G. H. RAISONI COLLEGE OF ENGINEERING

(An Autonomous Institute affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur)
Dual Accreditations NAAC "A+" Grade& NBA (Tier-I)
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B.E.MECHANICAL ENGG. 2018-19-SCHEME

Subject Code	Name of the Course	Teaching Scheme				Credits	Evaluation Scheme				
							Theory			Practical	Total Marks
		Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Cont.	
SEMESTER-I											
BFYL101	Matrices	1	1	-	2	2	10	15	25	--	50
BFYL102	Differential & Vector Calculus	1	1	-	2	2	10	15	25	--	50
BEEL101 BEEP101	AC & DC Circuits	1	-	2	3	2	10	15	25	25	75
BEEL102	AC & DC Machine	2	-	-	2	2	10	15	25	--	50
BEEL103	Energy Sources & Audit	1		-	1	1	10	15	--	--	25
BITL101 BITP101	Programming for Problem Solving	1	-	4	5	3	10	15	25	50	100
BECL104	Bio-System in Engg.	1	1	-	2	2	10	15	25	--	50
BCSP101	Data Analytics	-	-	2	2	1	--	--	--	25	25
BECL101 BECP101	Introduction to Digital System	1	1	2	4	3	10	15	25	25	75
BHUP103	Foreign Language	-	-	2	2	1	--	--	--	25	25
BHUP104	Liberal/ Creative Arts	-	-	1	1	0.5	--	--	--	25	25
BFYP131	Waste Management	-	-	2	2	1	--	--	--	25	25
BFYP132	Environmental Science	-	-	1	1	0.5	--	--	--	25	25
TOTAL		**9**	**4**	**16**	**29**	**21**	**80**	**120**	**175**	**225**	**600**

Subject Code	Name of the Course	Teaching Scheme				Credits	Evaluation Scheme				
							Theory			Practical	Total Marks
		Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Cont.	
SEMESTER-II											
BFYL103	Integral & Multiple Calculus	1	1	-	2	2	10	15	25	--	50
BFYL104	Ordinary & Partial Differential Equations	1	-	-	1	1	10	15	25	--	50
BCSP102	Data Structure	-	-	4	4	2	--	--	--	50	50
BFYP152	Internet of Things	-	-	2	2	1	--	--	--	25	25
BFYL121 BFYP121	Applied Physics	1	1	2	4	3	10	15	25	25	75
BMEP101	Engineering Graphics	-	-	2	2	1	--	--	--	25	25
BCEL101 BCEP101	Engineering Mechanics	1	-	2	3	2	10	15	--	25	50
BECP103	Embedded Programming	-	-	2	2	1	--	--	--	25	25
BMEP102	Digital Fabrication	-	-	4	4	2	--	--	--	50	50
BFYP151	Mini Model through Innovation & Creativity	-	-	4	4	2	--	--	--	50	50
BHUL101 BHUP101	Communication Skills	-	2	2	4	3	10	15	25	50	100
BHUP102	Ethics & Professional Competencies	-	-	2	2	1	--	--	--	25	25
BMBP101	Entrepreneurship	-	-	2	2	1	--	--	--	25	25
TOTAL		**4**	**4**	**28**	**36**	**22**	**50**	**75**	**100**	**375**	**600**

Subject Code	Name of the Course	Exam Mode	Teaching Scheme				Credits	Evaluation Scheme					
								Theory			Practical		Total Marks
			Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
SEMESTER-III													
BFYL116	Integral Transforms	Offline	1	1	-	2	2	10	15	25	-	-	50
BMEL222	Solid Mechanics	Offline	2	-	-	2	2	10	15	25	-	-	50
BMEL211 BMEP211	Fluid Mechanics and Machinery	Offline	2	-	2	4	3	10	15	50	-	25	100
BMEL212	Basics of Thermodynamics	Offline	1	1	-	2	2	10	15	25	-	-	50
BMEL213 BMEP213	Basics of Manufacturing Process	Offline	2	-	2	4	3	10	15	50	-	25	100
BMEL214 BMEP214	Materials &Nano Science	Offline	2	-	2	4	3	10	15	25	-	25	75
BMEP215	Computer Aided Machine Drawing	Online	-	-	2	2	1	-	-	-	-	25	25
BAIL101	Open Elective 1	Online	2	-	-	2	2	10	15	25	-	-	50
BAIP202	Skill Development - 1	Viva - Voice	-	-	2	2	1	-	-	-	25	-	25
BHUP202	Reasoning	Online	-	-	1	1	0.5	-	-	-	25	-	25
BHUP204	Liberal Arts/Creative Arts (Hobby Module)	Viva - Voice	-	-	1	1	0.5	-	-	-	25	-	25
TOTAL			**12**	**2**	**12**	**26**	**20**	**70**	**105**	**225**	**75**	**100**	**575**

Subject Code	Name of the Course	Exam Mode	Teaching Scheme				Credits	Evaluation Scheme					
								Theory			Practical		Total Marks
			Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
SEMESTER-IV													
BFYL117	Fourier series and Partial Differential Equations	Offline	1	1	-	2	2	10	15	25	-	-	50
BMEL216	Kinematics of Machines	Offline	2	-	-	2	2	10	15	25	-	-	50
BMEL217	Strength of Material	Offline	1	1	-	2	2	10	15	25	-	-	50
BMEL218	Applied Thermodynamics	Offline	2	-	-	2	2	10	15	25		-	50
BMEL219 BMEP219	Machining Process	Offline	2	-	2	4	3	10	15	50	-	25	100
BMEL220 BMEP220	Sensor, Actuators & Measurement	Offline (Activity Based)	1	-	2	3	2	10	15	50	-	25	100
BMEP221	Industrial safety practices	Practical Based	-	-	2	2	1	-		-	25	-	25
BMEP224	Skill Development - 2	Viva - Voice	-	-	2	2	1	-	-	-	25	-	25
BCSP208	Data Base	Practical Based	-	-	2	2	1	-	-	-	25	-	25
BMBP102	EDP	Viva - Voice	-	-	2	2	1	-	-	-	25		25
BHUP206	Aptitude 1	Online	-	-	1	1	0.5	-	-	-	25	-	25
BHUP203	Quant	Online	-	-	1	1	0.5	-	-	-	25	-	25
BHUP205	Business English Certification	Viva - Voice			4	4	2	-	-	-	-	25	25
TOTAL			**9**	**2**	**18**	**29**	**20**	**60**	**90**	**200**	**150**	**75**	**575**

Subject Code	Name of the Course	Exam Mode	Teaching Scheme				Credits	Evaluation Scheme					
								Theory			Practical		Total Marks
			Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
SEMESTER-V													
BFYL118	Statistics& Probability	Offline	1	-	-	1	1	10	15	25	-	-	50
BMEL321 BMEP321	Dynamics of Machines	Offline	2	-	2	4	3	10	15	50	-	25	100
BMEL322	Energy Conversion	Offline	2	-	-	2	2	10	15	50	-	-	75
BMEL323	Elective 1	Offline	2	-	-	2	2	10	15	50	-	-	75
xxxxxxx	Elective 2 (Science)	Offline	2	-	-	2	2	10	15	25	-	-	50
xxxxxxx	Elective 3 (Universal Human Values 2: Understanding Harmony)	Offline	2	1	-	3	3	10	15	50	-	-	75
BMEP331	Product Design and Packaging	Offline	-	-	1	1	0.5	-	-	-	25	-	25
BMEP332	Internship (2 Week)	Offline	-	-	2	2	2	-	-	-	25	-	25
MBP104	Advanced Communication Skills and Employability	Viva - Voice	-	-	4	4	2	-	-	-	50	-	50
BMEP333	Skill Development 3	Viva - Voice	-	-	2	2	1	-	-	-	25	-	25
BAIL203	Machine Learning Algorithms	Online	2	-	-	2	2	10	15	25	-	-	50
BHUP302	Aptitude 2	Online	-	-	1	1	0.5	-	-	-	25	-	25
TOTAL			**13**	**1**	**12**	**26**	**21**	**70**	**105**	**275**	**150**	**25**	**625**

Subject Code	Name of the Course	Exam Mode	Teaching Scheme				Credits	Evaluation Scheme					
								Theory		Practical			Total Marks
			Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
SEMESTER-VI													
BFYL119	Optimization techniques	Offline	1	-	-	1	1	10	15	25	-	-	50
BMEL336	Design of Machine elements	Offline	3	-	-	3	3	10	15	50	-	-	75
BMEL337 BMEP337	Thermal Engineering	Offline	2	-	2	4	3	10	15	50	25	-	100
BMEL338 BMEP338	Heat Transfer	Offline (Activity Based)	2	-	2	4	3	10	15	25	50	-	100
BMEL339	Elective 4	Offline	2	-	-	2	2	10	15	25	-	-	50
BMEP345	Design of Mechanical Drives	Practical Based	-	-	2	2	1	-	-	-	25	-	25
BMEP346	Vehicle Design	Practical Based	-	-	2	2	1	-	-	-	25	-	25
BMEP347	Project Management	Offline	-	-	2	2	1	-	-	-	25	-	25
XXXXXXX	Open Elective 2	Online	2	-	-	2	2	10	15	25	-	-	50
BHUP207	Soft Employability skill	Viva - Voice	-	-	1	1	0.5	-	-	-	25		25
BHUP303	Aptitude 3	Online	-	-	1	1	0.5	-	-	-	25	-	25
BMEP348	Product Development & IPR	Viva - Voice	-	-	2	2	1	-	-	-	25	-	25
BMEP349	Skill Development 4	Viva - Voice	-	-	2	2	1	-	-	-	25	-	25
TOTAL			**12**	**0**	**16**	**28**	**20**	**60**	**90**	**225**	**250**	**-**	**600**

Subject Code	Name of the Course	Exam Mode	Teaching Scheme				Credits	Evaluation Scheme					
								Theory			Practical		Total Marks
			Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
SEMESTER-VII													
BMEL411	MOOCs	Online	8	-	-	8	4	10	15	50	-	-	75
BMEP408	Six Month Industry Internship	Viva - Voice	-	-	24	24	12	-	-	-	100	200	300
BMEP409	Major Project phase I	Viva - Voice	-	-	8	8	4	-	-	-	50	50	100
TOTAL			**8**	**-**	**32**	**40**	**20**	**10**	**15**	**25**	**150**	**250**	**475**

Subject Code	Name of the Course	Exam Mode	Teaching Scheme				Credits	Evaluation Scheme					
								Theory			Practical		Total Marks
			Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
SEMESTER-VIII													
BMEL414 BMEP414	Elective 5	Offline	2	-	2	4	3	10	15	50	25	-	100
XXXXX	Elective 6 (Inter disciplinary)	Offline	2	-	-	2	2	10	15	25	-	-	50
BMEL420	Elective 7	Offline	2	-	-	2	2	10	15	25	-	-	50
BMEL426	Elective 8	Offline	2	-	-	2	2	10	15	25	-	-	50
BMEL432	Elective 9	Offline	2	-	-	2	2	10	15	50	-	-	75
BMEP410	Major Project Phase II	Viva - Voice	-	-	4	4	4	-	-	-	50	50	100
BHUP304	Career Development Practice	Activity Based	-	-	2	2	1	-	-	-	25	-	25
TOTAL			**10**	**0**	**8**	**18**	**16**	**50**	**75**	**175**	**100**	**50**	**450**

Department of Mechanical Engineering
Elective List (New scheme) 2018-19

V SEM **Elective I** **(Mechanical Department)**

Sr. No.	Subject code	Name of Elective
01	BMEL323	Non-conventional Energy Sources
02	BMEL324	Bio Mechanics
03	BMEL325	Industrial Engg. & Management
04	BMEL326	Smart Materials & Structures
05	BMEL327	Compressor and Pumps
06	BMEL328	Simulation of manufacturing system
07	BMEL329	Welding Technology (Industry Elective)

V SEM **Elective II** **(Science)**

Sr. No.	Subject code	Name of Elective
01		

V SEM **Elective III** **(Humanities)**

Sr. No.	Subject code	Name of Elective
01		

VI SEM **Elective IV** **(Mechanical Department)**

Sr. No.	Subject code	Name of Elective
01	BMEL339	Gas Turbine and Jet Propulsion
02	BMEL340	Advanced IC Engine
03	BMEL341	Reliability & TQM
04	BMEL342	Industrial Design
05	BMEL343	Mechanical Vibration
06	BMEL344	Engineering Ergonomics

VIII SEM **Elective V (Practical based)** **(Mechanical Department)**

Sr. No.	Subject code	Name of Elective
01	BMEL414	Refrigeration and Air-conditioning
02	BMEL415	Fuel and Combustion
03	BMEL416	Computer Aided Design
04	BMEL417	Finite Element Method
05	BMEL418	Maintenance Engineering
06	BMEL419	Automation in Production

VIII SEM **Elective VI** **(Interdisciplinary)**

Sr. No.	Subject code	Name of Elective
01		

VIII SEM **Elective VII** **(Mechanical Department)**

Sr. No.	Subject code	Name of Elective
01	BMEL420	Computational Fluid Dynamics
02	BMEL421	Power Plant Engg.
03	BMEL422	Machine Condition Monitoring
04	BMEL423	Vehicle Dynamics
05	BMEL424	Corrosion Engineering
06	BMEL425	Entrepreneurship and Development

VIII SEM **Elective VIII** **(Mechanical Department)**

Sr. No.	Subject code	Name of Elective
01	BMEL426	Automobile Engineering
02	BMEL427	Energy Management
03	BMEL428	Advanced Tool Design
04	BMEL429	Mechanics of Composite Materials
05	BMEL430	Advanced Casting Materials
06	BMEL431	Tribology

VIII SEM **Elective IX** **(Mechanical Department)**

Sr. No.	Subject code	Name of Elective
01	BMEL432	Advanced Cryogenics
02	BMEL433	Energy Storage System
03	BMEL434	Operation Research and Management
04	BMEL435	Robotics and Machine Vision
05	BMEL436	Stress Analysis
06	BMEL437	MEMS

SEMESTER-III

BFYL116: Integral Transforms

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
1	1	--	2	2	10	15	25	----	----	50

Course Objectives:

1. To understand the concept of Laplace transform & Fourier Transform.
2. To understand basic concept control system.

Course Outcomes: Upon the successful completion of course, the student shall be able to:

1. Understand properties of Laplace Transform.
2. Apply the concept of Laplace transform to solve problems on unsteady state heat transfer
3. Apply Laplace transform in Control system.
4. Solve the problems of Fourier transform in Mechanical Engineering.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	--	---	--	---	--	--	--
CO2	3	2	---	---	---	--	--	--	--
CO3	3	2	--	---	---	---	--	--	--
CO4	3	2	--	---	---	---	--	--	--

Contents:

UNIT-I **[6 Hrs]**

Laplace Transform: (CO1)

Definition of Laplace transform and its properties Laplace transform of periodic function. Unit Step functions.

UNIT-II **[9 Hrs]**

Applications of Laplace transform: (CO2)

Inverse Laplace transform Convolution theorem, Application of L.T. to solve ordinary differential equations.

UNIT-III (CO3) **[5 Hrs]**

Application of integral transform in Control system:

Analogous system, Transfer function, Stability of system, Routh criterion

UNIT-IV **[10 Hrs]**

Fourier Transform (CO4)

Definition, Fourier integral theorem, Fourier sine & cosine integrals, finite Fourier sine & cosine transforms, Parseval's identity, convolution theorem.

Text Books:

1. Higher engineering Mathematics by B S Grewal, 43rd edition, Khanna Publication.
2. Advanced engineering Mathematics by Erwin Kreysizig, 8th edition Wiley India

Reference Books:

1. Advanced Mathematics for Engineers and Scientists; Spiegel, M. R, McGraw-Hill
2. Advanced Engineering Mathematics, Jain, R.K. and Iyengar, S.R.K, Narosa Publishers; Alpha Science International, Ltd.

Online Courses:-

1. Advanced Engineering Mathematics Prof. P N Agrawal IIT Roorkee, https://onlinecourses.nptel.ac.in/noc19_ma11/preview

Subject Experts

1. Prof. P N Agrawal, Department of Mathematics, IIT Roorkee.

SEMESTER-III

BMEL222: Solid Mechanics

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	_	_	2	2	10	15	25	----	----	50

Course Objectives:

1. To understand the fundamentals of Mechanics.
2. To understand the concept of friction and its importance.
3. To facilitate the concept of stresses induced in beam.
4. To learn importance of principle stresses and strain in engineering.

Course Out Comes:

Upon the successful completion of course, the student shall be able to:

1. Understand concept of center of gravity and moment of inertia in context with engineering applications.
2. Apply the concept of friction in engineering applications and allied areas.
3. Identify and resolve the stresses induced in the beams.
4. Design various engineering application with consideration of principle stresses and strain.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	3	2	1	2	2	-	-
CO2	2	3	3	2	1	1	1	-	-
CO3	3	3	3	2	1	2	3	-	-
CO4	2	2	2	3	3	1	2	-	1

Contents:

Unit I (CO1) [8 Hrs.]

Introduction to Mechanics, Centre Of Gravity And Moment Of Inertia: Determination of Areas and Volumes, Centre of Gravity and Centroids, Centroid of a Line, First Moment of Area and Centroid, Second Moments of Plane Area, Moment of Inertia from First Principles, Moment of Inertia of Composite Sections, Theorems of Pappus-Guldinus, Centre of Gravity of Solids,

Unit II (CO2) [8 Hrs.]

Friction: Coefficient of Friction, Laws of Friction, Angle of Friction, Angle of Repose and Cone of Friction, Problems on Blocks Resting on Horizontal and Inclined Planes, Application to Wedge Problems, Application to Ladder Problems, Belt Friction.

Unit III (CO3) **[7 Hrs.]**

Columns and Struts: Failure of long and short column, slenderness ratio, assumptions made in Euler's column theory, end conditions for column. Expression for crippling load for various end conditions of column. Effective length of column, limitations of Euler's formula, Rankine formula, Johnson's parabolic formula.

Unit IV (CO4) **[7 Hrs.]**

Principal Stresses And Strains: Stresses on Inclined Planes Principal Stresses and Planes, Principal Stresses in Beams, Principal Strains.

Advance topic on the subject

Text Books:

1. Mechanics of Solids, Stephen H. Crandall, M.S. Shivakumar, Tata McGraw Hill Publishers, 2012.
2. Mechanics of Solids, Dr. H. J. Shah, Charotar publishing house pvt. Ltd., 1st edition 2008.
3. Engineering Mechanics, F.L. Singer, Harper Pollins Publisher, 1975.
4. Mechanics of Solids, S.S. Bhavikatti, New Age International pvt. Ltd. Publisher, first edition, 2010.

Reference Books:

1. Engineering Mechanics of Solids, Egor P. Popov, Prentice Hall Publishers, Second edition, 2013.
2. Strength of Materials, S. P. Timoshenko, East West Press, 5th edition, 2011.

Online Courses

1. Solid Mechanics By Prof. Ajeet Kumar, IIT Delhi, https:// swayam.gov.in/ nd1_noc19_me43/ preview.
2. Solid Mechanics By Professor Louis Bucciarelli, MIT, https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-050-solid-mechanics-fall-2004
3. Solid Mechanics By Dr. Wayne Whiteman, Georgia Institute of Technology, https://www.coursera.org/learn/mechanics-1

Subject Experts

1. Nachiketa Tiwari, Department of Mechanical Engg., IIT Kanpur
2. Bhanu Mishra, Department of Mechanical Engg., IIT Roorkee

SEMESTER-III

BMEL211/BMEP 211: Fluid Mechanics & Machinery

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	2	4	3	10	15	50	----	25	100

Course Objectives:

1. To understand the basic fluid properties like density, specific gravity etc.
2. To understand type of fluid flows, continuity equation, venturimeter, orificemeter.
3. To understand the concept of boundary layer
4. To study various techniques of dimensional analysis
5. To learn and understand the working principles of fluid machineries and to study their design aspects, performance characteristics.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand various pressure measurement instruments.
2. Apply basic laws for open and closed channel fluid flow.
3. Evaluate different hydraulic losses in fluid flow systems.
4. Analyze performance of different fluid machineries.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	2	2	2	1	2	3	3	--
CO2	3	2	3	2	2	2	3	3	--
CO3	2	3	3	2	1	2	3	3	--
CO4	1	3	2	3	3	2	3	3	--

Contents:

UNIT- I [8hrs]

Properties of Fluid :(CO 1)

Properties of fluid, Pressure measurement with Simple and differential manometers. Density, Specific gravity, Specific Weight, Specific Volume Dynamic Viscosity, Kinematic Viscosity, Surface tension, Capillarity, Vapour Pressure, Compressibility Fluid pressure, Pressure head, Pressure intensity Concept of absolute vacuum, gauge pressure, atmospheric Pressure, absolute pressure.

UNIT- II [7hrs]

Fluid Flow: (CO 2)

Types of fluid flows, Kinematics of fluid flow, Continuity equation, Euler's and Bernoulli's theorem and equation, Flow measurement.

UNIT-III [8 hrs]

Flow through Pipes :(CO 3)

Laws of fluid friction (Laminar and turbulent), Darcy's equation and Chezy's equation for frictional losses. Minor losses in pipes Hydraulic gradient and total gradient line. Hydraulic power transmission through pipe, Energy Gradient.

UNIT-IV [8 hrs]

Hydro Turbines (CO 4)

Theory of impulse & reaction turbines, Principle, Constructional features, analysis and governing. Specific speed. Cavitation in Turbines. Introduction to Positive and dynamic displacement pumps. Dimensional analysis and model Testing.

Text Books:

1. Fluid Mechanics and Fluid Machines, by Dr. D.S. Kumar, 4th Edition; S. K. Kataria & Sons, 1992.
2. Fluid Mechanics and Fluid Machines, by Dr. R.K. Bansal, 7th Edition; Laxmi Publications, 2002.

Reference Books:

1. Lal Jagdish; Hydraulic machines, 6th Ed; Metropolitan Book Co. Pvt. Ltd., 1984
2. Massey B.S.; Mechanics of Fluids, 6th Ed; Van Nostrand Reinhold Co., 1989
3. R.K. Rajput, A Text book of Fluid Mechanics and Hydraulic Machines, S. Chand 4th edition 2013
4. Mod i& Seth ,Fluid Mechanics & Fluid Machinery, Standard Book House 2002.
5. K. Subramanya, Hydraulic Machines, Tata McGraw Hill Publication Co., New Delhi, 1st Ed., 2013.

Online Courses

1. Fluid Mechanics Prof. S. K. Som, IIT Kharagpur NPTEL https://nptel.ac.in/courses/112105171/
2. Fluid Machinery Prof. Gautam Biswas, S. Sarkar, S. K. Som, IIT Kanpur, NPTEL https://nptel.ac.in/courses/112104117/
3. Fluid Machines S K Som IIT Kharagpur, swayam, https://swayam.gov.in/courses/3680-fluid-machines
4. Fluid Dynamics and Turbo-machines, Dhiman Chatterjee, IIT Madras, swayam, https://swayam.gov.in/courses/3683-fluid-dynamics-and-turbomachines
5. Fundamentals of Fluid Power. James D. Van De Ven. University of Minnesota, coursera, https://www.coursera.org/learn/fluid-power

Subject Experts

1. Prof. Gautam Biswas, Department of Mechanical Engg., IIT Guwahati.

SEMESTER-III

BMEL212: Basics of Thermodynamics

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
1	1	--	2	2	10	15	25	----	----	50

Course Objectives:

1. Identify the unique vocabulary associated with thermodynamics through the precise definition of basic concepts.
2. Explain the basic concepts of thermodynamics such as system, state, state postulate, equilibrium, process, cycle, energy, and various forms of energy.
3. Review concepts of temperature, temperature scales, pressure, and absolute and gage pressure.
4. Introducing basics of ideal and real gases, steam formation, basic laws of thermodynamics, and their applications.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Explain fundamental concepts of thermodynamics to thermodynamic systems.
2. Apply gas laws to thermodynamic processes.
3. Outline the first law of thermodynamics and compute the work involved, heat transfer in the given processes.
4. Analyze the second law of thermodynamics and their application to a wide range of systems with calculations of the efficiencies of heat engines and other engineering devices.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	2	2	1	2	3	--	3	--
CO2	2	3	2	1	2	2	--	3	--
CO3	3	2	2	1	2	2	--	3	--
CO4	3	2	2	2	2	2	--	3	--

Contents:

Unit I (CO1) Basic concepts and properties [6 Hrs]

Introduction, thermodynamic system, control volume, macroscopic and microscopic approaches, properties and state of a system, point and path functions, thermodynamic equilibrium, processes and cycles, quasi-static process, properties such as specific volume, pressure, temperature, zeroth law of thermodynamics, temperature scales, thermodynamic heat and work.

Unit II (CO2) Ideal Gas [6 Hrs]

Concept, Laws of ideal gas, Equation of state, universal gas constant.

Unit III (CO3) First law of thermodynamics [8 Hrs]

Energy of systems, classification of energy, law of conservation of energy, first law applied to closed system undergoing a cycle, Joule experiment, specific heat at constant volume and constant pressure, change in internal energy and heat transfer during various non-flow processes. First law applied to flow processes: steady-state steady flow process, mass balance and energy balance in steady flow process, steady flow energy equation and its application

Unit IV (CO4) Second law of thermodynamics [7 Hrs]

Second Law Of Thermodynamics: Second Law of Thermodynamics :- Introduction, Thermal energy reservoirs, Kelvin-Plank &Clausius statements, Heat engines, Refrigerator & Heat pump, Perpetual motion machines, Reversible & Irreversible processes, Carnot cycle, Entropy, Thermodynamic temperature scale.

Text Books:

1. Basic and Applied Thermodynamics, 4th Edition, Nag P. K., Tata McGraw-Hill, 2014
2. Thermodynamics: An Engineering Approach, 5th Edition, YunusCengel and Michael Boles, 2014

Reference Books:

1. Fundamental of Engineering Thermodynamics, 7th Edition, R. Yadav, Central publication house, 2012
2. Fundamentals of Thermodynamics, 5th Edition, Richard E. Songtag, Claus Borgnakke and Gordon J. Van Wylen, John Wiley and Sons, Inc.
3. Engineering Thermodynamics, 2nd Edition, Jones J.B. and Hawkins G.A., John Wyley and Sons.
4. Fundamentals of Engineering Thermodynamics, Moran M.S. and Shapiro H.N., John Wyley and Sons, 1988

Online Courses

1. Basic Thermodynamics Prof. S. K. Som IIT, Kharagpur, NPTEL, https:// nptel.ac.in/courses/ 112105123/
2. Basic Thermodynamics Prof. K. Srinivasan, IISc Bangalore NPTEL https://nptel.ac.in/ courses/112108148/
3. Laws of thermodynamics S K Som IIT Kharagpur, swayam https://swayam.gov.in/courses/3813-laws-of-thermodynamics
4. Introduction to Thermodynamics: Transferring Energy from Here to There" Margaret Wooldridge University of Michigan courser https://www.coursera.org/learn/thermodynamics-intro
5. Basic ThermodynamicsAlisonhttps://alison.com/topic/learn/46491/thermodynamics-learning-outcomes

Subject Experts

1. Prof. Uday N. Gaitonde, Department of Mechanical Engg., IIT Bombay
2. Prof. Srinivasan K, Department of Mechanical Engg., IIT Madras

SEMESTER III

BMEL 213/BMEP 213: Basics of Manufacturing Process

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	2	4	3	10	15	50	----	25	100

Course Objectives:

1. To understand basic material properties for bulk material shaping
2. To provide details of different joining processes for large scale manufacturing
3. To outline the basics of welding processes and its concepts.
4. To understand the basic concepts of powder metallurgy and its applications in engineering sector.

Course Out Comes:

Upon the successful completion of course, the student shall be able to:

1. Select and work with different casting processes for the different applications.
2. Select different joining processes and control the parameters in welding processes.
3. Perform various welding operations in engineering applications.
4. Operate various powder metallurgy processes

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes					Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PO7	PSO 1	PSO 2	PSO3
CO1	3	2	3	3	2	3	-	3
CO2	3	2	2	3	2	3	-	2
CO3	3	1	3	2	3	3	-	1
CO4	3	1	2	1	2	2	-	1

Contents:

Unit I (CO1) (8 Hrs.)

Casting process: Introduction, pattern making: types, materials used, pattern making allowances, colour codes core making: - types, core material and its properties. Classification of Casting, Rate of Solidification, Principal of gating system, Riser, Runner. Casting Inspection and Testing, Casting Defects. Molding: types of sand moulds, molding sand composition, molding sand properties, molding machines, Die Casting.

Unit II(CO2) (7 Hrs.)

Forming processes, advantages and drawbacks. Hot and cold rolling, forging, extrusion, wire drawing, embossing. Etc. Shot peening, Sheet metal working process, Punches and dies, Different Sheet metal operations, Metal spinning, Incremental Sheet metal forming, Die less forming.

Unit III(CO3) (7 Hrs.)

Joining processes: introduction to welding processes, Types of welding. arc welding (TIG, MIG, Submerged Arc, Metal arc), Gas Welding, Resistant welding, Friction welding, Laser

plasma and electron beam welding, defects and inspection of welding joints, electrodes, weldability of metals, welding equipment's of fixtures. Introduction to soldering and brazing processes.

Unit IV (CO4) (8 Hrs.)

Processing of plastics, general properties and applications of thermosetting and thermo plastics. General plastic processes: extrusion, injection moulding, compression moulding, transfer moulding, blow moulding, calendaring.Powder metallurgy: powder manufacture and conditioning, production of sintered structural components. Self-lubricating bearing. Cemented carbides, ceramics, sintered carbide cutting tools.

