Babu Banarasi Das University, Lucknow

School of Engineering
(School Code: 04)
Department of Mechanical Engineering
(University Branch Code: 35)
Bachelor of Technology
Evaluation Scheme

Semester I									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	BAS3101	Matrices and Calculus	3	1	0	40	60	100	4
C	BAS3102	Physics-I	2	1	0	40	60	100	3
Students need to select either GROUP 'A' or GROUP 'B'									
	GP3101	General Proficiency	0	0	0	100	0	100	1
Total			5	2	0	180	120	300	8

GROUP 'A'									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
F	BME3101	Engineering Mechanics	3	1	0	40	60	100	4
F	BCS3101	Fundamental of Information Technology	3	1	0	40	60	100	4
F	BEC3101	Basic Electronics Engineering	3	1	0	40	60	100	4
C	BAS3104	Environmental Studies	2	0	0	40	60	100	2
F	BME3151	Engineering Mechanics Lab	0	0	2	40	60	100	1
F	BCS3151	Fundamental of Information Technology Lab	0	0	2	40	60	100	1
F	BME3152	Workshop Practice	0	1	2	40	60	100	2
C	BAS3152	Physics-I Lab	0	0	2	40	60	100	1
Total			11	4	8	320	480	800	19

GROUP 'B'									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
F	**BEE3101**	Basic Electrical Engineering	**3**	**1**	**0**	**40**	**60**	**100**	**4**
F	**BME3102**	Basic Mechanical Engineering	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**BAS3103**	Chemistry	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**BHS3101**	Professional Communication	**3**	**1**	**0**	**40**	**60**	**100**	**4**
F	**BEE3151**	Basic Electrical Engineering Lab	**0**	**0**	**2**	**40**	**60**	**100**	**1**
F	**BME3153**	Engineering Graphics Lab	**0**	**1**	**2**	**40**	**60**	**100**	**2**
C	**BAS3153**	Chemistry Lab	**0**	**0**	**2**	**40**	**60**	**100**	**1**
Total			**12**	**5**	**6**	**280**	**420**	**700**	**20**

Semester II

Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	BAS3201	Differential Equations and Fourier Analysis	3	1	0	40	60	100	4
C	BAS3202	Physics-II	2	1	0	40	60	100	3
Students need to select either GROUP 'A' or GROUP 'B'									
	GP3201	General Proficiency	0	0	0	100	0	100	1
Total			5	2	0	180	120	300	8

Note: Students who have selected GROUP 'A' in the first semester will select GROUP 'B' in the second semester and Vice-Versa.

GROUP 'A'

Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
F	BME3201	Engineering Mechanics	3	1	0	40	60	100	4
F	BCS3201	Fundamental of Information Technology	3	1	0	40	60	100	4
F	BEC3201	Basic Electronics Engineering	3	1	0	40	60	100	4
C	BAS3204	Environmental Studies	2	0	0	40	60	100	2
F	BME3251	Engineering Mechanics Lab	0	0	2	40	60	100	1
F	BCS3251	Fundamental of Information Technology Lab	0	0	2	40	60	100	1
F	BME3252	Workshop Practice	0	1	2	40	60	100	2
C	BAS3252	Physics-I Lab	0	0	2	40	60	100	1
Total			11	4	8	320	480	800	19

GROUP 'B'									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
F	**BEE3201**	Basic Electrical Engineering	**3**	**1**	**0**	**40**	**60**	**100**	**4**
F	**BME3202**	Basic Mechanical Engineering	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**BAS3203**	Chemistry	**3**	**1**	**0**	**40**	**60**	**100**	**4**
F	**BEE3251**	Basic Electrical Engineering Lab	**0**	**0**	**2**	**40**	**60**	**100**	**1**
F	**BME3253**	Engineering Graphics	**0**	**1**	**2**	**40**	**60**	**100**	**2**
C	**BAS3253**	Chemistry Lab	**0**	**0**	**2**	**40**	**60**	**100**	**1**
Total			**9**	**4**	**6**	**240**	**360**	**600**	**16**

Legends:

L	Number of Lecture Hours per week
T	Number of Tutorial Hours per week
P	Number of Practical Hours per week
CIA	Continuous Internal Assessment
ESE	End Semester Examination

Category of Courses:

F	Foundation Course
C	Core Course
GE	Generic Elective
OE	Open Elective

Babu Banarasi Das University, Lucknow

School of Engineering
(School Code: 04)
Department of Mechanical Engineering
(University Branch Code: 35)
Bachelor of Technology
Evaluation Scheme

Semester III									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	BHS3301/ BHS3302	Industrial Psychology / Industrial Sociology	2	0	0	40	60	100	2
C	BAS3301	Complex Analysis & Integral Transform	3	1	0	40	60	100	4
C	BME3301	Materials Science	3	1	0	40	60	100	4
C	BME3302	Strength of Materials	3	1	0	40	60	100	4
C	BME3303	Manufacturing Science- I	2	1	0	40	60	100	3
C	BCE3303	Fluid Mechanics	3	1	0	40	60	100	4
C	BME3351	Material Science & Testing Lab	0	0	2	40	60	100	1
C	BME3352	Machine Drawing-I	0	0	2	40	60	100	1
C	BME3353	Manufacturing Science- I Lab	0	0	2	40	60	100	1
C	BCE3353	Fluid Mechanics Lab	0	0	2	40	60	100	1
	GP3301	General Proficiency	-	-	-	100	-	100	1
Total			16	5	8	500	600	1100	26

Legends:

L	Number of Lecture Hours per week
T	Number of Tutorial Hours per week
P	Number of Practical Hours per week
CIA	Continuous Internal Assessment
ESE	End Semester Examination

Category of Courses:

F	Foundation Course
C	Core Course
GE	Generic Elective
OE	Open Elective

Babu Banarasi Das University, Lucknow

School of Engineering
(School Code: 04)
Department of Mechanical Engineering
(University Branch Code: 35)
Bachelor of Technology
Evaluation Scheme

Semester IV									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	**BHS3401/ BHS3402**	Industrial Psychology / Industrial Sociology	**2**	**0**	**0**	**40**	**60**	**100**	**2**
C	**BME3401**	Applied Thermodynamics and Turbomachinery	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**BME3402**	Manufacturing Science-II	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**BME3403**	Measurement Metrology & Control	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**BAS3401**	Statistical & Numerical Techniques	**2**	**1**	**0**	**40**	**60**	**100**	**3**
C	**BCS3405**	Programming in 'C'	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**BME3451**	Machine Drawing-II	**0**	**0**	**2**	**40**	**60**	**100**	**1**
C	**BME3452**	Manufacturing Science-II Lab	**0**	**0**	**2**	**40**	**60**	**100**	**1**
C	**BME3453**	Measurement & Metrology Lab	**0**	**0**	**2**	**40**	**60**	**100**	**1**
C	**BCS3455**	'C'- Programming Lab	**0**	**0**	**2**	**40**	**60**	**100**	**1**
	GP3401	General Proficiency	**-**	**-**	**-**	**100**	**-**	**100**	**1**
Total			**16**	**5**	**8**	**500**	**600**	**1100**	**26**

Legends:

L	Number of Lecture Hours per week
T	Number of Tutorial Hours per week
P	Number of Practical Hours per week
CIA	Continuous Internal Assessment
ESE	End Semester Examination

Category of Courses:

F	Foundation Course
C	Core Course
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Babu Banarasi Das University, Lucknow

School of Engineering
(School Code: 04)
Department of Mechanical Engineering
(University Branch Code: 35)
Bachelor of Technology
Evaluation Scheme

Semester V									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	BHS3501	Engineering and Managerial Economics	3	0	0	40	60	100	3
C	BME3501	Machine Design-I	2	1	0	40	60	100	3
C	BME3502	Theory of Machines-I	3	1	0	40	60	100	4
C	BEE3505	Electrical Machines	2	1	0	40	60	100	3
C	BME3503	Heat & Mass Transfer	3	1	0	40	60	100	4
C	BME3504	I.C. Engines &Compressors	3	1	0	40	60	100	4
C	BME3551	Machine Design-I Lab	0	0	2	40	60	100	1
C	BME3553	Heat & Mass Transfer Lab	0	0	2	40	60	100	1
C	BEE3555	Electrical Machines & Automatic control Lab	0	0	2	40	60	100	1
C	BME3558	Seminar	0	0	2	40	60	100	1
	GP3501	General Proficiency	-	-	-	100	-	100	1
Total			16	5	8	500	600	1100	26

Legends:

L	Number of Lecture Hours per week
T	Number of Tutorial Hours per week
P	Number of Practical Hours per week
CIA	Continuous Internal Assessment
ESE	End Semester Examination

Category of Courses:

F	Foundation Course
C	Core Course
GE	Generic Elective
OE	Open Elective

Babu Banarasi Das University, Lucknow

School of Engineering
(School Code: 04)
Department of Mechanical Engineering
(University Branch Code: 35)
Bachelor of Technology
Evaluation Scheme

Semester VI									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	BHS3601	Industrial Management	2	1	0	40	60	100	3
C	BME3603	Machine Design-II	3	1	0	40	60	100	4
C	BME3601	Theory of Machine- II	2	1	0	40	60	100	3
C	BME3602	Refrigeration & Air-conditioning	3	1	0	40	60	100	4
C	BME3604	Advanced Welding Technology	2	1	0	40	60	100	3
GE		Generic Elective-I	3	1	0	40	60	100	4
C	BME3653	Fluid Machinery Lab	0	0	2	40	60	100	1
C	BME3652	Refrigeration & Air Conditioning Lab	0	0	2	40	60	100	1
C	BME3651	Theory of Machines Lab	0	0	2	40	60	100	1
C	BME3658	Seminar	0	0	2	40	60	100	1
	GP3601	General Proficiency	-	-	-	100	-	100	1
Total			15	6	8	500	600	1100	26

Note- Student needs to undergo 4-6 weeks of industrial training that will be evaluated in 7thSemester.

Legends:

L	Number of Lecture Hours per week
T	Number of Tutorial Hours per week
P	Number of Practical Hours per week
CIA	Continuous Internal Assessment
ESE	End Semester Examination

Category of Courses:

F	Foundation Course
C	Core Course
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Babu Banarasi Das University, Lucknow

School of Engineering
(School Code: 04)
Department of Mechanical Engineering
(University Branch Code: 35)
Bachelor of Technology
Evaluation Scheme

Semester VII									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	**BME3701**	Computer Aided Design	**3**	**1**	**0**	**40**	**60**	**100**	**4**
C	**BME3702**	Automobile Engineering	**3**	**1**	**0**	**40**	**60**	**100**	**4**
GE		Generic Elective-II	**3**	**1**	**0**	**40**	**60**	**100**	**4**
GE		Generic Elective-III	**3**	**1**	**0**	**40**	**60**	**100**	**4**
OE		Open Elective-I*	**-**	**-**	**-**	**40**	**60**	**100**	**4**
C	**BME3751**	CAD/CAM Lab	**0**	**0**	**2**	**40**	**60**	**100**	**1**
C	**BME3752**	Automobile Lab	**0**	**0**	**2**	**40**	**60**	**100**	**1**
C	**BME3759**	ProjectI#	**0**	**0**	**2**	**100**	**0**	**100**	**1**
C	**BME3757**	Industrial Training Evaluation	**0**	**0**	**2**	**100**	**0**	**100**	**1**
	GP3701	General Proficiency	**-**	**-**	**-**	**100**	**-**	**100**	**1**
Total			**12**	**4**	**8**	**580**	**420**	**1000**	**25**

***** Student will select any one of the open electives from the list of open electives provided by the university.

Student need to submit an abstract for the project, select the Guide and will complete at least 20% of the Project work.

Legends:

L	Number of Lecture Hours per week
T	Number of Tutorial Hours per week
P	Number of Practical Hours per week
CIA	Continuous Internal Assessment
ESE	End Semester Examination

Category of Courses:

F	Foundation Course
C	Core Course
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Babu Banarasi Das University, Lucknow

School of Engineering
(School Code: 04)
Department of Mechanical Engineering
(University Branch Code: 35)
Bachelor of Technology
Evaluation Scheme

Semester VIII									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	BME3801	Power Plant Engineering	3	1	0	40	60	100	4
GE		Generic Elective-IV	3	1	0	40	60	100	4
GE		Generic Elective-V	3	1	0	40	60	100	4
OE		Open Elective-II **	-	-	-	40	60	100	4
C	BME3859	Project II##	0	0	16	160	240	400	8
	GP3801	General Proficiency	-	-	-	100	-	100	1
Total			9	3	16	420	480	900	25

** Student will select any one of the open electives from the list of open electives provided by the university. The opted Subject should be different from the one selected in Semester VII.

This is in continuation with the Project work started in Semester VII. In this semester student will complete the Project.

