Course Code		:	**BMEA501C**	**Design of Machine Element**	**Semester**	:	**05**
L:T:P		:	**3:0:0**		**Course Type**	:	**PCC**
Hours/Sem.	**Teaching**	:	**42 Hrs**		**CIE Marks**	:	**50**
	Learning (TW)	:	**42 Hrs**		**SEE Marks**	:	**50**
	Exam	:	**06 Hrs**		**Total Marks**	:	**100**
	Total Hrs.	:	**90 Hrs**		**Credits**	:	**03**

Professional Competency:

Apply the principles of mechanics of materials, stress analysis, failure theories, and machine design to analyze, design, and evaluate machine elements such as shafts, springs, and gears for safe, reliable, and efficient engineering applications under static and dynamic loading conditions.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Summarize the terminologies and preliminary concepts related to normal, shear, biaxial, tri axial and principal stresses

CO2: Apply the concepts of stress analysis, theories of failure and material science to select commonly used machine components under different condition of failure.

CO3: Design the shafts subject to combined static and dynamic load failures

CO4: Design the springs, gears by identifying the failure modes and different load conditions.

UNIT–I	**12 Hrs**

Introduction: Definitions: Normal, Shear, Biaxial and Triaxial Stresses, Stress Tensor, Principal Stresses Engineering Materials and their Mechanical properties, Stress-Strain diagrams, Stress Analysis, Design considerations: Codes and Standards.

Design for Static strength: Static loads and Factor of Safety, Theories of failure. Maximum Normal Stress Theory, Maximum Shear Stress Theory, Distortion Energy Theory Failure of Brittle Materials, Failure of Ductile Materials, Stress Concentration, Determination of Stress Concentration Factor.

UNIT–II	**08 Hrs**

Design for Fatigue strength: Design For Fatigue Strength: Introduction- S-N Diagram, Low Cycle Fatigue, High Cycle Fatigue, Endurance Limit, Endurance Limit Factors: Size effect, Surface effect, Stress Concentration effects. Fluctuating Stresses, Goodman and Soderberg relationship, Stresses due to Combined Loading

Design of Threaded Fasteners: Stresses in Threaded Fasteners, Effect of Initial Tension, Design of Threaded Fasteners under Static, Dynamic and Impact loads, Design of Eccentrically loaded Bolted Joints.

UNIT-III	**10 Hrs**

Design of Shafts: Torsion of Shafts, Design for strength and Rigidity with Steady loading, ASME & BIS codes for Power Transmission shafting, Shafts under Fluctuating loads and Combined loads

Design of Keys: Design of Keys-Stresses in Keys (Rectangle and Square key)

UNIT-IV	**10 Hrs**

Design of Springs: Definitions, Types of springs, Stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, springs under fluctuating loads, Energy stored in springs, Torsion, Belleville and Rubber springs.

Design of Spur Gears: Spur Gears: Definitions, Stresses in gear tooth: Lewis's equation and form factor, Design for strength, Dynamic load and wear load.
Text Books:
Reference Books:
1. V.B. Bhandari, **Design of Machine Elements**, (5th Edition), McGraw Hill Education (India), Reprints: 2025–2026. 2. S. C. Sharma, **Design of Machine Elements**, PHI Learning Pvt. Ltd., reprint: 2023–2025. 3. Robert L. Norton, **Machine Design: An Integrated Approach**, (6th Edition), Pearson Education. 4. Joseph E. Shigley, Charles R. Mischke, Richard G. Budynas, Keith J. Nisbett, **Shigley's Mechanical Engineering Design,** (12th Edition), McGraw Hill Publications
Web links and Video Lectures (e-Resources):

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	2 (WK1,2,3,4)	2 (WK1,2,3)	1 (WK5)	-	1 (WK6)	-	-	-	-	-	1	3	1
CO2	2 (WK1,2,3,4)	3 (WK1,2,3,4)	2 (WK5)	1 (WK5)	2 (WK6)	-	-	-	-	-	1	3	2
CO3	3 (WK1,2,3,4)	2 (WK1,2,3,4)	3 (WK5)	2 (WK5)	3 (WK6)	-	-	-	-	-	1	3	2
CO4	3 (WK1,2,3,4)	2 (WK1,2,3,4)	3 (WK5)	2 (WK5)	2 (WK6)	-	-	-	-	-	1	2	3

Course Code		**:**	**BMEA502C**	**Finite Element Methods**	**Semester**	**:**	**05**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PCC**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Apply finite element methods to model and analyze engineering problems for structural design and analysis.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Generate the governing FE equations for engineering problems/Mechanical systems.

CO2: Apply FEM to solve bars subjected to static load and thermal load

CO3: Apply the concept of lagrange interpolation for 2D and 3D elements and solve problems.

CO4: Apply FEM to solve trusses and beam problems.

UNIT–I	**11 Hrs**

Introduction: Equilibrium equations in elasticity subjected to body force, traction forces, stress strain relations for plane stress and plane strain, Boundary conditions, Initial conditions, Euler's Lagrange's equations of bar, beams, Principle of a minimum potential energy, principle of virtual work, Rayleigh-Ritz method Galerkins method and Matrix techniques .

Basic Procedure: General description of Finite Element Method, , Discretization process; types of elements 1D, 2D and 3D elements, size of the elements, location of nodes, node numbering scheme, half Bandwidth, Stiffness matrix of bar element by direct method, Properties of stiffness matrix, Preprocessing, post processing. Engineering applications of finite element method. Advantages & Disadvantages of FEM.

UNIT–II	**10 Hrs**

Interpolation Models: Polynomial form of interpolation functions- linear, quadratic and cubic, Simplex, Complex, Multiplex elements, Selection of the order of the interpolation polynomial, Convergence requirements, static condensation. Penalty approach and elimination method.

UNIT-III	**11 Hrs**

TWO dimensional elements: Shape functions and stiffness matrix of 2D elements four-Node quadrilateral, Nine-Node quadrilateral Eight-Node quadrilateral, serendipity and lagrange comparison with 2D Pascal's triangle. CST and LST shape functions, Jacobean matrix, stiffness matrix, force terms, stress calculation and Numerical integration. Introduction to 3-D elements shape function of tetrahedron element

UNIT-IV	**10 Hrs**

TRUSSES AND BEAM ELEMENTS: Analysis of trusses, generation of transformation matrix, development of Stiffness matrix determination of direction cosines and Analysis of beam elements, development of stiffness matrix, comparison of bar and beam elements its shape functions, strain matrix and stress calculation. Problems on trusses and beams

Text Books:

1. **A First Course in the Finite Element Method. Daryl L. Logan (2023). 7th Edition. Cengage**

Learning.

2. **An Introduction to the Finite Element Method. J. N. Reddy (2019). 4th Edition. McGraw-Hill Education.**
3. **The Finite Element Method: Its Basis and Fundamentals. O. C. Zienkiewicz, R. L. Taylor, & J. Z. Zhu (2013). 7th Edition. Elsevier.**
4. **Finite Element Analysis: Procedures in Engineering. H. V. Lakshminarayana (2008). Universities Press**

Reference Books:

5. **Chandrupatla, T. R., & Belegundu, A. D.** (2020). *Introduction to Finite Elements in Engineering* (5th ed.). Pearson.
6. **Krishnamurthy, C. S.** (2002). *Finite Element Analysis: Theory and Programming*. Tata McGraw-Hill Education.
7. **Zienkiewicz, O. C., Taylor, R. L., & Zhu, J. Z.** (2013). *The Finite Element Method: Its Basis and Fundamentals* (7th ed.). Elsevier. *.)*
8. **Reddy, J. N.** (2019). *An Introduction to the Finite Element Method* (4th ed.). McGraw-Hill Education.
9. **Logan, D. L.** (2023). *A First Course in the Finite Element Method* (7th ed.). Cengage Learning.
10. **Lakshminarayana, H. V.** (2008). *Finite Element Analysis: Procedures in Engineering* (Universities Press).

Web links and Video Lectures (e-Resources):

1.Introduction to Finite Element Method (IIT Madras – NPTEL)
https://www.youtube.com/watch?v=KR74TQesUoQ
2.**Finite Element Method (NPTEL Playlist)**
https://www.youtube.com/results?search_query=NPTEL+Finite+Element+Method+playlist
3. **MIT Open Course Ware FEM Video Lectures**
https://www.youtube.com/MIT/Fem

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	2 (WK1, WK2, WK3, WK4)	2 (WK1, WK2, WK3, WK4)	1 (WK5)	–	2 (WK6)	–	–	–	–	–	–	2	
CO2	2 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	1 (WK5)	2 (WK5)	3 (WK6)	–	–	–	–	–	–	2	
CO3	2 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	3 (WK5)	3 (WK5)	2 (WK6)	–	–	–	–	–	–	2	
CO4	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	2 (WK5)	3 (WK6)	2 (WK1, WK5, WK7)	–	–	–	–	–	2	

Course Code		**:**	**BMEA503C**	**Management and Entrepreneurship**	**Semester**	**:**	**05**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PCC**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Develop the ability to plan, organize, execute, and monitor projects efficiently by applying project management principles, tools, and techniques. Enhance leadership, teamwork, communication, and decision-making skills to deliver projects successfully within scope, time, cost, and quality constraints.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Demonstrate the ability of understanding the fundamental concepts of management, including its meaning, scope, functions, managerial roles and levels of management, and apply the principles of planning, organizing, and staffing to analyze basic organizational and managerial practices.

CO2: Identify and apply the principles of motivation, directing, leadership, communication, and controlling, and apply major motivation theories and control techniques to evaluate and improve organizational effectiveness.

CO3: Exhibit the concepts of entrepreneurship, including the functions and types of entrepreneurs, and evaluate their role in economic development, entrepreneurship in India, and the barriers to entrepreneurial growth.

CO4: Explore the knowledge of fundamentals of Small Scale Industries (SSI), including their characteristics, objectives, scope, economic significance, establishment process, and the role of government support agencies in promoting SSI development.

UNIT–I	**10 Hrs**

Management: Introduction, Meaning, Scope and Functional areas of management, Roles of Manager, Levels of Management

Planning: Nature, importance of planning, purpose of planning process, Objectives, Types of plans (Meaning only), steps in planning and planning premises

Organizing and Staffing: Purpose of organization, Principles of organization, Types of organization, Nature and importance of staffing, Process of Selection and Recruitment (in brief)

UNIT–II	**11 Hrs**

Motivation And Behavior: Maslow's theory of needs, X-Theory and Y-Theory, Immaturity-Immaturity theory of motivation, Hygiene factor theory, McClelland‟s theory of motivation

Directing and Controlling: Meaning and nature of directing, Leadership styles, *Communication*: Meaning and importance, *Controlling*: Meaning and steps in controlling, Essentials of a sound control system, Methods of establishing control (in brief)

UNIT-III	**11 Hrs**

Entrepreneur: Meaning of Entrepreneur, Functions of an Entrepreneur, Types of Entrepreneur (only types), Role of entrepreneurs in Economic Development, Entrepreneurship in India, Entrepreneurship: its Barriers

UNIT-IV	**10 Hrs**

Small Scale Industries (SSI):Definition, Characteristics, Objectives, Scope, Role of SSI in economic development, Advantages of SSI, Steps to start a SSI, Supporting agencies of Government for SSI(Meaning, Nature of support, Objectives and Functions in brief)
Text Books:
1. Harold Koontz, (2010), Essentials of Management, (Eighth edition), Tata McGraw-Hill 2. Poornima M. Charantimath, (2015),Entrepreneurship Development and Small Business Enterprises, (Third edition), Pearson Education India 3. Harold Koontz, Cyril O'Donnell, (2018), Principles of Management, (Fifth edition), McGraw Hill 4. P. C. Tripathi and P. N. Reddy, (2012), Principles of Management (Fifth edition), Tata McGraw Hill
Reference Books:
1. O. P. Khanna, Industrial Engineering and Management, Dhanpat Rai Publications, 17th Edition, 2019. 2. R. K. Jain, Industrial Engineering and Management, Khanna Publishers, 18th Edition, 2021. 3. Martand T. Telsang, Industrial Engineering and Production Management, S. Chand Publishing, 2nd Edition, 2018. 4. S. C. Sharma, Industrial Engineering and Management, Khanna Book Publishing, 1st Edition, 2020. 5. S. K. Sharma & Savita Sharma, Industrial Engineering and Management, S. K. Kataria & Sons, 3rd Edition, 2022. 6. Banga, T. R. & Sharma, S. C., Industrial Engineering and Management Science, Khanna Publishers, Revised Edition, 2017.
Web links and Video Lectures (e-Resources):
1. https://www.youtube.com/playlist?list=PLm_MSClsnwm9Ma5ru6f1pxAo_RGDIs_JC 2. https://www.youtube.com/watch?v=uC4rLpYWSCw 3. https://www.youtube.com/watch?v=N9FSTHaB9qg 4. https://www.youtube.com/watch?v=Krv4z1eRbmU

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Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	**2** (WK1, WK2)	**3** (WK1, WK2, WK3, WK4)	–	–	–	–	–	**1**	**2**	**1**	**2** (WK8)	**1**	**2**
CO2	–	**2** (WK1–WK4)	**2** (WK5)	–	**1** (WK6)	**1** (WK1, WK5, WK7)	–	**2**	**3**	**2**	**2** (WK8)	–	**2**
CO3	–	**2** (WK1–WK4)	**3** (WK5)	–	**2** (WK6)	**2** (WK1, WK5, WK7)	**1**	**1**	**2**	**1**	**2** (WK8)	–	**3**
CO4	–	**2** (WK1–WK4)	**2** (WK5)	–	**1** (WK6)	**2** (WK1, WK5, WK7)	**1**	**1**	**2**	**1**	**2** (WK8)	**1**	**3**

Course Code		**:**	**1BMEA511L**	**CNC and ROBOTICS LAB**	**Semester**	**:**	**05**
L:T:P		**:**	**0:0:2**		**Course Type**	**:**	**PCCL**
Hours/Sem.	**Practical**	**:**	**26 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**00 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**04 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**30 Hrs**		**Credits**	**:**	**02**

Professional Competency:

Demonstrate proficiency in applying CNC machining and industrial robotics principles, modern engineering tools, and safe laboratory practices to solve practical manufacturing problems.

Course Outcomes:

After successful completion of the course, the student will be able to:

CO1: Operate CNC machines following standard safety practices.

CO2: Develop, simulate, and execute CNC part programs for machining operations.

CO3: Operate and program industrial robots for basic manufacturing tasks.

CO4: Demonstrate CNC and robotic applications in automated manufacturing environments**.**

PART-A	**13 Hrs**

1. Study of CNC lathe and CNC machining centre.
2. Familiarization with CNC machine control panel and safety procedures.
3. Preparation and execution of CNC turning programs.
4. Preparation and execution of CNC milling programs.
5. Tool offset setting and work coordinate system.
6. Verification of programs using simulation software.
7. Manufacturing of simple components using CNC machines.

PART - B	**15 Hrs**

1. Identification of robot components and robot configuration.
2. Robot teaching using teach pendant.
3. Joint and Cartesian motion programming.
4. Pick-and-place operation.
5. Palletizing/de-palletizing application.
6. Robot simulation using industrial robot software.
7. Integration of robot with simple manufacturing operation.

Text Books:

1. Mikell P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson Education, 2021.
2. S. K. Saha, Introduction to Robotics, 3rd Edition, McGraw Hill Education (India), 2021.

Reference Books:

1. P. N. Rao, CAD/CAM: Principles and Applications, 4th Edition, McGraw Hill Education (India), 2020.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 7th Edition, John Wiley & Sons, 2023.
3. Yoram Koren, Computer Control of Manufacturing Systems, McGraw-Hill International, 1983 (Reprint 2017).

4. Saeed B. Niku, Introduction to Robotics: Analysis, Control, Applications, 3rd Edition, John Wiley & Sons, 2020.

Web links and Video Lectures (e-Resources):

1. https://www.abb.com/global/en/areas/robotics/services/training/online-learning?
2. https://nptel.ac.in/courses/112104289?
3. https://nptel.ac.in/courses/110105155?
4. https://www.abb.com/global/en/areas/robotics/products/software/robotstudio-suite/robotstudio-tutorials?
5. https://www.abb.com/global/en/areas/robotics/services/training/online-learning?
6. https://www.fanucindia.com/academy?

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Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3 (WK2, WK4)	2 (WK2)	–	–	3 (WK4)	–	–	2 (WK8)	–	–	–	3	2
CO2	3 (WK3)	3 (WK3)	3 (WK3, WK4)	2 (WK4)	3 (WK4)	–	–	–	–	–	–	3	3
CO3	3 (WK3)	3 (WK3)	3 (WK3, WK5)	2 (WK4)	3 (WK4, WK5)	–	–	–	2 (WK 8)	–	–	2	3
CO4	2 (WK4)	2 (WK4)	2 (WK4)	3 (WK4, WK6)	3 (WK4)	2 (WK6)	–	2 (WK8)	2 (WK 8)	2 (WK 8)	–	2	2

Course Code		**:**	**BMEA531E**	**SAP for Finance Management**	**Semester**	**:**	**05**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PEC - I**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Apply SAP S/4HANA Financial Accounting (FI) concepts and ERP-based financial transaction processing to record, manage, and analyze organizational financial data for effective business decision-making.

Course Outcomes:

CO1: Explain ERP fundamentals, SAP architecture, SAP FI, CO, and organizational structure.
CO2: Configure and use SAP FI master data including G/L, customer, vendor, and bank master records.
CO3: Perform SAP FI transactions such as G/L postings, vendor invoice postings, and related accounting entries.
CO4: Execute MIRO transactions including invoice, credit memo, subsequent debit, and subsequent credit processing.
CO5: Analyze SAP S/4HANA financial processes and apply SAP-based financial information for business decisions.

UNIT–I	**10 Hrs**

Introduction to ERP & SAP: ERP concepts, SAP, SAP modules (FI, CO, MM, SD, PP, HCM, QM, PM), SAP ECC vs SAP S/4HANA, SAP FICO overview, SAP navigation, login procedure, business transaction examples.

UNIT–II	**11 Hrs**

FI Organizational Structure: Company, Company Code, Business Area, Chart of Accounts, Fiscal Year Variant, Posting Period Variant; FI Master Data: G/L, Customer, Vendor and Bank Master.

UNIT-III	**11 Hrs**

Basic FI Transactions: FI documents, debit and credit concepts, FB50 – G/L Posting, FB60 – Vendor Invoice, FI entries through MIRO.

UNIT-IV	**10 Hrs**

MIRO Processing: Incoming invoice, credit memo, subsequent debit, subsequent credit, Procure-to-Pay (P2P) cycle integration.

Text Books:

1. Venki Krishnamoorthy & Alexandra Carvalho, "Discover SAP ERP Financials", SAP Press.
2. David Burns, "Financial Accounting in SAP: Business User Guide", SAP Press.
3. Stoil Jotev, "Asset Accounting with SAP S/4HANA", SAP Press.

Reference Books:

1. Narayanan Veeriah, "SAP S/4HANA Finance: Business Processes and Configuration", SAP Press.
2. Janet Salmon, "Controlling with SAP S/4HANA", SAP Press.

Web links and Video Lectures (e-Resources):

1. https://learning.sap.com
2. https://open.sap.com
3. https://help.sap.com

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Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	**3** (WK1, WK2, WK3)	**3** (WK2, WK4)	1 (WK5)	–	2 (WK6)	–	–	–	–	1	2	3	2
CO2	**3** (WK1, WK2, WK3)	**3** (WK2, WK4)	2 (WK5)	1 (WK8)	**3** (WK6)	1 (WK7)	–	–	–	1	2	3	3
CO3	**3** (WK2, WK3, WK4)	**3** (WK4, WK8)	**3** (WK5)	2 (WK8)	**3** (WK6)	1 (WK7)	1 (WK7)	–	–	1	2	3	3
CO4	2 (WK2, WK3)	**3** (WK4, WK8)	2 (WK5)	**3** (WK8)	**3** (WK6)	2 (WK7)	2 (WK7)	1 (WK9)	–	2	2	3	3
	2 (WK3, WK4)	**3** (WK4, WK8)	2 (WK5)	**3** (WK8)	**3** (WK6)	2 (WK7)	2 (WK7)	2 (WK9)	1	2	**3**	3	3

Course Code		**:**	**BMEA532E**	**Fundamentals of Quality Control**	**Semester**	**:**	**05**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PEC -I**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Develop the ability to apply statistical quality control techniques, control charts, and acceptance sampling methods to monitor, analyze, and improve the quality of manufacturing and service processes for achieving continuous quality improvement.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Explain the philosophy, principles and statistical concepts of quality improvement in manufacturing and service industries.

CO2: Apply statistical quality control techniques and variable control charts for monitoring and improving process quality.

CO3: Analyze attribute control charts and interpret quality data for effective process control.

CO4: Evaluate and design appropriate acceptance sampling plans and quality control systems for industrial applications

UNIT–I	**11 Hrs**

Introduction to Quality: Meaning of quality and quality improvement, Quality of Design, factors controlling quality of design, Quality of Conformance, factors controlling quality of conformance, Quality of Performance, Quality Function, Quality Control, aims of quality control, Quality Characteristics, Cost of Quality, Statistical Methods for Quality Control, Benefits of Statistical Quality Control, Variables and Attributes.

Modelling Process Quality: Concept of variation, gathering of data, tabular summarization of data, classification and tabulation, objectives of classification, frequency distribution, histogram, frequency polygon, bar chart, ogive curve.

Statistical Measures: Measures of Central Tendency (Mean, Median and Mode), Measures of Dispersion (Range, Variance and Standard Deviation), Numerical Problems.

UNIT–II	**10. Hrs**

Control Charts for Variables

Control Charts: Introduction, purpose and construction of control charts, chance and assignable causes of variation, types of control charts, interpretation and analysis of control charts, guidelines for selecting control chart parameters.

Control Charts for Variables: Control Chart for Average and Range ($\bar{X}$–R Charts), construction, interpretation, calculation of control limits, applications and limitations. Control Chart for Average and Standard Deviation ($\bar{X}$–σ Charts), construction, interpretation, process capability analysis and numerical problems.

UNIT-III	**10 Hrs**

Control Charts for Attributes

Attribute Control Charts: Basics of attribute data, comparison between attribute charts and variable charts. Fraction Defective (p-chart), Number of Defectives (np-chart), Number of Defects (c-chart) and Number of Defects per Unit (u-chart), construction, interpretation, applications and numerical problems.

UNIT-IV	11 Hrs
Acceptance Sampling Lot-by-lot acceptance sampling for attributes, advantages and disadvantages of sampling methods, acceptance sampling problems. Single Sampling Plan, Operating Characteristic (OC) Curve, and design of single sampling plan. Double Sampling Plan, Multiple Sampling Plan and Sequential Sampling Plan. Dodge–Romig Sampling Plan, LTPD Plan, AOQL Curves and Numerical Problems.	

Text Books:

1. **R. C. Gupta**, *Statistical Quality Control*, 11th Edition, Khanna Publishers, New Delhi 2023.
   Douglas C. Montgomery, *Introduction to Statistical Quality Control*, 9th Edition, John Wiley & Sons, 2020

Reference Books:

1. **James R. Evans and William M. Lindsay**, *Managing for Quality and Performance Excellence*, 11th Edition, Cengage Learning, 2020
2. **D. H. Besterfield**, *Quality Control*, 9th Edition, Pearson Education, 2017
3. **James R. Evans and William M. Lindsay**, *Managing for Quality and Performance Excellence*, 11th Edition, Cengage Learning, 2020

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=9QC09eEfBBw
- https://www.youtube.com/watch?v=fCCyeaL8ROI
- https://www.youtube.com/watch?v=O5qDp-SdyKQ
- https://www.youtube.com/watch?v=Aj7lJLR-7b4

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	2 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	2 (WK5)	–	–	–	–	–	–	–	3	**2**
CO2	2 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	3 (WK5)		–	–	–	–	–	–	1	**2**
CO3	2 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	3 (WK5)	3 (WK5)	--	–	–	–	–	–	–	2	3
CO4	2 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	3 (WK5)	2 (WK5)	-	-	–	–	–	–	–	3	**1**

Course Code		**:**	**BMEA533E**	**Turbo Machines**	**Semester**	**:**	**05**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PEC - I**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Apply turbo machinery principles to analyze, design, and evaluate the performance of fluid machines for mechanical engineering applications.

Course Outcomes:

CO1: Analyze energy transfer mechanisms and performance characteristics of turbo machines using dimensional analysis, Euler's turbine equation, degree of reaction, and utilization factor.

CO2: Analyze the performance of centrifugal pumps and compressors by evaluating blade geometry, cavitation, and various efficiency parameters.

CO3: Analyze and evaluate the performance of impulse and reaction steam turbines using velocity diagrams, staging principles, and blade efficiency.

CO4: Analyze and evaluate the performance of hydraulic turbines using velocity triangles, efficiency relations, and design parameters for Pelton, Francis, and Kaplan turbines.

UNIT–I	**10 Hrs**

Introduction: Definition of turbo machine, Parts of a turbo machine, Comparison with positive displacement machine, Classification of turbo machines, Application of dimensional analysis to turbo machines and their physical significance, specific speed for power absorbing and power developing machines, Numerical problems on dimensional analysis and model studies.

Energy Transfer in Turbo machines: Euler turbine equation, Alternate form of Euler turbine equation, Components of energy transfer, Degree of reaction, General analysis of a turbo machine, Effect of blade discharge angle on energy transfer and degree of reaction, General analysis of turbines (axial flow machines), Utilization factor, Relation between utilization factor and degree of reaction, Condition for maximum efficiency, Condition for maximum utilization factor, Optimum blade speed ratio and maximum energy transfer, Numerical problems on above topics.

UNIT–II	**11 Hrs**

General analysis of power absorbing turbo machines: General analysis of centrifugal pumps and compressors, Effect of blade discharge angle, Analysis on performance, Theoretical head capacity relationship, Centrifugal machines stage parameters, Work done, Power, Stage pressure rise, Degree of reaction, Numerical problems on above topics.

Centrifugal Pumps: Working principle, Main parts of a centrifugal pump, Classification, Head, Static head, Monomeric head, Pump Efficiencies, Monomeric, Mechanical, Hydraulic, Volumetric and Overall efficiency; Work done by the pump, Pressure rise in a pump, Minimum starting speed, Multistage pumps; Cavitation, Numerical problems on above topics.

UNIT-III	**10 Hrs**

Steam and Gas Turbines: Impulse staging and need for compounding, Compounding, Velocity, Pressure, Velocity and pressure compounding, Impulse turbine, Performance parameters, Effects of friction and blade angles on blade efficiency, Condition for maximum efficiency, Maximum efficiency and work done, Numerical problems on above topics.

Multistage impulse turbine (two stage): Work done, Blade efficiency, Condition for maximum

efficiency, Maximum blade efficiency, Maximum work done, Maximum utilization factor with equiangular blades, Numerical problems on above topics.

Reaction turbines: Degree of reaction, Condition for maximum efficiency (without carry over efficiency), Maximum efficiency, Maximum work done, Utilization for factor, Condition for maximum utilization factor, Maximum utilization factor, Blade design parameters, Numerical problems on above topics.

UNIT-IV	**10 Hrs**

Hydraulic Turbine: Unit quantities, Terminology, Pelton Wheel, Velocity triangle, Power developed, Hydraulic efficiency, Condition for maximum hydraulic efficiency, Maximum hydraulic efficiency, Turbine efficiency, Hydraulic, Mechanical, Volumetric and Overall efficiency, important design parameters. Numerical problems on above topics.

Francis and Kaplan turbines: Velocity triangle, Runner shapes for different blade speeds (blade angles), Design parameters, Draft tube and types draft tubes, functions of a draft tube, Efficiency of a draft tube, Kaplan and Propeller turbines, Velocity triangles, Design parameters, Numerical problems on above topics.

Text Books:

1. M. S. Govindegowda& A. M. Nagaraj, Textbook *of Turbo machines* **Edition2022**M.M. Publishers, Davangere
2. V. Kadambi & Manohar Prasad, *An Introduction to Energy Conversion, Volume III: Turbomachinery***2021**New Age International
3. G. Gopalakrishnan & D. Prithviraj, *A Treatise on Turbo machines,* **2022**SciTech Publications

Reference Books:

1. S. M. Yahya *"Turbines, Compressors and Fans"* **5th Edition2019**McGraw Hill Education
2. R. K. Rajput, *Fluid Mechanics and Hydraulic Machines*Edition**2023**S. Chand Publishing
3. V. Ganesan, *Gas Turbines***4th Edition2018**McGraw Hill India
4. H. Cohen, G. F. C. Rogers, H. I. H. Saravanamuttoo& P. V. Straznicky, *Gas Turbine Theory,* **7th Edition, 2019**Pearson
5. B. K. Venkanna,*Fundamentals of Turbomachinery,* **1st Edition 2009**PHI Learning

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112106200
2. https://onlinecourses.nptel.ac.in/noc20_me55/preview
3. https://elearning.vtu.ac.in/econtent/ME.php
4. https://www.digimat.in/nptel/courses/video/112106303/L08.html
5. https://www.mathworks.com/solutions/engineering/fluid-dynamics.html

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	1 (WK8)	2 (WK2, WK6)	1 (WK1, WK5, WK7)	–	–	–	–	1 (WK8)	3	2
CO2	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	2 (WK8)	3 (WK2, WK6)	1 (WK1, WK5, WK7)	–	–	–	–	1 (WK8)	3	2
CO3	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	3 (WK5)	3 (WK8)	3 (WK2, WK6)	2 (WK1, WK5, WK7)	–	–	–	–	2 (WK8)	3	3
CO4	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	3 (WK5)	3 (WK8)	3 (WK2, WK6)	2 (WK1, WK5, WK7)	1 (WK7)	–	–	–	2 (WK8)	3	3

Course Code		**:**	**BMEA 534 E**	**Electric Vehicle Technology**	**Semester**	**:**	**05**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PEC - I**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Design, analyze, and implement intelligent energy management, control, communication, and testing strategies for hybrid electric vehicles using cognitive computing and artificial intelligence techniques

Course Outcomes:

After completion of the course, student will be able to:

CO1: Explain the fundamentals of cognitive computing, hybrid electric vehicle architectures, and their integration in intelligent automotive systems.

CO2: Apply reinforcement learning, machine learning, and cognitive energy management techniques for optimizing hybrid electric vehicle performance.

CO3: Analyze and design AI-based perception, sensor fusion, predictive control, and decision-making strategies for hybrid electric vehicles.

CO4: Evaluate V2X communication, cognitive networking, implementation methodologies, and testing procedures to ensure safety, reliability, and regulatory compliance of intelligent hybrid electric vehicles.

UNIT–I	**11 Hrs**

Introduction to Cognitive Computing: Definition and principles of cognitive computing, Cognitive architectures and frameworks, Applications in automotive industry, Comparison with traditional control systems.

Hybrid Electric Vehicle Basics: HEV architectures (Series, Parallel, Series-Parallel),Energy flow management, Traditional control strategies, Limitations of conventional approaches.

Integration of Cognitive Systems in HEVs: Cognitive-enabled vehicle architecture, Sensor fusion and data integration, Real-time processing requirements, Hardware and software considerations.

UNIT–II	**12 Hrs**

Reinforcement Learning for Energy Management: Q-learning ,Policy gradient methods, Deep Q-Networks (DQN).Multi-agent reinforcement learning, Reward function design.

Cognitive Energy Management Systems: Intelligent power distribution, Multi-objective optimization, Pareto optimization, Dynamic programming ,Battery management using AI,SOC estimation ,Battery health monitoring, Thermal management, Adaptive control strategies, Fault detection and accommodation.

UNIT-III	**08 Hrs**

Sensor Fusion and Perception Systems: LiDAR, Radar, Camera, GPS/IMU integration, V2V communication, Computer vision, Object detection and tracking, SLAM,HD mapping.

Predictive Control and Decision Making: Model Predictive Control, Linear and Nonlinear MPC, Neural-network-based MPC ,Robust MPC, Decision Trees, Expert Systems, Fuzzy Logic, Edge Computing ,Safety-critical decision making.

UNIT-IV	**10 Hrs**

Communication and Cognitive Networks: V2I, V2G, Communication standards, Network topology, Intelligent routing, QoS management, Network security, Swarm intelligence, Distributed optimization.

Implementation and Testing: Hardware-in-the-Loop (HIL), Real-time simulation, Performance validation, Safety testing, Field testing, Data analysis, Regulatory compliance.

Text Books:

1. C. Mi, M. A. Masrur and D. W. Gao, *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives*, Wiley, 2nd Edition, 2017.
2. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2nd Edition, 2012. Ali Emadi, *Advanced Electric Drive Vehicles*, CRC Press, 2014.

Reference Books:

1. V. N. Gudivada, V. V. Raghavan, V. Govindaraju and C. R. Rao, Cognitive Computing: Theory and Applications, Elsevier, 2016.
2. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, MIT Press, 2nd Edition, 2018.
3. J. B. Rawlings, D. Q. Mayne and M. Diehl, Model Predictive Control: Theory, Computation*, and* Design, Nob Hill Publishing, 2nd Edition, 2017.
4. Rudolf Rojas, Machine Learning for Autonomous Vehicles, Springer, 2020.
5. Thomas C., Sensor Fusion and its Applications, Sciyo, 2010.
6. João P. S. Catalão, Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, IET, 2017.
7. Alexander M. Wyglinski, Maziar Nekovee and Y. Thomas Hou, Cognitive Radio Communications and Networks: Principles and Practice, Academic Press, 2009.
8. Rajesh Rajamani, Vehicle Dynamics and Control, Springer, 3rd Edition, 2021.
9. Simona Onori, Lorenzo Serrao and Giorgio Rizzoni, Hybrid Electric Vehicles: Energy Management Strategies, Springer, 2016.
10. Frank Vahid and Roman Lysecky, Embedded Systems Design, Wiley, 2nd Edition, 2018.

Web links and Video Lectures (e-Resources):

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	**3** (WK1, WK2, WK3 & WK4)	**2** (WK1, WK2, WK3 & WK4)	1 (WK5)	–	1 (WK2 & WK6)	–	–	–	1	–	1 (WK8)	2	2
CO2	–	**2** (WK1, WK2, WK3 & WK4)	**3** (WK5)	**2** (WK8)	**3** (WK2 & WK6)	**2** (WK1, WK5 & WK7)	1 (WK9)	1	1	–	**2** (WK8)	2	3
CO3	–	**2** (WK1, WK2, WK3 & WK4)	**3** (WK5)	**3** (WK8)	**3** (WK2 & WK6)	**2** (WK1, WK5 & WK7)	–	1	1	–	**2** (WK8)	2	3
CO4	–	**2** (WK1, WK2, WK3 & WK4)	**2** (WK5)	**2** (WK8)	**3** (WK2 & WK6)	**2** (WK1, WK5 & WK7)	**2** (WK9)	1	2	1	**2** (WK8)	2	3

Course Code		**:**	**BMEX 541 N**	**Fluid Power Systems for Industry 4.0**	**Semester**	**:**	**05**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**OEC - I**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Develop and integrate hydraulic and pneumatic fluid power systems with electro-hydraulic, electro-pneumatic, PLC, and Industry 4.0 technologies to solve industrial automation problems.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Determine the force, velocity and power of single and double acting cylinders with sensors and IoT as per Industry 4.0 principles for predictive and preventive maintenance in fluid power systems.

CO2: Simulate electro-hydraulic meter-in and meter-out flow control circuits for applications including hydraulic crest gates, airport stair lifts, robotic arm movements, drilling and forging using simulation software tool.

CO3:Simulate electro-pneumatic circuits using OR and AND gates for applications including twin-control entry gates, emergency stop systems in lifting platforms and conveyors, two-hand safety start in paper cutting machines and log splitters in agriculture and wood cutting using simulation software tool.

CO4: Design pneumatic circuits along with PLC wiring and ladder diagrams for applications including pressing, punching, pneumatic doors and pick-and-place robot arms.

UNIT–I	**10 Hrs**

Introduction to Fluid Power Systems: Pascal's Law, Structure and working principles of hydraulic system and pneumatic system with pros and cons of each system. Comparison of electrical vs. mechanical vs. fluid power transmission systems. Numerical problems based on applications of Pascal's law (hydraulic lift in dentist chair, hand operated hydraulic car jack, car brake system, hydraulic elevator, bus/truck lifting for maintenance, etc.). Ethical and environmental awareness in fluid power systems.

Source of Hydraulic Power: Working principle of hydraulic pump and comparison with centrifugal pump. Overview of various types of hydraulic pumps (limited to classification).

Hydraulic Actuators and Motors: Linear Actuators (cylinders) and Rotary actuator (motors). Numerical problems involving pressure, velocity, and power requirements of hydraulic cylinders.

UNIT–II	**11 Hrs**

Control Components in Hydraulic Systems: Directional control valves, Pressure control valves and Flow control valves–Symbolic representation and Constructional features.

Introduction to Industry 4.0 in Fluid Power Systems: Overview of Industry 4.0, Role of sensors and internet of things (IOT) in monitoring and control of fluid power systems. Predictive and preventive maintenance concepts and applications. Numerical problems based on predictive and preventive maintenance scenarios (monitoring of landing gears of an aircraft, smart hydraulic elevator or lift, brake booster in train, hydraulic doors in the shopping malls, smart municipal garbage truck compactor, etc.).

Electrical Components in Fluid Power systems: Construction and working of normally open (NO) and normally closed (NC) contact switches. Function and use of relays and solenoids in fluid

power circuits. Design and analysis of electrical circuits to operate multiple devices (control of platform lights based on train arrival, controlling ceiling operations like fans and lights commonly used in auditorium and smart homes, etc.) using above elements with different ON/OFF switching conditions simultaneously.

UNIT-III	**11 Hrs**

Electro-Hydraulic Circuit Design and Analysis: Control of single acting and double acting hydraulic cylinder. Circuit design for drilling and forging machine applications. Implementation of metre-in and metre-out flow control circuits (hydraulic crest gate or damper in water management, airport stair lift, robotic arm movement, etc.) through simulation using simulation software tool.

UNIT-IV	**10 Hrs**

Electro-Pneumatic Circuit Design and Analysis: Introduction to the use of electro-pneumatic logic gates in automation systems. Design and implementation of circuits using OR gates (twin-control entry gates, emergency stop override system in lifting platforms and conveyors, etc.) and gates (two hand safety start in paper cutting machine, log splitters used in agriculture and wood cutting, etc.) through simulation using simulation software tool.

Introduction to Programmable Logic Controller (PLC): Overview of PLC components: Power supply, CPU, input/output modules, programming device, and memory. Working principles and operation of PLCs. Design the pneumatic circuit, PLC wiring diagram and ladder diagram for practical applications (pressing operation, bus/train pneumatic door, punching operation, pick and place robot arm, etc.).

Text Books:

1. Srinivasan Chandrasekaran, “Hydraulic and Pneumatic Control: Understanding the Industry 4.0 Approach”, CRC Press, 1st Edition, 2023.
2. S. R. Majumdar, “Oil Hydraulic Systems-Principles and Maintenance”, McGraw Hill Education, 1st Edition, 2017.
3. Anthony Esposito, “Fluid Power with Applications”, Pearson Education Limited, 7th Edition, 2013.

Reference Books:

1. R. Rajasekar *et al.*, “Integration of Mechanical and Manufacturing Engineering with IoT: A Digital Transformation”, Wiley-Scrivener, 1st Edition, 2023.
2. Frank D. Petruzella, Programmable Logic Controllers, McGraw-Hill Education, 5th Edition, 2017.
3. W. Bolton, Programmable Logic Controllers, Newnes/Elsevier, 6th Edition, 2015.
4. Andrew Parr, “Hydraulics and Pneumatics: A Technician's and Engineer's Guide”, Butterworth-Heinemann, 3rd Edition, 2011.
5. Bosch Rexroth Training Manuals (for laboratory and industrial practice), 2010.

Web links and Video Lectures (e-Resources):

1. https://onlinecourses.nptel.ac.in/e-learning/course/noc25_me58?unitId=17&lessonId=19
2. https://onlinecourses.nptel.ac.in/e-learning/course/noc25_me58?unitId=17&lessonId=20
3. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=77&lessonId=78
4. https://onlinecourses.nptel.ac.in/e-learning/course/noc25_me58?unitId=17&lessonId=21
5. https://onlinecourses.nptel.ac.in/e-learning/course/noc25_me58?unitId=45&lessonId=46
6. https://onlinecourses.nptel.ac.in/e-learning/course/noc25_me58?unitId=45&lessonId=47
7. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=90&lessonId=91
8. https://nptel.ac.in/courses/112107298?utm_source=chatgpt.com

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Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3 (WK1, WK2, WK3, and WK4)	3 (WK1, WK2, WK3, and WK4)	-	-	-	-	-	1	-	-	1		
CO2	-	2 (WK1,WK 3, and WK4)	3 (W K5)	-	3 (WK6)	1 (WK1, WK5 and WK7)	1 (W K9)	1	1	-	1 (WK8)		
CO3	-	2 (WK1, WK3, and WK4)	3 (W K5)	-	3 (WK6)	1 (WK1, WK5 and WK7)	1 (W K9)	1	1	-	1 (WK8)		
CO4	-	2 (WK1, WK3, and WK4)	2 (W K5)	-	-	1 (WK1, WK5 and WK7)	-	1	1	-	1 (WK8)		

Course Code		**:**	**BMEX542N**	**Quality and Reliability Engineering**	**Semester**	**:**	**05**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**OEC - I**
Hours/Sem.	**Teaching**	**:**	**42Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW+SL)	**:**	**42Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90Hrs**		**Credits**	**:**	**03**

Professional Competency:

Apply quality engineering principles, statistical quality management tools, and reliability analysis techniques to improve product quality, process performance, and system reliability in engineering applications.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Explain quality concepts, quality management principles, and quality improvement techniques.

CO2: Apply quality management tools and techniques for continuous process improvement.

CO3: Analyze reliability characteristics of engineering components using probability distributions and reliability models.

CO4: Evaluate system reliability and develop appropriate reliability testing plans for engineering applications.

UNIT-I	**10 Hrs.**

Introduction: Definition of quality; Evolution of Quality; Quality dimensions; Quality characteristics-variables, attributes and defects; Quality aspects-quality of design, quality of conformance and quality of performance; Quality Control-offline quality control, statistical process control and acceptance sampling plans (Only introduction); Quality Assurance; Quality Circles and Improvements; Quality Costs.

UNIT–II	**10 Hrs.**

Quality Management: Practices of management - TQM, Vision and Quality Policy; QFE- QFD process; Benchmarking and Quality Auditing; Tools for Continuous Quality Improvement- Pareto charts, Flow charts, Cause and Effect Diagram, Scatter plots.

UNIT–III	**11 Hrs.**

Reliability: Definition of reliability, reliability function, MTTF, hazard rate function, bathtub curve, derivation of the reliability function – constant failure rate model, time dependent failure rate models: Discrete and Continuous Distributions- Normal, Poisson and Binomial Distribution.

UNIT–IV	**11 Hrs.**

System Reliability: System reliability (Series, Parallel, Mixed and Standby components); OC curves; Reliability and life testing plans (failure terminated and time terminated tests).

Text Books:

1. Dale H. Besterfield, **"Quality Control"**, Pearson Education, 9th Edition, 2018.
2. Douglas C. Montgomery, **"Introduction to Statistical Quality Control"**, John Wiley & Sons, 8th Edition, 2020.
3. Patrick D. T. O'Connor and Andre Kleyner, **"Practical Reliability Engineering"**, John Wiley & Sons, 5th Edition, 2012.

Reference Books:

1. Juran, J. M., and De Feo, J. A., **"Juran's Quality Handbook"**, McGraw-Hill, 7th Edition, 2016.
2. Grant, E. L., and Leavenworth, R. S., **"Statistical Quality Control"**, McGraw-Hill.
3. Ebeling, C. E., **"An Introduction to Reliability and Maintainability Engineering"**, Waveland Press.

Web Links and Video Lectures (e-Resources):
NPTEL – Quality Engineering NPTEL – Reliability Engineering American Society for Quality (ASQ) ISO 9001 Quality Management Resources MIT Open Course Ware – Quality Systems

Matrix Describing the Mapping of COs with POs (Considering WKs) and PSOs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3 (WK1, WK2, WK3)	3 (WK2, WK4)	1 (WK5)	–	2 (WK6)	–	–	–	–	1	2	3	2
CO2	3 (WK1, WK2, WK3)	3 (WK2, WK4)	3 (WK5)	2 (WK8)	3 (WK6)	1 (WK7)	1 (WK7)	–	–	1	2	3	3
CO3	3 (WK2, WK3, WK4)	3 (WK4, WK8)	3 (WK5)	3 (WK8)	3 (WK6)	2 (WK7)	1 (WK7)	–	–	1	2	3	3
CO4	2 (WK2, WK3)	3 (WK4, WK8)	2 (WK5)	3 (WK8)	3 (WK6)	2 (WK7)	2 (WK7)	1 (WK9)	–	2	2	3	3

Course Code		:	BMEX 543 N	Digital Marketing	Semester	:	05
L:T:P		:	3:0:0		Course Type	:	OEC - I
Hours/Sem.	Teaching	:	42 Hrs		CIE Marks	:	50
	Learning (TW)	:	42 Hrs		SEE Marks	:	50
	Exam	:	06 Hrs		Total Marks	:	100
	Total Hrs.	:	90 Hrs		Credits	:	03

Professional Competency:

Develop the ability to design, implement, and evaluate digital marketing strategies using modern digital tools, analytics, and online platforms to achieve organizational marketing objectives.

Course Outcomes:

CO1: Explain the fundamental concepts, evolution, significance, key channels, elements, and benefits of digital marketing, and differentiate digital marketing from traditional marketing in the contemporary business environment.

CO2: Develop and evaluate user-friendly websites by applying website design principles, responsive design techniques, basic search engine optimization (SEO), and mobile optimization practices to enhance digital presence and user experience.

CO3: Design and implement effective social media and content marketing strategies by creating engaging content, selecting appropriate digital platforms, executing content distribution plans, and evaluating campaign performance using relevant metrics.

CO4: Develop comprehensive digital marketing strategies by integrating mobile marketing practices, goal setting, budgeting, resource allocation, performance tracking, and campaign evaluation to achieve organizational marketing objectives.

UNIT–I	11 Hrs

Introduction to Digital Marketing (DM): Definition of Digital Marketing, Historical background and Evolution of Digital Marketing, Importance of Digital Marketing in Today's Business Landscape, Key Digital Marketing Channels and Platforms, Benefits of Digital Marketing, Differences between Traditional and Digital Marketing, Elements of Digital Marketing.

UNIT–II	10 Hrs

Website Design and Development: Introduction, Importance of A Well-Designed and User-Friendly Website, Best Practices for Website Design and Development, Search Engine Optimization (SEO) Basics, Mobile Optimization and Responsive Design.

UNIT-III	11 Hrs

Social Media Marketing (SMM): Definition and Importance of SMM, Overview of major Social Media Platforms (Facebook, Twitter, Instagram, LinkedIn, Etc.), Developing A Social Media Strategy and Content Plan, Measuring and Optimizing Social Media Performance.

Content Marketing: Definition and Importance of Content Marketing, Key Steps Involved in Developing and Executing a Successful Content Marketing Strategy, Tips for Optimizing Content Marketing Strategy, Creating High-Quality, Engaging Content, Content Distribution and Promotion Strategies, Measuring and Optimizing Content Marketing Performance.

UNIT-IV	10 Hrs

Mobile Marketing: Definition and Importance of Mobile Marketing, Mobile Website Design and Development: Importance of Mobile Website Design and Development, Best Practices for Mobile Website Design and Development.

Digital Marketing Strategy and Planning: Developing a Comprehensive Digital Marketing Strategy, Budgeting and Resource Allocation, Setting Goals and Objectives, Performance Tracking and Reporting, Examples of How to Track and Report on the Performance of Digital Marketing Campaigns.
Text Books:
Dave Chaffey and Fiona Ellis-Chadwick, "Digital Marketing: Strategy, Implementation and Practice", Pearson Education, 9th Edition, 2022. Philip Kotler, Hermawan Kartajaya and Iwan Setiawan, "Marketing 5.0: Technology for Humanity", Wiley, 1st Edition, 2021
Reference Books:
Tracy L. Tuten and Michael R. Solomon, "Social Media Marketing", Sage Publications, 4th Edition, 2024 Ryan Deiss and Russ Honeyberry, "Digital Marketing for Dummies", John Wiley & Sons, 2nd Edition, 2020 Seema Gupta, "Digital Marketing", McGraw Hill Education (India), 3rd Edition, 2022 Puneet Singh Bhatia, "Fundamentals of Digital Marketing", Pearson India, 3rd Edition, 2023 Ian Dodson, "The Art of Digital Marketing: The Definitive Guide to Creating Strategic, Targeted, and Measurable Online Campaigns", Wiley, 1st Edition, 2016 Simon Kingsnorth, "Digital Marketing Strategy: An Integrated Approach to Online Marketing", Kogan Page, 3rd Edition, 2022 Annmarie Hanlon, "Digital Marketing: Strategic Planning & Integration", Sage Publications, 3rd Edition, 2022 Debra Zahay, Mary Lou Roberts, Michele Murphy and Elizabeth A. Moorman, "Internet Marketing: Integrating Online and Offline Strategies", Cengage Learning, 5th Edition, 2023
Web links and Video Lectures (e-Resources):
https://www.youtube.com/watch?v=qnBhOVH1QQ8 https://www.youtube.com/watch?v=bixR-KIJKYM https://www.youtube.com/watch?v=_3lWGKMaFPg&list=PLM4O0dsPeuMdQjYkLFG6Xxpbgwv3cQwbx&index=1 https://www.youtube.com/watch?v=Zc4Mu30xR9o

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	**3** (WK1, WK2, WK3, WK4)	**2** (WK1, WK2, WK3, WK4)	–	–	–	–	–	**1**	–	**1**	**1** (WK8)	**1**	**2**
CO2	–	**2** (WK1, WK2, WK3, WK4)	**3** (WK5)	**2** (WK5)	**3** (WK6)	**2** (WK1, WK5, WK7)	–	**1**	**1**	**1**	**1** (WK8)	**3**	**2**
CO3	–	**2** (WK1, WK2, WK3, WK4)	**3** (WK5)	**2** (WK5)	**3** (WK6)	**2** (WK1, WK5, WK7)	**1**	**1**	**2**	**2**	**1** (WK8)	**2**	**3**
CO4	–	**3** (WK1, WK2, WK3, WK4)	**3** (WK5)	**2** (WK5)	**2** (WK6)	**2** (WK1, WK5, WK7)	**1**	**1**	**2**	**2**	**2** (WK8)	**2**	**3**

Course Code		**:**	**BMEX544N**	**IT- ENABLED MANUFACTURING TECHN0LOGY**	**Semester**	**:**	**05**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**OEC - I**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

This course enables mechanical engineering students to acquire knowledge, technical skills, practical abilities, and professional attitudes needed to work effectively in modern manufacturing industries that use automation, digital technologies, and smart production systems. It also enables technical expertise with digital, analytical, and interpersonal skills. These competencies enable students to understand operation of advanced manufacturing systems efficiently, maintain high-quality standards, and contribute to the success of smart manufacturing environments.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Understand and apply the fundamental concepts of CAD/CAM, product system facilities, automated and computerized Manufacturing support systems, production system, production lines, strategies.

CO2: Determine and analysis the Transfer Lines, Automated Assembly System, Parts delivery at workstations, partial and complete automation in industries.

CO3: Understand and apply NC,APT and computer assisted part programming for various machining processes.

CO4: Determine and analysis Product life cycle management and advanced manufacturing technologies like Industry 4.0, Internet of things (IoT) and Big-Data and cloud computing for IoT, IoT for smart manufacturing.

UNIT–I	**12 Hrs**

Introduction: Introduction to CAD/CAM, product system facilities: Low, medium and high. Manufacturing support systems, Automation in production systems. Automated manufacturing systems. Computerized manufacturing systems. Reasons for automating, Automation principles and strategies. Freeware Software of Simulation CAD/CAM Software.

Fundamentals of Automated Production Lines: Introduction, System configurations, Work-part transfer mechanisms, Storage buffers, Control of the production line. Production Line Simulation Freeware Software.

UNIT–II	**10 Hrs**

Analysis of Transfer Lines: Analysis of Transfer Lines with no internal storage: Basic terminology and Performance measures, Workstation breakdown analysis: Upper bound approach, Lower bound approach, and Analysis of Transfer Lines with storage buffers. Numerical examples. Transfer Line Simulation Freeware Software.

Automated Assembly System: Introduction, System configurations, Parts delivery at workstations, Applications. Quantitative analysis: Parts delivery system, Multi-station and single station assembly machines. Partial automation. Manufacturing Assembly Line Simulation Freeware Software.

UNIT-III	**10 Hrs**

NC Part Programming: Basic components of an NC system, EIA and ISO coding standards, NC part programming exercises.

Computer Assisted Part Programming: Defining part geometry, Specifying tool path and operation

sequence, Computer task in computer-assisted part programming, Part programming with APT exercises

UNIT-IV	10 Hrs

PLM and PDM: Introduction, Product information, PLM framework, Benefits, Implementation, Enabling technologies, Example of business problem. Product data management: Evolution of PDM systems, Scope, Benefits, Implementation, Software capabilities, software functions Freeware Software of Product life cycle management.

Advances in Automated Factory: Industry 4.0: functions, applications and benefits, Components of Industry 4.0, Internet of things (IoT), IoT applications in manufacturing, Big-Data and cloud computing for IoT, IoT for smart manufacturing. Freeware Software of Advances in Automated Factory

Text Books:

1. Ajay Kumar, Parveen Kumar, Yang Liu (Eds.) "Industry 4.0 Driven Manufacturing Technologies" Edition 2024, Springer.
2. Vasdev Malhotra, "Advanced Manufacturing Processes" Edition 2024, CRC Press / Routledge.
3. Sandip Kunar, Prasenjit Chatterjee, M. Sreenivas Reddy, "Optimization of Advanced Manufacturing Processes", andip Kunar, Prasenjit Chatterjee, M. Sreenivas Reddy, Edition 2025 Apple Academic Press / CRC Press.
4. Sandip Kunar, T. Jagadeesha, Gurudas Mandal (Eds.) "Digital Manufacturing: Processes and Applications"Edition 2025 Wiley,
   Sandip Kunar, Prasenjit Chatterjee, M. Sreenivas Reddy," Optimization of Advanced Manufacturing Processes", Edition 2025, Apple Academic Press / CRC Press.

Reference Books:

1. Groover M. P., Automation, Production Systems and CIM, 2008, Prentice Hall of India,
2. Ibrahim Zeid, Mastering CAD/CAM, 2008, 4th edition, Tata McGraw Hill
3. P. N. Rao, CAD/CAM Principles and Applications, 3nd Edition 2018, McGraw Hill Education (India) rivate Limited.
4. Computer Integrated Manufacturing, Bharat Vijamuri, 4th Edition, 2018. Sunstar Publisher,

Web links and Video Lectures (e-Resources):

1. http://elearning.vtu.ac.in/
2. https://sjcit.ac.in/vtu-consortium-e-resources/
3. https://www.dsce.edu.in/e-resources-publishers-wise
4. https://www.advancedmanufacturing.org/
5. https://crridom.gov.in/open-access-e-resources
6. https://ess.inflibnet.ac.in/subject_list.php?subject=Manufacturing+Engineering

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	1 (WK1, WK3,)	-	-	-	1(WK6)	WK 5	-	1	-	-	1	1	--
CO2	1 (WK1, WK3,)	-	-	-	-	WK 5	-	1	-	-	1	1	-
CO3	1(WK1, WK3,)	-	-	-	-	-	-	1	-	-	1	1	-
CO4	2(WK1, WK3,)	-	-	-	1(WK6)	WK 5	-	1	-	-	1	1	-

6th Sem

Course Code		**:**	**BMEA611C**	**Heat Transfer**	**Semester**	**:**	**06**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PCC**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Develop thermal engineering solutions by applying heat transfer principles to analyze, design, and optimize thermal systems in mechanical engineering applications.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Analyze the fundamental modes of heat transfer and boundary conditions to evaluate thermal behavior in engineering systems.

CO2: Formulate and solve steady-state and transient conduction problems to determine temperature distribution and heat transfer characteristics.

CO3: Analyze convective heat transfer in internal and external flows using dimensional analysis and empirical correlations.

CO4: Design and evaluate heat exchangers using LMTD and Effectiveness–NTU methods for thermal system applications.

CO5: Analyze radiative heat exchange between surfaces using fundamental radiation laws and surface characteristics.

CO6: Evaluate boiling and condensation heat transfer processes using theoretical models and empirical correlations for engineering applications.

UNIT–I	**11 Hrs**

INTRODUCTION: Modes of heat transfer: Basic laws governing conduction, convection, and radiation heat transfer; combined heat transfer mechanism, Overall heat transfer coefficient, Boundary conditions of 1^{st}, 2^{nd} and 3^{rd} Kind.

CONDUCTION: Derivation of general three-dimensional heat conduction equation in Cartesian coordinate system, special cases, 3-D conduction in cylindrical and spherical coordinate systems (No derivation).

