Pimpri Chinchwad Education Trust's

PIMPRI CHINCHWAD COLLEGE OF ENGINEERING

SECTOR NO. 26, PRADHIKARAN, NIGDI, PUNE 411044

(An Autonomous Institute Approved by AICTE and Affiliated to SPPU, Pune)

Curriculum Structure and Syllabus

of

Third Year B. Tech. Mechanical Engineering

(Regulation 2023)

Effective from Academic Year 2025-26

Institute Vision

To be one of the top 100 Engineering Institutes of India in coming five years by offering exemplarily Ethical, Sustainable and Value Added Quality Education through a matching ecosystem for building successful careers.

Institute Mission

1. Serving the needs of the society at large through establishment of a state-of-art Engineering Institute.
2. Imparting right Attitude, Skills, and Knowledge for self-sustenance through Quality Education.
3. Creating globally competent and Sensible engineers, researchers and entrepreneurs with an ability to think and act independently in demanding situations.

EOMS Policy

"We at PCCOE are committed to offer exemplarily Ethical, Sustainable and Value Added Quality Education to satisfy the applicable requirements, needs and expectations of the Students and Stakeholders.

We shall strive for technical development of students by creating globally competent and sensible engineers, researchers and entrepreneurs through Quality Education.

We are committed for Institute's social responsibilities and managing Intellectual property.

We shall achieve this by establishing and strengthening state-of-the-art Engineering Institute through continual improvement in effective implementation of Educational Organizations Management Systems (EOMS)."

Course Approval Summary

Board of Studies - Department of Mechanical Engineering

Sr. No.	Name of the Course	Course Code	Page number	Signature and stamp of BoS chairman
1.	Heat Transfer	BME25PC10	15	
2.	Heat Transfer Lab	BME25PC11	17	
3.	Machine Design	BME25PC12	19	
4.	Machine Design Lab	BME25PC13	21	
5.	Mechatronics	BME25PC14	23	
6.	Mechatronics Lab	BME25PC15	25	
7.	Applied Thermal Engineering	BME25PE01	27	
8.	Machining Processes	BME25PE02	31	
9.	Industrial Hydraulics and Pneumatics	BME25PE03	35	
10.	Mechanical Power Transmission	BME25PE04	39	
11.	Applied Thermal Engineering Lab	BME25PE05	29	
12.	Machining Processes Lab	BME25PE06	33	
13.	Industrial Hydraulics and Pneumatics Lab	BME25PE07	37	
14.	Mechanical Power Transmission Lab	BME25PE08	41	
15.	Numerical Methods and Optimization	BME26PC16	58	
16.	Numerical Methods and Optimization Lab	BME26PC17	60	
17.	Metrology and Quality Control	BME26PC18	62	
18.	Metrology and Quality Control Lab	BME26PC19	64	
19.	Mechanical System Design	BME26PE09	66	
20.	Control Systems	BME26PE10	70	
21.	Advanced Materials and Characterization	BME26PE11	74	
22.	Internal Combustion Engines	BME26PE12	78	
23.	Fundamentals of Forming and Welding	BME26PE13	82	
24.	Mechanical System Design Lab	BME26PE14	68	
25.	Control Systems Lab	BME26PE15	72	

Board of Studies - Department of Civil Engineering

Board of Studies - Department of Computer Engineering

Sr. No.	Name of the Course	Course Code	Page number	Signature and stamp of BoS chairman
1.	Digital Marketing	BCE25OE01	51	

Board of Studies - Department of Computer Science Engineering (AIML)

Sr. No.	Name of the Course	Course Code	Page number	Signature and stamp of BoS chairman
1.	Business Intelligence	BCS25OE03	43	

Board of Studies - Department of Information Technology

Sr. No.	Name of the Course	Course Code	Page number	Signature and stamp of BoS chairman
1.	Cloud Computing	BIT25OE01	53	

Board of Studies - Department of Electronics and Telecommunication

Sr. No.	Name of the Course	Course Code	Page number	Signature and stamp of BoS chairman
1.	Introduction to Advanced Driver Assistance System	BET25OE01	49	
2.	Engineering Psychology	BET25OE02	55	

Approved by Academic Council:

Chairman, Academic Council
Pimpri Chinchwad College of Engineering

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CURRICULUM FRAMEWORK

(2023 Course)

LIST OF ABBREVIATIONS

Sr. No.	Abbreviation	Type of Course
1	BSC	Basic Science Course
2	ESC	Engineering Science Course
3	PCC	Programme Core Course
4	PEC	Programme Elective Course
5	MDM	Multidisciplinary Minor
6	OEC	Open Elective Course
7	VSEC	Vocational and Skill Enhancement Course
8	AEC	Ability Enhancement Course
9	EEM	Entrepreneurship/Economics/Management Course
10	IKS	Indian Knowledge System
11	VEC	Value Education Course
12	ELC	Experiential Learning Courses
13	LLC	Liberal Learning Courses

COURSE WISE CREDIT DISTRIBUTION

Sr. No.	Type of Course	No. of Courses	Total Credits	
			NO.	%
1	Basic Science Course	**8**	**14**	**8.75**
2	Engineering Science Course	**6**	**14**	**8.75**
3	Programme Core Course	**23**	**45**	**28.13**
4	Programme Elective Course	**9**	**19**	**11.88**
5	Multidisciplinary Minor	**6**	**14**	**8.75**
6	Open Elective	**3**	**6**	**3.75**
7	Vocational and Skill Enhancement Course	**8**	**8**	**5**
8	Ability Enhancement Course	**2**	**4**	**2.5**
9	Entrepreneurship/Economics/Management Course	**2**	**4**	**2.5**
10	Indian Knowledge System	**1**	**2**	**1.25**
11	Value Education Course	**2**	**4**	**2.5**
12	Experiential Learning Courses	**4**	**22**	**13.75**
13	Liberal Learning Courses	**2**	**4**	**2.5**
	Total	**76**	**160**	**100**

SEMESTER-WISE COURSE DISTRIBUTION

Course Distribution: Semester Wise										
Sr. No.	Type of Course	No. of Courses / Semester								Total
		1	2	3	4	5	6	7	8	
1.	Basic Science Course	4	4							8
2.	Engineering Science Course	2	4							6
3.	Programme Core Course	1		4	4	6	4	4		23
4.	Programme Elective Course					2	4	2	1	9
5.	Multidisciplinary Minor			1	1	2	1	1		6
6.	Open Elective			2	1					3
7.	Vocational and Skill Enhancement Course	2	2		2		2			8
8.	Ability Enhancement Course	1			1					2
9.	Entrepreneurship/Economics/Management Course			1	1					2
10.	Indian Knowledge System		1							1
11.	Value Education Course			1	1					2
12.	Experiential Learning Courses			1				1	2	4
13.	Liberal Learning Courses	1	1							2
Total		11	12	10	11	10	11	8	3	76

SEMESTER-WISE CREDIT DISTRIBUTION

Credit Distribution: Semester Wise										
Sr. No.	Type of Course	No. of Credits / Semester								Total
		1	2	3	4	5	6	7	8	
1.	Basic Science Course	7	7							14
2.	Engineering Science Course	5	7							12
3.	Programme Core Course	2		8	8	11	8	8		45
4.	Programme Elective Course					4	8	4	3	19
5.	Multidisciplinary Minor			2	2	4	2	4		14
6.	Open Elective			4	2	2				8
7.	Vocational and Skill Enhancement Course	1	2		2		2			7
8.	Ability Enhancement Course	3			2					5
9.	Entrepreneurship/Economics/Management Course			2	2					4
10.	Indian Knowledge System		2							2
11.	Value Education Course			2	2					4
12.	Experiential Learning Courses			2				4	16	22
13.	Liberal Learning Courses	2	2							4
Total		20	20	20	20	21	20	20	19	160

Curriculum Structure

Third Year B. Tech.

Mechanical Engineering

Semester V

CURRICULUM STRUCTURE THIRD YEAR B. TECH. (MECHANICAL ENGINEERING) Semester – V

Third Year B. Tech Mechanical Engineering (Academic Regulations 2023)																	
(With effect from Academic Year 2025-26)																	
Semester V																	
Course Type	Course Code	Course Name	Credit Scheme				Teaching Scheme (Hrs./Week)					Evaluation Scheme and Marks					
			L	P	T	Total	L	P	T	O	Total	FA		SA	TW	PR	OR	Total
												FA1	FA2					
PCC	BME25PC10	Heat Transfer	2	-	1	3	2	-	1	1	4	20	20	60	-	-	-	100
PCC	BME25PC11	Heat Transfer Lab	-	1	-	1	-	2	-	-	2				25	25	-	50
PCC	BME25PC12	Machine Design	2	-	1	3	2	-	1	1	4	20	20	60		-	-	100
PCC	BME25PC13	Machine Design Lab	-	1	-	1	-	2	-	-	2	-	-	-	25	-	25	50
PCC	BME25PC14	Mechatronics	2	-	-	2	2	-	-	1	3	10	10	30	-	-	-	50
PCC	BME25PC15	Mechatronics Lab	-	1	-	1	-	2	-	-	2	-	-	-	-	-	50	50
PEC	BME25PE01	Program Elective 1	3	-	-	3	3	-	-	1	4	20	20	60	-	-	-	100
PEC	BME25PE02	Program Elective 1 Lab	-	1	-	1	-	2	-	-	2	-	-	-	50	-	-	50
MDM		Multi-Disciplinary Minor 3 #	3	-	-	3	3	-	-	-	3	20	20	60	-	-	-	100
MDM		Multi-Disciplinary Minor 4 Lab #	-	1	-	1	-	2	-	-	2	-	-	-	50	-	-	50
OEC		Open Elective 4	2	-	-	2	2	-	-	-	2	10	10	30	-	-	-	50
Total			**14**	**05**	**02**	**21**	**14**	**10**	**02**	**04**	**30**	**100**	**100**	**300**	**150**	**25**	**75**	**750**

Refer separate booklet for multidisciplinary minor (MDM) courses

L- Lecture, **P**- Practical, **T**- Tutorial, **O**- Other i.e. self-directed learning, (self- study), FA-Formative Assessment, **SA**-Summative Assessment, **TW**-Term Work, **OR**-Oral, **PR**-Practical

Note:
Students must ensure that the same course (Contents) is not selected under multiple categories (Core Courses, Professional Electives, Open Electives, or Multidisciplinary Minors (MDMS), or any other Course where choices are given. Each course can only be credited once towards the degree requirements. Students are required to acknowledge and agree to this condition before proceeding with registration.

List of courses – Programme Elective Course – I

Course Code	Course Name	Remark
BME25PE01	Applied Thermal Engineering	Choose any one
BME25PE02	Machining Processes	
BME25PE03	Industrial Hydraulics and Pneumatics	
BME25PE04	Mechanical Power Transmission	
BME25PE05	Applied Thermal Engineering Lab	Choose respective Lab for the selected theory course
BME25PE06	Machining Processes Lab	
BME25PE07	Industrial Hydraulics and Pneumatics Lab	
BME25PE08	Mechanical Power Transmission Lab	

OPEN ELECTIVE 4 COURSES OFFERED TO MECHANICAL

Course Code	Course Name	Offered by	Remark
BET25OE01	Introduction to Advanced Driver Assistance System	E&TC	Choose any one
BET25OE02	Engineering Psychology	E&TC	
BCE25OE01	Data Security Resiliency and Governance	Computer Engg.	
BCE25OE01	Digital Marketing	Computer Engg.	
BIT25OE02	Cloud Computing	IT	
BCS25OE03	Business Intelligence	CSE(AI&ML)	
BME25OE06	Professional Ethics and Sustainability in the Age of AI	Mechanical Engg.	
BCI125OE04	Remote Sensing and GIS	Civil Engg.	

CURRICULUM STRUCTURE THIRD YEAR B. TECH. (MECHANICAL ENGINEERING) Semester – VI

Third Year B. Tech Mechanical Engineering (Academic Regulations 2023)																		
(With effect from Academic Year 2025-26)																		
Semester VI																		
Course Type	Course Code	Course Name	Credit Scheme				Teaching Scheme (Hrs./Week)					Evaluation Scheme and Marks						
			L	P	T	Total	L	P	T	O	Total	FA		SA	TW	PR	OR	Total
												FA1	FA2					
PCC	BME26PC16	Numerical Methods and Optimization	2	-	-	2	2	-	-	1	3	10	10	30	-	-	-	50
PCC	BME26PC17	Numerical Methods and Optimization Lab	-	2	-	2	-	4	-	-	4	-	-	-	50	50	-	100
PCC	BME26PC18	Metrology and Quality Control	2	-	-	2	2	-	-	1	3	10	10	30	-	-	-	50
PCC	BME26PC19	Metrology and Quality Control Lab	-	2	-	2	-	4	-	-	4	-	-	-	50	-	50	100
PEC	BME26PE03	Program Elective 2	3	-	-	3	3	-	-	1	4	20	20	60	-	-	-	100
PEC	BME26PE04	Program Elective 2 Lab	-	1	-	1	-	2	-	-	2	-	-	-	50	-	-	50
PEC	BME26PE05	Program Elective 3	3	-	-	3	3	-	-	1	4	20	20	60	-	-	-	100
PEC	BME26PE06	Program Elective 3 Lab	-	1	-	1	-	2	-	-	2	-	-	-	50	-	-	50
MDM		Multi-Disciplinary Minor 5#	2	-	-	2	2	-	-	-	2	10	10	30	-	-	-	50
VSEC	BME26VS05	Workshop Practice 3	-	1	-	1	-	2	-	-	2	-	-	-	50	-	-	50
VSEC	BME26VS06	CAE Lab	-	1	-	1	-	2	-	-	2	-	-	-	50	-	-	50
		Total	**12**	**08**	**00**	**20**	**12**	**16**	**00**	**04**	**32**	**70**	**70**	**210**	**300**	**50**	**50**	**750**

Refer separate booklet for multidisciplinary minor (MDM) courses

L-Lecture, **P**-Practical, **T**-Tutorial, **O**- Other i.e. self-directed learning, (self- study), FA-Formative Assessment, **SA**-Summative Assessment, **TW**-Term Work, **OR**-Oral, **PR**-Practical

Note: Refer separate document Exit Policy (If required)

PROGRAMME ELECTIVE 2 COURSES

Course Code	Course Name	Remark
BME26PE09	Mechanical System Design	Choose any one
BME26PE10	Control Systems	
BME26PE11	Advanced Materials and Characterization	
BME26PE12	Internal Combustion Engines	
BME26PE13	Fundamentals of Forming and Welding	
BME26PE14	Mechanical System Design Lab	Choose respective Lab for the selected theory course
BME26PE15	Control Systems Lab	
BME26PE16	Advanced Materials and Characterization Lab	
BME26PE17	Internal Combustion Engines Lab	
BME26PE18	Fundamentals of Forming and Welding Lab	

PROGRAMME ELECTIVE 3 COURSES

Course Code	Course Name	Remark
BME26PE19	Computational Fluid Dynamics	Choose any one
BME26PE20	Finite Element Analysis	
BME26PE21	Turbo Machinery	
BME26PE22	Industrial Engineering	
BME26PE23	Robot Kinematics & Programming	
BME26PE24	Computational Fluid Dynamics Lab	Choose respective Lab for the selected theory course
BME26PE25	Finite Element Analysis Lab	
BME26PE26	Turbo Machinery Lab	
BME26PE27	Industrial Engineering Lab	
BME26PE28	Robot Kinematics & Programming Lab	

Curriculum

Semester V
Third Year B. Tech.
Mechanical Engineering

Program:	B. Tech. (Mechanical Engineering)						Semester :V	
Course:	Heat Transfer						Code : BME25PC10	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
3	2	-	1	1	20	20	60	100

Prior knowledge of Fundamental concepts of Engineering Thermodynamics, Fluid Mechanics, and Mathematics is essential

Course Objectives:

This course aims at enabling the students to

1. To understand the application of the heat conduction equation to various geometries with and without heat generation
2. To get conversant with transient analysis of lumped systems.
3. To gain the knowledge of the methods used to determine heat transfer coefficients in natural and forced convection scenarios.
4. To estimate radiative heat transfer between surfaces of simple geometries using basic radiation equations and configurations.
5. To get conversant with methods of design and performance analysis of heat exchangers.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Apply One-Dimensional Heat Conduction equation to simple geometries with appropriate boundary conditions
CO2	Analyze complex Heat Transfer systems by applying heat conduction principles
CO3	Solve transient heat conduction problems in engineering systems.
CO4	Evaluate convective heat transfer coefficients in different flow scenarios using appropriate empirical correlations.
CO5	Calculate radiative heat exchange between surfaces by applying principles of radiation heat transfer
CO6	Analyze Heat Exchanger Performance for various flow configurations

Detailed Syllabus

Unit No.	Description Note: One tutorial on each unit. The tutorial will consist of numerical problems based on real-life or industrial applications.	Duration (Hrs.)
1	**Fundamentals of Heat Transfer:** Modes and Laws of heat transfer, thermal conductivity, thermal diffusivity. Boundary and initial Conditions, Introduction to general heat conduction equation in Cartesian coordinates. One dimensional steady state heat conduction with and without heat generation in plane wall, solid cylinder & sphere, with different boundary conditions.	07 (CO1)
2	**Composite Structures and Extended Surfaces:** Application Electrical analogy of heat transfer to multi-layered (Composite) structures ,plane wall, hollow cylinder and hollow sphere, thermal contact resistance, critical thickness of insulation, economical and cost consideration. Heat transfer from finned surfaces, types of fins, governing equation for constant cross sectional area fin, solution for infinitely long fin, negligible heat loss from fin tip, Short fins (corrected length), Fin efficiency & effectiveness.	08 (CO2)
3	**Transient heat transfer**: Validity and criteria of lumped system analysis, Biot and Fourier number, Transient analysis using lumped system analysis, Time constant and response of thermocouple, Transient heat analysis with special effects by using Heisler and Grober charts	07 (CO3)

4	**Convection heat transfer**: Fundamentals of convection, concept of velocity & thermal boundary layers, local and average heat transfer coefficient, Estimation of heat transfer coefficient using empirical correlations based on dimensionless numbers for the following cases: 1. External Forced Convection 2. Internal Forced Convection and 3. Natural Convection. Thermal analysis of internal forced convection with Constant surface heat flux and constant surface temperature boundary conditions	**08 (CO4)**
5	**Thermal Radiation, Boiling and condensation:** Fundamentals radiation heat transfer, Different laws of radiation, Radiation shape factor and relations, Radiation heat transfer between black surfaces, Radiation heat transfer between Diffuse Gray surfaces, Radiation Shield. Boiling and condensation: Pool boiling curve, different regimes of boiling heat transfer, critical heat flux, Film and drop wise condensation	**07 (CO5)**
6	**Heat Exchanger:** Classification, applications, concept of overall heat transfer coefficient, fouling factor, Heat exchanger analysis using LMTD for parallel flow and counter flow heat exchange, LMTD correction factor for multi-pass and cross flow heat exchangers by using charts, Effectiveness– NTU method for parallel flow heat exchanger and counter flow heat exchanger, use of charts for multi-pass and cross flow heat exchangers selection of heat exchangers.	**08 (CO6)**
	Total	**45**

Text Books:

1. Y.A. Cengel and A. J. Ghajar, Heat and Mass Transfer – Fundamentals and Applications, Tata McGraw-Hill Education Private Limited, 2019
2. F.P. Incropera, D.P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley, 2000

Reference Books

1. J. P. Holman, Heat Transfer, McGraw – Hill publication, 2002.
2. P. K. Nag, Heat and Mass Transfer, McGraw Hill Education Private Limited, 2011
3. R.C. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New Age Science, 2009.
4. C.P. Kothandaraman, S.V. Subramanyam, Heat and Mass Transfer Data Book, New Academic, 2008

E-resources:

12-week NPTEL course on Heat Transfer by Prof. Sunando DasGupta IIT Kharagpur
https://onlinecourses.nptel.ac.in/noc25_ch87/preview

Program:	B. Tech. (Mechanical Engineering)						Semester :V	
Course:	Heat Transfer Lab						Code : BME25PC11	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1		2	-	-	25	25	-	50

Prior knowledge of Mathematics: Integration and derivatives, Steady flow energy equation,. Concept of boundary layer **is essential.**

Course Objectives:

This course aims at enabling the students to

1. To experimentally determine the thermal conductivity of different materials
2. To analyze the temperature distribution and fin efficiency and evaluate numerical results using the Finite Difference Method (FDM)
3. Analyze external natural and internal forced convection to evaluate the convective heat transfer coefficient.
4. To study radiation heat transfer by determining emissivity and verifying Stefan-Boltzmann law.
5. To investigate heat transfer in a heat exchanger
6. To solve transient heat transfer problems

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Estimate experimentally the key heat transfer parameters of different modes of heat transfer
CO2	Analyze the temperature variation of heat transfer systems under steady and transient conditions by experimental methods.
CO3	Use software / AI tools to analyze temperature variations in different heat transfer systems

List of Experiments

Experiment No.	Description	Duration (Hrs.)
Note: 1 to 7 compulsory, any two from 8 to 10 and any 2 from 11 to 13		
1	Determination of Thermal Conductivity of metal rod	4
2	Determination of Thermal Conductivity of insulating powder	2
3	Determination of Thermal Conductivity of Composite wall	2
4	Determination of Thermal Conductivity of liquid	2
5	Analysis of heat transfer and temperature distribution in Natural Convection	2
6	Analysis of heat transfer and temperature distribution in Forced Convection	2
7	Determination of temperature distribution, fin efficiency in Natural / Forced Convection	4
8	Determination of Emissivity of a Test surface	2
9	Determination of Stefan Boltzmann Constant	2
10	Performance of shell and tube type heat exchanger	2
11	Software / AI-based prediction of temperature distribution in heat transfer applications	4
12	Analysis of temperature distribution in fins using numerical methods / software tools	4

13	Assignment to solve transient heat transfer problem using Heisler and Grober charts	4
	Total	**30**

Text Books:

1 Y.A. Cengel and A. J. Ghajar, Heat and Mass Transfer – Fundamentals and Applications, Tata McGraw Hill Education Private Limited, 2019
2 F.P. Incropera, D.P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley, 2000
3 Heat transfer data tables

Reference Books

1 J. P. Holman, Heat Transfer, McGraw – Hill publication, 2002.
2 P. K. Nag, Heat and Mass Transfer, McGraw Hill Education Private Limited, 2011
3 R.C. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New Age Science, 2009.
4 C.P. Kothandaraman, S.V. Subramanyam, Heat and Mass Transfer Data Book, New Academic, 2008
5 Bourg, D. M.. Artificial Intelligence and Machine Learning for Engineers. O'Reilly Media., 2021

Program:	B. Tech. (Mechanical Engineering)							Semester :V
Course:	Machine Design							Code : BME25PC12
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
3	2	-	1	1	20	20	60	100

Prior knowledge of: Engineering Mechanics, Strength of Materials, Engineering Materials, Theory of Machines, and Manufacturing Technology is essential.