Legends:

L	Number of Lecture Hours per week
T	Number of Tutorial Hours per week
P	Number of Practical Hours per week
CIA	Continuous Internal Assessment
ESE	End Semester Examination

Category of Courses:

F	Foundation Course
C	Core Course
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School of Engineering
(School Code: 04)
Department of Mechanical Engineering
(University Branch Code: 35)
Bachelor of Technology
Evaluation Scheme

Credit Summary Chart

Course Category	Semester								Total Credits	%age
	I	II	III	IV	V	VI	VII	VIII		
F	16/11	11/16							26	12.44%
C	10/16	16/10	25	25	25	21	12	12	147	70.33%
GE						4	8	8	20	9.57%
OE							4	4	8	3.83%
GP	1	1	1	1	1	1	1	1	8	3.83%
Total	27/28	28/27	26	26	26	26	25	25	209	100.00%

Discipline wise Credit Summary Chart

Course Category	Semester								Total Credits	%age
	I	II	III	IV	V	VI	VII	VIII		
Basic Sciences	10/12	12/10	4	3					29	13.88%
Humanities & Social Sciences		5	2	2	3	3			15	7.18%
Engineering Sciences	16	10							26	12.44%
Professional Subject - Core			19	20	21	17	10	4	91	43.54%
Professional Subject – Generic Elective						4	8	8	20	9.57%
Professional Subject – Open Elective							4	4	8	3.83%
Project Work, Seminar and/or Internship in Industry or elsewhere	1	1	1	1	2	2	3	9	20	9.57%
Total	28	27	26	26	26	26	25	25	209	100.00%

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School of Engineering
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Department of Mechanical Engineering
(University Branch Code: 35)
Bachelor of Technology
Evaluation Scheme

List of Generic Electives

S.N.	Course Code	Generic Elective-I
1	GE33511	Fluid Machinery
2	GE33512	Unconventional Manufacturing Processes
3	GE33513	Product Development & Design
4	GE33514	Concurrent Engineering

S.N.	Course Code	Generic Elective-II
1	GE33521	Reliability Engineering
2	GE33522	Non-Destructive Testing
3	GE33523	Design of Thermal Systems
4	GE33524	Design for Manufacturing

S.N.	Course Code	Generic Elective-III
1	GE33531	Mechanical Vibrations
2	GE33532	Operations Research
3	GE33533	Maintenance Engineering & Management
4	GE33534	Industrial Robotics and Expert Systems

S.N.	Course Code	Generic Elective-IV
1	GE33541	Advanced Synthesis of Mechanisms
2	GE33542	Six Sigma Methods & Applications
3	GE33543	Finite Element Method
4	GE33544	Mechatronics

S.N.	Course Code	Generic Elective-V
1	**GE33551**	Advanced Materials Technology
2	**GE33552**	Production & Operations Management
3	**GE33553**	Principles of Computer Integrated Manufacturing
4	**GE33554**	Optimization Techniques in Engineering

Babu Banarasi Das University, Lucknow

School of Engineering
(School Code: 04)
Department of Mechanical Engineering
(University Branch Code: 35)
Bachelor of Technology
Evaluation Scheme

List of Open Electives Offered by the Department

S.N.	Course Code	Open Electives	L	T	P
1	**OE33501**	Quality management	**3**	**1**	**0**
2	**OE33502**	Product development	**3**	**1**	**0**

BASIC MECHANICAL ENGINEERING (BME3102/BME3202)

Course Objective:

1. To learn the basic principles of classical thermodynamics.
2. To apply the laws of thermodynamics to various systems and analyze the significance of the results.
3. To learn the basic concepts of internal combustion engines.

Learning Outcome:

At the end of the course student should be able to:

1. Differentiate between closed and open systems and analyze related problems.
2. Apply the concept of first and second law to analyze thermodynamic systems.
3. Analyze the performance of IC engines and identify methods to improve the efficiency.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Fundamental Concepts and Definitions:** Definition of thermodynamics, Microscopic and Macroscopic approaches, Systems, surroundings and universe, Concept of continuum, Properties and state, Thermodynamic properties, Thermodynamic path, process and cycle, Thermodynamic equilibrium, Reversibility and irreversibility, Quasi static process, Work and heat, Zeroth law of thermodynamics, concept of temperature.	30	1
II	**First law of thermodynamics**: Thermodynamic processes, flow work, Joules' experiment, Internal energy and enthalpy, First law of thermodynamics applied to open systems, Steady flow systems and their analysis, Application of steady flow energy equation, Limitations of first law of thermodynamics, PMM-I. **Second law of thermodynamics:** Statement of second law, heat engine, heat pump and refrigerator, PMM- II, Efficiency of Carnot engine, Entropy, Clausius Inequality, definition of third law of thermodynamics.	30	1

III	**IC engines:** Classification of IC engines, engine terminology, Compression Ignition engines and Spark Ignition engines, Construction and working of two stroke and four stroke engines, Difference between SI and CI engines, difference between 2-stroke and 4-stroke engine, Efficiency of Otto cycle and diesel cycle. Boilers& Condensers **Boilers**: Steam generators-classifications, Working of fire-tube and water-tube boilers, Boiler mountings & accessories. **Condensers**: Classification of condenser, Air leakage, condenser performance parameters.	**30**	**1**

Reference Books:

1. P.K. Nag, Basic and Applied Thermodynamics, Tata McGraw-Hill Publishing Company Ltd.

2. Yunus A. Cengel and M.A. Boles, Thermodynamics: An Engineering Approach, Tata McGraw- Hill Publishing Company Ltd.

3. C.P. Arora,Thermodynamics, Tata McGraw- Hill Publishing Company Ltd.

ENGINEERING MECHANICS (BME3101/BME3201)

Course Objective:

1. A working knowledge of statics with emphasis on force equilibrium and free body diagrams.
2. To calculate the reactive forces and analyse the structures.
3. To know the geometric properties of the different shapes & to learn energy and momentum methods.
4. Provides an understanding of the kinds of stress and deformation and how to determine them in a wide range of simple, practical structural problems, and an understanding of the mechanical behavior of materials under various load conditions.

Learning Outcome:

At the end of the course student should be able to:

1. Solve the engineering problems in case of equilibrium and non- equilibrium conditions & solve the problems involving dry friction.
2. Calculate the reaction forces and forces in members of statically determinate structures.
3. Determine the centroid, centre of gravity and moment of inertia of various surfaces and solids &calculate the forces acting on the rigid body, structures using varying principles.
4. To find out the stress, strain and elastic properties of different bodies.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Two-Dimensional Force Systems:** Basic concepts, Laws of motion, Principle of Transmissibility of forces, Transfer of a force to parallel position, Resultant of a force system, Simple Resultant of Two dimensional concurrent Force systems and Non-concurrent Force systems, Distributed force system, free body diagrams, Equilibrium and Equations of Equilibrium, Applications of two dimensional force system. **Friction**: Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction, Equilibrium of bodies involving dry friction, Belt friction, Application of friction.	**30**	**1**

II	**Beam**: Introduction, Shear force and Bending Moment, Differential equations for shear force & bending moment, Shear force and Bending Moment Diagrams for Statically Determinate Beams. **Trusses:** Introduction, Simple Truss and Solution of Simple Truss, Method of Sections; Method of Joints; How to determine if a member is in tension or compression; Simple Trusses; Zero force members	**30**	**1**
III	**Centroid and Moment of Inertia:** Introduction, Centroid of plane, curve, area, volume and composite bodies, Moment of inertia of plane area,Parallel Axes Theorem & Perpendicular axes theorem, Moment of inertia of composite bodies. **Kinematics and Kinetics:** Linear motion, Instantaneous center, D'Alembert principle, Rotation of rigid bodies, Impulse and momentum principle, Work and energy principle.	**30**	**1**
IV	**Simple Stress and Strain:** Definition of stress, stress tensor, normal and shear stresses in axially loaded members, Stress-strain relationship, Stress-strain diagram for uniaxial loading of ductile and brittle materials, Hooke's law, Poisson's ratio, shear stress, shear strain, modulus of rigidity, Relationship between elastic constants. One Dimensional Loading of members of varying cross-sections, Temperature Stresses,Strain energy.	**30**	**1**

Reference Books:

1. Engineering Mechanics by Irving H. Shames. Prentice-Hall.

2. Engineering Mechanics: Principles of Statics and Dynamics by R. C. Hibbler. Pearson Press.

3. Engineering Mechanics: by Shanes and Rao. Pearson Education.

4. Engineering Mechanics by S.S. Bhavikatti, K.G. Rajashekarappa, New Age Publications.

5. A textbook of Engineering Mechanics by Dr. R.K. Bansal, Laxmi Publications.

6. Mechanics of Solids by Abdul Mubeen, Pearson Education Asia.

7. Mechanics of Materials by E.P. Popov, Prentice Hall of India Private Limited.

ENGINEERING MECHANICS LAB (BME3151/BME3251)

1. To conduct the tensile test and determine the ultimate tensile strength, percentage elongation for a steel specimen.
2. To determine the compression test and determine the ultimate compressive strength for a Specimen.
3. To conduct the Impact-tests (Izod/Charpy) on Impact-testing machine to find the toughness.
4. To determine the hardness of the given specimen using Vickers/Brinell/Rockwell hardness testing machine.
5. Friction experiment(s) on inclined plane and/or on screw-jack.
6. Worm & worm-wheel experiment for load lifting.
7. Belt-Pulley experiment.
8. Bending of simply-supported and cantilever beams for theoretical & experimental deflection.
9. Torsion of rod/wire experiment.
10. Experiment on Trusses.
11. Statics experiment on equilibrium.
12. Experiment on Moment of Inertia.

Note:

1. At least ten experiments are to be performed in the semester.

2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus.

WORKSHOP PRACTICE (BME3152/BME3252)

1. **Carpentry Shop:** Study of tools & operations and carpentry joints, Simple exercise using jack plane, to prepare half-lap corner joint, mortise & tennon joints, Simple exercise on wood working lathe.
2. **Fitting Bench Working Shop:** Study of tools & operations, Simple exercises involving fitting work, make perfect male-female joint, Use of drills/taps idea.
3. **Black Smithy Shop:** Study of tools & operations, Simple exercises base on black smithy operations such as upsetting, drawing down, punching, bending, fullering & swaging.
4. **Welding Shop:** Study of tools & operations of Gas welding & Arc welding, Simple butt and Lap welded joints, Oxy-acetylene flame cutting.
5. **Sheet-metal Shop:** Study of equipment & operations, Making Funnel complete with 'soldering', Fabrication of tool-box, tray, electric panel box etc.
6. **Machine Shop:** Study of machine tools and operations, Plane turning, Step turning, Taper turning, Threading, grinding of turning equipment.
7. **Foundry Shop:** Study of tools & operations, Pattern making, Mould making with the use of a core, Method of material pouring and Casting.

Note:

1. At least ten experiments are to be performed in the semester.

2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus

MATERIAL SCIENCE (BME3301)

Course Objective:

1. Understanding of the correlation between the internal structure of materials, their mechanical properties and various methods to quantify their mechanical integrity and failure criteria.
2. To develop the knowledge of how the structure of materials is described technically, including crystallography, microstructure, defects, and phase diagrams. To develop knowledge in various class of materials and their applications.
3. To develop the knowledge of how the properties of materials are described technically and how material failure is analyzed.

Learning Outcomes:

At the end of the course student should be able to:

1. Student will be able to identify crystal structures for various materials and understand the defects in such structures.
2. Understand how to use material properties in various engineering application.
3. How to quantify mechanical integrity and failure in materials.
4. Identification of smart Materials.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction to materials:** Historical perspective, importance of materials, classification of materials, ferrous and nonferrous materials, composites, Ceramics, and smart materials. **Crystal Structure:** Crystal Structure: Unit cells, Metallic crystal structures, Imperfection in solids: Point, line, interfacial and volume defects; dislocation strengthening mechanisms and slip systems, critically resolved shear stress. **Mechanical properties:** Brittleness, Ductility, Elastic deformation, Elastic recovery, Engineering strain, Engineering stress, Hardness, Modulus of elasticity, Plastic deformation, Poisson's ratio, Proportional limit, Shear, Tensile strength, Toughness, Yielding, Yield strength, Hardness, Creep. **Testing of material:** Strength testing of mild steel specimen, Rockwell, Brinell, Impact testing, Fatigue testing, Creep testing, Non-Destructive	**30**	**1**

	testing (NDT).		
II	**Microstructural Exam:** Pantograph, Microscope principle and methods, Preparation of samples and Microstructure exam and grain size determination, Comparative study of microstructure of various metals & alloys such as mild steel, CI, Brass. **Phase Diagram and Equilibrium Diagram:** Alloys, substitutional and interstitial solid solutions- Phase diagrams: Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. Iron Iron-carbide phase diagram and microstructural aspects of ledeburite, austenite, ferrite and cementite, cast iron etc. **Heat Treatment:** Heat treatment of Steel: Annealing, tempering, normalising and spheroidising, isothermal transformation diagrams for Fe-C alloys and microstructure development. Continuous cooling curves and interpretation of final microstructures and properties- austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening.	**30**	**1**
III	**Introduction to ferrous and non-ferrous metal.** **Ceramics:** Structure types and properties and applications of ceramics, Mechanical/Electrical behavior and processing of Ceramics. **Composites:** Types of composites, structure types and properties, applications of composites, structural behavior of composites. **Plastics:** Various types of polymers/plastics and its applications, Mechanical behavior and processing of plastics. Future of plastics. **Introduction to Smart materials:** Piezoelectric film, Polyvinylidene fluoride or polyvinylidene difluoride (PVDF), Piezoceramic, Magento Striction Material, super elastic nitinol, Shape memory alloy.	**30**	**1**

Reference Books:

1. W.D. Callister, Jr. - Material Science &Engineering-An Introduction Addition-6th Edition, Wiley India.
2. Kenneth G. Budinski and Michael K. Budinski, “Engineering Materials”,

Prentice Hall of India Private Limited, 4th Indian Reprint, 2002
3. K.M. Gupta, Materials Science, Umesh Publication.
4. Van Vlash -Elements of Material Science &Engineering, John Wiley &Sons Publication.
5. V.Raghvan –Material Science, Prentice Hall Publication.
6. Narula –Material Science, TMH Publication.
7. Srivastava, Srinivasan Science of Materials Engineering, New Age Publication.

STRENGTH OF MATERIALS (BME3302)

Course Objective:

1. Introduce to continuum mechanics and material modelling of engineering materials based on first energy principles: deformation and strain; momentum balance, stress and stress states; elasticity and elasticity bounds; plasticity and yield design.
2. The overarching theme is a unified mechanistic language using thermodynamics, which allows understanding, modelling and design of a large range of engineering materials.
3. The subject involves analytical methods for determining the strength, stiffness (deformation characteristics), and stability of the various members in a structural system.
4. The behavior of a member depends not only on the fundamental laws that govern the equilibrium of forces, but also on the mechanical characteristics of the material.

Learning Outcome:

At the end of the course student should be able to:

1. Describe the concepts and principles, understand the theory of elasticity including strain/displacement and Hooke's law relationships; and perform calculations, relative to the strength and stability of structures and mechanical components;
2. Apply concepts of strength of materials to obtain solutions to real time engineering problems. Define the characteristics and calculate the magnitude of combined stresses in individual members and complete structures; analyse solid mechanics problems
3. Analyse various situations involving structural members subjected to combined stresses by application of Mohr's circle of stress; locate the shear centre of thin wall beams and able to calculate the deflection at any point on a beam subjected to a combination of loads.
4. Solve for stresses and deflections of beams, apply various failure criteria for general stress states at points; solve torsion problems in bars and thin walled members

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Compound stress and strains:** Principal stresses and strain, maximum shear stress, Mohr's stress circle, Three-dimensional state of stress & strain, equilibrium equations, generalized Hook's law.	**30**	**1**

	Theory of failure, Casting lion's Theorem, Impact load: Theories of failure, Castigliano's Theorem, Impact load & stresses.		
II	**Flexural Stresses-Theory of simple bending:** Assumptions - Derivation of bending equation: M/I = f/y = E/R - Neutral axis - Determination of bending stresses - Section modulus of rectangular and circular sections (Solid and Hollow), I, T, Angle and Channel Sections- Design of simple beam sections. **Torsion:** Torsion- Derivation of torsion equation and its assumptions. Applications of the equation of the hollow and solid circular shafts, torsional rigidity, Combined torsion and bending of circular shafts, principal stress and maximum shear stresses under combined loading of bending and torsion. **Deflection of Beams:** Slope and deflection- Relationship between moment, slope and deflection, Moment area method, Macaulay's method. Use of these methods to calculate slope and deflection for determinant beams	**30**	**1**
III	**Helical and Leaf Springs:** Deflection of springs by energy method, Helical springs under axial load and under axial twist (respectively for circular and square cross sections) Axial load and twisting moment acting simultaneously both for open and closed coiled springs, Laminated springs. **Thin and Thick Cylinders & spheres:** Thin Cylinders and Spheres- Derivation of formulae and calculations of hoop stress, longitudinal stress in a cylinder, and sphere subjected to internal pressures, Radial, axial and circumferential stresses in thick cylinders subjected to internal or external pressures, Compound cylinder.	**30**	**1**
IV	**Columns and Struts:** Combined bending and direct stress, Middle third and middle quarter rules, Struts with different end conditions, Euler's theory and experimental results, Ranking Gardon Formulae. **Curved Beams:** Bending of beams with large initial curvature, Position of neutral axis for rectangular, trapezoidal and circular cross sections, Stress in crane hooks, circular rings subjected to tension or compression.	**30**	**1**

Reference Books:

1. S. Timoshenko and D.H. Young, “Elements of Strength of Materials”, DVNC, New York, USA.
2. S.M.A. Kazmi, Solid Mechanics.
3. S.S. Rattan, Strength of material, TMH, Delhi, India.
4. R.K. Bansal, Strength of Materials, 5th Edition, Laxmi Publications.
5. R. Subramanian, Strength of Materials, Oxford University Press, New Delhi.

MANUFACTURING SCIENCE- I (BME3303)

Course Objective:

1. To acquire basic knowledge about the behavior and manufacturing properties of engineering materials and concepts of foundry and casting processes.
2. To acquire knowledge about various Manufacturing process.
3. To understand Drawing, forging, Molding and powder metallurgy processes in detail and application of these in manufacture of a product.

Learning Outcome:

At the end of the course student should be able to:

1. Use the principles of foundry and casting.
2. Choose materials in a manufacturing process based on their properties.
3. Conduct experiments on various manufacturing processes.
4. Choose correct manufacturing process for a particular engineering application.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Importance of manufacturing, Classification of manufacturing processes, Conventional manufacturing Processes, Materials & manufacturing processes for common items. **Metal Forming Processes:** Elastic & plastic deformation, yield criteria, Hot working vs. cold working, Analysis (equilibrium equation method) of forging process with sliding friction, sticking friction and disc. Work required for forging, hand, Power, Drop Forging.	**30**	**1**
II	**Drawing:** Analysis of wire / strip drawing and maximum reduction, Tube drawing, **Extrusion and Rolling:** Extrusion and its application, Rolling and rolled section, condition for rolling force and power in rolling, Defects in metal forming processes.	**30**	**1**
III	**Sheet Metal working:** Presses and their classification. Die & punch assembly, press work methods and processes, Cutting/Punching mechanism, blanking vs. Piercing,	**30**	**1**

	Compound vs. Progressive die, Flat-face vs. Inclined-face punch and Load (capacity) needed, Analysis of forming process like cup/deep drawing, Bending & spring-back. **Powder Metallurgy:** Powder metallurgy manufacturing process, advantage and applications.		
IV	**Casting (Foundry):** Basic principle, Types of patterns and allowances, Types and properties of Molding sand, Elements of mould and design considerations, Gating, Riser, Runners, Core, Solidification of casting, Sand casting, defects, remedies and inspection, Cupola furnace, Die Casting, Centrifugal casting, Investment casting. **Jigs & Fixtures:** Locating and Clamping devices. Jigs, Fixtures and its applications.	**30**	**1**

Reference Books:

1. Manufacturing Science by Ghosh and Mallik, Prentice Hall PTR.

2. Production Engineering Science by P.C. Pandey, Standard Publishers Distributors.

3. Production Technology by R.K. Jain, Khanna Publishers.

4. Manufacturing Technology by P.N. Rao, TMH.

5. Materials and Manufacturing by Paul DeGarmo, Prentice Hall.

6. Manufacturing Science by K.M. Moeed, Umesh Publication.

7. Manufacturing Engineering & Technology by Kalpakjian, Pearson Publication.

Fluid Mechanics (BCE3303)

Course Objective:

1. Study of fluids (liquids, gases, and plasmas) rest or motion and its properties
2. Nature of fluid and types of flow.
3. Know about continuum mechanics,
4. Measurement of boundary layer conditions.

Learning Outcome:

1. It gives the knowledge of fluid properties.
2. It gives the knowledge of different type of flow.
3. It gives the knowledge of discharge measuring with different instruments and conditions.
4. It gives the knowledge of Laminar and turbulent flow.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction about fluid properties-fluid properties and classification, objective**,** Principal of conservation of mass, energy. Capillarity, Cavitation**,** Measurement of pressure by Manometers, Surface Tension**,** The Hydrostatic law, Stability of immersed and floating bodies, buoyancy, centre of buoyancy, metacentre.	**30**	**1**
II	Fluid Kinematics - Types of flows; Steady flow, Unsteady flow, Uniform and Non-Uniform flow, Rotational flow, Irrotational flow, 1-D, 2-D, 3-D flows, Streamlines, Path lines and Streak lines, Rotational, Vorticity, Circulation, Velocity potential lines.	**30**	**1**

III	Flow measuring instruments- Euler Equation, Bernoulli's equation and its applications, Pitot tube, Flow through Orifices meter**,** Venturimeter. Mouthpieces, Nozzles, Sluice gates under free Submerge flow condition, Dimension analysis**,** Angular momentum and force vortex.	**30**	**1**
IV	Boundary layers, Laminar flow and Turbulent flow, Boundary layer thickness, Drag and lift, Separation of boundary layer, Methods of separation of boundary layer.	**30**	**1**

References:

1. Fox & Donald, ―Introduction to Fluid Mechanics‖ John Wiley &Sons Pvt Ltd
2. Cengel &Cimbala, ―Fluid Mechanics‖ TMH, New Delhi
3. White F.M., ―Fluid Mechanics‖ TMH, New Delhi
4. Munsen, ―Fundamental of Fluid Mechanics‖ Wiley Newyork Ltd
5. Garde R.J., ― Fluid Mechanics, SciTech Publications Pvt. Ltd
6. Shames I.H., ―Mechanics of Fluids, McGraw Hill, Int. Student, Education

MATERIAL SCIENCE & TESTING LAB (BME3351)

Material Science Lab Experiments:

(Minimum 4 experiments out of the following)

1. Making a plastic mould for small metallic specimen.
2. Specimen preparation for micro structural examination-cutting, grinding, polishing, etching.
3. Grain Size determination of a given specimen.
4. Comparative study of microstructures of different given specimens (mild steel, gray C.I., brass, copper etc.).
5. Heat treatment experiment such as annealing, normalizing, quenching, case hardening and comparison of hardness before and after.
6. Material identification of say 50 common items kept in a box.

Material Testing Lab Experiments:

(Minimum 6 experiments out of the following)

1. Strength testing of a given mild steel specimen on UTM with full details.
2. Shear and bending tests on UTM.
3. Impact testing on impact testing machine like Charpy and Izod or both.
4. Hardness testing of given specimen using Rockwell and Vickers/Brinell testing machines.
5. Spring index testing on spring testing machine.
6. Fatigue testing on fatigue testing machine.
7. Creep testing on creep testing machine.
8. Deflection of beam experiment, comparison of actual measurement of deflection with dial gauge.
9. Torsion testing of a rod on torsion testing machine.
10. Study of non-destructive testing methods.

Note:

1. At least ten experiments are to be performed in the semester.

2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus

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MACHINE DRAWING-I (BME3352)

1. Introduction: (1 drawing sheet)

Graphics Language, Classification of drawings, Principles of drawing, IS codes for machine drawing, scales, types of lines, section lines, Dimensioning.

2. Orthographic Projections: (1 drawing sheet)

Principle of first angle and third angle projection, drawing of machine elements in first angle projection, selection of views, sectional views.

3. Screwed fasteners: (2 drawing sheet)

Thread nomenclature, Forms of thread, Thread series, designation, Representation of threads, Bolted joints, Locking arrangement of nuts.

4. Keys and Cotters and Pin joint: (1 drawing sheet)

Types of keys, Cotter joint or Knuckle joint.

5. Shaft Couplings: (1 drawing sheet)

Introduction, Rigid coupling or Flexible coupling.

6. Riveted joints: (1 drawing sheet)

Introduction, rivets and riveting, Types of rivet heads, Types of riveted joints, Boiler joint.

7. Assembly Drawing: (1drawing sheet)

Introduction, Engine parts-stuffing box, crosshead.

Note:

1. At least ten drawing sheets to be prepared in the semester.
2. At least eight drawing sheets to be prepared from the above list.

Remaining two drawing sheets may either be from the above list or designed & set by the concern faculty as per the scope of the syllabus.

MANUFACTURING SCIENCE- I LAB (BME3353)

1. Design of pattern for a desired casting (containing hole)
2. Pattern making
3. Making a mould (with core) and casting.
4. Sand testing (at least one such as grain fineness number determination)
5. Injection molding with plastics
6. Forging hand forging processes
7. Forging- power hammers study &operation
8. Tube bending with the use of sand and on tube bending m/c.
9. Press work experiment such as blanking/piercing, washer, making etc.
10. Wire drawing/extrusion on soft material.
11. Study of Rolling-experiment.
12. Bending & spring back.
13. Powder metallurgy experiment.
14. Jigs & Fixture experiment

Note:

1. At least ten experiments are to be performed in the semester.
2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus

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Fluid Mechanics Lab (BCE3353)

1. To determine the coefficient of discharge of an orifice of a given shape. Also, to determine the coefficient of velocity and the coefficient of contraction of the orifice mouthpiece.
2. To calibrate an orifice meter and study the variation of the co-efficient of discharge with the Reynolds number.
3. To calibrate a Venturimeter and study the variation of the co-efficient of discharge with the Reynolds number.
4. To study the calibrate a bend meter and study the variation of the co-efficient of discharge with the Reynolds number.
5. To study the transition from laminar to turbulent flow and to determine the lower critical Reynolds number.
6. To study the velocity distribution in a pipe and also to compute the discharge by integrating the velocity profile.
7. To determine Meta-centric height of a given ship model.
8. To study the head loss for a sudden enlargement.
9. To study the head loss for a sudden Contraction

Note:

1. At least ten experiments are to be performed in the semester.

2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus.

APPLIED THERMODYNAMICS AND TURBO MACHINERY (BME3401)

Course Objective:

1. To learn the basic principles of classical thermodynamics.
2. To apply the laws of thermodynamics to various systems and analyze the significance of the results.
3. To analyze the performance of thermodynamic gas and vapor power cycles.
4. To generate thermodynamic relation for real fluid system.

Learning Outcome:

At the end of the course student should be able to:

1. Differentiate between closed and open systems and analyze related problems.
2. Apply the concept of second law to design thermodynamic systems.
3. Analyze the performance of gas and vapor power cycles and identify methods to improve thermodynamic performance.
4. To analyze practical problems of combustion and stoichiometry.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Thermodynamic relations**: Mathematical conditions for exact differentials, Maxwell Relations, Clapeyron Equation, Joule-Thompson coefficient and inversion curve, Coefficient of volume expansion, adiabatic & isothermal compressibility. **Fuels and combustion:** Combustion analysis, heating values, air requirement, Air/Fuel ratio, Standard heat of reaction and effect of temperature on standard heat of reaction, Heat of formation, Adiabatic flame temperature.	**30**	**1**
II	**Properties of Pure substances:** Pure substance, Property of Pure Substance (steam), Triple point, Critical point, Saturation states, Sub cooled liquid state, Superheated vapour state, Phase transformation process of water, Graphical representation of pressure, volume and temperature, P-T, P-V and P-h diagrams, T-S and H-S diagrams, use of property diagram, Steam-Tables & Mollier chart, Dryness factor. **Vapor Power cycles:** Carnot vapor power cycle, Effect of pressure	**30**	**1**

	&temperature on Rankine cycle, Reheat cycle, Regenerative cycle, Feed water heater Binary vapor cycle, combined cycles, Cogeneration. **Boilers Draught:** Draught & its calculations, Air pre heater, feed water heater, super heater, Boiler efficiency, equivalent evaporation, Boiler trial and heat balance.		
III	**Available Energy, Availability and Irreversibility:** Available and unavailable energy, decrease in available energy when heat is transfer through a finite temperature difference, Available Energy from a Finite Energy Source, Maximum useful work in reversible process both open and closed system, Dead state Availability and Irreversibility and Gouy- Stodoula Theorem, Second law efficiency. **Steam & Gas Nozzles:** Flow through nozzle, variation of velocity, Area and specific volume. Choked flow, throat area, Nozzle efficiency, off design operation of nozzle, Effect of friction on nozzle, super saturated flow.	**30**	**1**
IV	**Turbo machinery:** **Steam Turbines:** Classification of steam turbine, Impulse and reaction turbines, Velocity diagram of simple & compound multistage impulse and reaction turbines, Staging, stage and overall efficiency, reheat factor, bleeding, &, state point locus. Comparison with steam engines, losses in steam turbines, Governing of turbines. **Gas Turbine:** Gas turbine classification, Brayton cycle, principles of gas turbine. Gas turbine cycles with intercooling, reheat and regeneration and their combinations, Stage efficiency, polytrophic efficiency, Deviation of actual cycles from ideal cycles. **Jet Propulsion:** Introduction to the principles of jet propulsion, turbojet and turboprop engines & their processes, Principle of rocket propulsion, introduction to	**30**	**1**

	rocket Engine.		

Reference Books:

1. Yunus A. Cengel (2009), Thermodynamics an Engineering Aproch, Tata McGraw-Hill Publishing Company Ltd.
2. P K Nag (2008), Engineering Thermodynamics, Tata McGraw-Hill Publishing Company Ltd.
3. Onkar Singh (2009) Applied Thermodynamics, New Age International
4. P K Nag (2008), Power Plant Engineering, Tata McGraw-Hill Publishing Company Ltd.

MANUFACTURING SCIENCE-II (BME3402)

Course Objective:

1. To acquire knowledge about the theory of metal cutting, mechanism of machining and the parameters that influence the machining processes.
2. To get basic idea about different conventinal and non conventional machining process.
3. To gain knowledge of various instruments for linear measurement, angular measurement and surface finish etc.

Learning Outcome:

At the end of the course student should be able to:

1. Explain the mechanisim of chip formation in machining.
2. Explain the various machining processes such as turning, drilling, boring, shaping, slotting, milling and grinding.
3. Describe the principle of gear generation and non-traditional machining processes.
4. Identify and suggest correct manufacturing process for particular application. Know the principle of different metrology instrument.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Metal Cutting:** Mechanics of metal cutting. Geometry of single point turning tools and nomenclature, ASA system Orthogonal vs. oblique cutting, Mechanics of chip formation, types of chips, Shear angle relationship. Merchant's force circle diagram, cutting forces, power required, Cutting fluids/lubricants and Tool materials. Tool wear and tool life, Machinability, Brief introduction to machine tool vibration and surface finish, Economics of metal cutting.	**30**	**1**
II	**Machine Tools-Lathe:** Principle, construction and working of center lathe, Machining operations on it, Turret /Capstan/ Automatic Lathes. **Shaper, Slotter and Planer:** Shaper, Slotter and Planer: Principle, construction and working, Machining operations **Milling:** Principle, construction and working, Milling cutters, up & down milling. Dividing head & indexing. **Drilling and boring:** Principle, construction and working of Drilling, boring, reaming tools, Geometry of twist drills.	**30**	**1**

	Grinding: Grinding wheels, abrasive & bonds, cutting action, grinding wheel, specification, Grinding wheel wear - attritions wear, fractures wear, Dressing and Truing, Surface and cylindrical grinding, Center less grinding. Super finishing: Honing, lapping and polishing.		
III	**Metal Joining (Welding):** Introduction to welding processes, Gas welding process and equipment, Arc welding: power sources and consumables, TIG & MIG processes and their parameters, Resistance welding, submerged arc, Electroslag, friction, welding, Soldering and Brazing. **Non-conventional Welding:** Non-conventional welding applications such as LBW, USW, EBW, Plasma-arc welding, Diffusion welding, Explosive welding.	**30**	**1**
IV	**Unconventional Machining Processes:** Abrasive Jet Machining, Water Jet Machining, Abrasive Water Jet Machining, Ultrasonic Machining, principles and process parameters Electrical Discharge Machining, principle and processes parameters, Wire EDM; Electro-chemical machining (ECM), MRR and surface finish. **Current Manufacturing practices:** Introduction to CNC machining, Rapid prototyping and rapid tooling,3D (Three-dimensional) Printing, Nanomanufacturing, Flexible Electronics and Custom Apparel, Sustainable Manufacturing, Use of Artificial Intelligence in manufacturing.	**30**	**1**

Reference Books:

1. Manufacturing science by Ghosh and Mallik, Prentice Hall Publication.
2. Fundamentals of Metal Cutting and Machine tools by Boothroyd, Scripta Book Co.
3. Production Technology by R.K. Jain, Khanna Publication.
4. Production Technology - H.M.T.
5. Production Engineering Science by P.C. Pandey, Standard Publishers Distributors.
6. Modern Machining Processes by P.C. Pandey & H.S. Shan, Tata McGraw-Hill.
7. Manufacturing science by DeGarmo, Wiley.
8. Fundamentals of metal cutting &machine tools by Juneja & Shekhon, Wiley.
9. Process & of manufacturing by Lindburg, Allyn and Bacon.
10. Advanced Machining Process - VK Jain.
11. Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Mikell P. Groover,

MEASUREMENT METROLOGY & CONTROL (BME3403)

Course Objectives:

1. To gain knowledge of various instruments for linear measurement, angular measurement and surface finish.
2. Measuremeants of various instruments with the help of various gauges.
3. Statistical analysis of errors.

Learning Outcome:

At the end of the course student should be able to:

1. Identify and suggest correct manufacturing process for particular application.
2. Know the principle of different metrology instrument.
3. To perform statistical analysis for calculating errors.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Mechanical Measurements:** **Introduction:** Introduction to measurement and measuring instruments, Generalized measuring system and functional elements, Units of measurement, Static and dynamic performance characteristics of measurement devices, Calibration, Concept of error, Sources of error, Statistical analysis of errors. **Sensors and Transducers:** Types of sensors, Types of transducers, Characteristics of Transducers. **Signal transmission and processing:** Devices and systems, Signal display & recording devices. **Metrology and Inspection:** Standards of linear measurement, Line and end standards, Limit fits and tolerances, Interchangeability and standardization, Linear and angular measurements devices and systems, Comparators- Sigma, Johansson's Microkrator, Limit gauges classification, Taylor's Principle of gauge design.	**30**	**1**

II	**Time related measurements:** Stroboscope, Frequency measurement by direct comparison, Measurement of displacement, Measurement of Velocity/Speed. **Measurement of pressure:** Gravitational, direct acting, elastic and indirect type pressure transducers, Measurement of very low and very high pressure. **Strain measurement:** Types of strain gauges and their working, Strain gauge circuits, Temperature compensation, Strain rosettes, calibration of strain gauge. **Measurements of force and torque:** Different types of load cells, Elastic transducers, Pneumatic & hydraulic systems. **Temperature measurement:** Thermometers, Classification of Thermometers, Thermocouples, Thermistors and pyrometers. **Vibration:** Seismic instruments, Vibrometers, Accelerometers.	**30**	**1**
III	**Introduction:** Measurement of geometric forms like- Straightness, Flatness & Roundness, Tool maker's microscope, Profile project autocollimator, Interferometry, Principle and use of interferometry, Optical flat, Measurement of screw threads and gears. **Surface texture:** Quantitative evaluation of surface roughness and its measurement. **Measurement and Inspection:** Dimensional inspection – Tolerance, Limit gauging, Comparators, Surface roughness. **Introduction:** Concept of automatic control- open loop & closed loop system, Servomechanisms, Block diagrams, Transfer functions, Applications of Laplace transform in control system. **Representation of control components &systems:**	**30**	**1**

	Translation and rotational mechanical components, Series and parallel combinations, Cascade system, Analogous system. **Controllers:** Brief introduction of pneumatic, Hydraulic, & electric controllers.		

Reference Books:

1. Experimental Methods for Engineers, by Holman, McGraw Hill India.
2. Mechanical Measurements, by Beckwith, Pearson.
3. Engineering Metrology, by R.K. Jain, Khanna Publishers.
4. Mechanical Measurements, by R.K. Jain, Khanna Publishers.

MACHINE DRAWING-II (BME3451)

1. Review of Orthographic Projections (1 drawing sheet)
   Orthographic Projection of solids in First angle of projection, missing lines views, interpretation of views.
2. Part and Assembly Drawing (2drawingsheet)
   Assembly drawing of eccentric, lathe tail stock, air valve, screw jack, connecting rod, safety valve etc.
3. Specification of Materials (1 drawing sheet)
   Engineering materials, representation, Code designation of steel, copper, aluminum etc.
4. Limits, Tolerance and Fits (1 drawing sheet)
   Limit system, Tolerances, Method of placing limit dimensions, Fits-types.
5. Surface Roughness (1drawingsheet)
   Introduction, nomenclature, machining symbols, indication of surface roughness.
6. Production Drawing (1drawingsheet)
   Types, Examples of simple machine elements like helical gear, bevel gear, crank, connecting rod, belt pulley, piston etc.
7. Computer Aided Drafting (2 drawing sheet)
   Introduction, input, output devices, introduction to software like AutoCAD, Pro-E, basic command sand developmentof2-D and3-Ddrawingsof simple parts

Note:

1. At least ten experiments are to be performed in the semester.
2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concerned faculty as per the scope of the syllabus.

MANUFACTURING SCIENCE-II LAB (BME3452)

1. Shear-angle determination (using formula) with tube cutting (for orthogonal) on lathe machine.
2. Bolt (thread) making on Lathe machine.
3. Tool grinding (to provide tool angles) on tool-grinder machine.
4. Gear cutting on milling machine.
5. Machining a block on shaper machine.
6. Finishing of a surface on surface-grinding machine.
7. Drilling holes on drilling machine and study of twist-drill.
8. Study of different types of tools and its angles & materials.
9. Experiment on tool wear and tool life.
10. Experiment on jigs/Fixtures and its uses.
11. Gas welding experiment.
12. Arc welding experiment.
13. Resistance welding experiment.
14. Soldering & Brazing experiment.
15. Experiment on unconventional machining.
16. Experiment on unconventional welding.
17. Experiment on TIG/MIG Welding.

Note:

1. At least ten experiments are to be performed in the semester.
2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concerned faculty as per the scope of the syllabus.

MEASUREMENT & METROLOGY LAB (BME3453)

1. Study &working of simple measuring instruments – Vernier calipers, Micrometer, Tachometer.
2. Measurement of angle using sine bar & slip gauges. Study of limit gauges.
3. Study & angular measurement using Bevel protector.
4. Adjustment of spark plug gap using feeler gauges.
5. Study of dial indicator &its constructional details.
6. Use of dial indicator to check Surface Texture.
7. Study and understanding of limits, fits &tolerances.
8. Study of Pressure & Temperature measuring equipment.
9. Study of Speed measurement using stroboscope.
10. Study and Understanding of Vibration/work measuring experiment.

Note:

1. At least ten experiments are to be performed in the semester.
2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus.

MACHINE DESIGN-I (BME3501)

Course Objective:

1. To understand the design methodology for machine elements and analyze the forces acting on a machine element and apply the suitable design methodology.
2. To understand the working of Riveted Joints and shafts under different type of condition as stresses, moments and types of loads.
3. To understand Keys, Coupling and Power Screws.

Learning Outcome:

At the end of the course student should be able to:

1. Analyze and select machine elements/components.
2. Upon completion of this course, students will get an overview of the design methodologies employed for the design of various machine components.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Design requirements of machine elements, Design procedure, Standards in design, Selection of preferred sizes, Indian Standards designation of carbon & alloy steels, Selection of materials for static and fatigue loads. **Design against Static Load:** Modes of failure, Factor of safety, Stresses due to bending and torsion, Theory of failure. **Design against Fluctuating Loads:** Cyclic stresses, Fatigue and endurance limit and Stress concentration factor, Stress concentration factor for various machine parts, Notch sensitivity, Design for finite and infinite life, Soderberg, Goodman & Gerber criteria.	**30**	**1**
II	**Riveted Joints**: Riveting methods, Types of rivet heads, Types of riveted joints, Caulking and Fullering, Failure of riveted joint, Efficiency of riveted joint,	**30**	**1**

	Design of boiler joints, Eccentric loaded riveted joint. **Shafts:** Cause of failure in shafts, Stresses in shafts, Design of shafts subjected to twisting moment, bending moment and combined twisting and bending Moments, Shafts subjected to fatigue loads, Design for rigidity.		
III	**Keys and Couplings:** Types of keys, Splines, Selection of square & flat keys, Strength of sunk key, Couplings- design of rigid and flexible couplings. **Mechanical Springs:** Design of helical and leaf springs subjected to constant and varying loading. **Power Screws:** Forms of threads, Multiple threads, Efficiency of square threads, Trapezoidal threads, Stresses in screws, Design of screw jack.	**30**	**1**

Reference Books:

1. Mechanical Engineering Design – Joseph E. Shigely, McGraw Hill Publications.
2. Design of Machine Members-Alex Valance and VI Doughtie, McGraw Hill Co.
3. Machine design -Black & Adams, McGraw Hill.
4. Machine Design-Sharma and Agrawal, S.K. Katara& Sons.
5. Design of Machine Elements-V.B. Bhandari, Tata McGraw Hill Co.

THEORY OF MACHINES-I (BME3502)

Course Objective:

1. To provide students an understanding of different types of mechanisms.

2. To familiarize students with basic concepts of displacement, velocity and acceleration analysis using graphical and analytical methods.

3. To teach students the kinematic analysis of cam-follower motion and gear train configurations.

4. To understand Friction and types of brakes and dynamometer.

Learning Outcome:

At the end of the course student should be able to:

1. Demonstrate an understanding of the concepts of various mechanisms and pairs.

2. Conduct velocity and acceleration analysis of simple mechanisms.

3. Design a layout of cam for specified motion and demonstrate an understanding of principles of operation of gears.

4. Analyze the principle of Friction, Brakes and Dynamometer.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Links-types, Kinematics pairs-classification, Constraints-types, Degrees of freedom of planar mechanism, Grubler's equation, Mobility-Grashof's law, Limit positions- Mechanical advantage- Transmission angle **Mechanisms with Lower Pair:** Kinematic inversions of four bar chain and slider crank chains, Straight line generators- Universal Joint- Rocker mechanisms, Davis and Ackermann steering gear mechanisms.	**30**	**1**
II	**Velocity in Mechanisms:** Velocity of point in mechanism, Relative velocity method, Velocities in four bar mechanism, Slider crank mechanism and quick return motion mechanism, Rubbing velocity at a pin joint, Instantaneous center	**30**	**1**

	method, Types & location of instantaneous centers, Kennedy's theorem, Velocities in four bar & slider crank mechanism. **Acceleration in Mechanisms:** Acceleration of a point on a link, Acceleration diagram, Coriolis component of acceleration, Crank and slotted lever mechanism, Klein's construction for Slider Crank mechanism.		
III	**CAMS:** Classification of cams and followers- Terminology and definitions- Displacement Diagrams-Uniform velocity, parabolic, simple harmonic and cycloidal motions-derivatives of follower motions- specified contour cams-circular and tangent cams- pressure angle and undercutting, sizing of cams, graphical and analytical disc cam profile synthesis for roller and flat face followers **Gears& Gear Trains:** Classification & terminology, Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference/undercutting- helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics	**30**	**1**
IV	**Friction:** Friction in journal bearing-friction circle, Pivots and collar friction-uniform pressure and uniform wear, Belt and pulley drive, Length of open and cross belt drive, Ratio of driving tensions for flat belt drive, Centrifugal tension, Condition for maximum power transmission, V belt drive. **Brakes & Dynamometers:** Shoe brake, Band brake, Band and block brake, Absorption and transmission type dynamometers.	**30**	**1**

Reference Books:

1. Theory of Machines - Thomas Bevan.

2. Kinematics and Dynamics of Machinery- Robert L. Norton

3. Theory of Machines and Mechanisms- Shigley.

4. Theory of Machines and Mechanisms-Ghosh & Mallik.

5. Theory of Machines and Mechanisms- Rao & Dukkipati.

6. Theory of Machines-S.S. Rattan.

7. Kinematics of Machines-Dr. Sadhu Singh.

8. Mechanics of Machines – V. Ramamurti.

9. Theory of Machines – Khurmi & Gupta.

HEAT & MASS TRANSFER (BME3503)

Course Objective:

1. To comprehend and evaluate various modes of heat and mass transfer

2. To design fin enhanced systems, Transient conduction and forced convection.

3. To understand Natural Convection and Thermal Radiation.

4. To determine effectiveness of heat exchangers using LMTD and NTU.

Learning Outcome:

At the end of the course student should be able to:

1. Apply basic principles of fluid mechanics, thermodynamics, heat transfer for designing heat and mass transfer systems.

2. Model Fins and analyze different type of boundary layer condition.

3. Model heat, mass and momentum transport systems and develop predictive correlation.

4. Assess and evaluate various designs for heat and mass transfer and optimize the solution

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction to Heat Transfer:** Concepts of the mechanisms of heat flows, Conduction, Convection and radiation, Effect of temperature on thermal conductivity of materials, Introduction to combined heat transfer mechanism. **Conduction:** One-dimensional general differential heat conduction equation in the rectangular, Cylindrical and spherical coordinate systems, Initial and boundary conditions. **Steady State one-dimensional Heat conduction:** Composite Systems in rectangular, Cylindrical and spherical coordinates with and without energy generation, Thermal resistance concept, Analogy	**30**	**1**

	between heat and electricity flow, Thermal contact resistance, Critical thickness of insulation.		
II	**Fins:** Heat transfer from extended surfaces, Fins of uniform cross-sectional area, Errors of measurement of temperature in thermometer wells. **Transient Conduction:** Transient heat conduction, Lumped capacitance method, Time constant, Unsteady state heat conduction in one dimension only, Heisler charts. Introduction to 3-D heat transfer in conduction. **Forced Convection:** Basic concepts, Hydrodynamic boundary layer, Thermal boundary layer, Approximate integral boundary layer analysis, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Mixed boundary layer, Flow over a flat plate, Flow across a single cylinder and a sphere, Flow inside ducts, Empirical heat transfer relations, Relation between fluid friction and heat transfer, Liquid metal heat transfer.	**30**	**1**
III	**Natural Convection:** Physical mechanism of natural convection, Buoyant force, Empirical heat transfer relations for natural convection over vertical planes and cylinders, Horizontal plates and cylinders and sphere, combined free and forced convection. **Thermal Radiation:** Basic radiation concepts, Radiation properties of surfaces, Black body radiation Planck's law, Wein's displacement law, Stefan Boltzmann law, Kirchhoff's law, Gray body, Shape factor, Black-body radiation, Radiation exchange between diffuse nonblack bodies in an enclosure, Radiation shields, Radiation combined with conduction and convection, Absorption and emission in gaseous medium, Solar	**30**	**1**

	radiation, Greenhouse effect.		
IV	**Heat Exchanger:** Types of heat exchangers, Fouling factors, Overall heat transfer coefficient, Logarithmic mean temperature difference (LMTD) method, Effectiveness-NTU method, & Compact Heat Exchangers. **Condensation and Boiling:** Introduction to condensation phenomena, Heat transfer relations for laminar film condensation on vertical surfaces and on outside & inside of a horizontal tube, Effect of non-condensable gases. **Introduction to Mass Transfer:** Introduction, Fick's law of diffusion, Steady state equimolar counter diffusion, Steady state diffusion though a stagnant gas film.	**30**	**1**

Reference Books:

1. Elements of Heat transfer by Bayazitouglu & Ozisik, McGraw-Hill Book Company.

2. Heat Transfer by J.P. Holman, McGraw-Hill International edition.

3. Schaum's outline of Heat Transfer by Pitts & Sisson McGraw-Hill International edition.

4. Principles of Heat Transfer by Frank Kreith, McGraw-Hill Book co.

5. Fundamentals of Momentum, Heat and Mass Transfer by James R. Welty; John Wiley & Sons (Pvt). Ltd.

6. Heat Transfer, by Vijay Gupta, New Age International (P) Ltd. Publishers.

7. Heat Transfer, by Y.V.C. Rao, University Press.

8. Heat Transfer, by R. Yadav, Central Publishing House, Allahabad.

I.C. ENGINES & COMPRESSORS (BME3504)

Course Objective:

1. To apply the laws of thermodynamics, heat and mass transfer to thermal energy systems.

2. To apply and understand the concepts S.I. Engine.

3. To apply and understand the concepts C.I. Engine.

4. To understand the basic principle of Engine Cooling, Lubrication, Supercharging etc.

Learning Outcome:

At the end of the course student should be able to:

1. Appreciate the application of the laws of thermodynamics in heat and mass transfer and operations of core thermal engineering systems like engines.

2. Learn basic principle of S.I. Engine.

3. Learn basic principle of C.I. Engine.

4. Learn basic principle of Engine Cooling, Lubrication, and Supercharging etc.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction to I.C. Engines:** Engine classification, Air standard cycles, Otto cycle, Diesel cycle, Dual cycle, Comparison of Otto, Diesel and Dual cycles, Stirling cycle, Ericsson cycles, Actual cycle analysis, Two and four stroke engines, SI and CI engines, Valve timing diagram, Rotary engines, Stratified charge engine. **Fuels:** Fuels for SI and CI engine, Important qualities of SI and CI engine fuels, Rating of SI engine and CI engine fuels, Dopes & Additives, Gaseous fuels, LPG, CNG, Biogas, Producer gas, Alternative fuels for IC engines. **Testing and Performance:** Performance parameters, Basic measurements, Blow by measurement, Testing of SI and CI engines.	**30**	**1**
II	**S.I. Engines:** Combustion in SI engine, Flame speed,	**30**	**1**

	Ignition delay, Abnormal combustion and its control, Combustion chamber design for SI engine, Carburetion, Mixture requirements, Carburetor types, Theory of carburetor, M. P. F. I., Ignition system requirements, Magneto and battery ignition systems, Ignition timing, Spark plug, Electronic ignition.		
III	**C.I. Engine:** Combustion in CI engines, Ignition delay, Knock and its control, Combustion chamber design of CI engines, Fuel injection in CI engines, Types of injection systems, Fuel pumps, Fuel injectors, Scavenging in 2 Stroke engines, Pollution and its control.	**30**	**1**
IV	**Engine Cooling:** Different cooling systems, Radiators and cooling fans. **Lubrication:** Engine friction, Lubrication principle, Type of lubrication, Lubrication oils, Crankcase ventilation. **Supercharging:** Superchargers, Types of supercharging. **Compressors:** Classification, Reciprocating compressors, Single and Multi-stage compressors, Intercooling, Volumetric efficiency, Rotary compressors, Centrifugal compressor, Axial compressors, Surging and stalling, Roots blower, Vaned compressor.	**30**	**1**

Reference Books:

1. Fundamentals of Internal Combustion Engine by Gill, Smith, Ziurs, Oxford & IBH Publishing Co.

2. IC Engines, by Rogowsky, International Book Co.

3. A Course in International Combustion Engines, by Mathur& Sharma, Dhanpat Rai & Sons.

4. I.C Engine Analysis & Practice by E.F Obert.

5. I.C Engine, by Ganeshan, Tata McGraw Hill Publishers.

6. I.C Engine, by R. Yadav, Central Publishing House, Allahabad.

7. Reciprocating and Rotary Compressors, by Chlumsky, SNTI Publications, Czechoslovakia.

8. Turbines, Compressors and Fans, by S.M. Yahya, Tata McGraw Hill.

MACHINE DESIGN-I LAB (BME3551)

1. Design & drawing of Cotter joint.
2. Design & drawing of Knuckle joint.
3. Design of machine components subjected to combined steady and variable loads.
4. Design of eccentrically loaded riveted joint.
5. Design of boiler riveted joint.
6. Design of shaft for combined constant twisting and bending loads.
7. Design of shaft subjected to fluctuating loads.
8. Design and drawing of flanged type rigid coupling.
9. Design and drawing of flexible coupling.
10. Design and drawing of helical spring.
11. Design and drawing of screw jack.

Note:

1. At least ten experiments are to be performed in the semester.
2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus.

HEAT & MASS TRANSFER LAB (BME3553)

1. Conduction - Composite wall experiment

2. Conduction - Composite cylinder experiment

3. Convection - Pool boiling experiment

4. Convection - Experiment on heat transfer from tube-natural convection.

5. Convection - Heat Pipe experiment.

6. Convection - Heat transfer through fin-natural convection.

7. Convection - Heat transfer through tube/fin-forced convection.

8. Any experiment on Stefan's Law, on radiation determination of emissivity, etc.

9. Any experiment on solar collector, etc.

10. Heat exchanger - Parallel flow experiment

11. Heat exchanger - Counter flow experiment

12. Any other suitable experiment on critical insulation thickness.

13. Conduction - Determination of thermal conductivity of fluids.

14. Conduction - Thermal Contact Resistance Effect.

Note:

1. At least ten experiments are to be performed in the semester.
2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concerned faculty as per the scope of the syllabus.

MACHINE DESIGN-II (BME3603)

Course Objective:

1. To understand and design of the Spur Gears and Helical Gears.

2. To understand and design of the Worm and Bevel Gears.

3. To understand and design of the Sliding Contact Bearing and Rolling Contact Bearings.

4. To understand and design the various parts of I.C. Engine.

Learning Outcome:

At the end of the course student should be able to:

1. Design various types of Gears.

2. Analyze and design Sliding Contact Bearing.

3. Analyze and design Rolling Contact Bearing.

4. Analyze and design various parts of I.C. Engine.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Spur Gears:** Terminology, System of gear teeth, Standard proportions of gear systems, Interference in involute gears, Backlash, Selection of gear materials, Gear manufacturing methods, Design considerations: Beam strength of gear tooth, Dynamic tooth load, Wear strength of gear tooth, Failure of gear tooth, Design of spur gears. **Helical Gears:** Terminology, Tooth Proportions for helical gears, Beam strength and wear strength of helical gears, Herringbone gears, crossed helical gears, Design of helical gears.	**30**	**1**
II	**Worm Gears:** Terminology, Gear tooth proportions, Efficiency of worm gears, Heat dissipation in worm gearing, Strength and wear tooth load for worm gears, Design of worm gearing. **Bevel Gears:** Terminology, Classification of Bevel gears. Design of right-angle bevel gears.	**30**	**1**

III	**Sliding Contact Bearing:** Types, Selection of bearing, Plain journal bearing, Lubricants and lubrication, Properties and materials, Hydrodynamic journal bearing, Bearing Characteristics Number and Bearing Modulus, Mckee's Investigation, Design of journal bearing. **Rolling Contact Bearing:** Advantages and disadvantages, Types of Rolling contact bearing, Bearing life, Dynamic equivalent load for roller contact bearing under constant and variable loading, Reliability of Bearing, Lubrication of Rolling contact bearing, Design of Rolling Bearing.	**30**	**1**
IV	**Design of Internal Combustion Engine Parts:** Introduction to different parts of IC engine, Design of Cylinder and cylinder head, Design of piston, Piston ring and gudgeon pin, Design of connecting rod, Design of center crankshaft.	**30**	**1**

Reference Books:

1. Mechanical Engineering Design – Joseph E. Shigely, McGraw Hill Publications.

2. Design of Machine Memebers-Alex Valance and VI Doughtie, McGraw Hill Co.

3. Machine design-M.F. Spott, Prentice Hall India.

4. Machine Design-Maleev and Hartman, CBS.

5. Machine design -Black & Adams, McGraw Hill.

6. Machine Design-R.S. Khurmi and J.K. Gupta, S. Chand Technical

7. Design of Machine Elements-V.B. Bhandari, Tata McGraw Hill Co.

8. Design Data Handbook –K Mahadevan and K Balaveera Reddy, CBS.

THEORY OF MACHINE- II (BME3601)

Course Objective:

1. To understand the concepts of turning moment diagrams, flywheel design and the dynamics of reciprocating engines.

2. To understand the balancing procedures for rotating and reciprocating masses, rotors and engines and gyroscopic motion.

3. To understand the fundamentals of Governors, free and forced vibrations.

Learning Outcome:

At the end of the course student should be able to:

1. Demonstrate skills to design flywheel for an IC engine and punching press with the consideration of geometrical and economic constraints.
2. Perform static and dynamic balancing of high-speed rotary and reciprocating machines and Calculate gyroscopic couple and finds its effect on various vehicles.
3. Apply concept of governors for speed control, analyze free and forced vibrations of machines, engines and structures.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Static & Dynamic Force Analysis:** Static equilibrium of two/three forces members, Static equilibrium of member with two forces and torque, Static force analysis of linkages, D'Alembert's principle, Equivalent offset inertia force, Dynamic force analysis of four link mechanism and slider crank mechanism, Engine force analysis-Piston and crank effort. **Turning Moment & Flywheel:** Turning moment on crankshaft, Turning moment diagrams-single cylinder double acting steam engine, Four stroke IC engine and multi-cylinder steam engine, Fluctuation of energy, Flywheel.	**30**	**1**
II	**Balancing of Machines:** Static and dynamic balancing, balancing of several masses in the same plane and different	**30**	**1**

	planes, balancing of reciprocating masses, Balancing of primary force in reciprocating engine, Partial balancing of two-cylinder locomotives, Variation of tractive force, Swaying couple, Hammer blow. **Gyroscopic Motion:** Principles, Gyroscopic torque, Effect of gyroscopic couple on the stability of aero planes & automobiles.		
III	**Governors:** Terminology, Centrifugal governors-Watt governor, Dead weight governors-Porter & Proell governor, Spring controlled governor-Hartnell governor, Sensitivity, Stability, Hunting, Isochronism, Effort and Power of governor, Controlling force diagrams for Porter governor and spring-controlled governors. **Mechanical Vibrations:** Types of vibrations, Degrees of freedom, Single degree free & damped vibrations. Torsional Vibrations, Whirling of Shafts.	**30**	**1**

Reference Books:

1. Theory of Machines - Thomas Bevan

2. Kinematics and Dynamics of Machinery- Robert L. Norton

3. Theory of Machines and Mechanisms- Shigley

4. Theory of Machines and Mechanisms-Ghosh & Mallik

5. Theory of Machines and Mechanisms- Rao & Dukkipati

6. Theory of Machines - S.S. Rattan

7. Theory of Machines – R.K. Bansal

8. Mechanics of Machines – V. Ramamurti

9. Theory of Machines – Khurmi & Gupta

REFRIGERATION & AIR-CONDITIONING (BME3602)

Course Objective:

1. To apply the laws of thermodynamics, heat and mass transfer to thermal energy systems

2. To apply the concepts of thermal energy systems to practical problems and finding solutions.

3. To arrive at a basic and holistic understanding of the design of refrigeration and air-conditioning systems.

4. To understand Refrigerant Equipment and its application.

Learning Outcome:

At the end of the course student should be able to:

1. Appreciate the application of the laws of thermodynamics in heat and mass transfer and operations of core thermal engineering systems like engines, compressors, refrigerators and air-conditioners.

2. Possess skills to distinguish the various types of ideal gas cycles, engine cycles, refrigeration cycles and power cycles and their engineering applications.

3. Possess engineering knowledge to arrive at basic innovative ideas on design and performance enhancements of heat and mass transfer systems like engines, compressors, refrigerator cycles and air-conditioning cycles.

4. Develop a full-fledged knowledge of thermal engineering systems and technical practices of energy efficiency improvement and Gain the ability to apply the concepts of heat engineering and applied thermodynamics to the computation of performance parameters of engines, compressors, refrigerators and air-conditioning cycles.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Refrigeration:** Introduction to refrigeration system, Methods of refrigeration, Carnot refrigeration cycle, Unit of refrigeration, Refrigeration effect & C.O.P. **Air Refrigeration cycle:** Open and closed air refrigeration cycles, Reversed	**30**	**1**

	Carnot cycle, Bell Coleman or Reversed Joule air refrigeration cycle, Aircraft refrigeration system, Classification of aircraft refrigeration system, Boot strap refrigeration, Regenerative, Reduced ambient, Dry air rated temperature (DART).		
II	**Vapour Compression System:** Single stage system, Analysis of Vapour compression cycle, Use of T-S and P-H charts, Factor Affecting the performance of vapour compression cycle-Effect of change in suction and discharge pressures on C.O.P, Effect of sub cooling of condensate & superheating of refrigerant Vapour on C. O. P of the cycle, Regenerative vapour compression system Actual vapor compression refrigeration cycle, Two stage vapour compression system requirement- Removal of flash gas, Intercooling, Cascade system. **Vapour Absorption system:** Working Principal of vapor absorption refrigeration system, Comparison between absorption & compression systems, Elementary idea of refrigerant absorbent mixtures, Ammonia – Water Vapour absorption system, Lithium- Bromide water Vapour absorption system, Comparison.	**30**	**1**
III	**Refrigerants:** Classification of refrigerants, Nomenclature, Desirable properties of refrigerants, Common refrigerants, Secondary refrigerants and CFC free refrigerants. **Air Conditioning:** **Psychometry:** Introduction to air conditioning, Psychometric properties and their definitions, Psychometric chart, Different Psychometric processes. **Human Comfort Condition:** Introduction, Thermal Exchange of body with Environment, Physiological Hazards Resulting from heat, Factor affecting Human Comfort Effective	**30**	**1**

	temperature and comfort chart.		
IV	**Air conditioning Design: -** Cooling and heating load calculations, Selection of inside & outside design conditions, Room Sensible Heat Factor (RSHF), Design of summer Air Conditioning: - summer Air Conditioning system with ventilation air (Zero bypass factor), summer Air Conditioning system with ventilation air (bypass factor X), Design of Winter Air Conditioning. **Refrigeration Equipment & Application:** Elementary knowledge of refrigeration & air conditioning equipment's e. g. compressors, Condensers, Evaporators & expansion devices, Cooling Tower, Food preservation, Cold storage, Refrigerates Freezers, Ice plant, Water coolers, Basic difference between comfort and industrial air conditioning.	**30**	**1**

Reference Books:

1. Refrigeration and Air conditioning, by Manohar Prasad, New Age International (P) Ltd. Pub.
2. Refrigeration and Air conditioning by C.P Arora.
3. Refrigeration and Air conditioning by Arora & Domkundwar.
4. Refrigeration and Air conditioning by Stoecker & Jones.
5. Refrigeration and Air conditioning by Roy J. Dossat.
6. Refrigeration and Air conditioning by P.L. Baloney.

ADVANCED WELDING TECHNOLOGY (BME3604)

Course Objective:

1. To understand the basic principles of various types of welding.
2. To know about the different types of advanced joining processes.
3. To understand metallurgy of welding defects and remedial measures for it.

Learning Outcome:

At the end of the course student should be able to:

1. Understand welding concepts.
2. Describe special welding techniques of laser beam, plasma arc, electron beam and plasma arc welding.
3. Select proper welding technique for the application.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Importance and application of welding, Classification of welding process, Selection of welding process. **Brief review of conventional welding process:** Gas welding, Arc welding, MIG, TIG welding, Resistance welding, Electroslag welding, Friction welding etc., Welding of MS, CI, Al, and stainless steel, Schaefflar diagram, Soldering & brazing.	**30**	**1**
II	**Advanced welding Techniques**: Principle, working and application of advanced welding techniques such as Plasma Arc welding, Laser beam welding, Electron beam welding, Ultrasonic welding, Explosive welding, Underwater welding, Cold Welding etc. **Weld Design:** Welding machines/equipment and its characteristics and arc-stability, Weld defects and distortion and its remedies, Inspection/testing of welds, Weld Design, Welding of pipe-lines and pressure vessels.	**30**	**1**
III	**Repair and Maintenance Welding:** Hard facing, Cladding, Surfacing and Metallizing Processes. **Thermal and Metallurgical consideration**: Thermal considerations for welding and Temperature distribution, Analytical/Empirical	**30**	**1**

	analysis/formulae, Heating & cooling curves, Metallurgical consideration of weld, HAZ and Parent metal, Micro & macro structure, Solidification of weld and properties.		

Reference Books:

1. Welding and Welding Technology, by – Richard L. Little, McGraw Hill Education.
2. Welding Principals and Practices, by- Edwards R. Bohnart, McGraw Hill Education.
3. Welding Engineering and Technology, by – R.S. Parmar, Khanna Publishers.
4. Welding Technology, by – O.P. Khanna, Dhanpat Rai Publication.

FLUID MACHINERY LAB (BME3653)

1. Impact of Jet experiment.
2. Turbine experiment on Pelton wheel.
3. Turbine experiment on Francis turbine.
4. Turbine experiment on Kaplan turbine.
5. Experiment on Reciprocating pump.
6. Experiment on centrifugal pump.
7. Experiment on Hydraulic Jack/Press.
8. Experiment on Hydraulic Brake.
9. Experiment on Hydraulic Ram.
10. Study through detailed visit of any water pumping station/plant.
11. Experiment on Compressor.
12. Experiment for measurement of drag and lift on aero foil in wind tunnel

Note:

1. At least ten experiments are to be performed in the semester.
2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus.

REFRIGERATION & AIR CONDITIONING LAB (BME3652)

1. To study of vapour compression refrigeration Test ring

2. To study different types of expansion devices used in refrigeration system.

3. To study different types of evaporators used in refrigeration systems.

4. To study basic components of air-conditioning system.

5. To study of air-conditioning test rig.

6. To study of Desert coolers.

7. Study of window air conditioner.

8. Study & determination of volumetric efficiency of compressor.

9. Visit of a central air conditioning plant and its detailed study.

10. To study of Ice-plant.

Note:

1. At least ten experiments are to be performed in the semester.
2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus.

THEORY OF MACHINES LAB (BME3651)

1. Study of simple linkage models/mechanisms.

2. Study of inversions of four bar linkage.

3. Study of inversions of single/double slider crank mechanisms.

4. Study of different types of brake.

5. Study of various types of clutch.

6. Experiment on gear trains.

7. Experiment on longitudinal vibration.

8. Experiment on transverse vibration.

9. Experiment on spring-controlled governor.

10. Experiments on dead weight type governor.

11. Experiment on gyroscope.

12. Experiment on static/dynamic balancing.

Note:

1. At least ten experiments are to be performed in the semester.

2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus

COMPUTER AIDED DESIGN (BME3701)

Course Objective:

1. To get aware with basic concept of Computer Aided Designing.
2. To acquire the skills needed for various types of Graphics & Transformations.
3. To understand the various methods involved in 2 Dimensional and 3-Dimensional Graphics.
4. To understand the various types of CAD models.

Learning Outcome:

At the end of the course student should be able to:

1. Develop various types of graphs and curves.
2. Apply the practical aspect of 2D & 3D Graphics.
3. Use the various types of Numerical methods for various types of practical applications.
4. To understand the basic modeling of Finite Element Method.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Introduction to CAD, Elements and essential requirements of CAD, Necessity & importance of CAD, Engineering Applications. **Computer Graphics-I:** CAD/CAM systems, Graphics Input devices-cursor control Devices, Digitizers, Keyboard terminals, Image scanner, Speech control devices and Touch panels, Random & Raster scan display, Direct View Storage Tubes, Flat Panel display, Hard copy printers and plotters. **Computer Graphics-II:** Graphics standards, Graphics Software, Graphics Functions, Output primitives- Bresenham's line drawing algorithm and Bresenham's circle generating algorithm.	**30**	**1**

	Geometric Transformations: World Coordinate Representation, Windowing and clipping, 2D Geometric transformations: Translation, Scaling, Shearing, Rotation & Reflection Matrix representation, Composite transformation, 3D transformations.		
II	**Curves:** Curves representation, Properties of curve design and representation, Interpolation vs. approximation, Parametric representation of analytic curves, Parametric continuity conditions, Parametric representation of analytic and synthetic curves, B-Spline curves and its properties. Hermite cubic Splines: Blending function formulation and its Properties, Bezier curves: Blending function formulation and its properties, Composite Bezier curves.	**30**	**1**
III	**Three-Dimensional Graphics:** Polygon surfaces-Polygon mesh representations, Quadric and Superquadric surfaces and blobby objects, Solid Modeling-Solid entities, Fundamentals of Solid modeling: Set theory, Regularized set operations, half spaces, Boundary representation, Constructive solid geometry, Sweep representation, Color models, Application commands for AutoCAD.	**30**	**1**
IV	**Numerical Methods:** Introduction, Root finding Bisection method, Newton Raphson method, Curve Fitting-Least square method, Numerical differentiation-Newton's interpolation, Numerical Integration-Trapezoidal and Simpson's 1/3 and 3/8 method. **Finite Element Method:** Introduction, Principles of Finite elements modeling, Stiffness matrix/displacement matrix, Stiffness matrix for spring system, Bar & beam elements, Bar elements in 2D space (truss element).	**30**	**1**

Reference Books:

1. CAD/CAM Theory and Practice, Ibrahim Zeid & R Sivasubramaniam, McGraw Hill.

2. C. Mcmohan and J. Browne, CAD/CAM Principles, II edition, Pearson Education, 1999.

3. W.M. Neumann and R.F. Sproul, Principles of Computer Graphics, McGraw Hill, 1989.

4. Computer Graphics, Hearn & Baker, Prentice Hall of India.

5. Computer Aided Engineering Design, Anupam Saxena & B. Sahay, Anamaya Publishers

AUTOMOBILE ENGINEERING (BME3702)

Course Objective:

1. To have the knowledge of elementary components of an automobile.
2. To know about the various mechanisms of an automobile.
3. To get the knowledge of various properties, which are suitable for its different types of components.
4. To know about fuel supply system & electrical system.
5. To control the emission of unburnt hydrocarbon from the engine.

Learning Outcome:

At the end of the course student should be able to:

1. Select the various components according to the requirement of an automobile.
2. Have the knowledge of various types of ratio`s and angles which are involved in an automobile.
3. Latest technologies which are used in automobile sector.
4. Can develop new types of electrical system which are more energy efficient.
5. Control the emission from the engines.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Power Unit and Gear Box:** Principles of Design of main components, Valve mechanism, Power and Torque characteristics, Rolling, air and gradient resistance, Tractive effort, Gear Box, Gear ratio determination, Design of Gear box: Manual and automatic shift mechanisms, Turbo Charger.	**30**	**1**
II	**Transmission System:** Requirements. Clutches, Torque converters, Over Drive and free wheel, Universal joint, Differential Gear Mechanism of Rear Axle, Automatic transmission, Steering and Front Axle. Castor Angle, Wheel camber & Toe-in, Toe-out etc., Steering geometry, Power steering system. Ackerman mechanism, Under-steer and Over-	**30**	**1**

	steer.		
III	**Braking System:** General requirements, Road tyre adhesion, Weight transfer, Braking ratio, Mechanical brakes, Hydraulic brakes, Vacuum and air brakes, Thermal aspects, Anti-lock braking system (ABS), Electronic brake force distribution (EBD), Traction control. **Chassis and Suspension System:** Loads on the frame, Strength and stiffness, Various suspension systems.	**30**	**1**
IV	**Electrical System:** Types of starting motors, Generator & regulators, Lighting system, Ignition system, Horn, Battery etc. **Fuel Supply System & Emission control:** Diesel & Petrol vehicle system such as Fuel Injection Pump, Injector & Fuel Pump, Carburetor etc. MPFI, Engine emission control by 3-way catalytic converter system, Emission Norms (Euro & BS), Introduction to electric vehicles.	**30**	**1**

Reference Books:

1. Kirpal Singh, Automobile Engineering, 7th ed., Standard Publishers, New Delhi, 1997.

2. Jain K.K. and Asthana R.B., Automobile Engineering, Tata McGraw Hill, New Delhi,

2002.

3. Heitner J., Automotive Mechanics, 2nd ed., East-West Press, 1999.

4. Heisler H., Advanced Engine Technology, SAE International Publ., USA, 1998.

CAD/CAM LAB (BME2751)

Total TEN Experiments are to carried out. FIVE Experiments each from CAD and CAM.

A. CAD Experiments:

1. Line Drawing or Circle Drawing experiment: Writing and validation of computer program.
2. Geometric Transformation algorithm experiment for translation/rotation/scaling: Writing and validation of computer program.
3. Design of machine component or other system experiment: Writing and validation of computer program.
4. Understanding and use of any 3-D Modeling Software commands.
5. Pro/E/Idea etc. Experiment: Solid modeling of a machine component.
6. Writing a small program for FEM for 2 spring system and validation of program or using a FEM Package.
7. Root findings or curve fitting experiment: Writing and validation of computer program.
8. Numerical differentiation or numerical integration experiment: Writing and validation of compute program.

B. CAM Experiments:

1. To study the characteristic features of CNC machine.
2. Part Programming (in word address format) experiment for turning operation (including operations such as grooving and threading) and running on CNC machine.
3. Part Programming (in word address format or ATP) experiment for drilling operation (point to point) and running on CNC machine.
4. Part Programming (in word address format or ATP) experiment for milling operation (contouring) and running on CNC machine.
5. Experiment on Robot and programs.
6. Experiment on Transfer line/Material handling.
7. Experiment on difference between ordinary and NC machine, study or retrofitting.
8. Experiment on study of system devices such as motors and feedback devices.
9. Experiment on Mechatronics and controls.

Note:

1. At least ten experiments are to be performed in the semester.
2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus.

AUTOMOBILE LAB (BME3752)

1. Study & experiment on Gear Box
2. Study & experiment on Valve mechanism.
3. Study & experiment on Differential Gear Mechanism of Rear Axle.
4. Study & experiment on Steering Mechanism.
5. Study & experiment on Automobile Braking System.
6. Study & experiment on Chassis and Suspension System.
7. Study & experiment on Ignition system of I.C. Engine.
8. Study & experiment on Fuel Supply System of S.I. Engines- Carburetor, Fuel Injection Pump and MPFI.
9. Study & experiment on Fuel Supply System of C.I. Engines- Injector & Fuel Pump.
10. Study & experiment on Air Conditioning System of an Automobile.
11. Comparative study of technical specifications of common small cars (such as Maruti Swift, Hyundai i20, Chevrolet Aveo, Tata Indica, Ford Fusion etc.
12. Comparative study & technical features of common scooters & motorcycles available in India.
13. Experiment on Engine Tuning
14. Experiment on Exhaust Gas Analysis of an I.C. Engine.

Note:

1. At least ten experiments are to be performed in the semester.
2. At least eight experiments should be performed from the above list.

Remaining two experiments may either be performed from the above list or designed & set by the concern faculty as per the scope of the syllabus.

POWER PLANT ENGINEERING (BME3801)

Course Objective:

1. To have the basic knowledge of various types of loads and also of economics of a power plant.
2. To know about the various basic components of steam power plant.
3. To get the knowledge of diesel power plant, Gas turbine power plant & Nuclear power plant.

Learning Outcome:

At the end of the course student should be able to:

1. To calculate the various types of loads and can calculate the cost of electricity per unit as produced from power plant.
2. Have the knowledge of type of component used for a particular type of application.
3. Develop the new methods by which overall efficiency of plant can increase**.**

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Power and energy, sources of energy, Review of thermodynamic cycles related to power plants, Fuels and combustion calculations, Load estimation, load curves, Various terms and factors involved in power plant calculations, Effect of variable load on power plant operation, Selection of power plant units, Effect of plant type on costs, rates, Fixed elements, Energy elements, customer elements and investor's profit, Depreciation and replacement, Theory of rates, Economics of plan selection.	**30**	**1**
II	**Steam power plant:** General layout of steam power plant, Power plant boilers including critical and super critical boilers, Fluidized bed boilers, Different systems such as coal handling system, Pulverizers and coal burners, Combustion system, draft, ash handling system, Dust collection system, Feed water treatment, cooling towers and cooling ponds, Turbine auxiliary systems such as Flange heating	**30**	**1**

	and gland leakage, Operation and maintenance of steam power plant, Site selection of a steam power plant.		
III	**Diesel power plant:** General layout, Components of Diesel power plant, Performance of diesel power plant, Fuel system, Lubrication system, Air intake and admission system, Supercharging system, Exhaust system, Diesel plant operation and efficiency, Heat balance, Sites election of diesel power plant, Comparative study of diesel power plant with steam Power plant.	**30**	**1**
IV	**Gas turbine power plant:** Layout of gas turbine power plant, Elements of gas turbine power plants, Gas turbine fuels, Cogeneration, Auxiliary systems such as fuel, Controls and lubrication, Operation and maintenance, Combined cycle power plants, Site selection of gas turbine power plant. **Nuclear power plant:** Principles of nuclear energy, Lay out of nuclear power plant, Basic components of nuclear reactions, Nuclear power station, Nuclear waste disposal, Site selection of nuclear power plants.	**30**	**1**

Reference Books:

1. "Power Plant Engineering" F.T. Morse, Affiliated East-West Press Pvt. Ltd, New Delhi/Madras.
2. "Power Plant Engineering" Mahesh Verma, Metropolitan Book Company Pvt. Ltd. New Delhi.
3. "Power Plant Technology" El-Vakil, McGraw Hill.
4. Power Plant Engineering by P.K. Nag, Tata McGraw Hill.
5. Steam & Gas Turbines & Power Plant Engineering by R. Yadav, Central Pub. House.

FLUID MACHINERY (GE33511)

Course Objective:

1. To familiarize student with Classification of fluid machines, devices and turbines.

2. To make aware students of different types of turbines and pumps with their working principles.

3. To make aware students of Positive Displacement Pumps and their types.

4. To teach them the basics and principle working of other fluid machinery.

Learning Outcome:

At the end of the course student should be able to:

1. Demonstration of hydraulic and reaction turbines with their classification.

2. Demonstration of Centrifugal of pumps.

3. Demonstration of Positive Displacement pumps.

4. Demonstration of different fluid-based machineries.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Classification of Fluid Machines & Devices, Application of momentum and momentum equation to flow through hydraulic machinery, Euler's fundamental equation, Impact of jet: Introduction to hydrodynamic thrust of jet on a fixed and moving surface (flat & curve), Effect of inclination of jet with the surface. **Hydraulic Turbines:** Classification of turbines, Impulse turbines, Constructional details, Velocity triangles, Power and efficiency calculations, Governing of Pelton wheel. **Reaction Turbines:** Francis and Kaplan turbines, Constructional details, Velocity triangles, Power and efficiency calculations, Degree of reaction, Draft tube, Cavitation in turbines, Principles of similarity, Unit and specific speed,	**30**	**1**

	Performance characteristics, Selection of water turbines.		
II	**Centrifugal Pumps**: Classifications of centrifugal pumps, Vector diagram, Work done by impellor, Efficiencies of centrifugal pumps, Specific speed, Model testing, Cavitation & separation and their control, Performance characteristics.	**30**	**1**
III	**Positive Displacement Pumps**: Reciprocating pump theory, Slip and coefficient of discharge, Indicator diagram, Effect and acceleration, Work saved by fitting air vessels, Comparison of centrifugal and reciprocating pumps, Positive rotary pumps, Gear and Vane pumps, Performance characteristics.	**30**	**1**
IV	**Other Machines:** Hydraulic accumulator, Special duty pumps, Intensifier, Hydraulic press, Lift and cranes, Theory of hydraulic coupling and torque converters, Performance characteristics, Water Lifting Devices: Hydraulic ram, Jet pumps, Air lift pumps.	**30**	**1**

Reference Books:

1. Hydraulic Machines by JagdishLal, Metropolitan book co. Pvt ltd.

2. Hydraulic Machines: Theory & Design, V.P. Vasandhani, Khanna Pub.

3. Applied Hydraulics by Addison.

4. Hydraulic Machines by R K Rajput, S. Chand& co Ltd.

5. Hydraulic Machines by D S Kumar.

UNCONVENTIONALMANUFACTURINGPROCESSES (GE33512)

Course Objective:

1. To teach the principles of material removal mechanism of advanced machining processes such as mechanical, electro-chemical and thermal.

2. To provide in depth knowledge in selection of advanced machining process to fabricate intricate and complex shapes in difficult to machine material.

3. To provide awareness of advanced finishing processes to achieve submicron/Nano surface finish.

4. To teach the principles of EBM, EDM and High Explosive Forming.

Learning Outcome:

At the end of the course student should be able to:

1. Identify and suggest the suitable manufacturing process for advanced materials and critical finishing.

2. Select a process for a given application such as IBM, EBM, PAM etc.

3. Learn the basic principle of Unconventional Welding Process.

4. Select Right path to achieve Unconventional Forming Process.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Limitations of conventional manufacturing processes Need of unconventional manufacturing processes & its classification and its future possibilities. **Unconventional Machining Process:** Principle and working and applications of unconventional machining process such as Electro-Discharge machining, Electro-chemical machining, Ultrasonic machining, Abrasive jet machining etc.	**30**	**1**
II	**Unconventional Machining Process (continued):**	**30**	**1**

	Principle and working and application of unconventional machining processes such as Laser beam machining, Electron beam machining, Ultrasonic machining etc.		
III	**Unconventional welding processes:** Explosive welding, Cladding, under water welding, Metalizing, Plasma are welding/cutting etc.	**30**	**1**
IV	**Unconventional Forming processes:** Principle. Working and applications of High energy forming processes such as Explosive Forming, Electromagnetic forming, Electro-Discharge forming, Water hammer forming. **Electronic-device Manufacturing:** Brief description of Diffusion and Photo-Lithography process for electronic-device manufacturing.	**30**	**1**

Reference Books:

1. Modern Machining Processes – P.C. Pandey.

2. Unconventional Machining – V.K. Jain.

PRODUCT DEVELOPMENT AND DESIGN (GE33513)

Course Objective:

1. To acquire skills to design and develop products in a structured way.

2. To get aware with general design principles for manufacturability.

3. To understand the incorporation of ergonomics in product design.

4. To understand the various methods and techniques used for product appraisal.

Learning Outcome:

At the end of the course student should be able to:

1. Explain product development process and review design of existing product.

2. Incorporate the ergonomics into the product design.

3. Explain product development process considering Reliability.

4. Explain Product appraisal methods.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction to Product Design:** Introduction to PDD, Applications, Relevance, Product Definition, Scope, Terminology, Design definitions, the role and nature of design, Old and new design methods, Design by evolution, examples such evolution of bicycle, Safety razor etc., Need based development, Technology based developments, Physical reliability & Economic feasibility of design concepts.	**30**	**1**
II	**Morphology of Design:** Divergent, Transformation and convergent phases of product design, Identification of need, Analysis of need, Design criteria, Functional aspects, Aesthetics, Ergonomics, Form (structure), Shape, Size, Color, Mental blocks, Removal of blocks, Ideation Techniques, Creativity, Checklist.	**30**	**1**

III	**Transformations:** Brainstorming & Synectics, Morphological techniques, Utility concept, Utility value, Decision making under multiple criteria, Economic aspects of design, Fixed and variable costs, Break-even analysis. **Reliability:** Reliability considerations, Bath tub curve, Reliability of systems in series and parallel, Failure rate, MTTF and MTBF, Optimum spares from reliability consideration, Design of displays and controls, Man-Machine interface, Compatibility of displays and controls, Ergonomic aspects, Anthropometric data and its importance in design, Applications of Computers in product design.	**30**	**1**
IV	**Product Appraisal:** Information and literature search, Patents, Standards and codes, Environment and safety considerations, Existing techniques such as work-study, Sqc etc., Innovation versus invention, Technological forecasting.	**30**	**1**

Reference Books:

1. Product Design & Manufacturing - A.K. Chitab & R.C. Gupta, PHI (EEE).

2. The Technology of Creation Thinking - R.P. Crewford – Prentice Hall.

3. The Art of Thought – Grohem Walls – Bruce & Co., New York.

4. Product Design & Decision Theory - M.K. Starr - Prentice Hall.

5. Engineering Product Design -C.D. Cain, Business Books.

6. Industrial design for Engineers –W.H. Mayall, Itiffe.

7. Design Methods – seeds of human futures – J. Christopher Jones, John Wiley & Sons.

8. Human Factor Engineering – Mccormick E.J., McGrawHill.

9. Engineering: An Introduction to Creative profession – G.C. Beakley HW leach, Macmillan.

10. Industrial Design in Engineering – A marriage of Techniques – Charles H. Flurscheim,

11. Design Council - London.

CONCURRENT ENGINEERING (GE33514)

Course Objective:

Purpose to study the principles of concurrent engineering and its implementation.

Learning Outcome:

At the end of the course student should be able to:

1. To familiarize with the basics of concurrent engineering
2. The tools and methodologies available in CE
3. Various approaches to CE
4. The other related aspects of CE

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Introduction to Concurrent Engineering – Definitions - Historical Background – Goals of CE - need for CE – Development process with CE Role of CAD/CAM in CE – Product life cycle.	**30**	**1**
II	**Concurrent engineering tools:** Concurrent Engineering Tools & Techniques – Quality function Deployment – Value function analysis – Failure Mode & Effect Analysis – Design for Manufacture & Assembly – Design for X – Taguchi's Robust Design approach – Pugh process – customer Focused Design – rapid prototyping – simulation.	**30**	**1**
III	**Implementation of concurrent engineering:** Implementing CE in an organization – concurrent Engineering Teams – their roles and responsibilities Organizational functions to support CE team environment. Setting Team goals, measuring performance of team &managing a CE Team, Limitations of team.	**30**	**1**
IV	**Concurrent approaches to design and manufacture other aspects of engineering:** Design for manufacture & Assembly – Design for economics – Design for X – Product Data Management – Agile manufacturing – rapid prototyping& simulation. Introduction Design, development & management for JIT – Implementation of JIT, supply product Life cycle management – Project time management – Techniques of time management.	**30**	**1**

	Collaborative product commerce simple case studies in CE.		

References:

1. Thomas A. “Concurrent Engineering”, Salomone, Maarcel Dekker Inc. New York, 1995.
2. Moustapha. I “Concurrent Engineering in product Design Development” New Age International (p) Ltd., 2003.
3. Prasad, “Concurrent Engineering fundamentals - Integrated Product Development”, Prentice Hall, 1996.
4. Sammy G. Sinha, “Successful implementation of concurrent product & process”, Wiley, John &Sons, Inc., 1998.
5. Anderson M.M. & Hein L. Berlin, “Integrated Product Development”, Springer Verlog, 1987.

RELIABILITY ENGINEERING (GE33521)

Course Objective:

1. To enable the students, understand the reliability mathematics.
2. To provide students details of methods of reliability improvement.
3. To acquire skills to develop the reliability testing techniques.
4. To provide students an understanding of methods of reliability evaluation.

Learning Outcome:

At the end of the course student should be able to:

1. Apply the knowledge of mathematics and engineering to solve problems by approximate and numerical methods.

2. Demonstrate an understanding of the concepts of reliability improvement.

3. Conduct various analysis of reliability testing.

4. Explain reliability system and can develop logic diagram.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Definition of reliability, Types of failures, Definition and factors influencing system effectiveness, Various parameters of system effectiveness. **Reliability Mathematics:** Definition of probability, Laws of probability, Conditional probability, Bay's theorem, Various distributions: Data collection, Recovery of data, Data analysis Procedures, Empirical reliability calculations	30	1
II	**Reliability:** Types of system-Series, Parallel, series parallel, stand by and complex, Development of logic diagram, Methods of reliability evaluation, cut set and tie set methods, Matrix methods event trees and fault trees methods, Reliability evaluation using probability distributions, Markov method, Frequency and duration method.	30	1

III	**Reliability Improvements:** Methods of reliability improvement, Component redundancy, System redundancy, Types of redundancies- Series, Parallel, series parallel, Stand by and hybrid, Effect of maintenance.	**30**	**1**
IV	**Reliability Testing:** Life testing, Requirements, Methods, Test planning, Data reporting system, Data reduction and analysis, Reliability test standards.	**30**	**1**

Reference Books:

1. R. Billintan& R.N. Allan, “Reliability Evaluation of Engineering and Systems", Plenum Press.
2. K.C. Kapoor& L.R. Lamberson, “Reliabilityin Engineering and Design", John Wiely and Sons.
3. S.K. Sinha& B.K. Kale, “Life Testing and Reliability Estimation", Wiely Eastern Ltd.
4. M.L. Shooman, "Probabilistic Reliability, An Engineering Approach", McGrawHill.
5. G.H. Sandler, “System Reliability Engineering", Prentice Hall.

NON-DESTRUCTIVE TESTING (GE33522)

Course Objective:

1. To have knowledge of different types of Non-Destructive testing techniques.
2. To understand the various types of Non-Destructive testing techniques.
3. To get an idea about Radiographic methods.
4. To know about Ultrasonic testing methods.

Learning Outcome:

At the end of the course student should be able to:

1. Know the importance of different types of Non-Destructive Testing techniques.
2. Have an idea of new types of Non-Destructive Testing techniques which can be developed in near future.
3. To have knowledge about latest technology in Radiography.
4. To have knowledge about applications of Ultrasonic.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Scope and advantages of NDT, Comparison of NDT with DT, some common NDT methods used since ages, Terminology. Flaws and Defects, Visual inspection, Equipment used for visual inspection, Ringing test chalk test (oil whitening test), Attractive uses of above tests in detecting surface cracks, Bond strength & surface defects. **Die penetrate test:** Liquid penetrate inspection, Principle, scope, Equipment & techniques, Tests stations, Advantages, types of penetrant and developers, Illustrative examples –Heavy casting of large size, Frame of jet engine, Porosity testing of nickel, Leak testing. Zyglo test.	**30**	**1**
II	**Magnetic particle Inspection:** Scope, Principle, Ferro magnetic and non-Ferro magnetic materials, Equipment & testing, Advantages, limitations, Interpretations of results, DC & AC magnetization, Skin Effect, use of dye & wet powders for magna glow, Different methods to generate magnetic fields,	**30**	**1**

	Applications.		
III	**Radiographic methods:** X-ray radiography principle, Equipment & methodology, Applicability, Types of radiations, Limitations. Interpretation of Radiographs, Limitations of γ-ray radiography – principle, Attenuation of electromagnetic radiations, Sources of radioactive materials & technique, Photo electric effect, Rayleigh's scattering (coherent scattering), Compton`s scattering (Incoherent scattering), Pair production, Beam geometry, Scattering factor, Advantages of γ-ray radiography over X-ray radiography, Precautions against radiation hazards, Case Study ─ X-ray of human body.	**30**	**1**
IV	**Ultrasonic testing methods:** Introduction, Principle of operation, Piezoelectricity, Ultrasonic probes, CRO Techniques, Advantages, Limitation & typical applications, Applications in inspection of castings, Forgings, Extruded steel parts, Bars, Pipes, Rails and dimensions measurements, Case Study- Ultrasonography of human body. **Eddy Current Inspection:** Principle, Methods, Advantages, Scope and limitations, Types of Probes, Case Studies.	**30**	**1**

Reference Books:

1. ASM Handbook Vol. 11, 8th Edition – Non-destructive Testing & Evaluation.
2. Research Techniques in NDT Vol.3, R.S. Shah, Academic.
3. Industrial Quality Control, Webstar.
4. Bray, Don E. and Stanley, Roderic K., Nondestructive Evaluation: A Tool in Design, Manufacturing, and Service. Revised Edition 1997, CRC Press New York

DESIGN OF THERMAL SYSTEMS (GE33523)

Course Objective:

1. To apply the laws of thermodynamics, heat and mass transfer to thermal energy systems.
2. To apply the concepts of thermal energy systems to practical problems and finding solutions.
3. To arrive at a basic and holistic understanding of the design of refrigeration and air-conditioning systems.
4. To understand the basic principles of design of turbo machines and heat exchangers.

Learning Outcome:

At the end of the course student should be able to:

1. Appreciate the application of the laws of thermodynamics in heat and mass transfer and operations of core thermal engineering systems like engines, compressors, refrigerators and air-conditioners.
2. Possess skills to distinguish the various types of ideal gas cycles, engine cycles, refrigeration cycles and power cycles and their engineering applications.
3. Possess engineering knowledge to arrive at basic innovative ideas on design and performance enhancements of heat and mass transfer systems like engines, compressors, refrigerator cycles and air-conditioning cycles.
3. Develop a full-fledged knowledge of thermal engineering systems and technical practices of energy efficiency improvement.
4. Gain the ability to apply the concepts of heat engineering and applied thermodynamics to the computation of performance parameters of engines, compressors, refrigerators and air-conditioning cycles.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Psychrometry of Air Conditioning Processes, Design Conditions & Load Calculations Psychrometric, Processes in Air Conditioning Equipment's, Analysis of Air Conditioning systems for summer & winter conditions, Inside & outside design conditions for comfort, Industrial Air Conditioning.	**30**	**1**

	Cooling & Heating Load calculations: Heat transfer through building structures, Solar heat gain, Internal heat gain, Occupancy & Product load, Room sensible heat factor, Effective sensible heat factor & Grand sensible heat factor, Capacity of the plant.		
II	**Design & Selection of Airconditioning Apparatus:** Heat & moisture transfer in Air conditioning apparatus, