, W. G., Piezoelectricity, Dover Publication

Reference Books

- Mel Scwartz, “Encyclopedia of Smart Materials Vol. I and II”, John Wiley & Sons
- SenolUtku, “Theory of Adaptive Structures : Incorporating Intelligence into Engineered Products”, CRC Press (1998), ISBN: 9780849374319
- A.V. Srinivasan, “Smart Structures: Analysis and Design”, Cambridge University Press,Cambridge; New York, 2001 (ISBN: 0521650267)
- G. Gautschi, “Piezoelectric Sensorics: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors, Materials and Amplifiers”, Springer, Berlin; New York, 2002 (ISBN:3540422595)
- K. Uchino, “Piezoelectric Actuators and Ultrasonic Motors”, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114)
- G. Engdahl, “Handbook of Giant Magneto strictive Materials”, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X)
- K. Otsuka and C.M. Wayman, “Shape Memory Materials”, Cambridge University Press, Cambridge; New York, 1998 (ISBN: 052144487X)

Online Reference

Introduction to Smart Material - https://nptel.ac.in/courses/112104173
NOC:Smart Materials and Intelligent System Design - https://archive.nptel.ac.in/courses/112/104/112104251/

Strength of CO-PO/PSO Mapping

	PO												PSO	
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO 1	2	2	-	-	-	2	2	2		2	-	2	2	2
CO 2	2	2	2	-	-	2	-	-		-	-	2	2	2
CO 3	3	3	2	-	-	2	-	-	-	-	-	2	2	2
CO 4	3	3	-	-	-	2	2	2	-	2	-	2	2	2
Average	2.5	2.5	2	-	-	2	2	2	-	2	-	2	2	2
Level	3	3	2	-	-	2	2	2	-	2	-	2	2	2

Course Code	**MEC224002C**						
Course Name	**Design of Heat Exchangers**						
Type of Course	DEC						
Teaching Scheme and Credits	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
Weekly Working Hrs	3		---		---		3
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
(Marks)	40	---	---	---	---	60	100

Prerequisites for the Course: Basic Heat Transfer, Fluid Mechanics

The course aims to:

Course Objectives	Description
1	To equip students with comprehensive knowledge and practical skills required for the design, analysis, and performance evaluation of various heat exchangers used in industrial and engineering applications. The course focuses on thermal and mechanical design principles, modern technologies, standards, and real-world case studies.

On completion of the course, learner will be able to–

Course Outcomes	Description	Bloom's Level
CO1	Understand the fundamental principles of heat exchangers, their types, classifications, and performance analysis using LMTD and NTU methods.	2 - Understand
CO2	Apply thermal and mechanical design methodologies to standard heat exchangers, including material selection, pressure drop, and adherence to design standards like ASME and TEMA.	3 - Apply
CO3	Evaluate advanced and special types of heat exchangers and understand the role of modern simulation tools and enhancement techniques in exchanger design.	4 - Analyze
CO4	Analyze real-life applications and case studies of heat exchangers across industries, considering economic, environmental, and performance factors to propose optimized design solutions.	4 - Analyze

Course context, Relevance, Practical Significance:

The design of heat exchangers is a critical subject in mechanical, chemical, petrochemical, power, HVAC, and process engineering disciplines. As global industries aim to improve energy efficiency, minimize losses, and adopt sustainable practices, the demand for advanced heat exchanger design and optimization has grown exponentially. This course equips students with the theoretical foundation and practical skills to design, analyze, and optimize heat exchangers for diverse industrial applications.

Course Contents:

Unit	Contents	Lecture Hours	COs Mapped

1	**Fundamentals of Heat Exchangers** Introduction to heat exchangers: types and applications, Classification: based on flow arrangement, construction, and surface area, Basic heat transfer mechanisms: conduction, convection, radiation, Overall heat transfer coefficient, Log Mean Temperature Difference (LMTD) and Effectiveness-NTU methods	6 Hrs	CO1
2	**Design Methodology for Heat Exchangers** Thermal design procedure for shell-and-tube and compact heat exchangers, Heat transfer coefficient correlations for various fluids and flow regimes, Pressure drop calculations, Selection of materials and geometry, Fouling factors and maintenance considerations	8 Hrs	CO2
3	**Mechanical Design and Standards** Mechanical design of shell, tubes, tube sheets, baffles, Stress analysis and expansion considerations, ASME and TEMA standards, Fabrication, inspection, and testing procedures, Design software tools (introductory overview)	8 Hrs	CO2
4	**Special Heat Exchangers and Modern Techniques** Plate heat exchangers, finned tube heat exchangers, Heat pipe exchangers, regenerative heat exchangers, Micro and mini channel heat exchangers, Use of CFD and simulation tools in design (overview), Thermal enhancement techniques	8 Hrs	CO3
5	**Applications and Case Studies on heat Exchangers** Heat exchangers in process industries, power plants, HVAC, automotive systems, Environmental and economic considerations in design, Case studies: failure analysis and optimization examples, Design project / term paper / simulation assignment	8 Hrs	CO4

References Books:

1. **Kakac, Sadik, Liu, Hongtan, and Pramuanjaroenkij, Anchasa,** *Heat Exchangers: Selection, Rating, and Thermal Design*, CRC Press
2. **Laxminarayana P.,** *Heat Exchangers Design*, CRC Press
3. **Shah, R. K., and Sekulic, D. P.,** *Fundamentals of Heat Exchanger Design*, Wiley

Text Books:

1. F.P. Incropera, D.P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley.
2. Y. A. Cengel and A.J. Ghajar, Heat and Mass Transfer: Fundamentals and Applications, Tata McGraw Hill Education Private Limited.
3. S.P. Sukhatme, A Textbook on Heat Transfer, Universities Press.
4. R.C. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New Age Science.
5. A.F. Mills, *Basic Heat and Mass Transfer*, Pearson.

e Resources:

1. https://modelon.com/library/heat-exchanger-library/
2. https://www.hrs-heatexchangers.com/resource/how-to-design-a-tubular-heat-exchanger/

Useful websites / Video

1. https://nptel.ac.in Video lectures of *Heat Exchangers: Fundamentals and Design analysis* by Prof. Prasanta Kr Das and Prof. Indranil Ghosh (IIT Kharagpur)

Strength of CO - PO/PSO Mapping (Sample): Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped

• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1- Low,2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping

Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	3	2	1	1	1	-	-	-	-	-	-	-	2	-
CO 2	3	3	3	2	2	-	-	-	-	-	-	-	2	-
CO 3	2	3	2	2	3	-	-	-	-	-	-	-	2	-
CO 4	2	3	3	2	2	-	2	-	-	-	-	-	3	

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment on each unit	10
2	Test (Online/Offline) on each unit	10
3	Presentation on case studies on Design of heat Exchangers	20
	Total	**40**

Final Year B. Tech.
Pattern 2022 Semester: VII (Mechanical Engineering)
MEC224003 : **Principles of Macro Economics**

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :02 hrs/week	02	**Continuous Comprehensive Evaluation: 50Marks** --

Prerequisite Courses, if any: - Basic Mathematics for Economics

Course Objectives

1. To provide students with a fundamental understanding of macroeconomic concepts, theories, and models.
2. To analyze the determinants of national income, unemployment, and inflation, and their implications for economic policy.
3. To develop critical thinking skills for evaluating macroeconomic policies and their impact on economic stability and growth.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	To comprehend and explain the key macroeconomic concepts, including GDP, inflation, unemployment, and fiscal policy.	2-Understand
CO2	Analyzing macroeconomic data and interpreting economic indicators to assess the state of the economy.	4- Analyze
CO3	The ability to evaluate the effectiveness of macroeconomic policies in achieving economic objectives and promoting sustainable growth.	5- Evaluate

COURSE CONTENTS

Unit I	Introduction to Macroeconomics	**(08hrs)**	**COs Mapped -**

Overview of Macroeconomics
Scope and Importance of Macroeconomics
Macroeconomic Variables and Indicators
Circular Flow of Income and Expenditure
Macroeconomic Models: Classical vs. Keynesian

Unit II	National Income Accounting	**(08hrs)**	**COs Mapped -**

Measurement of National Income and Output
GDP Calculation Methods
Real vs. Nominal GDP
National Income Identity and Expenditure Approach
GDP Deflator and Price Indexes

Unit III	Money, Banking, and Monetary Policy	**(8hrs)**	**COs Mapped -**

Functions of Money and Types of Money
Central Banking and the Federal Reserve System
Money Supply and Monetary Policy Tools
Interest Rates and Monetary Policy Transmission Mechanisms
Monetary Policy and Inflation Targeting

Text Books
1. Macroeconomics: Principles and Policy" by William J. Baumol, Alan S. Blinder, and John L. Solow, Cengage Learning, 2017. 2. Macroeconomics" by N. Gregory Mankiw, Worth Publishers, 2019. 3. Principles of Macroeconomics" by Karl E. Case, Ray C. Fair, and Sharon C. Oster, Pearson, 2020. 4. Macroeconomics: A European Perspective" by Olivier Blanchard, Alessia Amighini, and Francesco Giavazzi, Pearson, 2019.
Reference Books
1. Macroeconomics" by Rudiger Dornbusch, Stanley Fischer, and Richard Startz, McGraw-Hill Education, 2018. 2. The Economics of Money, Banking, and Financial Markets" by Frederic S. Mishkin, Pearson, 2021. 3. Macroeconomics" by Paul Krugman, Robin Wells, and Margaret Ray, Worth Publishers, 2018. 4. Macroeconomics: Understanding the Global Economy" by David Miles, Andrew Scott, and Francis Breedon, Wiley, 2019.