Text Books:

1. 'Manufacturing Technology (foundry Forming and Welding)', by P.N. Rao, TMH education,2006.
2. 'Manufacturing Science', by Ghosh and Malik , Affiliated East-West Press Private Limited,1996.
3. 'Workshop Technology (Volume – I)', by Hajra Choudhary , Media Promoters and Publishers,2007.
4. 'Manufacturing Engineering and Technology', by S. Kalpakjain and S R Schmid , Wesley.

Reference Books

1. 'Workshop Technology Vol I-III', W.A.J Chapman, Oxford and IBH Publishing Company Private Limited,1988
2. 'Manufacturing Processes' M Begman 'Processes and Materials of Manufacture', R Lindberg , CBS Publication and Distributors,2002
3. 'Workshop Technology (Volume I & II)', Bawa H.S , Tata McGraw Hill,1995
4. 'Workshop Technology Vol. I & II' , B.S. Raghuvanshi , DhanpatRai Publications,2009

Online Courses

1. Manufacturing Process-1, Prof. Inderdeep Singh IIT Roorkee, nptel, https://nptel.ac.in/courses/112107145/
2. Manufacturing Process-2 Prof. A.B. Chattopadhyay IIT Kharagpur, nptel , https://nptel.ac.in/courses/112105126/
3. Metal Casting Prof. D.B. Karunakar IIT Roorkee, nptel, https://nptel.ac.in/courses/112107083/
4. Manufacturing Process Technology -Part I and II Prof. Shantanu Bhattacharya, IIT Madras, swayam, https://swayam.gov.in/course/4500-manufacturing-process-technology-
5. Advanced Manufacturing Processes, Prof. Apurbba Kumar Sharma, IIT Roorkee, nptel, https://nptel.ac.in/courses/112107078/

Subject Experts

1. Prof. Swarup Bag, Manufacturing Engineering, IIT Guwahati.
2. Prof. Sushanta Kumar Panda, Manufacturing Engineering, IIT Kharagpur
3. Prof. Somnath Chattopadhyaya, Manufacturing Engineering IIT Dhanbad
4. Prof. P.M. Pandey, Unconventional Machining, IIT Delhi
5. Prof. A. Subhash Babu, Manufacturing Engineering, IIT Bombay

SEMESTER III

BMEL 214/BMEP 214: Materials and Nano Science

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	2	4	3	10	15	25	----	25	75

Course Objectives:

1. To introduce various materials used in manufacturing of metallic components
2. To introduce & correlate between science and engineering of metallic materials
3. To introduce various techniques for enhancing the inherent characteristics of nano materials
4. To introduce the quantitative measurement of nanomaterial properties

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Apply basic knowledge related to Alloys Iron- Carbon phase diagram
2. Observed various heat treatment processes and handle various Material Testing methods.
3. Apply sufficient theoretical knowledge about various types of nanomaterial and its application.
4. Select proper characterization of Nano Materials methods to find material structure and acquired sufficient theoretical knowledge about properties of nanomaterials for industrial applications

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes					Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PO7	PSO1	PSO 2	PSO3
CO1	3	1	1	1	2	3	1	1
CO2	3	2	1	2	3	2	1	1
CO3	3	2	3	3	2	2	3	3
CO4	3	2	2	3	2	2	3	1

Contents:

Unit- I (CO1) [8Hrs]

Phase Diagrams and Ferrous Materials

Alloys and solid solutions, Binary phase diagrams Isomorphous systems, Partial miscibility, Metallic systems completely miscible in liquid state and completely immiscible in solid state. Allotropy of Iron. Iron –Iron carbide equilibrium diagram, Alloying, Different alloying elements and their effect, Designation of steels. Cast iron, type of cast iron, Maurer Diagram, Microstructure, Properties and Application of each type.

Unit- II (CO2) [8Hrs]

Heat Treatment and Testing of Materials

Introduction, Basic heat treatments such as annealing, normalizing, hardening and tempering, procedure, TTT diagram, Hardenability, Jominy end quench test.

Surface Treatments, Need of testing, Mechanical testing, tensile test, Impact test, Rockwell, Brinell hardness test, Nondestructive testing methods.

Unit- III (CO3) [7Hrs]

Non-Ferrous material and Nanoscience

Brief introduction to different nonferrous materials and study of the Aluminium and its alloy, Copper and its alloys, high temperature smart materials, Introduction to nano materials, Nanorevolution of the XX century, Properties at nanoscale. Carbon based nano materials and other nanomaterials, Nano composites.

Unit- IV (CO4) [7Hrs]

Synthesis and Characterization of Nanomaterials

Top-down, Bottom-up, Wet Deposition techniques, Self-assembly (Supramolecular approach), Molecular design. Microwave Synthesis of materials, TEM, SEM and SPM technique, Fluorescence Microscopy and Imaging.

Advance topic on the subject

Text Books:

1. "Introduction to Physical Metallurgy" by S. H. Avener , McGraw Hill Publication,,2001.
2. 'Nanostructured Materials and Nanotechnology', by Hari Singh Nalwa, Academic Press, 2002.
3. 'Nano: The Essentials', by Pradeep T , McGraw Hill Publishing Co. Ltd., 2007
4. 'Nanotechnology', by Mick Wilson et al, Overseas Press (India) Pvt. Ltd., 2005.

Reference Books:

1. Engineering Physical Metallurgy & Heat Treatment, Lakhtin Y.; 6th Ed; Mir Publishers, 1998.
2. Nanomaterials- Synthesis, Properties and Applications, Edited by A.S. Edelstein and R.C. Cammarata, Institute of Physics Publishing, London, 1998 (paper back edition)
3. Nanochemistry: A Chemical Approach to Nanomaterials, by G. Ozin and A. Arsenault, RSC Publishing, 2005
4. Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Edward L. Wolf, Wiley-VCH, 2nd Reprint (2005)

Online Courses

1. Introduction to Material science and Engineering, Prof. Rajesh Kumar, IIT Delhi, nptel, https://nptel.ac.in/courses/113102080/
2. Introduction to Material science and Engineering Prof. Ranjit Bauri, IIT Madras, nptel, https://nptel.ac.in/courses/113106032/
3. Material Science Prof. Satish V. Kailash IISc Banglore, https://nptel.ac.in/courses/112108150/

4. Phase Diagrams in Materials Science and Engineering Prof. Krishanu Biswas, IIT Madras, swayam, https://swayam.gov.in/course/1308-phase-diagrams-in-materials-science-and-engineering.

5. Surface Engineering Of Nanomaterials Prof. Kaushik Pal, IIT Roorkee swayam, https://swayam.gov.in/course/3548-surface-engineering-of-nanomaterials

Subject Experts

1. Prof. Amit Bhaduri, Department of Metallurgy, IIT Kharagpur
2. Prof. B.K. Satapathy, Department of Metallurgy, IIT Delhi
3. Prof. Shobha Shukla, Department of Metallurgy, IIT Bombay
4. Prof. Sabita Sarkar, Department of Metallurgy, IIT Madras
5. Prof. Devendra Singh, Department of Metallurgy, IIT Roorkee

SEMESTER III

BMEP215: Computer Aided Machine Drawing

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	2	2	1	-	-	-	----	25	25

Course Objectives

1. To get awareness of computer aided machine drawing and its latest development
2. To develop ability to create solid models of machine components of various applications.
3. To develop an ability to create assembly models of machine.
4. To know the application of drafting method of CAD for the generation of production drawing with Geometric Tolerances as per ASME Y14.5 – 2009.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Define basics of engineering drawing in mechanical engineering and applications.
2. Demonstrate the various command for generation of geometrical model in orthographic and sectional views with dimensions.
3. Understand the principles, techniques and able to interpret assembly drawing.
4. Create production drawing of any component by choosing various CAD tool with the allocation of fits and Tolerances.

List of Experiment for Machine Drawing:

Sr. No.	Experiment Name
01	Introduction and practices of Various Icon, shortcut Keys etc
02	To Prepare 2-D Geometrical model
03	To Prepare 2-D Geometrical model By using drawing constraints
04	To prepare the 3D geometrical model using all constraints
05	Prepared two component by using Part Modeling commands
06	Introduction of Assembly by using various tool bars
07	Preparation of Assembly by considering all parameters
08	Preparation of Production drawing by using ASME Y14.5 – 2009.

Text Books:

1. Dr. K L Narayana, Dr. P. Kannaih , K. Venkata Reddy, Machine Drawing, New Age International (P) Ltd. 4th Edition year of publication 2012.
2. Ajeet Singh, Machine Drawing, Tata McGraw-Hill Education and Publication 2nd Edition 2012.

Reference Books:

1. Sham Tickoo Professor Department of Mechanical Engineering Technology Purdue University Calumet, Hammond, Indiana, USA, CATIA V5-R2014 for Designer, CADCIM Technologies525 St Andrews Drive Schererville, Indiana 46375.
2. K.L. Narayana, P. Kannaiah, K. Venkata Reddy, Production Drawing, New Age International Publication 2009.
3. N. D. Bhat, Charotar Publishing House, 26th Edition 1991.

SEMESTER-III

BAIL101: (Open Elective 1) Artificial Intelligence and its application

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. Gain a historical perspective of AI and its foundations. Become familiar with basic principles of AI toward problem solving, inference, perception, knowledge representation, and learning.
2. Investigate applications of AI techniques in intelligent agents, expert systems, artificial neural networks and other machine learning models.
3. Experience AI development tools such as an 'AI language', expert system shell, and/or data mining tool.
4. Experiment with a machine learning model for simulation and analysis. Explore the current scope, potential, limitations, and implications of intelligent systems

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations. Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.
2. Demonstrate awareness and a fundamental understanding of various applications of AI
   techniques in intelligent agents, expert systems, artificial neural networks and other machine learning models.
3. To understand and use basic program of R-programming. Demonstrate proficiency in applying scientific method to models of machine learning.
4. Demonstrate an ability to share in discussions of AI, its current scope and limitations, and societal implications.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes				Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PSO 1	PSO 2	PSO3
CO1	3	2	3	2	2	-	-
CO2	3	1	2	1	2	-	-
CO3	3	2	1	2	3	-	-
CO4	3	1	1	1	2	-	-

Contents:

Unit I: (CO 1) (7hrs)

Artificial Neural Networks Introduction to Artificial Intelligence, Understanding the Brain, Neural Networks as a Paradigm for Parallel Processing, The Perceptron, Training a Perceptron, Learning Boolean Functions, Multilayer Perceptron, Back-propagation Algorithm

Unit II: (CO 2) (8Hrs)

Introduction to Machine Learning, Examples of Machine Learning Applications, Learning Associations, Supervised & Unsupervised Learning, Reinforcement Learning, Classification, Regression

Unit III: (CO 3) (8Hrs)

Introduction to R-Programming R - Basic Syntax, Data Types, Variables, Operators, Decision Making, Loops, Functions, Strings, Vectors, Lists, Matrices, Arrays, Factors, Data Frames, Packages-chart & graphs

Unit IV: (CO 4) (7Hrs)

Application of AI in Mechanical Engineering, and its Case Study

Text Books:

1. Machine Learning: a Probabilistic Perspective by Kevin Patrick (Murphy Machine learning textbook)
2. Pattern Recognition and Machine Learning by Christopher Bishop Christopher (Bishop at Microsoft Research)
3. The Elements of Statistical Learning by Trevor Hastie, Robert Tibshirani & Jerome Friedman
4. Artificial Intelligence – A Modern Approach (3rd Edition) By – Stuart Russell and Peter Norvig
5. Artificial Intelligence Engines: A Tutorial Introduction to the Mathematics of Deep Learning By – James V Stone

Reference Books:

1. Artificial Intelligence: A Modern Approach, Third Edition Stuart Russell and Peter Norvig, 2010. Pearson Education, Inc. ISBN: 978-0-13-604259-4
2. Introduction to Data Mining by Pang-Ning Tan, Michael Steinbach, Anuj Karpatne & Vipin Kumar.
3. Convex Optimization by Stephen Boyd and Lieven Vandenberghe Convex Optimization - Boyd and Vandenberghe

Online Courses:

1. NPTEL on “Artificial Intelligence in Machine Learning”- IIT Kharagpur, Prof. Sudeshna Sarkar.
2. NPTEL on “Artificial Intelligence”- IIT Madras, Prof. Deepak Khemani
3. UDACITY- Introduction to Artificial Intelligence, https://www.udacity.com/

Subject Experts:

1. Prof. Sudeshna Sarkar, Department of Computer Science and Engg., IIT Kharagpur,
2. Prof. Deepak Khemani, Department of Computer Science and Engg., IIT Madras

SEMESTER-IV

BFYL117: Fourier series and Partial Differential Equations

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
1	1	--	2	2	10	15	25	----	----	50

Course Objectives:

1. To introduce Fourier Series and its applications in the field of Mechanical Engineering
2. To develop skills to use Partial differential equations and its applications in the field of Mechanical Engineering

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand and use Fourier series to solve engineering problems.
2. Choose Fourier series expansion of periodic functions in field of Mechanical engineering.
3. Apply the concept of partial differential equation in solving problems.
4. Develop skills to use Partial differential equations and its applications in heat transfer.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	2	--	---	--	---	--	---	-
CO2	3	2	---	---	---	--	--	--	-
CO3	3	2	--	---	---	---	--	--	--
CO4	3	2	---	---	---	----	--	---	--

Contents:

UNIT-I **[6 Hrs]**

Fourier series (CO1)

Representation of periodic function of in terms of sine & cosine series.

UNIT-II **[6 Hrs]**

Fourier series (CO2)

Even and odd functions

Half range series Fourier series for discontinuous function

UNIT-III **[8 Hrs]**

Partial differential: (CO3)

Partial differential equation of 1^{st} order & 1^{st} degree.

UNIT-IV **[10 Hrs]**

Applications of Partial differential: (CO4)

Higher order PDE, Method of separation of Variables Applications of PDE in heat transfer.

Text Books:

1. Higher Engineering Mathematics by B S Grewal, 43rd edition, Khanna Publication.
2. Advanced Engineering Mathematics by Erwin Kreysizig, 8th edition Wiley India.

Reference Books:

1. Advanced Mathematics for Engineers and Scientists ; Spiegel, M. R, McGraw-Hill
2. Advanced Engineering Mathematics, Jain, R.K. and Iyengar, S.R.K, Narosa Publishers; Alpha Science International, Ltd

Online Courses:-

1. Transforms Calculus and its Applications in Differential equations, Prof Adrijit Goswami IIT Kharagpur https://onlinecourses.nptel.ac.in/noc19_ma04/preview

Subject Experts:-

1. Prof Adrijit Goswami, Department of Mathematics, IIT Kharagpur

SEMESTER-IV

BMEL216: Kinematics of Machines

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	_	_	2	2	10	15	25	----	----	50

Course Objectives:

1. To understand basic concepts of different mechanisms and its applications to various fields.
2. To develop competency in graphical methods in solving problems of quantitative kinematic analysis of mechanism.
3. To make students conversant with Concepts of cam mechanism.
4. To make the students conversant with basic concepts of gears, its applications and torque analysis.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Apply the basics concepts of different mechanisms.
2. Identify the exact solving problems of quantitative kinematic analysis of mechanism.
3. Develop an appropriate application of Cam and follower mechanism.
4. Calculate the velocity ratio and select the gears & gear trains for real life application.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	1	3	1	3	-	3	-	2
CO2	3	3	2	2	2	1	3	-	-
CO3	2	1	3	1	3	2	2	-	-
CO4	2	3	3	1	3	2	3	-	-

Contents:

Unit I: CO-1 **[8 Hrs.]**

Basic concept of mechanism, link, kinematic pairs, kinematic chain, mechanism, machine, simple and compound chain, Degree of freedom, estimation of degree of freedom of mechanism by Kutchbach theory and Grubber's criterion, classification of four bar chain [class – I & class – II], inversion of Kinematic chain.

Unit II: CO-2 **[6Hrs.]**

Quantitative kinematic analysis of mechanism: - Displacement, Velocity and Acceleration analysis of planer mechanism by graphical method, Coriolis component of acceleration Velocity by I-Centre Method, Kennedy's Theorem,

Unit III: CO-3 **[6Hrs.]**

Concepts of cam mechanism, comparison of cam mechanism with linkages. Types of cams and followers and applications. Synthesis of cam for different types of follower motion like constant velocity, uniform acceleration & retardation, SHM, cycloid etc.

Unit IV: CO-4 **[10Hrs.]**

Concept of motion transmission by toothed wheels, comparison with cams and linkages, various tooth profiles, their advantages and limitations, gear tooth terminologies, concept of conjugate action, law of conjugate action, kinematics of involutes gear tooth pairs during the contact duration, highlighting locus of the point of contact, arc of contact, numbers of pairs of teeth in contact, path of approach and path of recess, interference, undercutting for involutes profile teeth. Kinematic analysis of simple, epicyclic and double epicyclic gear trains.

Text Books:

1. Theory of mechanisms and machines by Amitabha Ghosh and Ashok Kumar Mallik, East West Press pvt. Ltd. New Delhi, Third edition, 2017.
2. Theory of Machines, S.S. Ratan, McGraw Hill Publications, New Delhi, 2011.
3. Theory of Machines by V. P. Singh, DanpatRai publication Third edition, 2012.

Reference Books:

1. Mechanism and Machine Theory by J.S. Rao & DukkiPatti, new age publication, Second edition, 1992.
2. Theory of Machine by Thomas Bevan, Pearson Education India, CBS publication, Second edition, 1992.
3. Theory of mechanisms and machines, Shigley J.E. and John Joseph Uicker, McGraw Hill Publications, 2003.

Online Courses:

1. https://nptel.ac.in/courses/112104121/ Prof. Ashok K Mallik, Department of Mechanical Engineering IIT Kanpur.
2. https://www.youtube.com/watch?v=mDTjTt-oViQ/ Kinematics of Mechanism and Machines by Prof. Anirvan Das Gupta, IIT Kharagpur.
3. https://engineering.purdue.edu/online/courses/kinematics, An equivalent Junior-level mechanism design course covering kinematics of mechanisms, statics and dynamics of rigid bodies.
4. https://www.youtube.com/watch?v=FzxlQl0GW7A&gclid=EAIaIQobChMInvCRwdaZ6AIVUyQrCh38_Q8AEAMYAiAAEgJggvD_BwE.
5. https://www.coursera.org/learn/robotics-mobility.
6. https://www.coursera.org/learn/modernrobotics-course2?=
7. https://www.coursera.org/learn/spacecraft-dynamics-kinematics
8. https://www.coursera.org/specializations/modernrobotics

Subject Experts:

1. Dr. Bishakh Bhattacharya, Mechanical Engineering Department, IIT Delhi.
2. Prof. Ashok K Mallik, Mechanical Engineering Department, IIT Kanpur.
3. Prof. Anirvan Das Gupta, Mechanical Engineering Department, IIT Kharagpur.
4. Dr. Anindya Chatterjee Mechanical Engineering Department, IIT Delhi.
5. Dr. Sangamesh, Mechanical Engineering Department, IIT Guwahati Assam, India,
6. Dr. Amol Ghokle, Mechanical Engineering Department, IIT Bombay

SEMESTER-IV

BMEL217: Strength of Materials

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
1	1	_	2	2	10	15	25	----	----	50

Course Objectives:

1. To teach the fundamentals of simple and principal stresses and strains.
2. To imbibe concept of shear force and bending moment with practical exposure and applications.
3. To facilitate the concept of bending and its theoretical analysis.
4. To learn torsion of shaft

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand the concepts of various stresses and strains and their relative effects in context with engineering applications.
2. Effectively use the concepts of shear force and bending moment diagrams in various designs of machine elements.
3. Estimate the slope and deflection of beams.
4. Resolve the stresses induced in shafts.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	3	3	2	1	2	-	-
CO2	1	1	3	2	1	1	2	-	-
CO3	2	3	3	2	2	2	2	-	-
CO4	2	3	3	2	3	1	2	-	-

Contents:

Unit I (CO1) [8 Hrs.]

Concept of simple stresses and strains: Introduction, stress, strain, types of stresses, stress – strain diagram for brittle and ductile material, elastic limit, Hooks law, modulus of elasticity. Modulus of rigidity, factor of safety, analysis of tapered rod, analysis of composite section, Longitudinal strain and stress, lateral stresses and strains, Poisson's ration, volumetric stresses and strain. Bulk modulus, relation between Young's modulus and modulus or rigidity, Poisson's ratio and bulk modulus.

Unit II (CO2) **[6 Hrs.]**

Shear force and bending moment: Types of beam (cantilever beam, simply supported beam, overhung beam etc.). Types of loads (Concentrated and UDL), shear force and bending moment diagrams for different types of beams subjected to different types of loads, sign conventions for bending moment and shear force.

Unit III (CO3) **[8 Hrs.]**

Deflection of beams: Derivation of differential equation of elastic curve with the assumptions made in it. Deflection and slope of cantilever, simply supported, subjected to concentrated load UDL, Relation between slope, deflection and radius curvature, Macaulay's method & Double integration method.

Unit IV (CO4) **[8 Hrs.]**

Torsion of circular shafts: Derivation of torsion equation with the assumptions made in it. Torsional shear stress induced in the shaft, when it is subjected to torque. Strength and rigidity criteria for design of shaft. Torque transmitted by solid and hollow circular shaft.
Tutorial: Based on above syllabus

Text Books:

1. Strength of Materials, by S. P. Timoshenko, East West Press, 5th edition, 2011.
2. Strength of Materials, by F. L. Singer, Harper Pollins Publisher, 4th edition.
3. Strength of Materials, by R. K. Rajput, S. Chand Publisher, 4th edition, 2015.
4. Strength of Materials, by S. Ramamrutham and R. Narayanan, DhanpatRai Sons Publisher, 4th edition, 2016.

Reference Books:

1. Mechanics of Solids, Dr. H. J. Shah, Charotar publishing house pvt. Ltd., 1st edition 2008.
2. Mechanics of Materials, Dr. Kripal Singh, Standard publications, Delhi, 7th edition 2013.

Online Courses:

1. Mechanics of Materials II: Thin-Walled Pressure Vessels and Torsion Dr. Wayne Whiteman, PE, Woodruff School of Mechanical Engineering (COURSERA) https://www.coursera.org/learn/mechanics2
2. Mechanics of Materials III: Beam Bending Dr. Wayne Whiteman, PE, Woodruff School of Mechanical Engineering (COURSERA) https://www.coursera.org/learn/beam-bending
3. Mechanics of Materials IV: Deflection , Buckling Woodruff School of Mechanical Engineering (COURSERA) https://www.coursera.org/learn/materials-structures
4. Advance Strength of Material Prof. S Maiti, NPTEL Video, https://nptel.ac.in/courses/112101095/

Subject Experts:

1. Prof. Amol Gokhale, Department of Mechanical Engg., IIT Bombay.
2. Prof. Rama Krishna K., Department of Mechanical Engg., IIT Delhi
3. Prof. Shailesh J. Kundalwal, Department of Mechanical Engg., IIT Indore

SEMESTER-IV

BMEL 218: Applied Thermodynamics

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	25	----	----	50

Course Objectives:

1. To understand the basic concept of entropy.
2. To understand the various gas power cycle.
3. To study the properties of steam and analysis of steam using indicator diagrams.
4. To study vapor power cycle with the help of P-v, T-s and h-s diagram

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand concept of entropy.
2. Compare various gas power cycles.
3. Make use of steam tables to find out the properties of steam.
4. Explain vapor power cycles with the help of P-v, T-s and h-s diagrams

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO9	PO 12	PSO 1	PSO 2	PSO3
CO1	3	2	3	2	3	3	--	3	--
CO2	2	3	3	2	3	3	--	3	--
CO3	2	3	3	1	3	3	--	3	--
CO4	2	2	3	1	2	2	--	3	--

Contents:

Unit I (CO 1) Entropy [8 Hrs]

Entropy: - The Clausius inequality, Entropy, Principle of increase of entropy, Change in entropy for Closed & Steady flow open systems. Second law analysis of engineering systems: - Availability, Reversible work & Irreversibility.

Unit II (CO 2) Gas Power Cycle [8 Hrs]

Gas power cycles: Otto cycle, Diesel cycle, semi-Diesel, Sterling cycles, their efficiency and mean effective pressure calculations, Dual cycle, Ericsson cycle.

Unit III (CO 3) Properties of steam [8 Hrs]

Properties of steam, Phase change process of pure substance, Sensible heat and latent heat, specific volume and entropy of steam, dryness fraction of steam, throttling of steam, determination of dryness fraction, steam tables and their use, T-S and H-S diagram.

Unit IV (CO 3) Vapor power cycles [6 Hrs]

Rankine and modified Rankine cycle, work done and efficiency, specific steam consumption, comparison of Rankine and Carnot cycle, representation on P-v, T-s and h-s diagram.

Advanced Topics

Text Books:

1. Basic and Applied Thermodynamics, 4th Edition, by P. K. Nag, Tata McGraw-Hill, 2014
2. Thermodynamics: An Engineering Approach, 5th Edition, Yunus Cengel and Michael Boles, 2014

Reference Books:

1. Fundamental of Engineering Thermodynamics, 7th Edition, R. Yadav, Central publication house, 2012
2. Fundamentals of Thermodynamics, 5th Edition, Richard E. Songtag, Claus Borgnakke and Gordon J. Van Wylen, John Wiley and Sons, Inc.
3. Engineering Thermodynamics, 2nd Edition, Jones J.B. and Hawkins G.A., John Wyley and Sons.
4. Fundamentals of Engineering Thermodynamics, Moran M.S. and Shapiro H.N., John Wyley and Sons, 1988.

Online Courses

1. Applied Thermodynamics by Prof. U S P Shet, T. Sunderajan, J M Mallikarjun, IIT Madras, NPTEL https://nptel.ac.in/courses/112106133/

Subject Experts

1. Prof. Sundararajan T, Department of Mechanical Engg., IIT Madras
2. Dr. Mallikarjuna J.M, Department of Mechanical Engg., IIT Madras

SEMESTER: IV

BMEL219/BMEP 219: Machining Processes

Teaching Scheme				Credit	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hour		TAE	CAE	ESE	Int.	Ext.	
2	-	2	4	3	10	15	50	----	25	100

Course Objectives:

1. To develop an insight into metal cutting principles.
2. To provide details of the construction of conventional metal cutting machine tools.
3. To provide details of manufacturing operations for gears and super finishing processes.
4. To select machining parameters for optimum utilization of resources and time for high productivity and dimensional accuracy.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Select tool based on the material and desirable properties
2. Operate and perform different operations on Lathe machine.
3. Perform milling operations.
4. Select the process and machine based on finishing requirement.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes					Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PSO 1	PSO 2	PSO3
CO1	3	2	2	3	2	3	-	1
CO2	3	2	2	3	2	3	-	2
CO3	3	1	1	2	1	3	-	1
CO4	3	2	1	2	1	3	-	2

Contents:

Unit-I: (CO 1) (06hrs)

Introduction to Machining Parameters:

Introduction to machining, tool materials and their properties nomenclature and tools geometry of single point cutting tool, cutting tool material, Cutting fluids and lubricants. Cutting parameters, cutting force, surface roughness, Merchant's circle, tool wear and tool failure, tool wear mechanism, Tool life equation, Chip morphology, Heat generation and friction in metal.

Unit II: (CO 2) (08Hrs)

Lathe : Introduction, type, construction of simple lathe, mechanism and attachments for various operations, machine specifications, basis for selection of cutting speed, feed and depth of cut, time estimation for turning operations such as facing, step turning, taper turning, threading, knurling..

Unit III: (CO 3) **(08Hrs)**

Milling: Introduction, specifications, types, column and knee type milling machine, fixed bed type milling machines, production milling machines, special purpose milling machines such as thread milling machines, profile milling machine, Gear Milling /Hobbing machines. Mechanisms and Attachments for Milling. Cutting parameters, Types of milling operations, Types of milling cutters, Tool geometry and their specifications.

Unit IV: (CO 4) **(08Hrs)**

Grinding operations, grinding wheel, specifications and selection of grinding wheel, cylindrical and centreless, grinding operation, surface grinding, tool and cutter grinding, time estimation for grinding operations, Glazing, loading, truing, dressing and selection of grinding wheel, Broaching and its types, Drilling, Types of Drilling machine, Drill Nomenclature, Reaming, Super finishing processes such as honing, lapping, polishing, buffing and Burnishing. Jigs and Fixture.

Text Books:

1. Manufacturing Technology (Metal Cutting and Machine Tools) – by P.N. Rao TMH education, 2006.
2. Manufacturing Science – by Ghosh and Malik Affiliated East-West Press Private Limited, 1996.

Reference Books:

1. Workshop Technology (Volume – II) – By Hajra Choudhary
2. Manufacturing Engineering and Technology – S. Kalpak Jain and SR Schmid
3. Technology of machine Tools – Krar and Oswald
4. Manufacturing Processes – M Begman
5. Processes and Materials of Manufacture – R. Lindberg
6. Workshop Technology (Volume I & II) – By Bawa.

Online Courses

1. Advanced machining Processes, Prof. Manas Das IIT Guwahati, nptel, https://nptel.ac.in/courses/112103202/
2. Introduction to machining and machining fluids, Prof. Mamillaravi Sankar, IIT Guwahati, nptel, https://nptel.ac.in/courses/112103245/
3. Mechanics of Machining, Prof. Uday S. Dixit, IIT Guwahati, nptel: https://nptel.ac.in/ courses/ 112103248/
4. Metal Cutting and Machine Tools, Prof. Asimava Roy Choudhury, IIT Kharagpur, nptel, https://nptel.ac.in/courses/112105233/

Subject Experts

1. Prof. Uday S. Dixit, Manufacturing Engineering IIT Guwahati
2. Prof. Amitava Mandal, Manufacturing Engineering IIT Dhanbad
3. Prof. Sunil Jha, Advanced Machining IIT Delhi
4. Prof. S.S. Joshi, Micro Machining IIT Bombay
5. Prof. Sushanta Kumar Panigrahi, Manufacturing Engineering IIT Madras.

SEMESTER IV

BMEL 220/BMEP 220: SENSOR, ACTUATORS & MEASUREMENT

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
1	-	2	3	2	10	15	50	----	25	100

Course Objectives:

1. To understand the basic concept of sensors, actuators, and measurement system, along with its functional element.
2. To understand the performance characteristics, and working of measuring instruments

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Make a use of Sensor, actuators, and measuring instrument in any application.
2. Develop skill to select proper sensors, measuring instruments for measurement of various engineering parameters.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes					Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PO 6	PSO 1	PSO 2	PSO3
CO1	3	2	2	3	3	3	2	1
CO2	3	1	2	1	2	3	2	1

Contents:

Unit-I: (CO 1) (5hrs)

Sensor, Actuators and Measurement system:

Sensors, Basic requirements of a sensor, Classification of sensors, significance of measurement system, generalized measurement system, Static and Dynamic characteristics.

Unit-II: (CO2) (10hrs)

Various Measurements:

Construction & working of sensors

Displacement:- LVDT, Capacitive, Inductive Pick Up, Temperatures: Thermocouple, Thermistor, Pyrometer. Strain Measurement: Types of strain gauges, Strain gauge circuits, Pressure: Bourdon Tube, Dead Weight, Mc Load, Ionization, Thermal conductivity, Force: Hydraulic Pneumatic Load cell, Piezoelectric Load cell, Strain gauge Load cell, Vibration: Free and Force, Humidity, speed: Tachometers, liquid level Measurements

Advance topic on the subject

Text Books:

1. Erenest O. Doebeling, 'Measurement Systems', McGraw Hill, 2nd edition 2014
2. T.G. Beckwith & N.L. Bulk, 'Mechanical Measurements', Addison Werlly, 3rd edition 2012.

Reference Books:

1. J.P. Holman, 'Experimental Methods for Engineers', McGraw Hill, 2nd edition 2013.
2. Nakra Choudhari, 'Instrumental Measurement & Analysis', Tata McGraw Hill, 3rd edition 2011.
3. Ramgan, Sharma & Mani, 'Instrumentation', Tata McGraw Hill, 3rd edition 2013
4. D.S. Kumar, 'Mechanical Measurement & Control', Metropolitan Book Company, 4th edition 2014.
5. Collette & Hope, 'Engineering Measurement', ELBS, 2nd edition 2010.

Online Courses

1. Mechanical Measurements and Metrology, Prof. S.P. Venkateshan, IIT Madras nptel, https://nptel.ac.in/courses/112106138/
2. Principles of Mechanical Measurement, Prof. R. Raman, IIT Madras, nptel, https://nptel.ac.in/courses/112106140/

Subject Experts

1. Prof. Dilip Kumar Pratihar, Department of Production Engg., IIT Kharagpur
2. Prof. Sachin Kumar Singh, Department of Production Engg., IIT Dhanbad
3. Prof. Sudip Mukharjee, Department of Production Engg., IIT Delhi
4. Prof. P.S. Gandhi, Department of Production Engg., IIT Bombay
5. Prof. Pushparaj, Mani Pathak, Department of Production Engg., IIT Roorkee

SEMESTER IV

BMEP221: Industrial Safety Practices

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	2	2	1	-		-	25	-	25

It is expected to visit the nearby industry and study the industrial safety. Students are required to submit the brief report on the safety practices in the industry.

Objective

- To enable understanding of the importance of industrial safety.
- To develop personal habits and work culture aimed at minimizing hazards, accidents and waste.

Guidelines for students:

1. Each practical batch will be divided into three groups.
2. Each group will consist of 6-7 students.
3. The faculty member will be allocated to every group.
4. The faculty member will explain the safety practices followed in the industry.
5. The faculty member will explain the safety practices at various industries like Manufacturing, Chemical, Textile, Petroleum, Power, Steel, Pharmaceuticals etc.
6. The students will deliver the presentation on safety practices on the above mentioned industry before applying to an industry.
7. The students under the guidance of faculty member will identify the industry.
8. The students will collect the relevant information of the industry from the website and other resources.
9. The students will deliver the presentation on the identified industry and will take the approval from the respective faculty member.
10. After identifying the industry they will issue the letter from the department.
11. After issuing the letter the faculty member will guide the students regarding the industry and the initial formalities that must be followed at the company entrance.
12. In the first visit the students will observe the entire processes and work culture in the industry.
13. In subsequent visits they will study the product, manufacturing processes and shop floor management.
14. They will observe and study the current safety practices followed at industry.

15. After observing the safety practices they will suggest the possible improvements in the existing practices.
16. The students will collect the remark from the industry person on the suggestions made by them.
17. After visiting the industry, the student will deliver the presentation on the observations and suggestions made by them.
18. They will prepare the report on the same and submit to respective faculty members.
19. The students need to submit the certificate from the industry that they have visited the industry and learn safety practices.

Marking scheme

Sr. No.	Roll No.	Name of student	Presentation 1 (10 Marks)	Presentation 2 (10 Marks)	Industry Visit (10 Marks)	Attendance (10 Marks)	Report (10Marks)

Guidelines for Industrial safety practices.

First cover page containing college name, dept. name, name of students, roll no. name of Teacher, session. Name of industry should be capital & Bold (Font size 12 Times New Roman)

1) Prepare Index Page
2) Contents of index are as follows.

i) **Introduction:**

Introduction of the industry which includes name of industry, type of industry, location, layout, name of products, no of Persons working, shift timing, their customers(clients), and other related information of industry.

ii) **Equipment / Machines present and used in the industry**

Description of Machines present and used in the industry should be given with their purpose and applications. With photos /figures of Equipment should also be added.

iii) **Processes used in the industry**

Working of Complete process of converting raw material into finished product including block diagram should be given.

iv) **Probable hazards of each process and their safety measures**

Study the probable hazards in each process and suggest the safety measures for the process.

v) **General safety practices followed at industry**

General safety practices observations.

vi) **Conclusions**

Overall conclusion of study should be written in half page.

vii) **Group photo of students in the industry.**

viii) **Name of students with signature.**

ix) **Attach industry certificate** (from proprietor/authorized person in the industry) **where you have worked.**

Other Important Points:

1) 2 Copies of report should be prepared. One report should be submitted to respective Industrial case study Teacher and one copy should be retained by students.
2) Spiral binding should be used for the preparation of report
3) Page should be of A4 size and Times new roman font should be followed for all text. Spacing of line should be 1.5.
4) Report should be 15 to 20 no of pages.
5) Main title of the report should be 16 font size and Bold.
6) Heading should be 14, Bold and sub heading should be12 Bold size.
7) Give numbers to title, subtitle and sub subtitle as – 1, 1.1, 1.1.1, etc.
8) Each figure & Table should be numbered. Figures title should be written in below the figure. Table title should be written above table.
9) Both figure and table should be numbered as 1, 2, 3, ------ etc.
10) Care should be taken to minimize the spelling mistakes.

SEMESTER IV

Skill Development-2

BMEP224: 3D Geometric Modeling using CATIA

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	2	2	1	-	-	-	25	-	25

Course Objectives

1. To get awareness and importance of computer aided machine drawing and to familiarize with the latest developments in mechanical engineering drawing.
2. To develop an ability to Create Solid Models of machine components. The student should be able to apply these skills to the solution of a variety of practical problems.
3. To develop an ability to create assembly models of simple machine .The student should be prepared to continue the study of computer aided machine drawing through further subjects for the preparation of his project in engineering.
4. To know the application of Drafting method of CAD for the generation of Production Drawing with Geometric Tolerances as per ASME Y14.5 – 2009.

Course Outcomes

Upon the successful completion of course, the student shall be able to:

1. Define the application of basic command use in CAD software
2. Apply Basic knowledge of engineering graphic and machine drawing while creation of 2D model in CAD software
3. Understand application of part modeling command by creation of knowledge of 3D model in CAD software
4. Compared application of advanced part modeling command by creation of knowledge of 3D model in CAD software
5. Elaborate the application of basic command use to generation of drafting in CAD software
6. Create production drawing by using basic knowledge of symbol like surface finfish, welding etc

Contents:

Unit I: Drawing Standards (4Hrs)

Introduction of CAD, Importance of CAD in solid modeling,. Grapihc user Interface of any Solid modeling CAD software . Creation of Parametric sketing, introduction of entities like circle, rectangal etc.

Unit II: Creation of 2D parametric draiwng by operation tools (4Hrs)

Craeting object (2D) Using Draw comnand and modify of 2D entites , operation on entitys apply cntraint, apply modify , Basic dimensioning, Editing dimentioning, Dimention style . Alignment & Dimentioning.

Unit III: Parametric solid modeling ion of mechanical componant (4Hrs)

Crationtion of 2D sketches into 3D solid geomentrical model. Prepartion of 3D pectorial view of mechanical componanat by using 3D modeling tools.

Unit. IV: Assembling Modeling (6Hrs)

Creation of 3D Geometrical mechanical component by using advanced modeling tool in CAD software , Introduction to Unit Assembly Step involve in preparation of assembly drawing D , Introduction of Pipe joint and preparation of pipe joint ,Preparation of Small component for sub assembly

Unit V: Creation of Assembling by using Fits and Tolerence (9Hrs)

Cration of assmebling drawing of (any Two Assmebly), Screw Jack,Sleeve and Cotter Joint, Giband cotter joint, Knucle joint, Plubmer block, Machine vice, Protected type ,flange coupling, bushcouplong, Pipe vice Tool post ,top valve, foot step bearing , Uviversal coupling Fits and Tolerence allocation for mating parts-Geometric Tolerance and Allowance, standard and as per

Unit VI: Production Drawing (3Hrs)

Generation of 2D sketches from parts and assembly 3D model with tolerance, machining symbol, welding symbol, manufacturing methods surface finish symbols, Indicating on drawing of position Elements of production drawing standards, Preparation of Process planning . Modeling and Production drawing by using CAD software

List of Experiments

Exp No	Experiment Name
1	Basic Introduction of CATIA software, and application and Introduction of Various Icon, ,shortcut Keys and practices
2	To Prepare Two 2-D Geometrical Modal in given sheet by using Profile tool bar like circle, line, rectangle etc.
3	To Prepare Two 2-D Geometrical Modal in given sheet by using operation and transform tool bar.
4	To Prepare 2-D Geometrical Model By using DRAWING constraint
5	Instruction of PART modeling icon To prepare the 3D geometrical model using all constraint sketch based feature tool bar like, pad , pocket, revolve
6	To prepare the 3D geometrical model using all constraint create dress up feture on existing drawing by using dress up toll bar like, shell ,draft, chamfer, fillet operation
7	To prepare the 3D geometrical model using all constraint transformation tool bar, like array, symmetry , hole , etc.
8	To Prepared any two component with sectional view by using Part Modeling command
9	Introduction of Assembly by using various tool bar, manipulation, smart move, coincident, offset, angle, constraint, reuse pattern and Practice
10	Preparation of Assembly by considering all parameter one problem three component
11	To prepare assembles of any mechanical component i) Tool post ii) C-clamp iii) Screw jack iv) coupling v)Pipe clamp
12	Preparation of Drawing by generative drawing , introduction of views, projection, section tool bar
13	Preparation of Production drawing of any mechanical component and assembly by using also prepared part list ASME Y14.5 – 2009

Reference Books:

1. Sham Tickoo, Professor, Department of Mechanical Engineering Technology Purdue University Calumet, Hammond, Indiana, USA, CATIA V5-R2014 for Designer, CADCIM Technologies 525 St Andrews Drive Schererville, Indiana 46375.
2. Dr. K L Narayana, Dr. P. Kannaih, K. Venkata Reddy New Age International (P) Ltd. 4th Edition year of publication 2012.

SEMESTER-V

BFYL118: Statistics & Probability

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
1	--	--	1	1	10	15	25	----	----	50

Course Objectives:

1. To introduce basic concept of statistics and probability.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand the concept of statistics in mechanical engineering.

2. Apply the concept probability in Mechanical engineering.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	2	--	---	--	---	--	---	-
CO2	3	2	---	---	---	--	--	--	-

Contents:

UNIT-I **[6 Hrs]**

Statistics (CO1)

Mean, Median, Mode, Standard deviation, Mean deviation

UNIT-II **[9 Hrs]**

Probability: (CO2)

Discrete & continues random variable, Probability density function, Probability distribution function ,Joint density function, Mathematical expectation, Variance, standard deviation, Co-Variance.

Text Books:

1. Higher engineering Mathematics by B S Grewal, 43rd edition, Khanna Publication.
2. Probability and Statistics by Spiegel M. R., Murray R. Spiegel, McGraw-Hill

Reference Books:

1. Advanced Mathematics for Engineers and Scientists; Spiegel, M. R, McGraw-Hill Ltd.
2. Advanced Engineering Mathematics, Jain, R.K. and Iyengar, S.R.K, Narosa Publishers; Alpha Science International, Ltd.

Online Courses:-

1. Probability and Statistics Prof. Somesh Kumar IIT Kharagpur https://www.classcentral.com/course/nptel-probability-and-statistics-5228
2. Probability: Basic Concepts & Discrete Random Variables Mark D. Ward Purdue University via edXhttps://www.class-central.com/course/edx-probability-basic-concepts-discrete-random-variables-6989

Subject Experts:-

1. Prof. Somesh Kumar, Department of Mathematics, IIT Kharagpur.

SEMESTER-V

BMEL 321/BMEP 321: Dynamics of Machines

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	2	4	3	10	15	50	----	25	100

Course Objectives:

1. To make the students conversant with force analysis of mechanism.
2. To Design & develop the concept of flywheel and its applications.
3. To develop competency in graphical and analytical methods in solving problems in rotating and reciprocating machineries.
4. To develop conversancy with basic concepts of vibrations, it's effects and measurement.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Apply the requirement of static and dynamics force analysis.
2. Explain and solve the problems related to flywheel and energy storage
3. Identify and solve problems of rotating and reciprocating machinery and balancing of machinery.
4. Select advanced computing techniques and tools in the area of longitudinal, transverse and torsional vibrations.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	2	3	2	1	1	-	-
CO2	3	3	1	2	2	1	2	-	-
CO3	2	3	2	3	2	1	2	-	-
CO4	3	2	2	2	3	-	2	-	-

Contents:

Unit I: CO-1 **[7 Hrs]**

Static Force and Dynamic Force Analysis

Static force Analysis in linkages, Superposition Method, FBD, Equilibrium of four force members, Principal of Virtual Work, D'Alembert's Principal, Engine Force Analysis,

Unit II: CO-2 **[7 Hrs]**

Turning Moment Diagram, Flywheel, Turning moment Vs crank angle diagram for single – cylinder and multiple – cylinder engines, punching machines etc. Flywheel selection.

Unit III: CO-3 **[8 Hrs]**

Balancing of Rotary Masses

Static and Dynamic balancing of Rotary masses, Balancing of several masses rotating in different planes. Balancing of Reciprocating masses: Partial balancing of locomotive, balancing of primary and secondary forces of Multi cylinder In-Line Engine.

Unit IV: CO-4 **[8 Hrs]**

Longitudinal and Transverse Vibration, Free Vibration, Critical or whirling speed of shaft, free and forced damped vibration, vibration isolation and transmissibility, Vibration Measurement techniques.

Torsional Vibration, Free Torsional Vibration, mode shape, Single, Two and Three rotor system, numerical on multi degree freedom.

Text Books

1. Theory of mechanisms and machines by Shigley J.E., McGraw Hill, Second edition, 2013
2. Theory of Mechanism and Machine by Ghosh and Malik, affiliated East West Press Pvt. Ltd., Second Edition, 2014.
3. Mechanism and Machine Theory by J.S. Rao &Dukki Patti, new age publication, Second edition, 2011
4. Theory of Machine by S. S. Rattan, New Jersey Tata Mcgraw-Hill Pub. Co. Ltd., Third edition, 2010

Reference Books

1. Theory of Machine by Thoman Bevan, Pearson Education India, CBS publication Second edition, 2009.
2. Theory of Machines by V.P.Singh, DanpatRai publication Third edition, 2012.

Online Courses:

1. "Advanced Engineering Systems in Motion: Dynamics of Three Dimensional (3D) Motion" By: Dr. Wayne Whiteman, Georgia Institute of Technology Url: https://www.coursera.org/learn/motion-and-kinetics#about
2. "Dynamics of Machines" By: Prof. C. Amarnath, Prof. K. Kurien Issac, Prof. P. Seshu, IIT Bombay Url: https://nptel.ac.in/courses/112/101/112101096/
3. "Dynamics and Control" By: Prof. Pedro Albertos, Systems Engineering and Control Dept., Universitat Politècnica de Valencia Url: https://www.edx.org/course/dynamics-and-control

Subject Experts:

1. Anindya Chatterjee, Department of Mechanical Engg., IIT-Kharagpur
2. Mohit Law, Department of Mechanical Engg., IIT-Kanpur
3. Nalinaksh S. Vyas, Department of Mechanical Engg., IIT-Kharagpur

SEMESTER-V

BMEL 322: Energy Conversion

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	50	----	----	75

Course Objectives:

1. To get awareness and importance of steam generation and fluidized bed boiler.
2. To familiarize with the latest developments in chimney draught system and performance of steam nozzle
3. To study working principle and performance of steam turbine
4. To study steam condensers and cooling towers

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand the working of different types of boilers.
2. Illustrate principle of chimney draught and steam nozzles.
3. Make use of velocity triangles to calculate performance of steam turbine
4. Design steam condensers and cooling Towers.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO6	PO 7	PSO 1	PSO 2	PSO3
CO1	3	2	3	2	3	1	3	3	--
CO2	3	3	3	2	2	1	3	3	--
CO3	2	2	2	3	2	3	3	3	--
CO4	2	2	3	3	2	1	3	3	--

Contents:

UNIT- I (CO1) [8 Hrs]

Principles of Steam Generation, Classification of Steam Generators, Fire Tube and Water Tube Steam Generators, High Pressure Steam Generators. Fluidized Bed Boilers: Bubbling Fluidized Bed Boilers, Circulating Fluidized Bed Boiler Mountings and Accessories. Performance of Steam Generators. Evaporation Capacity, Equivalent Evaporation, Boiler Efficiency.

UNIT- II (CO2) [8 Hrs]

Draught and Its Classification, Chimney Height, Chimney Diameter, Efficiency.

Steam Nozzles: Adiabatic Expansion In Nozzles, Maximum Discharge, Critical Pressure Ratio And Effects Of Friction, Calculation Of Throat And Exit Areas, Supersaturated Flow, Wilson Line.

UNIT- III (CO3) **[8 Hrs]**

Steam Turbines :Principles Of Working Of Steam Turbines, Classification Of Steam Turbines, Comparison of Impulse And Reaction Turbines, Compounding Of Steam Turbines. Energy Losses In Steam Turbines, Flow Of Steam Through Turbine Blades, Velocity Diagrams, Graphical And Analytical Methods, Work Done, Thrust And Power, Dimensions And Proportioning Of the Blades, Steam Turbine Efficiencies, and Condition For Maximum Efficiencies.

UNIT- IV (CO4) **[6 Hrs]**

Steam Condensers: Types Of Condensers, Classification Of Condensers, And Quantity Of Cooling Water Required, Design Calculations For Surface Condensers, Daltons Law Of Pressures, Sources Of Air Leakages And Air Removal. Cooling Towers: Wet Cooling, Dry Cooling Towers Cooling Pond

Advance topic on the subject

Text Books:

1. Power Plant Engineering, V.M. Domkundwar, 3rd edition, DhanpatRai and Sons Publication, 2005.
2. Power plant engineering, P.K. Nag, fourth edition, McGraw Publication (India) Pvt. Limited, 2014

Reference Books:

1. Thermal Engineering, by P.L. Ballaney, 26th edition, Khanna Publication, 2007.
2. Thermal Engineering, by B.K. Sarkar, Eighth edition, Tata McGraw Publishing Company limited, 2005.
3. Applied Thermodynamics. By Dr. R. Yadav, 6th revised edition, Central Publishing House Allahabad, 2011.

Online Courses

1. Steam and Gas Power Systems Prof. Ravi Kumar, IIT Roorkee, NPTEL https://nptel.ac.in/ courses/ 112107216/
2. Steam And Gas Power Systems, Ravi Kumar, IIT Roorkee, swayam, https://swayam.gov.in/courses/3554-steam-and-gas-power-systems
3. Energy conservation and waste heat recovery, Bhattacharya A, IIT Kharagpur, swayam, https://swayam.gov.in/courses/3814-energy-conservation-and-waste-heat-recovery

Subject Experts

1. Prof. Ravi Kumar, Department of Mechanical Engg., IIT Roorkee

SEMESTER-V

Elective I: (BMEL 323) Non-Conventional Energy System

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	50	----	----	75

Course Objectives:

1. To understand the importance of Unconventional Energy System to meet energy crisis.
2. To understand systems and applications of different Unconventional Energy System such as solar energy, wind energy, etc.
3. To understand the knowledge of Direct Energy Conversion techniques to meet energy crisis.
4. To understand economic aspects of Unconventional Energy System

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand the importance of renewable energy in present energy crisis and Use of solar energy for generation of energy and other appliances.
2. Define Wind Energy systems as energy input various applications.
3. Apply knowledge of various Biomass Conversion technologies to developed new efficient systems.
4. Analyze chemical energy sources to design new efficient system.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO6	PO7	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	2	3	2	2	--	3	--
CO2	3	3	2	3	2	2	--	3	---
CO3	1	2	2	2	3	2	--	3	--
CO4	1	2	2	2	3	2	--	3	--

Contents:

Unit I (CO 1) (8 Hrs)

Solar Energy:- Energy Sources, convectional energy sources, prospects of Renewable & non Renewable energy sources ,Solar radiation &its measurement, solar energy collectors, performance of flat plate, cylindrical parabolic concentric collectors, solar energy storage, applications

Unit II (CO 2) (8 Hrs)

Energy from Biomass: - Introduction, Biomass conversion Technology, biogas generation, biogas plant, materials used, site selection, fuel property of biogas, methods for obtaining biomass, gasification.

Unit III (CO 3) **(7 Hrs)**

Tidal, wave and ocean thermal energy conversion plants, geothermal plants. Economic analysis of renewable energy system, problem on Economic analysis.

Unit IV (CO 4) **(7 Hrs)**

Chemicals energy sources :- Introduction , Fuel Cell, design & principle of operation, classification, types, applications, MHD power generation, methods, MHD design problems, status, Thermo electrical power, Thermionic generation.

Text books:

1. 'Renewable Energy Recourses, Basic principle and applications', G.N.Tiwari and M.K.Ghosal, Narosa publication, 3rd edition 2010.
2. 'Non-conventional energy resources', B.H...Khan, Tata McGraw Hill Publication, 2nd edition 2012.
3. 'Solar Energy Utilization', G.D.Rai, Khanna publisher New Delhi, 5th edition 2001.

Reference Books:

1. 'Non-c onventional energy resourses', S. K. Dubey and S. K. Bhargava, Dhanpat Rai & Co., 2nd edition 2011.
2. 'Non-conventional Energy Sources', G.D.Rai, Khanna publisher New Delhi, 4th edition 2009.
3. 'Solar Energy' by S.P.Shukhatme, J. K. Nayak, Tata McGraw Hill Publication, 3rd edition 2008.

Online courses:

1. Non conventional energy Sources, NPTEL Course,
   Link: https://nptel.ac.in/courses/121/106/121106014/
2. Non Conventional Energy Systems, NPTEL Course,
   Link: https://nptel.ac.in/courses/108108078/
3. Solar Energy Technologies, NPTEL Course,
   Link: https://nptel.ac.in/courses/112105050/
4. Technologies for clean and renewable energy Production, NPTEL Course,
   Link: https://nptel.ac.in/courses/103107157/#

Subject Experts

1 Prof. Ravi Kumar, Department of Mechanical Engg., IIT Roorkee

SEMESTER-V

Elective-I: (BMEL 324) Bio Mechanics

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	50	----	----	75

Course Objectives:

1. To acquire knowledge of Forces and moments, types of forces, resultant of system of forces in human bones and tissues.
2. To study applications to biomedical system in human anatomy. Mechanical properties of human bone, cortical bone, cancellous bone, viscoelasticity & elastic model of bone.
3. To understand Principle of continuum mechanics, Dental forces, implant-tissue biomechanics, Crack propagation in bones.
4. To be able to obtain linear vibratory models of dynamic systems with changing complexities.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Demonstrate how bones, joints, and muscles serve as components of human levers, acting in accordance with the laws of mechanics.
2. Demonstrate the application of knowledge of joint structure, joint stability factors and those factors influencing joint range of motion to the selection of developmental exercises for muscle strengthening, treatment and prevention of sport/athletic injuries.
3. Demonstrate the basic principles of mechanics as they apply to the analysis of human movement.
4. Able to approach training, rehabilitation, and/or coaching from an analytical point of view.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 6	PSO1	PSO 2	PSO3
CO1	3	2	3	1	1	1	2	2	-
CO2	1	2	3	2	1	1	1	3	-
CO 3	2	1	3	3	1	1	1	1	-
CO4	3	1	3	2	1	1	3	2	-

Contents:

UNIT I – (CO1) (08 Hrs.)

Forces and moments, types of forces, resultant of system of forces, Forces and Torques in Equilibrium, Applications with example on human body. Work energy equations, Stress-strain diagram of human bones, Stress concentration.

UNIT II – (CO2) (08 Hrs.)

Applications to Biomedical system. Mechanical properties of human bone, Mechanical properties of cortical bone, properties of cancellous bone, viscoelasticity, elastic model of bone. Mechanical testing of soft tissues.

UNIT III – (CO3) (07 Hrs.)

Principle of continuum mechanics, Tensor treatment to explain elastic, viscoelasticity, electric and electromechanical properties of bones, teeth and connective tissues. Dental forces, implant-tissue biomechanics, Crack propagation in bones.

UNIT IV – (CO4) (07 Hrs.)

Wolf's law and introduction to orthopedic biomechanics, Human body dynamics and locomotion analysis. Pressure sore biomechanics, Interaction between tissues and support surface. Mechanics of spinal distraction rods, Biomechanics of human motion and control interfaces with application to limb orthotics and prosthetics.

Text Books:

1. "Principles of Biomechanics" by Robert L. Huston, CRC Press publisher.
2. "Fundamentals of Biomechanics" Equilibrium, Motion and deformation, Nihat Ozkaya and Margareta Nordin, 2nd Edi. Springer 1999.
3. "Kinetics of Human Motion" by Zatsiorsky & Vladimir, Oswal Camrage Publication, 2008.

Reference Books:

1. "An introduction to Biomechanics of joints and joint replacements", by Dowson and V. Wright, Mechanical Engineering Publications, 1980.
2. "Mechanism of Human bones" by Berne & Levy Physiology, 6th Updated Edition, 2009 edition.

Online Courses

1. Basics of Bio Mechanics & Human Movements, Dr. Sujatha Shrinivasan, IIT, Madras, https://nptel.ac.in/courses/112106248/

Subject Experts

1. Dr. Sujatha Shrinivasan, Applied Ergonomics & Biomechanics Department, IIT, Madras
2. Prof. Shantanu Bhattacharya, Department of Mechanical Engineering, Indian Institute of Technology, Kanpur

SEMESTER-V

Elective-I: (BMEL 325) Industrial Engineering and Management

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	50	----	----	75

Course Objectives:

1. Contribute to the success of companies through effective problem solving
2. Design, develop, implement, and improve integrated systems that include people, materials, information, equipment, and environments
3. Effectively manage business operations and project management teams
4. Continue to develop holistically, including the personal and professional skills necessary to adapt to our changing societal, technological, and global environments

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Apply knowledge of mathematics, science, and engineering;
2. Design and conduct experiments, as well as to analyze and interpret data;
   Ability design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
3. Evaluate and Implement the function on a multidisciplinary team.
4. Develop the maintenance strategies for case study.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes				Programme Specific Outcomes		
	PO1	PO2	PO6	PO7	PSO 1	PSO 2	PSO3
CO1	3	3	1	2	3	-	-
CO2	3	2	2	1	3	-	-
CO3	3	3	2	2	3	2	-
CO4	3	1	3	3	3	-	-

Contents:

UNIT I (CO1) (7 Hrs)

Productivity concept and definition, Techniques of productivity improvement- Work content and ineffective time, improving productivity by reducing work content and ineffective time, Benefits of higher productivity.

UNIT II (CO2) (8Hrs)

Productivity Measurement: Need for productivity measurement, total productivity index, partial productivity indices. Productivity models, Viz (1) Craig & Harris (2) Total productivity Model (3) American Productivity Centre model and Numerical Problems.

UNIT III (CO3) (7 Hrs)

Format and Functions of the objective matrix, productivity criteria, performance scores, weights, values and Indicators. OMAX applications. Computer applications in work study.

UNIT IV (CO4) (8Hrs)

Work Sampling: Theory of sampling and the law of averages, the normal and Binomial distribution as applied to work sampling.

Accuracy of work sampling measurement, procedure for making a work sampling measurement, procedure for making a work sampling study, use of control chart in work sampling, Advantages and disadvantages of work sampling.

Text Books:

1. "Productivity Engineering & Management", by Sumanth D J, McGraw Hill (1995).
2. "Motion & Time Study - Design & Measurement of work "by Ralph M-Barnes, John Wiley & sons, Pearsons Publication (2002).
3. International Labour organization, "Introduction to work-study", Universal Publishing Company. ISBN 81-850270.

Reference Books:

1. "Industrial Engineering Handbook", by Maynard H. B., 3rd edition, McGraw Hill Book Company. ISBN 0-07-041084-4
2. Business Dynamics: Systems Thinking and Modeling for a Complex World, by John Sterman , in Irwin, McGraw Hill(2000).
3. System Dynamics : A Practical Approach for Managerial Problems, by Sushil, Wiley Eastern (1993).
4. Industrial Dynamics, by J.W. Forrester, Cambridge MA: Productivity Press (1961)
5. Study Notes in System Dynamics, by Michael R. Goodman, Pegasus Communications (1989).

Online Courses:

1. Product Design & development, https://freevideolectures.com/course/2367/industrial-engineering/2 , by Prof. Pradeep Kumar, IIT Roorkee.
2. Production, Planning and Control, https://nptel.ac.in/courses/112/107/112107292/ by Prof. D. K. Diwedi, IIT Roorkee.
3. Principle of Industrial Engineering, https://swayam.gov.in/nd1_noc20_me43/preview, by Prof. D.K. Diwedi, IIT Roorkee.
4. Acceptance Sampling (Six Sigma), https://nptel.ac.in/courses, by Dr. T P Bagchi, IIT Kharagpur.

Subject Experts

1. Dr. Pradeep Kumar, Department of Mechanical and Industrial Engineering, IIT Roorkee.
2. Prof. H.S. Shan, Department of Mechanical and Industrial Engineering, IIT Roorkee.
3. Dr. T P Bagchi, Vinod Gupta School of Management, IIT Kharagpur.

SEMESTER-V

Elective-I: (BMEL 326) Smart Materials and Structure

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	50	----	----	75

Course Objectives:

1. To explain the basic concepts of Smart materials.
2. To develop competency in selection high-band width low strain smart sensors
3. To make students conversant with Smart Actuators.
4. To make the students conversant with Advances of smart materials and structures.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Explain basic principles of piezoelectricity.
2. Apply Modelling of smart materials
3. Evaluate the concept of smart actuators
4. Adapt the applications of Smart materials and advancements.

CO Mapping with PO and PSO:

Course Outcomes	Programme Specific Outcomes					Programme Specific Outcomes		
	PO1	PO6	PO7	PO8	PO12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	1	1	2	1
CO2	3	2	2	2	1	3	2	1
CO3	3	2	2	1	2	2	1	1
CO4	2	3	3	3	2	2	2	2

Contents:

UNIT 1 (CO-1) (8 Hrs)

Introduction to Smart Materials, Principles of Piezoelectricty, Perovskyte Piezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers , Principles of Magnetostriction, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rhelological Fluids

UNIT 2 (CO-2) (8 Hrs)

High-Band Width Low Strain Smart Sensors Piezeoelctric Strain Sensors, In-plane and Out-of Plane Sensing, Shear Sensing, Accelerometers, Effect of Electrode Pattern, Active Fibre Sensing, Magnetostrictive Sensing, Villari Effect, Matteuci Effect and Nagoka- Honda Effect, Magnetic Delay Line Sensing, Application of Smart Sensors for Structural Health Monitoring (SHM), System Identification using Smart Sensors

UNIT 3 (CO-3) **(8 Hrs)**

Smart Actuators

Modelling Piezoelectric Actuators, Amplified Piezo Actuation –Internal and External Amplifications, Magneto strictive Actuation, Joule Effect, Wiedemann Effect, Magneto volume Effect, Magneto strictive Mini Actuators, IPMC and Polymeric Actuators, Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control

UNIT 4 (CO-4) **(7 Hrs)**

Advances in Smart Materials and Structure

Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self-Healing Polymers, Intelligent System Design, Emergent System Design

Text Books:

1. M V Gandh& B.S. Thomson CHAPMAN & HALL Publications, 1992
2. Introduction to Physical Metallurgy by S. H. Avener McGraw Hill Publication,,2001Engineering Physical Metallurgy & Heat Treatment, Lakhtin Y.; 6th Ed; Mir Publishers, 1998.
3. Metallurgy for Engineers, Rollason E.C.; Edward Arnold publications, 1959.
4. Introduction to Engineering Metallurgy, B.K. Agrawal;

Reference Books:

1. Smart Structures by Afzal Suleman Springer -Verlag PUBLICATIONS, 200.
2. Smart Materials by Thoman Bevan, Pearson Education India, CBS publication Second edition, 1992
3. Smart Materials by V.P. Singh, Dhanpat Rai publication Third edition, 2012

Online Courses:

1. Smart Materials and Intelligent System Design, https://onlinecourses.nptel.ac.in/noc19_me68
2. Smart Material, Adaptive Structures and Intelligent Mechanical Systems - IITK https://nptel.ac.in/courses/112104173/#

Subject Experts:

1. Prof. V. K. Gupta, Department of Mechanical Engineering, IIITDM Jabalpur
2. Prof. Bishakh Bhattacharya, Department of Mechanical Engineering, IIT Kanpur
3. Prof. Nachiketa Tiwari, Department of Mechanical Engineering, IIT Kanpur

SEMESTER-V

Elective-I: (BMEL 327) Compressor and Pumps

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	50	----	----	75

Course Objectives:

1. To understand the principle of pump and compressor for Industrial applications.
2. To understand the control of performance and operating parameters during operation of pump and compressor.
3. To understand various types of pumps and compressors
4. To understand trouble shooting in compressor and pump

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Describe the basic principles of compressors as used in Industry.
2. Implement & apply the knowledge for smooth working of utility system.
3. Select the pump and compressor for various application.
4. Apply the knowledge for trouble shooting and maintenance of pump and compressor.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO6	PO7	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	3	3	2	2	--	3	--
CO2	3	3	3	3	2	2	--	3	---
CO3	3	2	3	2	3	2	--	3	--
CO4	3	2	3	2	3	2	--	3	--

Contents:

Unit I (CO 1) (8 Hr)

Reciprocating compressors: Types, Performance parameters, Selection criteria, Applications of compressed air in industry, Compressed air network, Leak detection in compressed air network, Load unload test, pump-up test, Methods to improve performance

Unit II (CO 2) (8 Hrs)

Centrifugal compressor: Velocity diagrams, work input, Efficiency, Effect of blade shape, Slip factor, Types of casings, Impeller and diffuser system and design aspects

Axial flow compressors: Velocity triangles and calculation of work input and efficiency

Losses in Compressors: Choking, Surging and Stalling

Unit III (CO 3) (7Hrs)

Pumps

Types of pumps - positive displacement and non - positive displacement.

Positive Displacement pumps: Types and applications, general features of rotary pumps like gear pumps, vane pumps etc., general feature of reciprocating pumps, definition of head, discharge, work done and efficiency, types of reciprocating pumps, indicator diagram, use of air vessel.

Types - radial flow, mixed flow and axial flow, Priming of pumps, components of the pump, Euler's equation and velocity triangles, correction factors for the head, design constant e.g., head constant, flow constant etc.,

Types of blade profiles, aero foil theory of axial flow pumps, Pressure recuperating devices, Radial thrust and axial thrust and methods used to balance them.

Trouble shooting in centrifugal pumps, self-priming pumps. Concept of system and system characteristics, Series and parallel operation of pumps. System curve for branch network. Determination of operating point. Cavitation in pumps, Determination of available and required NPSH. Testing of pumps as per BIS.

Unit IV (CO 4) (7Hrs)
Application based pumps:

Submersible pumps, deep well pumps, ejector pump, mud pump, chemical pumps. Problems and testing of submersible pump as per BIS, operating parameters, determination of percentage loading, efficiency at part loading and methods of improving efficiency, Improving loading, Changing impeller, trimming impeller, Variable speed drive, etc.

Text Books:

1. Centrifugal Compressor and Pump Selection by David H. Midgley (Author), McGraw Hill Publication Ltd. ISBN-10: 007180000X. ISBN-13: 978-0071800006.

2. Fluid Movers: Pumps, Compressors, Fans and Blowers Hardcover – 1 April 1980 by N/A Chemical Engineering Magazine (Author) Publisher: McGraw-Hill Education (1 April 1980) ISBN-10: 0070107696 ISBN-13: 978-0070107694.

Reference Books:

1. Performance Monitoring of Pumps and Compressors, Jayaraman Ganesh, Publisher: IDC Technologies Pvt. Ltd, Edition: 2, 2008.
2. Positive Displacement Machines, Ibrahim Sultan Truong Phung, Academic Press
3. Pump Handbook, Igor J. Karassik and Joseph P. Messina, ISBN-13: 978-0070333024,Second Edition, McGraw-Hill Book Company (January 1, 1987)
4. Vertical Turbine, Mixed Flow, and Propeller Pumps Hardcover – January 1, 1987 John L Dicmas, McGraw-Hill Book Company (January 1, 19)

Online Courses:

1. NOC: Principle of Hydraulic Machines and System Design , NPTEL, IIT, Guwahati
2. NOC: Fluid Dynamics and Turbomachines, NPTEL, IIT, Madras
3. Introduction to Fluid Machines and Compressible Flow, NPTEL, IIT Kharagpur

Subject Experts:

1. Prof. Pranab K. Mondal, Department of Mechanical Engg., IIT, Guwahati
2. Prof. Shamit Bakshi, Department of Mechanical Engg., IIT, Madras
3. Prof. S.K. Som, Department of Mechanical Engg., IIT Kharagpur

SEMESTER-V

Elective-I: (BMEL 328) Simulation of Manufacturing System

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
4	-	-	4	2	10	15	50	----	----	75

Course Objectives:

1. To understand the importance of Simulation and modeling in manufacturing technique.
2. To understand systems and applications of Simulation models and there effective implementation
3. To understand the knowledge of application of Random numbers, managerial information flow and SPSS
4. To understand technical aspects of Design of simulation experiments

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Develop mathematical model for real life system and perform simulation.
2. Define and choose the random numbers using suitable statistical tool
3. Construct the random number variety of various distributions like normal, exponential, uniform, etc
4. Examine simulation study of real life system using random number table

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO9	PSO 1	PSO 2	PSO3
CO1	3	3	2	2	3	2	2	-	2
CO2	3	2	2	2	3	2	2	-	1
CO3	3	2	2	2	3	2	2	-	2
CO4	3	2	2	2	2	3	2	-	2

Contents:

UNIT I: INTRODUCTION (CO 1) [8Hrs]

Manufacturing Systems: Definition of systems; basic concepts and problems concerning systems; Systems design: Decision making procedures; Structural, Transformational and procedural aspects of manufacturing; Modes of production. Process systems for manufacturing; logistic systems; material flow & technological information flow. Management and information systems for manufacturing: Managerial information flow in manufacturing systems.

UNIT II: RANDOM NUMBERS (CO 2) [8 Hrs]

Probability and statistical concepts of simulation – Pseudo random numbers – methods of generating random numbers – discrete and continuous distribution – testing of random numbers – sampling – simple, random and simulated.

UNIT III: DESIGN OF SIMULATION EXPERIMENTS (CO 3) [10 Hrs]

Problem formulation – data collection and reduction – time flow mechanical – key variables – logic flow chart starting condition – run size – experimental design consideration – output analysis, interpretation and validation – application of simulation in engineering industry.

UNIT IV: CONTINUOUS SYSTEM SIMULATION (CO 4) [8 Hrs]

Numerical solution of differential equation, analog computers, hybrid computers, continuous system simulation languages CSMP, system dynamic growth models, logistic curves. Discrete systems simulation: Events generation of arrival patterns, simulation programming tasks, analysis of simulation output. Queuing theory: Arrival pattern distribution, service times, queuing disciplines, and measure of queues.

Text Books:

1. Gray Beal, Wajne J. and Pooch U. W., "Simulation Principles and Methods", Winthrop Publishing Incorporate.
2. Severance Frank, "System Modelling and Simulation", John Wiley & Sons, 2005.
3. Banks J., Carson J.S., Nelson and Nicole, "Discrete Event System Simulation", Pearson Education, Asia, 2001.
4. Hopp W. J. and Spearmen M.L., "Factory Physics", McGraw Hill Higher Education, 2000.
5. Kelton W.D., Sadowski R.P., and Swets N.B., " Simulation with Arena", McGraw Hill, 2010.
6. Banks J. and Carson J.S., "Discrete Event System Simulation", Prentice Hall, 2001.

Reference Book:

1. John H. Mize and J. Grady Cox, "Essential of simulation" – Prentice hall 1989.
2. Geoffrey Gordon "System simulation" – Prentice Hall of India, 1992
3. Jeffrey L.Written, Lonnie D, Bentley and V.M. Barice, "System analysis and Design Methods", Galgotia publication, 1995
4. Averill M. Law and W. David Kelton, "Simulation Modelling and analysis", McGraw Hill International Editions, 1991
5. Shannon R.E., "System simulation", Prentice Hall 1993.
6. David Bedworth & James Bailey, Integrated production control system management, analysis & design, 2nd ed., John Wiley & Sons Ltd.
7. Ronald Zskin& Charles Standridge, Modeling and Analysis of Manufacturing Systems, John Wiley & Sons Ltd.
8. Geofery Gordan, Systems Simulation, Prentice Hall, 1980.
9. Deo. N., System Simulation with Digital Computers, Prentice Hall, 1980.

Online Courses:

1. Modeling and Simulation of Discrete Event Systems, www.nptel.ac.in
2. Modelling and Simulation of Dynamic Systems, www.swayam.gov.in
3. Simulation of Business Systems: An Applied Approach, www.swayam.gov.in

Subject Experts:

1. Prof. Pradeep Kumar Jha, Department of Mechanical Engg., IIT Roorkee
2. Prof. Pushparaj Mani Pathak, Department of Mechanical Engg., IIT Roorkee
3. Prof. Deepu Philip, Department of Mechanical Engg., IIT Kanpur

SEMESTER-V

Elective-I: (BMEL329) Welding Technology (Industry Elective)

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int	Ext	
4	-	-	4	2	10	15	50	----	----	75

Course Objectives:

1. Identify the different sources of energy and associated principles for welding and also, understand the importance of filler material.
2. Explain the mechanisms of different types of welding and their applications in industries.
3. Understand the procedure and uses of different testing methods.
4. Analyze different microstructural behavior of welded joints and various defects which occur during welding.

Course Outcomes:

At the end of this course, students shall be able to

1. Understand the concept of Arc stability and its working during welding.
2. Apply the knowledge of different welding techniques for industrial applications.
3. Analyze welded joints by employing various testing methods.
4. Evaluate different failure modes in weldment.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	2	1	1	3	2	--	3	--
CO2	3	2	2	1	3	3	--	3	--
CO3	2	3	2	3	3	2	3	3	3
CO4	2	2	1	1	2	2	3	3	3

Contents:

CO1: Introduction of Joining (8 Hr)

Classification of welding processes, Source of energy for welding, Fusion welding, heat generation; principle, Physics of Welding Arc; voltage distribution along the arc theories of cathode and anode mechanism; arc characteristics, application of fillers.

CO2: Arc Welding Processes (8 Hr)

Consumable electrode welding processes. Manual metal arc (MMA) welding; Gas metal arc welding (GMAW), Pulsed spray welding, Submerged arc welding, MIG welding; Gas tungsten arc welding (TIG welding), selection of polarity, Plasma arc welding; transferred and non-transferred plasma arc welding; selection of gases; welding parameters.

CO3: Testing and inspection of weld joints (7 Hr)

Non-Destructive Testing of Weldments, Ultrasonic inspection-principle of ultrasonic testing, N.D.T.: Standard procedure for specification and qualification of welding procedure; Welding process sheet (WPS), Welding performance qualification (WPQ)

CO4: Weldability of metals and its various defects (7 Hr)

Solidification of weld metal, heat affected zone (HAZ), factors affecting properties of HAZ; lamellar tearing and hydrogen damage; weldability; definition, factor affecting the weldability of steel. Failure analysis of welded joints. Common defects during welding.

Text Books:

1. Welding Fundamental, by William A Bowditch A & Kevin A Bowditch, Publisher: Good heart-Willcox, 1991, *4th Edition.*
2. Welding Metallurgy & Weldaility of Stainless Steel, John C Lippold, *2th Edition,* 2014

Reference Books:

1. Metallurgy of Welding, J. F. Lancaster, William Andrew Publishing, 6th Edition.
2. Principles of Welding (Processes, Physics, Chemistry and Metallurgy), by Robert W Messler, Wiley Publishers, 6th Edition.
3. Welding Metallurgy, by Sindo Kou, Wiley Publishers, 2016, 2nd edition.
4. Welding Hand Book, Publisher: American Welding Society; 7th edition.

Online Courses:

1. Fundamental of Welding Science and Technology, https://www.classcentral.com/course/swayam-fundamental-of-welding-science-and-technology-13016.
2. Source of Heat and Protection of Weld Pool, https://nptel.ac.in/courses/112107089/.
3. Physics of Welding arc, https://nptel.ac.in/courses/113106087/.

Subject Experts:

1. Dr. Pankaj Biswas, Professor, Department of Mechanical Engg., Indian Institute of Technology Guwahati.
2. Dr. Murugaiyan Amirthalingam, Professor, Department of Mechanical Engg., Indian Institute of Technology Madras.
3. Dr. D K Diwedi, Professor, Department of Mechanical Engg., Indian Institute of Technology Roorkee.

SEMESTER-V

BMEP331: Product Design & Packaging

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	1	1	0.5	-	-	-	25	----	25

Course Objectives:

After completing this course students will be able to –

1. Evaluate Engineering Design process & Manufacturing fundamentals
2. Analyze and apply the fundamentals of 3D modeling, modeling of components.
3. Understand and apply suitable packaging techniques for different applications.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Evaluate product Design characteristics & determining manufacturing concepts.
2. Understand and apply Rapid prototyping (3 D Printing), Component sourcing, Assembly modeling, Assembly testing.
3. Identify the packaging material consideration for various goods
4. Understand and apply Innovative packaging Techniques for sustainable environment.

List of Experiments

Expt. No	Experiment Name
1	Overview of engineering design process, Engineering notebooks/documentation
2	Overview of manufacturing fundamentals.
3	Fundamentals of 3D modeling, Modeling of components.
4	Component development from customer specifications, Identification of Customer Needs and Market Research Essentials.
5	New product design and development from conceptual model & Product manufacturing.
6	Rapid prototyping (3 D Printing).
7	Component sourcing, Assembly modeling, Assembly testing
8	Final product testing-Manufacturing Process plan.
9	Packaging Materials & its characterization.
10	Product Package Development Processes.
11	Specially and Innovative packaging Technology & Packaging Dynamics
12	Sustainability in Packaging.

SEMESTER-V

BMEP332: Internship (2 Week)

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	2	2	2	-	-	-	25	-	25

Guidelines for Two Week Social Internship

Procedure:

1. Based on the area of interest the student will find an appropriate NGO for two social internship.
2. After verification of NGO from III cell student will be permitted to proceed.
3. Student will work for the NGO at least 6 hours a day.
4. Student must be a part of one of the event organized by NGO.
5. After completion of internship the student has to submit the hard copy of certificate and report to the department.
6. Student need to present the work in form of power point presentation for the final assessment.
7. Student must complete two week internship during the vacation and before the start of fifth semester.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Find social issues and contribute to the society for better livelihood.
2. Build qualities like empathy, patience, optimism etc.
3. Make use of communication skill to communicate people from various background.
4. Develop soft and technical skill such as teamwork, leadership, event management etc.

Marks Distribution:

Parameters	Evaluation by NGO	Nature of work	Presentation	Report
Marks	5	5	5	10

SEMESTER-V

BMEP333: Skill Development 3

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	2	2	1	-	-	-	25	-	25

Measurement and Quality Control

Exp No	Experiment Name
1	Elementary Metrology: Definition, objective, Precision and accuracy Sources of errors, Concept of Repeatability, Sensitivity, Readability and Reliability.
2	Linear Measurement: Slip Gauges, Vernier Height Gauges, Depth gauges, Vernier micrometers (Description of various parts and their specification)
3	Angular Measurement: Introduction, Vernier and optical Bevel protractor, Sine Principle and Sine Bars, Optical Instruments for angular measurement, Calibration of angle gauges
4	Comparative Measurement: Comparators, use, classifications, Working Principle of optical and pneumatic comparators.
5	Instruments and Gauges for Testing straightness, flatness, squareness, parallelism: Definition of straightness, flatness of surface, parallelism. Testing of straightness, flatness and parallelism
6	Limits, Fits and Gauges,: Introduction.: Concept of Tolerances, Interchangeability. Terms associated with an assembly - basic size, normal size, limits, deviation and zero line. Methods of limit systems - hole basis and shaft basis.
7	Introduction to National and International Quality norms, bodies and agencies and Standards
8	Inspection Introduction and Definition of Inspection. Principle of Inspection. Inspection Stages. Floor Inspection - advantages and disadvantages.
9	Quantity function in Industry: Concept of Quality. Quality of design, conformance and performance. Concept of reliability and maintainability. Factors affecting quality. Quality circles - basic concept, purpose and functioning
10	Fundamentals of Statistical Concept in Quality Control: Types of variations. Types of quality characteristics: variable, attribute and variable treated as attribute. Terminology used in frequency distribution. Graphical presentation of frequency distribution (Histogram, Frequency Bar Chart, Frequency Polygon).
11	Control Charts in S.Q.C.: Introduction to X-R Chart. Steps required to construct X-R Chart. Analysis of X and R Chart. Concept of process capability. Control Charts for percent defective (p-chart). Application of p-chart. Introduction of c-chart. Construction of c-chart and its analysis.
12	Operation Characteristics (OC) Curve: Definition and explanation of an OC Curve. Different parameter of OC Curves -(Producer's risk, consumer's risk, Acceptance Quality Level (AQL) etc. Zone of acceptance, rejection and indecision. Relationship between the parameters of OC-Curves.

Reference Book:

1. Quality Control, Tata McGraw Hill Publishing Ltd., TTTI Madras
2. Industrial Organisation, Khanna Publishers, T.R. Banga
3. Inspection and Quality Control, National Productivity Council.

SEMESTER-VI

BFYL119: Optimization Techniques

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
1	--	--	1	1	10	15	25	--	----	50

Course Objectives:

1. To understand the techniques of optimization method.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Apply concept of Graphical methods.
2. Apply basic concepts of Optimization Techniques.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	2	--	---	--	---	--	---	-
CO2	3	2	---	---	---	--	--	--	-

Contents:

UNIT-I **[6 Hrs]**

Linear Programming Problems (CO1)

Linear programming, mathematical model formulation, solutions by graphical.

UNIT-II **[9 Hrs]**

Simplex and Big M-Methods **(CO2)**

Simplex method, Dual Simplex method, Big M Method

Fuzzy and genetic algorithm

Text Books:

1. Higher engineering Mathematics by B S Grewal, 43rd edition, Khanna Publication.
2. Linear Programming: methods and application by Saul I Gass.
3. Linear Programming: theory and application by Catherine Lewis.

SEMESTER-VI

BMEL336: Design of Machine Elements

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
3	-	-	3	3	10	15	50	--	----	75

Course Objectives:

1. To develop proficiency of fundamental concepts of design.
2. To develop an ability in designing a mechanical elements involved in design projects.
3. To develop analytical & computational skills in designing basic mechanical components used for general purposes.
4. To give exposure of designing of transmission shafts.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Apply basic concepts of design, selection of materials in the design of a Machine Components.
2. Make use of the design principles of power screw, helical & leaf spring in the design of suspension system.
3. Apply the design procedure of clutches, brakes and Pressure Vessel for various applications.
4. Design of shafts for various power transmission systems.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 8	PSO 1	PSO 2	PSO3
CO1	3	3	2	2	3	1	1	2	1
CO2	2	3	2	2	3	1	2	1	1
CO3	2	3	2	2	3	1	2	1	1
CO4	2	3	2	2	3	1	2	1	1

Contents:

UNIT I (CO1): (8Hrs.)

Definition of design, types of design, design process, need, defining the problem, design for manufacturing aspects, Mechanical Properties, applications and designations as per ISI and their equivalence with other standards of engineering materials, selection of materials, Various types of joints: Riveted and Welded, Cotter and Knuckle Joints.

UNIT II (CO2): (8Hrs.)

Design of Power Screw, Derivation of expression for deflection and shear stress in helical spring, Design of helical spring, Design of leaf spring.

UNIT III (CO3): (7Hrs.)

Kinematics of Friction Drives such as brakes clutches. Design of single plate and multiple plate, clutch. Design of brake: shoe brake, band brake. Classification of thin and thick cylindrical pressure vessel, stresses in thin and thick cylindrical pressure vessels.

UNIT IV (CO4): (7Hrs.)

Design of transmission shafts on the basis of strength, rigidity and critical speed, ASME code for shaft design, design of stepped shaft, axle, splined shaft, keys.

Text Books:

1. "Design of Machine Elements",V. B. Bhandari ,Tata McGraw-Hill Education, Third edition, Firs Reprint 2010.
2. "A Textbook of Machine Design", R.S. Khurmi and J. K. Gupta, Eurasia Publishing House Pvt. Ltd. Fourteenth Edition, 2005.
3. Design Data for Machine elements, B.D. Shiwalkar, Benett& Co Publishing Division, revised edition, 2015.

Reference Books:

1. "Mechanical Design of Machine", Martin J. Siegel, Vladimir L. Maleev, James Busse Hartman, Pennysilveria, International Textbook Co, Fourth Edition, 1972.
2. "Machine Design", P.H. Black, McGraw-Hill, Third Edition, 1983.
3. "Mechanical Engg. Design", J. E. Shigley, Charles R. Mischke, Richard G. Budynas, McGraw-Hill, Tenth Edition, 2014.

Online Courses

1. Understanding Design Prof. Nina Sabnani IIT, B (mooc) https://www.iitbombayx.in/courses/understanding-design
2. Basic 3D animation using Blender Sameer S Sahasrabudhe IIT, B (mooc) https://www.iitbombayx.in/courses/basic-3d-animation-using-blender-1
3. Engineering Design Process with Autodesk Fusion 360 Autodesk Coursera, https://www.coursera.org/learn/engineering-design-process-fusion-360
4. Machine Design part 1 Dr. Kathryn Wingate, Academic Professional Georgia Institute of Technology (COURSERA) https://www.coursera.org/learn/machine-design1

Subject Experts

1. V Huzur Saran, Department of Mechanical Engg., IIT Roorkee
2. Bandopadhya Dibakar, Department of Mechanical Engg., IIT Guwahati

SEMESTER-VI

BMEL 337/BMEP 337: Thermal Engineering

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	2	4	3	10	15	50	25	--	100

Course Objectives:

1. To study applications reciprocating compressor.
2. To familiarize with the characteristics of rotary compressor.
3. To study internal combustion engines, various testing methods of internal combustion engines
4. To study applications of gas turbine and jet propulsions.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Illustrate the different types of air compressors.
2. Evaluate the performance of different types of air compressors
3. Evaluate performance of internal combustion engine.
4. Apply basic gas power cycle for the analysis of gas turbines.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PO7	PO 12	PSO 1	PSO 2	PSO3
CO1	3	2	2	2	2	2	--	3	--
CO2	3	3	2	2	3	2	--	3	--
CO3	3	2	2	2	2	2	--	3	--
CO4	3	2	2	2	2	1	--	3	--

Contents:

Unit I (CO 1) Positive Displacement Compressors: (8Hrs)

Reciprocating compressors : Parts, Operations, Work done during isothermal, polytropic and adiabatic compression process, PV diagram, isothermal efficiency, Effect of clearance, volumetric efficiency, Mechanical efficiency, Multistage compressor, condition for minimum work input, capacity control, Actual indicator diagram.

Unit II (CO 2) Rotary Compressors: (6Hrs)

Rotary and vanes blower and screw compressor:

Principle, operation, parts, indicator diagram, work done, Roots efficiency, vanes efficiency.

Centrifugal Compressor:

Principle, operation, parts, velocity diagram, static & total head quantities, work done by impeller, isentropic efficiency of compressor, slip factor, pressure coefficient, power input factor.

Axial flow compressor:
Principle, operation, parts, velocity diagram, work done, Degree of reaction stage efficiency compressor characteristics, surging& chocking. Poly tropic efficiency.

Unit III (CO 3) I.C. Engines: (8Hrs)
Introduction to I.C. Engine: Air standard & fuel air cycles, parts of I.C. Engines, working of I.C. Engines, Two stroke and four stroke I.C. Engines SI & CI Engines, Introduction to combustion in SI & CI Engine, carburetion and fuel injection.
I.C. Engine Testing: Measurement of power- Indicated, friction and brake power, measurement of speed, fuel land air consumption, calculation of indicated and brake thermal efficiency, volumetric efficiency, mechanical efficiency, percentage of excess air, Heat balance sheet, performance, characteristics and factors influencing the performance of I.C. Engines.

Unit IV (CO 4) Gas Turbines and Jet propulsion: (8 Hrs)
Ideal cycles isentropic and small stage efficiency, application of gas turbine pressure losses, effect of inter-cooling, reheat and regeneration, fuel – air ratio, combustion efficiency performance calculation, open cycle and closed cycle gas turbine plants Principles and working of turbojet, turboprop, Ramjet and pulse jet simple turbojet cycle, Thrust power, propulsive power. Thermal efficiency propulsive efficiency, overall efficiency.

Text Books:

1. Thermal Engineering , B.K. Sarkar, Tata McGraw publication,1998
2. Internal Combustion Engine, fourth edition, V. Ganeshan, Tata McGraw publication, 2012.
3. Gas Turbine, V. Ganeshan, third edition, Tata McGraw publication, 2010

Reference Books:

1. Applied Thermodynamics, Dr. R. Yadav, sixth revised edition, Central Publishing House Allahabad, 2011.
2. Fundamentals of Internal Combustion Engines, Second Edition H.N.Gupta, PHI (Prentice Hall India Learning Private Limited) Publication, 2012
3. Gas Turbine Theory , H. cohen and G.H. Rogers, H. I.H. Saravanamattoo, Fifth edition, Pearson Education limited, 2001.

Online Courses
1. Jet Aircraft Propulsion Prof. A.M. Pradeep, Bhaskar Roy, IIT Bombay, NPTEL https://nptel.ac.in/courses/101101002/
2. Refrigeration and Air Conditioning, Prof. M. Ramgopal, R.,C. Arora IIT Kharagpur, NPTEL, https://nptel.ac.in/courses/112105128/
3. Engineering Thermodynamics Jayant K. Singh IIT- Kanpur swayamhttps://swayam.gov.in/courses/3543-engineering-thermodynamics

<u>Subject Experts</u>
1. Prof. A.M. Pradeep, Department of Mechanical Engg., IIT Bombay
2. Prof. Bhaskar Roy, Department of Mechanical Engg., IIT Bombay

SEMESTER-VI

BMEL 338/BMEP 338: Heat Transfer

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	2	4	3	10	15	25	50	--	100

Course Objectives:

1. To provide a general knowledge on the basic mechanisms of heat transfer
2. Make the right assumptions and approximations for tackling practical situations
3. To develop intellectual skills of providing analytical solutions to variety of real life situation involving heat transfer.
4. Exploring the advanced career opportunities in the area of heat transfer like design of heat exchangers, heat transfer augmentation methods, Thermal analysis etc.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Apply basic laws of heat transfer to solve heat conduction problem.
2. Relate various empirical correlation to solve convective heat transfer problem.
3. Apply laws of radiation on problems of heat transfer.
4. Evaluate the performance of heat exchanger using LMTD and NTU method.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	2	2	2	2	3	3	--
CO2	2	3	2	2	3	2	3	3	--
CO3	2	3	2	2	2	2	3	3	--
CO4	2	3	2	3	3	2	3	3	--

Contents:

UNIT-I [8 hrs]

Introduction: Modes of Heat Transfer. Laws of Heat Transfer and General Heat Conduction Equation in Coordinate systems. One Dimensional Steady State Conduction Equation for the Plane Wall, Cylinder and Sphere. Thermal Resistance of Composite Structures, Contact Resistance, Overall Heat Transfer Coefficient, Critical Thickness of Insulation. Extended Surfaces, Types Of Fins. Fins of Uniform Cross Section Area, Temperature Distribution and Heat Transfer Rate, Fin Efficiency and Effectiveness.

UNIT-II [8 Hrs]

Forced Convection, Physical Signification Of Non Dimensional Parameters. Flow over a Flat Surface. Concept of Velocity & Thermal Boundary Layer Thickness, Local and Average Heat Transfer Coefficients

Free Or Natural Convection, Non dimensional Parameters. Horizontal and Vertical Plate. Heat Transfer with Phase Change, Boiling and Condensation,

UNIT-III [7 hrs]

Radiation, Nature of Thermal Radiation, Black Body Radiation, Radiation Intensity, Laws of Radiation. Emissivity, Absorbtivity, Transmissivity, Reflectivity, Radiosity, Emissive Power, Irradiation. Radiation Network, Radiation Exchange between Surfaces, Idea of Shape Factor & Reciprocity Theorem.

UNIT-IV [7 hrs]

Heat Exchanger: Classification, Overall Heat Transfer Coefficient, Fouling Factor, LMTD Method of Heat Exchanger Analysis. Effectiveness NTU Method, Heat Exchanger Analysis by NTU Method, Design Aspects of Heat Exchangers. Introduction to Compact Heat Exchanger.

Text Books:

1. Heat and mass transfer,3rd edition, P. K. Nag Tata McGraw Hill Book Company, 2011
2. Heat Transfer,10th edition, J.P. Holman McGraw Hill Book Company, New York, 2014

Reference Books:

1. Fundamentals of Heat and Mass Transfer, 7th Edition, Incropera and Dewitt, John Wiley and Sons, 2011.
2. Heat and Mass Tranfer,4th edition, Yunus .A. Cengel Tata McGraw Hill Publication, 2011.

Online Courses

1. Heat and Mass Transfer Prof. S. P. Sukhatme, IIT Bombay NPTEL https://nptel.ac.in/courses/112101097/
2. Thermal conduction, convection, and radiation, khans academy https://www.khanacademy.org/science/physics/thermodynamics/specific-heat-and-heat-transfer/v/thermal-conduction-convection-and-radiation
3. Convective Heat Transfer, Arup Kumar Das, IIT Roorkee, swayam, https://swayam.gov.in/courses/3599-convective-heat-transfer
4. Two phase flow and heat transfer, Arup Kumar Das, swayam, https://swayam.gov.in/courses/3685-two-phase-flow-and-heat-transfer

Subject Experts

1. Dr. Sukhatme, Department of Mechanical Engg., IIT Bombay

SEMESTER-VI

Elective IV: (BMEL 339) Gas Turbine and Jet Propulsion

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int	Ext	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To get awareness and familiarize with the latest developments in turbojet propulsion systems.
2. To know principles of jet propulsion and rocketry.
3. To study solid and liquid rocket propulsion system.
4. To know ramjet and integral rocket ramjet propulsion system.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand and Build various concepts of turbojet propulsion systems.
2. Distinguish the jet propulsion and rocketry.
3. Categorize solid and liquid rocket propulsion system.
4. Interpret ramjet and integral rocket ramjet propulsion system

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PO6	PO 7	PSO 1	PSO 2	PSO3
CO1	3	2	2	1	2	1	1	2	-
CO2	3	1	2	1	1	1	-	1	-
CO3	3	1	1	1	1	2	-	1	-
CO4	3	1	2	2	2	1	-	1	-

Contents:

Unit-I: (CO 1) (7hrs)

Turbo Jet Propulsion System

Gas turbine cycle analysis – layout of turbo jet engine. Turbo machinery- compressors and turbines, combustor, blade aerodynamics, engine off design performance analysis. Flight Performance: Forces acting on vehicle – Basic relations of motion – multi stage vehicles.

Unit-II (CO2) (8hrs)

Principles of Jet Propulsion and Rocketry

Fundamentals of jet propulsion, Rockets and air breathing jet engines – Classification – turbo jet , turbo fan, turbo prop, rocket (Solid and Liquid propellant rockets) and Ramjet engines.

Unit-III (CO3) **(8hrs)**

Solid and Liquid Rocket Propulsion System

Solid propellants – classification, homogeneous and heterogeneous propellants, double base propellant compositions and manufacturing methods. Composite propellant oxidizers and binders. Effect of binder on propellant properties. Burning rate and burning rate laws, factors influencing the burning rate, methods of determining burning rates.

Liquid propellants – classification, Mono and Bi propellants, Cryogenic and storage propellants, ignition delay of hypergolic propellants, physical and chemical characteristics of liquid propellant. Liquid propellant rocket engine – system layout, pump and pressure feed systems, feed system components.

Unit VI: (CO 4) **(7hrs)**

Ramjet and Integral Rocket Ramjet Propulsion System

Fuel rich solid propellants, gross thrust, gross thrust coefficient, combustion efficiency of ramjet engine, air intakes and their classification – critical, super critical and sub-critical operation of air intakes, engine intake matching, classification and comparison of IIRR propulsion systems.

Text Books:

1. Sarvanamuttoo, H.I.H., Rogers, G. F. C. and Cohen, H., Gas Turbine Theory, 6th Edition, Pearson PrenticeHall, 2008.
2. Ganesan, V., Gas Turbines, 3rd Edition, Tata McGraw Hill, 2010.
3. Yahya, S. M., Turbines, Compressors and Fans, 4th Edition, Tata McGraw Hill, 2010.
4. Mechanics and Dynamics of Propulsion/ Hill and Peterson/John Wiley & son.

Reference Books:

1. Rocket propulsion elements/Sutton/John Wiley & Sons edition 8.
2. Gas Turbines/Ganesan /TMH
3. Gas Turbines & Propulsive Systems/Khajuria & Dubey/Dhanpat Rai & Son.
4. Rocket propulsion/Bevere/ 6. Jet propulsion /Nicholas Cumpsty/

Online Courses:

1. Jet Aircraft Propulsion, https://nptel.ac.in/courses/101101002/#

Subject Experts:

1. Prof. Bhaskar Roy, Department of Mechanical Engg., IIT Bombay
2. Prof. S. Pradeep, Department of Mechanical Engg., IIT Bombay

SEMESTER-VI

Elective IV: (BMEL 340) Advanced I.C. Engines

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	0	0	2	2	10	15	25	--	----	50

Course Objectives:

1. To understand various systems of I C engine.
2. To learn the emerging Technology in the field of automobile engines Engineering
3. To learn performance of I C engines
4. To study various emission norms.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand and Choose various engine components
2. Classify various combustion process
3. Select various fuel injection techniques
4. Create appropriate alternate fuel to reduce emission.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes				Programme Specific Outcomes		
	PO1	PO2	PO3	PO6	PSO 1	PSO 2	PSO3
CO1	3	2	2	1	2	3	-
CO2	3	3	1	2	2	3	-
CO3	3	3	3	1	1	3	-
CO4	3	3	3	3	2	3	-

Contents:

Unit-I: (CO 1) (7 hrs)

Engine nomenclature and components Engine nomenclature, losses in engines, actual and air standard engines.

Unit – II: (CO 2) Combustion in SI & CI Engines **(8 hrs)**

Combustion Phenomenon in SI & CI Engines, Knock, Detonation, combustion chambers,

Unit – III: **(CO 3) (7hrs)**

Fuel injection & ignition, engine performance

Diesel injection system, MPFI, electronic ignition and injection system, carburetors. Determination of BP, IP, performance characteristics, Energy balance.

Unit – IV: **(CO 4)** Alternate Fuels and Emission **(8 hrs)**

Engine emission, alternate fuels, exhaust after treatment devices, emission norms.

Text Books:

1. John B. Heywood," Internal Combustion Engine," McGraw-Hill publication.
2. Kirpal Singh Automotive Engineers, vol.1 & vol.2 , Standard publication
3. V Ganeshan, : "Internal Combustion Engines", McGraw-Hill publication

Reference Books:

1. V Ganeshan, : "Internal Combustion Engines", McGraw-Hill publication

Online Courses:

1. NPTEL course on "IC Engines and Gas Turbines"

Subject Experts:

1. Dr. Pranab K. Mondal, Department of Mechanical Engineering, IIT Guwahati

2. Dr. Vinayak N. Kulkarni, Department of Mechanical Engineering, IIT Guwahati

SEMESTER-VI

Elective IV: (BMEL 341) Reliability and TQM

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	--	----	50

Course Objectives:

1. To illustrate the basic concepts and techniques of modern reliability engineering tools.
2. To demonstrate the approaches and techniques to assess and improve process and/or product quality and reliability.
3. To know the principles of total quality management and peculiarities of their implementation.
4. To use quality management methods for analyzing and solving problems of organization.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand the concepts of reliability and maintainability.
2. Apply the basic techniques of quality improvement, fundamental knowledge of statistics and probability.
3. Acquire basic knowledge of total quality management.
4. Outline the business process modeling in engineering applications.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes				Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PSO 1	PSO 2	PSO3
CO1	3	2	3	2	2	-	-
CO2	3	1	2	1	2	-	-
CO3	3	2	1	2	3	-	-
CO4	3	1	1	1	2	-	-

Contents:

Unit-I: (CO 1) (7hrs)

Reliability: Definition, bath-tub-curve, system reliability, reliability improvement, maintainability and availability, Life tests, Acceptance sampling plan based on life tests.

Unit II: (CO 2) (8Hrs)

Reliability: System effectiveness mission reliability design adequacy, operational readiness serviceability performance indices, their evaluation, uses and limitations. Reliability models of maintained systems, fundamental definitions, relationship between reliability and maintainability single equipment systems parallel stand by K-out-of n-configuration steady

state availability. Maintainability predication, Inspection policies bases on profits, downtime and performance degradation, inspection under emergency condition.

Unit III: (CO3) (7Hrs)

Total Quality Management: Introduction, Meaning and Dimensions of Quality, Quality Control Techniques, Quality Based Strategy, Total Quality Management (TQM), Towards TQM – ISO 9000 as a Platform – Working with Intranet, Total Productive Maintenance (TPM)

Unit IV: (CO4) (8Hrs)

Business Process Modelling: Introduction, Importance of Business Process Modelling, Business Process Modelling, Data Driven Approach to Process Definition. Logical vs. Physical Database Modelling, Business Process, the Way Forward

Text Books:

1. Total Quality Management, M.P. Poonia and S.C. Sharma, Khanna Publishing, 2017.
2. Fundamentals of Quality Control and Improvement, Amitava Mitra, Wiley Publishers, 2016.

Reference Books:

1. Modern Methods for Quality Control and Improvement, Harrison M. Wadsworth, Kenneth S. Stephens, A. Blanton Godfrey, Wiley and Sons Publishers, second edition, 2008.
2. Quality Control and Total Quality Management, P.L. Jain, Tata McGraw-Hill Publishers, 2001.

Online Courses:

1. (NPTEL) IIT Bombay, Prof. Indrajit Mukherjee
2. (NPTEL) IIT Kanpur, Prof. Rahunandan Sengupta

Subject Experts:

1. Prof. Indrajit Mukherjee, Department of Mechanical Engg., IIT Bombay, and
2. Prof. Rahunandan Sengupta, Department of Mechanical Engg., IIT Kanpur

SEMESTER-VI

Elective IV: (BMEL 342) Industrial Design

Teaching Scheme				Credit	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hour		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	--	----	50

Course Objectives:

1. To understand the engineering knowledge, innovation associated with designing and development of industrial products effectively.
2. To grow in the development of skills, knowledge and dispositions that enable graduates to immediately function as entry-level professional industrial designers.
3. To design, develop, implement and improve integrated systems or products that include people, materials, information, equipment and energy using appropriate analytical, computational and experimental practices.
4. To provide education and to develop leadership qualities required for industries by nurturing multiple.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Design a component, system or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
2. Interpret, represent and respond to the socio-economic and cultural contexts of industrial design and the ethical responsibilities of the professional designer.
3. Contextualize, generate and apply aesthetic aspects of industrial design.
4. Recognize and contribute to professional practice relevant to industrial design and develop an ability to engage in lifelong learning.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes				Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PSO 1	PSO 2	PSO3
CO1	3	2	3	2	3	-	-
CO2	3	1	2	1	2	-	-
CO3	3	2	1	2	3	-	-
CO4	3	2	1	1	3	-	-

Contents:

Unit-I: (CO 1) (7hrs)

Introduction: Investigations and study of visual function and ergonomic requirements of control and display elements.

Legibility of display elements, character of different typefaces and their readability. Individually planned design projects involving research, analysis and design of control and display panels.

Unit II: (CO 2) (8Hrs)

Human being in man-made world, Gross human anatomy, Anthropometry, static and dynamic, Muscles and work physiology, Static and dynamic work including maximum capacity Bio-mechanics.

Unit III: (CO 3) (7Hrs)

Environmental condition including thermal, illumination, noise and vibration. Biological transducers and nervous system including their limitation. Controls and display Psycho physiological aspects of design, needs of ergonomics and aesthetic design, Physiological aspects of work, Work measurement through physiological tests, Work physiology, Paced and un–paced work performance.

Unit IV: (CO 4) (8Hrs)

User-centred design, human cognitive processes, human memory, human errors, conceptual models, understanding users through models, usability goals, heuristic evaluation, human-computer interaction design process.

Text Books:

1. J. Raskin, The Humane Interface: New Directions for Designing Interactive Systems, Pearson Education, 2000.
2. J. Nielson, Usability Engineering, Morgan Kaufmann, 1993.

Reference Books:

1. D. B. Edward, Lateral Thinking, A Textbook of Creativity, Penguin Books, 1970.
2. D. J. Mayhew, The Usability Engineering Lifecycle: A Practitioner's Handbook for User Interface Design, Morgan Kaufmann, 1999.
3. J. S. Dumas, J. C. Redish, Practical Guide to Usability Testing, Exeter: Intellect, 1999.
4. N. F. M. Roozenburg, J. Eekels, Product Design, Fundamentals and Methods, Willey Publications, 2008.

Online Courses:

1. Ergonomics for beginners: Industrial design perspective (https://nptel.ac.in/course.html)
2. Industrial Engineering (https://nptel.ac.in/courses/112/107/112107143/)

Subject Experts:

1. Prof. Debkumar Chakrabarti, Department of Mechanical Engg., IIT Guwahati
2. Prof. P.K. Jain and Dr. Pradeep Kumar, Department of Mechanical Engg., IIT Roorkee

SEMESTER-VI

Elective-IV: (BMEL 343) Mechanical Vibration

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	----	----	50

Course Objectives:

1. To know the general concepts of vibration.
2. To acquire the knowledge of undamped free vibration
3. To know the concept of damped vibration.
4. To understand the various forced vibration systems.

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand the basic concepts of vibration.
2. Apply the concept of single degree of freedom to solve the problem.
3. Design the system using damped vibration.
4. Evaluate & analyze the forced vibration systems.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO12	PSO 1	PSO 2	PSO3
CO1	3	3	2	2	3	1	3	2	2
CO2	3	1	1	2	2	1	3	2	1
CO3	2	3	3	1	2	1	3	2	1
CO4	2	3	3	2	1	1	3	1	2

Contents:

CO-1: Introduction (6Hrs)

Introduction to noise, Vibration and harshness, Types of vibrations, Definitions, Simple Harmonic Motion (S.H.M.), Work done by harmonic force, Principle of super position applied to SHM, Beats, Fourier theorem and problems.

CO-2: Undamped (Single Degree of Freedom) Free Vibrations (8Hrs)

Derivations for spring mass systems, Methods of Analysis, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and Problems

CO-3: Damped vibrations (8Hrs)

Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and Problems.

CO-4: Forced Vibrations (8Hrs)

Introduction, Analysis of forced vibration with constant harmonic excitation - magnification factor, rotating and reciprocating unbalances, excitation of support (relative and absolute amplitudes), force and motion transmissibility, Energy dissipated due to damping and Problems.

Text Books:

1. Benson H. Tongue, "Principles of Vibrations", 2nd Edition, Oxford University, 2007
2. William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, "Theory of Vibration with Application", 5th Edition Pearson Education, 2011
3. Grover. G.T., "Mechanical Vibrations", Nem Chand and Bros., 1996
4. Rao, J.S and Gupta, K., "Introductory course on Theory and Practice of Mechanical Vibration", 2nd Edition, New Age International Publications, 2010
5. Shabana. A.A., "Theory of vibrations – An introduction", 2nd Edition, Springer, 2010
6. Balakumar Balachandran and Edward B. Magrab, "Fundamentals of Vibrations", 1st Editon, Cengage Learning, 2009
7. Elements of vibration 'by Leonard Meirovitch, McGrawhill, Book Company

Reference Books:

1. Singiresu S. Rao, "Mechanical Vibrations", 5th Edition, Pearson Education, 2010

Online Courses:

1. Mechanical Vibration, https://nptel.ac.in/courses/112103111/

Subject Experts:

1. Prof. V. Kartik, Department of Mechanical Engg., IIT Bombay
2. Prof. A. K. Darpe, Department of Mechanical Engg., IIT Delhi
3. Prof. S. V. Modak, Department of Mechanical Engg., IIT Delhi
4. Prof. Anand Parey, Department of Mechanical Engg., IIT Indore

SEMESTER VI

Elective-IV: (BMEL 344) Engineering Ergonomics

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	--	----	50

Course Objectives:

1. To expose the students to the various aspects of Industrial Design
2. To imbibe concept of physical factors affecting human beings.
3. To facilitate the concept of cognitive ergonomics
4. To deliver complete ergonomic analysis of product and workplace

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand basic knowledge of physical ergonomics such as physical load, anthropometry, biological variation and biomechanics
2. Apply basic knowledge of physical factors affecting human beings
3. Explain and apply basic knowledge of cognitive ergonomics
4. Present a complete ergonomic analysis of product and workplace and prepare a basis for a production ergonomic analysis

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO6	PO7	PO8	PO9	PO12	PSO 1	PSO 2	PSO3
CO1	1	3	1	2	2	3	1	1	1
CO2	1	2	2	2	2	3	2	1	1
CO3	1	2	2	2	2	3	2	1	1
CO4	3	2	1	2	3	2	2	1	1

Contents:

Unit I (CO1) [7Hrs.]

Overview of ergonomics and design relevances; Man- the prime system component; Man-machine-environment interaction system and user-friendly design practice; Human compatibility, comfort and adaptability.

Unit II (CO2) [7Hrs.]

Fundamentals of ergonomics: Physical (anthropometrics, human body- structure and function, posture, movement and biomechanics), Physiological (work physiology) and Psychological aspects (behavior, cognitive aspects and mental workload).

Unit III (CO3) **[8Hrs.]**

Information processing, human error and risk perception; Visual performance and visual displays; environmental factors influencing human performance;

Unit IV (CO4) **[8Hrs.]**

Occupational stress; safety and health issues; Ergonomics Criteria/check while designing; Design process involving ergonomics check and ergonomic design evaluation and Participatory ergonomics aspects.

Text Books:

1. Human Factors in engineering and Design, M. S. Sanders and Ernest J. Sixth Edi.,McGraw-Hill International Editions, 1987
2. Textbook of work physiology, P.O. Astrand and K. Rodahl, McGraw Hill, New York, 1970.
3. An Introduction to Human Factors in Engineering, Wickens, C.D., Lee, J.D., Liu, Y., Gordon Becker, S.E. (2004). (2nd Ed.). Upper Saddle River, New Jersey: Pearson Prentice-Hall

Reference Books:

1. Introduction to Ergonomics, Bridger, 2nd Edition, Taylor & Francis, 2003.
2. Ergonomics for beginners, a quick reference guide, Dul, J. and Weerdmeester, Taylor & Francis, 1993.
3. Human Factors in Product Design, Green, W.S. and Jordan, P .W, Taylor & Francis, 1999.
4. Ergonomics Interventions for Health and Productivity, Singh, S (Edt), Himanshu Publications, Udaipur, New Delhi, 2007

Online Courses:

1. Ergonomics Workplace Analysis, www.swayam.gov.in
2. Applied Ergonomics, www.swayam.gov.in
3. Ergonomics for Beginners: Industrial Design Perspective, www.nptel.ac.in
4. Digital Human Modelling and Simulation for Virtual Ergonomics, www.nptel.ac.in
5. Ergonomics in Automotive Design, www.nptel.ac.in

Subject Experts:

1. Prof. Urmi Ravindra Salve, IIT Guwahati
2. Prof. Shantanu Bhattacharya, IIT Kanpur
3. Prof. Ankur Gupta, IIT Kanpur
4. Prof. Sougata Karmakar, IIT Guwahati
5. Prof. Debkumar Chakrabarti, IIT Guwahati

SEMESTER-VI

BMEP345: Design of Mechanical Drives

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext	
-	-	2	2	1	-	-	-	25	----	25

Course objectives:

1. To develop competency in designing couplings, flywheel.
2. To develop competency in designing transmission system.
3. To develop skills in designing profiles of the various gears.
4. To make students conversant with tools for designing gear drive

Course outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand the various mechanical components used in drive system.
2. Apply and select the different components for mechanical system.
3. Design of components for various application.
4. Design of Gears for transmission systems.

List of Experiments

Expt. No.	Experiment Name	Course Outcome Mapping
1.	Design of Fly wheel.	CO1,CO2, CO3
2.	Design of Coupling.	CO1,CO2, CO3
3.	Design of Journal Bearing.	CO1,CO2, CO3
4.	Design of Antifriction Bearing.	CO1,CO2, CO3
5.	Design of Belt Drive.	CO1,CO2, CO3
6.	Design of Chain Drive.	CO1,CO2, CO3
7.	Design of Wire Rope.	CO1,CO2, CO3
8.	Design of Gear Drive	CO1,CO2, CO3,CO4

SEMESTER-VI

BMEP346: Vehicle Design

Teaching Scheme				Credits	Evaluation Scheme					
					Theory		Practical			Total Marks
Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	2	2	1	-	-	-	25	-	25

Course Outcomes

Upon the successful completion of course, the student shall be able to:

1. Compare electric and gasoline vehicles
2. Calculate torque for vehicle propulsion
3. Design Vehicle Architecture
4. Select various motors as per torque requirement
5. Choose battery as per the need

Expt. No.	Experiment Name
1.	**Introduction: Electric Vehicle** Components of Electric Vehicle, Comparison with Internal combustion Engine, EV classification and their electrification levels, EV Terminology
2.	**Motor Torque Calculations for Electric Vehicle** Calculation of Rolling Resistance, grade resistance, Acceleration Force, Total Tractive Effort, Torque required on the Drive Wheel
3.	**Electric Vehicle Architecture Design** Types of Electric Vehicle and components, Electrical protection and system requirement, Battery Electric vehicle (BEV), Hybrid electric vehicle (HEV), Fuel cell electric vehicle (FCEV), Electrification Level of EV.
4.	**Electric Drive and controller** Types of Motors, Selection and sizing of Motor, RPM and Torque calculation of motor, Motor Controllers, Mechanical connection of motor, Electrical connection of motor.
5.	**Energy Storage Solutions (ESS)** Cell Types (Lead Acid/Li/NiMH), Battery charging and discharging calculation, Cell Selection and sizing, Battery lay outing design, Battery selection criteria, **Battery Management System**.
6.	**Control Unit** Function of CU, Development Process, Software & Hardware, Data Management, GUI/HMI.

SEMESTER-VI

BMEP 347: Project Management

Teaching Scheme				Credits	Evaluation Scheme					
					Theory		Practical			Total Marks
Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	2	2	1	-	-	-	25	-	25

Contents:

Project Management Concepts, Project Planning, Resource Scheduling, Critical Chain Scheduling, Project Quality Management, Project performance Measurement and Control, Project Closure / Termination, Managing Project Teams, IT in Projects, International Projects: Issues in managing international projects, Selection and training of employees, PERT and CPM, cross cultural considerations.

Reference Books:

1. Clifford F Gray, Erik W Larson, "Project Management-The Managerial Process", Tata Mcgraw-Hill Publishing Co Ltd
2. Jack Meredith, Samuel J. Mantel Jr. "Project Management- A Managerial Approach", John Wiley and Sons
3. John M Nicholas "Project Management For Business And Technology" Prentice Hall of India Pvt Ltd
4. James P Lewis "Project Planning, Scheduling and Control" Tata Mcgraw -Hill Publishing Co Ltd.

SEMESTER-VI

BMEP 348: Product Development & IPR

Teaching Scheme				Credits	Evaluation Scheme					
					Theory		Practical			Total Marks
Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	2	2	1	-	-	-	25	-	25

Course Objectives

1. To get awareness and importance of new product developments in mechanical engineering.
2. To develop an ability to create new product by conceptual generation.
3. The student should be able to apply these skills to the solution of a variety of new product.
4. To get awareness and importance of Intellectual property
5. The student should be able to apply these skills for the preparation of patent draft of new product

Course Outcomes

Upon the successful completion of course, the student shall be able to:

1. Define the application of new product development
2. Apply Basic knowledge of product design for generation of new product
3. Understand application of part modeling command by creation of knowledge of 3D for new product
4. Apply basic knowledge for file patent of innovation

List of Experiments

Expt. No	Experiment Name
1	Basic Introduction of New product development and classification
2	Idea generation scanning and concept generation concept development of new product
3	Idea design ,system design, details design of new product
4	Specification finalization of new product
5	Generation of 3D geometric model of New product
6	Development of new product design according to patent norms
7	Introduction of IPR, Trade mark, GI , Design patent , copyright
8	Details of patentable and non-patentable invention
9	Detail procedure of drafting of patent for new product

10	Introduction of all forms for filing of patent
11	General procedure of fling patent in India.
12	Application and procedure of Trade marking , GI , copy right
13	Case study related to patent infringement

Reference

1. The Copyright Act, 1957 ,The Patent Act, 1970,The Trade Marks Act, 1999,The Designs Act, 2000
2. The Geographical Indication of Goods Act, 1999 ,
3. The Protection of Plant Varieties and Farmers' Rights Act, 2001 Books Lionel Bently& Brad Sherman, Intellectual Property Law, Oxford. P. Narayanan, Intellectual Property Law, Eastern Law House
4. Intellectual Property Rights, By Neeraj Pandey, Khushdeep Dharni, Phi Learning Pvt Ltd, 2014.
5. Agile Product Development by Tathagat Varma, Apress, 2015.

SEMESTER-VI

Skill Development-4

BMEP349: Hydraulics & Pneumatics System

Teaching Scheme				Credits	Evaluation Scheme					
					Theory		Practical			Total Marks
Th.	Tu.	Pr.	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	2	2	1	-	-	-	25	-	25

Course Outcomes:

Upon the successful completion of course, the student shall be able to:

1. Understand the knowledge about hydraulic and pneumatic systems.
2. Understand about behavior of working media in hydraulic and pneumatic systems.
3. Control of motions through hydraulic and pneumatic systems.
4. Automation by integration of electrical and mechanical components in hydraulic and pneumatic systems.

List of Experiments

Expt. No	Experiment Name
1	**Introduction:** Basics of Hydraulics, Major advantages and disadvantages, Comparison between mechanical, electrical, hydraulic and pneumatic power transmission, **Application of Hydraulics and Pneumatics.**
2	**Hydraulic Oils, Fluid Properties and Filter:** Types, Properties, functions of hydraulic Oils, ISO Viscosity grades, Classification-Mineral based, Fire resistant& Bio degradable Oils, Filters, Contaminations, Filter rating, location of filter.
3	**Hydraulic Pumps:** Classification of hydraulic pumps, Gear Pumps, Vane Pumps, Radial piston Pumps, Axial piston Pumps, Selection of Hydraulic Pumps.
4	**Hydraulic Valves:** Types, Direction control valves, Pressure control valves, Flow control valves, Non-returnvalves, Electro-Hydraulic Servo valves.
5	**Hydraulic Actuators:** Linear and Rotary Actuators, Hydrostatic Transmission Systems.
6	**Hydraulic system Accessories:** Reservoirs, Accumulators, Heating & cooling devices,
7	**Design of hydraulic circuits:** Basic hydraulic circuits, Industrial hydraulic circuits, Power losses in flow control circuits
8	**Introduction to Pneumatic systems & Air Compressor:** Basic Requirements for Pneumatic System, Applications, Types & Selection criteria for Air Compressor
9	**Service Unit, pneumatic actuators and Pneumatic valves:** Air receiver, FRL unit, Air filter, Pressure regulator and Lubricator, Types of Pneumatic Cylinders & Air motors, Cushion assembly, Pneumatic Direction control valves, Quick exhaust, Time delay, Shuttle and Twin pressure valves.
10	**Pneumatic circuits:**

	Basic pneumatic circuits, Conventional method, Cascade method.
11	Electro-Pneumatics and Electro Hydraulics: Overview and applications, System components, Development of single and multiple Actuator Circuits
12	**Trouble Shooting And Applications:** Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for Pick and Place applications and tool handling in CNC Machine tools – Low cost Automation – Hydraulic and Pneumatic power packs.

Reference Books:

1. S R Majumdar, Oil Hydraulic Systems ,Tata McGraw-Hill
2. S R Majumdar, Pneumatic Systems, Tata McGraw-Hill
3. John Pippenger & Taylor Hicks, Industrial Hydraulics, McGraw-Hill
4. Anthony Esposito, Fluid Power, Prentice Hall
5. Andrew Parr, Hydraulics & Pneumatics , Jaico Publications

SEMESTER-VII

BMEL 411: MOOCs

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
8	-	-	8	4	10	15	50	--	--	75

NOTE: Students can registered this course online during their Internship.

SEMESTER-VII

BMEP 408: Six Month Industry Internship

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	24	24	12	--	--	--	100	200	300

NOTE: Compulsory Industrial Training for full semester commencing from immediately after the 6th semester End Semester Examination. A group of students (not more than four) shall be placed in reasonably large/ medium industry, where they can also search a problem for project phase I which they will continue in 8th semester in the college.

Study during training may include various aspects such as plant layout, mechanical handling systems, assembly shop, quality control system, maintenance system, various service system, development and planning functions, feasibility study of small scale industry. Those who are interested in entrepreneurship can also get training in appropriate place.

Exhaustive report of industrial training shall be prepared by the group of students and to be submitted after completion of training. The group shall present a seminar on the training using audio visual aids before the seminar committee constituted for the purpose of evaluating the seminar / quality of training. Seminar delivery will be followed by question answer.

Course Outcome: - Upon successful completion of the course, students shall be able to:

1. Learn various aspects such as plant layout, mechanical handling systems assembly shop, quality control system, and maintenance system.
2. Learn various service system.
3. Learn development and planning functions.
4. Learn various operational feasibility of small scale industries.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	2	3	3	1	2	3	3
CO2	3	3	2	2	3	3	2	2	2
CO3	2	2	2	3	2	2	2	3	2
CO4	1	2	3	3	3	1	3	3	1

SEMESTER-VII

BMEP 409: Major Project Phase-I

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	8	8	4	--	--	--	50	50	100

NOTE: A group of students shall select project topic as per the guide lines during industrial training in the industry. Project phase I may consist of the following broad based work.

1. Detailed study of the literature on the normal topic along with the comparative study of various approaches studied under literature.
2. Study of some products manufactured in the industry where the student is undergoing training and identifying of the problem project point of view.
3. Design of some mechanical system may also comprise of machines, thermal, hydraulic/pneumatic system.
4. Finalizing the project title, design, fabrication, experimental aspects

Each student shall submit the detail type written report of his work. Each project group has to give presentation, in the College immediately after completion of the training giving all the details of the respective project work that has been done during the training period. The committee shall be constituted for the purpose of evaluating project work done.

Course Outcome: -

Upon successful completion of the course, students shall be able to:

1. Learn how to do the literature survey on the normal topic along with the comparative study of various approaches studied under literature.
2. Study some products manufactured in the industry where the student is undergoing training and identifying of the problem project point of view.
3. Design of some mechanical system may also comprise of machines, thermal, hydraulic/pneumatic system.
4. Finalizing the project title, design, fabrication, experimental aspects.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	2	1	3	3	2	3	3
CO2	3	3	3	2	3	1	2	3	2
CO3	2	2	2	3	2	2	2	2	3
CO4	3	2	3	3	1	1	3	3	1

SEMESTER-VIII

Elective-V: (BMEL 414) Refrigeration & Air Conditioning

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	2	4	3	10	15	50	25	--	100

Course Objectives:

1. To get awareness and familiarize with the latest developments in refrigeration and air-conditioning.
2. To know environment related issues with use of refrigerants and ecofriendly refrigerants.
3. To study both conventional and non -conventional refrigeration systems.
4. To deal with air conditioning equipment, design of air conditioning, and air handling units.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Build various concepts of refrigeration systems and environment related issues with use of refrigerants related to engineering field in order to become professionally efficient.
2. Distinguish the multistage refrigeration system also analyze various non-conventional refrigeration systems to develop new efficient systems.
3. Determine various psychometric terminologies and load calculation
4. Design air transmission, handling and distribution systems.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 7	PSO 1	PSO 2	PSO 3
CO1	3	3	2	3	2	3	2	3	1
CO2	3	1	2	2	1	2	2	3	1
CO3	3	3	3	2	1	1	2	3	-
CO4	3	3	3	2	1	1	2	3	-

Contents:

Unit 1 (CO 1) (8hrs)

Refrigeration

Introduction, Definition, Applications. Study of simple vapour compressions refrigeration system: Analysis of simple vapour compression refrigeration system, effect of sub-cooling, superheating, polytropic compression & pressure drops on the performance of the system.

Study of vapour absorption refrigeration system: Introduction Ammonia –Water, Lithium bromide-water systems, three fluid refrigerator.

Nomenclature of refrigerants, refrigerant properties, mixture refrigerants, global warming potential & Ozone depletion potential Montreal & Kyoto protocol. Alternate refrigerants.

Unit 2 (CO2) **(7hrs)**

Multi stage Vapour compression Refrigeration system and Other Refrigeration Techniques

Multiple compressor & multiple evaporator systems, cascade refrigeration systems. Study of equipment's such as compressors, evaporators, expansion devices & controls defrosting Methods (types & principle only). Testing & charging of refrigeration systems.

Other Refrigeration Techniques

Air cycle refrigeration, Applications in air refrigeration systems, Vortex tube, and thermoelectric refrigeration.

Cryogenics: Introduction Application of cryogenics Houle – Thomson coefficient, inversion curve methods of liquefaction of air.

Unit 3 (CO3) **(8hrs)**

Psychrometry: Introduction, Psychometric properties of air, psychometric chart psychometric processes by pass factor, apparatus dew point temperature.

Human Comfort: Mechanism of body heat losses, factors affecting human comfort effective temperature, Comfort chart. Application of psychometric to various air-conditioning systems RSHF, GSHF, ESHF, Air washers, air coolers. Heat Load Calculations: Data collection for load calculation, various components of heat load estimate, method of cooling load calculation.

Unit 4 (CO4) **(7hrs)**

Air Transmission & Distribution

Principle of air distribution, types of grills & diffusers & their selection criteria, air alteration ,types of air filter, distribution of air through ducts, pressure losses in ducts, methods of duct design, duct friction chart, air conditioning controls.

Text Books:

1. Refrigeration & Air conditioning, C.P. Arora, 3rd Edition, Tata McGraw Hill Publication, 2016
2. Refrigeration & Air conditioning, Dr. Manohar Pressed, 3rd Edition, New Age International Publication, 2017
3. Refrigeration & Air conditioning, P. L. Ballany, Second Edition Khanna Publisher, 2007
4. A Course in Refrigeration & Air conditioning, Domkundwar, 3rd Edition, Dhanpat Rai & Co. 2016
5. ASHRAE hand books, Air Conditioning Engineers, 2018.

Reference Books:

1. Refrigeration & Air conditioning, Stocker & Jones, 4th Edition, McGraw Hill Publication, 2018
2. Principles of Refrigeration, R J Dosset & T J Horan, 3rd edition, Prentice Hall, 2016

Online Courses:

1. Swayam Course: - https://swayam.gov.in/nd1_noc19_me58 by By Prof. Ravi Kumar, IIT Roorkee, 8 Weeks.
2. NPTEL Video Lectures :- Refrigeration & Air Conditioning – https://nptel.ac.in/courses/112105128/

Subject Experts:

1. Dr. M. P. Maiya, Department of Mechanical Engg., IIT Madras
2. Dr. Shridhar Laxman Bapat, Department of Mechanical Engg., IIT Bombay
3. Dr. Milind Atrey, Department of Mechanical Engg., IIT Bombay

SEMESTER VIII

Elective-V: (BMEL415) Fuels and Combustion

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	2	4	3	10	15	50	25	--	100

Course Objectives:

1. To understand concepts and theories of fuel combustion.
2. To develop and understanding advanced fuel combustion and control process.
3. To provide students with the required skills to analyzing thermal cycles.
4. To understand fundamentals of control of air pollutants in industrial and technological processes.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Understand the concepts of combustion for various engines
2. Recognize the different types fuels used in combustion.
3. Perceive configurations of flames and boundary layer combustion.
4. Identify ccombustion stoichiometry and chemical equilibrium

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO6	PO 7	PSO 1	PSO 2	PSO 3
CO1	3	2	2	3	3	3	2	1	-
CO2	3	1	2	2	3	3	2	2	-
CO3	3	1	1	2	1	3	1	2	-
CO4	3	2	2	1	2	3	1	2	-

Contents:

Unit 1 (CO1) **(7 Hrs.)**

Introduction to Combustion Processes

Energy and Combustion, the Fuel-Engine Interface, Engineering Science and Combustion, Engineering and Applied Combustion, Kinetic Theory of Gases, Collision Theory and Chemical Reactions, Complex Chemical Kinetics Mechanisms, Nitrogen-Oxygen, Chemical Kinetics, Basic Flame Theory.

Unit 2 (CO2) **(8 Hrs.)**

Solid fuels and liquid fuels

Solid Fuel Thermo-chemistry, Coal and Other Solid Fuel Resources, Solid Fuel Combustion, Solid Fuel Combustion Pollution Control, Boiler Energy Balance.

Liquid Fuel Properties, Crude Oil and Distillate Fuels, Synthetic Liquid Fuels, Unconventional Liquid Fuels, Liquid Fuel Combustion and Burners.

Unit 3 (CO3) (7 Hrs.)

Gaseous Fuels and Spark-Ignition Engine Combustion

Gaseous Fuel Properties, Natural Gas, Coal-Derived Gaseous Fuels, Biomass and Synthetic Natural Gas, Hydrogen, Gaseous Fuel Burners.

Thermodynamics and Spark-Ignition Engine Modeling, Fuel Thermo-chemistry and Spark Ignition Engines, Spark-Ignition I.C. Engine Combustion Chemistry, Spark-Ignition I.C. Engine Emissions, Spark-Ignition Engine Fuel Alternatives.

Unit 4 (CO4) (8 Hrs.)

Compression-ignition engine combustion

Thermodynamics and Compression-Ignition Engine Modeling, Fuel Thermo-chemistry and Compression-Ignition Engines, Compression- Ignition I.C. Engine Combustion Chemistry, Compression-Ignition I.C. Engine Emissions, Compression-Ignition Engine Fuel Alternatives, Advanced Spark- and Compression-Ignition Combustion Concepts.

Text Books:

1. An Introduction to Combustion, Stephen R. Turns, Tata McGraw publication, 2000.
2. Fundamentals and Technology of Combustion, By F El-Mahallawy, S. E-Din Habik, Elsevier Publication, 2002.

Reference Books:

1. Fuels combustion and furnaces, John Griswold, Chemical engineering series, McGraw Hill Book Company, Inc. 1946.
2. Fuels and combustion, S. Sarkar, 2nd edition, Orient Longman Ltd., 1990.

Online Courses:

1. Fundamental of combustion, Dr. D. P. Mishra, IIT, Kanpur https://nptel.ac.in/courses/101104070/
2. Fundamentals of combustion for propulsion by Dr. S. Varunkumar and Prof. H.S.Mukunda, IIT Madras, https://nptel.ac.in/courses/112/106/112106290/

Subject Experts:

1. Dr. Anjan Rey, Department of Mechanical Engg., IIT Delhi
2. Dr. Devendra Deshmukh, Department of Mechanical Engg., IIT,Indore
3. Prof. Arindrajit Chowdhury, Department of Mechanical Engg., IIT,Bombay

SEMESTER-VIII

Elective-V: (BMEL416) Computer Aided Design

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	2	4	3	10	15	50	25	-	100

Course Objectives:

1. To introduce the concept of computer aided design to students.
2. To introduce the concept of finite element analysis
3. To develop skills for problem solving through finite element analysis
4. To establish a general understanding of components of a typical CAD system and its operation

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Recognize the principles of CAD and its applications in various fields of engineering.
2. Understand the engineering problem solving approach
3. Apply skills for the development of computer aided designs.
4. Solve complex engineering design problems using finite element analysis

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	2	1	3	2	1	2	-
CO2	3	2	3	2	2	1	1	-	-
CO3	2	3	3	2	1	1	2	-	-
CO4	1	3	3	2	1	1	-	-	-

Contents:

Unit 1 (CO1) (8hrs)

Introduction: A typical product cycle, CAD tools for the design process of product cycle, CAD / CAM system evaluation criteria, Input / Output devices;

Line and Curve generation algorithm: DDA, Bresenham's algorithms. Graphics exchange standards and Database management systems.

Homogeneous representation; Translation, Scaling, Reflection, Rotation, Shearing in 2D and 3D; Orthographic and perspective projections. Window to View-port transformation.

Unit 2 (CO2) **(7hrs)**

Parametric representation of lines, parametric representation of circle, Ellipse, parabola and hyperbola. Synthetic Curves: Concept of continuity, Cubic Spline: equation, properties and blending. Bezier Curve: equations, properties; Properties and advantages of B-Splines and NURBS. Various types of surfaces along with their typical applications.

Unit 3 (CO3) **(7hrs)**

Geometry and Topology, Comparison of wireframe, surface and solid models, Properties of solid model, properties of representation schemes, Concept of Half-spaces, Boolean operations. Schemes: B-rep, CSG, Sweep representation, primitive instancing, Cell Decomposition and Octree encoding.

Unit 4 (CO4) **(8hrs)**

Review of stress-strain relation and generalized Hooke's Law, Plane stress and Plane strain conditions, Basic finite element concepts-Basic ideas in a finite element solution, General finite element solution procedure, Finite element equations using modified Galerkin method, Application: Axial deformation of bars, Axial spring element. Linear and Quadratic 1D Elements, 1-D Analysis: Concept of Shape function and natural coordinates, strain - displacement matrix, derivation of stiffness matrix for structural problems, properties of stiffness matrix, Finite Element to 2D Problems.

Text Books:

1. Ibrahim Zeid, "CAD/CAM Theory and Practice, Mcgraw Higher Ed., 2008.
2. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing management " Second Edition, Pearson Education, 1999.
3. Foley, Wan Dam, Feiner and Hughes – "Computer graphics principles & practice" Pearson Education – 2012.
4. J.N. Reddy, An Introduction to Finite Element Method, McGraw Hill Publication, (2009)

Reference Books:

1. S.S. Rao, The Finite Element Method in Engineering, Pergamon (2010).
2. William M Neumann and Robert F. Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.

Online Courses:

1. Computer Aided Engineering Design (http://www.nptelvideos.in/2012/12/computer-aided-engineering-design.html)
2. Computer Aided Design (http://www.nptelvideos.in/2012/12/computer-aided-design.html)

Subject Experts:

1. Dr. Anoop Chawla, Department of Mechanical Engg., IIT Delhi.
2. P. V. Madhusudan Rao, Department of Mechanical Engg., IIT Delhi.
3. Prof. Anupam Saxena, Department of Mechanical Engg., IIT Kanpur.

SEMESTER-VIII

Elective-V: (BMEL417) Finite Element Method

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	2	4	3	10	15	50	25	--	100

Course Objectives:

1. To teach the fundamentals of finite element method with emphasize on the underlying theory and assumption.
2. To develop theoretical foundations and appropriate use of finite element methods.
3. To provide hands on experience using finite element software to model, analyze and design systems.
4. To inculcate programming knowledge of generating algorithms.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Derive element matrix equation by different methods by applying basic laws in mechanics and integration by parts.
2. Apply the steps required for FEM solution to variety of physical systems and obtain engineering design quantities
3. Demonstrate and identify the application and characteristics of FEA elements such as bars, beams, planar elements, and common 3-D elements.
4. Relate existing 3-D computer-aided design (CAD) skills to prepare models for finite element analysis.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	3	3	3	2	2	2
CO2	3	3	3	3	3	3	3	3	2
CO3	3	3	2	3	2	3	3	2	2
CO4	3	2	2	3	3	3	3	3	3

Contents:

Unit 1 (CO1) (7Hrs)

Fundamentals of stress and strain, stress and strain components, stress strain relationship, Elastic constants, plane stress, plane strain, differential equation of equilibrium, compatibility equations, boundary conditions, Saint Venant's principle, Airy's Stress function.

Unit 2 (CO2) **(7Hrs)**

Fundamental concept of FEM – Historical background, Scope of FEM in Engg. Applications, Principle of minimum potential energy. Concept of Virtual work Raleigh – Ritz method. FEM analysis procedure. Mathematical understanding required for FEM, Matrix algebra and operations, Eigen values and Eigen vectors. Methods for solution of simultaneous equations. Like Gauss elimination, Matrix decomposition method.

Concept of discretization of body into elements, degrees of freedom, bandwidth, Basic types of 2-D & 3-D elements, displacement models, convergence requirements, shape function Commercial FEM Software's. Finite element modeling and analysis using Bar and Beam element – stiffness matrix assembly, boundary conditions, load vector, temperature effects. Two dimensional plane - Local and Global coordinate system, element stiffness matrix, assembly, boundary conditions, load vector, force and stress calculations.

Unit 3 (CO3) **(8Hrs)**

Two dimensional problems using CST and LST – formulation of CST and LST elements, element stiffness matrix, assembly, boundary conditions, load vector. Stress calculation. Axis-symmetric solids subjected to axi-symmetric loading – axi – symmetric formulation using CST ring, element, stiffness matrix, boundary conditions, load vector, calculation of stresses.

Unit 4 (CO4) **(8Hrs)**

Steady state one dimensional and two dimensional heat conduction problems using I-D and triangular element respectively. Programming aspects of FEM – Algorithms for, reading Finite Element modeling data, formation of element stiffness matrix, formation of elemental load vector. Assembly of individual elemental spiffiness matrix into global ' stiffness' matrix, assembly of individual elemental load vector into global load vector, application of boundary conditions, solution of equations, determination of stresses and strains. Pre – Post processing in FEA.

Text Books:

1. Introduction to Finite Elements in Engineering-Tirupathi R. Chandrupatla, Ashok D. Belegundu, 3rd Edition, Pearson Education, 2002
2. Theory Of Elasticity- GoodierJn, Sp Timoshenko, Timoshenko Sp, 3rd Edition, Tata Mcgraw Hill Publishing Co. Ltd-2012

Reference Books:

1. Concept and applications of Finite element Analysis- David S Malkus, Robert D Cook, Michael E Plesha,4th Edition, John Wiley & Sons Inc (sea) Pte Ltd-2012.
2. The Finite Element Method – A basic introduction for engineers – D.W. Griffiths, D.A. Nethercot, Granada Publishing,1983

Online Courses:

1. Corsera , Introduction to FEM, University of Mishigun, Krishna Garikipatti.
2. (One NPTEL Course is needed)

Subject Experts:

1. Prof. G. K. Tiwari, Department of Mechanical Engg., IIT Roorkee,
2. Prof. V. K. Gupta, Department of Mechanical Engg., IIITDM Jabalpur

SEMESTER-VIII

Elective-V: (BMEL418) Maintenance Engineering

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	2	4	3	10	15	50	25	--	100

Course Objectives:

1. To assess the condition of various machine installations based on Insulation status.

2. To implement condition monitoring plan for complete machine System
3. To identify amount of damage in the Equipment
4. To check the mechanical integrity of the equipmentt

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Understand the types of maintenance used and its significance.
2. Iimplement the basic signal processing techniques.
3. Recognize the role of condition based monitoring in industries, familiarize with different condition monitoring techniques and its advantages in industries.
4. Relate the significance of mechanical fault diagnosis in monitoring and maintenance.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes				Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PSO 1	PSO 2	PSO 3
CO1	3	1	3	1	3	2	-
CO2	3	2	2	1	2	3	-
CO3	3	2	1	2	2	2	-
CO4	3	1	2	2	2	3	-

Contents:

Unit 1 (CO1) (7hrs)

Principal of maintenance: Definition, system approach, objectives, responsibilities of maintenance department, maintenance strategies, principles of maintenance, concepts of maintainability, availability and reliability, implementation of CBM, comparison of CBM with other maintenance techniques and case studies.

Unit 2 (CO2) (8hrs)

Digital Signal Processing: Probability distribution and density, Fourier analysis, Hilbert Transform, Cepstrum analysis, Digital filtering, Deterministic / random signal separation, Time-frequency analysis Wavelet Transform: Introduction to Wavelets, Continuous Wavelet Transform (CWT), Discrete Wavelet Transform (DWT), Wavelet Packet Transform (WPT), Types of wavelets.

Unit 3 (CO3) (7hrs)

Condition Based Monitoring: Basic concept, techniques-visual monitoring, temperature monitoring, vibration monitoring, lubricant monitoring, crack monitoring, thickness monitoring, noise and sound monitoring.

Unit 4 (CO4) (8hrs)

Machine Condition Monitoring and Fault Diagnostics Techniques: Wear monitoring and lubricant analysis-sources of contamination, techniques, Spectrometric Oil Analysis Procedure (SOAP) and ferrography. Recoding Analysis and instrumentation: Vibration meters, data collectors, frequency domain analyser, time domain instruments, Gear Diagnostics.

Text Books:

1. Amiya Ranjan Mohanty, 'Machinery Condition Monitoring: Principles and Practices',CRC Press, Taylor and Francis Group.
2. R.C. Mishra, K. Pathak, 'Maintenance Engineering and Management',Prentice Hall of India Pvt. Ltd., 2002.
3. R.A. Collacot, 'Mechanical Fault Diagnosis and condition monitoring', Chapman and Hall Ltd.

Reference Books:

1. Hamid A Toliyat, Subhasis Nandi, Seungdeog Choi, Homayoun Meshgin-Kelk, 'Electric Machines: Modeling, Condition Monitoring and Fault Diagnostics, CRC Press Theory, Implementation and Analysis', Springer, 2013
2. Dr. A. Ramachandra, 'ISTE-STTP on Maintenance of Machinery, SJCE, Mysore', June18-31, 2000.
3. John S. Mitchell, 'Introduction to Machinery Analysis and Monitoring',PennWell Books.
4. Robert Bond Randall, 'Vibration-Based Condition Monitoring–Industrial, Aerospace and Automotive applications', John Wiley & Sons Ltd., 2011.

Online Courses:

1. Machinery Fault Diagnosis and Signal Processing, https://nptel.ac.in/courses/112105232/
2. Failure Analysis and Prevention, https://nptel.ac.in/courses/112107241/
3. Digital Signal Processing, https://nptel.ac.in/courses/117102060/

Subject Experts:

1. Prof. A.R. Mohanty, Department of Mechanical Engg., IIT Kharagpur
2. Prof. D.K. Dwivedi, Department of Mechanical Engg., IIT Roorkee
3. Prof. S.C. Dutta Roy, Department of Mechanical Engg., IIT Delhi

SEMESTER-VIII

Elective-V: (BMEL419) Automation in Production

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	2	4	3	10	15	50	25	--	100

Course Objectives:

1. To introduce concept of fixed automation through design of transfer lines and automated handling systems
2. To introduce numerical control of machine tools, their construction as well programming of robot.
3. To provide exposure to automated material handling and tool handling systems such as industrial robots, AGVs and AS/RS
4. To introduce FMS and awareness of usage of computers in process planning and quality control

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Apply the automation techniques in industry.
2. Work on part programming of CNC and robotics.
3. Design automated storage and retrieval systems
4. Implement GT and FMS concepts in manufacturing and use various quality inspection techniques.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes				Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PSO 1	PSO 2	PSO 3
CO1	3	2	3	3	3	-	-
CO2	3	1	2	3	2	-	-
CO3	3	2	1	2	3	-	-
CO4	3	1	2	2	2	-	-

Contents:

Unit 1 (CO1) (7 Hrs)

Automation – Definition, Comparison of fixed, programmable and flexible automation, automation strategies, reasons for automation, applications. Automated Flow Line - Methods of work part transport, transfer mechanisms, analysis of transfer lines with and without buffer storage, Assembly line: Line balancing problem, methods of line balancing, parts delivery system.

Unit 2 (CO2) **(8 Hrs)**

Numerical Control – Basic concepts, components of NC, types of NC Systems – point to point, straight cut and continuous path, applications and economics of NC, CNC part programming: Manual part programming and APT programming.

Industrial Robotics – Definition, robot anatomy, robot configurations, robot specifications. Robot peripherals: End effectors, sensors, Robot applications.

Unit 3 (CO3) **(7 Hrs)**

Automated Guided Vehicle Systems: Types, Vehicle guidance & Routing, Traffic control & Safety system management, Analysis of AGVS systems, AGVS applications. Automated Storage & Retrieval System: Types, Basic components & special features of AS/RS, Carousel storage systems, quantitative analysis of AS/RS & Carousel.

Unit 4 (CO4) **(8 Hrs)**

Flexible manufacturing system and Group technology: FMS – Components, Types of systems, FMS layout configuration computer functions, level of flexibility, data files system reports, FMS benefits. Computer Aided Process Planning and Computer Aided Quality Control: CAPP - Retrieval & generative CAPP systems, benefits of CAPP

Text Books:

1. P. Radhakrishnan, S. Subramanyam, V. Raju, "CAD/CAM/CIM", New Age Publisher, 2004
2. Mikell P. Groover, "Automation, Production Systems, and Computer-integrated Manufacturing", Prentice Hall, 2013

Reference Books:

1. Krar, S., and Gill, A., "CNC Technology and Programming", McGraw Hill Publication Co, 2012.
2. Gibbs, D., "An Introduction to CNC Machining", Casell, 2015.
3. Seames, W.S., "Computer Numerical Control Concepts and Programming", Delmar Publishers, 1986.
4. Lynch, M., "Computer Numerical Control for Machining", McGraw Hill, 2002.
5. Koren Y, "Computer Control of Manufacturing Systems", McGraw, 2005.

Online Courses:

1. Manufacturing Automation, Prof S K Chaudhary, IIT Kanpur, https://nptel.ac.in/courses/112104288/
2. Computer numeric control of machines and processes, Prof A R Chaudhury, IIT Kharagpur, https://nptel.ac.in/courses/112105211/

Subject Experts:

1. Dr. S K Chaudhary, Professor, Department of Mechanical Engineering, IIT Kanpur
2. Prof A R Chaudhury, Department of Mechanical Engineering, IIT Kharagpur.

SEMESTER VIII

Elective-VII: (BMEL420) Computational Fluid Dynamics

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To introduce the students to widely use differential equations in computational fluid dynamics
2. To understand various governing equations and boundary conditions.
3. To learn commercial CFD code

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Solve non-linear partial differential equations (PDE) primarily in simple and complex geometries.
2. Choose optimal solution method among all possible methods
3. Identify optimal solution method to solve hyperbolic equations
4. Apply various governing equations and boundary conditions to formulate incompressible viscous flow.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 9	PSO 1	PSO 2	PSO 3
CO1	3	3	2	3	3	3	2	3	-
CO2	2	3	2	3	3	3	2	3	-
CO3	3	3	2	3	3	2	2	3	-
CO4	3	3	2	3	3	2	2	3	-

Contents:

Unit 1 (CO- 1) (8 Hrs)

Introduction: Finite difference method, finite volume method, finite element method, governing equations and boundary conditions. Derivation of finite difference equations.

Unit 2 (CO- 2) (8 Hrs)

Solution methods: Solution methods of elliptical equations – finite difference formulations, interactive solution methods, direct method with Gaussian elimination. Parabolic equations- Explicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction

implicit schemes, approximate factorization, fractional step methods, direct method with tridiagonal matrix algorithm.

Unit 3 (CO3) (7 Hrs)

Hyperbolic equations: explicit schemes and Von Neumann stability analysis, implicit schemes, multi step methods, nonlinear problems, second order one-dimensional wave equations. Burgers equations: Explicit and implicit schemes, Runge-Kutta method.

Unit 4 (CO4) (7 Hrs)

Formulations of incompressible viscous flows: Formulations of incompressible viscous Flows by finite difference methods, pressure correction methods, vortex methods. Treatment of compressible flows: potential equation, Euler equations, Navier-stokes system of equations, flow field-dependent variation methods, boundary conditions, example problems. Finite volume method: Finite volume method via finite difference method, formulations for two and three-dimensional problems. Standard variation methods - 1: Linear fluid flow problems, steady state problems, Standard variation methods – 2: Transient problems.
Advance topic on subject

Text Books:

1. Computational fluid dynamics, T. J.Chung, Cambridge University press,2002.
2. Text book of fluid dynamics, Frank Chorlton, CBS Publishers & distributors, 1985.

Reference Books:

1. Ferziger J. H., Springer P.M, "Computational Methods for fluid Dynamics", Verlag Berlin
2. Anderson J. D. JR, "Computational fluid Dynamics", McGraw Hill Inc, 1995
3. Patankar S. P, " Numerical Heat Transfer & Fluid flow"
4. Sunderarajan M.K., "Computational Fluid Flow and Heat Transfer", 2nd Ed, Narosa Publishing

Online Courses:

1. NPTEL Course, 'Computational Fluid dynamics' by Dr. K. M. Singh, IIT Roorkee Link: https://nptel.ac.in/courses/112107080/#
2. NPTEL Course 'Computational fluid dynamic for incompressible flow' by Prof. Amaresh Dalal, IIT Guwahati, Link: https://nptel.ac.in/courses/112/103/112103289/
3. NPTEL Course 'Computational fluid dynamic' by Prof. Shriniwas Jayanti, , IIT Madras, Link: https://nptel.ac.in/courses/103106073/

Subject Experts:

1. Dr. K. M. Singh, Department of Mechanical Engg., IIT Roorkee
2. Prof. Amaresh Dalal, Department of Mechanical Engg., IIT Guwahati
3. Prof. Shriniwas Jayanti, , Department of Mechanical Engg., IIT Madras

SEMESTER-VIII

Elective-VII: (BMEL421) Power Plant Engineering

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To understand the power capacity of nuclear power plant
2. To study performance of hydro power plants
3. To perceive the steam power plant
4. To describe the various components of power plant and unconventional power sources

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Demonstrate the nuclear power plant and its subcomponents
2. Utilize knowledge of hydroelectric power plant in application
3. Analyzing the components of steam power plant
4. Categorize the various sub components of power plant and unconventional power sources

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PO6	PO 7	PSO 1	PSO 2	PSO 3
CO1	3	1	1	1	2	3	1	2	-
CO2	3	3	3	1	2	3	1	2	-
CO3	2	3	3	2	1	1	2	2	-
CO4	3	1	2	1	1	2	1	2	-

Contents:

Unit 1 (CO1) (7 hrs)

Introduction to Nuclear Engineering: Binding Energy, Energy release, Nuclear reactions & its initiation, Fission, Component of nuclear reactors & its material, Numericals based on energy release. Nuclear Reactors: Types of reactors, PWR, BWR, CANDU, Gas cooled liquid metal cooled, Breeder reactor problems of operation, location of nuclear station, present & proposed nuclear plant in India.

Unit 2 (CO2) (8 hrs)

Hydroelectric Power Plant Hydrology: Rainfall, Runoff, Hydrograph, flow duration curve, mass curve. Hydroelectric power plant: Site selection, classification of hydroelectric power

plant, general arrangement, details of different components prime movers, governing, model & model testing advantages, comparison with other power plant.

Unit 3 (CO3) (7 hrs)

Introduction: Coal – its properties, handling & storage, fuel firing methods ash & dust handling boiler accessories, high pressure boiler, draught system, steam turbine, condenser, cooling towers. Water treatment, steam pipes, power plant layouts, pollution from steam power plant.

Unit 4 (CO4) (8 hrs)

Introduction, classification, various components, different arrangement, governing, methods to improve efficiency, comparison with other power plant. Diesel Electric Power Plant: Introduction, Outline, type of engines, different components, performance, plant layout comparison with other power plant. Introduction to unconventional power sources – Solar, wind, Tidal, geothermal, MHD.

Text Books:

1. Power Plant Engineering, R. K. Rajput, Laxmi Publication Fourth Edition
2. Power Plant Engineering, Nag, P.K., Tata MacGraw Hill, 2008
3. El-Wakil, M.M., "Power plant Technology", McGraw-Hill Book Co, 2002

Reference Books:

1. Norris & Therkelsen, "Heat Power", McGraw Hill, 1999
2. Rust, J.H., "Nuclear Power Plant Engineering", Haralson Pub. Co., 1999
3. Potter, P.J., "Power Plant Theory & Design", Kreiger Publishing Co

Online Courses:

1. Power Plant Engineering, on swayam https://swayam.gov.in/nd1_noc20_me10/preview
2. Fundamentals of Nuclear Power Generation https://swayam.gov.in/nd1_noc20_me40/preview

Subject Experts:

1. Prof. Ravi Kumar, Department of Mechanical Engg., IIT Roorkee
2. Prof. Dipankar Basu, Department of Mechanical Engg., IIT Guwahati

SEMESTER-VIII

Elective-VII: (BMEL422) Machine Condition Monitoring

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To understand the maintenance strategies in the industrial sectors.
2. To study performance of condition monitoring and its compliments monitoring.
3. To develop plant maintenance so that it reduce the maintenance expenditure
4. To describe different case studies that require gathering information using the modern testing equipment and processing

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

CO1: Understand the maintenance scheme, their scope and limitations –apply the maintenance strategies to various problems in the industrial sectors & vibration measurements.
CO2: Analyze for machinery condition monitoring and explain how this compliments monitoring the condition.
CO3: Develop an appreciation for the need of modern technological approach for plant maintenance to reduce the maintenance expenditure.
CO4: Emphasizes on case studies that require gathering information using the modern nondestructive testing equipment and processing it to identify the malfunction in that system

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PO6	PO 7	PSO 1	PSO 2	PSO 3
CO1	3	1	1	1	2	3	1	2	-
CO2	3	3	3	1	2	3	1	2	-
CO3	2	3	3	2	1	1	2	2	-
CO4	3	1	2	1	1	2	1	2	-

Contents:

Unit 1: (CO-1) **(8 hrs)**

Introduction, Maintenance –objectives –types –concepts and economic benefits, Preventive maintenance –time based & condition based, Condition Monitoring & Performance monitoring, Vibration Monitoring –causes and effects of vibration, Review of Fundamentals of Vibrations, Vibration Measuring Equipment -Sensors, Signal conditioners, recording elements, Sensors Contact type sensors –Non contact type sensors,

Unit 2: (CO-2) **(7 hrs)**

Signal conditioning –Display/Recording elements, Vibration meters and analyser, Overall Level Measurement, Vibration limits & Standards, Signal Analysis -Frequency Analysis, Measurement of overall vibrations levels. Shock Pulse Method, Kurtosis, Cepstrum Analysis, Critical speed analysis, Wear behavior monitoring and Contaminants Monitoring Technique, Filters,

Unit 3: (CO-3) **(8 hrs)**

Performance trend monitoring –Primary and secondary parameters, Performance trend analysis, Performance trend monitoring systems, Case studies, Temperature Monitoring – Various techniques –thermometer, thermocouple, Thermography, infrared pyrometers etc,

Unit 4: (CO-4) **(7 hrs)**

Selection of condition motoring techniques, Non-destructive techniques –important features, Types of defects detected by NDT –Visual, Dye Penetration, Acoustic Emission and its applications, X-ray, Radiographic, Magnetic Flux test etc, Application of NDT Techniques, Application of computer in experimental analysis, Data acquisition and recording and storage device, Flow chart of a case study.

Text Books:

1. Robert Bond Randall –Vibration-Based Condition Monitoring –Industrial, Aerospace and Automotive applications, John Wiley & Sons Ltd., 2011
2. R. C. Mishra, K. Pathak –Maintenance Engineering and Management, Prentice Hall of India Pvt. Ltd.

Reference Books:

1. Isermann R., Fault Diagnosis Applications, Springer-Verlag, Berlin, 2016.
2. Rao, J S., Vibration Condition Monitoring, Narosa Publishing House,
3. Allan Davies, Handbook of Condition Monitoring, Chapman and Hall.

Online Courses:

1. NPTEL Video Course: Condition Monitoring, Prof Rajiv Tiwari, IIT Guwahati
2. Vibtotech Trainers & Consultant, http://www.vibrotech.co.in/vibration-course-one-month.php#
3. NPTEL Video Course : NOC: Machinery Fault Diagnosis and Signal Processing, A.R. Mohanty

Subject Experts:

1. Prof A.R. Mohanty, Department of Mechanical Engg., IIT Kharagpur
2. Prof Rajiv Tiwari, Department of Mechanical Engg., IIT Guwahati

SEMESTER-VIII

Elective-VII: (BMEL423) Vehicle Dynamics

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To expose the field and fundamentals of vehicle dynamics.
2. To explain importance of aerodynamics in vehicles.
3. To develop an ability to explain tire mechanics & its importance in vehicle dynamics.
4. To demonstrate the selection of a suitable suspension system for modern vehicles.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Apply the concepts of dynamics of vehicle for better performance of vehicle.
2. Analyze the vehicular model through aerodynamics point of view.
3. Recognize the mechanics of tire considering various design aspects.
4. Assimilate the knowledge to define the suspension system.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	2	3	2	2	-	-
CO2	2	2	3	3	2	1	3	-	-
CO3	2	2	3	3	2	2	3	1	-
CO4	3	1	2	1	2	2	2	1	-

Contents:

Unit 1 (CO1) **(8 Hrs.)**

Performance Characteristics of Vehicle:

SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system, Dynamic axle loads, Equations of motion, transmission characteristics, vehicle performance, power limited and traction limited acceleration, braking performance, Brake proportioning, braking efficiency.

Unit 2 (CO2) **(7Hrs.)**

Aerodynamics: Mechanics of Air Flow around a Vehicle, Pressure Distribution on a Vehicle, Aerodynamic Forces, Drag Components, Aerodynamics Aids.

Unit 3 (CO3) (8Hrs.)

Tire Mechanics: Tire Construction, Size and Load Rating, Terminology and Axis System, Tractive Properties, Cornering Properties, Camber Thrust, Aligning Moment, Combined Braking and Cornering, Conicity and Ply Steer, Slip, Skid, Rolling Resistance, Elastic Band Model for longitudinal slip, Simple model for lateral slip, Combined longitudinal/lateral slip (friction ellipse), Taut string model for lateral slip, Magic Tire Formula, safety measures.

Unit 4 (CO4) (7Hrs.)

Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Anti-Dive Suspension Geometry, Roll Center Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points, Controllable Suspension Elements**:** Active, Semi-Active. Choice of suspension spring rate, Calculation of effective spring rate, Vehicle suspension in force and apt directions.

Text Books:

1. Hans Pacejka, Tire and Vehicle Dynamics, Elsevier, 2012.
2. Thomas D Gillespie, "Fundamentals of Vehicle dynamics", SAE USA 1992.
3. Rajesh Rajamani, Vehicle Dynamics & control, Springer.
4. R.V. Dukkipati, Vehicle dynamics, Narsova Publications.
5. Wong J Y, "Theory of Ground Vehicles", John Wiley & Sons, New York, 1978.

References books:

1. Milliken W F and Milliken D L, Race car Vehicle Dynamics, SAE.
2. Garrett T K, Newton K and Steeds W, "Motor Vehicle", Butter Worths & Co., Publishers Ltd., New Delhi, 2001.
3. Heinz Heister, "Vehicle and Engine Technology", SAE Second Edition, 1999.
4. Vittore Cossalter, Motorcycle Dynamics, 2nd Edition, Publisher: LULU.com
5. R N Jazar, Vehicle Dynamics: Theory and Application, Springer

Online Courses:

1. NPTEL course on Vehicle Dynamics
2. https://www.diyguru.org/course/vehicle-dynamics/

Subject Experts:

1. Prof. R. Krishnakumar, Department of Mechanical Engg., IIT Madras
2. Dr. Pravesh C. Sukla, Department of Mechanical Engg., IIT Bhilai

SEMESTER VIII

Elective-VII: (BMEL424) Corrosion Engineering

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To explain the concept of corrosion & its control.
2. To describe the types of corrosion in various materials.
3. To discuss corrosion in selected environments & its control.
4. To make students conversant with Corrosion Testing & Corrosion Prevention.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Understand the Concept of corrosion & its control, Cost of corrosion, Corrosion damage, Corrosion rate expressions, electrochemical corrosion of metals origin of Pourbaix diagram.
2. Explain the types of corrosion in various materials, corrosion of steels, stainless steels and different alloys.
3. Identify corrosion in selected environments & its control overview of corrosion in body, overview of corrosion in aircraft, Corrosion in the Petrochemical Industry.
4. Demonstrate corrosion testing & corrosion prevention, purpose and importance of testing, laboratory, semi-plant and field tests, ASTM standards for testing & prevention.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	2	1	1	2	2	1	2	1
CO2	3	3	2	1	2	2	1	1	1
CO3	2	2	1	1	2	3	1	3	1
CO4	2	3	2	1	2	1	2	2	2

Contents:

Unit 1 (CO1) Introduction to Corrosion & its Control (08 Hrs)

Cost of corrosion, Corrosion damage, Corrosion rate expressions, and electrochemical corrosion of metals origin of Pourbaix diagram. NACE Terminology Importance of corrosion control. General corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching, erosion corrosion, stress corrosion, overview of hydrogen cracking. High temperature corrosion.

Unit 2 (CO2) Corrosion of Various Materials (07 Hrs)

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

Unit 3 (CO3) Corrosion in Selected Environments & its Control (8 Hrs)

Atmospheric Corrosion, Corrosion of Automobiles, Corrosion of Steel in Concrete, Corrosion in Sea water, Microbiologically Induced Corrosion, overview of corrosion in body, overview of corrosion in aircraft, Corrosion in the Petrochemical Industry, Corrosion in Paper and pulp industry and its control.

Unit 4 (CO4) Corrosion Testing & Corrosion Prevention (07 Hrs)

Purpose Importance of testing, laboratory, semi-plant and field tests, ASTM standards for testing, stress corrosion cracking and pitting, sequential procedure for laboratory and on -site corrosion investigations. Purification & alloying of metal, Material selection, Alteration of Environment, Design modification, Cathodic and Anodic protection, Coatings (metallic, inorganic, nonmetallic and organic)

Text Books:

1. Fontana G., "Corrosion Engineering ", McGraw-Hill, 1985.
2. Schweitzer P.A., "Corrosion Engineering Hand Book ", Marcel Dec ker, 1996.
3. Winston Revie and R, Uhlig, "Corrosion Hand Book ", John Wiley, 2000.

Reference Books:

1. Raj Narayan, “An Introduction to Metallic Corrosion and its Prevention”, Oxford and IBH, 1983.
2. ASM International, “Metals Handbook", 1996.

Online Courses:

1. Cathodic Protection; https://www.coursera.org/lecture/corrosion/welcome-to-cathodic-protection-12eKh
2. Corrosion, Metallurgy, Failure Analysis and Prevention; https://www.corrosionclinic.com/corrosion_courses/metallurgy_weldment_corrosion.ht
3. Surface Engineering for Corrosion and Wear Resistance Application; https://www.classcentral.com/course/swayam-surface-engineering-for-corrosion-and-wear-resistance-application-13028
4. Basic Corrosion; https://www.nace.org/education/courses-by-program/general-corrosion/basic-corrosion.

Subject Experts:

1. Prof. Indranil Manna, Prof. Jyotsna Dutta Majumder, Department of Mechanical Engg., IIT Kharagpur.
2. Dr. A P Patil, Department of Mechanical Engg., NIT Nagpur
3. Prof. Kallol Mandol, Department of Mechanical Engg., IIT Kanpur.
4. Dr. Srinivasan Chandrasekaran, Department of Mechanical Engg., IIT Madras

SEMESTER-VIII

Elective-VII: (BMEL425) Entrepreneurship and Development

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To develop and strengthen entrepreneurial quality and motivation in students and to impart basic entrepreneurial skills and understanding to run a business efficiently and effectively.
2. To explain basic entrepreneurial skills and control process.
3. To demonstrate the required skills for analysing entrepreneurial development.
4. To perceive fundamentals of business control strategy in industrial and technological processes.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Understand the concepts of entrepreneurial development.
2. Recognize the different types entrepreneurial development Skills.
3. Analyze the configurations of entrepreneurial development.
4. Applying the skills of entrepreneurial development in Mechanical Core Industries.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO6	PO 7	PSO 1	PSO 2	PSO 3
CO1	3	2	2	3	3	3	2	1	-
CO2	3	1	2	2	3	3	2	2	-
CO3	3	1	1	2	1	3	1	2	-
CO4	3	2	2	1	2	3	1	2	-

Contents:

Unit 1 (CO1) **(7 Hrs.)**

Entrepreneurship

Entrepreneur – Types of Entrepreneurs – Difference between Entrepreneur and Intrapreneur Entrepreneurship in Economic Growth, Factors Affecting Entrepreneurial Growth.

Unit 2 (CO2) **(8 Hrs.)**

Motivation

Major Motives Influencing an Entrepreneur – Achievement Motivation Training, Self Rating, Business Games, Thematic Apperception Test – Stress Management, Entrepreneurship Development Programs – Need, Objectives.

Unit 3 (CO3) **(7 Hrs.)**

Business

Small Enterprises – Definition, Classification – Characteristics, Ownership Structures – Project Formulation – Steps involved in setting up a Business – identifying, selecting a Good Business opportunity, Market Survey and Research, Techno Economic Feasibility Assessment – Preparation of Preliminary Project Reports – Project Appraisal – Sources of Information – Classification of Needs and Agencies.

Unit 4 (CO4) **(8 Hrs.)**

Financing and Accounting

Need – Sources of Finance, Term Loans, Capital Structure, Financial Institution, Management of working Capital, Costing, Break Even Analysis, Taxation – Income Tax, Excise Duty – Sales Tax.

Text Books:

1. Donald F Kuratko, "Entrepreneurship – Theory, Process and Practice", 9th Edition, Cengage Learning, 2014.
2. Khanka. S.S., "Entrepreneurial Development" S.Chand & Co. Ltd., Ram Nagar, New Delhi, 2013.

Reference Books:

1. EDII "Faulty and External Experts – A Hand Book for New Entrepreneurs Publishers: Entrepreneurship Development", Institute of India, Ahmadabad, 1986.
2. Hisrich R D, Peters M P, "Entrepreneurship" 8th Edition, Tata McGraw-Hill, 2013.
3. Mathew J Manimala, "Enterprenuership theory at cross roads: paradigms and praxis" 2nd Edition Dream tech, 2005.
4. Rajeev Roy, "Entrepreneurship" 2nd Edition, Oxford University Press, 2011.

Online Courses:

1. NPTEL Course, 'Entrepreneurship essentials', by Prof. Manoj Kumar Mandal, IIT Kharagpur, Link: https://nptel.ac.in/courses/127105007/
2. NPTEL Course, 'Entrepreneurship, by Prof. C Bhaktvatsalya Rao, , IIT Madras Link: https://nptel.ac.in/courses/110106141/
3. StartupIndia Learning Program sponsored by Upgrad and Governement of India, Link https://startupindia.upgrad.com/login?redirect=startupindia.upgrad. com/v/dashboard& (Free)

Subject Experts:

1. Prof. Manoj Kumar Mandal, Department of Mechanical Engg., IIT Kharagpur
2. Prof. C Bhaktvatsalya Rao, Department of Mechanical Engg., IIT Madras

SEMESTER-VIII

Elective-VIII: (BMEL426) Automobile Engineering

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To understand various systems & mechanisms in automobiles
2. Demonstrate the emerging Technology in the field of automobile Engineering
3. Explain maintenance of automobiles

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Understand the transmit power developed by engine to vehicle reducing transmission losses.
2. Control the vehicle with the help of automobile mechanism and its knowledge.
3. Choose various human confront for driving automobile vehicle.
4. Select recent technologies for maintain the higher efficiency.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO6	PO 7	PSO 1	PSO 2	PSO 3
CO1	3	2	2	3	3	2	3	2	-
CO2	3	1	2	3	3	2	1	2	-
CO3	3	1	1	3	3	1	2	2	-
CO4	3	1	1	1	3	1	1	3	-

Contents:

Unit 1 (CO1) **(8hrs)**

Chassis and Transmission, Chassis, Clutch, Gear box, Differential, Automatic and manual transmission.

Unit 2 (CO2) **(8hrs)**

Steering and Brakes, Steering geometry, mechanical and electrical brakes, tyres.

Unit 3 (CO3) **(7hrs)**

Suspension & Electrical System, Independent & Conventional, active and passive suspension system, batteries, alternator, ignition.

Unit 4 (CO4) **(7hrs)**

Recent trends in automobile engineering, Adaptive cruise control, Automatic emergency brakes, collision avoidance, electric vehicles.

Text Books:

4. John B. Heywood," Internal Combustion Engine," McGraw Hill publication.
5. R.K. Rajput, A Textbook of Automobile Engineering, Lakshmi Publication, 2008

Reference Books:

1. Kirpal Singh Automotive Engineers, vol.1 & vol.2, Standard publication.
2. Automotive Mechanics: Joseph Heitner Motor Vehicle Technology W.H. Crouse.

Online Courses:

1. NPTEL course on Fundamentals of Automotive systems
2. The Automobile Fundamentals Certificate Course, DIYguru

Subject Experts:

1. Prof. C. S. Shankar Ram, Department of Mechanical Engg., IIT Madras
2. Dr. P. C. Shukla, Department of Mechanical Engg., IIT Bhilai

SEMESTER-VIII

Elective-VIII: (BMEL427) Energy Management

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To understand the need of energy audit and management
2. To improve energy optimization techniques
3. To collect the required information for audit
4. To write an energy report

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Apply the principles of energy management
2. Maximize the performance of system
3. Accumulate the required data of system
4. Prepare an energy audit report with a suggestion of improvement.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO4	PO8	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	2	2	1	1	2	3	3	--
CO2	2	3	2	2	2	1	3	3	--
CO3	2	3	2	2	1	2	3	3	--
CO4	1	1	2	2	3	2	3	3	--

Contents:

Unit 1 (CO 1) (7hrs)

General Philosophy and need of Energy Audit and Management. Definition and Objective of Energy Management, General Principles of Energy Management, Energy Management Skills, Energy Management Strategy.

Unit 2 (CO 2) (7hrs)

Energy Audit: Need, Types, Methodology and Approach. Energy Management Approach, Understanding Energy Costs, Bench marking, Energy performance, Matching energy usage

to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution.

Unit 3 (CO 3) (8hrs)

Data gathering : Level of responsibilities, energy sources, control of energy and uses of energy get Facts, figures and impression about energy /fuel and system operations, Past and Present operating data, Special tests, Questionnaire for data gathering.

Analytical Techniques: Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of Electric load characteristics, process and energy system simulation.

Unit 4 (CO4) (8Hrs)

Evaluation of saving opportunities:

Determining the savings in Rs, Noneconomic factors, Conservation opportunities, estimating cost of implementation. Energy Audit Reporting: The plant energy study report- Importance, contents, effective organization, report writing and presentation.

Text Books:

1. Barunkumar De, Vrinda Publication" Energy Audit & Management" 2nd Edition 2010.
2. Allen P. Rossister, Energy Management and Efficiency for the Process Industries, Wiley Publications.

Reference Books:

1. "Handbook on Energy Audit" by Sonal Desai, McGraw Hills publication.
2. Energy Management Principles, by C.B. Smith, Elsevier Publication

Online Courses:

1) https://online.stanford.edu/courses/xeiet139-energy-storage
2) https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/112105221
3) https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/112105221
4) https://nptel.ac.in/content/storage2/courses/108103009

Subject Experts:

1) Prof. Anandaroop Bhattacharya, Indian Institute of Technology, Department of Mechanical Engg., Kharagpur
2) Prof. Anil Tiwari, National Institute of Technology, Department of Mechanical Engg., Raipur

SEMESTER-VIII

Elective-VIII: (BMEL428) Advanced Tool Design

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To reveal the essential properties, selection and recent progress in cutting tool materials
2. To select suitable single point cutting tool and multipoint cutting tool for machining process
3. To develop skill on design of Jigs and Fixtures for holding tool and work price respective.
4. To create expertise in press tool design and fixtures for CNC machines.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Identify the properties of tool material, tool nomenclature and to classify the cutting tools
2. Interpret the parameters of the cutting tools for machining process
3. Distinguish the various locating and clamping methods
4. Design the jigs, fixtures, press tools and CNC machine tools

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes					Programme Specific Outcomes		
	PO1	PO2	PO3	PO5	PO7	PSO 1	PSO 2	PSO 3
CO1	3	2	3	3	2	3	-	3
CO2	3	2	2	3	2	3	-	2
CO3	3	1	3	2	3	3	-	1
CO4	3	1	2	1	2	2	-	1

Contents:

Unit 1 (CO1) (7 Hrs.)

INTRODUCTION TO TOOL DESIGN: Introduction –Tool Engineering –Tool Classifications–Tool Design Objectives –Tool Design in manufacturing-Challenges and requirements-Standards in tool design-Tool drawings -Surface finish –Fits and Tolerances -Tooling Materials-Ferrous and Non-ferrous Tooling Materials-Carbides, Ceramics and Diamond –Non-metallic tool materials-Designing with relation to heat treatment.

Unit 2 (CO2) (8 Hrs.)

DESIGN OF CUTTING TOOLS Mechanics of Metal cutting –Oblique and orthogonal cutting-Chip formation and shear angle -Single-point cutting tools –Milling cutters –Hole

making cutting tools-Broaching Tools -Design of Form relieved and profile relieved cutters-Design of gear and thread milling cutters

Unit 3 (CO3) (7 Hrs.)

DESIGN OF JIGS AND FIXTURES Introduction –Fixed Gages –Gage Tolerances –selection of material for Gages –Indicating Gages –Automatic gages –Principles of location –Locating methods and devices –Principles of clamping –Drill jigs –Chip formation in drilling –General considerations in the design of drill jigs –Drill bushings –Methods of construction –Thrust and Turning Moments in drilling -Drill jigs andmodern manufacturing-Types of Fixtures –Vice Fixtures –Milling Fixtures –Boring Fixtures –Broaching Fixtures –Lathe Fixtures –Grinding Fixtures –Modular Fixtures –Cutting Force Calculations.

Unit 4 (CO4) (8 Hrs.)

DESIGN OF PRESS TOOL DIES Types of Dies –Method of Die operation–Clearance and cutting force calculations-Blanking and Piercing die design –Pilots –Strippers and pressure pads-Presswork materials –Strip layout –Short-run tooling for Piercing –Bending dies –Forming dies –Drawing dies-Design and drafting. TOOL DESIGN FOR CNC MACHINE TOOLS Introduction –Tooling requirements for Numerical control systems –Fixture design for CNC machine tools-Sub plate and tombstone fixtures-Universal fixtures–Cutting tools–Tool holding methods–Automatic tool changers and tool positioners –Tool presetting–General explanation of the Brown and Sharp machine.

Text Books:

1.Cyrll Donaldson, George H.LeCain, V.C. Goold, "Tool Design", Tata McGraw Hill Publishing Company Ltd., 2010.
2. E.G. Hoffman," Jig and Fixture Design", Thomson Asia Pvt Ltd, Singapore, 2013
3. Prakash Hiralal Joshi, "Tooling data", Wheeler Publishing, 2006

Reference Books

1. M. Weck, "Handbook of Machine Tools, Vol. 1-4", John Wiley, USA. 20102.
2. Mehta, N.K., "Machine Tool Design", Tata McGraw Hill, 2012.
3. Web References:1.www.irdi.on.ca/irdi/front.html 2.www.techsolve.org/flashhome.html

Online Courses:

1. https://www.coursera.org/specializations/digital-manufacturing-design-technology.
2. https://www.edx.org/learn/mechanical-engineering.
3. https://nptel.ac.in/courses/112105126/35.

Subject Experts:

1. Prof. A. B. Chattopadhyay, Department of Mechanical Engg., IIT Kharagpur
2. Prof. Asimava Roy Choudhary, Department of Mechanical Engg., IIT Kanpur

SEMESTER VIII

Elective-VIII: (BMEL429) Mechanics of Composite Materials

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To understand Composite materials and their applications
2. To imbibe students about Micromechanical Analysis of Composite
3. Familiarization with the basic expressions and methods used in the mechanics of composite structures.
4. To understand Analysis of Unidirectional and Laminated Composite

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Understand the specifics of mechanical behavior of layered composites
2. Apply constitutive equations of composite materials and understand mechanical behavior at micro, macro and meso level.
3. Determine stresses and strains in composites.
4. Analyse failure criteria and critically evaluate the results

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	2	2	1	2	1	1	1	1
CO2	3	3	1	1	2	1	1	2	1
CO3	2	2	3	3	2	1	2	2	2
C04	2	2	3	3	2	2	2	2	2

Contents:

Unit 1 (CO1) (7 Hrs.)

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

Unit 2 (CO2) **(8 Hrs.)**

Micromechanical Analysis of Composite Strength and Stiffness: Properties of typical composite materials. Volume and Weight Fractions. Longitudinal Strength and Stiffness. Transverse Modulus. In-plane shear Modulus. Poisson's ratio.

Unit 3 (CO3) **(8 Hrs.)**

Elastic Properties of the Unidirectional Lamina: Stress-strain relationships. Engineering Constants. Stress strain relations of a Thin Lamina. Examples.

Unit 4 (CO4) **(7Hrs.)**

Analysis of Laminated Composites: Laminates, Basic Assumptions, Strain-Displacement Relationship, Stress-Strain Relationships, Equilibrium Equations, Laminate Stiffness, Determination of Lamina Stresses and Strains, Types of Laminate Configuration, Balanced Laminate, Anti-symmetric Laminate, Examples.

Text Books:

1. Mechanics of Composite Materials and Structures, Madhujit Mukhopadhyay, Universities Press.
2. Mechanics of Composite Materials, R M Jones, CRC Press.

Reference Books:

5. Engineering Mechanics of Composite Materials, Issac M. Daniel, OriIshai, Abebooks
6. Micro-mechanics of Composite Materials, George J Dvorac, Springer

Online Courses:

1. Mechanics of Composites, online.stanford.edu › courses › aa256-mechanics-composites
2. Mechanics of Composite Materials, https://engineering.purdue.edu/online/courses/mechanics-composite-materials

Subject Experts:

1. Prof. Nachiketa Tiwari, Department of Mechanical Engg., (IIT Kanpur)
2. Prof. Rajesh Prasad, Department of Mechanical Engg., (IIT Delhi)

SEMESTER-VIII

Elective-VIII: (BMEL430) Advanced Casting Methods

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To understand importance of newer pattern materials, mould and core making technologies
2. To apply modern tools of analysis and design
3. To understand newer energy efficient melting techniques and pouring practices
4. To be able to analyze metal flow in moulds and accordingly design gating and risering system that realizes sound castings

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Use knowledge of advances in casting design to prepare patterns and moulds for the conventional and intricately shaped castings.
2. Select energy efficient processes of melting as well as design
3. Make use of optimum gating and risering systems
4. Design risering system by considering various parameters.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO3	PO4	PO5	PO9	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	1	2	3	-	2
CO2	2	3	3	2	1	3	3	-	1
CO3	3	3	3	1	2	3	3	1	2
CO4	2	3	3	3	2	2	3	2	1

Contents:

Unit 1 (CO 1) (07 Hrs)

Pattern making, design consideration in manufacturing of patterns and dies, CAD modeling, patternmaking machines and equipments, core making, core making machines, shell molding, traditional pattern making materials versus novel materials, pattern making materials, mold making and core making sand and their characterization.

Unit 2 (CO 2) **(08 Hrs)**

Advances in melting, current versus emerging melting practices, experimental melting furnaces, heat recovery methods, molten metal handling systems, preheating systems, potential energy saving technologies, future challenges,

Unit 3 (CO 3) **(08 Hrs)**

Basics of gating system design, high pressure gating system design, analysis of the metal flow, selection of gate and vent design, die fill time, total gate area, runner design, riser types, and their function, progressive and directional solidification, factors affecting the solidification.

Unit 4 (CO 4) **(07 Hrs)**

Risering system design, typical volume change pattern, cooling rate, mould quality, conventional risering, pressure controlled risering, bottle riser design, riser less design, selection of pouring temperature based on risering method, other risering aid, case studies

Text Books:

1. Principles Of Metal Casting 2nd Edition 2nd Edition (English, Paperback, Heine R W) Richard W. Heine, Carl R. Loper and Philip C. Rosenthal's "Principles of Metal Casting", published by McGraw-Hill Education.
2. Principles of Foundry Technology Paperback – 1 Jul 2017 by P. L. Jain published by TATA McGraw-Hill Education.

Reference Books:

1. 'P.L.Jain, 'Principles of Foundary Technology', Tata McGraw Hill
2. T.V.RamanaRao, 'Metal casting – Principles and Practice', New age International Pvt.Ltd.

Online Courses:

1. https://www.amrctraining.co.uk/userfiles/files/New%20Training%20Leaflets/Casting%20Processes%20AMRC%20and%20BVAA%20-%20GS032.pdf
2. https://swayam.gov.in/nd1_noc20_me35/preview "Principles of Casting Technology" By Prof. Pradeep Kumar Jha, IIT Roorkee.
3. https://www.tms.org/portal/MEETINGS___EVENTS/TMS_Meetings___Events/Upcoming_TMS_Meetings/CastShop17/portal/Meetings___Events/2017/CastShop17/default.aspx?hkey=48349903-aa85-40dc-a25d-501a66fcfda7.
4. TMS Aluminum Cast Shop Science & Technology Course (Cast Shop 17) November 6–10, 2017 Crowne Plaza London-Heathrow London, United Kingdom

Subject Experts:

1. Prof. Pradeep Kumar Jha, Department of Mechanical Engg., IIT Roorkee
2. Dr. Anil Kumar Singh, National Institute of Foundry and Forge Technology (NIFFT).
3. Dr Sudarsan Ghosh, Department of Mechanical Engg., IIT Delhi.
4. Arvind Kumar, Department of Mechanical Engg., IISc Bangalore

SEMESTER-VIII

Elective-VIII: (BMEL431): Tribology

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	25	--	--	50

Course Objectives:

1. To Introduce And Expose Students To The Field And Fundamentals In Tribology And Its Applications.
2. To explain the different Friction and wear processes in contacts between metallic, ceramic and polymeric surfaces.
3. To develop an ability to Explain the processes of lubrication in all regimes select a suitable lubricant for a specific application.
4. To develop analytical skills for general purposes and select a suitable material combination for tribological contacts.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Design Friction, Wear And Lubrication
2. Identify Different Types Of Sliding & Rolling Friction, Wear And Related Theories
3. Distinguish Among The Different Lubricant Regime.
4. Select Materials For Bearing.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	3	3	3	3	2	3	3
CO2	3	3	2	3	2	2	3	3	2
CO3	3	2	2	3	2	3	2	3	2
CO4	2	3	3	3	2	3	2	3	2

Contents:

Unit 1 (CO1) (8 Hrs.)

Defining Tribology, Tribology in Design - Mechanical design of oil seals and gasket - Tribological design of oil seals and gasket, Tribology in Industry (Maintenance), Defining Lubrication, Basic Modes of Lubrication, Properties of Lubricants, Lubricant Additives, Defining Bearing Terminology - Sliding contact bearings - Rolling contact bearings, Comparison between Sliding and Rolling Contact Bearings.

Unit 2 (CO2) **(7Hrs.)**

Friction - Laws of friction - Friction classification - Causes of friction Theories of Dry Friction, Friction Measurement, Stick-Slip Motion and Friction Instabilities, Wear - Wear classification - Wear between solids - Wear between solid and liquid - Factors affecting wear - Measurement of wear, Theories of Wear, Approaches to Friction Control and Wear Prevention, Boundary Lubrication, Bearing Materials and Bearing Construction.

Unit 3 (CO3) **(8Hrs.)**

Mechanics of Fluid Flow - Theory of hydrodynamic lubrication - Mechanism of pressure development in oil film, Two Dimensional Reynolds's Equation and its Limitations. Idealized Bearings, Infinitely Long Plane Fixed Sliders, Infinitely Long Plane Pivoted Sliders, Infinitely Long Journal Bearings, Infinitely Short Journal Bearings, Designing Journal Bearing - Somerfield number - Raimondi and Boyd method - Petroff's Solution - Parameters of bearing design - Unit pressure - Temperature rise - Length to diameter ratio - Radial clearance - Minimum oil-film thickness.

Unit 4 (CO4) **(7Hrs.)**

Flat plate thrust bearing, Tilting pad thrust bearing, Pressure Equation, Load, center of pressure, Friction, gear teeth bearings, rolling element bearings. Hydrostatic Lubrication, Squeeze Film Lubrication, journal bearings. Thrust bearings with air lubrication,

Text Books:

1. Fundamentals Of Engineering Tribology With Applications, Harish Hirani, Cambrideg university press, 2017
2. A Textbook of Tribology, A kumar,S K KATARIA & SONS, edition, 2014.
3. Tribology, Krishan Kant Sharma, Laxmi Publications; First edition (2016),
4. Fundamentals of Tribology, Basu,Prentice Hall, 2005
5. "Principles and applications of tribology", by B. Bhushan, Wiley,2012
6. A. Harnoy. "Bearing Design In Machinery "Marcel Dekker Inc, New York, 2003.

References books

1. Introduction to Tribology of Bearings, B C Majumdar, S. Chand and company ltd. 2010.
2. Engineering Tribology" by G. Stachowiak and A.W. Bachelor.

Online Courses:

1. https://nptel.ac.in/courses/112/102/112102014/
2. https://professional.mit.edu › course-catalog › tribology-friction-wear-and-lubrication

Subject Experts:

1. Dr. Harish Hirani, Department of Mechanical Engg., IIT Delhi.
2. Dr. Ramkumar, Department of Mechanical Engg., IIT Madras
3. Dr. Subrata Kumar Ghosh, Department of Mechanical Engg., IIT (ISM) Dhanbad

SEMESTER-VIII

Elective-IX: (BMEL432) Advanced Cryogenics

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	50	--	--	75

Course Objectives:

1. Understand importance of low temperature in variety of applications such as manufacturing processes, space technology, electronics, and medical field.
2. Explain the gas liquefaction systems, principle of separation of gases, which have wide applications in industry.
3. Demonstrate principle of working of cryogenic refrigerators for temperatures above 2K for the application such as liquefaction of air, miniature cooling systems for electronic components etc.
4. Identify basic features of cryogenic fluid storage vessel, safety devices, transfer systems, fill and drain design schemes, suspension systems, various types of insulation systems, very important liquefaction of gases industry point of view.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Interpret the importance of low temperature, cryogenics in various applications
2. Choose gas liquefaction Systems and cold gas refrigerators
3. Analyze gas separation and purification systems
4. Decide cryogenic fluid storage and transfer systems

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 7	PSO 1	PSO 2	PSO3
CO1	3	1	1	1	1	3	3	3	-
CO2	3	2	1	2	2	3	3	3	-
CO3	3	3	3	3	1	3	3	3	-
CO4	2	2	3	2	1	3	3	3	-

Contents:

Unit 1 (CO 1) **(8hrs)**

Basics of Cryogenic

Review of solid and fluid properties at low temperature, Gas-liquefaction systems, System performance parameters, thermodynamically ideal liquefaction system, Joule-Thomson

effect, Simple Linde-Hampson system, Precooled Linde-Hampson system, Claude system, Heyland system, Kapitza system, Helium-liquefaction system.

Unit 2 (CO2) (8hrs)

Critical Components of Liquefaction Systems and Cold Gas Refrigerators

Heat exchangers, effect of heat exchanger effectiveness on system performance, losses for real machines, effect of compressor and expander efficiency on system performance, effect of heat transfer to the system. Cold Gas Refrigerators. Philips refrigerator, Solvay refrigerator, Gifford-McMahon (A.D.Little) refrigerator, Vuilleumier refrigerator, Pulse tube refrigerator. Magnetic cooling, Magnetic refrigeration.

Unit 3 (CO3) (7hrs)

Gas Separation and Purification Systems

The thermodynamically ideal separation system, Principle of gas separation, principles of rectification, types of rectification columns, Linde single-column air separation system, and Linde double-column air separation system. Gas purification methods.

Unit 4 (CO 4) (7hrs)

Storage and Transfer Systems

Various types of insulation used, basic features of conventional Dewar, fill and drain design schemes, Safety devices on a cryogenic storage vessel, transfer systems, transfer from storage, transfer line spacer designs, Industrial storage and transfer.

Text Books:

1. Cryogenic Engineering, Thomas Flynn, Taylor & Francis, 2nd Edition, 2004
2. A Text Book of Cryogenics, Valery V. Kostionk, Applied Science Series, 2010

Reference Books:

1. Cryogenic Process Engineering, KlausD. Timmergausand Thomas M. Flynn-Plenum Press, New York.
2. Cryogenic Systems R.F.Barron- Oxford University Press, London. Cryogenic Fundamentals Helden G Academic Press, 1971.

Online Courses:

1. NPTEL Video Lectures: - Cryogenics Engineering by Dr. Milind Atrey, IIT Bombay https://nptel.ac.in/courses/112/101/112101004/
2. https://freevideolectures.com › course › cryogenic-engineering

Subject Experts:

1. Dr. Milind Atrey, Professor, Department of Mechanical Engg., IIT Bombay
2. Dr. Abhay Singh Gour, Professor, Department of Mechanical Engg., IIT Kharagpur
3. Dr. Indranil Ghosh, Professor, Department of Mechanical Engg., IIT Kharagpur

SEMESTER-VIII

Elective-IX: (BMEL433) Energy Storage System

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-		2	2	10	15	50	--	--	75

Course Objectives:

1. To understand the basics consideration in thermal design problem formulation, steps in thermal design process, basics elements of thermal systems design.
2. To understand modeling of thermal systems such as mathematical, physical, numerical modeling and system simulation.
3. To understand different thermal design steps, involved in systems from different application areas.
4. To understand the various methods of optimization of thermal systems.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Formulate the steps in thermal design process.
2. Apply various mathematical, physical & numerical modeling techniques to solve thermal design problems.
3. Analyze optimization techniques to thermal systems.
4. Think of various economical consideration with respect to applications to thermal systems

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes					Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PSO 1	PSO 2	PSO3
CO1	3	1	3	3	2	3	-	-
CO2	2	3	3	3	3	3	-	-
CO3	2	3	3	3	3	3	-	-
CO4	3	3	1	2	1	1	-	-

Contents:

Unit 1 (CO-1) (8hrs)

Design of Thermal System:

Introduction, Thermal systems, Brief history of thermal system design, Future trends in design systems, Basic considerations in design, Formulation of the design problem, Conceptual design, Steps in the design process, Material selection, Basic elements of thermal system design.

Modeling of Thermal Systems: Types of models, Mathematical modeling, Physical modeling and dimensional analysis.

Unit 2 (CO-2) (8hrs)

Synthesis of Different Design Steps:

Initial design, Design strategies, Design of systems from different application areas, Additional considerations for large practical systems.

Economic Considerations: Calculation of interest, Worth of money as a function of time, Series of payments, Raising capital, Application to thermal systems.

Unit 3 (CO-3) (7hrs)

Problem Formulation for Optimization:

Optimization methods, Optimization of thermal systems, Practical aspects in optimal design, Lagrange multipliers, Optimization of constrained & unconstrained problems, Applicability to thermal systems.

Unit 4 (CO-4) (7hrs)

Search Methods:

Single-variable problem, Multivariable constrained optimization, Examples of thermal systems, Geometric, linear and dynamic programming and other methods for optimization, Knowledge-based design and additional considerations, Professional ethics, Overview of design of thermal systems.

Text Books:

1. W. F. Stoecker, Design of Thermal Systems- McGraw- Hill, 1971
2. A. Rufer, Energy Storage: Systems and Components, CRC Press, 2006

References

1. Y. Jaluriya, Design & Optimization of Thermal Systems- CRC Press, 2007
2. Bejan, G. Tsatsaronis, M.J. Moran, Thermal Design & Optimization- Wiley, 1996
3. R. F. Boehm, Developments in the Design of Thermal Systems- Cambridge University Press-1997
4. N. V. Suryanarayana, Design & Simulation of Thermal System- MGH, 2002

Online Courses:

1. Energy Storage, XEIET139, Stanford School of Engineering, https://online.stanford.edu/courses/xeiet139-energy-storage
2. Lecture – 51Energy storage systems – https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/112105221/lec51.pdf
3. Lecture – 56 Energy Storage Systems – V - https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/112105221/lec56.pdf
4. Module 9: Energy Storage Lecture 31: Batteries - https://nptel.ac.in/content/storage2/courses/108103009/download/M9.pdf

Subject Experts:

1. Prof. Anandaroop Bhattacharya, Indian Institute of Technology, Kharagpur
2. Prof. N Verma, Indian Institute of Technology, Department of Mechanical Engg., Kanpur

SEMESTER-VIII

Elective-IX: (BMEL434) Operation Research & Management

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext	
2	-	-	2	2	10	15	50	--	--	75

Course Objectives:

1. To study operational research methodology and its application to engineering
2. To illustrate students the use of quantitative methods and techniques for effective decision making
3. To study Transportation and Assignment problems and its application to engineering
4. To study project management and its importance to engineering students

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Apply operation research methodology to solve industrial problems.
2. Convert the real world problem into a mathematical form and provide an optimum solution for implementation.
3. Formulate the real world Assignment and Transportation Models and provide an optimum or feasible solution.
4. Utilize the concept and knowledge of project management to achieve the project goals.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	3	1	2	3	-	-
CO2	3	3	1	2	2	L	2	-	-
CO3	3	3	1	1	1	2	3	-	-
CO4	3	3	3	3	3	1	1	-	-

Contents:

Unit 1 (CO 1) **(07 Hrs)**

Introduction:

OR methodology, Definition of OR, Application of OR to engineering and Managerial problems, Features of OR models, Limitation of OR.

Unit 2 (CO 2) **(08 Hrs)**

Linear Programming:

Definition, mathematical formulation, standard form, solution space, solution – feasible, basic feasible, optimal, infeasible, multiple, optimal, Redundancy, Degeneracy. Graphical and simplex methods, Big M Method, formulation of Dual of LPP.

Unit 3 (CO 3) **(07 Hrs)**

Transportation & Assignment Problems

Formulation of transportation model, Basic feasible solution using different methods (North-West corner, Least Cost, Vogel's Approximation Method) Optimality Methods, Unbalanced transportation problem, Variants in Transportation Problems, Applications of Transportation problems. Transhipment problems. Formulation of the Assignment problem, unbalanced assignment problem, typical assignment & travelling salesman problem.

Unit 4 (CO 4) **(08 Hrs)**

Project Planning

Project Management: Drawing of Network, CPM & PERT, Probability of completion of project, Cost analysis of project, Allocation & updating of Network.

Text Books:

1. Operation Research' by Ashkhedkar & Kulkarni
2. Operation Research' by Hira& Gupta, S. Chand Publishers, Revised Edition.
3. Operation Research' by S. D. Sharma, Pearson Publication, Revised Edition.

Reference Books:

1. 'Operation Research' by Hira& Gupta, S. Chand Publishers, Revised Edition.
2. 'Operation Research' by J.K. Sharma, Trinity Publishers, sixth edition.
3. 'Operation Research' by Vohra N D, McGraw Hills Publishers, third edition.
4. 'Operation Research' by Liberman, McGraw Hills Publishers, 10^{th} edition, 2015.
5. 'Operation Research' by A P Verma, S.K. Kataria & Sons publishers, 2012 edition.
6. 'Operation Research' by Manohar & Mahajan, Dhanpat Rai Publications, 2004.

Online Courses:

1. https://www.coursera.org/specializations/supply-chain-management.
2. Operations Research by Prof. Kusum Deep, IIT Roorkee, Mechanical Department.

Subject Experts:

1.) Prof. Debjit Roy Assistant, Indian Institute of Management Ahmedabad, Gujarat, India.
2.) Dr. M. Punniyamoorthy, National Institute of Technology, Department of Mechanical Engg., Tiruchirappalli,
3.) Dr. P. Parthiban, National Institute of Technology, Department of Mechanical Engg., Tiruchirappalli
4.) Dr. Ajinkya NandkumarTanksale, Department of Mechanical Engg., Indian Institute of Technology(BHU) Varanasi

SEMESTER-VIII

Elective-IX: (BMEL435) Robotics and Machine Vision

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	50	--	--	75

Course Objectives:

1. To gain fundamental skills in industrial and mobile robotics
2. To obtain knowledge and understand basic concepts of robot kinematics
3. To understand the basic concepts of robot motion planning
4. To attain the principles of machine vision and its applications in robotics

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Understand the principles of robotic automation used in the industry
2. Derive the kinematic equations of the robot
3. Analyze and plan robot motion
4. Apply robotics and vision based techniques to engineering applications

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO!1	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	3	2	--	--
CO2	3	3	3	2	3	2	2	--	--
CO3	3	3	3	3	3	3	3	2	--
C04	3	3	3	3	3	3	3	2	2

Contents:

Unit 1: Introduction to Robotics (CO1) (8 Hrs)

Historical context, laws of robotics, industrial robot anatomy, arm configurations, design and control issues, introduction to mobile robots, robot applications.

Unit 2: Robot Kinematics (CO2) (10 Hrs)

Mapping of coordinate frames, homogeneous transformations, frame assignment, DH parameters, forward kinematics, inverse kinematics, kinematics of mobile robots.

Unit 3: Robot Motion Planning (CO3) (6 Hrs)

Fundamentals of robot motion planning, joint space technique, cartesian space technique, obstacle avoidance.

Unit 4: Machine Vision (CO4) (6 Hrs)

Image forming, image processing, image feature extraction, robotic vison and its applications, vision based control, advanced visual servoing.

Text Books:

1. R K Mittal & I J Nagrath, Robotics and Control, Mcgraw Hill Education Private Limited (2017).
2. K. S. Fu, R. C. Gonzalez, and C. S. G. Lee, Robotics - Control, Sensing, Vision, and Intelligence, McGraw-Hill Book Company (1987).
3. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer (2011).
4. B. Sicilliano -Robotics. Modelling, Planning and Control, Springer (2019).

Reference Books:

1. S K Saha, Introduction to Robotics, (2nd Edition), Mcgraw Hill Education Private Limited (2017).
2. Roland Siegwart, Illah Reza Nourbakhsh, and Davide Scaramuzza, Introduction to Autonomous Mobile Robots, (2nd Edition), The MIT Press (2011).
3. M P Groover, Industrial Robotics: Technology, Programming and Applications, Tata Mcgraw Hill Education Private Limited (2012).

Online Courses:

1. Modern Robotics, Course 1: Foundations of Robot Motion, by Prof. Kevin Lynch, url: https://www.coursera.org/learn/modernrobotics-course1
2. Robotics, Prof. D. K. Pratihaar, https://nptel.ac.in/courses/112105249/#
3. Introduction to Robotics, by Prof. O. Khatib, https://see.stanford.edu/Course/CS223A

Subject Experts:

1. Prof. S K Saha, Department of Mechanical Engg., IIT Delhi
2. Prof. Ashish Dutta, Department of Mechanical Engg., IIT Kanpur
3. Prof. T Asokan, Department of Mechanical Engg., IIT Madras

SEMESTER-VIII

Elective-IX: (BMEL436) Stress Analysis

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	50	--	--	75

Course Objectives:

1. To understand basic concepts of stress analysis.
2. To develop competency in analytical methods in solving problems of stress distribution
3. To make the students conversant with 3-D photo elasticity and to give exposure on fringes.
4. To learn and apply various methods in stress and strain analysis and exposure to new advancements in stress analysis.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Evaluate and compare Able to justify on the suitability of selected material it is capable to sustain load or pressure to given problem
2. Check elasticity of any material by the help of polar scope.
3. Identify stress propagation of dynamic load problem , heat transfer problem and fluid related problem if it is isoclinic and is chromatic basic
4. Analyze some casting material in view of stress freezing phenomenon and fringe multiplication

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	2	1	1	2	3	2	1	-
CO2	3	2	2	1	2	2	2	-	-
CO3	3	2	2	2	2	1	2	2	1
CO4	2	3	2	2	1	3	2	2	2

Contents:

Unit 1 (CO1) (8 Hrs.)

Two Dimensional Problems in Cartesian coordinate system – Fundamentals of stress and strain, stress – strain relationship, Elastic constant, plane stress, plane strain, differential equation of equilibrium Boundary conditions, Saint Venant's principle, compatibility equation, Airys stress function. Stress analysis of cantilever subjected to concentrated load at its end and simply supported beam subjected to uniformly distributed load

Unit 2 (CO2) **(7 Hrs.)**

Two dimensional problem in polar coordinate systems – General equations of equilibrium in polar coordinate compatibility equation, stress distribution about symmetric, axis, stress analysis of cylinder subjected to ~ internal and external pressure, Pure bending of curved beams, effect of hole on the stress distribution in plates, Stress analysis of rotating circular disk. Two Dimensional Photo elasticity – Introduction to basic optics related to photo elasticity, various photo elastic materials and their properties, Casting of photo elastic models, Tardy's compensation technique, Separation techniques like, shear difference, oblique incidence and electrical analogy.

Unit 3 (CO3) **(8 Hrs.)**

Introduction to 3-D photo elasticity – Phenomenon of Stress freezing, Method of stress freezing, slicing techniques, determination of material fringe constant at critical temperature. Scaling Model – Prototype relations.

Unit 4 (CO4) **(7 Hrs.)**

Grid technique of strain analysis, Brittle coating method for stress and strain analysis, Morie fringe method for stress and strain analysis.

Text Books:

1. Theory of Elasticity, S. P. Timoshenko ,3rd Edition, Tata McGraw Hills, 1970
2. Experimental Stress Analysis, U.C.Jindal, Second Edition, Pearson Publications.
3. Applied Stress Analysis, Sadhu Singh, Khanna Publishers
4. Essentials of Mechanical Stress Analysis, Amir Javidinejad, CRC Press, First Edition,2014

Reference Books:

1. Experimental stress analysis, Dally and Riley, 3rd Edition, Tata McGraw Hills, 1991
2. Applied Stress Analysis,T.H.Hyde,Eric Ollerton, Elsevier Applied Science, 1990
3. Structural and Stress Analysis,T.H.G.Megson,Second Edition,BH Publications.
4. Stress Analysis:Recent Developments in Numerical and Experimental Methods,O.C,Zienkiewicz,G.S.Holister

Online Courses:

1) Experimental Stress Analysis ,NPTEL Course
2) NPTELLecture
https://www.youtube.com/watch?v=Ujtv5NY4Sq8&list=PL21BB25670CDC2AEB
3) NPTELLecture
https://www.youtube.com/watch?v=r8KzP7G7Uks&list=PL21BB25670CDC2AEB&index=3
4) NPTELLecture
https://www.youtube.com/watch?v=kzWbdP5gqb0&list=PL21BB25670CDC2AEB&index=4
5) NPTELLecture
https://www.youtube.com/watch?v=CV0c9Sd0g5w&list=PL21BB25670CDC2AEB&index=5
6) NPTELLecture
https://www.youtube.com/watch?v=_7sXKtHQC54&list=PL21BB25670CDC2AEB&index=9
7) NPTELLecture
https://www.youtube.com/watch?v=ukMP2zkI1h0&list=PL21BB25670CDC2AEB&index=11

Subject Experts:

1) Prof. K. Ramesh, Department of Mechanical Engg., IIT Madras
2) Prof. S.K.Bhattacharya, Department of Mechanical Engg., IIT Kharagpur.

SEMESTER-VIII

Elective-IX: (BMEL437) Micro-Electro Mechanical System (MEMS)

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
2	-	-	2	2	10	15	50	--	--	75

Course Objectives:

1. Understand the benefits and consequences of scaling.
2. Understand properties of actuator and Sensors.
3. Explain the concept of Micro Fabrication. Understand bulk micromachining.
4. Explain the concept of MEMS devices.

Course Outcomes:

Upon the successful completion of course, the students shall be able to:

1. Understand the MEMS
2. Identify Different Types Of sensors and actuators
3. Distinguish Among materials and fabrication process
4. Make MEMS devices.

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	2	1	3	1	2	3	3
CO2	3	3	2	2	3	1	2	2	2
CO3	2	2	2	1	2	2	2	2	2
CO4	1	2	3	3	1	1	3	3	1

Contents:

Unit 1 (CO1) **(7 Hrs.)**

Fundamentals of micro electro mechanical (MEMS) systems including design, fabrication of microstructures.

Unit 2 (CO2): **(8 Hrs.)**

Working principles of Micro Sensors, Actuators and applications in real systems. Design considerations, modeling and innovations.

Unit 3 (CO3) **(7 Hrs.)**

Materials selection, Micro Fabrication. Microfluidics, Biomedical & Bio-MEMS, and Lab-on-a-chip. System Integration and Packaging.

Unit 4 (CO4) **(8 Hrs.)**

Fabrication principles of integrated circuit device and their applications for making MEMS devices; high-aspect-ratio microstructures; scaling issues in the micro scale (heat transfer, fluid mechanics and solid mechanics)

Text Books:

1. Hsu T.R., MEMS & MICROSYSTEMS Design and Manufacture, Tata McGraw Hill Education Pvt. Ltd.
2. Madou M., Fundamentals of Microfabrication: The Science of Miniaturization, Vol. I, II, & III, CRC Press.

References Books:

1. Journal of Microelectromechanical Systems (IEEE) http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=84 4 ECE 6030 | MEMS Design | Spring 2019
2. Journal of Micromechanics and Microengineering (IoP Science) http://iopscience.iop.org/journal/0960-1317
3. Sensors and Actuators A: Physical (Elsevier) https://www.journals.elsevier.com/sensors-and-actuators-a-physical
4. Collection of MEMS review papers - Oldies but goodies: Proceedings of the IEEE, Vol. 86, Nov. 8, August 1998.

Online Courses:

1. https://nptel.ac.in/courses/112/104/112104181/
2. https://nptel.ac.in/courses/117/105/117105082/
3. https://www.coursera.org/lecture/sensor-manufacturing-process-control/2-mems-construction-0tHJV

Subject Experts:

1. Dr. Shantanu Bhattacharya, Department of Mechanical Engg., IIT Kanpur
2. Dr. Vijay Kumar Gupta, Department of Mechanical Engg., IIIT Jabalpur
3. Dr. Santiram Kal, Department of Mechanical Engg., IIT Kharagpur

SEMESTER-VIII

BMEP 410: Major Project Phase-II

Teaching Scheme				Credits	Evaluation Scheme					
					Theory			Practical		Total Marks
Th	Tu	Pr	Total Hours		TAE	CAE	ESE	Int.	Ext.	
-	-	4	4	4	--	--	--	50	50	100

NOTE: Major project phase II shall be continued after satisfactory completion of phase I. Project work may consist of fabrication and experimental work or exhaustive analysis of system in the context of 2-3 factors identified belonging to the industry, where he/she has undergone the training. The group has to present at least two project progress seminars. Each student has to prepare final project report, phase I and phase II, under the guidance of the project guide. Each group has to present on ppt. final project seminar consisting of both phase I and phase II before the committee constituted for the purpose of evaluating the project.

Course Outcomes: -

Upon the successful completion of course, the student shall be able to:

1. Learn how to do the literature survey on the normal topic along with the comparative study of various approaches studied under literature.
2. Study some products manufactured in the industry where the student is undergoing training and identifying of the problem project point of view.
3. Design of some mechanical system may also comprise of machines, thermal, hydraulic/pneumatic system
4. Learn various aspects such as plant layout, mechanical handling systems, assembly shop, quality control system, maintenance system, various service system, development and planning functions,

CO Mapping with PO and PSO:

Course Outcomes	Programme Outcomes						Programme Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO 12	PSO 1	PSO 2	PSO3
CO1	3	3	2	1	3	1	2	3	3
CO2	3	3	2	2	3	1	2	2	2
CO3	2	2	2	1	2	2	2	2	2
CO4	1	2	3	3	1	1	3	3	1