Course Objectives:

This course aims at enabling the students to

1. Learn the fundamental principles of various steps involved in the design process using standard design practices.
2. Acquire knowledge of standards, codes and design practices for selecting appropriate materials
3. Instill design principles to assess machine elements parameters, ensuring functional performance and strength requirements.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Apply** fundamental principles to design machine elements under static loading.
CO2	**Analyze** the machine components subjected to cyclic loads
CO3	**Design** the shafts, keys, and couplings for real-life applications
CO4	**Design** spur gears for the specific applications
CO5	**Design** bolted and welded joints for various loads
CO6	**Design** mechanical springs based on strength and rigidity

Detailed Syllabus

Unit No.	Description	Duration (Hrs.)
1	**Design of machine elements against static loading**- Design, types of design, design cycle, design considerations, Design for manufacture, design for assembly, preferred number and series, use of standards and code in design, Material selection methods, Design of Knuckle joint, design of axially and eccentrically loaded parts.	07 (CO1)
2	**Design of Machine elements against varying loads-** S N Diagram, Endurance limit, endurance strength, and design of components for infinite and finite life under cyclic loading, Design of parts for infinite and finite life under fluctuating stresses based on Soderberg, Goodman diagrams and Gerber parabola.	08 (CO2)
3	**Design of Shafts, keys, and couplings** Design of shafts based on strength and rigidity. Design of Keys, Splines, and Flange Couplings.	08 (CO3)
4	**Design of Spur Gears** Design of spur gears- Selection of appropriate gear drive for given application, Fundamental geometric relations, Gear tooth failures, Design based on reversed bending stress fluctuating contact stresses, Gear lubrication.	08 (CO4)
5	**Design of bolted and welded mechanical joints** Design of bolted and welded joints against axial and eccentric loads	07 (CO5)
6	**Design of Mechanical Springs** Design of helical springs, compound springs, and multi-leaf springs. Surge in springs.	07 (CO6)
Note: Tutorial on each unit to solve a variety of numerical based on real-life applications		
	Total	45

Text Books:

1 V. B. Bhandari, Design of Machine Elements, 2020, 5th Edition, Tata McGraw Hill.
2 J K Gupta, R S Khurmi, A text Book of Machine Design, S Chand Publication, 2005.
3 Kamlesh Purohit, K. C. Sharma, Design of Machine Elements - Prentice Hall India Publication, 2002.
4 N. C. Pandya, C. N. Shah, Machine Design, Charotar Publishing, 2006.
5 P C Gope, Machine Design Fundamentals and Applications, PHI, EEE, 2012.

Reference Books

1 Robert L Norton, Machine Design: An Integrated Approach, Pearson Education, 2000
2 George E. Dieter, George Ellwood Dieter, Linda C. Schmidt, Engineering Design, McGraw-Hill Education, 2008
3 Richard Gordon Budynas, J. Keith Nisbett, Shigley's Mechanical Engineering Design, McGraw Hill, 2015
4 Paul H. Black, O. Eugene Adams, Paul H. Black, O. Eugene Adams, Machine Design by, McGraw Hill, 1981
5 V B Bhandari, Machine Design Data Book, , TMH Publication, 2019.
6 Merhyle Franklin Spotts, Terry E. Shoup, Lee Emrey Hornberger, Design of Machine Elements Vol 1 and 2, 2004
7 PSG Design Data: Data Book of Engineers, 2020, Kalaikathir Achchagam.

e-Recourses:

1 Design of Machine Elements, IIT Kharagpur: nptel.ac.in/courses/112105124

Program:	B. Tech. (Mechanical Engineering)						Semester :V	
Course:	Machine Design Lab						Code : BME25PC13	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1	-	2	-	-	25	--	25	50

Prior knowledge of: Engineering Mechanics, CAMD and GD&T, Strength of Materials, Engineering Materials, Theory of Machines, and Manufacturing Technology is essential

Course Objectives:

This course aims at enabling the students to

1. Conduct Problem analysis, define the real-life problem, and provide the solution
2. Present the design decisions graphically using modern tools for modelling and drafting.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course Outcome Statement	Experiment mapping
CO1	Design the mechanical components based on aspects of strength, rigidity, wear, manufacture, assembly, and weight.	1,2
CO2	Apply design principles to generate detailed production drawings.	1

List of Experiments

Experiment No.	Description	Duration (H)
1	**Design Project based on a real-life application** i. Design of Knuckle joint or Flange Couplings (Limited to design report) ii. Design of Screw Jack / Shaft design for Multi stage/ multi speed gearbox/ Agitator or mixer shaft in chemical plants/ Machine tool spindles.	20
2	**Assignment** one is compulsory, and any one of the remaining assignments. I. **Selection of Bearing from the manufacturer's catalogue** II. Select an industrial application where bolted or welded joints are commonly used. Perform a comparative analysis of bolted vs. welded joints for the selected application, considering factors like strength, ease of manufacturing, maintenance, and cost. III. Case study on the design of spur gears for a real-life industrial application. IV. Case study on spring design for any real-life condition where the spring shall sustain higher load and rigidity.	10
	Total	30

Note:

i.	**Material selection for the selected design project should be done using AI tool**
ii.	Design data book shall be used wherever necessary to achieve a selection of standard components leading to a minimum cost of the product being developed.
iii.	Submit a detailed design report including problem selection, analysis, definition, and a solution based on all relevant design considerations. Provide a summary with final part dimensions, a leaflet with product specifications, cost details, and user instructions.
iv.	Submit a 2D part drawing with two views, including one sectional view to reveal internal features. Ensure

	the representation of geometric and dimensional tolerances, surface roughness symbols, and additional instructions like surface coating and heat treatments.
v.	Create a 2D assembly drawing with two views, including one sectional view to show internal features. Include overall dimensions, centre distances, and alignment dimensions for proper assembly. Indicate fit locations, and provide a Bill of Materials (BOM)

Reference Books:

1. Robert L Norton, Machine Design: An Integrated Approach, Pearson Education, 2000
2. V B Bhandari, Machine Design Data Book, TMH Publication, 2019.
3. PSG Design Data: Data Book of Engineers, 2020,
4. S. K. Basu, D. K. Pal, Design of Machine Tools, 5th ed. New Delhi, India: Oxford & IBH Publishing Co. Pvt. Ltd., 2008. ISBN: 978-81-204-1721-2
5. CMTI Handbook of Machine Tool Design, KOJO Press, January 2024, ISBN: 178-81-19525-34-8

Program:	B. Tech. (Mechanical Engineering)						Semester :V	
Course:	Mechatronics						Code : BME25PC14	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
2	2	-	-	1	10	10	30	50

Prior knowledge of: Fundamentals of Electromechanical Systems is essential

Course Objectives:

This course aims at enabling the students to

1. Comprehend the fundamentals of Mechatronics and select appropriate sensors and transducers.
2. Explore the data acquisition system and its various components.
3. Examine different control systems, as well as the modeling and analysis of mechanical systems.
4. Evaluate system modelling, controller modes, and their industrial applications.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Select** the sensors/transducers to measure the physical parameter.
CO2	**Apply** the concept of DAQ to interface a sensor to acquire the data
CO3	**Determine** the transfer function and predict the stability of a mechanical system.
CO4	**Analyze** the PID controller for a mechanical system.

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Introduction to Mechatronics & Sensors / Transducers:** Introduction to Mechatronics and its Applications, Sensors Characteristics (Static/Dynamic), Classification of sensors/ transducers, strain gauges, Load cells, Flow sensors, Level Sensors, LiDAR.	08 (CO1)
2	**Signal Communication and Data Acquisition System :** Signal Communication, Data Acquisition System (DAQ), Aliasing, Sample and hold circuit, Quantisation, Analogue-to-digital converters (Successive Approximation type ADC), Digital-to-Analogue converters (R2R type DAC)	07 (CO2)
3	**Mathematical Modelling & Analysis:** Introduction to control systems, need, Types- Open and Closed loop, Concept of Transfer Function, Block Diagram & Reduction principles, Transfer Function-based modeling of Mechanical system, Concept of Poles & Zeros, Stability Analysis using Routh-Hurwitz Criterion	08 (CO3)
4	**PID control:** Introduction to controllers, Need for control, Proportional (P), Integral (I) and Derivative (D) control actions, PI, PD and PID control systems, Manual PID tuning	07 (CO4)
	Total	30

Text Books:

1. William Bolton, Mechatronics: Electronics Control Systems in Mechanical and Electrical Engineering, 6th Ed, 2019
2. K.P. Ramachandran, G.K. Vijyaraghavan, M.S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley Publication, 2008

Reference Books

1. Alciatore and Histand, Introduction to Mechatronics and Measurement Systems, 5th Ed, 2019
2. Robert H. Bishop, Mechatronics – An Introduction, Taylor & Francis, CRC Press, 2006
3. Nitaigour P. Mahalik, Mechatronics – Principles, Concepts and Applications, Tata McGraw-Hill publication, 2003
4. C.D. Johnson, Process Control Instrumentation Technology, Pearson, 8th Ed.,2014

e-Sources

1. **https://onlinecourses.nptel.ac.in/noc21_me27/preview** (By Prof. Pushparaj Mani Pathak, IIT Roorkee)
2. **https://onlinecourses.nptel.ac.in/noc21_me129/preview** (By Prof. Prasanna Gandhi, IIT Bombay)

Program:	B. Tech. (Mechanical Engineering)						Semester :V	
Course:	Mechatronics Lab						Code : BME25PC15	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1	-	2	-	-	-	-	50	50

Prior knowledge of: Mathematics, Fundamentals of Electromechanical Systems is essential

Course Objectives:

This course aims at enabling the students to

1. Acquaint with modern tools /software in Mechatronics engineering
2. Learn how to interface different sensors to acquire the data in Mechanical Engineering

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Develop** skills in using software tools and techniques for mechatronics applications.
CO2	**Demonstrate** knowledge of interfacing any sensor to acquire the data.
CO3	**Develop** PLC programs to simulate various mechatronics applications

List of Experiments

The manual / file will include the completion of all practical, along with self-learning experiments. An external oral examination will be conducted based on the file / manual completed throughout the semester.
From the list below, conduct Compulsory Experiments 4,5,13, Any 2 from Experiments 1 to 3, Experiment 6 OR 10, Any 2 from Experiments 7,8,9,11,12.

Experiment No.	Description	Duration (Hrs.)
1	Measurement of temperature using a suitable sensor using DAQ and LabVIEW.	04
2	Measurement of displacement using a suitable sensor using DAQ and LabVIEW.	04
3	Measurement of load/force by using a load cell and estimation of error in percentage	04
4	Modelling and analysis of a mechanical system and its verification using MATLAB software.	04
5	PID tuning and performance analysis for a mechanical system using simulation software	04
6	Develop a mechatronics application using software/hardware (Self-Study)	02
7	Ladder logic simulation using suitable software for logic gates	04
8	Automatic reciprocation of a double-acting pneumatic cylinder using PLC ladder programming	04
9	Design a Meter-In and Meter-Out Circuit for Speed Control of Pneumatic Cylinder using suitable software	04
10	Design a ladder program for the Pick and Place Robot application (Self Study)	02
11	Simulation of a SCADA System for a suitable mechatronics application	04
12	Pneumatic cylinder sequencing using PLC control system.	04
13	AI for Sensor Data Analysis	04
	Total	**30**

Text Books:

1 William Bolton, Mechatronics: Electronics Control Systems in Mechanical and Electrical Engineering, 6th Ed, 2019

2 K.P. Ramchandran, G.K. Vijyaraghavan, M.S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Willey Publication, 2008

3 S.R.Deb and S.Deb, Robotics Technology and Flexible Automation, McGraw-Hill Education, 2017.

Reference Books:

1 Alciatore and Histand, Introduction to Mechatronics and Measurement Systems, 5th Ed, Mc-Graw Hill, 2019

2 Robert H.Bishop, Mechatronics – An Introduction, CRC press, 2017.

3 Mahalik, Mechatronics – Principles, concepts and applications, Tata Mc-Graw Hill publication, New Delhi, 2003.

4 S. K.Saha, Introduction to Robotics, McGraw-Hill Education, 2017.

5 J.Craig, Introduction to Robotics: Mechanics and Control, 4th Ed, Pearson Education 2022.

6 S.B.Niku, Introduction to Robotics, Analysis,Control, Applications,2nd Ed, Wiley Publication,2020

e Resources:

1 https://onlinecourses.nptel.ac.in/noc23_de12/preview

2 https://archive.nptel.ac.in/courses/108/105/108105112/

3 https://onlinecourses.nptel.ac.in/noc21_me27/preview

4 https://onlinecourses.nptel.ac.in/noc23_me120/preview

Program:	**B. Tech. (Mechanical Engineering)**						**Semester :V**	
Course:	**Applied Thermal Engineering** (Program Elective I)						**Code : BME25PE01**	
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**FA**		**SA**	**Total**
					FA1	**FA2**		
3	**3**	**-**	**-**	**1**	**20**	**20**	**60**	**100**

Prior knowledge of Fundamental concepts of Thermodynamics, fluid mechanics is essential

Course Objectives:

This course aims at enabling the students to

1. To understand the theory and performance calculations of reciprocating air compressors
2. To understand the performance evaluation of boilers
3. To study various thermodynamic cycles with gas and steam as working medium
4. To get familiar with the characteristics of compressible fluid flow
5. To understand the analysis of flue gases and calculation of Air fuel ratio.
6. To explore contemporary research trends and advancements in applied thermodynamics.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	**Course outcome Statement**
CO1	**Analyze** the performance of the Reciprocating Air Compressor**.**
CO2	**Estimate** the performance parameters of the boiler.
CO3	**Analyze** the performance of Vapor power cycles**.**
CO4	**Analyze** the performance of Gas power cycles.
CO5	**Analyze** steady one-dimensional isentropic compressible fluid flow**.**
CO6	**Explore** contemporary research trends and advancements in thermal engineering**.**

Detailed Syllabus

Unit	**Description**	**Duration (Hrs.)**
1	**Positive Displacement Compressors:** Reciprocating Compressor - Single stage compressor – computation of work of compression, isothermal efficiency, effect of clearance volume, volumetric efficiency, Free air delivery, Theoretical and actual indicator diagram, Multistage compressor, Computation of work of compression, Volumetric efficiency, Ideal Intermediate pressure, Inter-cooling and after cooling, Rotary Compressor – Introduction, vane compressors, roots blower. Compressor performance curve interpretation for Surge, choke, and efficiency mapping	**08 (CO1)**
2	**Steam Generation:** Types of Fuels, Higher and Lower Calorific value, Determination of Air Fuel Ratio (Actual and Stoichiometric), Adiabatic Flame temperature, Dew point temperature of products of combustion. Working of Boiler, Classification, Applications, Introduction to IBR, Boiler performance calculations- Equivalent evaporation, Boiler efficiency (direct & indirect), Heat balance, Boiler draught (natural and artificial draught)	**08 (CO2)**
3	**Vapour Power Cycle:** Carnot cycle, Rankine cycle, Comparison, Efficiency of Rankine cycle, Relative efficiency, Effect of superheat, boiler and condenser pressure on the performance of Rankine cycle, Deciding maximum pressure of boiler	**07 (CO3)**
4	**Gas Power Cycles:** Air Standard cycles assumptions, Otto Cycle, Diesel cycle, Dual cycle, Comparison of cycles, Brayton cycle, Efficiency, Work output, Effect of pressure ratio, Reheat and regeneration and intercooling	**07 (CO4)**

5	**Thermodynamic Analysis of Compressible Fluid Flow:** Definition, Speed of sound and Mach No., Sonic, Subsonic and Supersonic flow, Effect of Area variation on one dimensional Steady isentropic compressible flow, Convergent - Divergent Nozzle, Effect of friction and heat transfer on steady one-dimensional compressible fluid flow, Fanno Lines, Rayleigh lines	**08 (CO5)**
6	**Advancements in thermal engineering**: Application of steam in process industries (as a heating medium), Use of Steam traps for energy conservation, Steam & condensate loop in process heating applications, Condensate recovery in process heating, Digital technology in Steam Engineering. AI application in thermal systems, contemporary/ research areas in applied thermodynamics	**07 (CO6)**
	Total	**45**

Text Books:

1. Y. Cengel & Boles: Thermodynamics – An Engineering Approach, Tata McGraw-Hill , 2019
2. P. K. Nag, Engineering Thermodynamics, Tata McGraw Hill Publications 2017
3. Mahesh M. Rathore, Thermal Engineering, Tata McGraw-Hill 2010

Reference Books

1. Michael Moran, Howard Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley 2020
2. Claus Borgnakke, Richard E. Sonntag, Fundamentals of Engineering Thermodynamics, John Wiley , 2020
3. V. Ganesan: Internal Combustion Engines, Tata McGraw-Hill, 2017
4. M.L. Mathur and R.P. Sharma, A course in Internal combustion engines, Dhanpat Rai Publication, New Delhi,2016
5. Introduction to Fluid Mechanics, Robert W. Fox, Alan T. McDonald, John W. Mitchell, John Wiley, 2019
6. Steam Tables and Mollier Chart

e-Resources:

NPTEL Twelve Week course on Applied Thermodynamics by Prof. V. Raghvan IIT Madras

Program:	B. Tech. (Mechanical Engineering)						Semester :V	
Course:	Applied Thermal Engineering Lab (Program Elective-I)						Code : BME25PE05	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1	-	2	-	-	50	-	-	50

Prior knowledge of Fundamental concepts of thermodynamic, Laws of thermodynamic, Use of steam tables and Mollier chart, Ideal Gas Equations and processes is essential

Course Objectives:

This course aims at enabling the students to

1. To understand the theory and performance calculations of reciprocating air compressors
2. To understand the performance evaluation of boilers
3. To study various thermodynamic cycles with gas and steam as working medium
4. To get familiar with the characteristics of compressible fluid flow
5. To explore contemporary research trends and advancements in applied thermodynamics.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Experimentally Analyze** the performance of the Reciprocating Air Compressor.
CO2	**Estimate** the performance of the boiler.
CO3	**Analyze** steady one-dimensional isentropic compressible fluid flow.
CO4	**Use** software tools to do parametric analysis of thermal systems and cycles
CO5	**Apply** the principles of thermal engineering to understand the working of thermal systems

List of Experiments

Experiment No.	Description	Duration (H)
Experiment number 1 ,5,13 compulsory, any two from 2 to 4, any two from 6 to 8 and any 2 from 9 to 12		
1	Trial on reciprocating Air compressor to determine • Volumetric efficiency • Isothermal Efficiency • Heat rejected in the intercooler	4
2	Determination of Calorific Value of Solid/ Gaseous Fuel	2
3	Study and demonstration of various types of boilers and their application	2
4	Demonstration of Boiler Mounting and Accessories	2
5	Trial on Boiler to determine • Efficiency with and without economizer • Equivalent Evaporation Rate • Heat Balance Sheet	4
6	Analysis of the Rankine cycle using EES or any suitable software to investigate • Effect of superheat • Boiler and condenser pressure on the performance of the Rankine cycle • Deciding the maximum pressure of the boiler	4
7	Analysis of the Brayton cycle using EES or any suitable software to investigate • Effect of pressure ratio • Reheat and regeneration	4

8	Analysis of compressible fluid flow by using EES or any suitable software • Study of mass, momentum and energy equation for generating Fanno lines • Generation of Fanno line using software tools	**4**
9	Demonstration of Jaggery plant using thermic fluid	**2**
10	Demonstration of steam generation by solar energy	**2**
11	Demonstration of solar air dryer with phase change material	**2**
12	Demonstration of Compressible fluid flow through convergent- Divergent Nozzle	**2**
13	A case study on AI applications in Thermal Systems	**4**
	Total	**30**

Text Books:

1 Y. Cengel & Boles: Thermodynamics – An Engineering Approach, Tata McGraw-Hill , 2019

2 P. K. Nag, Engineering Thermodynamics, Tata McGraw Hill Publications 2017

3 Mahesh M. Rathore, Thermal Engineering, Tata McGraw-Hill 2010

Reference Books

1 Michael Moran, Howard Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley 2020

2 Claus Borgnakke, Richard E. Sonntag, Fundamentals of Engineering Thermodynamics, John Wiley , 2020

3 V. Ganesan: Internal Combustion Engines, Tata McGraw-Hill, 2017

4 M.L. Mathur and R.P. Sharma, A course in Internal combustion engines, Dhanpat Rai Publication, New Delhi,2016

5 Introduction to Fluid Mechanics, Robert W. Fox, Alan T. McDonald, John W. Mitchell, John Wiley, 2019

6 Steam Tables and Mollier Chart

e-Resources:

NPTEL Twelve Week course on Applied Thermodynamics by Prof. V. Raghvan IIT Madras

Program:	**B. Tech. (Mechanical Engineering)**						**Semester :V**	
Course:	**Machining Processes** (Program Elective I)						**Code : BME25PE02**	
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**FA**		**SA**	**Total**
					FA1	**FA2**		
3	**3**	**-**	**-**	**1**	**20**	**20**	**60**	**100**

Prior knowledge of: Basic manufacturing processes, Basic mechanical components is essential

Course Objectives:

This course aims at enabling the students to

1. Give a broad understanding of conventional machining processes with an emphasis on the mechanics of machining.
2. Familiarize with the design of jigs, fixtures, and scientific principles governing various advanced machining processes.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Evaluate** the influence of machining parameters.
CO2	**Determine** the process parameters for Turning and Milling operations.
CO3	**Explain** the fundamentals of Drilling and Broaching operations.
CO4	**Analyze** the performance of grinding and super-finishing processes.
CO5	**Design** Jigs / fixtures for a machining and assembly of components.
CO6	**Select** the appropriate advance machining process as per the application under consideration.

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Mechanics of Machining Process** Tool geometry and tool designation, mechanism of chip formation, heat generation and cutting tool temperature, cutting forces, Merchant's analysis, tool life and machinability, tool materials, tool inserts, tool wear and failure, cutting fluids	**08 (CO1)**
2	**Turning and Milling** Lathe and Milling machine: types, construction, and cutting operations, Gear manufacturing, indexing mechanism, vibration and chatter in machining, evaluation of process parameters, machining time and material removal rate calculation.	**07 (CO2)**
3	**Drilling and Broaching** Drilling machines: types, construction and kinematics; Drills, Reaming and reamers, Tapping and taps, Boring; Design considerations for drilling, reaming, and tapping. Broaching: principle, broach tool: construction, functioning, properties, material, tool geometry, selection of broach tool and broaching machines.	**07 (CO3)**
4	**Grinding and Super finishing** Principle, interactions, relation between cutting force, cutting velocity, and critical grit depth of cut, analysis of grinding, specific energy vs. material removal rate, grinding wheel: composition, type, specification, wheel/chip loading, balancing, dressing. Finishing processes – honing, lapping and super finishing.	**08 (CO4)**
5	**Jigs and Fixtures** Design of Jigs and Fixtures: Principles and applications, elements of location and clamping. Types of jigs and fixtures. Tool guidance (bushes/setting block) and body construction. Design of jigs and fixtures for drilling, turning and milling bushes.	**07 (CO5)**

6	**Advanced Machining Processes** Principles and applications of: Abrasive Jet Machining, Water Jet Machining, Electrical Discharge Machining, Laser Beam Machining, Chemical Machining, Electrochemical Machining, Ultrasonic Machining, Electron Beam Machining. Effect of process parameters on material removal rate, surface roughness and power consumption. Micromachining.	**08 (CO6)**
	Total	**45**

Text Books:

1. P. C. Sharma, A Textbook of Production Engineering and production technology, S. Chand Publication, 2022.
2. Serope Kalpak Jian, Steven Schmid, Manufacturing Engineering & Technology, Pearson, 2022.

Reference Books

1. P. N. Rao, Manufacturing Technology, Volume I & II, McGraw Hill Education (India) Private Limited, 2018.
2. Workshop Technology by Chapman vol. 1, 2, and 3, Routledge, London, 2019.
3. Amitabha Ghosh, Ashok Kumar Mallik, Manufacturing Science, East-West Press Pvt. Ltd 2- Edition, 2010.
4. P. H. Joshi, Jigs and Fixture, Tata McGraw Hill, 2013.
5. Geoffrey Boothroyd: Fundamentals of Metal Machining and Machine Tools, 2005.
6. Groover, M.P, Fundamentals of Modern Manufacturing, John Wiley.
7. Juneja and Shekhon, Metal Cutting and Machine Tools, New Age International, 2003.
8. A. Bhattacharya: Metal Cutting,New Central Book,2015

e-Resources:

1. https://archive.nptel.ac.in/courses/112/107/112107219/
2. https://archive.nptel.ac.in/courses/112/104/112104290/

Program:	**B. Tech. (Mechanical Engineering)**						**Semester :V**	
Course:	**Machining Processes Lab** (Program Elective-1)						**Code : BME25PE06**	
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**TW**	**PR**	**OR**	**Total**
1	**-**	**2**	**-**	**-**	**50**	**-**	**-**	**50**

Prior knowledge of Trigonometry, hand tools and accessories, basic manufacturing processes, basic mechanical components is essential

Course Objectives:

This course aims at enabling the students to

1. To impart knowledge on cutting tool design, tool life evaluation, and regrinding processes along with experimental studies on conventional and advanced machining processes.
2. To enable students to design cutting tools, jigs, and fixtures for machining applications and analyze the effect of machining parameters through hands-on experiments and industrial visits

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	**Course outcome Statement**	**Experiment No.**
CO1	**Analyze and evaluate** the performance characteristics of various machine tools.	1,2,3
CO2	**Design and develop** tooling solutions for machining processes, including the design of cutting tools, fixtures (drilling, milling, and turning).	4,5
CO3	**Understand** the working principle of advanced machining processes.	6,7,8,9

List of Experiments

Experiment No.	**Description**	**Duration (Hrs.)**
Note: Experiment one is compulsory. Perform any seven out of remaining.		
1	Regrinding or re-sharpening of single point cutting tool on Pedestal Grinder or Tool and Cutter Grinder.	**2**
2	Evaluate the Tool Life and material removal rate on any Machine Tools.	**4**
3	Determine the effect of grinding parameters on surface finish.	**4**
4	Design of Cutting tools: Turning Tool/Milling Cutter/Twist Drill/Reamer/Broach and Form Tool.	**4**
5	Design and draw a drilling Jig, milling fixture and turning fixture.	**4**
6	Job preparation using Laser machining for acrylic or plywood material.	**4**
7	Study of process parameters on ECM/PCM setup.	**4**
8	Demonstration of micromachining experimental setup and understanding the process parameters.	**4**
9	Industry visit to plant having Advanced Machining Processes.	**4**
	Total	**30**

Text Books:

1 P. C. Sharma, A Textbook of Production Engineering and production technology, S. Chand Publication, 2022.

2 Serope Kalpak Jian, Steven Schmid, Manufacturing Engineering & Technology, Pearson, 2022.

Reference Books

1 P. N. Rao, Manufacturing Technology, Volume I & II, McGraw Hill Education (India) Private Limited, 2018.
2 Workshop Technology by Chapman vol. 1, 2, and 3, Routledge, London, 2019.
3 Amitabha Ghosh, Ashok Kumar Mallik, Manufacturing Science, East-West Press Pvt. Ltd 2nd Edition, 2010.
4 P. H. Joshi, Jigs and Fixture, Tata McGraw Hill, 2013.
5 Geoffrey Boothroyd: Fundamentals of Metal Machining and Machine Tools, 2005.
6 Groover, M.P, Fundamentals of Modern Manufacturing, John Wiley.
7 Juneja and Shekhon, Metal Cutting and Machine Tools, New Age International, 2003.
8 A. Bhattacharya: Metal Cutting,New Central Book,2015

e-Resources:

https://archive.nptel.ac.in/courses/112/107/112107219/

Program:	B. Tech. (Mechanical Engineering)						Semester :V	
Course:	Industrial Hydraulics and Pneumatics (Program Elective I)						Code : BME25PE03	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
3	3	-	-	1	20	20	60	100

Prior knowledge of: fluid mechanics, Physics is essential

Course Objectives:

This course aims at enabling the students to

1 To summarize governing laws & understand different components used in a fluid power system
2 To demonstrate the working principle and construction of different types of pump/accumulator/ intensifier
3 To describe the working principle and construction of the hydraulic actuator and control valves
4 To create a hydraulic circuit using different components for industrial applications
5 To develop a pneumatic circuit using different pneumatic components for industrial applications
6 To design hydraulic/pneumatic systems using manufacturer's catalogue

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Demonstrate** the basics of fluid power
CO2	**Analyse** the performance of the pump & accumulator.
CO3	**Describe** the working principle and construction of hydraulic actuators and control valves
CO4	**Build** a hydraulic circuit for different industrial applications
CO5	**Apply** knowledge of pneumatics for the design of a pneumatic system
CO6	**Design** a fluid power system using the manufacturer's catalogue

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Introduction to Fluid Power** Fluid power basics, advantages and limitations, Fluid power systems, Hydraulic fluids, Seals, Fluid Conductors, Sources of contamination and contamination control, Filters, Standard Symbols of fluid power components, ISO 1219-1: Standard symbols for fluid power circuits	08 (CO1)
2	**Sources of power- Pump & Accumulator** Pumps vane pumps, gear pumps, radial and axial plunger pumps, screw pumps, performance parameters, selection of pumps for hydraulic power transmission. Power units and accessories, pressure switches, temperature switches, Accumulators, Intensifier	07 (CO2)
3	**Hydraulic Actuators & Control Valves** Actuator, limited rotary actuator, constructional details, characteristics, Cylinder mountings, cushioning, Control valves: Necessity of fluid control, Direction control, two stage valves, Flow control valves, pressure and temperature compensated, Pressure control valves, sequence valve, unloading valve, brake valve, back pressure valve, counter balance valve, check valves, prefill valve, servo valves, cartridge valves, proportional valves.	08 (CO3)
4	**Hydraulic Circuit** Need, Structure, Simple reciprocating, regenerative, speed control, sequencing, synchronization, traverse and feed, automatic reciprocating, fail safe circuit, counter balance circuit, actuator locking, unloading circuit, motor breaking circuit. Hydraulic circuit simulation using software	07 (CO4)

5	**Pneumatics** Principle of Pneumatics: Laws of compression, Comparison of Pneumatics with Hydraulic power transmissions, compressors, compressed air distribution system, filters, regulators, lubricators, mufflers, dryers, Pressure regulating valves, Direction control valves, two pressure valve, quick exhaust valve and time delay valves, electro-pneumatics, Pneumatic actuators, two hand safety circuit, Air motors, shuttle valve, Speed regulating methods, pneumatic circuits, reciprocating, cascading time delay	**08 (CO5)**
6	**System Design** Estimation of piston velocity, thrust under static and dynamic applications, considering friction, inertia loads, design considerations for cylinders, Selection of different components such as reservoir, valves, actuators, filters, pumps based on design by using manufacturer‘s catalogues, Design of hydraulic circuits for practical application. Industry 4.0 in Fluid Power: Digital hydraulics, electro-hydraulic systems Smart sensors & IoT-enabled fluid power applications Energy-efficient hydraulic and pneumatic systems	**07 (CO6)**
	Total	**45**

Text Books:

1. Esposito, Anthony. Fluid power with applications. Columbus, Ohio: Pearson Prentice Hall, 2022.
2. Majumdar S.R, Oil Hydraulic system- Principle and maintenance, Tata McGraw Hill ,2020, ISBN 0071406697 :
3. Majumdar S.R, Pneumatics Systems Principles and Maintenance, Tata McGraw Hill ,2020, ISBN 0074602314
4. Stewart H. L, Hydraulics and Pneumatics, Industrial Press Inc., 2000, ISBN 0831111143

Reference Books

1. Pipenger J.J, Industrial Hydraulics, McGraw Hill ,2021, ISBN Code: 978-0070664777
2. Pinches, Industrial Fluid Power, Prentice Hall,2019
3. Yeaple, Fluid Power Design Handbook, CRC Press,2005
4. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books,3rd edition, 2021
5. Pipenger J.J, Industrial Hydraulics, McGraw Hill ,2015, ISBN Code: 978-0070664777

e-Resources

https://archive.nptel.ac.in/courses/112/105/112105047/ (IIT,Kharagpur)

Program:	B. Tech. (Mechanical Engineering)						Semester :V	
Course:	Industrial Hydraulics and Pneumatics Lab (Program Elective-I)						Code : BME25PE07	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1	-	2	-	-	50	-	-	50

Prior knowledge of: Fluid mechanics, physics is essential

Course Objectives:

This course aims at enabling the students to

1 To analyze the performance of the pump for the hydraulic system
2 To demonstrate the various fluid power components and different circuits using a hydraulic trainer
3 To test the hydraulic actuator/ pressure relief valve for the hydraulic system
4 To design a fluid power system for any hydraulic/pneumatic application

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Estimate the hydraulic pump performance under different loading conditions
CO2	Demonstration of different hydraulic/pneumatic system components
CO3	Testing of hydraulic actuator/ pressure relief valve for hydraulic/pneumatic system using a simulation tool like Automation Studio software
CO4	Design and simulate the Hydraulic and pneumatic circuits using Automation Studio software

List of Experiments

Experiment No.	List of Experiments (Compulsory 1,3,5,6,7,8, Any 1 from 2 and 4 , any 2 from 9,10,11)	Duration (Hrs.)
1	Test the Gear pump and plot its performance characteristics	4
2	Test on pressure relief valve/flow control valve using software such as Automation Studio	2
3	Following experiments to be done on hydraulic trainer / using software such as Automation Studio (any 3) a) Regenerative circuit b) Speed control circuit c) Sequencing circuit d) Traverse and feed circuit etc.	4
4	Test on linear /rotary actuator	2
5	Following experiments to be done on pneumatic trainer/ / using software such as Automation Studio (any 3) a) Automatic reciprocating circuit b) Speed control circuit c) Pneumatic circuit involving a Shuttle valve/ Quick exhaust valve / Two-pressure valve d) Electro-pneumatic circuits	4
6	Design of simple hydraulic systems used in practice using manufacturers' catalogue and analysis using software such as Automation Studio	4
7	Design of simple pneumatic systems used in practice using manufacturers' catalogues and analysis using software such as Automation Studio	4
8	Industrial visit to study Hydraulic / Pneumatic-based Automation systems	2

9	Assignment 1: Symbols for different components as per standards	2
10	Assignment 2: Troubleshooting procedures in a hydraulic system	2
11	Assignment 3: Standard specifications of hydraulic/ pneumatic components using manufacturer's catalogues.	2
	Total	**30**

Text Books:

1 Esposito, Anthony. Fluid power with applications. Columbus, Ohio: Pearson Prentice Hall, 2022.
2 Majumdar S.R., Oil Hydraulic system- Principle and maintenance, Tata McGraw-Hill,2020, ISBN 0071406697
3 Majumdar S.R, Pneumatics Systems Principles and Maintenance, Tata McGraw Hill ,2020, ISBN 0074602314
4 Stewart H. L, Hydraulics and Pneumatics, Industrial Press Inc., 2000, ISBN 0831111143

Reference Books

1 Pipenger J.J, Industrial Hydraulics, McGraw Hill ,2021, ISBN Code: 978-0070664777
2 Pinches, Industrial Fluid Power, Prentice Hall,2019
3 Yeaple, Fluid Power Design Handbook, CRC Press,2005
4 Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books,3rd edition, 2021

e- Resources

1 Standard Manufacturer's Catalogues
2 ISO - 1219, Fluid Systems and components, Graphic Symbols (ISO 1219-1:2012 - Fluid power systems and components — Graphical symbols and circuit diagrams — Part 1: Graphical symbols for conventional use and data-processing applications)

Program:	**B. Tech. (Mechanical Engineering)**						**Semester :V**	
Course:	**Mechanical Power Transmission** (Program Elective I)						**Code : BME25PE04**	
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**FA**		**SA**	**Total**
					FA1	**FA2**		
3	**3**	**-**	**-**	**1**	**20**	**20**	**60**	**100**

Prior knowledge of: Theory of Machines is essential.

Course Objectives:

This course aims at enabling the students to

1. To evaluate different power transmission systems such as belt drives, chain drives, gear drives, shaft, and couplings.
2. Select appropriate mechanical power transmission components based on load, speed, and efficiency requirements.
3. Apply industry standards, safety guidelines, and best practices in mechanical power transmission applications.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	**Course outcome Statement**
CO1	**Select** flat belt and V belt from manufacturer's catalogue for any application
CO2	**Design** the friction clutches and brakes for automotive applications
CO3	**Design** the Helical and Bevel gears for real life applications
CO4	**Select** suitable Worm gear pair for any application and Select the chain from manufacturer's catalogue
CO5	**Analyse** a power split device suitable for HEV and EVs.

Detailed Syllabus

Unit	**Description**	**Duration (Hrs.)**
1	Belt drives: Selection of Flat belt from manufacturer's catalogue, Selection of V Belt from manufacturer's catalogue	**09 (CO1)**
2	Design of Clutch and Brake: Design of single, multi plate clutch, heat generated during slip period, Design of drum and disc brakes	**09 (CO2)**
3	Helical and Bevel gear design: Design of helical and bevel gears against bending and pitting	**09 (CO3)**
4	Design of lifting machinery: Worm gears- Selection of worm gears and checking suitability using strength rating, wear rating and thermal rating as per IS 7443 (2002). -Selection of chain from manufacturer's catalogue	**09 (CO4)**
5	Transmission in Hybrid Electric Vehicle and Electric Vehicle: Design of power split devices.	**09 (CO5)**
	Total	**45**

Text Books:

1 V. B. Bhandari, Design of Machine Elements, 5th Edition, Tata McGraw Hill,2020

2 Machine Elements in Mechanical Design, Robert L Mott, Pearson/Prentice Hall, 2004

3 Mechanical Power Transmission Components, David W. South, Marcel Dekker, 1994

Reference Books

1. Shigley's Mechanical Engineering Design, Richard G. Budynas, J. Keith Nisbett, Tata McGraw Hill, 9781265472696
2. Mechanical Engineering Design (McGraw-Hill Series in Mechanical Engineering), Joseph Edward Shigley, Charles R. Mischke, Shigley's Mechanical Engineering Design: 2024 Release ISE
3. Analysis and Design of the Power-Split Device for Hybrid Systems, Xiaohuva Zeng, Jixin Wang, Springer, 2018

Program:	**B. Tech. (Mechanical Engineering)**						**Semester :V**	
Course:	**Mechanical Power Transmission Lab** (Program Elective-1)						**Code : BME25PE08**	
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**TW**	**PR**	**OR**	**Total**
01	**--**	**02**	**-**	**-**	**50**	**-**	**-**	**50**

Prior knowledge of: Theory of Machines is essential

Course Objectives:

This course aims at enabling the students to

1. Explore the design of transmission system elements
2. Explore the design of gearbox
3. Explore the use of coding for improvising the performance of transmission system elements.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement	Experiment mapping
CO1	**Analyze** the transmission system elements using Matlab Simulink coding to improvise the performance	1,2
CO2	**Select** the Belt from manufacturer's catalogue for real life applications	3
CO3	**Design** the elements of transmission system for real life applications	4,5,6
CO4	**Design** a Worm gearbox for real life applications	5

List of Experiments

Experiment No.	Description	Duration (Hrs.)
1	Dual clutch transmission model: Using programming demonstrate how to optimize a shift schedule for maximum fuel economy.	**8**
	OR	
2	Electric Vehicle Powertrain modelling using Simulation: Create mathematical modelling includes all necessary components to produce the required forces to propel the vehicle and the other resistive force acting on the vehicle.	**8**
3	Case study on Belt Selection	**4**
4	Design of Helical/ Bevel gear for real life application	**6**
5	Case Study on Worm gearbox design	**12**
	OR	
6	Mini Project based on any 3 units covering study of existing design, scope for design modifications.	**12**
	Total	**30**

Text Books:

1 Design of Machine Elements, V B Bhandari, Tata McGraw Hill Publication, 5th edition, 2020
2 Design of Machinery, L E Norton, 6th edition, McGraw Hill Publication, 2019

Reference Books

1. Design data book, V B Bhandari, Tata McGraw Hill Publication, 2nd edition, 2019
2. PSG Design Data book, PSG College of Engineering, Coimbtor
3. Peter Lynwander (1983), Gear Drive Systems : Design and Application, Marcel Dekker Inc, New York
4. G. Lechner and H. Naunheimer (1999), Automotive Transmissions: Fundamentals, Selection, Design and Application, Springer, Berlin

e-Resources

1. Dual Clutch Transmission Model in Simulink - File Exchange - MATLAB Central (mathworks.com)
2. https://onlinecourses.nptel.ac.in/noc24_me71/preview

Program:	**B. Tech. (Mechanical Engineering)**						**Semester :V**	
Course:	**Business Intelligence** Open Elective IV offered by CSE-AI &ML						**Code : BCS25OE03**	
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**FA**		**SA**	**Total**
					FA1	**FA2**		
2	**2**	**-**	**-**	**-**	**10**	**10**	**30**	**50**

Prior knowledge of basic mathematics is essential

Course Objectives:

This course aims at enabling the students to

1. To understand the fundamentals of Business Intelligence, Decision support system and BI Infrastructure.
2. To understand Data preprocessing and Data warehousing techniques to provide solutions to the real time BI problems.
3. Business and Data Analytics techniques for solving BI problems.
4. To learn Modern tools for BI applications

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	**Course outcome Statement**
CO1	Demonstrate the role of Business Intelligence in Decision Support System.
CO2	Apply the data pre-processing techniques to solve BI problems.
CO3	Apply Data Analytics Life Cycle for Business Intelligence Application.
CO4	Use modern analytical tools to develop BI applications

Detailed Syllabus

Unit	**Description**	**Duration (Hrs.)**
1	**Introduction:** Introduction, Defining BI Cycle, BI Environment and Architecture, Role of Mathematical model in BI, Factors Responsible for successful BI Project. **Decision Support System:** Structure and Development of Decision Support System (DSS), Role of Business Intelligence in DSS, Managing BI operations for business continuity	**07**
2	**Data Preprocessing and Data Warehousing :** Data preparation, Preprocessing requirements, data cleaning, data integration, data reduction, data transformation, Data discretization and concept hierarchy generation; Data warehouse Modeling, data warehouse design, Distributed data warehouse, and materialized view.	**08**
3	**Business Data Analytics:** Data analytics, business analytics, Data Analytics life cycle, Data Mining techniques for Business Analytics **BI Metrics & Pattern Visualization:** Metrics for performance evaluation: Accuracy, Error Rate, precision, Recall, F-measure, Sensitivity, Specificity, BI metrics on Dashboard, Need of Visualization, Pattern visualization tools and techniques (Tableau or PowerBI)	**08**
4	**BI Tools and Applications:** Analytical Tools for Business Intelligence, Case studies: WEKA, KNIME, Rapid Miner, BI applications: ERP and Business Intelligence, BI Applications in CRM, BI Applications in Marketing, Finance, Banking, Fraud Detection.	**07**
	Total	**30**

Text Books:

1 R. Sharda, D. Delen, & E. Turban, Business Intelligence and Analytics. Systems for Decision Support, 10th Edition. Pearson/Prentice Hall, 2015. ISBN-13: 978-0-13-305090-5, ISBN-10: 0-13-305090-4;

2 Business Process Automation, Sanjay Mohapatra, PHI.

Reference Books

1. Introduction to business Intelligence and data warehousing, IBM, PHI.
2. Data mining concepts and techniques, Jawai Han, Michelline Kamber, Jiran Pie,Morgan Kaufmann Publishers 3rd edition.
3. Building the data Warehouse, William H Inmon, Wiley Publication 4th edition.
4. Data Mining for Business Intelligence, WILEY
5. EMC Educational Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Wiley ISBN-13 978 1118876138
6. Ken W. Collier, Agile Analytics: A value driven Approach to Business Intelligence and Data Warehousing, Pearson Education,2012, ISBN-13 978 8131786826

e-resources:

1. https://www.knime.com/sites/default/files/inline-images/KNIME_quickstart.pdf
2. www.cs.ccsu.edu/~markov/weka-tutorial.pdf

Program:	**B Tech (Mechanical Engineering)**							**Semester:** V
Course:	**Professional Ethics for AI and Sustainable Engineering** Open Elective- IV Offered by Mechanical, applicable to all branches of Engineering							**Code: BME25OE06**
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**FA**		**SA**	**Total**
					FA1	**FA2**		
02	**02**	**–**	**-**	**-**	**10**	**10**	**30**	**50**

About the Course :

This course introduces the ethical dimensions of engineering and artificial intelligence (AI), helping students make responsible decisions in technology design and practice. It explores real-world dilemmas, sustainability challenges, and global regulatory perspectives to prepare future engineers for ethical leadership in an AI-driven world.

Prior knowledge of : None

Course Objectives:

This course aims to

1. Develop an understanding of ethical principles, professional conduct, and responsibilities in engineering and artificial intelligence (AI) practices.
2. Adapt the ability to identify and apply ethical frameworks for decision-making in research, AI system design, intellectual property, and sustainable engineering activities.
3. Create awareness of environmental ethics, sustainability principles, and the societal impacts of engineering and AI-based technological advancements.
4. Promote a global and culturally inclusive perspective on ethical issues, focusing on regulatory frameworks and the role of engineers in addressing contemporary challenges related to AI governance and sustainable development.

Course Outcomes:

The students will be able to,

Sr. No.	**Course outcome statement**
CO1	Understand fundamental ethical principles and professional responsibilities related to engineering, artificial intelligence (AI), and emerging technologies.
CO2	Apply ethical frameworks and decision-making models to analyze dilemmas involving AI systems, research practices, intellectual property, and sustainable engineering solutions.
CO3	Evaluate the environmental and societal impacts of engineering and AI technologies, and promote sustainable and responsible innovations aligned with ethical standards.
CO4	Demonstrate awareness of global, cultural, and regulatory perspectives in professional practice, with an emphasis on ethics in AI governance, sustainability initiatives, and inclusive technological development.

Detailed Syllabus

Unit	**Description**	**Duration (Hrs.)**
1	**Foundations of Professional Ethics and Emerging Technologies** Role of ethics in engineering and AI; moral autonomy; types of ethics; professional responsibilities in AI-driven world; ethical theories (utilitarianism, deontology, virtue ethics) with practical case studies.	**8**
2	**Ethical Decision-Making, AI Ethics, and Research Practices** Frameworks for ethical decision-making (with AI case examples); analyzing dilemmas; stakeholder responsibilities; ethical considerations in AI model development (bias, fairness, accountability); ethical issues in research, intellectual property, and emerging technologies.	**8**
3	**Sustainability, Environmental Ethics, and Social Responsibility** Introduction to sustainability in engineering; ethical resource management; circular economy; environmental impact of AI technologies; social justice, health, and safety responsibilities in sustainable design; role of engineers in building sustainable futures.	**7**

4	**Global, Cultural, and Regulatory Perspectives in AI and Sustainability** Ethical issues in global engineering projects; cultural perspectives on technology adoption; diversity, equity, and inclusion in AI; international regulations and governance of AI (GDPR, AI Act, IEEE standards); sustainability goals (SDGs) in a global context.	**7**
	Total	**30**

Text Books:

1. Harris, C. E., Pritchard, M. S., &Rabins, M. J. (2019). Engineering ethics: Concepts and cases. 6th Edition, Cengage Learning, Inc.
2. Coeckelbergh, M. (2020). AI Ethics (1st ed.). MIT Press.

Reference books:

1. Mike W. Martin and Roland Schinzinger, (2019). Ethics in Engineering, 3rdEdition,Tata McGraw Hill, New Delhi,
2. Caroline Whitbeck, Ethics in Engineering practice and Research. (2011) 2nd Edition, Cambridge.
3. Virginia Dignum (2019). Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way. Springer.
4. Wendell Wallach and Colin Allen (2008). Moral Machines: Teaching Robots Right From Wrong. Oxford University Press.

Program:	**B. Tech. (Mechanical Engineering)**						**Semester: V**	
Course:	**Remote Sensing and GIS** Open Elective IV Offered by Civil Department						**Code:**	**BCI25OE04**
Credits	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**Other**	**FA**		**SA**	**Total**
					FA1	**FA2**		
2	**2**	**-**	**-**	**-**	**10**	**10**	**30**	**50**

Prior Knowledge:

1. Fundamental related to Surveying
2. Types and Importance of various surveys
3. Global Positioning System (GPS)

Course Objectives: This course aims at enabling students,

1. To understand the fundamental principles and techniques of remote sensing and GIS.
2. To develop skills in processing, analyzing, and interpreting remote sensing data.
3. To gain proficiency in GIS concepts, spatial data models, and geospatial analysis
4. To integrate remote sensing and GIS for applications in urban planning, environmental monitoring, and disaster management

Course Outcomes: After learning the course, the students should be able to:

Sr. No.	**Course Outcome Statement**
CO1	Demonstrate a clear understanding of remote sensing principles, systems, and sensor characteristics.
CO2	Apply remote sensing and GIS techniques to analyze data for various civil engineering and interdisciplinary applications.
CO3	Use GIS tools for spatial data processing, analysis, and visualization.
CO4	Integrate remote sensing data with GIS to solve real-world problems in urban planning, environmental monitoring, and disaster management

Detailed Syllabus

Unit	**Description**	**Duration (Hrs.)**
1	**Fundamentals of Remote Sensing:** Introduction to Remote Sensing: Definition, History, and Applications Electromagnetic Radiation (EMR): Spectrum, Energy Interactions with Atmosphere and Earth Surface, Remote Sensing Sensors and Platforms: Optical, Microwave, and Hyperspectral Sensors, Resolution in Remote Sensing: Spatial, Spectral, Temporal, and Radiometric Resolution, Recent Advances: UAV (Drone) Remote Sensing, AI-based Remote Sensing	8
2	**Satellite Image Processing and Interpretation:** Types of Remote Sensing Data, Satellite Image Acquisition and Preprocessing Techniques: Radiometric and Geometric Corrections, Image Enhancement and Filtering Techniques, Image Classification Methods: Supervised and Unsupervised Approaches, Cloud-based Remote Sensing: Google Earth Engine and Big Data GIS	8
3	**Geographic Information System (GIS) Fundamentals:** Introduction to GIS: Definitions, Components, and Functions, Spatial Data Models: Raster vs. Vector Data, Topology, GIS Data Sources: Digitization, GPS Data Collection, Open-Source Data, GIS Software and Tools: ArcGIS, QGIS, Python for GIS, Georeferencing, Map Projections, and Coordinate Systems, Thematic Mapping and Visualization Techniques	7
4	**GIS Data and Case Studies:** Role of AI & Machine Learning in GIS: Object Detection, Land Cover Classification Real-time GIS and Web-based GIS Technologies, Case Studies: GIS Applications in Urban Planning, Disaster Management, Environmental Monitoring, and Smart Cities	7
	Total	**30**

Text Books:

1. Bhatta, B. – Remote Sensing and GIS (Oxford University Press, 2011)
2. Lillesand, T., Kiefer, R., & Chipman, J. – Remote Sensing and Image Interpretation (Wiley, 7th Ed., 2015)
3. Remote Sensing & Geographical Information System, M. Anji Reddy, BS Publications, Hyderabad, 4th Edition, 2022

Reference Books:

1. Textbook on Remote Sensing, C. S. Agarwal and P. K. Garg, Wheeler Publishing House, 2000.
2. Campbell, J. B., & Wynne, R. H. – Introduction to Remote Sensing (Guilford Press, 5th Ed., 2011)
3. Chang, K. – Introduction to Geographic Information Systems (McGraw Hill, 9th Ed., 2019)

e-Resources

1. https://onlinecourses.nptel.ac.in/noc22 ce84/preview
2. https://onlinecourses.nptel.ac.in/noc23_ce52/preview
3. https://onlinecourses.nptel.ac.in/noc22_ce26/preview
4. https://elearn.nptel.ac.in/shop/nptel/remote-sensing-and-gis/

Program :	**B. Tech. (Mechanical Engineering)**						**Semester: V**	
Course :	**Introduction to Advanced Driver Assistance Systems** Open Elective IV Offered by E&TC to all						**Code :**	**BET25OE01**
Credits	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**Other**	**FA**		**SA**	**Total**
					FA1	**FA2**		
02	**02**	**-**	**-**	**-**	**10**	**10**	**30**	**50**

Prior knowledge of

a. Electronics and electrical engineering

b. Basic programming concepts **is essential.**

Course Objectives:

1. Equip students with a comprehensive understanding of ADAS technologies.
2. Enable students to evaluate and apply sensor technologies.
3. Foster proficiency in integrating embedded systems and real-time data processing.
4. Prepare students to design and implement testing strategies for ADAS

Course Outcomes:

After learning the course, the students should be able to:

Sr. No.	**Course Outcome Statement**
CO1	Analyze the role of ADAS in vehicle safety and automation.
CO2	Evaluate sensor technologies and sensor fusion methods for ADAS functionality.
CO3	Apply embedded system concepts and real-time processing in ADAS.
CO4	Create testing strategies for ADAS using V2X communication.

Detailed Syllabus:

Unit	**Description**	**Duration [Hrs.]**
1	**Overview of ADAS and Core Functionalities:** Introduction to ADAS, importance of ADAS in vehicle safety, ADAS levels of automation, sensor technologies in ADAS, lane-keeping assist, adaptive cruise control, automatic emergency braking, collision avoidance, parking assist, and traffic sign recognition.	**07 (CO1)**
2	**Sensor Technologies and Sensor Fusion in ADAS:** Types of sensors used in ADAS, principles of sensor operation, sensor fusion for enhanced ADAS functionality, challenges of sensor calibration, sensor performance in various conditions, sensor integration with vehicle control systems.	**08 (CO2)**
3	**Embedded Systems and Real-Time Data Processing in ADAS:** Role of embedded systems in ADAS, microcontroller architectures for ADAS, real-time operating systems for data processing, system integration and communication between ECUs, decision-making algorithms, embedded software for ADAS, fault detection and self-diagnostics in ADAS systems.	**07 (CO3)**
4	**Vehicle-to-Everything (V2X) Communication and Testing ADAS:** Introduction to V2X communication (Vehicle-to-Vehicle, Vehicle-to-Infrastructure, Vehicle-to-Pedestrian), V2X communication protocols, integration of V2X with ADAS, testing methodologies for ADAS, validation of sensor fusion algorithms, ethical concerns, regulatory standards for ADAS.	**08 (CO4)**
	Total	**30**

Text Books:

1. Hussein T. Mouftah, Melike Erol-Kantarci, and Mubashir Husain Rehmani, "Connected and Autonomous Vehicles in Smart Cities", CRC Press, 1st Edition, 2020.
2. Claire Vishik, Simon Winberg, and Axel Sikora, "Cybersecurity for Connected and Automated Vehicles", Artech House, 1st Edition, 2021.
3. Andreas Herrmann, Walter Brenner, and Rupert Stadler, "Autonomous Driving: How the Driverless Revolution Will Change the World", Emerald Publishing, 1st Edition, 2018.

Reference Books:

1. Burkhard Huhnke, Markus Maurer, and Christoph Stiller, "Handbook of Driver Assistance Systems: Basic Information, Components and Systems for Active Safety and Comfort", Springer, 1st Edition, 2016.
2. Ramiro Liscano, Juan Carlos Garcia, and Miguel Angel Sotelo, "Advanced Driver Assistance Systems: Fundamentals, Applications, and Advances", CRC Press, 1st Edition, 2021.
3. Wolfgang Runge, "Autonomous Driving: Technical, Legal and Social Aspects", Springer, 1st Edition, 2016.

Program:	B. Tech. (Mechanical Engineering)							Semester: V
Course:	**Digital Marketing** Open Elective IV Offered by Computer Engineering							Code: BCE25OE01
Credit	Teaching Scheme (Hrs./Week)				Evaluation Scheme and Marks			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
2	2	-	-	-	10	10	30	50

Prior knowledge of Understanding of design thinking and planning is essential.

Course Objectives:

This course aims at enabling students:

1. To introduce the fundamental concepts and various types of digital marketing.
2. To familiarize students with different social media advertising platforms and their role in effective digital marketing campaigns.
3. To equip students with essential skills to implement Search Engine Optimization (SEO) technique.
4. To provide an understanding of E-commerce principles and business models, and to develop the ability to apply E-marketing techniques in digital environments

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statements
CO1	Understand the different types of Digital Marketing.
CO2	Learn social media advertising platforms for digital marketing campaigns.
CO3	Apply the fundamental principles and concepts of Search Engine Optimization (SEO).
CO4	Apply e-commerce and e-marketing concepts in Business Models

Detailed Syllabus

Unit	Description	Duration (H)
1	**Types of Digital Marketing** Digital Marketing – The concept, Digital Marketing Types : Mobile Marketing, Online Marketing, Email Marketing,	6 (CO1)
2	**Digital marketing using social media** Consumer Generated Contents (CGC), Impact of Social Media, Advantages and Disadvantages of Social Media, Types of Social Media, Social Media Marketing using Instagram, Snap Chat, Twitter and LinkedIn	8 (CO2)
3	**Search Engine Optimization (SEO)** Search Engine Optimization Basics, Keyword Research, SEO Tool- SEMrush: Overview and Features, Top Search Engine Ranking Factors. Case Study: Dominos India: Building Traffic through content propagation.	8 (CO3)
4	**E-commerce Business Models & E-marketing** E-commerce: Meaning, Benefits and limitations, Business Models for E-commerce: Business-to-Consumer (B2C), Business-to-Business(B2B), Consumer-to-Consumer (C2C), Consumer To-Business (C2B). Case Study: Revenue sources at YouTube Traditional Marketing Vs. E-Marketing, Impact of E-commerce on markets, Issues in E-Marketing Case Study: Create an own business EC model example -Shopify	8 (CO4)
	Total	30

Text Books:

1. Damian Ryan& Calvin Jones . Understanding DIGITAL Marketing
2. Vandana Ahuja(2015), Digital Marketing. Oxford University Press, New Delhi
3. Neetu Kapoor, Concept Building Approach to Digital Marketing, Cengage, 2nd Edition.
4. The digital marketing Handbook, A step by step guide, Mohit Pawar,2015 Edition.
5. Joseph P. T., E - Commerce – An Indian Perspective, PHI publication, 6th Edition

Reference Books:

1. George Pain(2019). Marketing Automation and Online Marketing: Automate Your Business through Marketing Best Practices such as Email Marketing and Search Engine Optimization
2. Barker, M., Barker, D., & Bormann, N. (2016), Social Media Marketing: A Strategic Approach, Boston, MA : Cengage Learning.
3. Tuten, T., Solomon M., Social Media Marketing, SAGE, 2nd Edition.
4. Ian Dodson, The art of Digital Marketing, 2016, Wiley, 978-1-119-26570-2.

E-resources:

1. https://www.coursera.org/learn/foundations-of-digital-marketing-and-e-commerce
2. https://open.umn.edu/opentextbooks/textbooks/1602
3. https://www.coursera.org/learn/social-media-marketing-introduction
4. https://www.coursera.org/specializations/social-media-marketing
5. https://www.coursera.org/projects/create-your-ecommerce-store-with-shopify

Program	**B. Tech. (Mechanical Engineering)**					**Semester**	**V**
Course	**Cloud Computing** Open Elective IV Offered by IT department and Suggested for Mech./ E&TC/Civil students					**Code: BIT25OE01**	
Credits	**Teaching Scheme (Hrs./Week)**				**Evaluation Scheme and Marks**		
	Lecture	**Practical**	**Tutorial**	**Other**	**FA**		**SA**	**Total**
					FA1	**FA2**		
2	**2**	**-**	**-**	**-**	**10**	**10**	**30**	**50**

Prior Knowledge of Computer Network Fundamentals **is essential.**

Course Objectives:

1. To learn the fundamentals of cloud computing.
2. To know the emergence of cloud as the next generation computing paradigm.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	**Course Outcome Statement**
CO1	Explore the basic terminologies in cloud computing
CO2	Categorize cloud service models and their utilities
CO3	Demonstrate cloud security mechanisms and policies
CO4	Examine common standard in cloud computing

Detailed Syllabus

Unit	**Description**	**Duration (Hrs.)**
1.	**Fundamentals of Cloud Computing** Computer Network Fundamentals : OSI Reference Model, Computer Network architecture Origin and Influences of Cloud Computing - History, definitions, technology innovations; Cloud Computing terminologies, Applications, benefits and limitations, risk and challenges, roles and boundaries, cloud characteristics, Cloud Delivery Models, cloud Deployment Models.	**7 (CO1)**
2.	**Cloud Service and Platforms** Software as a Service, Platform as a Service, Infrastructure as a Service, Database as a Service, Monitoring as a Service, Communication as services, Service providers: Google Cloud platform, Microsoft Azure Service Platform, Amazon EC2, Salesforce, IBM.	**7 (CO2)**
3.	**Cloud Enabling Technology and Cloud Security** Broadband Networks and Internet Architecture, Data Centre Technology, Virtualization Technology, Web Technology, Multitenant technology, Service Technology, Cloud Security**:** Confidentiality, Integrity, Authenticity, availability, Vulnerability, Security Control, Security Mechanisms, Security Policies. Case study on Identity Access Management (IAM)	**8 (CO3)**
4.	**Common Standards in Cloud Computing** Open Cloud Consortium- Open Virtualization Format, Working of Virtualization system, Types of Virtualization, Benefits of Virtualization, Standards for Application Developers- browsers, data and solution Stack; Standards for Messaging- SMTP, POP, IMAP, RSS, HTTP; Standards for Security- Security (SAML OAuth, OpenID, SSL /TLS).	**8 (CO4)**
	Total	**30**

Text Books:

1. Ricardo Puttini, Thomas Erl, and Zaigham Mahmood, “Cloud Computing: Concepts, Technology & Architecture”, Pearson May 2013, ISBN: 9780133387568.
2. Toby Velte, Anthony Velte, Robert Elsenpeter, “Cloud Computing – A Practical Approach, Tata Mcgraw Hill.
3. Rittinghouse, John W., and James F. Ransome, Cloud Computing: Implementation, Management, And Security, CRC Press, 2017.

Reference Books:

1. Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, ―Mastering Cloud Computing, Tata Mcgraw Hill, 2013.
2. Tim Mather,Subra Kumaraswamy,Shahed Latif, “Cloud Security and Privacy:An Enterprise Perspective on Risks and Compliance”, O'Reilly Media, Inc. 2009

Online Material :

1. NPTEL Course on Cloud Computing : https://nptel.ac.in/courses/106105167
2. Google Cloud Computing Foundation Course: https://nptel.ac.in/courses/106105223

Program :	**B. Tech. (Mechanical Engineering)**						**Semester: V**	
Course :	**Engineering Psychology** Open Elective IV offered by E&Tc to all						**Code :**	**BET25OE02**
Credits	**Teaching Scheme (Hrs./Week)**				**Evaluation Scheme and Marks**			
	Lecture	**Practical**	**Tutorial**	**Other**	**FA**		**SA**	**Total**
					FA1	**FA2**		
02	**02**	**-**	**-**	**-**	**10**	**10**	**30**	**50**

Prior knowledge of is not essential.

Course Objectives:

This course aims at enabling students,

1. Introduce engineers to key psychological principles relevant to personal and professional development.
2. Understand human behavior, cognition, and emotion to improve interpersonal effectiveness and Team work.
3. Develop skills to integrate psychological insights into problem-solving and innovation.
4. Foster ethical decision-making and leadership through Emotional Intelligence.

Course Outcomes:

After learning the course, the students should be able to:

Sr. No.	**Course Outcome Statement**
CO1	Understand fundamental psychological concepts and their engineering applications.
CO2	Understand the theories of cognitive works
CO3	Apply psychological principles to improve teamwork and leadership.
CO4	Integrate human-centered approaches in engineering design and problem-solving.

Detailed Syllabus:

Unit	**Description**	**Duration [Hrs.]**
1	**Introduction to Engineering Psychology** History of Engineering Psychology, Methods of Engineering Psychology Perspective on Engineering Psychology-Human-Centric Design, Balance in Cognitive Load, Ethical & Sustainable Technology, Holistic Decision-Making:	**08 (CO1)**
2	**Design of Cognitive Work-1** Attention Vigilance and Fatigue Information Processing Training and Automaticity Stress and Workload Displays, Monitors, and Screens Usability Teams and Performance	**08 (CO2)**
3	**Design of Cognitive Work-2** Situation Awareness Emotion, Motivation, and Boredom Decision-Making and Expertise Language and Artificial Intelligence	**07 (CO3)**
4	**Importance of EI for engineering professionals** Components of EI (as per Goleman's Model) Daniel Goleman's Model (Five components: Self-awareness, Self-regulation, Motivation, Empathy, Social skills) Role of EI in team collaboration, leadership, and conflict resolution Applications of EI in decision-making and problem-solving Examples of high-EI engineering leaders Developing Emotional Intelligence- Techniques for enhancing self-awareness and empathy, Managing emotions under stress	**07 (CO4)**
	Total	**30**

Text Books: :
1. Elliott, L. J. (2021). Engineering psychology. Penn State University Libraries. https://doi.org/10.26209/engin-psych
2. D. Goleman, Emotional Intelligence: Why It Can Matter More Than IQ. New York, NY, USA: Bantam Books, 1995..

Reference Books:
1. Baron, R. A., & Branscombe, N. R. Psychology (13th Edition). Pearson.
2. A. Nagraj, Vyavhar Darshan (The Conduct Perspective)
3. Schultz, D. P., & Schultz, S. E. Psychology and Work Today
4. A. Nagraj, Jeevan Vidya: Ek Parichay
5. R.R. Gaur, R. Sangal, G.P. Bagaria, A Foundation Course in Human Values and Professional Ethics

Curriculum
Semester VI
Third Year B. Tech.
Mechanical Engineering

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Numerical Methods and Optimization						Code : BME26PC16	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
2	2	-	-	1	10	10	30	50

Prior knowledge of: System of linear equations, Partial differentiation, Problem-solving and programming is essential

Course Objectives:

This course aims at enabling the students to

1. Effectively use Numerical Techniques for solving complex Mechanical engineering problems
2. Develop logical sequencing for the solution procedure.
3. Optimize the solution for different real-life problems with available constraints.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Select** numerical methods to solve the roots of equations, simultaneous equations, and integration-based mechanical engineering problems.
CO2	**Develop** regression models and predict the system's behaviour for the experimental data.
CO3	**Estimate** the solutions for ordinary and partial differential equations.
CO4	**Generate** solutions for real-life problems using optimization techniques

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Solution of Linear algebraic equations** **Root of an equation:** Bisection Method, Newton-Raphson method **Simultaneous equations:** Gauss Elimination Method with Partial pivoting, Gauss-Seidel method, and Thomas algorithm for Tri-diagonal Matrix. **Numerical Integration:** Trapezoidal rule, Simpson's 1/3rd Rule, Simpson's 3/8th Rule.	**08 (CO1)**
2	**Curve Fitting and Regression Analysis** **Curve Fitting:** Least square technique- Straight line, Power equation, Exponential equation and Quadratic equation, AI techniques for curve fitting. **Regression Analysis:** Lagrange's Interpolation, Newton's Forward interpolation, multi regression analysis	**07 (CO2)**
3	**Solution of Differential Equations** **Ordinary Differential Equations [ODE]:** Euler Method, Modified Euler Method, Runge-Kutta 2nd order and 4th order method, Simultaneous ODE equations. (Runge-Kutta second-order: *One-step only*). **Partial Differential Equations [PDE]:** Finite difference method, Simple Laplace method, PDEs- Parabolic explicit solution.	**08 (CO3)**
4	**Optimization** Introduction to optimization, Classification, Constrained optimization: Graphical and Simplex method (limited to two variables), Nonlinear Optimization, Modern Optimization Techniques (theoretical treatment only)	**07 (CO4)**
	Total	**30**

Text Books:

1. Steven C. Chapra, Raymond P. Canale, Numerical Methods for Engineers, McGraw-Hill Higher Education, 2015
2. Dr. B. S. Garewal, Numerical Methods in Engineering & Science with Programs in C, C++ & MATLAB, Khanna Publishers, 2013
3. Steven C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, Tata Mc-Graw Hill Publishing, 2022

Reference Books

1. Rao V. Dukkipati, Applied Numerical Methods using Matlab, New Age International Publishers, 2020
2. Gerald and Wheatley, Applied Numerical Analysis, Pearson Education, 2004
3. E. Balagurusamy, Numerical Methods, Tata McGraw Hill, 2017
4. S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall India, 2012

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Numerical Methods and Optimization Lab						Code : BME26PC17	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
2	-	4	-	-	50	50	-	100

Prior knowledge of: System of linear equations, Partial differentiation, Problem-solving and programming is essential

Course Objectives:

This course aims at enabling the students to

1. Effective use of Numerical methods for solving complex Mechanical engineering problems
2. Develop a logical solution for Mechanical engineering problems.
3. Effective utilization of AI in solving Numerical Methods

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Select** appropriate Numerical Methods to solve complex mechanical engineering problems.
CO2	**Formulate** algorithms and programming.
CO3	**Select** AI based Numerical Methods to solve complex mechanical engineering problems.

Detailed Syllabus

Experiment No	Description	Duration (Hrs.)
1	**Program on Roots of Equation** (Validation using a suitable solver, anyone per student) Bisection Method, Newton Raphson method	4
2	**Program on Simultaneous Equations** (Validation using a suitable solver, anyone per student) Gauss Elimination Method, Thomas algorithm for tridiagonal matrix, Gauss-Seidel method.	8
3	**Program on Numerical Integration** (Validation using a suitable solver, anyone per student) Trapezoidal rule, b) Simpson's Rules (1/3rd, 3/8th) [In one program only]	2
4	**Program on Curve Fitting using the Least square technique** (Validation using a suitable solver, anyone per student) Straight line, Power equation, Exponential equation, Quadratic equation	4
5	**Program on Curve Fitting using the Least square technique and AI** Any AI technique for solving curve fitting (anyone from the 4th assignment given above)	4
6	**Program on Interpolation** (Validation using a suitable solver, anyone per student) Lagrange's Interpolation, Newton's Forward interpolation,	4
7	**Program on Regression analysis**	4
8	**Program on ODE** (Validation using a suitable solver, anyone per student) Euler Method, Runge-Kutta Methods- fourth-order,	4

	Simultaneous equations. (Runge-Kutta second-order: *One-step only*).	
9	**Program on PDE (**Validation using a suitable solver, anyone per student): Laplace equation	**4**
10	**Numerical Analysis of the Simplex Method Using Statistical Software**	**4**
11	**Program me on non-linear Optimization using the Newton-Raphson method.**	**4**
12	**Case study on Modern Optimization Technique** Ant Colony Optimization (ACO)	**4**
13	**Case study on Modern Optimization Technique** Genetic Algorithm (GA),Particle Swarm Optimization (PSO)	**6**
14	**Case study on Modern Optimization Technique** Simulated Annealing (SA)	**4**
	Total	**60**

NOTE:

- Complete all assignments using suitable software
- Solver is compulsory for all the above programs compared with the solution.
- Manual solution for each problem.
- Algorithms and Flowcharts are compulsory for all programs

Text Books:

1. Numerical Methods for Engineers, Steven C. Chapra and Raymond P. Canale, 2015.
2. Applied Numerical Methods with MATLAB for Engineers and Scientists, Steven C. Chapra., 8th edition, 2022.
3. Introductory Methods of Numerical Analysis, S. S. Sastry, 2012.

Reference Books

1. Numerical Methods in Engineering with Python 3, Jaan Kiusalaas, 3rd edition, 2013.
2. Optimization for Engineering Design: Algorithms and Examples, Kalyanmoy Deb, 2nd edition, 2020.
3. Artificial Intelligence with Python, Prateek Joshi, 2nd edition, 2020.

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Metrology and Quality Control						Code : BME26PC18	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
2	2	-	-	1	10	10	30	50

Prior knowledge of: Basic mechanical components, Geometric Dimensioning and Tolerances, Manufacturing processes, Trigonometry, Statistics is essential

Course Objectives:

This course aims at enabling the students to

1. Use and apply various metrology instruments / gauges / calibration and advanced metrological methods and systems of measurement and inspection for determining geometrical and dimensional measurements.
2. Select and apply appropriate Quality Control Technique, Quality Management Tool and suggest appropriate Quality Management System (QMS) for given application.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Interpret fundamentals of measurement and design limit gauges.
CO2	Compare and select appropriate measuring instruments for complex engineering parts.
CO3	Apply Quality Control Techniques and TQM for real life problems.
CO4	Use Statistical Control Techniques to analyze process capability.

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Measurement Standards and Design of Gauges** **Measurement Standards:** Introduction, Precision, Accuracy, Errors in Measurement, Calibration, Abbe's principle, Types and sources of errors Linear Measurement: Standards, Line Standard, End Standard, Wavelength Standard, awareness on various global standards. **Design of Gauges**: Taylor's principle, Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials, Considerations of gauge design (Numerical treatment on Gauge Design).	08 (CO1)
2	**Comparators, Thread Metrology Gear Metrology, Surface Roughness Measurement and Interferometry** **Comparators:** Types Comparators, Uses, Advantages and Disadvantages of various types of Comparators. **Thread Metrology:** Screw Thread terminology, Gear Terminology, Errors in Thread. **Gear Metrology:** Gears, Measurement of Minor, Major and Effective diameter (Two Wire Method), Constant chord, Base tangent and Numerical treatment, Gear Rolling Tester. **Surface Roughness Measurement:** Introduction to Surface roughness, Meaning of RMS and CLA values, Surface roughness measuring instrument: TalySurf and Tomlison's Surface Meter. **Interferometry:** Introduction, Working Principle and applications of NPL Interferometer, Laser Interferometry.	08 (CO2)
3	**Introduction to Quality, Quality Tools and Total Quality Management** Concept of Quality: Meaning of Quality, Quality of Product, Quality of Service, Cost of Quality, Types of audits ISO, IATF etc. Difference between Inspection, Quality Control and Quality Assurance. Deming's cycles & 14 Points, Old and New Seven Tools, Case studies on transformation done through TQM, Corrective Action and Preventive Action report filling technique.	07 (CO3)

4	**Statistical Quality Control** Statistical concept, Frequency diagram, Control Chart for Variable (X & R Chart) & Attribute (P & C Chart), Statistical Process Control (Numerical). Acceptance Sampling: Sampling Inspection, OC Curve and its characteristics, sampling methods, Sampling Plan: Single, Double (Numerical), AOQ.	**07 (CO4)**
	Total	**30**

Text Books:

1 Jain R.K., Engineering Metrology, Khanna Publication, 22nd Edition, 2022
2 Bewoor A. K. and Kulkarni V. A., Metrology and Measurements, Tata McGraw hill Publication, 2017

Reference Books

1 Narayana K.L., Engineering Metrology, 2010
2 Gupta I.C., Engineering Metrology, Dhanpatrai Publications, 2019.
3 Francis T. Farago, Mark A. Curtis, Handbook of dimensional measurement, 5th Edition,2013
4 ASTME, Handbook of Industrial Metrology, Prentice Hall of India Ltd.,1972
5 Kulkarni V. A. and Bewoor A. K., Quality Control, John Wiley Publication,2009

e-Resources:

1 nptel.ac.in/courses/112106179;
2 www.nptelvideos.in/2012/12/mechanical-measurements-and-metrology.html;
3 www.me.iitb.ac.in/~ramesh/courses/ME338/metrology6.pdf; nptel.ac.in/courses/110101010/;
4 freevideolectures.com › Mechanical › IIT Madras
5 nptel.ac.in/courses/112107143/37;

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Metrology and Quality Control Lab						Code : BME26PC19	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
2	-	4	-	-	50	-	50	100

Prior knowledge of: Basic mechanical components, Geometric Dimensioning and Tolerances, Manufacturing processes, Trigonometry, Statistics is essential

Course Objectives:

This course aims at enabling the students to

1. Select and use of suitable measuring and inspection instruments for different geometrical and dimensional measurements.
2. Select and use of suitable Quality Control and statistical quality control techniques

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement	Experiment No.
CO1	Use measuring instruments for linear, angular dimensions and surface finish .	1,2,3
CO2	Measure dimensions of complex parts such as thread, gear and profile using appropriate measurement systems.	4,5
CO3	Analyse process capability of manufacturing processes using statistical quality control techniques.	6,8
CO4	Perform risk-based quality assessment and advanced inspection by conducting Failure Mode and Effects Analysis (FMEA) through case studies and practical examples.	7
CO5	Implement machine vision principles in virtual labs to detect, identify and mitigate, potential failures in manufacturing processes.	9

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	Demonstration and use of linear and angular measuring instruments, slip gauges and their applications.	6
2	Demonstration of surface inspection using optical flat and surface roughness measurement using surface roughness tester.	6
3	Calibration of measuring instrument, like Pressure gauge, Dial gauge, Micrometer, Vernier Calliper (any one)	6
4	Measurement of complex components such as thread, gear, etc.	6
5	Verification of dimensions and geometry of given components using Mechanical /Pneumatic/Electrical comparator.	6
6	Plot the 7 QC charts by using suitable software/excel.	6
7	Conduct the Failure Mode and Effects Analysis (FMEA) with suitable examples	6
8	Perform the Process Capability Analysis (Cp, Cpk, Pp, Ppk) with suitable examples.	6
9	AI integrated Machine vision based quality control. (VLab IIT, Kharagpur OR comparable sources)	6
	Mandatory Industrial Visit.	6
	Total	60

Text Books:

1 Jain R.K., Engineering Metrology, Khanna Publication, 2022
2 Bewoor A. K. and Kulkarni V. A., Metrology and Measurements, Tata McGraw hill Publication, 2017.

Reference Books

1 Narayana K.L., Engineering Metrology, 2010
2 Gupta I.C., Engineering Metrology, Dhanpatrai Publiartions,2019.
3 Francis T. Farago, Mark A. Curtis, Handbook of dimensional measurement, 5th Edition,2013
4 ASTME, Handbook of Industrial Metrology, Prentice Hall of India Ltd.,1972
5 Kulkarni V. A. and Bewoor A. K., Quality Control, John Wiley Publication,2009

e-Resources:

1 nptel.ac.in/courses/112106179;
2 www.nptelvideos.in/2012/12/mechanical-measurements-and-metrology.html;
3 www.me.iitb.ac.in/~ramesh/courses/ME338/metrology6.pdf; nptel.ac.in/courses/110101010/;
4 freevideolectures.com › Mechanical › IIT Madras
5 nptel.ac.in/courses/112107143/37;

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Mechanical System Design (Programme Elective 2)						Code : BME26PE09	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
3	3	-	-	1	20	20	60	100

Prior knowledge of: Engineering Materials**,** Manufacturing Technology, Strength of Materials, Machine Design is essential.

Course Objectives:

This course aims at enabling the students to

1. Design cylinders and pressure vessels using IS code
2. Design machine tool gearbox
3. Design material handling systems.
4. Optimize the mechanical systems.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Analyze** the stress in thin & thick cylinders under internal and external pressure
CO2	**Design** an unfired pressure vessel using IS 2825:1969 and ASME Code.
CO3	**Determine** the optimum kinematic diagram and **identify** the various speeds in a multi-speed machine tool gearbox
CO4	**Select** the appropriate material handling equipment for any application and to design the material handling system.
CO5	**Optimize** the performance parameters of mechanical systems

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Design of Cylinders** Design of Cylinders: Thin and thick cylinders, Lame's equation, Clavarino's and Bernie's equations, Auto-frettage and compound cylinders.	09 (CO1)
2	**Design of Unfired Pressure vessel :** Classification of pressure vessels as per IS code 2825-1969, Categories and types of welded joints, Weld joint efficiency, Stresses induced in pressure vessels, materials for pressure vessel, Design of cylindrical shells and end closures as per code, Design of nozzles and openings in pressure vessels, Types of vessel supports.	09 (CO2)
3	**Machine Tool Gearbox Design** Introduction to machine tool gearboxes, Design and its applications, Basic considerations in design of drives, Determination of variable speed range, graphical representation of speed and structure diagram, ray diagram, selection of optimum ray diagram, gearing diagram, deviation diagram.	09 (CO3)
4	**Material Handling System Design** System concept, basic principles, Classification of conveyors, Objectives of material handling system, Unit and bulk load. Belt conveyors, Troughed belt conveyors, Capacity of conveyor, Rubber covered and fabric ply belts, belt tensions, Conveyor pulleys, belt idlers, tension take-up systems, Power requirement of belt conveyors for frictional resistance of idler and pulleys. Selection of wires and rope drive from manufacture's catalogue.	09 (CO4)

5	**Design Optimization** Design of Mechanical Elements ,Classification of design parameters-Functional, Geometric and Material .Design Equation .Design of Mechanical Element ,Adequate design, Optimum design ,Johnsons method of optimum design ,AI based decision in Mechanical system design	**09 (CO5)**
	Total	**45**

Text Books:

1. Design of Machine Elements, V B Bhandari, Tata McGraw Hill Publication, 5th edition, 2020
2. Juvinal R.C, Fundamentals of Machine Components Design, Wiley, India, 2019, 978-1-119-47568-2

Reference Books

1. Design Data- P.S.G. College of Technology, Coimbatore, Printed in 2017
2. Bhandari, V. B. Machine Design data book, Tata McGraw Hill Publication Co. Ltd, 5th edition 2017
3. I.S. 2825: Code for unfired pressure vessels
4. Shigley J. E. and Mischke C.R., ―Mechanical Engineering Design‖, McGraw Hill Pub. Co, 11th edition 2020
5. M. F. Spotts, Design of Machine Elements Prentice Hall Inc, 8th edition 2019
6. Black P.H. and O. Eugene Adams, ―Machine Design‖ McGraw Hill Book Co. Inc.
7. Johnson R.C., ―Mechanical Design Synthesis with Optimization Applications‖, Von Nostrand Reynold Pub.
8. S.K. Basu and D. K. Pal, ―Design of Machine Tools, Oxford and IBH Pub Co, 6th edition 2018
9. Rudenko,‖Material Handling Equipment‖, M.I.R. publishers, Moscow
10. P. Kannaiah ,‖Design of Transmission systems‖, SCIETCH Publications Pvt Ltd, 2nd edition 2015.
11. Pandy, N. C. and Shah, C. S., Elements of Machine Design, Charotar Publishing House.
12. Mulani, I. G., ―Belt Conveyors
13. Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley & Sons, 5th edition 2019
14. Joshi's Process Equipment Design, by V V Mahajani and S B Umargi, Mc-Millan, 5th edition 2017

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Mechanical System Design Lab (Programme Elective 2)						Code : BME26PE14	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1	-	2	-	-	50	-	-	50

Prior knowledge of: Engineering Materials**,** Manufacturing Technology, Strength of Materials, Machine Design is essential

Course Objectives:

This course aims at enabling the students to

1. Optimize design and use optimization methods to design mechanical components.
2. Design machine tool gearboxes.
3. Design material handling systems
4. Design cylinders and pressure vessels and to use IS code

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Design** various mechanical systems like pressure vessels, machine tool gearboxes, and material handling systems for the specifications stated/formulated problem.
CO2	**Prepare** structured technical design reports for mechanical systems, documenting problem analysis, design calculations, material selection, cost estimation, and user specifications as per industry standards

Detailed Syllabus

Expt. No.	Description	Duration (Hrs.)
1	A group of 4-5 students will select any One projects out of the following 1. Design of Material Handling Equipment for industrial application. 2. Design of multispeed Gear box for machine tool. 3. Design of unfired pressure vessel for industrial application. The following are the contents of the submission for the design projects. i. The detailed **design report** containing, problem selection, problem analysis, problem definition, Solution based on all applicable design considerations, exclusive summary reflecting final dimensions of parts, Leaflet comprising the final specifications of the product designed, cost, Instructions to the users shall be submitted. ii. **2D Part drawing** in two views (preferably one sectional view exploring internal features of the parts) with representation of geometric, dimensional tolerances, surface roughness symbols, other instructions such as the surface coating, heat treatments to be submitted iii. **2D assembly drawing** in two views (preferably one sectional view exploring internal features of the assembly), with representation of overall dimensions, centre distances, dimensions ensuring alignment of parts in assembled condition, locations at which a particular fit is to be achieved, bill of materials representing clearly the OEM parts and parts to be manufactured in-house with correct representation of materials quantity, costing, Warrantee applicable to OEM parts	30
	Total	30

Text Books:

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

Reference Books

1 Design Data- P.S.G. College of Technology, Coimbatore, Printed in 2017
2 Bhandari, V. B. Machine Design data book, Tata McGraw Hill Publication Co. Ltd, 5th edition 2017
3 I.S. 2825: Code for unfired pressure vessels
4 Shigley J. E. and Mischke C.R., ―Mechanical Engineering Design‖, McGraw Hill Pub. Co, 11th edition 2020
5 M. F. Spotts, Design of Machine Elements Prentice Hall Inc, 8th edition 2019
6 Black P.H. and O. Eugene Adams, ―Machine Design‖ McGraw Hill Book Co. Inc.
7 Johnson R.C., ―Mechanical Design Synthesis with Optimization Applications‖, Von Nostrand Reynold Pub.
8 S.K. Basu and D. K. Pal, ―Design of Machine Tools, Oxford and IBH Pub Co, 6th edition 2018
9 Rudenko,‖Material Handling Equipment‖, M.I.R. publishers, Moscow
10 P. Kannaiah ,‖Design of Transmission systems‖, SCIETCH Publications Pvt Ltd, 2nd edition 2015.
11 Pandy, N. C. and Shah, C. S., Elements of Machine Design, Charotar Publishing House.
12 Mulani, I. G., ―Belt Conveyors
13 Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley & Sons, 5th edition 2019
14 Joshi’s Process Equipment Design, by V V Mahajani and S B Umargi, Mc-Millan, 5th edition 201

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Control Systems (Programme Elective 2)						Code : BME26PE10	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
3	3	-	-	1	20	20	60	100

Prior knowledge of: fundamentals of electrical and electronics, basics of mathematics, mechatronics, basics of simulation and coding using tools like MATLAB is essential

Course Objectives:

This course aims at enabling the students to

1. Basics of control systems, mathematical modelling and stability analysis of the control systems.
2. The implementation of various control strategies for the mechanical / electro-mechanical application.
3. Modeling the control systems.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Describe** the concept and design principles of control systems.
CO2	**Categorize,** identify, and select an appropriate control system for any application.
CO3	**Perform** system modelling of a control system.
CO4	**Perform** stability analysis of a control system
CO5	**Develop** a controlling strategy for a control system.
CO6	**Model** the control system using state space methods

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Fundamentals of control systems** Definition, classification, Relative merits and demerits of open-loop and closed-loop control systems, Linear and nonlinear systems, Design principles of control systems, System stability.	**07 (CO1)**
2	**Types of control systems and their applications** Servo systems, Automatic regulating systems, Process control systems, Adaptive control systems, Learning control systems, Discrete control systems, Multivariable control systems.	**07 (CO2)**
3	**System modelling** Concept of the transfer function, Block diagram reduction, Signal flow graph: Mason's gain formula, Modelling of mechanical systems, Applications.	**08 (CO3)**
4	**Stability analysis** Concept of stability analysis, frequency domain analysis, Bode Plot, Root locus technique, Nyquist criterion, Applications.	**06 (CO4)**
5	**PID control action** Introduction, proportional control, integral control, derivative control, combination of control actions and their effect on system performance, Discrete PID Controller, Gain scheduling, Lead compensation, Lag compensation, Lead and Lag compensation, PID tuning, Ziegler-Nichols method, Low pass filter and high pass filter.	**08 (CO5)**

6	**State space analysis** Concept of state, state variables and state models, state space equations, transfer function from state variable representation, transfer model, State space representation of dynamic systems, state transition matrix, controllability and observability, Kalman Filter	**09 (CO6)**
	Total	**45**

Text Books:

1. Mechatronics: Electronics Control Systems in Mechanical and Electrical Engineering, William Bolton, 6th Ed, 2019.
2. Automatic Control Systems, B. C. Kuo, 9th ed. Wiley, 2017.
3. Modern Control Engineering, K. Ogata, 5th ed. Pearson, 2015

Reference Books

1. Control Systems Engineering, I. J. Nagrath, and M. Gopal, 6th ed. New Age International, 2020.
2. Modern Control Systems, R. C. Dorf and R. H. Bishop, 11th ed. Pearson Education, 2021.
3. Introduction to Mechatronics and Measurement Systems, Alciatore and Histand, 5th Ed, 2019
4. Mechatronics – An Introduction, Bishop, CRC, Taylor & Francis, 2017.
5. Electric Motors and Control Systems, Petruzella, F.D. McGraw-Hill, New York, New York (2010). ISBN 978-0-07-352182-4

e-Resources:

1. https://onlinecourses.nptel.ac.in/noc20_ee90/preview (By Prof. C. S. Shankar Ram, IIT Madras)

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Control Systems Lab (Programme Elective 2)						Code : BME26PE15	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1	-	2	-	-	50	-	-	50

Prior knowledge of: Fundamentals of electromechanical systems, Basics of mathematics, Mechatronics, Basics of simulation and coding using tool like MATLAB is essential

Course Objectives:

This course aims at enabling the students to

1. Equip with the skills to design, model, and analyze control systems using simulation software, enabling them to apply theoretical concepts to practical scenarios.
2. Develop the ability to design and implement controllers for various mechanical systems, fostering a deep understanding of control theory and its applications in real-world engineering problems.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Design and analyze control systems to optimize response characteristics for specific engineering applications.
CO2	Demonstrate software skills for modelling control systems.
CO3	Predict the performance and assess the stability of the control system.
CO4	Apply different control techniques and evaluate their effects on control system characteristics.

Detailed Syllabus

Experiment No.	*From the list below, conduct Compulsory Experiments 1 and 7, Any 1 from Experiments 3 and 4, Any 5 from the remaining list of experiments (Total 8 experiments)*	Duration (H)
1	Modelling and analysis of a mechanical system using suitable software.	02
2	Design a mathematical model for a Quarter Car system using Simulink.	04
3	Modelling and simulation of Anti-Lock Braking System (ABS) using suitable software (Self-study)	04
4	Modeling and simulation of a Mechanical system using Simscape (Self-study)	04
5	Stability analysis of a mechanical system using a suitable method	04
6	Construct the root locus plot in Simulink for a transfer function and observe the effect of changing system parameters on the pole locations.	04
7	Design of a PID controller for any mechanical system using simulation software.	04
8	Design and analyze a PID Controller for DC Motor.	04
9	Create an unstable system in Simulink, apply different control strategies to stabilize it, and analyze the stability of the closed-loop system	04
10	Compare the open-loop and closed-loop responses of a system in Simulink to understand the impact of feedback on system performance.	04
11	Modelling and simulation of a DC motor using Python.	04
12	Implement a machine learning algorithm for predictive control of any system	04
	Total	**30**

Text Books:

1. Kuo, B. C., & Golnaraghi, F. (2018). Automatic Control Systems (10th ed.). Wiley.
2. Chen, C. L., & Kuo, B. C. (2018). Linear Control System Analysis and Design with MATLAB (2nd ed.). Wiley.
3. Dorf, R. C., & Bishop, R. H. (2011). Modern Control Systems (12th ed.). Prentice Hall.
4. Nise, N. S. (2015). Control Systems Engineering (7th ed.). Wiley.
5. Khalil, H. K. (2015). Nonlinear Systems (3rd ed.). Prentice Hall.

Reference Books

1. Hughes, A., & Drury, B. (2019). Electric Motors and Drives: Fundamentals, Types and Applications. Newnes.
2. Chapman, S. J. (2012). Electric Machinery Fundamentals (5th ed.). McGraw Hill.
3. Ogata, K. (2010). Modern Control Engineering (5th ed.). Prentice Hall.
4. Franklin, G. F., Powell, J. D., & Emami-Naeini, A. (2015). Feedback Control of Dynamic Systems (7th ed.). Pearson.

e-Resources:

1. https://nptel.ac.in/courses/108102113 (Prof.Shubhendu Bhasin,IIT Delhi)
2. https://onlinecourses.nptel.ac.in/noc25_cs50/preview (By Prof. Carl Gustaf Jansson,KTH, The Royal Institute of Technology)
3. https://onlinecourses.nptel.ac.in/noc20_ee90/preview (Prof.Shankar Ram,IIT Madras)

Program:	**B. Tech. (Mechanical Engineering)**						**Semester :VI**	
Course:	**Advanced Materials and Characterization** (Programme Elective 2)						**Code : BME26PE11**	
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**FA**		**SA**	**Total**
					FA1	**FA2**		
3	**3**	**-**	**-**	**1**	**20**	**20**	**60**	**100**

Prior knowledge of: fundamental understanding of: Engineering Materials (Material Science and Metallurgy) Manufacturing Processes (Casting, Forming, Machining). Strength of Materials (Basic mechanical properties) Basic Physics and Chemistry (Atomic structure, bonding, phase transformations) is essential

Course Objectives:

This course aims at enabling the students to

1. Provide in-depth knowledge of advanced materials used in modern engineering applications.
2. Develop an understanding of the relationship between material structure, defects, properties, and performance.
3. Familiarize students with different material characterization techniques for microstructural, mechanical, and thermal analysis.
4. Establish foundation to analyse material performance and failure mechanisms.
5. Enhance the ability to select appropriate materials based on application-specific requirements.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	**Course outcome Statement**
CO1	**Explain** the significance of advanced materials.
CO2	**Justify** the selection of specific advanced material for a given application based on the structure-defect-property relationship.
CO3	**Predict** the mechanical behaviour of given sample by **analysing** its structure, texture and composition by applying fundamentals of material characterization techniques.
CO4	**Select** the most suitable material characterization techniques such as spectroscopy, thermal analysis and mechanical testing for specific applications with appropriate justification.
CO5	**Analyse** material performance and failure mechanisms using characterization data.

Detailed Syllabus

Unit	**Description**	**Duration (Hrs.)**
1	**Introduction to Advanced Materials:** Definition and importance of advanced materials, Classification, Introduction to the advanced alloys, Ceramics, Polymers, Composites, Smart materials, Nano materials, Biomaterials, and Functionally Graded Materials (FGMs), Self-healing materials, Case Studies on engineering applications.	**09 (CO1)**
2	**Structure-defect-property relationship:** Types of structures and textures in advanced materials, Defects in materials: Point defects, Line defects, Surface and volume defects, Strengthening mechanisms: grain refinement, solid solution strengthening, precipitation hardening, and Structure-Defect-Property relationship in advanced materials.	**09 (CO2)**
3	**Material Characterization Techniques– I:** Optical Microscopy (OM) and Image Analysis, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and Atomic Force Microscopy (AFM), X-ray Diffraction (XRD), Energy Dispersive Spectroscopy (EDS) and Electron Backscatter Diffraction (EBSD)	**09 (CO3)**
4	**Material Characterization Techniques– II:** Spectroscopy Techniques: X-ray Fluorescence (XRF), and Fourier Transform Infrared Spectroscopy (FTIR), Thermal Analysis: Differential Scanning Calorimetry (DSC) and Thermo gravimetric Analysis (TGA)	**09 (CO4)**

5	**Material Performance and Failure Analysis:** Wear and corrosion resistance of materials, stress-strain behaviour of advanced materials, High-temperature behaviour of advanced materials, Failure mechanisms: ductile, brittle and mix mode failure, fatigue failure, creep failure, Case studies of engineering failures of advanced materials, Applications of characterization techniques in material failure analysis.	**09 (CO5)**
	Total	**45**

Text Books:

1. Material Science and Engineering: An Introduction, William D. Callister, Wiley Publication, 10th Edition 2009.
2. Advanced Techniques for Materials Characterization, A. K. Tyagi, Mainak Roy, S. K. Kulshreshtha and S. Banerjee, Trans Tech Publications,2009

Reference Books

1. Materials for Engineering, John Martin, Woodhead Publishing Limited, CRC Press, 3rd Edition, 2006.
2. ASM Handbook, George F. Vander Voort, Metallography and Microstructures, Vol. 9.
3. Elements of X-ray Diffraction, B. D. Cullity S.R. Stock, Pearson New International Edition, 3rd Edition, 2014.
4. Scanning Electron Microscopy and X-Ray Microanalysis, Goldstein Joseph, Dale Newbury, David Joy, Charles Lyman, Patrick Echlin, Eric Lifshin, Linda Sawyer Springer-Verlag New York Inc., Third Edition 2003.
5. Foundations of Materials Science and Engineering, Smith, W. F., McGraw-Hill, 7th Edition,2023
6. Advanced Materials: An Introduction to Modern Materials Science, Ajit Behera, Springer Nature, 2021.
7. Advanced Materials Characterization, Ch Sateesh Kumar, M. Muralidhar Singh, Ram Krishna, CRC Press, 1st Edition, 2023.

e-Resources:

1. **NPTEL Course:** Advanced Materials and Processes by Prof. Jayanta Das, IIT Kharagpur (12 weeks) - https://onlinecourses.nptel.ac.in/noc22_mm40/preview
2. **Udemy:** Advanced Materials Characterization Techniques (Analytical): From Microscopy to Spectroscopy: A Comprehensive Approach, Electron Microscopy, Thermal analysis, X-ray Diffraction- https://www.udemy.com/course/advanced-materials-characterization-techniques-analytical/
3. Graduate Certificate in Advanced Materials Characterization, University of Kentucky - https://engr.uky.edu/academics/departments/mse/courses-curriculum/advanced-materials-characterization-certificate

Program:	**B. Tech. (Mechanical Engineering)**							**Semester :VI**
Course:	**Advanced Materials and Characterization Lab** (Programme Elective 2)							**Code** : **BME26PE16**
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**TW**	**PR**	**OR**	**Total**
1	**-**	**2**	**-**	**-**	**50**	**-**	**-**	**50**

Prior knowledge of: Type of materials, basic structure and properties of materials is essential

Course Objectives:

This course aims at enabling the students to

1. Significance of various material characterization techniques.
2. The use of various material testing standards and methods.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement	Experiment No
CO1	**Apply** optical metallography techniques to analyze grain size, phase distribution, and microstructural features.	**1**
CO2	**Interpret** X-ray diffraction (XRD) patterns to determine crystal structure and phase composition.	**2**
CO3	**Analyze** SEM, EDS and EBSD images for microstructural, elemental composition and textural characterization.	**3,4**
CO4	**Investigate** failure mechanisms through fractographic image analysis and **evaluate** defects using ultrasonic flaw detection.	**5,6**

Detailed Syllabus

Experiment No.	Description	Duration (Hrs.)
1	**Optical Metallography and Image Analysis** Sampling, polishing, etching techniques, and microstructure observation. Analysis of grain shape, grain size and phases. Image analysis for phase fraction determination using software tools.	**06**
2	**X-ray Diffraction (XRD) Image Analysis** Understanding Bragg's law and XRD pattern interpretation. Identification of phases and determination of crystallite size using Scherrer's equation. Determination of crystal structure and phase composition	**06**
3	**Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) Analysis** Grain morphology analysis of SEM images. Analysis of elemental composition using EDS data.	**06**
4	**Electron Backscatter Diffraction (EBSD) Image Analysis** Understanding Kikuchi patterns and indexing. Crystallographic orientation mapping and grain boundary analysis.	**04**
5	**Fractography Analysis** SEM Image analysis of Fracture surface. Identification of ductile, brittle, mix mode and fatigue fracture mechanisms.	**04**
6	**Ultrasonic Flaw Detection** Understanding the working principle of ultrasonic testing. Flaw detection in welded joints and metallic specimens.	**04**
	Total	**30**

Reference Books

1 ASM Handbook, George F. Vander Voort, Metallography and Microstructures, Vol. 9.

2 Elements of X-ray Diffraction, B. D. Cullity S.R. Stock, Pearson New International Edition, 3rd Edition, 2014.

3 Scanning Electron Microscopy and X-Ray Microanalysis, Goldstein Joseph, Dale Newbury, David Joy, Charles Lyman, Patrick Echlin, Eric Lifshin, Linda Sawyer Springer-Verlag New York Inc. Third Edition 2003

e-Resources:

1 **NPTEL Course:** Advanced Materials and Processes by Prof. Jayanta Das, IIT Kharagpur (12 weeks) - https://onlinecourses.nptel.ac.in/noc22_mm40/preview

2 **Udemy:** Advanced Materials Characterization Techniques (Analytical): From Microscopy to Spectroscopy: A Comprehensive Approach, Electron Microscopy, Thermal analysis, X-ray Diffraction- https://www.udemy.com/course/advanced-materials-characterization-techniques-analytical/

3 Graduate Certificate in Advanced Materials Characterization, University of Kentucky - https://engr.uky.edu/academics/departments/mse/courses-curriculum/advanced-materials-characterization-certificate

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Internal Combustion Engines (Programme Elective 2)						Code : BME26PE12	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
3	3	-	-	1	20	20	60	100

Prior knowledge of: Fundamental concepts of Thermodynamics, fluid mechanics is essential

Course Objectives:

This course aims at enabling the students to

1. To familiarize with the construction and working various engine systems
2. To understand the methods of theoretical analysis of I. C. engines
3. To learn the theory of combustion of S. I. and C. I. engines
4. To have understanding of various engine performance parameters and methods of measurement
5. To get familiar with the alternative fuels , pollution form I.C. engine and methods of controlling it

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Analyze air standard cycles of I. C. Engines based on various parameters.
CO2	Analyze Fuel-Air cycles and actual cycles of I. C. Engines based on various parameters.
CO3	Analyze the P-theta diagram of S.I. Engine for stages of combustion, rate of pressure rise, abnormal combustion etc.
CO4	Analyze the P-theta diagram of C.I. Engine for stages of combustion, rate of pressure rise, abnormal combustion etc.
CO5	Estimate the performance parameters of I. C. Engines and analyze the characteristics curves.
CO6	Compare various alternative fuels based on the desirable properties for I.C. Engines

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Engine Fundamentals** Heat Engine, IC and EC engines, Engine classification, I.C. Engine construction - components and materials, Engine nomenclature, Comparison of S.I. & C.I., 4-s and 2-s Engines, P-thetha Diagram comparison, Applications. Valve operating system, Valve timing diagram (Theoretical & Actual), Air standard cycles: Otto Cycle, Diesel cycle, Dual cycle and their comparison.	07 (CO1)
2	**Fuel-air and actual cycles** Fuel air cycle analysis and its importance, Assumptions and considerations, Effect of variables specific heat, dissociation, Effect of A/F ratio, Comparison with air standard cycle, Comparison of efficiencies of Fuel Air cycle, Air Standard cycle and Actual cycle, various losses in actual cycles, Effect of parameters on losses in actual cycle.	07 (CO2)
3	**SI Engines:** Fuel supply system of S. I. Engine: Air Fuel mixture requirements, Simple carburetor, systems of carburetor, Electronic fuel injection system T.B.I, M.P.F.I., G.D.I. System, sensors, actuators and ECU. Combustion in spark Ignition engines, stages of combustion, factors affecting combustion, rate of pressure rise, abnormal combustion: Detonation, Pre-ignition. Combustion chambers of S.I. Engine, Rating of fuels in SI engines, Additives.	08 (CO3)
4	**CI Engines:** Fuel supply system of C.I. engine, Mechanical Fuel Injection system, Electronic Diesel Injection system. Combustion in compression ignition engines, stages of combustion, factors affecting combustion, Phenomenon of knocking in CI engine. Types of combustion chambers, rating of fuels in CI engines, Dopes & Additives, Comparison of knocking in SI & CI engines, Supercharging and turbo-charging methods and their limitations	08 (CO4)

5	**Engine Performance & Testing:** Engine performance parameters, Methods of determination of various performance parameters, Engine performance characteristic curves, heat balance sheet, Comparison of Engine requirements of ICEV and HEV.	**07 (CO5)**
6	**Fuels and Emissions Control:** Important requirements of S.I. & C.I. Engine fuels, Possible alternative fuels: Alcohols, C.N.G., L.P.G., Biodiesel, Hydrogen etc., Air pollution due to IC engine and its effect, Emissions Norms, Sources of emissions, Components of emission, their causes, and Emission control methods for SI and CI engines.	**08 (CO6)**
	Total	**45**

Text Books:

1. M.L. Mathur and R.P. Sharma, A course in Internal combustion engines, Dhanpat Rai Publication, New Delhi,2016
2. V. Ganesan: Internal Combustion Engines, Tata McGraw-Hill, 2017
3. S. Shrinivasan, Automotive Engines, Tata McGraw-Hill,2019

Reference Books

1. Alternative Fuels for IC Engines, Anand Krishnasamy, Saurabh K Gupta, McGraw Hill, 2024
2. John B. Heywood, Internal Combustion Engine Fundamentals, Tata McGraw-Hill,2016
3. Internal Combustion Engine Technology and Applications of Biodiesel Fuel, Enhua Wang, IntechOpen, 2021

e-Resources:

1. NPTEL , IC Engines And Gas Turbines, By Prof. Pranab K. Mondal, Prof. Vinayak N. Kulkarni, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc24_me38/preview
2. NPTEL Course on 'Introduction to IC Engines and Air Pollution' by Prof. BP Pundir, IIT Kanpur

Program:	**B. Tech. (Mechanical Engineering)**						**Semester :VI**	
Course:	**Internal Combustion Engines Lab** (Programme Elective 2)						**Code : BME26PE17**	
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**TW**	**PR**	**OR**	**Total**
1	**-**	**2**	**-**	**-**	**50**	**-**	**-**	**50**

Prior knowledge of: Engineering Thermodynamics and Applied Thermal Engineering is essential

Course Objectives:

This course aims at enabling the students to

1. Get familiar with various components and sub-systems of an Internal Combustion (IC) engine.
2. Learn various software/programming tools to analyze IC engine
3. Get familiar with various engine test rigs for performance evaluation
4. Study latest emission norms

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	**Course outcome Statement**
CO1	Identify the components and sub-systems of IC Engines
CO2	Analyze IC engine using software tools
CO3	Conduct trials on SI/CI Engine to determine performance parameters
CO4	Interpret the Emission test results as per the latest pollution norms

List of Experiments

Experiment No	**Description:** **Note: All experiments are compulsory**	**Duration (Hrs.)**
1	Dismantling and assembly of two stroke/four stroke IC Engine	4
2	Visit the industry/servicing center to study various I.C. Engine types and their sub-systems	4
3	Study of Engines systems and their types: Cooling system, Lubrication system, Ignition system, governing system	2
4	Comparison of thermal efficiencies of air standard cycle and fuel air cycle using EES / suitable software tools	2
5	Drive cycle based engine sizing using EES / suitable software tools	4
6	Variable load test on Single cylinder CI engine to determine thermal efficiency, BSFC, Torque, Volumetric efficiency	4
7	Trial on single cylinder CI engine to calculate heat balance sheet	2
8	Variable speed test on Multi cylinder S.I. engine to determine various performance parameters	4
9	Morse test on Multi cylinder S.I. engine	2
10	Analysis of exhaust gases of S.I./C.I. Engines aligned with latest emission norms	2
	Total	**30**

Text Books

1. M.L. Mathur and R.P. Sharma, A course in Internal combustion engines, Dhanpat Rai Publication, New Delhi,2016
2. V. Ganesan: Internal Combustion Engines, Tata McGraw-Hill, 2017
3. S. Shrinivasan, Automotive Engines, Tata McGraw-Hill,2019

Reference Books

1. Alternative Fuels for IC Engines, Anand Krishnasamy, Saurabh K Gupta, McGraw Hill, 2024
2. John B. Heywood, Internal Combustion Engine Fundamentals, Tata McGraw-Hill,2016
3. Internal Combustion Engine Technology and Applications of Biodiesel Fuel, Enhua Wang, IntechOpen, 2021

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Fundamentals of Forming & Welding (Programme Elective 2)						Code : BME26PE13	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
3	3	-	-	1	20	20	60	100

Prior knowledge of: Introduction to manufacturing technology or manufacturing processes.
of basic concept of welding is essential

Course Objectives:

This course aims at enabling the students to

1. To apply metal casting principles, including pattern design, gating, risering, defects, and special casting processes.
2. To analyze bulk forming processes like rolling, forging, and extrusion by determining key process parameters.
3. To evaluate material properties' effects on sheet metal forming, defect identification, and forming techniques.
4. To classify welding processes and assess welding parameters' impact on heat distribution and weldability.
5. To explore powder metallurgy principles, including fabrication, characterization, compaction, and sintering effects.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Design** the gating system for casting.
CO2	**Compare** the forming output parameters for given applications.
CO3	**Analyze** the effect of material properties on sheet metal formability and understand various sheet metal processes.
CO4	**Apply** the principles of various welding, brazing, and soldering processes to analyze heat distribution, heat-affected zone (HAZ), and weldability of different materials.
CO5	**Implement** the principles of powder metallurgy to analyze the effects of particle size, shaping, compaction, and sintering on the microstructure and properties of materials.

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Metal Casting Processes** Introduction, Pattern Design, Gating System Design, Riser Design and Placement, Casting cleaning and defects, Special Casting Processes: Shell Moulding, Investment Casting, Die-casting, Centrifugal Casting, Continuous Casting, Squeeze Casting. Automation and smart manufacturing in casting, Sustainability and Eco friendly practices in casting.	**09 (CO1)**
2	**Bulk Forming Processes** Rolling: Determination of rolling pressure, roll separating force, torque and power. Forging: Basic steps of Forging, Forging of strip, disc, and determination of forging force. Extrusion: Determination of workload from stress analysis and energy consideration. Drawing: Wire Drawing, Tube Drawing, Determination of drawing force and power, Analysis of deep drawing operation.	**09 (CO2)**
3	**Sheet Metal Forming** Effect of properties on forming and formability, Shearing zone geometry, Sheet metal working processes – blanking, punching, bending, stretch forming, spinning, embossing, trimming, Deep Drawing: Determination of drawing force and power Ideal work and slab analysis; Defects in sheet metal formed products and their causes.	**09 (CO3)**
4	**Welding** Classification of welding processes, Arc welding processes – SMAW, GMAW, GTAW, plasma arc, submerged arc welding processes; modes of metal transfer in arc welding, Heat flow characteristic, Principles of solid-state welding processes – friction welding, friction	**09 (CO4)**

	stir welding, ultrasonic welding, Effect of welding parameter on heat distribution, heat affected zone (HAZ), factors affecting properties of HAZ, weldability of steel, cast iron and aluminium alloys, Advanced welding techniques.	
5	**Powder Metallurgy** Introduction to Powder Metallurgy, Powder Fabrication, Powder Characterization, Crystalline and Amorphous Structure, Effect of particle size on microstructure, Powder packing, mixing and blending, Shaping and Compaction, Sintering,Post sintering operations, Powder Injection Molding,.	**09 (CO5)**
	Total	**45**

Text Books:

1 Manufacturing Science, Amitabha Ghosh, Ashok Kumar Mallik, East-West Press Pvt. Ltd 2- Edition, 2010.
2 Manufacturing Technology, P. N. Rao, Volume I & II, McGraw Hill Education (India) Private Limited, 2018.
3 A Textbook of Production Technology, P. C. Sharma,, S. Chand Publication, 2022.

Reference Books

1 Manufacturing Engineering & Technology,Kalpakjian, Serope, and Steven R. Schmid.,9th Edition, Pearson Education, 2024.
2 Metal Forming Processes: Fundamentals, Analysis, Calculations, Z. Huda,, Springer, 2023.
3 Welding Metallurgy, Kou, Sindo, 3rd edition., Wiley, 2020.
4 Metal Forming Science and Practice, Lenard, John G. Elsevier Science, 2002.
5 The Metallurgy of Welding, Lancaster, J. F. 6th Edition, Woodhead Publishing, 1999.
6 Metal Forming Handbook, Schuler GmbH. Springer Berlin Heidelberg, 1998.

e-Resources:

1 Manufacturing Processes I, IIT Roorkee https://archive.nptel.ac.in/courses/112/106/112106153/#
2 Forming, IIT Madras **https://nptel.ac.in/courses/112107144**
3 Principles Of Metal Forming Technology, IIT Roorkee, https://archive.nptel.ac.in/courses/112/107/112107250/
4 Welding Engineering, IIT Roorkee, https://archive.nptel.ac.in/courses/112/107/112107090/
5 Welding Processes, IIT Madras, https://onlinecourses.nptel.ac.in/noc21_mm01/preview
6 Powder Metallurgy, IIT Madras, https://onlinecourses.nptel.ac.in/noc22_mm31/preview
7 E-Foundry, https://nkn.gov.in/en/services-lt-en/community-services-lt-en/e-foundry-lt-en

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Fundamentals of Forming & Welding Lab (Programme Elective 2)						Code : BME26PE18	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1	-	2	-	-	50	-	-	50

Prior knowledge of: basics of manufacturing processes, basic concepts of welding is essential

Course Objectives:

This course aims at enabling the students to

1. To develop an understanding of casting, bulk and sheet metal forming processes through simulation and experimental analysis, focusing on material behaviour, and process optimization.
2. To analyze and simulate the welding process using computational tools, studying temperature distribution, residual stresses
3. To study the principles of powder metallurgy by performing powder compaction and sintering, evaluating the effects of process parameters on material properties

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement	Experiment No.
CO1	**Evaluate** mold filling, solidification time using casting simulation software and validate results through experimental casting.	1,2
CO2	**Analyze** the sheet metal forming process using simulation or experimentation to assess material flow and stress distribution	3
CO3	**Execute** press cold forging by performing metal deformation and analyzing process parameters	4
CO4	**Apply** computational tools to simulate welding and analyze temperature, stresses, and weld formation	5
CO5	**Demonstrate** powder metallurgy principles by performing compaction and sintering and analyzing process parameter	6

Detailed Syllabus

Experiment No	Description:	Duration (Hrs.)
1	Analyze and understand the casting process by conducting a simulation using suitable software to predict mold filling, solidification, and potential defects and comparing it with AI-Enhanced Simulation	6
2	Validate the simulation for the casting process to analyze metal flow, solidification time, and defect formation using computational tools, evaluating the effects of process parameters on casting quality and comparing results through an actual casting experiment.	4
3	Study the sheet metal forming (stamping) process through simulation or experimental analysis, understanding material flow, stress distribution and defects such as spring back and wrinkling.	6
4	Understand the principles of press cold forging by performing metal deformation under compressive forces and analyzing the effects of different process parameters.	4

5	Simulate and analyze the welding process using computational tools to study temperature distribution, residual stresses, and weld bead formation.	6
6	Understand the principles of powder metallurgy by performing powder compaction and sintering, analyzing the effects of process parameters on material properties**.**	4
	Total	**30**

Text Books

1 Manufacturing Science, Amitabha Ghosh, Ashok Kumar Mallik, East-West Press Pvt. Ltd 2nd Edition, 2010.
2 Manufacturing Technology, P. N. Rao, Volume I & II, McGraw Hill Education (India) Private Limited, 2018.
3 A Textbook of Production Technology, P. C. Sharma,, S. Chand Publication, 2022.

Reference Books

1 Manufacturing Engineering & Technology, Kalpakjian, Serope, and Steven R. Schmid.,9th Edition, Pearson Education, 2024.
2 Metal Forming Processes: Fundamentals, Analysis, Calculations, Z. Huda,, Springer, 2023.
3 Welding Metallurgy, Kou, Sindo, 3rd edition, Wiley, 2020.
4 Metal Forming Science and Practice, Lenard, John G. Elsevier Science, 2002.
5 The Metallurgy of Welding, Lancaster, J. F. 6th Edition, Woodhead Publishing, 1999.
6 Metal Forming Handbook, Schuler GmbH. Springer Berlin Heidelberg, 1998.

e-Resources:

1 Manufacturing Processes I, IIT Roorkee https://archive.nptel.ac.in/courses/112/106/112106153/#
2 Forming, IIT Madras **https://nptel.ac.in/courses/112107144**
3 Principles Of Metal Forming Technology, IIT Roorkee, https://archive.nptel.ac.in/courses/112/107/112107250/
4 Welding Engineering, IIT Roorkee, https://archive.nptel.ac.in/courses/112/107/112107090/
5 Welding Processes, IIT Madras, https://onlinecourses.nptel.ac.in/noc21_mm01/preview
6 Powder Metallurgy, IIT Madras, https://onlinecourses.nptel.ac.in/noc22_mm31/preview
7 E-Foundry, https://nkn.gov.in/en/services-lt-en/community-services-lt-en/e-foundry-lt-en

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	**Computational Fluid Dynamics** (Programme Elective 3)						Code : BME26PE19	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
3	3	-	-	1	20	20	60	100

Prior knowledge of: Engineering Mathematics (Differential Equations, Linear Algebra), Fluid Mechanics, Thermodynamics, Heat Transfer, Programming Languages is essential

Course Objectives:

This course aims at enabling the students to

1. To introduce the fundamentals of CFD and its applications in engineering.
2. To develop skills in discretization techniques and numerical methods for solving fluid flow problems
3. To enable students to model, simulate, and analyze real-world fluid dynamics problems using CFD software.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Explain** the importance and applications of CFD, and **Describe** physical laws and mathematical tools.
CO2	**Interpret** and **Classify** the governing equations and boundary conditions for fluid flow problems
CO3	**Apply** discretization techniques to convert governing equations into algebraic forms.
CO4	**Implement** numerical methods for convection-diffusion and fluid flow problems, and **Analyze** their stability and convergence.
CO5	**Apply** appropriate CFD techniques to solve both compressible and incompressible flow problems.
CO6	**Analyze** real-world CFD applications, **Evaluate** model accuracy, and **Identify** errors and post-processing techniques.

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Introduction to Computational Fluid Dynamics** Importance and Applications of CFD; Governing laws: conservation of mass, momentum, and energy; CFD Workflow Essentials; Concept of Substantial Derivative, Divergence & Curl of Velocity; Reynolds transport theorem (RTT). CFD and AI/ML Interface,	07 (CO1)
2	**Governing Equations, Boundary Conditions, and Classification of PDEs** Fundamental Governing Equations for Fluid Flow; Conservative vs. Non-conservative form of the equations; Boundary and Initial Conditions; Classification of Partial Differential Equations: Elliptic, Parabolic, Hyperbolic	08 (CO2)
3	**Discretization Techniques** Introduction to Discretization Methods; Finite Volume Method (FVM): 1-D diffusion equation, Crank-Nicholson scheme; Finite Difference Method (FDM): Forward, Backward, and Central Differencing Schemes. Implicit, and Explicit; Grid Generation and Mesh Quality: Types, Quality Check and Mesh Independency.	08 (CO3)
4	**Numerical Methods for Solving Equations** Finite volume discretization of convection-diffusion problem: convection-diffusion formulation (1D and 2D) using FVM; Solution Techniques for Linear Algebraic Equations, Iterative Methods; Time Marching and Space Marching Techniques; Stability, Consistency, and Convergence of Numerical Methods.	08 (CO4)

5	**CFD Modeling of Flows: Compressible and Incompressible** Pressure-Velocity Coupling: SIMPLE, SIMPLER, and PISO Algorithms; Turbulence Modeling: Introduction to commonly used turbulence models like RANS, k-ε, and k-ω Models.	**07 (CO5)**
6	**Applications, Validation, and Error Analysis** CFD applications in heat transfer and fluid flow (internal and external); industrial case studies; verification and validation of CFD models; error sources and grid independence; post-processing and result interpretation.	**07 (CO6)**
	Total	**45**

Text Books:

1. Atul Sharma, Introduction to Computational Fluid Dynamics: Development, Application and Analysis, Ane Books Pvt. Ltd., Springer, 2022.
2. John D Anderson: Computational Fluid Dynamics- The Basics with Applications, McGraw-Hill, 2017.
3. H. Versteeg, and W. Malalasekara, An Introduction to Computational Fluid Dynamics: The Finite Volume, 2 nd Ed., Method, Pearson, 2011

Reference Books

1. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2012
2. H. Schlichting and K. Gersten, Boundary-Layer Theory, Springer, 2017.
3. Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, 2018.
4. W. Date, Introduction to Computational Fluid Dynamics, Cambridge Univ. Press, USA, 2012.
5. David C. Wilcox, Turbulence Modeling for CFD, DCW Industries, 2006.

e-Resources:

1. https://archive.nptel.ac.in/courses/112/105/112105254/, (by Prof. S. Chakraborty, IIT Kharagpur)
2. https://nptel.ac.in/courses/112105045 (by Prof. S. Chakraborty, IIT Kharagpur)
3. https://archive.nptel.ac.in/courses/112/106/112106186/

Program:	**B. Tech. (Mechanical Engineering)**						**Semester :VI**	
Course:	**Computational Fluid Dynamics Lab** (Programme Elective 3)						**Code : BME26PE24**	
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Hours**	**Other**	**TW**	**PR**	**OR**	**Total**
1	**-**	**2**	**-**	**-**	**50**	**-**	**-**	**50**

Prior knowledge of: Engineering Mathematics (Differential Equations, Linear Algebra), Fluid Mechanics, Thermodynamics, Heat Transfer, Programming Languages is essential

Course Objectives:

This course aims at enabling the students to

1. To understand and implement numerical methods for solving fluid flow and heat transfer problem
2. To develop CFD models and analyze flow behavior using MATLAB, Python, and ANSYS.
3. To validate simulation results by comparing them with theoretical and experimental data.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Apply numerical methods to solve fluid flow and heat transfer problems using MATLAB and Python.
CO2	Perform CFD simulations and analyze results using ANSYS Fluent.
CO3	Validate CFD results by comparing them with analytical and experimental data.

Detailed Syllabus

Experiment No	**Description:** **Note: Exp.1 is Compulsory; Exp. 2 to 7 (Any four); Exp. 8 to 13 (Any Four)**	**Duration (H)**
1	Introduction to CFD Lab: Problem Setup & Basic Concepts	6
2	Discretization of 1D/2D Heat Conduction Equation (FDM)	2
3	1D Unsteady Heat Conduction: Explicit / Implicit Methods	2
4	Lumped Heat Capacity Model	2
5	Heat Conduction Through a Slab	2
6	Laminar Pipe Flow Simulation	2
7	Lid Driven Cavity	2
8	Turbulent Pipe Flow Simulation	4
9	Flow Over a Cylinder (External Flow Study)	4
10	Natural Convection in a Cavity (Steady State/ Unsteady)	4
11	Heat Transfer in Porous Media	4
12	Conjugate Heat Transfer Problem	4
13	AI-Based CFD Problem Report Analysis and Submission	4
	Total	**30**

Text Books

1 Atul Sharma, Introduction to Computational Fluid Dynamics: Development, Application and Analysis, Ane Books Pvt. Ltd., Springer, 2022.
2 John D Anderson: Computational Fluid Dynamics- The Basics with Applications, McGraw-Hill, 2017.
3 H. Versteeg, and W.Malalasekara, An Introduction to Computational Fluid Dynamics: The Finite Volume, 2 nd Ed., Method, Pearson, 201

Reference Books

1 T. J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2012
2 H. Schlichting and K. Gersten, Boundary-Layer Theory, Springer, 2017.
3 Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, 2018.
4 W. Date, Introduction to Computational Fluid Dynamics, Cambridge Univ. Press, USA, 2012.
5 David C. Wilcox, Turbulence Modeling for CFD, DCW Industries, 2006.

e-Resources:

1 https://archive.nptel.ac.in/courses/112/105/112105254/, (by Prof. S. Chakraborty, IIT Kharagpur)
2 https://nptel.ac.in/courses/112105045 (by Prof. S. Chakraborty, IIT Kharagpur)

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	**Finite Element Analysis** (Programme Elective 3)						Code : BME26PE20	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
3	3	-	-	1	20	20	60	100

Prior knowledge of: Mathematics, Strength of Materials, Machine Design is essential

Course Objectives:

This course aims at enabling the students to

1. To understand the philosophy and general procedure of the Finite Element Method applied to solid mechanics and thermal analysis problems.
2. To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Apply the FEA method and develop finite element formulations of engineering problems from various applications.
CO2	Solve 1D problems like Spring, bar, beam, and Plane frame for displacements and stresses.
CO3	Derive and use 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.
CO4	Apply numerical integration methods to solve iso-parametric element problems.
CO5	Solve Dynamic problems and formulate Mass matrices of bar and beam elements.
CO6	Apply different methods to solve eigenvalue problems

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Unit 1: Fundamental Concepts of FEA** Introduction, A brief history of FEM, Finite Element terminology (nodes, elements, domain, continuum, degrees of freedom, loads & constraints), general steps involved in FEM, applications of FEM in various fields, advantages and disadvantages of FEM, essential and natural boundary conditions, Types of Analysis (Introduction): Linear static analysis, Non-linear analysis, Dynamic analysis, Linear buckling analysis, Thermal analysis, Fatigue analysis, and Crash analysis	**07 (CO1)**
2	**1D Elements** Review of solid Mechanics, Types of 1D elements, displacement function, Pascal's triangle, compatibility and completeness requirement, geometric isotropy, convergence requirements, global, local and Natural coordinate systems, Interpolation functions- linear, quadratic, properties of shape function, primary and secondary variables. Formulation of elemental stiffness matrix and load vector for Spring, bar, truss and beam using any approach, Assembly of global stiffness matrix and load vector, properties of stiffness matrix, half bandwidth, treatment of boundary conditions- elimination approach / Penalty Approach, stress and reaction forces calculations	**09 (CO2)**
3	**2D Elements** Two-Dimensional Stress Analysis: Plane Stress/Strain, Constant Strain Triangle (CST), geometry associative, mesh, quality checks, mesh refinement- p vs h refinements, Formulation of element stiffness matrix and load vector for Plane Stress/Strain problems Assembly of global stiffness matrix and load vector, Boundary conditions, solving for primary variables (displacement), stress calculations	**08 (CO3)**

4	**Iso-parametric Elements and Numerical Integration** Concept of isoperimetric elements: The terms are isoperimetric, super-parametric, and sub-parametric. Coordinate mapping: Natural coordinates, Area coordinates (for triangular elements), higher order triangular and quadrilateral elements (Lagrangian and serendipity elements), Numerical integration: Gauss Quadrature in one and two dimensions, Order of Gauss integration; sub-modelling, sub-structuring.	**06 (CO4)**
5	**Modal Analysis** Types of dynamic analysis include the general dynamic equation of motion, lumped and consistent mass, and mass matrices formulation of bar, truss, and beam elements. Undamped-free vibration: Eigenvalue problem, evaluation of eigenvalues and eigenvectors, natural frequency	**07 (CO5)**
6	**Transient Analysis** Finite element equations for vibration problems, Modelling for damping, Transformation-based method, Vector iteration method, Mode superposition scheme	**08 (CO6)**
	Total	**45**

Text Books:

1. Daryl L, A First Course in the Finite Element Method, Logan, 5th Revised ed. 2010.
2. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 4th Revised edition, 2012.
3. P. Seshu, Textbook of Finite Element Analysis, PHI Learning Private Ltd. , New Delhi, 2010.

Reference Books

1. Bathe K. J., Finite Element Procedures Prentice, Hall of India (P) Ltd., New Delhi.
2. Gokhale N. S., et al., Practical Finite Element Analysis, Finite to Infinite, Pune, 2020

e-Resources:

1. https://onlinecourses.nptel.ac.in/noc22_me43/preview [NPTEL COURSE]
2. https://nptel.ac.in/courses/112104193 [NPTEL COURSE]

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Finite Element Analysis Lab (Programme Elective 3)						Code : BME26PE25	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1	-	2	-	-	50	-	-	50

Prior knowledge of: Engineering Mechanics, Manufacturing Science is essential

Course Objectives:

This course aims at enabling the students to

1. To provide knowledge on different CAE Tools and CAE analysis.
2. To provide hands-on experience with finite element methods and the skills to analyze engineering problems with commercially available FEA software.

Course Outcomes: After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Apply the various meshing techniques for better evaluation of approximate results.
CO2	Apply material properties and boundary conditions.
CO3	Solve engineering problems using FEA software and generate the results as a contour plot using CAE tools.

Detailed Syllabus

Experiment No	Description:	Duration (Hrs.)
1	Introduction to Computer-Aided Engineering (CAE) • Use of CAE in Product development and its applications to engineering problems • Discretization method commonly used (FEM) for CAE. • Use of application software and different available software • CAE Tools- Pre-processor, Solver and Post-Processor. • Nodal unknowns and shape function (Quadratic function) • Meshing Techniques • Introduction to Ansys UI	2
2	1D Element – Structural Linear Analysis for 1D bar and Beam (Mesh Convergence), Validation of results using matrix method	4
3	Truss Analysis using 1D Element (Mesh Convergence), Validation of results using matrix method / solid mechanics method	4
4	Analysis of a Plate with a hole, and calculation of the stress concentration factor	4
5	Modal Analysis of any 1D and 3D component (Mesh Convergence), Validation of results (1D) using the eigenvalue method	4
6	Transient Structural Analysis (Mesh Convergence)	4
7	Analysis of any Machine Component using 3D Elements	4
8	Mini project/case study based on a research paper and presentation (group activity) • Static / Dynamic Analysis of components in the published paper • Match the contour plots of results with actual and published data • Prepare the presentation	4
	Total	30

Text Books

1. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis, Finite to Infinite, Pune, 1st Edition, 2008
2. The Finite Element Method and Applications in Engineering Using ANSYS® by Madenci, Erdogan, Guven, Ibrahim (Springer)
3. Seshu P., ―Textbook of Finite Element Analysis‖, PHI Learning Private Ltd., New Delhi, 2010.

Reference Books

1. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 3rd Edition, 2008.
2. Reddy, J. N., An Introduction to The Finite Element Method, Tata McGraw-Hill, 3rd Edition, 2017.

e-Resources:

1. https://onlinecourses.nptel.ac.in/noc22_me43/preview [NPTEL COURSE]
2. https://nptel.ac.in/courses/112104193 [NPTEL COURSE]

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	**Turbo machines** (Programme Elective 3)						Code : BME26PE21	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	FA		SA	Total
					FA1	FA2		
3	3	-	-	1	20	20	60	100

Prior knowledge of: Fundamental concepts of Thermodynamics, fluid mechanics is essential

Course Objectives: This course aims at enabling the students to

1. To provide the knowledge of basic principles, governing equations and applications of turbo machine.
2. To provide the students with opportunities to apply basic thermo-fluid dynamics flow equations to Turbo machines.
3. To explain construction and working principle and evaluate the performance characteristics of Turbo Machines

Course Outcomes: After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Articulate the fluid flow and thermodynamics fundamentals to turbo machines
CO2	Apply the governing equations of Turbo Machines
CO3	Outline the construction , working and performance of steam turbines
CO4	Analyze the performance of hydraulic turbines
CO5	Elucidate the performance parameters of centrifugal pumps
CO6	Analyze the performance of axial and centrifugal compressors

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Introduction to Turbo Machines:** Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification, Application of first and second law of thermodynamics to turbo machines, Efficiencies of turbo machines, Static and Stagnation states, Incompressible fluids and perfect gases, overall isentropic efficiency, stage efficiency (their comparison) and polytrophic efficiency for both compression and expansion processes. Reheat factor for expansion process, preheat factor	08 (CO1)
2	**Energy exchange in Turbo machines:** Euler's turbine equation, Alternate form of Euler's turbine equation, Velocity triangles for different values of degree of reaction, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance, Components of energy transfer, Degree of Reaction, utilization factor, Relation between degree of reaction and Utilization factor, blade nomenclature and cascade nomenclature	08 (CO2)
3	**Steam Turbines:** Steam nozzles: types and applications, Equation for velocity and mass flow rate, Steam Turbines: Classifications, construction details, compounding of steam turbines, velocity diagrams and analysis of Impulse and reaction turbines (single & multi stage), governing, dimensional analysis, performance characteristics. Losses in steam turbines, selection of turbines, governing of steam turbines.	07 (CO3)
4	**Hydraulic Turbines:** Classification, various efficiencies, Pelton turbine – velocity triangles, design parameters, Maximum efficiency, Francis turbine - velocity triangles, design parameters, runner shapes for different blade speeds. Kaplan and Propeller turbines - velocity triangles, design parameters, Draft tubes- Types and functions	07 (CO4)
5	**Centrifugal Pumps:** Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, velocity triangles and their analysis, effect of outlet blade angle, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel,	07 (CO5)

	system resistance curve, selection of pumps	
6	**Centrifugal & Axial Compressor:** Centrifugal compressor: Classification of compressors, Construction, velocity diagram, flow process on T-S Diagram, Euler's work, actual work input, performance characteristics, various losses in centrifugal compressor. Axial Compressor: Construction, stage velocity triangles and its analysis, enthalpy entropy diagram, stage losses and efficiencies, performance characteristics. [No numerical treatment]	**08 (CO6)**
	Total	**45**

Text Books:

1 Turbo Machines, B.U.Pai, Wiley India Pvt, Ltd, 1st Edition, 2013
2 Turbines, Compressors and Fans, S. M. Yahya Tata McGraw Hill Co. Ltd, 4th Edition, 2012
3 Turbo machinery- Introduction To Energy Conversion, Vol-3, V. Kadambi and Manohar Prasad, New Age International Publishers, reprint 2008
4 Turbo Machines, B.U.Pai, Wiley India Pvt, Ltd, 1st Edition, 2013

Reference Books

1 Fluid Mechanics & Thermodynamics of Turbo machines, S. L. Dixon, Elsevier, 2005
2 Fundamentals Of Turbo machines, Erik Dick, Springer, 2022

e-Resources:

1 https://archive.nptel.ac.in/courses/112/104/112104305/
2 https://archive.nptel.ac.in/courses/112/103/112103249/

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Turbo machines Lab (Programme Elective 3)						Code : BME26PE26	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1		2	-	-	50	-	-	50

Prior knowledge of: Fundamental concepts and laws/governing equations of physics and Mathematics, Fundamental concepts and laws/governing equations of Fluid Mechanics, thermodynamics, fluid machines is essential

Course Objectives: This course aims at enabling the students to

1. To experimentally verify the governing principle of Fluid machinery.
2. To learn to conduct trials on various machineries like water turbine, pumps, compressors, steam turbine
3. To learn to evaluate and analyze the performance of equipment water turbine, pumps, compressors, steam turbine
4. To understand operation, monitoring, controlling and troubleshooting of hydro/steam/gas turbine power plants /pumping station/water treatment plant and sewage plant.

Course Outcomes: After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Verify the impulse momentum principle.
CO2	Estimate the performance of various turbines.
CO3	Evaluate the performance of centrifugal pump and compressor.
CO4	Demonstrate the operation, monitoring, controlling and troubleshooting of turbo machines

List of experiments

Experiment No	Description: **Note: Experiment no. 1 to 6 and 9 are compulsory. Perform any 2 from the remaining experiments**.	Duration (Hrs.)
1	Verification of Impulse Momentum Principle	2
2	Study and trial on Impulse water turbine(Pelton Wheel Turbine) and plotting of performance characteristics curves	4
3	Study and trial on Reaction water turbine(Francis Turbine) and plotting of performance characteristics curves	4
4	Study and trial on Steam turbine and estimation of performance parameters.	4
5	Study and trial on Centrifugal Pump and plotting of performance characteristics curves	4
6	Study and trial on Centrifugal fan/blower/compressor and plotting of performance characteristics curves	4
7	Study and trial on convergent divergent water/steam/gas nozzle	2
8	Visit to pumping station/water treatment plant/sewage treatment Plant and preparation of report on operation, monitoring, controlling and troubleshooting.	2
9	Visit to hydro/steam /Gas turbine power plant and preparation of report on operation, monitoring, controlling and troubleshooting.	9
10	Design of pumping system	2
11	Determination of Thoma's cavitation factor' for a centrifugal pump	2
12	Performance prediction of water turbines/centrifugal pump/centrifugal compressor using ANN or any other prediction tool	2
13	Noise and Vibration analysis of Impulse/Reaction water turbine	2
14	Noise and Vibration analysis of Centrifugal pump/Centrifugal Compressor	2
	Total	**30**

Text Books

1 Modi P N & Seth S N, Hydraulics, Fluid Mechanics and Machinery, Standard Book House, New Delhi, 2017
2 Manish Dubey, BVSSS Prasad, Archana Nema ,Turbo-Machinery, , McGraw Hill,2018
3 Chow, V.T. and Maidment, Hydrology for Engineers, McGraw-Hill Inc., Ltd,2014

Reference Books

1 William W. Perg, Fundamentals of Turbo machinery, John Wiley & Sons,2007
2 S.M. Yahya ,Turbines, Compressors & Fans, Tata-McGraw Hill, 1983
3 B. U. Pai ,Turbo machines, Wiley India,2018
4 Johann Friedrich Gülich ,Centrifugal Pump ,2007ca
5 C. Witte, P.S. Schmidt, D.R. Brown,Industrial Energy Management and Utilization, Hemisphere Publication Washington,1988.

e-Resources:

1 https://fm-nitk.vlabs.ac.in/
2 https://www.damtp.cam.ac.uk/user/tong/fluids/fluids.pdf

Program:	**B. Tech. (Mechanical Engineering)**						**Semester :VI**	
Course:	**Industrial Engineering** (Programme Elective 3)						**Code : BME26PE22**	
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**FA**		**SA**	**Total**
					FA1	**FA2**		
3	**3**	**-**	**-**	**1**	**20**	**20**	**60**	**100**

Prior knowledge of: basic manufacturing processes, basic mechanical components is essential

Course Objectives: This course aims at enabling the students to

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

Course Outcomes: After learning the course, the students will be able to:

Sr. No.	**Course outcome Statement**
CO1	Apply principles of management and evaluate productivity of an organization/Scenario.
CO2	Apply different steps in method study/use different Recording methods to an operation.
CO3	Determine work content and standard time using different methods of work measurement including developing an understanding of Rating.
CO4	Apply/use different techniques / concepts of production planning and control.
CO5	Apply different techniques / concepts of work system design and facilities design pertinent to manufacturing industry.
CO6	Perform break-even analysis for investment decisions.

Detailed Syllabus

Unit	**Description**	**Duration (H)**
1	**Introduction to Industrial Engineering and Productivity** Definition and Role of Industrial Engineering, Functions of management, Types of production systems and organization structure. Measurement of productivity: Factors affecting the productivity, Productivity improvement techniques, Productivity Models and Index. Introduction to Value Engineering and Value Analysis.	**07 (CO1)**
2	**Method Study** Work Study: Definition, objective and scope of work-study, Human factors in work-study. Method Study: Definition, objective and scope of method study, work content, activity recording and exam aids, micro motion study. Applied Anthropometry, Work-Space Design, and Seating.	**08 (CO2)**
3	**Work Measurements** Work Measurements: Definition, objectives and uses, Work measurement techniques. Work Sampling: Need, confidence levels, sample size determinations, random observation, conducting study with the simple problems. Time Study: Definition, time study equipment, selection of job, steps in time study. Breaking jobs into elements, recording information, Rating and standard rating, standard performance, scales of rating, allowances and standard time determination. Introduction to PMTS and MTM: (Numerical), Introduction to MOST.	**07 (CO3)**
4	**Production Planning and Control** Introduction: Types of production systems, Need and functions of PPC, Aggregate production planning. Capacity Planning, ERP: Modules, Master Production Schedule, MRP and MRP-II. Forecasting Techniques: Causal and time series models, moving average, exponential smoothing, trend and seasonality (Numerical), Demand Control strategies (MTO, MTA, MTS). Introduction to Supply Chain Management: Basic terminologies. Role of Artificial Intelligence (AI) in Optimized Resource Allocation and Scheduling.	**08 (CO4)**

5	**Plant Location and Inventory Management** Plant Location: Need and factors influencing plant location, Plant Layout: Objectives, principles, types of plant layouts, Introduction to Assembly Line Balancing and Layout parameters to evaluate. Inventory control and Management: Types of inventories, Need of inventories, terminology, costs, Inventory Models: Basic production models, (with and without shortage and discount), ABC, VED Analysis. Role of Artificial Intelligence (AI) in Predictive Maintenance, Real-time Monitoring and Optimization.	**07 (CO5)**
6	**Costing and Human Factor in Industrial Engineering** Introduction to Marginal Costing: Elements of Cost, Break-Even Analysis. Techniques for Evaluation of capital investments. Human factors: Introduction to computer aided ergonomic analysis of workstation. Assessment of postures and identification of risks to body regions. Human Error, Accidents, and Safety, Human relation in industry, Performance appraisal, Human Factors in Systems Design.	**08 (CO6)**
	Total	**45**

Text Books:

1 Industrial Engineering and Production Management, M Mahajan, Dhanpat Rai and Co., 2015
2 Industrial Engineering and Production Management, M. Telsang, S. Chand Publication, 2018

Reference Books

1 Introduction to Work Study by ILO, ISBN 978-81-204-1718-2, Oxford & IBH Publishing Company, New Delhi, Second Indian Adaptation, 2008.
2 Maynard‘s Industrial Engineering Hand Book, H. B. Maynard, K Jell, McGraw Hill Education, 2001
3 Design and Analysis of Lean Production System, R. Askin, Wiley, 2001
4 Most Work Measurement Systems, Zandin K.B., ISBN 0824709535, CRCPress, 2002
5 SAP ERP: Functionality and Technical Configuration, Martin Murry, SAP Press, 2010
6 Motion and time Study design and Measurement of Work, R. Barnes, Wiley, 2009
7 ‘Process Simulation using WITNESS’, R. Al-Aomar, A. Williams, O. M. Uigen, Wiley, 2015
8 Applied Ergonomics, Hand Book, Brien Shakel, Butterworth Scientific, 1988
9 Introduction to Human factor and Ergonomics, R. C. Bridger, McGraw Hill, 2017
10 Human Factor Engineering and Design, M. Sanders and E. McCormick, McGraw Hill, 1992
11 Ergonomics: How to Design for Ease and Efficiency, K. Elbert and H. Kroemer, Prentice Hall, 2018

e-Resources:

1 https://onlinecourses.nptel.ac.in/noc21_me15/preview

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Industrial Engineering Lab (Programme Elective 3)						Code : BME26PE27	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1	-	2	-	-	50	-	-	50

Prior knowledge of: basic manufacturing processes, basic mechanical components is essential

Course Objectives:

This course aims at enabling the students to

1. To understand and apply the method study approach and work measurement techniques to analyze motions and time components involved in machining operations of a given job.
2. To develop detailed process plans, prepare motion charts, and design plant layouts for manufacturing operations, using standard symbols, CAD software, and simulation tools.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement	Experiment No.
CO1	Conduct motion and time analysis of machining operations using method study and work measurement techniques, identifying and eliminating inefficiencies.	1,2
CO2	Prepare comprehensive process plans and sequence of operation charts for the manufacturing of various components, ensuring systematic and efficient production planning.	3,4
CO3	Create detailed motion charts using standard therblig symbols to visually represent and analyze activities, aiding in process optimization.	5,
CO4	Design and simulate efficient plant layouts using simulation software, optimizing the arrangement of facilities and resources for improved production flow.	6,7,8

Detailed Syllabus

Experiment No	Description:	Duration (Hrs.)
1	Apply method study approach to analyze the motions involved in machining operation of the given job.	4
2	Apply work measurement technique to analyze the time components involved machining operation of given job using stop watch. Calculate standard time for all the operations involved.	4
3	Prepare motion chart of given activity using standard symbols of therbligs.	4
4	Prepare supply chain chart in day-to-day situation like supply of Cold drink/tooth paste/any grocery item/online purchase of goods/products.	4
5	Prepare detailed process plan/Sequence of operation chart for manufacturing of Hexagonal Nut/Hexagonal headed bolt/Stud/Wing Nut/Plain Washer.	4
6	Assembly line balancing, scheduling using any software.	4
7	Design the plant layout by using simulation software like Flexsim or any other open source.	4
8	Application of AI based tools for forecasting, planning, scheduling.	2
	Total	**30**

Text Books

1 Industrial Engineering and Production Management, M Mahajan, Dhanpat Rai and Co., 2015
2 Industrial Engineering and Production Management, M. Telsang, S. Chand Publication, 2018

Reference Books

1 Introduction to Work Study by ILO, ISBN 978-81-204-1718-2, Oxford & IBH Publishing Company, New Delhi, Second Indian Adaptation, 2008.
2 Maynard‘s Industrial Engineering Hand Book, H. B. Maynard, K Jell, McGraw Hill Education, 2001
3 Design and Analysis of Lean Production System, R. Askin, Wiley, 2001
4 Most Work Measurement Systems, Zandin K.B., ISBN 0824709535, CRCPress, 2002
5 SAP ERP: Functionality and Technical Configuration, Martin Murry, SAP Press, 2010
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7 ‘Process Simulation using WITNESS’, R. Al-Aomar, A. Williams, O. M. Uigen, Wiley, 2015
8 Applied Ergonomics, Hand Book, Brien Shakel, Butterworth Scientific, 1988
9 Introduction to Human factor and Ergonomics, R. C. Bridger, McGraw Hill, 2017
10 Human Factor Engineering and Design, M. Sanders and E. McCormick, McGraw Hill, 1992
11 Ergonomics: How to Design for Ease and Efficiency, K. Elbert and H. Kroemer, Prentice Hall, 2018

e-Resources:

1 https://onlinecourses.nptel.ac.in/noc21_me15/preview
2 http://vlabs.iitkgp.ac.in/cim/#

Program:	B. Tech. (Mechanical Engineering)						Semester :VI
Course:	**Robot Kinematics & Programming** (Programme Elective 3)						Code : BME26PE23
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme		
	Lecture	Practical	Tutorial	Other	FA	SA	Total
					FA1 / FA2		
3	3	-	-	1	20 / 20	60	100

Prior knowledge of: Solution of Matrices, Kinematics of Mechanisms, Force analysis of Mechanism, Mechatronics is essential

Course Objectives:

This course aims at enabling the students to

1. Classification of robots and homogeneous transformation of matrices.
2. Represent the robot in matrix form and perform Direct and Inverse kinematics.
3. Velocity, static force and dynamics analysis of the robot.
4. Generation of the required trajectory.
5. Identify the required robot programming.
6. Program the Robot for a given motion

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Classify** robots according to their application, and **Solve** homogeneous transformations for robot frame manipulation.
CO2	**Determine** the DH parameters of a robot and **Analyze** the forward and inverse kinematics of it.
CO3	**Analyze** the Velocity, Static Force, and Dynamics of a robot.
CO4	**Generate** a trajectory for robot for a given path.
CO5	**Describe** various types of programming methods used in robots.
CO6	**Develop** a program that solves a specific problem, **demonstrating** the application of programming principles.

Detailed Syllabus

Unit	Description	Duration (Hrs.)
1	**Fundamentals of robotics** Structure of a robot. Classification and applications of robots. Robot anatomy. Configurations of robots, work envelope, Dexterity and compliance of robots. Description of the frame in the robotic system. Homogeneous transformations and mapping of frames.	07
2	**Manipulator kinematics** Representation of joints and links using Denavit- Hartenberg parameters. Forward and Inverse kinematics of robots.	08
3	**Velocity, static force, and Dynamics** Linear and angular velocity of links, velocity propagation, manipulator Jacobians, manipulability, and singularity analysis. Static forces in manipulators. Introduction to Robot Dynamics.	07
4	**Trajectory generation** Considerations in path description, Joint space schemes, and Cartesian space schemes. Geometric problems in the generated paths.	08
5	**Basics of Robot Programming** Robot task planning, Robot programming methods, Robot programming languages and their requirements, Motion interpolation, motion & task level languages, robot language classifications and structures, Robot Safety.	07
6	**Robot Language: VAL** VAL language commands, motion control, hand control, program control, pick and place application, palletizing application, welding application.	08
	Total	45

Text Books:

1 Craig, J., (2022), "Introduction to Robotics Mechanics and Control" Pearson, ISBN-13: 978-1292164953.

2 Saha, S. K., (2024), "Introduction to Robotics", McGraw-Hill Education, ISBN-13: 978-9355326461.

Reference Books

1 Tsai, L. W., (1999), "Robot Analysis: The Mechanics of Serial and Parallel Manipulators," Wiley-Interscience, ISBN: 9780471325932

2 Niku, S. B., (2020), "Introduction to Robotics, Analysis, Control, Applications," Wiley, ISBN: 9781119527626

3 Mittle, R., Nagrath, I., (2017), "Robotics and Control," McGraw Hill Education, ISBN: 9780070482937

e-Resources:

1 Introduction to Robotics, by Prof. Asokan T, Prof. Balaraman Ravindran, Prof. Krishna Vasudevan, IIT Madras.
https://onlinecourses.nptel.ac.in/noc21_de13/preview

2 Robotics, by Prof. Dilip Kumar Pratihar, IIT Kharagpur.
https://onlinecourses.nptel.ac.in/noc21_me76/preview

3 Mechanism and Robot Kinematics, by Anirvan Dasgupra, IIT Kharagpur,
https://archive.nptel.ac.in/courses/112/105/112105236/

Program:	**B. Tech. (Mechanical Engineering)**						**Semester :VI**	
Course:	**Robot Kinematics & Programming Lab** (Programme Elective 3)						**Code : BME26PE28**	
Credit	**Teaching Scheme (Hrs./week)**				**Evaluation Scheme**			
	Lecture	**Practical**	**Tutorial**	**Other**	**TW**	**PR**	**OR**	**Total**
1	**-**	**2**	**-**	**-**	**50**	**-**	**-**	**50**

Prior knowledge of: Theory of Machines, Mechatronics, Basics of Electrical and Electronics Engineering is essential

Course Objectives:

This course aims at enabling the students to

1. Simulation of various types of Robots
2. Write robot programs

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	**Demonstrate** how to use transformation matrices to convert between different robot coordinate systems.
CO2	**Choose** an appropriate robot configuration for a given simple task and **set up** a basic simulation of that configuration in a suitable software.
CO3	**Demonstrate** the use of a programming language for the generated robot trajectory.
CO4	**Write** a basic robot program to perform a task and **simulate** its execution in suitable software.

Detailed Syllabus

Experiment No	List of Experiments (any six):	Duration (Hrs.)
1	Homogeneous **transformations and mapping** of frames using suitable software	**5**
2	**Simulation** of Cartesian/cylindrical/spherical robot.	**5**
3	**Simulation** of Articulated/SCARA robot.	**5**
4	**Virtual modelling** for the kinematics of a robot using suitable software	**5**
5	**Generate trajectory** for a path generation task	**5**
6	**Robot program for** a pick and place application	**5**
7	**Robot program for** the palletizing application	**5**
8	**Robot program for** the welding application	**5**
	Total	**30**

Text Books

1 Craig, J., (2022), "Introduction to Robotics Mechanics and Control" Mechanics and Control, Pearson, ISBN-13: 978-1292164953.

2 Saha, S. K., (2024), "Introduction to Robotics" McGraw-Hill Education, ISBN-13: 978-9355326461.

Reference Books

1. Tsai, L. W., (1999), "Robot Analysis: The Mechanics of Serial and Parallel Manipulators," Wiley-Interscience, ISBN: 9780471325932
2. Niku, S. B., (2020), "Introduction to Robotics, Analysis, Control, Applications," Wiley, ISBN: 9781119527626
3. Mittle, R., Nagrath, I., (2017), "Robotics and Control," McGraw Hill Education, ISBN: 9780070482937

e-Resources:

1. Introduction to robotics, By Prof. Asokan T, Prof. Balaraman Ravindran, Prof. Krishna Vasudevan, IIT Madras https://onlinecourses.nptel.ac.in/noc21_de13/preview
2. Robotics, by Prof. Dilip Kumar Pratihar, IIT Kharagpur. https://onlinecourses.nptel.ac.in/noc21_me76/preview
3. Mechanism and Robot Kinematics, by Anirvan Dasgupra, IIT Kharagpur, https://archive.nptel.ac.in/courses/112/105/112105236/

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Workshop Practice 3						Code : BME26VS05	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1	-	2	-	-	50	-	-	50

Prior knowledge of: Workshop Practice 1, Workshop Practice 2 is essential

Course Objectives:

This course aims at enabling the students to

1. To Familiarize students with the different types of CNC/VMC machines.
2. Introduce students to CNC/VMC control systems and programming software (such as CAD/CAM) used in machining.
3. Enable students to operate CNC/VMC machines safely and set up machines for production. to operate CNC/VMC machines safely and set up machines for production

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Write, modify, and execute CNC/VMC programs using G-code and M-code.
CO2	Select appropriate tools and execute tool presetting for CNC/VMC machining operations.
CO3	Work in a team for manufacturing given project.
CO4	Demonstrate safety practices while working on CNC/VMC.

Detailed Syllabus

Experiment No	List of Experiments	Duration (Hrs.)
1	Introduction to CNC/VMC machine.	4
2	Introduction to G and M codes and part programming.	4
3	Part programming and simulation using any simulation software for the part under consideration.	4
4	CNC Machine setup: Setting the machine's zero point, Loading and unloading materials, tools, and fixtures.	4
5	Manufacturing of any job assembly using CNC/VMC operations.	10
6	Inspection of the manufactured job.	2
7	CNC/VMC Machine Maintenance and Troubleshooting.	2
	Total	30

Text Books

1. P. N. Rao - Manufacturing Technology Volume I & II, McGraw Hill Education (India) Private Limited. W. F. Hosford, R. M. Caddell, Metal forming Mechanics and Metallurgy, Prentice-Hall, 2007
2. Mikel P. Groover – Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition by Pearson, 15 May 2024

e-Resources:

1. Computer numerical control CNC of machine tools and processes: https://onlinecourses.nptel.ac.in/noc19_me46/preview

Program:	B. Tech. (Mechanical Engineering)						Semester :VI	
Course:	Computer Aided Engineering Lab						Code : BME26VS06	
Credit	Teaching Scheme (Hrs./week)				Evaluation Scheme			
	Lecture	Practical	Tutorial	Other	TW	PR	OR	Total
1	-	2	-	-	50	-	-	50

Prior knowledge of: Fundamental knowledge of Engineering Thermodynamics, Fluid Mechanics, and Strength of Materials, Basics of Numerical Methods and Engineering Mathematics, Hands on experience on commercial design software like AutoCAD, PRO-E, CATIA, etc. is essential

Course Objectives:

This course aims at enabling the students to

1. To develop simulation skills using modern CAE tools, focusing on pre-processing, solving, and post-processing workflows.
2. To engage students in analyzing and interpreting fluid-thermal-structural interactions in mechanical systems.

Course Outcomes:

After learning the course, the students will be able to:

Sr. No.	Course outcome Statement
CO1	Use appropriate CAE tools to simulate thermo-fluid and structural engineering problems involving FEA and CFD.
CO2	Analyze simulation results to interpret thermal, fluid, and structural responses in real-world multi physics systems

Detailed Syllabus

Experiment No	List of Experiments: Note: Experiment 1, 2, and 3 are compulsory and any four from Remaining	Duration (Hrs.)
1	Introduction to CAE & Multi physics Applications (Overview of FEA + CFD integration)	2
2	Geometry Clean-up & Meshing for CFD/FEA	2
3	Basics of Fluid-Structure Interaction (FSI) (Coupled physics understanding)	2
4	Thermal Stress Analysis of Heat Exchanger (FEA + thermal analysis)	6
5	Heat Sink with Conjugate Heat Transfer (CFD + heat transfer + thermal stress)	6
6	Brake Disc Simulation: Thermal & Structural (Transient thermal stress)	6
7	Wind Load on Signboard / Panel (CFD wind force → Structural stress	6
8	Solar Panel Mount with Natural Convection (CFD + Thermal expansion)	6
9	Piping System: Flow + Structural Loading (Internal flow + Stress)	6
10	FSI Analysis of a Wing (CFD+ FEA)	6
11	Drone Arm Simulation under Rotor Thrust (CFD lift + FEA bending	6
	Total	**30**

Text Books

1. John D Anderson: Computational Fluid Dynamics- The Basics with Applications, McGraw-Hill, 2012.
2. H. Versteeg, and W.Malalasekara, An Introduction to Computational Fluid Dynamics: The Finite Volume, 2 nd Ed., Method, Pearson, 2011.
3. https://ansyshelp.ansys.com/public/account/secured?returnurl=/Views/Secured/corp/v242/en/icm_user/icm_user.html

Reference Books

1. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2012
2. H. Schlichting and K. Gersten, Boundary-Layer Theory, Springer, 2017.
3. Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, CRC Press, 2018.
4. W. Date, Introduction to Computational Fluid Dynamics, Cambridge Univ. Press, USA, 2012.
5. David C. Wilcox, Turbulence Modeling for CFD, DCW Industries, 2006.

e-Resources:

1. https://learninghub.ansys.com/learn
2. https://archive.nptel.ac.in/courses/112/105/112105254/, (by Prof. S. Chakraborty, IIT Kharagpur)
3. https://nptel.ac.in/courses/112105045 (by Prof. S. Chakraborty, IIT Kharagpur)

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To be the department of sustainable academic excellence, fostering innovation, skill development, and work ethics leading to globally competent mechanical engineers.

जागतिक स्तरावर सक्षम यांत्रिक अभियंत्यांना मार्गदर्शन करणारा नावीन्य, कौशल्य विकास आणि कामाच्या नैतिकतेला चालना देणारा शाश्वत शैक्षणिक उत्कृष्टतेचा विभाग बनणे.

MISSION

1. **Nurture cohesive learning environment and develop matching ecosystem.**

   एकसंध शिक्षण वातावरण जोपासणे आणि जुळणारी परिसंस्था विकसित करणे.

2. **Cultivate excellent work ethics and right attitude among students by imparting essential skills and knowledge.**

   आवश्यक कौशल्ये आणि ज्ञान देऊन विद्यार्थ्यांमध्ये उत्कृष्ट कार्य नैतिकता आणि योग्य दृष्टिकोन विकसित करणे.

3. **Instill a sense of creativity, social responsibility and environmental awareness among students.**

   विद्यार्थ्यांमध्ये सर्जनशीलता, सामाजिक जबाबदारी, आणि पर्यावरण विषयक जागरुकता निर्माण करणे.

Program Educational Objectives

1. **Conceptualize, design, model, simulate, and analyze mechanical components, systems and processes in complex interdisciplinary applications.**

2. **Develop sustainable solutions to real-life mechanical engineering problems in products and process industries.**

3. **To practice professional codes and conducts, safety norms, industrial engineering and management principles while working in the industry or as an entrepreneur.**

Program Specific Outcomes

1. **To cultivate knowledge and skills in formulating, analyzing, and solving interdisciplinary engineering problems among the mechanical engineering graduates.**

2. **To inculcate right attitude and awareness about codes of professional practice, social commitment, and life-long learning among the mechanical engineering graduates.**

3. **To enhance professional competence for catering to the needs and expectations of society as a profound Mechanical Engineer.**