Strength of CO-PO/PSO Mapping														
Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1														
CO 2														
CO 3														
CO 4														
Avg														

Guidelines for Continuous Comprehensive Evaluationof Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	One Assignments on Unit-1, Unit-2, Unit-3	30
2	Sincerity in class work	20
	Total	**50**

Final Year B. Tech.
Pattern: 2022 Semester: VIII (Mechanical Engineering)
MEC224011: Heating Ventilation Air Conditioning & Refrigeration

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Lecture: 03 hr / week	03	INSEM : 20 ENDSEM : 60 CCE : 20

Prerequisite Courses: - Thermodynamics, Applied Thermodynamics, Fluid Mechanics, Heat and Mass transfer.

Course Objectives:

- To acquainted with balancing problems of machines.
- To understand fundamentals of vibrations.
- To develop competency in understanding of vibration and noise in Industry.
- To develop analytical competency in solving vibration problems.
- To understand the various techniques of measurement and control of vibration and noise.

	Course Outcomes	**Bloom's Level**
CO1	Apply concepts of two-stage compression, multi-evaporator systems, and cascade refrigeration cycles to real-world refrigeration scenarios. .	3- Apply
CO2	Apply the working principles and control mechanisms of compressors, condensers, evaporators, and expansion devices in advanced refrigeration systems.	3- Apply
CO3	Apply heating and cooling load calculations using psychrometric processes, considering factors like SHF, ADP, and outdoor weather data.	3- Apply
CO4	Analyze air distribution layouts, pressure losses in ducts, and design efficient ventilation systems, supported by numerical calculations.	4- Analyze
CO5	Analyze advanced HVAC systems, such as desiccant-based and thermal storage systems, to determine suitability for specific scenarios.	4- Analyze

COURSE CONTENTS

I	**Multi Pressure Systems** **Multistage or compound system:** -Need of multi staging, Two stage compression with flash gas removal, flash intercooler and complete multistage compression system. **Multi evaporator system:**-single compressor-individual expansion valve, single compressor-multiple expansion valve, individual compressor-multiple expansion valve, individual compressor with compound compression and flash inter cooling. (Limited to two evaporators). Ammonia-CO2 cascade cycle. **Refrigerants:** Introduction-Definition and requirement, Classification of refrigerants, Designation of refrigerants, Desirable properties of refrigerants-Thermodynamic, Chemical and Physical. Properties of ideal refrigerant. Environmental issues like ODP, GWP & LCCP. Selection of environment friendly refrigerants,	(08hrs)	COs Mapped – CO1

	Alternative refrigerants, Secondary refrigerants, Anti-freeze solutions, Zeotropes and Azeotropes, Refrigerant recovery, reclaims, recycle and recharge.		
II	**Practical aspects of Vapour Compression System & Advanced Refrigeration Systems** **Major components of refrigeration cycle –** Types of compressors, Characteristics of reciprocating and centrifugal compressors, Types of evaporators, Types of condensers and Types of expansion valves. **Safety Controls:** LP/HP cut-off, Low temperature control, Frost control, Motor overload control, Oil pressure failure control. Capacity control of different compressors. **Advanced Refrigeration System: -**Transcritical cycle and their types, Simple ejector refrigeration system (analysis and numerical).	(07 hrs)	COs Mapped – CO2
III	**Applied Psychrometry** Psychrometric Chart, Psychrometric processes using BPF, ADP, SHF, RSHF, GSHF, ESHF, ERSHF and adiabatic mixing of two air streams. Heat load estimation:- Air conditioning, heating & cooling load calculations, **Envelop Load estimation**: -Concept of sol-air temperature, ETD and CLTD methods **Thermal Comfort:** Basic parameters, Thermodynamics of human body, Thermal comfort and Comfort charts, Factors affecting thermal comforts. **Indoor Air Quality (IAQ):** Indoor air contaminants, Basic strategies to improve indoor air quality. **Outdoor Design Conditions:** Outdoor air requirements for occupants, Use of outdoor weather data in design, Outdoor weather characteristics and their influence.	(07 hrs)	COs Mapped – CO3
IV	**Ventilation, Infiltration & Air Distribution Systems (Ducts)** **Ventilation and infiltration:** Natural ventilation, Mechanical ventilation, Extraction system and infiltration and different methods of infiltration. **Duct Design:** Definition of duct and types of ducts, Economic factors influencing duct layout, Materials for ducts and its specification, Flow through duct, Pressure in ducts, Friction loss in ducts, Friction chart for circular ducts, Equivalent diameter of a circular duct for rectangular sections, Methods of duct designs. **(Numerical treatment on duct design).** **Air Distribution System:** Factors considered in air	(07hrs)	COs Mapped – CO4

	distribution system, (simple numerical).Types of air distribution devices. Fan coil unit, Fan laws, Types of fans used air conditioning applications, Types of supply air outlets, Selection and location of outlets, Filters, Diffusers, Grillers, and Dampers.		
V	**Advanced Air Conditioning Systems** **Advanced AC Systems:** Working of summer, winter and all year round AC systems, all air system, all water system, air water system, variable refrigerant flow and variable air volume systems, unitary and central air conditioning. *Desiccant-Based Air Conditioning Systems*: Introduction, Sorbents & Desiccants, Dehumidification, Liquid spray tower, Solid packed tower, Rotary desiccant dehumidifiers, Hybrid cycles, Solid desiccant Air-Conditioning (Theoretical treatment). Evaporative Cooling Air Conditioning Systems, Thermal storage Air Conditioning systems, Clean room Air Conditioning systems, Radiant cooling. (No numerical) Heat pumps and its different circuits	(07 hrs)	COs Mapped – CO5

Text Books

1. Arora C. P., Refrigeration and Air Conditioning, Tata McGraw-Hill.
2. Manohar Prasad, Refrigeration and Air Conditioning, Willey Eastern Ltd, 1983.
3. McQuiston, ― Heating Ventilating and air Conditioning: Analysis and Design‖ 6th Edition, Wiley India.
4. Arora and Domkundwar, Refrigeration & Air Conditioning, Dhanpatrai & Company, New Delhi.
5. Khurmi R.S. and Gupta J.K., Refrigeration and Air conditioning, Eurasia Publishing House Pvt.Ltd, New Delhi,1994.
6. Ballaney P.L., Refrigeration and Air conditioning, Khanna Publishers, New Delhi, 19921.
7. S.N.Sapali , Refrigeration and Air conditioning ,Eastern Economy Edition.
8. Arora R.C., Refrigeration and Air Conditioning, PHI, India

Reference Books

1. Dossat Ray J, Principles of refrigeration, S.I. version, Willey Eastern Ltd, 2000.
2. Stockers W.F and Jones J.W., Refrigeration and Air conditioning, McGraw Hill International
3. editions 1982.
4. Threlkeld J.L, Thermal Environmental Engineering, Prentice Hall Inc., New Delhi.
5. Aanatnarayan, Basics of refrigeration and Air Conditioning, Tata McGraw Hill Publications.
6. Roger Legg, Air Conditioning System Design, Commissioning and Maintenance.
7. ASHRAE Handbook (HVAC Equipments) & ISHRAE handbook.
8. Shan Wang, Handbook of Refrigeration and Air Conditioning, McGraw Hill Publications.
9. Wilbert Stocker, Industrial Refrigeration, McGraw Hill Publications

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignments on each unit (10 marks) (Total marks will be converted into 10 marks)	10
2	LMS Test on each unit (10 marks) (Total marks will be converted into 10 marks)	10
	Total	**20**

Strength of CO-PO/PSO Mapping														
	PO's												PSO	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	3	3	3	-	-	-	-	-	-	-	-	-	-	-
CO 2	-	3	-	3		-	-	-	-	-	-	-	2	-
CO 3	3	3	3	-	-	-	-	-	-	-	-	-	2	-
CO 4	-	3	-	3	-	-	3	-	-	-	-	-	2	-
CO 5	-	-	-	3	-	-	3	-	-	-	-	3	-	-
Average	3	3	3	3	-	-	3	-	-	-	-	3	2	-
Level	3	3	3	3	-	-	3	-	-	-	-	3	2	-

Final Year B. Tech.
Pattern: 2022 Semester: VIII (Mechanical Engineering)
MEC224012 : Dynamics of Machinery

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Lecture: 03 hr / week	03	INSEM : 20 ENDSEM : 60 CCE : 20

Prerequisite Courses: - Mechanism and Machines, Mathematics for Mechanical Engineers, Solid Mechanics, Machine Design-I, Machine Design-II, Numerical and Statistical Methods

Course Objectives:

- To acquainted with balancing problems of machines.
- To understand fundamentals of vibrations.
- To develop competency in understanding of vibration and noise in Industry.
- To develop analytical competency in solving vibration problems.
- To understand the various techniques of measurement and control of vibration and noise.