ONE DIMENSIONAL CONDUCTION: Derivation for heat flow and temperature distribution in plane wall, hollow cylinder and hollow sphere without heat generation. Thermal resistance concept & its importance. Composite wall, cylinder and sphere, contact resistance; Critical thickness of insulation without heat generation, Heat transfer in extended surfaces of uniform cross-section without heat generation, Long fin, tip insulated fin and with heat transfer from the tip. Fin efficiency and effectiveness. Numerical problems.

UNIT–II	**11 Hrs**

ONE-DIMENSIONAL TRANSIENT CONDUCTION: Conduction in solids with negligible internal temperature gradient (Lumped system analysis), Use of Transient temperature charts (Heisler's charts) for slab, long cylinder and sphere, Numerical Problems.

CONCEPTS AND BASIC RELATIONS IN BOUNDARY LAYERS: Flow over a body velocity boundary layer; critical Reynolds number; general expressions for drag coefficient and drag force; thermal boundary layer; general expression for local heat transfer coefficient; Average heat transfer coefficient; Nusselt

number. Flow inside a duct- velocity boundary layer, hydrodynamic entrance length and hydro dynamically developed flow. Numericals based on empirical relation given in data handbook.

FREE OR NATURAL CONVECTION: Application of dimensional analysis for free convection- physical significance of Grashoff number; use of correlations of free convection in vertical, horizontal and inclined flat plates, vertical and horizontal cylinders and spheres, Numerical problems.

UNIT-III	**10 Hrs**

FORCED CONVECTIONS: Applications of dimensional analysis for forced convection. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Use of various correlations for hydro dynamically and thermally developed flows inside a duct, use of correlations for flow over a flat plate, over a cylinder and sphere. Numerical problems.

HEAT EXCHANGERS: Classification of heat exchangers; overall heat transfer coefficient, fouling and fouling factor; LMTD, Effectiveness-NTU methods of analysis of heat exchangers. Numerical problems.

UNIT-IV	**10 Hrs**

RADIATION HEAT TRANSFER: Thermal radiation; definitions of various terms used in radiation heat transfer; Stefan-Boltzmann law, Kirchhoff's law, Planck's law and Wien's displacement law. Radiation heat exchange between two parallel infinite black surfaces, configuration factor or view factor, intensity of radiation and solid angle; Lambert's law; radiation heat exchange between two parallel infinite gray surfaces; effect of radiation shield (only discussion on non black surfaces); Numerical problems.

CONDENSATION AND BOILING: Types of condensation (discussion only) Nusselt theory for laminar condensation on a vertical flat surface (no derivation); use of correlations for condensation on vertical flat surfaces, horizontal tube and horizontal tube banks; Reynolds number for condensate flow; regimes of pool boiling, pool boiling correlations. Numerical problems.

Text Books:

1. R. C. Sachdeva, '*Fundamentals of Engineering Heat and Mass Transfer',*2022 New Age International
2. R. K. Rajput, '*Heat and Mass Transfer'* Latest Revised Edition 2022 S. Chand Publishing.
3. D. S. Kumar, '*Heat and Mass Transfer'* Latest Revised Edition 2021 S. K. Kataria & Sons
4. Dr. C P Kothandaraman Heat and Mass Transfer Data Book 27 July 2025 11th Edition

Heat and Mass Transfer data handbook:

C.P. Kothandaraman and S. Subramanya, New Age International Publishers, 11th Edition 2025.

Reference Books:

1. Yunus A. Çengel & Afshin J. Ghajar, *Heat and Mass Transfer: Fundamentals and Applications (SI Units)* 6th Edition 2020 McGraw Hill.
2. P. K. Nag, *Heat and Mass Transfer,* Latest Indian Reprint 2023 McGraw Hill India.
3. S. P. Sukhatme, *A Textbook on Heat Transfer* 5th Edition 2019, Universities Press.
4. Frank P. Incropera, David P. DeWitt, Theodore L. Bergman & Adrienne S. Lavine, *Introduction to Heat Transfer* 7th Edition 2018 Wiley.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112101097?utm
2. https://nptel.ac.in/courses/103105140?utm
3. https://nptel.ac.in/courses/112108149?utm
4. https://www.mathworks.com/discovery/heat-transfer.html?utm
5. https://elearning.vtu.ac.in?utm

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3 (WK1, WK2, WK3, WK4)	2 (WK1, WK2, WK3, WK4)	1 (WK5)	–	1 (WK2, WK6)	–	–	–	–	–	–	2	1
CO2	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	2 (WK8)	2 (WK2, WK6)	–	–	–	–	–	–	3	2
CO3	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	2 (WK8)	3 (WK2, WK6)	1 (WK1, WK5, WK7)	–	–	–	–	–	3	2
CO4	2 (WK1, WK2, WK3, WK4)	2 (WK1, WK2, WK3, WK4)	3 (WK5)	3 (WK8)	3 (WK2, WK6)	1 (WK1, WK5, WK7)	–	–	–	–	–	3	2
CO5	2 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	2 (WK8)	2 (WK2, WK6)	1 (WK1, WK5, WK7)	–	–	–	–	1 (WK8)	2	2
CO6	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	3 (WK5)	3 (WK8)	2 (WK2, WK6)	2 (WK1, WK5, WK7)	–	–	–	–	1 (WK8)	3	2

Course Code		**:**	**BMEA612C**	**Mechanical Vibrations**	**Semester**	**:**	**06**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PCC**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Apply the principles of mechanical vibrations to model, analyze, and evaluate single and multi-degree of freedom vibratory systems, utilize vibration measurement techniques, determine critical speeds, and assess Noise, Vibration, and Harshness (NVH) characteristics for engineering design and control.

Course Outcomes:

After completion of the course student will be able to

CO1: Understand the fundamentals, causes and the need of mechanical vibrations and mathematical models for undammed single degree of freedom systems.

CO2: Analyze the mechanical model of damped free and forced vibratory system and formulating mathematical models and analyze the systems.

CO3: Understand, analyze and discus on different vibration measuring instruments, Critical speed of the shaft. Ability to understand and formulate mathematical models for two degree of freedom systems of theoretical and real life examples.

CO4: Analyze and formulate mathematical models for several degree of freedom systems using different numerical techniques. Able to understand causes and effects of Noise, Vibration, Harshness (NVH) and control.

UNIT–I	**11 Hrs**

Introduction: Types of vibrations, Simple Harmonic Motion (S.H.M), principle of super position applied to Simple Harmonic Motions. Beat's phenomena.

UNDAMPED FREE VIBRATIONS: Single degree of freedom systems. Undamped free vibration-natural frequency of free vibration, stiffness of spring elements, effect of mass of spring, Compound Pendulum (with and without considering masses). Determination of natural frequency using Newton's law and energy method.

UNIT–II	**11 Hrs**

DAMPED FREE VIBRATIONS: Single degree freedom systems, different types of damping, concept of critical damping and its importance, study of response of viscous damped systems for cases of under damping, critical and over damping, Logarithmic decrement.

FORCED VIBRATION: Single degree freedom systems, steady state solution with viscous damping due to harmonic force. Reciprocating and rotating unbalance, vibration isolation transmissibility ratio due to harmonic excitation and support motion.

UNIT-III	**10 Hrs**

VIBRATION MEASURING INSTRUMENTS & WHIRLING OF SHAFTS: Vibrometer velocity pickup and accelerometer. Whirling of shafts with and without air damping. Discussion of speeds above and below critical speeds.

SYSTEMS WITH TWO DEGREES OF FREEDOM: Introduction, principle modes and Normal modes of vibration, co-ordinate coupling, generalized and principal co-ordinates,. Applications: a) Vehicle suspension. b) Dynamic vibration absorber.

UNIT-IV	10 Hrs
NUMERICAL METHODS FOR MULTI DEGREE FREEDOM SYSTEMS: Introduction, Influence coefficients, Maxwell reciprocal theorem, Determination of the natural frequencies by, Reyleigh's method, Dunkerley's method, matrix iteration method, Stodola method, and Holzer's method. **Introduction to Noise, Vibration, Harshness (NVH) :** Subjective response of sound: Frequency and sound dependent human response; the decibel scale, introduction to condition monitoring.	
Text Books:	
1. G. K. Grover, Mechanical Vibrations 7th edition, Neamchand and Bros, Roorkee India. 2. J.B.K Das, 2008, Mechanical Vibrations2008 Edition Sapna Book House – Bangalore.	
Reference Books:	
1. V.P. Singh, 2006, Mechanical Vibrations 3rd edition, DhanpatRai& Company Pvt. Ltd. 2. S.S. Rao, 2003, Mechanical Vibrations 4th Edition, Pearson Education Inc. 3. Thammaiah Gowda, 2023, Mechanical Vibrations" Technical Publications, 10th Edition, , Pune.	
Web links and Video Lectures (e-Resources):	
https://nptel.ac.in/courses/112107212 https://ocw.mit.edu/courses/2-003sc-engineering-dynamics-fall-2011/pages/mechanical-vibration	

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3 (WK1, WK2, WK3)	3 (WK1, WK2, WK3)	2 (WK1, WK2, WK3)	1 (WK1, WK2, WK3)	-	-	-	-	-	-	-	1	2
CO2	3 (WK1, WK2, WK3)	3 (WK1, WK2, WK3)	2 (WK1, WK2, WK3)	1 (WK1, WK2, WK3)	-	-	-	-	-	-	-	3	2
CO3	3 (WK1, WK2, WK3)	3 (WK1, WK2, WK3)	2 (WK1, WK2, WK3)	1 (WK1, WK2, WK3)	-	-	-	-	-	-	-	3	2
CO4	3 (WK1, WK2, WK3)	3 (WK1, WK2, WK3)	2 (WK1, WK2, WK3)	1 (WK1, WK2, WK3)	-	-	-	-	-	-	-	3	2

Course Code		**:**	**BMEA613C**	**Optimization Techniques**	**Semester**	**:**	**06**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PCC**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Develop optimal solutions for engineering decision-making problems using operations research and optimization techniques for efficient planning, scheduling, and resource allocation in mechanical engineering applications.

Course Outcomes:

After completion of the course student will be able to

CO1: Formulate and solve linear programming problems using graphical and simplex methods to obtain optimal solutions for engineering decision-making.

CO2: Develop and solve transportation and assignment models using appropriate optimization techniques for efficient resource allocation and decision-making.

CO3: Analyze project scheduling and sequencing problems using CPM, PERT, and Johnson's algorithms to optimize project completion time and production schedules..

CO4: Analyze engineering decision-making problems using game theory and replacement models to determine optimal strategies and replacement policies.

UNIT–I	**11 Hrs**

Introduction: Definition of OR, Application of OR to Engineering and Managerial problems,

Linear Programming: Definition, Mathematical Formulation, Standard Form, Solution through Graphical Method.

Simplex methods: How to Convert an LP to Standard Form, Preview of the Simplex Algorithm, The Simplex Algorithm, Using the Simplex Algorithm to Solve Minimization Problems, The Two-Phase Simplex Method(simple problems)

UNIT–II	**10 Hrs**

Transportation Problem: Formulation of Transportation Model, Basic Feasible Solution using North-West corner, Least Cost, Vogel's Approximation Method, Optimality Methods (MODI)

Assignment Problem: Formulation of the Assignment problem, solution method of assignment problem- Hungarian Method, Variants in assignment problem.

UNIT-III	**11 Hrs**

Project Management Using Network Analysis: Network construction, CPM & PERT, Determination of critical path and duration.

Sequencing: Johnson's algorithm, n - jobs to 2 machines, n - jobs 3machines.2 jobs and m machines problems.

UNIT-IV	**10 Hrs**

Game Theory: Introduction, Two-person Zero Sum game, Pure strategies, Games without saddle point - Arithmetic method, The rules of dominance, Graphical Method

Replacement models: Introduction, replacement of items whose maintenance and repair costs increase with time, ignoring changes in the value of money during the period, replacement of items

whose maintenance costs increase with time and value of money also changes with time.

Text Books:

1. . K. Gupta and D. S. Hira, *Operations Research*, Latest Reprint, S. Chand Publishing, New Delhi, 2023.
2. Hamdy A. Taha, *Operations Research: An Introduction*, 10th Global Edition, Pearson Education, 2017.
3. Frederick S. Hillier and Gerald J. Lieberman, *Introduction to Operations Research*, 11th Edition, McGraw Hill, 2021.
4. J. K. Sharma, *Operations Research*, 6th Edition (Latest Reprint), Trinity Press, 2019.
5. Kanti Swarup, P. K. Gupta and Man Mohan, *Operations Research*, 19th Revised Edition, Sultan Chand & Sons, 2022.

V. K. Kalavathy, *Operations Research*, **4th Edition**, McGraw Hill Education (India), **2013**

Reference Books:

1. Manohar Mahajan, *Operations Research*, **Latest Reprint**, Dhanpat Rai & Co. (P) Ltd., **2016**.
2. A. Ravindran, Don T. Phillips and James J. Solberg, *Operations Research: Principles and Practice*, 2nd Edition (Wiley India Reprint), 2007.
3. Wayne L. Winston, *Operations Research: Applications and Algorithms*, 4th Edition, Brooks/Cole, 2004.
4. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows*, 4th Edition, Wiley, 2010.
5. Frederick S. Hillier and Gerald J. Lieberman, *Introduction to Operations Research*, 11th Edition, McGraw Hill, 2021

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/110106062
2. https://swayam.gov.in/nc_details/NPTEL
3. https://elearning.vtu.ac.in/
4. https://developers.google.com/optimization

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	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	1 (WK8)	2 (WK2, WK6)	–	–	–	–	1	1 (WK8)	3	2
CO2	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	2 (WK8)	3 (WK2, WK6)	1 (WK5, WK7)	–	–	–	1	1 (WK8)	3	2
CO3	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	3 (WK5)	3 (WK8)	2 (WK2, WK6)	1 (WK5, WK7)	–	–	–	2	2 (WK8)	3	3
CO4	2 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	3 (WK8)	2 (WK2, WK6)	2 (WK1, WK5, WK7)	1 (WK9)	–	–	1	2 (WK8)	2	3

Course Code		**:**	**BMES614L**	**CAE LAB**	**Semester**	**:**	**06**
L:T:P		**:**	**0:0:4**		**Course Type**	**:**	**PCCL**
Hours/Sem.	**Practical**	**:**	**52 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**02 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**60 Hrs**		**Credits**	**:**	**01**

Professional Competency:

Apply Computer Aided Engineering (CAE) tools to model, simulate, analyze, validate, and optimize mechanical engineering components under structural, thermal, fluid flow, and dynamic loading conditions.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Develop finite element and computational fluid dynamics models of engineering components using commercial CAE software.

CO2: Perform structural, thermal, fluid flow, and dynamic analyses by applying appropriate material properties, boundary conditions, and meshing techniques.

CO3: Interpret and validate simulation results for engineering decision-making and design improvement.

CO4: Optimize mechanical components using CAE tools considering strength, thermal performance, flow characteristics, and vibration response..

PART-A	**13 Hrs**

Structural:

- Static structural analysis of a cantilever beam subjected to point and uniformly distributed loads.
- Stress and deformation analysis of a bracket/plate with holes under tensile loading; comparison of different mesh sizes.

Thermal Analysis:

- Steady-state thermal analysis of an extended surface (fin) and temperature distribution.

Steady-state thermal analysis of a compound wall (furnace) and temperature distribution.

PART – B	**13 Hrs**

Fluid Flow Analysis:

- CFD analysis of flow through a pipe to determine pressure and velocity distributions
- External flow analysis over a circular cylinder or airfoil to evaluate pressure contours and drag characteristics.

Dynamic Analysis:

- Modal analysis of a simply supported beam or cantilever beam to determine natural frequencies and mode shapes.
- Harmonic response analysis of a rotating shaft or machine component subjected to dynamic excitation.

Text Books:

1. Practical Finite Element Analysis, Finite to Infinite, 4th Edition, 2022.
2. Introduction to Finite Elements in Engineering, Pearson Education, 5th Edition, 2019.
3. Introduction to Computational Fluid Dynamics, Wiley India, 2nd Edition, 2022.

Reference Books:

1. Finite Element Analysis: Theory and Application with ANSYS, Pearson Education, 4th Edition, 2019.
2. Concepts and Applications of Finite Element Analysis, Wiley, 4th Edition, 2007 (Reprint editions available).
3. Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill Education, 1st Edition, 1995 (Latest Indian reprints available).

Web links and Video Lectures (e-Resources):

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3 (WK1, WK2, WK3)	2 (WK2, WK4)	1 (WK5)	–	3 (WK2, WK5)	–	–	–	–	–	1	3	-
CO2	3 (WK1, WK2)	3 (WK2, WK3, WK4)	2 (WK3, WK5)	2 (WK4)	3 (WK2, WK5)	–	–	–	–	–	1	-	3
CO3	2 (WK2)	3 (WK3, WK4)	2 (WK5)	3 (WK4)	2 (WK5)	–	–	–	1	1	1	-	3
CO4	2 (WK2)	2 (WK3)	3 (WK5)	2 (WK4)	3 (WK5)	–	1 (WK7)	–	1	2	2	3	-

Course Code		**:**	**BMES615L**	**Heat Transfer Laboratory**	**Semester**	**:**	**06**
L:T:P		**:**	**0:0:4**		**Course Type**	**:**	**PCCL**
Hours/Sem.	**Practical**	**:**	**26 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**00 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**04 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**30 Hrs**		**Credits**	**:**	**01**

Professional Competency:

Develop experimental skills to analyze heat transfer phenomena and evaluate the performance of thermal systems using standard laboratory equipment and engineering practices.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Perform heat transfer experiments to determine thermal properties and evaluate conduction heat transfer in engineering materials.

CO2: Analyze convection and transient heat transfer processes using experimental measurements and engineering correlations

CO3: Evaluate the performance of heat exchangers, radiation systems, and phase-change heat transfer processes through laboratory investigations.

CO4: Interpret experimental observations and **prepare** technical reports by applying engineering practices, modern laboratory instruments, and safety procedures.

PART-A	**26 Hrs**

1. Determination of thermal conductivity of a metal rod/Powder.
2. Determination of overall heat transfer coefficient of a composite wall.
3. Determination of effectiveness of a metallic fin.
4. Determination of heat transfer coefficient in free convection on a vertical tube.
5. Determination of heat transfer coefficient in forced convection flow through a pipe.
6. Determination of emissivity of a surface.

PART-B	**26 Hrs**

1. Determination of Stefan–Boltzmann constant.
2. Determination of LMTD and effectiveness in parallel-flow and counter-flow heat exchangers.
3. Experiments on boiling of liquid and condensation of vapour.
4. Performance test on vapour compression refrigeration system.
5. Performance test on vapour compression air-conditioning system..
6. Experiment on transient conduction heat transfer.

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3 (WK1, WK2, WK3, WK4)	2 (WK3, WK4)	1 (WK5)	2 (WK8)	3 (WK6)	–	–	–	1 (WK9)	1	–	3	2
CO2	3 (WK1, WK2, WK3, WK4)	3 (WK3, WK4)	2 (WK5)	3 (WK8)	3 (WK6)	1 (WK7)	–	–	1 (WK9)	1	–	3	2
CO3	3 (WK1, WK2, WK3, WK4)	3 (WK3, WK4)	2 (WK5)	3 (WK8)	3 (WK6)	2 (WK7)	1 (WK7)	–	1 (WK9)	1	1 (WK8)	3	3
CO4	2 (WK3, WK4)	3 (WK3, WK4)	2 (WK5)	3 (WK8)	3 (WK6)	1 (WK7)	–	1 (WK9)	2 (WK9)	2	2 (WK8)	3	3

Course Code		**:**	**BMEA616L**	**Dynamics Laboratory**	**Semester**	**:**	**06**
L:T:P		**:**	**0:0:1**		**Course Type**	**:**	**PCCL**
Hours/Sem.	**Practical**	**:**	**26Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW+SL)	**:**	**00Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**04Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**30Hrs**		**Credits**	**:**	**01**

Professional Competency:

Perform experimental investigations on mechanical dynamic systems to determine vibration characteristics, stress distribution, balancing requirements and dynamic performance of machine elements using standard laboratory equipment.

Course Outcomes:

CO1: Conduct experiments on single degree of freedom vibrating systems to determine natural frequency, damping characteristics and critical speed.
CO2: Perform experiments on rotating systems, governors and journal bearings to evaluate balancing, speed regulation and pressure distribution.
CO3: Investigate stress distribution, principal stresses and strains using photo elasticity and strain rosettes.
CO4: Analyze the dynamic behaviour of gyroscopes and compound pendulums through laboratory experiments.

Part A	**13 Hrs.**

1. Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in longitudinal and torsional vibration systems.
2. Balancing of rotating masses.
3. Determination of critical speed of a rotating shaft.
4. Determination of fringe constant of photo elastic material.
5. Circular disc subjected to diametric compression.
6. Pure bending specimen (Four-point bending).
7. Determination of stress concentration using photo elasticity.

Part B	**31 Hrs.**

1. Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proell/Hartnell governor.
2. Determination of pressure distribution in journal bearing.
3. Determination of principal stresses and strains using strain rosettes.
4. Determination of natural frequency of compound pendulum.
5. Experiments on gyroscope.

Text Books:

S. S. Rao, Mechanical Vibrations, Pearson.
R. S. Khurmi & J. K. Gupta, Theory of Machines, S. Chand.
Dally & Riley, Experimental Stress Analysis, McGraw-Hill.

Web Links and Video Lectures (e-Resources):

https://nptel.ac.in
https://www.vlab.co.in
https://ocw.mit.edu

Scheme for SEE

One Question from Part A - 15 Marks (05 Write-up + 10 Experiment) One Question from Part B - 25 Marks (05 Write-up + 20 Experiment) Viva-Voce - 10 Marks Total: 50 Marks

Matrix Describing the Mapping of COs with POs (Considering WKs) and PSOs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	**3** (WK1, WK2, WK3)	**2** (WK2, WK4)	–	**3** (WK8)	**3** (WK6)	–	–	–	–	1	–	**3**	**2**
CO2	**3** (WK2, WK3)	**3** (WK4)	1 (WK5)	**3** (WK8)	**3** (WK6)	–	–	–	–	1	–	**3**	**3**
CO3	**2** (WK2)	**3** (WK4, WK8)	–	**3** (WK8)	**3** (WK6)	–	–	–	–	1	–	**3**	**3**
CO4	**2** (WK2)	**3** (WK4)	–	**3** (WK8)	**3** (WK6)	–	–	–	–	1	–	**3**	**3**

Course Code		**:**	**BMEA631E**	**SAP for Materials Management**	**Semester**	**:**	**06**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PEC-II**
Hours/Sem.	**Teaching**	**:**	**42Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW+SL)	**:**	**42Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90Hrs**		**Credits**	**:**	**03**

Professional Competency:

Apply SAP Materials Management concepts and ERP-based procurement, inventory management, invoice verification and reporting for effective enterprise resource management.

Course Outcomes:

CO1: Explain ERP concepts, SAP architecture and SAP MM module.
CO2: Apply SAP MM tools for procurement and purchasing.
CO3: Demonstrate inventory management and material valuation in SAP.
CO4: Analyze invoice verification and reporting using SAP MM. introduction to ERP, SAP, SAP MM, organizational structure, master data and navigation.

UNIT-I	**10 Hrs.**

Introduction to ERP, SAP, SAP MM, organizational structure, master data and navigation.

UNIT-II	**11 Hrs.**

Procurement cycle, PR, RFQ, vendor selection, PO, pricing, inventory concepts and FI integration.

UNIT-III	**11 Hrs.**

Goods receipt/issue, stock transfer, valuation, batch management, physical inventory and warehouse management.

UNIT-IV	**10 Hrs.**

Invoice verification, three-way matching, invoice posting, credit memo, SAP FI integration, reports and case studies.

Text Books:

1. Monk, E. & Wagner, B., "Concepts in Enterprise Resource Planning", Cengage Learning, 4th Ed., 2013.
2. Magal, S. & Word, J., "Integrated Business Processes with ERP Systems", Wiley, 2011.
3. Jones, G. & Rama, D., "Accounting Information Systems with SAP", Wiley, 2013.

Reference Books:

1. SAP AG, "Materials Management (MM) Configuration Guide", SAP Press.

Web Links and Video Lectures (e-Resources):

1. https://learning.sap.com
2. https://open.sap.com
3. https://help.sap.com

Matrix Describing the Mapping of COs with POs (Considering WKs) and PSOs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	**3** (WK1, WK2, WK3)	**3** (WK2, WK4)	1 (WK5)	–	2 (WK6)	–	–	–	–	1	2	3	2
CO2	**3** (WK1, WK2, WK3)	**3** (WK2, WK4)	**3** (WK5)	1 (WK8)	**3** (WK6)	1 (WK7)	–	–	–	1	2	3	3
CO3	**3** (WK2, WK3, WK4)	**3** (WK4, WK8)	**3** (WK5)	**2** (WK8)	**3** (WK6)	**2** (WK7)	**1** (WK7)	–	–	1	2	3	3
CO4	**2** (WK2, WK3)	**3** (WK4, WK8)	**2** (WK5)	**3** (WK8)	**3** (WK6)	**2** (WK7)	**2** (WK7)	**1** (WK9)	–	2	2	3	3

Course Code	:	BMEA632E	Reverse Engineering and Its Applications	Semester	:	06
L:T:P	:	3:0:0		Course Type	:	PEC - II
Hours/Sem. Teaching	:	42 Hrs		CIE Marks	:	50
Hours/Sem. Learning (TW)	:	42 Hrs		SEE Marks	:	50
Hours/Sem. Exam	:	06 Hrs		Total Marks	:	100
Hours/Sem. Total Hrs.	:	90 Hrs		Credits	:	03

Professional Competency:

Develop mechanical products through reverse engineering by integrating 3D scanning, metrology, CAD modelling, Artificial Intelligence, computer vision, additive manufacturing and digital twin technologies for product redesign, quality improvement and Industry 4.0 applications.

Course Outcomes:

CO1: Explain the principles, methodologies and workflow of reverse engineering for mechanical Components using modern digital technologies.

CO2: Apply 3D scanning, metrology and geometric reconstruction techniques for developing accurate CAD models of engineering components.

CO3: Analyze reverse engineering systems using AI-assisted modelling, computer vision and additive manufacturing for product development and inspection.

CO4: Evaluate industrial applications of reverse engineering considering digital twin, intellectual property rights, sustainability and ethical engineering practices.

UNIT–I	10 Hrs

Introduction to Reverse Engineering and Digital Product Development: Introduction to Reverse Engineering ,Product Lifecycle and Product Development ,Need and Applications of Reverse Engineering ,Conventional Engineering vs Reverse Engineering ,Reverse Engineering Workflow ,Contact and Non-contact Reverse Engineering ,Computer Aided Reverse Engineering (CARE) ,Digital Product Development ,CAD–CAE–CAM Integration ,Industry 4.0 and Reverse Engineering ,Product Benchmarking ,Product Redesign ,Engineering Ethics ,Sustainability in Reverse Engineering ,**Applications: ,**Automotive components, Aerospace structures, Medical implants, Consumer products.

UNIT–II	11 Hrs

3D Scanning, Metrology and Geometric Reconstruction: Principles of 3D Digitization ,Contact Measurement Systems ,Coordinate Measuring Machines (CMM) ,Laser Scanners ,Structured Light Scanners ,Photogrammetry ,CT Scanning ,Point Cloud Generation ,Point Cloud Processing ,Mesh Generation ,Surface Reconstruction ,Feature Extraction ,Geometric Dimensioning and Tolerancing (GD&T) ,CAD Model Reconstruction ,Accuracy Assessment ,Reverse Engineering Software **Industrial Software:** SolidWorks ScanTo3D.

UNIT-III	10 Hrs

Reverse Engineering Systems, AI-assisted Modelling and Additive Manufacturing: Artificial Intelligence in Reverse Engineering, Computer Vision Fundamentals ,Image Processing for Feature Extraction ,Deep Learning for Object Recognition ,AI-based Surface Reconstruction ,Machine Learning for Shape Recognition ,Feature Recognition Algorithms ,Digital Twin Concepts ,Additive Manufacturing Integration ,Rapid Prototyping ,Topology Optimization ,Inspection using Reverse Engineering ,Reverse Engineering of Free-form Surfaces ,Reverse Engineering for Legacy Components **Case Studies:** Automotive Engine Component ,Aircraft Turbine Blades, Biomedical Prosthetic Components.

UNIT-IV	10 Hrs
Industrial Applications, Digital Twin, Intellectual Property and Case Studies: Reverse Engineering in Automotive Industry ,Reverse Engineering in Aerospace ,Reverse Engineering in Biomedical Engineering ,Reverse Engineering in Defence ,Reverse Engineering in Heritage Conservation ,Digital Twin Applications ,Product Inspection and Quality Control ,Failure Analysis ,Product Optimization ,Intellectual Property Rights ,Patent Issues ,Copyright ,Trade Secrets ,Ethical and Legal Issues ,Future Trends in AI-enabled Reverse Engineering.	
Text Books:	
1. Vinesh Raja and Kiran J. Fernandes, *Reverse Engineering: An Industrial Perspective*, Springer, First Edition, 2008. (Hardcover published October 11, 2007; copyright 2008.) 2. Wego Wang, *Reverse Engineering: Technology of Reinvention*, CRC Press (Taylor & Francis), First Edition, 2010. 3. Ali K. Kamrani and Emad Abouel Nasr, *Engineering Design and Rapid Prototyping*, Springer, First Edition, 2010.	
Reference Books:	
1. Andrew (Andy) C. Birt, *3D Scanning for Advanced Manufacturing, Design and Construction*, CRC Press, 2022. 2. Richard Leach, *Optical Measurement of Surface Topography*, Springer, 2011. 3. John M. Hollister, Richard F. Jacobs and Brent Stucker, *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing*, Springer, 3rd Edition, 2021. 4. Ibrahim Zeid, *CAD/CAM Theory and Practice*, McGraw-Hill Education, 2nd Edition, 2009. 5. Mikell P. Groover, *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson Education, 4th Edition, 2020. 6. Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2nd Edition**,** 2022. 7. Francis H. Froes and Rodney Boyer (Editors), *Additive Manufacturing for the Aerospace Industry*, Elsevier, 2019. 8. B. Ravi, *CAD/CAM: Principles and Applications*, New Age International Publishers, 3rd Edition, 2018	
Web links and Video Lectures (e-Resources):	

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	**3** (WK1, WK2, WK3 & WK4)	**2** (WK1, WK2, WK3 & WK4)	–	–	–	–	–	**1**	–	–	**1** (WK8)	–	**2**
CO2	–	**3** (WK1, WK2, WK3 & WK4)	**3** (WK5)	**2** (WK4)	**3** (WK6)	**1** (WK1, WK5 & WK7)	–	**1**	**1**	–	**1** (WK8)	–	**3**
CO3	–	**2** (WK1, WK2, WK3 & WK4)	**3** (WK5)	**2** (WK4)	**3** (WK6)	**1** (WK1, WK5 & WK7)	**1** (WK9)	**1**	**1**	–	**1** (WK8)	–	**3**
CO4	–	**2** (WK1, WK2, WK3 & WK4)	**2** (WK5)	**2** (WK4)	**2** (WK6)	**2** (WK1, WK5 & WK7)	**2** (WK9)	**2**	**1**	**1**	**2** (WK8)	–	**2**

Course Code		**:**	**BMEA632E**	**NON TRADITIONAL MACHINING**	**Semester**	**:**	**06**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PEC - II**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

This course enables mechanical engineering students to acquire the knowledge of various modern machining processes and use these processes along with the traditional machining processes to obtain maximum material rate, accuracy and required surface finish.

Course Outcomes:

CO1: Identify a suitable unconventional machining process for a material and it with conventional methods.

CO2: Analyze the parameters that affect material removal in EDM and EBM by applying thermal metal removal concepts.

CO3: Analyze material removal mechanisms and parameter effects in USM, AJM, PAM, and LBM.

CO4: Evaluate material removal rate in ECM and CHM using chemical principles.

UNIT–I	**10 Hrs**

Introduction to Non-traditional machining: Introduction to Non-traditional machining, Need for Non-traditional machining process, Comparison between traditional and non-traditional machining, general classification Non-traditional machining processes, classification based on nature of energy employed in machining, selection of non-traditional machining processes, Specific advantages, limitations and applications of non-traditional machining processes.

Ultrasonic Machining (USM): Introduction, Equipment and material process, Effect of process parameters: Effect of amplitude and frequency, Effect of abrasive grain diameter, effect of slurry, tool & work material. Process characteristics: Material removal rate, tool wear, accuracy, surface finish, applications, advantages & limitations of USM.

Abrasive Jet Machining (AJM): Introduction, Equipment and process of material removal, process variables: Carrier gases, type of abrasive, work material, stand-off distance (SOD). Process characteristics-Material removal rate, Nozzle wear, accuracy & surface finish. Applications, advantages & limitations of AJM.

UNIT–II	**11 Hrs**

Electrical Discharge Machining (EDM): Introduction, mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), dielectric medium-its functions & desirable properties, electrode feed control system. Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current & spark gap, surface finish, Heat Affected Zone. Advantages, limitations & applications of EDM, Electrical discharge grinding, Traveling wire EDM.

Electron Beam Machining (EBM): Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations.

UNIT-III	**10 Hrs**

Plasma Arc Machining (PAM): Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions, applications, advantages and limitations.

Laser Beam Machining (LBM): Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations.

UNIT-IV	10 Hrs
Electrochemical machining (ECM): Introduction, Principle of electro chemical machining, ECM equipment, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish. Process parameters: Current density, Tool feed rate, Gap between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. ECM Tooling: ECM tooling technique & example, Tool & insulation materials. Applications ECM: Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH. **Chemical Machining (CHM):** Elements of the process, Resists (maskants), Etchants. Types of chemical machining Process -chemical blanking process, chemical milling process. Process characteristics of CHM: material removal rate, accuracy, surface finish, advantages, limitations and applications of chemical machining process.	
Text Books:	
1. P.C Pandey & H.S. Shan – 2017, Modern Machining Processes, Tata McGraw Hill. 2. HMT– 2013 reprint, Production technology, Tata Mc Graw Hill.	
Reference Books:	
1. Hassan Abdel – 2005, Advanced Machining Processes, Mc Graw Hill, Mechanical Engineering Series. 2. ASME – Metals hand book, ASM Handbook series, Vol-3. 3. F.M Wilson – High velocity forming of metals, ASTME Prentice Hall. 4. B. L. Juneja - "Workshop/Manufacturing Practices" Cengage Learning India Pvt. Ltd. 2019 Edition.	
Web links and Video Lectures (e-Resources):	
1. https://nptel.ac.in/courses/112105127 2. https://www.ajiet.edu.in 3. https://www.slideshare.net 4. https://link.springer.com 5. https://www.scribd.com https://www.ijert.org	

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Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	2 (WK1, WK2, WK3, and WK4)							1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	
CO2	2 (WK1, WK2, WK3, and WK4)	1 (WK1, WK2, WK3, and WK4)						1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	
CO3	2 (WK1, WK2, WK3, and WK4)							1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	
CO4	2 (WK1, WK2, WK3, and WK4)	1 (WK1, WK2, WK3, and WK4)						1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	

Course Code		**:**	**BMEA633E**	**Engineering Economics**	**Semester**	**:**	**06**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**PEC - II**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Apply engineering economics principles, costing methods, and financial analysis techniques to evaluate engineering alternatives, estimate project costs, and make informed economic decisions for engineering projects.

Course Outcomes:

CO1: Evaluate financial feasibility of alternatives by applying engineering economics principles and worth comparison methods.

CO2: Evaluate alternatives using equivalent annual worth and rate of return methods for informed economic decision-making.

CO3: Estimate depreciation and product costs using standard methods for economic evaluation.

CO4: Analyze breakeven, payback, and financial statements for assessing project viability and performance.

UNIT–I	**10 Hrs**

Introduction: Engineering and Economics, Definition, Engineering, Problem solving and Decision making, Law of demand and supply, Interest and Interest factors: Interest rate, Simple interest, Compound interest, Cash - flow diagrams, Exercises and Discussion.

Present Worth Comparisons: Conditions for present worth comparisons, Basic Present worth comparisons, Present worth equivalence, Net Present worth, Assets with unequal lives, infinite lives, Future worth comparison, Exercises and Discussion.

UNIT–II	**11 Hrs**

Electrical Discharge Machining (EDM): Introduction, mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), dielectric medium-its functions & desirable properties, electrode feed control system. Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current & spark gap, surface finish, Heat Affected Zone. Advantages, limitations & applications of EDM, Electrical discharge grinding, Traveling wire EDM.

Electron Beam Machining (EBM): Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations.

UNIT-III	**10 Hrs**

Plasma Arc Machining (PAM): Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions, applications, advantages and limitations.

Laser Beam Machining (LBM): Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations.

UNIT-IV	**10 Hrs**

Electrochemical machining (ECM): Introduction, Principle of electro chemical machining, ECM equipment, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish. Process parameters: Current density, Tool feed rate, Gap

between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. ECM Tooling: ECM tooling technique & example, Tool & insulation materials. Applications ECM: Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH.

Chemical Machining (CHM): Elements of the process, Resists (maskants), Etchants. Types of chemical machining Process -chemical blanking process, chemical milling process. Process characteristics of CHM: material removal rate, accuracy,surface finish, advantages, limitations and applications of chemical machining process.

Text Books:

3. P.C Pandey & H.S. Shan – 2017, Modern Machining Processes, Tata McGraw Hill.
4. HMT– 2013 reprint, Production technology, Tata Mc Graw Hill.

Reference Books:

5. Hassan Abdel – 2005, Advanced Machining Processes, Mc Graw Hill, Mechanical Engineering Series.
6. ASME – Metals hand book, ASM Handbook series, Vol-3.
7. F.M Wilson – High velocity forming of metals, ASTME Prentice Hall.
8. B. L. Juneja - "Workshop/Manufacturing Practices" Cengage Learning India Pvt. Ltd. 2019 Edition.

Web links and Video Lectures (e-Resources):

6. https://nptel.ac.in/courses/112105127
7. https://www.ajiet.edu.in
8. https://www.slideshare.net
9. https://link.springer.com
10. https://www.scribd.com
    https://www.ijert.org

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Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	2 (WK1, WK2, WK3, and WK4)							1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	
CO2	2 (WK1, WK2, WK3, and WK4)	1 (WK1, WK2, WK3, and WK4)						1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	
CO3	2 (WK1, WK2, WK3, and WK4)							1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	
CO4	2 (WK1, WK2, WK 3, and WK4)	1 (WK1, WK2, WK3, and WK4)						1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	

Course Code		**:**	**BMEA641N**	**Optimization Techniques**	**Semester**	**:**	**06**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**OEC - II**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Develop and implement optimization-based solutions for engineering decision-making, planning, scheduling, and resource allocation in mechanical engineering systems.

Course Outcomes:

After completion of the course student will be able to

CO1: Formulate and solve linear programming problems using graphical and simplex methods to obtain optimal solutions for engineering decision-making.

CO2: Develop and analyze transportation and assignment models using appropriate optimization techniques for efficient resource allocation and decision-making.

CO3: Analyze and evaluate project scheduling and sequencing problems using CPM, PERT, and Johnson's algorithms to optimize project completion time and production schedules.

CO4: Apply game theory and replacement models to analyze and determine optimal strategies and replacement policies for engineering decision-making problems.

UNIT–I	**11 Hrs**

Introduction: Definition of OR, Application of OR to Engineering and Managerial problems,

Linear Programming: Definition, Mathematical Formulation, Standard Form, Solution through Graphical Method.

Simplex methods: How to Convert an LP to Standard Form, Preview of the Simplex Algorithm, The Simplex Algorithm, Using the Simplex Algorithm to Solve Minimization Problems, The Two-Phase Simplex Method(simple problems)

UNIT–II	**11 Hrs**

Transportation Problem: Formulation of Transportation Model, Basic Feasible Solution using North-West corner, Least Cost, Vogel's Approximation Method, Optimality Methods (MODI)

Assignment Problem: Formulation of the Assignment problem, solution method of assignment problem- Hungarian Method, Variants in assignment problem.

UNIT-III	**10 Hrs**

Project Management Using Network Analysis: Network construction, CPM & PERT, Determination of critical path and duration.

Sequencing: Johnson's algorithm, n - jobs to 2 machines, n - jobs 3machines.2 jobs and m machines problems.

UNIT-IV	**10 Hrs**

Game Theory: Introduction, Two-person Zero Sum game, Pure strategies, Games without saddle point - Arithmetic method, The rules of dominance, Graphical Method

Replacement models: Introduction, replacement of items whose maintenance and repair costs increase with time, ignoring changes in the value of money during the period, replacement of items whose maintenance costs increase with time and value of money also changes with time.

Text Books:

6. . K. Gupta and D. S. Hira, *Operations Research*, Latest Reprint, S. Chand Publishing, New Delhi, 2023.
7. Hamdy A. Taha, *Operations Research: An Introduction*, 10th Global Edition, Pearson Education, 2017.
8. Frederick S. Hillier and Gerald J. Lieberman, *Introduction to Operations Research*, 11th Edition, McGraw Hill, 2021.
9. J. K. Sharma, *Operations Research*, 6th Edition (Latest Reprint), Trinity Press, 2019.
10. Kanti Swarup, P. K. Gupta and Man Mohan, *Operations Research*, 19th Revised Edition, Sultan Chand & Sons, 2022.
    V. K. Kalavathy, *Operations Research*, **4th Edition**, McGraw Hill Education (India), **2013**

Reference Books:

6. Manohar Mahajan, *Operations Research*, **Latest Reprint**, Dhanpat Rai & Co. (P) Ltd., **2016**.
7. A. Ravindran, Don T. Phillips and James J. Solberg, *Operations Research: Principles and Practice*, 2nd Edition (Wiley India Reprint), 2007.
8. Wayne L. Winston, *Operations Research: Applications and Algorithms*, 4th Edition, Brooks/Cole, 2004.
9. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows*, 4th Edition, Wiley, 2010.
10. Frederick S. Hillier and Gerald J. Lieberman, *Introduction to Operations Research*, 11th Edition, McGraw Hill, 2021

Web links and Video Lectures (e-Resources):

5. https://nptel.ac.in/courses/110106062
6. https://swayam.gov.in/nc_details/NPTEL
7. https://elearning.vtu.ac.in/
8. https://developers.google.com/optimization

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**
CO1	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	1 (WK8)	2 (WK2, WK6)	–	–	–	–	1	1 (WK8)	3	2
CO2	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	2 (WK8)	3 (WK2, WK6)	1 (WK5, WK7)	–	–	–	1	1 (WK8)	3	2
CO3	3 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	3 (WK5)	3 (WK8)	2 (WK2, WK6)	1 (WK5, WK7)	–	–	–	2	2 (WK8)	3	3
CO4	2 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	3 (WK8)	2 (WK2, WK6)	2 (WK1, WK5, WK7)	1 (WK9)	–	–	1	2 (WK8)	2	3

Course Code		**:**	**BMEX642E**	**Product Design & Rapid Prototyping**	**Semester**	**:**	**06**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**OEC - II**
Hours/Sem.	**Teaching**	**:**	**42Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW+SL)	**:**	**42Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90Hrs**		**Credits**	**:**	**03**

Professional Competency:

Develop the ability to apply product design principles, Design for Manufacture and Assembly (DFMA), and rapid prototyping technologies to design, evaluate, and realize engineering products that are manufacturable, functional, sustainable, and industry-oriented.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Explain the fundamental concepts, objectives, requirements and product development process, including Design for Manufacture and Concurrent Engineering.

CO2: Apply Design for Manufacture and Assembly (DFMA), maintainability, environment, safety and ergonomic principles in product design.

CO3: Analyze prototype development, rapid prototyping principles and stereo lithography systems for engineering applications.

CO4: Evaluate different rapid prototyping technologies such as SLS, FDM, LOM and SGC for suitable product development applications.

UNIT-I	**11 Hrs.**

Introduction to Product Design: Definition, importance, objectives and essential requirements of product design. Product designer and project team. Steps in new product development, characteristics of successful product development, duration and cost of product development, challenges in product development, Design for Manufacture (DFM), Design for Remanufacture, Sequential Engineering and Concurrent Engineering.

Design for Manufacture and Assembly (DFMA): History of DFMA, implementation of Design for Assembly, Design for Manufacture, working methodology of DFMA and advantages of DFMA in product development.

Design Considerations: Design for Maintainability, Design for Environment, Design for Safety, Vision and Illumination Design.

UNIT–II	**10 Hrs.**

Development Processes and Organizations: Introduction to product development process, generic development process, market-pull and technology-push products, usefulness of a well-defined development process, tasks and responsibilities of marketing, design and manufacturing teams.

Concept Development: Front-end process, adopting generic product development process, process flow diagrams for different product variants (market-pull, technology-push and complex systems), functional, project and matrix product development organizations.

UNIT–III	**11 Hrs.**

Introduction to Additive Manufacturing: Prototype fundamentals, definition and types of prototypes, need for time compression in product development, Rapid Prototyping (RP) fundamentals, RP wheel, history and growth of Rapid Prototyping industry, applications of RP.

Rapid Prototyping Processes: Basic principles of rapid prototyping, classification of RP systems, advantages and limitations.

Stereo lithography (SLA): Principle, process details, materials used, advantages, disadvantages and applications.

UNIT–IV	**11 Hrs.**

Selective Laser Sintering (SLS): Principle, process details, materials used, advantages, disadvantages and applications.

Fused Deposition Modelling (FDM): Principle, process details, materials used, advantages, disadvantages and applications.

Laminated Object Manufacturing (LOM): Principle, process details, materials used, advantages, disadvantages and applications.
Solid Ground Curing (SGC): Principle of operation, machine details, advantages, disadvantages and applications.

Text Books :

1. Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, 7th Edition, McGraw-Hill, 2020.
2. C. K. Chua, K. F. Leong and C. S. Lim, Rapid Prototyping: Principles and Applications, 3rd Edition, World Scientific Publishing

Reference Books :

1. **Ian Gibson, David Rosen and Brent Stucker**, *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing*, 3rd Edition, Springer, 2021
2. **Andreas Gebhardt and Jan-Steffen Hötter,** *Additive Manufacturing: 3D Printing for Prototyping and Manufacturing,* Hanser Publications, 2016

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=HN9GtL21rb4&list=PLSGws_74K018yZOnbSaqWJZ837QyBB7vu
2. https://www.youtube.com/watch?v=JNzvLWC2cGQ
3. https://www.youtube.com/watch?v=Fi7RXDUuX7I&list=PLQmc-I2-FO2Gnp2s74U5fBjfHDg1tUbOh
4. https://www.youtube.com/results?search_query=additive+manufacturing

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3 (WK1, WK2, WK3, WK4)	2 (WK1, WK2, WK3, WK4)	1 (WK5)	–	2 (WK6)	1 (WK7)	–	–	–	–	–	2	2
CO2	2 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	2 (WK5)	2 (WK5)	3 (WK6)	1 (WK7)	–	–	–	–	–	2	3
CO3	3 (WK1, WK2, WK3, WK4)	2 (WK1, WK2, WK3, WK4)	3 (WK5)	2 (WK5)	2 (WK6)	–	–	–	–	–	–	2	2
CO4	2 (WK1, WK2, WK3, WK4)	3 (WK1, WK2, WK3, WK4)	3 (WK5)	2 (WK5)	3 (WK6)	2 (WK5, WK7)	–	–	–	–	–	3	2

Course Code		**:**	**22UME643N**	**Mechatronics**	**Semester**	**:**	**06**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**OEC - II**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW+SL)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Develop and integrate sensor-based measurement, signal conditioning, data acquisition, and embedded systems using microcontrollers for industrial instrumentation and automation applications.

Course Outcomes:

After completion of the course, student will be able to:

CO1: Calculate performance parameters of sensors using static and dynamic characteristics and identify components and control types in mechatronic systems.

CO2: Design the performance characteristics of sensors for measuring displacement, position, proximity, force, fluid pressure, temperature and light using simulation based sensor and instrumentation virtual Labs.

CO3: Analyze signal conditioning circuits and signal conversion techniques using operational amplifiers, filters, protection devices, comparators, encoders, Flash Analog-to-Digital Converter (ADC) and Binary Weighted Resistor Digital-to-Analog Converter (DAC) for industrial instrumentation and control applications.

CO4: Develop assembly language programs using addressing modes and data transfer instructions of the microcontroller for simple embedded applications.

UNIT–I	**11 Hrs.**

Introduction to Mechatronics: System, Measurement system and Control system. Open loop and closed loop control systems. Sequential controllers, microprocessor based controllers. Examples of mechatronics system viz., washing machine system, antilock braking system, digital camera and autofocus, MEMS and automobile airbag control system. Basic understanding of ethics in mechatronics products.

Characteristics of Sensors and Transducers: Classification of transducers, Difference between transducer and sensor. Performance characteristics of sensors, including static characteristics (range and span, error, accuracy, sensitivity, non-linearity error, hysteresis error, repeatability/reproducibility, stability, dead band /time, drift and zero drift, resolution, and output impedance) and dynamic characteristics (response time, time constant, rise time and settling time). Numerical problems on static and dynamic characteristics of sensors.

UNIT–II	**11 Hrs.**

Principles and Applications of Industrial Sensors: Measurement of displacement, position, and proximity using sensors viz. potentiometer sensor, strain gauge sensor, capacitive sensor, differential transformer (LVDT and RVDT), inductive proximity switch, optical encoder, pneumatic sensor, proximity switch, and Hall effect sensor; working principles, characteristics, applications, and numerical problems. Force measurement using strain gauge load cells. Fluid pressure measurement using diaphragm, capsule, bellows, LVDT with bellows, and piezoelectric sensors, including numerical problems. Temperature measurement using bimetallic strips, RTDs, thermistors, and thermocouples, including numerical problems. Light measurement using photo resistors and photo diodes.

UNIT-III	**10 Hrs.**

Signal Conditioning: Signal conditioning processes, Operational amplifier and inverting operational amplifier. Filtering with low pass, high pass and band pass and band reject filters. Pulse width modulation and its uses. Protection devices viz. zener diode, opt isolators and Wheatstone bridge, along with numerical problems. Importance of signal conversion, Components: Comparators and Encoders, Analog to Digital Conversion using Flash ADC , Digital to Analog Converters ion using Binary Weighted Resistor DAC.

UNIT-IV	**10 Hrs.**

Microprocessor and Microcontrollers: Introduction to microprocessors and microcontrollers; comparison between microprocessors and microcontrollers. Microprocessor architecture: CPU, buses (address, data, and control), Arithmetic Logic Unit (ALU), Control Unit, registers (Accumulator, General-Purpose Registers, Program Counter, Stack Pointer, Memory Address Register, Instruction Register, and Status/Flag Register), memory organization, machine cycles (fetch and write cycles), states, and bus interrupts. Architecture of the Intel 8085A microprocessor. Assembly language programming: addressing modes, data transfer instructions and simple assembly language programs.

Text Books:

1. A. K. Sawhney and Puneet Sawhney, "A Course in Electrical and Electronic Measurements and Instrumentation", Dhanpat Rai and Co., 20th Revised Edition, 2023.
2. R. K. Rajput, "A Textbook of Mechatronics", S. Chand Publishing, 3rd Edition, 2021.
3. William Bolton, "Mechatronics–Electronic Control Systems in Mechanical and Electrical Engineering", Pearson Education Limited, 6th Edition, 2015.
4. Ramesh S. Gaonkar, "Microprocessor Architecture, Programming and Applications with the 8085", McGraw Hill, 6th Edition**,** 2013**.**

Reference Books:

1. Biswanath Samanta, "Introduction to Mechatronics: An Integrated Approach", Springer Nature, 1st Edition, 2023.
2. Nitaigour Premchand Mahalik, "Mechatronics: Principles, Concepts and Applications", McGraw Hill Education Pvt. Ltd., 1st Edition, 2011.
3. HMT Ltd., "Mechatronics", Tata McGraw-Hill Publishing Company Limited, 1st Edition, 1998.

Web Links and Video Lectures (e-Resources):

9. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=17&lessonId=18
10. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=17&lessonId=19
11. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=24&lessonId=25
12. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=24&lessonId=26
13. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=24&lessonId=27
14. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=31&lessonId=33
15. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=47&lessonId=48
16. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=47&lessonId=49
17. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=47&lessonId=50
18. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=47&lessonId=52
19. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=56&lessonId=57
20. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=56&lessonId=58
21. https://onlinecourses.nptel.ac.in/e-learning/course/noc23_me105?unitId=56&lessonId=59

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

Course Outcomes (COs)	Program Outcomes and (WKs)											Program Specific Outcomes (PSOs)	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3 (WK1, WK2, WK3, and WK4)	2 (WK1, WK2, WK3, and WK4)	-	-	-	-	1 (WK9)	1	-	-	-		
CO2	-	2 (WK1, WK2,WK3, and WK4)	2 (WK5)	-	3 (WK6)	-	-	1	1	-	1 (WK8)		
CO3	-	2 (WK1, WK2,WK3, and WK4)	3 (WK5)	-	-	-	-	1	1	-	1 (WK8)		
CO4	-	2 (WK1, WK2,WK3, and WK4)	2 (WK5)	-	-	-	-	1	1	-	1 (WK8)		

Course Code		**:**	**BMEA644N**	**Engineering Economics**	**Semester**	**:**	**06**
L:T:P		**:**	**3:0:0**		**Course Type**	**:**	**OEC - II**
Hours/Sem.	**Teaching**	**:**	**42 Hrs**		**CIE Marks**	**:**	**50**
	Learning (TW)	**:**	**42 Hrs**		**SEE Marks**	**:**	**50**
	Exam	**:**	**06 Hrs**		**Total Marks**	**:**	**100**
	Total Hrs.	**:**	**90 Hrs**		**Credits**	**:**	**03**

Professional Competency:

Apply engineering economics principles, costing methods, and financial analysis techniques to evaluate engineering alternatives, estimate project costs, and make informed economic decisions for engineering projects.

Course Outcomes:

CO1: Evaluate financial feasibility of alternatives by applying engineering economics principles and worth comparison methods.

CO2: Evaluate alternatives using equivalent annual worth and rate of return methods for informed economic decision-making.

CO3: Estimate depreciation and product costs using standard methods for economic evaluation.

CO4: Analyze breakeven, payback, and financial statements for assessing project viability and performance.

UNIT–I	**10 Hrs**

Introduction: Engineering and Economics, Definition, Engineering, Problem solving and Decision making, Law of demand and supply, Interest and Interest factors: Interest rate, Simple interest, Compound interest, Cash - flow diagrams, Exercises and Discussion.

Present Worth Comparisons: Conditions for present worth comparisons, Basic Present worth comparisons, Present worth equivalence, Net Present worth, Assets with unequal lives, infinite lives, Future worth comparison, Exercises and Discussion.

UNIT–II	**11 Hrs**

Electrical Discharge Machining (EDM): Introduction, mechanism of metal removal, EDM equipment: spark erosion generator (relaxation type), dielectric medium-its functions & desirable properties, electrode feed control system. Flushing types; pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current & spark gap, surface finish, Heat Affected Zone. Advantages, limitations & applications of EDM, Electrical discharge grinding, Traveling wire EDM.

Electron Beam Machining (EBM): Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations.

UNIT-III	**10 Hrs**

Plasma Arc Machining (PAM): Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions. Safety precautions, applications, advantages and limitations.

Laser Beam Machining (LBM): Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations.

UNIT-IV	**10 Hrs**

Electrochemical machining (ECM): Introduction, Principle of electro chemical machining, ECM equipment, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish. Process parameters: Current density, Tool feed rate, Gap

between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. ECM Tooling: ECM tooling technique & example, Tool & insulation materials. Applications ECM: Electrochemical grinding and electrochemical honing process. Advantages, disadvantages and application of ECG, ECH.

Chemical Machining (CHM): Elements of the process, Resists (maskants), Etchants. Types of chemical machining Process -chemical blanking process, chemical milling process. Process characteristics of CHM: material removal rate, accuracy,surface finish, advantages, limitations and applications of chemical machining process.

Text Books:

1. P.C Pandey & H.S. Shan – 2017, Modern Machining Processes, Tata McGraw Hill.
2. HMT– 2013 reprint, Production technology, Tata Mc Graw Hill.

Reference Books:

1. Hassan Abdel – 2005, Advanced Machining Processes, Mc Graw Hill, Mechanical Engineering Series.
2. ASME – Metals hand book, ASM Handbook series, Vol-3.
3. F.M Wilson – High velocity forming of metals, ASTME Prentice Hall.
4. B. L. Juneja - "Workshop/Manufacturing Practices" Cengage Learning India Pvt. Ltd. 2019 Edition.

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112105127
2. https://www.ajiet.edu.in
3. https://www.slideshare.net
4. https://link.springer.com
5. https://www.scribd.com
   https://www.ijert.org

Table: Matrix to describe the mapping of COs with POs (considering WKs) and PSOs

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	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	2 (WK1, WK2, WK3, and WK4)							1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	
CO2	2 (WK1, WK2, WK3, and WK4)	1 (WK1, WK2, WK3, and WK4)						1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	
CO3	2 (WK1, WK2, WK3, and WK4)							1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	
CO4	2 (WK1, WK2, WK 3, and WK4)	1 (WK1, WK2, WK3, and WK4)						1 (WK1, WK2, WK3, and WK4)			1 (WK8)	1	