	Course Outcomes	**Bloom's Level**
CO1	**Describe** the concept of vibration and noise, its measurement and control techniques	2 - Understand
CO2	**Estimate** natural frequency for undamped and damped free vibratory systems.	3- Apply
CO3	**Determine** response of vibratory system due to forced vibrations	3- Apply
CO4	**Illustrate** static and dynamic balancing techniques for Mechanical systems	4- Analyze

COURSE CONTENTS

I	**Single Degree of Freedom Systems – Free Vibration**	(08hrs)	COs Mapped – CO1, CO2

Fundamentals of Vibration : Elements of a vibratory system, Introduction to Physical and Mathematical modeling of vibratory systems : Bicycle, Motor bike types of vibration, equivalent stiffness and damping, formulation of differential equation of motion (Newton, D'Alembert or Energy method)
Undamped free vibrations: Natural frequency for longitudinal, transverse and torsional vibratory systems. (Numericals on longitudinal only)
Damped free vibrations: Different types of damping, Viscous damping – over damped, critically damped and under damped systems, initial conditions, logarithmic decrement (Numericals), Dry friction or coulomb damping

II	**Single Degree of Freedom Systems - Forced Vibrations**	(07 hrs)	COs Mapped –

			CO1, CO3
Forced vibrations of longitudinal and torsional systems, Frequency Response to harmonic excitation, excitation due to rotating and reciprocating unbalance, base excitation (Numericals), magnification factor, Transmissibility (Numericals), Quality Factor.			
III	**Vibrations in coupled Systems – Undamped Vibrations**	(07 hrs)	COs Mapped – CO1, CO2
Free vibration of spring coupled systems – longitudinal and torsional, torsionally equivalent shafts, natural frequency and mode shapes, Eigen value and Eigen vector by Matrix method (Numericals up to 2 DoF for longitudinal system), Combined rectilinear and angular motion.			
IV	**Balancing**	(07hrs)	COs Mapped – CO4
Static and dynamic balancing, balancing of rotating masses in single and several planes (Numericals), primary and secondary balancing of reciprocating masses, balancing in single cylinder engines, balancing in multi-cylinder in-line engines, direct and reverse cranks method - radial and V engines (Numericals).			
V	**Vibration & Noise : Measurement and Control**	(07 hrs)	COs Mapped – CO1
A) Measurement: Vibration Measuring Instruments, Accelerometers, Impact hammer, Vibration shakers, Vibration Analyzer, Vibration based condition monitoring, B) Control : Types of Vibration control methods, Vibration isolators, Tuned mass damper, Introduction to Torsional Damper C) Introduction to Noise: Fundamentals of noise, Sound concepts, Decibel Level, Logarithmic addition, subtraction and averaging, sound intensity, Noise control techniques, Noise standards.			

Text Books

1. S. S. Rao, Mechanical Vibrations, Pearson Education Inc. New Delhi.

2. G. K. Grover, Mechanical Vibrations, New Chand and Bros.,Roorkee

3. Wiiliam J Palm III, Mechanical Vibration, Wiley India Pvt. Ltd, New Delhi

4. Uicker J. John, Jr, Pennock Gordon R, Shigley Joseph E., Theory of Machines and Mechanisms, International Version, OXFORD University Press, New Delhi.

5. M L Munjal, Noise and Vibration Control, Cambridge University Press India

6. S. S. Rattan, Theory of Machines, Third Edition, McGraw Hill Education (India) Pvt. Ltd. New Delhi.

Reference Books

1. Weaver, Vibration Problems in Engineering, 5th Edition Wiley India Pvt. Ltd, New Delhi.

2. Bell, L. H. and Bell, D. H., Industrial Noise Control – Fundamentals and Applications‖, Marcel Dekker

3. Alok Sinha, Vibration of Mechanical System, Cambridge university Press, India

4. Debabrata Nag, Mechanical Vibrations, Wiley India Pvt. Ltd, New Delhi.

5. Kelly S. G., Mechanical Vibrations, Schaums outlines, Tata McGraw Hill Publishing Co. Ltd.

6. Meirovitch, L., Elements of Mechanical Vibrations‖, McGraw Hill.

7. Ver, Noise and Vibration Control Engineering, Wiley India Pvt. Ltd, New Delhi.
8. Bies, D. and Hansen, C., Engineering Noise Control - Theory and Practice, Taylor and Francis.
9. Shrikant Bhave, Mechanical Vibrations Theory and Practice, Pearson, New Delhi

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignments on each unit (10 marks) (Total marks will be converted into 10 marks)	10
2	LMS Test on each unit (10 marks) (Total marks will be converted into 10 marks)	10
	Total	**20**

Strength of CO-PO/PSO Mapping														
	PO's												PSO	
CO's	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	3	2	-	-	-	2	-	-	-	-	-	2	-	-
CO 2	3	3	2	-	-	-	-	-	-	-	-	2	2	-
CO 3	3	3	2	-	-	-	-	-	-	-	-	2	2	-
CO 4	3	3	2	-	-	2	-	-	-	-	-	2	-	-
Average	3	3	2	-	-	-	-	-	-	-	-	2		-
Level	3	3	2	-	-	2	-	-	-	-	-	2	2	-

Final Year B. Tech.Pattern 2022 **SEM : VIII** **MEC224013 : Dynamics of Machinery Lab**		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 02hrs/week	**01**	**Term work:** 25 Marks **Oral:** 25 Marks

Prerequisite Courses: - Mechanism and Machines, Mathematics for Mechanical Engineers, Solid Mechanics, Machine Design-I, Machine Design-II, Numerical and Statistical Methods

Course Objectives:

1. To conversant with balancing problems of machines.
3. To understand fundamentals of free and forced vibrations.
4. To develop competency in understanding of vibration in Industry.
5. To develop analytical competency in solving vibration problems.
6. To understand the various techniques of measurement and control of vibration and noise.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	**Estimate** response for vibratory systems.	3 -Apply
CO2	**Illustrate** static and dynamic balancing techniques for Mechanical systems	4- Analyze
CO3	**Illustrate** noise, its measurement & noise reduction techniques for industry and real life problems.	4- Analyze
CO4	**Measure** the vibration signals using vibration measuring instruments and **classify** the faults.	5- Evaluate

List of Experiments

- **Students should perform any eight experiments from the following List**

Sr. No.	**Title**	**CO Mapped**
1	To determine the natural frequency of damped vibration of single degree freedom system and to find it's damping coefficient.	**CO1**
2	To obtain frequency response curves of single degree freedom system of vibration for different amount of damping.	**CO1**
3	To verify natural frequency of torsional vibration of two rotor system and position of node.	**CO1**
4	To determine critical speed of shaft with single rotor.	**CO1**
5	Balancing of wheel / rotor on computerized balancing machine OR Experimental verification of dynamic balancing of rotating masses.	**CO2**
6	Experimental verification of principle of dynamic vibration absorber.	**CO1**
7	To measure vibration of healthy and faulty for any mechanical element using FFT analyzer	**CO1, CO4**
8	To find the natural frequency of the beam using FFT Analyzer	**CO1, CO4**
9	To measure noise of any machine element healthy and faulty conditions	**CO3**

10	Industrial visit based on dynamic balancing of rotating masses OR Conditioning Monitoring and Fault Diagnosis	**CO1, CO2**

Text Books
1. S. S. Rao, Mechanical Vibrations, Pearson Education Inc. New Delhi.
2. G. K. Grover, Mechanical Vibrations, New Chand and Bros.,Roorkee
3. Wiiliam J Palm III, Mechanical Vibration, Wiley India Pvt. Ltd, New Delhi
4. Uicker J. John, Jr, Pennock Gordon R, Shigley Joseph E., Theory of Machines and Mechanisms, International Version, OXFORD University Press, New Delhi.
5. M L Munjal, Noise and Vibration Control, Cambridge University Press India
6. S. S. Rattan, Theory of Machines, Third Edition, McGraw Hill Education (India) Pvt. Ltd. New Delhi.
Reference Books
1. Weaver, Vibration Problems in Engineering, 5th Edition Wiley India Pvt. Ltd, New Delhi.
2. Bell, L. H. and Bell, D. H., Industrial Noise Control – Fundamentals and Applications‖, Marcel Dekker
3. Alok Sinha, Vibration of Mechanical System, Cambridge university Press, India
4. Debabrata Nag, Mechanical Vibrations, Wiley India Pvt. Ltd, New Delhi.
5. Kelly S. G., Mechanical Vibrations, Schaums outlines, Tata McGraw Hill Publishing Co. Ltd.
6. Meirovitch, L., Elements of Mechanical Vibrations‖, McGraw Hill.
7. Ver, Noise and Vibration Control Engineering, Wiley India Pvt. Ltd, New Delhi.
8. Bies, D. and Hansen, C., Engineering Noise Control - Theory and Practice, Taylor and Francis.
9. Shrikant Bhave, Mechanical Vibrations Theory and Practice, Pearson, New Delhi

Guidelines for Term work Assessment		
Sr. No.	**Components for Term work Assessment**	**Marks Allotted**
1	Experiment (Each Experiment carries 30 marks) R1- Timely completion of assignments (10 Marks) R2- Understanding of assignment (10 Marks) R3 – Presentation/Clarity of journal writing (10 Marks) For all Experiments total marks will be converted into 25 Marks.	25

Guidelines for Oral examination	
Oral examination will be conducted based on complete syllabus at the end of the semester	**Marks Allotted:** 25

T. Y. B. Tech. Pattern 2022	**MEC224014: Data Analytics Laboratory**	
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical:02 hrs/week	**01**	**Term work:** 25 Marks **Oral:**25 Marks

Prerequisite Courses: -Artificial Intelligence and Machine Learning, Engineering Mathematics, Linear Algebra, Probability, Basic Statistics

Course Objectives:

1. UNDERSTAND the fundamentals of Data science and Machine Learning.
2. APPLY Feature Engineering to datasets.
3. APPLY Machine learning algorithms for dataset of Mechanical Engineering domain.
4. DEMONSTRATE the ability to develop and Implement machine learning models in mechanical engineering domain.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	Apply fundamental principles of data science and Machine Learning.	2-Understanding
CO2	Explore solutions for engineering problems using Machine Learning.	2-Understanding
CO3	Apply feature engineering techniques to preprocess the given dataset	3- Apply
CO4	Develop machine learning models to address complex problems in mechanical engineering domain	4 -Analyze

List of Experiments		
Sr. No.	**Title**	**CO Mapped**
A)	All experiments are compulsory	
1	Assignment on overview of data analytics, Data types, Data Preprocessing Techniques	CO1
2	To Perform and compare hypothesis tests (t-tests, ANOVA, chi-square test, etc.) on given dataset	CO1, CO3
3	To develop one classification or Regression model and compare performance for various algorithms by applying feature engineering on given dataset	CO1, CO2, CO3, CO4
4	To Develop machine learning model (ARIMA /SERIMA) on time series dataset and evaluate its performance	CO1, CO2, CO3, CO4
5	To Develop machine learning model based on CNN for image dataset	CO1, CO2, CO3, CO4
B)	**Case study:** Comprehensive case study based on research paper machine learning technique implemented in mechanical engineering domain	CO1, CO2, CO3, CO4
C)	**Capstone Project:** Based on fundamentals of data Analytics	CO1, CO2, CO3, CO4

Text Books

1. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
2. Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems", PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015

Reference Books

1. Stuart Russell and Peter Norvig (1995), "Artificial Intelligence: A Modern Approach," Third edition, Pearson, 2003.
2. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
3. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
4. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.

Strength of CO-PO Mapping

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

Guidelines for Conduction of Experiments

Section B contains an assignment

1. In this group of 2/3 student will conduct a comprehensive case study based on a selected machine learning research paper.
2. Students will critically analyse and synthesize the key concepts, methodologies, and findings presented in the chosen research, with a focus on understanding the practical implications and potential applications of the proposed machine learning approaches.
3. Students will prepare report that reflects a deep understanding of the selected machine learning research.

Section C contains Capstone project

1. In this group of 2/3 student will Gather data from databases/real time data/dataset from research paper
2. Clean and Pre-process the data to handle missing values, outliers, and ensure data quality.
3. Perform EDA to understand patterns, trends, and relationships within the data.
4. Build a predictive model to forecast future trend on historical data/ Calculate and analyse key performance indicators (KPIs)/ Suggest actionable recommendations based on the analysis.

Guidelines for Term work Assessment

Sr. No.	Components for Term work Assessment	Marks Allotted
1	Presentation in group of 2-3 students on i. Case study (5 marks) ii. Capstone project (5 marks)	10
2	Experiment (Each Experiment carries 30 marks) R1- Timely completion of assignments (10 Marks) R2- Understanding of assignment (10 Marks)	15

	R3 – Presentation/Clarity of journal writing (10 Marks) For all Experiments total marks will be converted into 15 Marks.	

Guidelines for Oral examination	
Oral examination will be conducted based on syllabus at the end of the semester	**Marks Allotted:** 25

Final Year B. Tech.
Pattern: 2022 Semester: VIII (Mechanical Engineering)
MEC224015A **: Heat Transfer in Electronic Devices**

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Lecture: 03 Hrs / week	03	Insem : 20 Marks End Sem : 60 Marks CCE : 20 Marks

Prerequisite Courses: Heat Transfer and Basics of Electronics Engineering

Course Objectives:

To introduce the fundamentals of heat transfer mechanisms as applied to electronic devices and systems.
To understand heat generation, conduction, and thermal resistance in electronic components and packaging.
To study convection-based and fluid-based cooling techniques for electronics.
To familiarize students with advanced thermal management technologies used in modern electronic systems.
To develop the ability to apply thermal modelling and design principles for reliable electronic device operation.

	Course Outcomes	**Bloom's Level**
CO1	Explain heat transfer mechanisms and heat generation in electronic devices.	2
CO2	Analyze conduction heat transfer and thermal resistance in electronic packages and printed circuit boards.	3
CO3	Apply convection and fluid-based cooling techniques for electronic thermal management.	3
CO4	Evaluate advanced thermal management technologies such as heat sinks, heat pipes, and thermoelectric cooling.	3
CO5	Design and assess thermal solutions for electronic systems using analytical and simulation-based approaches.	3

COURSE CONTENTS

Unit	**Description**	**Hours**	**COs Mapped**
I	**Fundamentals of Heat Transfer in Electronics** Introduction to electronic thermal management; modes of heat transfer such as conduction, convection, and radiation; heat generation in electronic components including ICs, power electronics, LEDs, and batteries; thermal resistance networks and lumped modeling; steady-state and transient thermal behavior; reliability aspects, junction temperature, and derating.	08	CO1
II	Conduction Heat Transfer in Electronic Packages Conduction in solids and Fourier's law; thermal conductivity of materials; thermal interface materials and contact resistance; PCB	08	CO2

	thermal behavior including FR-4 and metal core PCBs; heat spreading in substrates and spreading resistance; role of encapsulants, underfills, and die-attach materials; electronic packaging case studies.		
III	**Convection and Fluid-Based Cooling** Natural and forced convection fundamentals; air cooling using fans and blowers; flow distribution and pressure drop; liquid cooling basics and coolants; microchannel heat sinks and jet impingement cooling; two-phase cooling including boiling, condensation, heat pipes, and vapor chambers; introduction to CFD for thermal design.	08	CO3
IV	Advanced Thermal Management Techniques Heat sink design, fin types, and material selection; phase change materials for transient thermal control; thermoelectric coolers and applications; nanomaterials and high-conductivity composites; immersion cooling concepts; thermal management in wearable and flexible electronics.	08	CO4
V	**Thermal Design, Modeling, and Applications** Electronic cooling design process and thermal guidelines; analytical and numerical thermal modeling methods; overview of thermal simulation tools; thermal management in smartphones, data centers, electric vehicle batteries, power electronics, and LED systems; reliability, thermal cycling, and failure mechanisms.	08	CO5

Text Books

1. **"Thermal Management of Electronics Packaging"** *by Allan D. Kraus & Avram Bar-Cohen*
2. **"Heat Transfer: A Practical Approach"** *by Yunus A. Çengel & Afshin J. Ghajar*
3. **"Thermal Management for LED Applications"** *by Clemens J.M. Lasance & S.P. V. N. Selvadurai*

Reference Books

1. **"Cooling of Electronic Systems"** *edited by H. Braun & E. Schmidt*
2. **"Handbook of Thermal Management of Electronic Systems"** *edited by Ali Shakouri*
3. **"Thermal Analysis of Power Electronic Devices"** *by G. Chen & J. Lin.*
4. **"Thermal Design and Thermal Behavior of Electronic Components"** *by J. R. Wilson & Y. Bar-Cohen*

COs	**PO**												**PSO**	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	3	2	1	1	1	-	-	-	-	-	-	-	2	-
CO 2	3	3	2	2	2	-	-	-	-	-	-	-	2	-
CO 3	2	3	3	2	2	-	-	-	-	-	-	-	2	-
CO4	2	2	3	2	3	-	-	-	-	-	-	-	2	-
CO5	2	3	3	3	3	-	-	-	-	-	2	2	2	-
Avg.	2	3	3	2	2	-	-	-	-	-	2	2	2	-

Guidelines for Continuous Comprehensive Evaluation		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**

1	Assignment on each Unit	10
2	Tests and LMS	10
	Total	**20**

Final Year B. Tech.
Pattern 2022
Semester: VIII (Mechanical Engineering)
MEC224015B **: Smart manufacturing with Industry 4.0**

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Theory : 03hrs/week	**03**	**InSem Exam: 20 Marks** **EndSem Exam: 60 Marks** **Continuous Comprehensive Evaluation: 20 Marks**

Prerequisite Courses, if any: -
Basics of Electrical and Electronics Engineering, Manufacturing Process, Mechatronics, Industrial Engg

Course Objectives:

- Understand the concept of Smart Manufacturing and Industry 4.0
- Understand the concepts of Sensor networks in Smart Manufacturing
- Understand Key Technologies in Smart Manufacturing
- Understand the applicability of Cyber-Physical Systems and Digital Twins
- Understand the challenges in implementation of Industry 4.0

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level
CO1	**Describe** the concept of Smart Manufacturing and Industry 4.0	2- Understand
CO2	**Summarise** the concepts of Sensor networks in Smart Manufacturing	2- Understand
CO3	**Apply** Key Technologies in Smart Manufacturing	3 - Apply
CO4	**Analyze** the applicability of Cyber-Physical Systems and Digital Twins	4 - Analyze
CO5	**Evaluate** the challenges in implementation of Industry 4.0	5 – Evaluate

COURSE CONTENTS

Unit I	Introduction to Industry 4.0	(7hrs)	COs Mapped - CO1

- The Fourth Industrial Revolution: Key Concepts and Historical Context
- Smart Factories: Characteristics and Components
- Value Creation and Business Model Transformation in Industry 4.0
- Implications of Industry 4.0 on manufacturing processes
- Case Studies: Real-world Applications of Industry 4.0 Technologies

Unit II	IoT and Sensor Networks in Smart Manufacturing	(7hrs)	COs Mapped – CO1

- Role of IoT in the industrial context
- Sensor networks and their applications
- Data collection, analysis, and visualization
- Industrial Communication Protocols (e.g., Modbus, OPC UA)
- Industrial Internet of Things (IIoT) Architecture and Applications
- Real-time monitoring and control in smart factories
- Practical exercises with IoT devices

Unit III	Key Technologies in Smart Manufacturing	(7hrs)	COs Mapped – CO2

- Big Data and its Applications in Manufacturing
- Cloud Computing and its Role in Industry 4.0
- Data Analytics Techniques for Manufacturing (e.g., machine learning, process

mining)
- Machine Learning Algorithms for Manufacturing (e.g., anomaly detection, regression)
- Applications of AI in manufacturing processes
- Integration of AI and ML in Smart Manufacturing workflows
- Predictive Maintenance and Condition Monitoring Strategies
- Case Studies: Utilizing data analytics for production optimization

Unit IV	**Cyber-Physical Systems and Digital Twins**	**(7hrs)**	**COs Mapped –CO3**

- Understanding cyber-physical systems
- Integration of digital twins in manufacturing
- Benefits of digital twins for product lifecycle management
- Simulation and optimization using digital twins
- Practical exercises with digital twin software

Unit V	**Implementation and Challenges of Industry 4.0**	**(7hrs)**	**COs Mapped – CO4**

- Strategies for implementing Industry 4.0 in existing processes
- Challenges and considerations in the transition to smart manufacturing
- Cybersecurity Considerations in Smart Manufacturing and Industry 4.0
- Sustainability and Environmental Impact of Industry 4.0
- The Future of Work: Reskilling and Upskilling the Workforce

Text Books

Text Books:

- Smart Manufacturing: Concepts and Methods - by Masoud Soroush, Michael Baldea, Thomas F. Edgar
- Smart Manufacturing: Applications and Case Studies - Masoud Soroush, Michael Baldea, Thomas F. Edgar
- SMART MANUFACTURING - by Kamalakar Mutalik, Elsevier Science, 2020
- Artificial Intelligence for Smart Manufacturing - Methods, Applications, and Challenges, Kim Phuc Tran

Reference Books

Reference Books:

- Designing Smart Manufacturing Systems - Daniel Rossit, Chaudhery Mustansar Hussain · 2023
- Implementing Industry 4.0 - Carlos Toro, Humza Akhtar, Wei Wang, Springer International Publishing
- Smart Automation to Smart Manufacturing-Industrial Internet of Things, Uthayan Elangovan, Momentum Press
- Industry 4.0: The Industrial Internet of Things" by Alasdair Gilchrist, Apress
- Smart Manufacturing: Innovation and Transformation" by Massimo Tronci and Sauro Longhi

Strength of CO-PO/PSO Mapping

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

CO 4	2	2	-	-	3	2	2	2	2	2	-	2	2	2
CO 5	2	2	-	-	-	2	2	2	2	2	-	2	2	2

Guidelines for Continuous Comprehensive Evaluation of Theory Course			
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**	**Evaluation Rubrics**
1	One Assignment on each unit	10	R1 – Timely Completion (10marks) R2 – Understanding (10marks) R3 – Presentation & Clarity (10marks) 5 Assignments each of 30 marks, total 150 marks converted to 10 marks
2	Class Test	05	Pre Insem – 30 Marks, Pre end Sem – 60 Total 100 marks converted to 05 marks
3	LMS Test on Each Unit	05	MCQ test marks, 5 test one on each Unit of 10 marks each Total 50 converted into 5 marks
	Total	**20**	

Final year B. Tech
Pattern 2022
Semester: VII (Mechanical Engineering)
MEC224015C: Elective IV - Design of Electromechanical Systems

Teaching Scheme:	Credit Scheme:	Examination Scheme:
Theory : 03hrs/week	**03**	**InSem Exam: 20 Marks** **EndSem Exam: 60 Marks** **Continuous Comprehensive Evaluation: 20 Marks**

Prerequisite Courses, if any: -
Basics of Electrical and Electronics Engineering, Engineering Mathematics

Course Objectives:

- Understand the concept of electro mechanical systems
- Understand the Design Principles for Electro mechanical Components
- Understand the given system for integration and control
- Understand the Design Challenges, Standards through case studies

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level
CO1	**Demonstrate** the concept of electro mechanical systems	2- Understand
CO2	**Apply** the Design Principles for Electro mechanical Components	3 - Apply
CO3	**Analyze** the given system for integration and control	4 - Analyze
CO4	**Evaluate** the **Design Challenges, Standards through case studies**	5 - Evaluate

COURSE CONTENTS

Unit I	**Introduction to Electromechanical Systems Design**	**(7hrs)**	**COs Mapped - CO1**

Definition, scope and Importance of electromechanical systems in various industries, Basic Principles of Electromechanical Systems Design, Modelling and Analysis of real-world electromechanical systems

Unit II	**Electro-Mechanical Components in Electro-Mechanical Systems**	**(7hrs)**	**COs Mapped – CO2**

Electrical / Electronic Components and Design Principles -
Selection criteria for electrical components based on system requirements
Understanding electrical specifications and datasheets, Design considerations for effective electrical integration, Introduction to power electronic components (e.g., inverters, converters)
Mechanical Components and Design Principles -
Design considerations for mechanical components such as strength, stiffness, and durability
Simulation and analysis techniques for mechanical components
Integration of mechanical components with electrical systems

Unit III	**System Integration and control**	**(7hrs)**	**COs Mapped – CO3**

Principles of System Integration, Control theory fundamentals for electro-mechanical systems, Identifying and overcoming challenges in integrating electrical and mechanical systems, Design and implementation of control algorithms for system performance optimization
Prototyping and Testing - Prototyping techniques for electromechanical systems, Testing methodologies for performance validation

Design Optimization - Techniques for optimizing the overall system design, Balancing trade-offs between conflicting requirements			
Unit IV	**Design Challenges, Standards and Case Studies**	**(7hrs)**	**COs Mapped –CO4**
Emerging Technologies in Electro-Mechanical Systems, Case Studies of Complex Systems (Robotics, Automotive, Aerospace), Design Challenges and Solutions, Ethical Considerations and Standards			
Unit V	**Micro Electro Mechanical Systems**	**(7hrs)**	**COs Mapped – CO1**
Miniaturization - Applications and Markets**, MEMS and Microsystem, Microsensors, Microactuation, Microaccelerometers, Microfluidics,** Microfabrication			

Text Books

Text Books:

- "Electromechanical Systems and Devices" by Sergey Edward Lyshevski
- "Electric Motors and Drives: Fundamentals, Types and Applications" by Austin Hughes and William Drury
- "Design of Machinery" by Robert L. Norton
- "Mechatronics: Principles and Applications" by Godfrey C. Onwubolu
- "Introduction to Robotics: Mechanics and Control" by John J. Craig

Reference Books

- **Micro Electro Mechanical System Design, By James J. Allen, CRC Press**
- **2. Microsensors, MEMS, and Smart Devices, Julian W. Gardner, Osama O. Awadelkarim, and V. K. Varadan, Wiley Publishers**

Strength of CO-PO/PSO Mapping

	PO												PSO	
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO 1	2	2	2	-	2	-	-	-	2	2	-	2	2	2
CO 2	2	2	2	-	2	2	2	-	2	2	-	2	3	2
CO 3	3	3	2	2	2	2	3	2	2	2	2	2	3	2
CO 4	3	3	2	2	2	2	3	2	2	2	2	2	3	2
Average	2.5	2.5	2	2	2	2	2.66	2	2	2	2	2	2.75	2
Level	3	3	2	2	2	2	3	2	2	2	2	2	3	2

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted	Evaluation Rubrics
1	One Assignment on each unit	10	R1 – Timely Completion (10marks) R2 – Understanding (10marks) R3 – Presentation & Clarity (10marks) 5 Assignments each of 30 marks, total 150 marks converted to 10 marks
2	Class Test	05	Pre Insem – 30 Marks, Pre end Sem – 70 Total 100 marks converted to 05 marks
3	LMS Test on Each Unit	05	MCQ test marks, 5 test one on each Unit of 10 marks each Total 50 converted into 5 marks
	Total	**20**	

K.K.Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

Final Year B. Tech.
Pattern: 2022 Semester: VIII (Mechanical Engineering)
MEC224015D **: Supply Chain Management**

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Lecture: 03hr / week	03	Insem : 20 Marks End Sem : 60 Marks CCE : 20 Marks

Prerequisite Courses: -Industry Management

Course Objectives:
To understand the fundamental concepts, principles, and strategies involved in supply chain management.
To analyze and evaluate the key components of supply chain management including procurement, production, distribution, and logistics.
To apply various tools and techniques for optimizing supply chain processes and enhancing operational efficiency.
To develop critical thinking skills for solving real-world supply chain problems and making informed decisions.

	Course Outcomes	**Bloom's Level**
CO1	To demonstrate a comprehensive understanding of supply chain management principles and practices.	2
CO2	Apply various tools and methodologies for optimizing supply chain processes.	3
CO3	To apply critically supply chain issues and proposes solutions to enhance efficiency and effectiveness.	3
CO4	To analyze and design effective supply chain strategies to improve organizational performance.	4

COURSE CONTENTS

I	**Introduction to Supply Chain Management** Overview of Supply Chain Management Evolution and Importance of Supply Chain Management Key Concepts and Definitions in Supply Chain Management Supply Chain Processes and Integration Supply Chain Performance Metrics	(05hrs)	COs Mapped – CO1
II	**Supply Chain Strategy and Design** Supply Chain Strategy Formulation Demand Forecasting and Planning Network Design and Configuration Supplier Relationship Management Outsourcing and Global Supply Chains	(5hrs)	COs Mapped - CO2

III	**Supply Chain Planning and Inventory Management** Inventory Management Fundamentals Inventory Models and Optimization Techniques Aggregate Planning and Sales & Operations Planning (S&OP) Material Requirements Planning (MRP) and Just-In-Time (JIT) Distribution Requirements Planning (DRP)	(05hrs)	COs Mapped – CO2
IV	**Supply Chain Execution and Operations** Procurement and Purchasing Management Production Planning and Control Lean Manufacturing and Six Sigma in Supply Chain Warehousing and Distribution Management Transportation Management and Logistics Operations		COs Mapped – CO3
V	**Supply Chain Coordination and Collaboration** Supply Chain Coordination Strategies Collaborative Planning, Forecasting, and Replenishment (CPFR) Vendor-Managed Inventory (VMI) and Collaborative Logistics Information Technology in Supply Chain Management Sustainability and Green Supply Chain Management		COs Mapped – CO4

Text Books

4. Supply Chain Management: Strategy, Planning, and Operation" by Sunil Chopra and Peter Meindl, Pearson, 2019.
5. Operations and Supply Chain Management" by F. Robert Jacobs and Richard B. Chase, McGraw-Hill Education, 2020.
6. Introduction to Operations and Supply Chain Management" by Cecil B. Bozarth and Robert B. Handfield, Pearson, 2019.
7. Logistics & Supply Chain Management" by Martin Christopher, Pearson, 2021.

Reference Books

5. Supply Chain Management: A Logistics Perspective" by John J. Coyle, C. John Langley Jr., and Robert A. Novack, Cengage Learning, 2019.
6. Operations Strategy: Principles and Practice" by Nigel Slack and Michael Lewis, Pearson, 2020.
7. The Handbook of Logistics and Distribution Management" by Alan Rushton, Phil Croucher, and Peter Baker, Kogan Page, 2021.
8. Supply Chain Logistics Management" by Donald J. Bowersox, David J. Closs, and M. Bixby Cooper, McGraw-Hill Education, 2018.

	Strength of CO-PO/PSO Mapping															
	PO												PSO			
Strength Of CO	1	2	3	4	5	6	7	8	9	10	11	12	1	2		
CO 1	3	3	2	-	2	3	-	-	2	3	3	-	2	2		
CO 2	3	3	3	-	3	2	-	-	-	-	3	2	2	2		
CO 3	3	3	3	-	3	2	-	-	-	-	3	-	2	2		
CO4	3	3	3	-	3	2	-	-	2	3	3	2	2	2		
Avg.	3	3	3	-	3	2	-	-	2	3	3	2	2	2		

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	One Assignments on each Unit	10
2	Pre In-sem and Pre End-sem Test	5
3	Use of LMS	5
	Total	**20**

Pattern 2022
Semester: VIII
MEC224016A **: Lubrication, Friction and Wear**

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory:02hr/week	**02**	**In-Sem Exam: 20Marks** **End-Sem Exam: 30Marks**

Prerequisite Courses: - Physics, Chemistry, Machine design

Course Objectives:

1. To explain properties of lubricants, types and modes of lubrication etc.
2. To study the basics principles of friction, wear and lubrication
3. To study bearing, types of bearings, design of a bearing for simple applications
4. To explore impacts of friction, wear and lubrication in machine components

Course Outcomes: On completion of the course, students will be able to,

COs	**Course Outcomes**	**Bloom's Level**
CO1	Explain the basics of friction, wear and lubrication	2-Understand
CO2	Identify the types of lubricants, additives, bearings and wear mechanisms	2-Understand
CO3	Apply bearing design principles for sliding contact bearing	3-Apply

COURSE CONTENTS

Unit I	**Lubrication and bearing fundamentals**	**(06hrs)**	**COs Mapped – CO1, CO2**

Introduction to Tribology, Tribology in industry, Lubrication: Definition, modes of lubrication, lubricants-properties, types, additives used, Recycling of used oil. Bearing-Definition, Types of sliding contact, rolling contact bearings, comparison between sliding and rolling contact bearing, Types of sliding contact bearings with short explanation of its working and use.

Unit II	**Friction and Wear**	**(06hrs)**	**COs Mapped – CO1, CO2**

Friction- Introduction, laws of friction, types of friction, causes of friction. Theories of friction and friction measurement, stick-slip motion and friction instabilities. Wear-classification, wear between solids, wear between solid and liquids, factors affecting wear, Theories of wear, Wear measurement, Techniques to control of friction and wear (short theoretical treatment)

Unit III	**Sliding contact bearings**	**(10hrs)**	**COs Mapped – CO1, CO2, CO3**

Hydrodynamic lubrication: Theory of hydrodynamic lubrication, mechanism of pressure development in oil film. Two dimensional Reynolds's equation and its limitations, Petroff`s equation. Infinitely long journal bearing, infinitely short journal bearing and finite bearing, Designing journal bearing using Raimondi and Boyd approach.

Hydrostatic lubrication: Hydrostatic lubrication-Basic concept, advantages, limitations, viscous flow through rectangular slot, load carrying capacity, flow requirement of hydrostatic step bearing, energy losses, optimum design of stepped bearing, compensators and their actions. Squeeze film lubrication- Basic concept, circular and rectangular plate approaching a plane

(Numericals on hydrostatic bearing, Squeeze film lubrication).

Unit IV	**Controlling friction and wear**	**(6hrs)**	**COs Mapped – CO1, CO2, CO3**

Methods to control friction and wear in various machine components like use of lubricants, additives, surface modification, surface coating etc. should be explained in detail. 2 Case studies associated with controlling friction and wear observed in rotating/reciprocating parts in machine components should be discussed and explained to the students.

Text Books

1. Cameron A., ―Basic Lubrication Theory, Wiley Eastern Ltd,
2. Mujumdar B. C., ―Introduction to Tribology and Bearings, S. Chand and Company Ltd. New Delhi.
3. Bharat Bhushan, ―Principles and Applications of Tribology, 2nd Edition, Wiley India

Reference Books

1. Fuller D. D., ―Theory and Practice of Lubrication for Engineers, John Wiley and Sons.
2. Tadausz Burakowski, ―Surface Engineering of Metals: Principles, Equipments and Technologies, Taylor and Francis
3. Halling J., ―Principles of Tribology, McMillan Press Ltd.

Strength of CO-PO Mapping

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

Final Year B. Tech.Pattern 2022
SEM : VIII
MEC224016B **:** Unmanned Aerial Vehicles

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :02hrs/week	**02**	**In Sem Exam:** 20 Marks **End Sem Exam:** 30 Marks

Prerequisite Courses: Fluid Mechanics, Mechatronics, Turbo Machines, Programming Language (Python /C/C++), Design of Machines. Kinematics of Machines

Course Objectives:

1. To introduce students to the fundamental concepts and principles of Unmanned Aerial Vehicles (UAVs) technology.
2. To provide students with an understanding of the aerodynamics, propulsion, structures, control, and navigation systems relevant to UAV design and operation.
3. To familiarize students with the regulatory frameworks, legal considerations, and ethical issues associated with UAV deployment.
4. To develop students' skills in analyzing, designing, and implementing UAV systems for various applications.
5. To encourage critical thinking and problem-solving abilities in the context of UAV engineering challenges.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	Recall and describe basic principles and functions of UAVs, including historical development and applications.	Remember
CO2	Apply engineering principles to select materials and configurations for UAV construction, considering strength, weight, and durability.	Apply
CO3	Analyse aerodynamic principles governing UAV flight to optimize design for specific applications.	Analyze
CO4	Evaluate effectiveness of control and navigation systems for UAVs across various operational scenarios.	Evaluate
CO5	Synthesize knowledge to design and implement UAV systems meeting specified performance objectives and requirements.	Evaluate

COURSE CONTENTS

Unit I	**Introduction to UAVs**	**(06 hrs)**	**COs Mapped -**

Overview of UAV technology and applications, Historical development and evolution of UAVs, Classification of UAVs based on size, range, and payload capacity, Regulatory framework and legal considerations for UAV operation.

Unit II	**Aerodynamics of UAVs**	**(06 hrs)**	**COs Mapped –**

Fundamentals of aerodynamics related to UAV design, Lift and drag forces, Bernoulli's principle, and airflow around UAV structures, Wing design considerations, including airfoil selection and wing aspect ratio, Stability and control of UAVs, including flight dynamics and stability augmentation

systems.

Unit III	**UAV Propulsion Systems**	**(06 hrs)**	**COs Mapped –**

Types of propulsion systems used in UAVs (e.g., electric, piston engine, gas turbine), Performance characteristics and selection criteria for UAV propulsion systems, Energy sources for UAV propulsion (e.g., batteries, fuel cells, combustion engines), Propeller and rotor design considerations for UAV propulsion efficiency

Unit IV	**UAV Structures, Components and Materials**	**(06 hrs)**	**COs Mapped –**

Structural design principles for UAVs, including strength, stiffness, and weight considerations, Materials selection for UAV construction, Components, including composites, metals, and polymers, Structural analysis techniques for UAV components, such as finite element analysis (FEA), Design optimization strategies for lightweight and durable UAV structures.

Unit V	**UAV Control and Navigation**	**(06 hrs)**	**COs Mapped**

Principles of UAV control systems, including sensors, actuators, and feedback control loops, Navigation methods for UAVs, including GPS, inertial navigation, and computer vision, Autonomous flight control algorithms and software development for UAVs, Mission planning and execution for UAV applications in various fields, such as agriculture, surveillance, and disaster response.

Text Books

1. "Unmanned Aircraft Systems: UAV Design, Development and Deployment" Author: Reg Austin Publisher: Wiley
2. "Aerodynamics for Engineers" Author: John J. Bertin, Russell M. Cummings Publisher: Pearson
3. "Aircraft Propulsion" Author: Saeed Farokhi Publisher: Wiley
4. "Aircraft Structures" Author: David J. Peery, Azar Gatsonides Publisher: McGraw-Hill Education
5. "Modern Control Engineering" Author: Katsuhiko Ogata Publisher: Pearson

Reference Books

1. "Introduction to Unmanned Aircraft Systems" by Douglas M. Marshall, Richard K. Barnhart, and Eric Shappee
2. "Small Unmanned Aircraft: Theory and Practice" by Randal W. Beard and Timothy W. McLain
3. "Fundamentals of Aerodynamics" by John D. Anderson Jr.
4. "Aerodynamics for Engineering Students" by E.L. Houghton and P.W. Carpenter
5. "Aircraft Propulsion and Gas Turbine Engines" by Ahmed F. El-Sayed
6. "Electric Flight Technology: The Unfolding of a New Future" by Rui Cortesão
7. "Composite Materials: Fabrication Handbook #1" by John Wanberg
8. "Introduction to Aerospace Materials" by Adrian P. Mouritz and Ken G. N. Sinclair
9. "Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms" by Nikolaus Correll, Bradley Hayes, and Springer Tracts in Advanced Robotics
10. "Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems" by Paul D. Groves

Strength of CO-PO Mapping												
	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
CO1	3	2	2					2				1
CO2	3	2	2									1
CO3	3	2	2									1
CO4	3	2	2					2				1
CO5	3	2	2					2				1

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
	NA	
	NA	

Final. Year. B. Tech.Pattern 2022
SEM VIII
MEC224016C **: Sustainable Futures and Materials**

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory: 2 hrs./week	**2**	**Insem :** 20 Marks **Endsem:** 30 Marks

Prerequisite Courses: --

Course Objectives:

- Understand the material cycle's significance in the economy.
- Develop a sustainability model integrating various frameworks.
- Apply appropriate recycling processes based on material properties.
- Evaluate metal recovery methods and their environmental impact.
- Propose effective strategies for handling toxic materials.

Course Outcomes: On completion of the course, students will be able to–
CO1. Define the material cycle and its significance in the economy.
CO2. Develop a model of sustainability integrating various sustainability concepts and frameworks.
CO3. Demonstrate the ability to select appropriate recycling processes based on material characteristics.
CO4. Analyze different methods of metal recovery from industrial waste and their environmental implication
CO5. Propose strategies for handling and transporting toxic materials in recycling operations.

Unit I Materials and the Materials Cycle

The material cycle, Material flows in the economy, with a focus on the wastes produced at various stages, Quantifying the materials cycle, Materials and energy balances
Material flow analysis: Substance flow analysis, material flow analysis, Life cycle assessment, Business level material flow analysis, Economic-wide material flow analysis.

Unit II Introduction to Sustainability

Brief history of the idea of Sustainability, The concepts of sustainable development and sustainability, Interpretations of sustainability, Responses to the challenge of sustainability, sustainability frameworks: Triple bottom line, Eco-efficiency, Natural Capitalism, Biomimicry, The five capital models, Green chemistry, Green Engineering, A model of sustainability

Unit III Wet and Dry Recycling Processes

Dry Recycling Processes: Hand sorting, Dry screening, Electrostatic separation, Magnetic Separation, Eddy current separation, Optical separation, Pneumatic separation, Melting temperature based centrifugal separation, shredding
Wet Recycling Processes: Wet screening, Gravity screening, Heavy media screening, Shaking table screening, Spiral concentrator, multi gravity separation, centrifugal screening, froth flotation, Hydro cyclone, Chemical leaching

Unit IV Metal Recovery and Recycling
Regulatory considerations, Resource conserve
ation, Methods of metal recovery from industrial waste, Recovery Technology for Metals in Solution, Metal recovery from multi-metal wastes

Unit V Environmental impacts of Recycling
Introduction, Toxic materials and resources, Heavy metals/compounds and their toxicity, Handling of toxic materials, Transporting toxic materials, Reusing toxic material

Reference Books:
1. Minerals, Metals and Sustainability, W. J. Rankin, CSIRO publishing, 2011
2. Metal Recovery from Industrial Waste, Clyde S. Brooks, CRC Press, 2018
3. Recycling and Reusing of Engineering Materials, Wasim S, Khan, Eylem Asmatulu, Elsevier Inc, 2022

Mapping of Course outcomes with PO's:

Course Outcome	After successful completion of course students will be able to	Blooms Level	PO
CO1	Define the material cycle and its significance in the economy.	Understand	1,2
CO2	Develop a model of sustainability integrating various sustainability concepts and frameworks.	Apply	1,2
CO3	Demonstrate the ability to select appropriate recycling processes based on material characteristics.	Apply	1,2
CO4	Analyze different methods of metal recovery from industrial waste and their environmental implication	Analyze	1,2,8
CO5	Propose strategies for handling and transporting toxic materials in recycling operations.	Evaluate	1,8

Mapping of Course Outcome (CO) with

Program Outcome (PO) and Program Specific Outcome (PSO)
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)
If there is no correlation, put "-"

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	-	-	-	-	-	-	-
CO2	3	3	-	-	-	-	-	-	-	-	-	-
CO3	3	3	-	-	-	-	-	-	3	-	-	-
CO4	3	3	-	-	-	-	-	3	-	-	-	-
CO5	3	-	-	-	-	-	-	-	-	-	-	1
Avg.	3	3	-	-	-	3	-	3	3	3	3	1
Level	3	3	-	-	-	3	-	-	3	3	3	1

Course-PO matrix

Course Code	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
--------	3	3	-	-	-	3	-	-	3	3	3	1

Final Year B. Tech. Pattern 2022
Semester: VIII (Mechanical Engineering)
MEC224017 **: Robot Kinematics and Dynamics**

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory : 03hrs/week	**03**	**InSem Exam: 20 Marks** **EndSem Exam: 60 Marks** **Continuous Comprehensive Evaluation: 20 Marks**

Prerequisite Courses, if any: -
Basics of Electrical and Electronics Engineering, Engineering Mathematics, Mechanics, Mechatronics

Course Objectives:

- Understand the Anatomy of Robot
- Understand Robot Kinematics and Dynamics with simulation
- Understand control laws for simple robot
- Understand robot program for robot application

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	**Demonstrate** the Robot Anatomy	2- Understand
CO2	**Analyze** Robot Kinematics and Dynamics with simulation	3 - Apply
CO3	**Summarize** control laws for simple robot	4 - Analyze
CO4	**Develop** robot program for robot application	5 - Evaluate

COURSE CONTENTS

Unit I	**Robot Anatomy**	**(6 hrs)**	**COs Mapped - CO1**

Introduction to Robotics – Laws of Robotics, Robot Anatomy, Classification of Robots, Robots Links and Joints, Degrees of Freedom, Robot Configurations, Work Envelope
Robot Performance – Resolution, repeatability, accuracy, dexterity, Compliance, RCC
Applications of Robots – in Unmanned systems, Defense, medical, Industries

Unit II	**Robot Kinematics**	**(7hrs)**	**COs Mapped – CO2**

Robot Kinematics – Translation and Rotation representation, Coordinate Transformation, Denavit Hartenberg parameters, Forward and Inverse Kinematics, Jacobian, Singularity and Statics

Unit III	**Robot Dynamics**	**(7hrs)**	**COs Mapped – CO2**

Robot Dynamics – Forward and Inverse Dynamics, Equation of Motion using Euler – Lagrange Formulation and Newton – Euler Formulation, Case study on kinematic and dynamics of Industrial robot, Introduction to Trajectory Planning

Unit IV	**Robot Control System**	**(7hrs)**	**COs Mapped –CO3**

Basics of Control – Open and Closed Loop, Transfer Functions, Control Law Partitioning, PID Control, Linear and Nonlinear control, Force / Position Control, Adaptive control, Artificial Intelligence in Robotics, Robotic Simulation

Unit V	**Robot Programming**	**(7hrs)**	**COs Mapped – CO4**

Robot Programming – Methods of Robot Programming, Lead through Programming, Motion Interpolation, Robot Language Structure, Programming in VAL II, motion commands, End effector and Sensor Commands, Monitor mode commands, Robot program on palletizing and Depalletizing

Text Books

Text Books:

- Groover M.P.- Automation, production systems and computer integrated manufacturing‘ - Prentice Hall of India
- John Craig, Introduction to Robotics, Mechanics and Control, 3rd Edition, Pearson Education, 2009
- R K Mittal & I J Nagrath, Robotics and Control, McGraw Hill Publication, 2015
- Ganesh Hegde, Industrial Robotics, Laxmi publication
- S. K. Saha, Introduction to Robotics, TMH International
- Groover, Industrial Robotics, Tata McGraw-Hill Education

Reference Books

- Mark W Spong, M. Vidyasagar, Robot Dynamics And Control, John Wiley & Sons
- Richard D. Klafter, Robotics Engineering: An Integrated Approach, Pearson

Strength of CO-PO/PSO Mapping

	PO												PSO	
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO 1	2	2	2	2	2	2	-	-	2	-	-	2	2	2
CO 2	2	3	2	2	2	-	-	-	2	-	-	2	2	2
CO 3	2	3	2	2	2	-	-	-	2	-	-	2	2	2
CO 4	2	-	-	2	2	2	-	-	2	-	-	2	2	2
Average	2.5	2.5	2	2	2	2	2	2	2	2	2	2	2	2
Level	3	3	2	2	2	2	2	2	2	2	2	2	2	2

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**	**Evaluation Rubrics**
1	One Assignment on each unit	10	R1 – Timely Completion (10marks) R2 – Understanding (10marks) R3 – Presentation & Clarity (10marks) 5 Assignments each of 30 marks, total 150 marks converted to 10 marks
2	Class Test	05	Pre Insem – 30 Marks, Pre end Sem – 70 Total 100 marks converted to 05 marks
3	LMS Test on Each Unit	05	MCQ test marks, 5 test one on each Unit of 10 marks each Total 50 converted into 5 marks
	Total	**20**	

Final Year B. Tech.
Pattern: 2022 Semester: VIII (Mechanical Engineering)
MEC224018**: Industrial Engineering**

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Lecture: 02 hr / week	02	CCE : 50

Prerequisite Courses: - Manufacturing Processes, Engineering Mathematics for Mechanical Engg. Industrial Psychology and organizational behavior, Financial management etc.

Course Objectives:
To introduce the concepts, principles and framework of contents of Industrial Engineering.
To acquaint the students with various productivity enhancement techniques.
To acquaint the students with different aspects of Production Planning and Control and Facility Design.
To introduce the concepts of various cost accounting and financial management practices as applied in industries.
To acquaint the students with different aspects of Human Resource activities and Industrial Safety rules.

	Course Outcomes	**Bloom's Level**
CO1	**Calculate** the productivity and **Predict** various productivity improvement techniques	3
CO2	**Analyze** work study techniques and **Illustrate** its importance for better productivity.	4
CO3	**Categorize** inventory requirements and **Select** effective control on manufacturing requirements	4

COURSE CONTENTS

Part A

I	**Introduction** to Industrial Engineering, Historical background and scope, **Productivity:** Definition of productivity, Measures of Productivity, Total Productivity Model, Need for Productivity Evaluation, Productivity measurement models, Productivity improvement approaches, Principles, Productivity Improvement techniques – Technology based, Material based, Employee based, Product based techniques. (Numerical on productivity measurement)	(06hrs)	COs Mapped – CO1
II	**Method Study:** Introduction and objectives, Areas of application of work study in industry, Selection and Basic procedure. Recording techniques, Operations Process Chart, Flow Process Chart (Man, Machine & Material) Multiple Activity Chart, Two Handed process chart, Flow Diagram, String Diagram and Travel Chart, Cycle and chronocycle graphs, SIMO chart, Therbligs, Micro motion and macro-	(12 hrs)	COs Mapped - CO2

	motion study: Principles of motion economy, Normal work areas and work place design. **Work Measurement:** Techniques, time study, steps, work sampling, Determination of time standards. Observed time, basic time, normal time, rating factors, allowances, standard time, and standard time determination. (Numerical) Introduction to PMTS, MTM, and MOST		
III	**Purchase Management:** Purchase management, incoming material control. Acceptance sampling and inspection. Vendor rating system. **Inventory:** Functions, Costs, Classifications, Deterministic inventory models and Quantity discount Inventory Control: EOQ (Numericals), concepts, type of Inventory models- deterministic and probabilistic, Selective inventory control, Fundamental of Material Requirement Planning (MRP-I), Manufacturing Resource Planning (MRP-II), Enterprise Resource Planning (ERP), Just-in-Time system (JIT) and Supply Chain Management (SCM)	(06 hrs)	COs Mapped – CO3

Text Books

1. O. P. Khanna, Industrial engineering and management, Dhanpat Rai publication
2. M Mahajan, Industrial Engineering and Production Management, Dhanpat Rai and Co.
3. Martend Telsang, Industrial Engineering, S. Chand Publication.
4. Banga and Sharma, Industrial Organization& Engineering Economics, Khanna publication.

Reference Books

1 H. B. Maynard, K Jell, Maynard's Industrial Engineering Hand Book, McGraw Hill Education.
2. Zandin K.B., Most Work Measurement Systems, ISBN 0824709535, CRCPress,2002
3. Martin Murry, SAP ERP: Functionality and Technical Configuration, SAP Press.
4. Barnes, Motion and time Study design and Measurement of Work, Wiley India
5. Sumanth, D.J, "Productivity Engineering and Management", TMH, New Delhi, 1990.
6. Edosomwan, J.A, "Organizational Transformation and Process re- Engineering", British Cataloging in publications, 1996.

e resources

1. https://archive.nptel.ac.in/courses/112/107/112107143/#
2. https://nptel.ac.in/courses/112107249
3. https://onlinecourses.nptel.ac.in/noc22_me04/preview
4. https://nptel.ac.in/courses/112107292
5. https://nptel.ac.in/courses/112107142

	Strength of CO-PO/PSO Mapping															
	PO												PSO			
Strength Of CO	1	2	3	4	5	6	7	8	9	10	11	12	1	2		
CO 1	3	3	2	-	2	3	-	-	2	3	-	-	2	2	3	3
CO 2	3	3	3	-	3	2	-	-	-	-	-	2	2	2	3	3
CO 3	3	3	3	-	3	2	-	-	-	-	3	-	2	2	3	3
Avg.	3	3	3	-	3	2	-	-	2	3	3	2	2	2	3	3

Guidelines for Continuous Comprehensive Evaluationof Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	One Assignments on Unit-1, Unit-2, Unit-3	30
2	Unit Test	10
3	Use of LMS	10
	Total	**50**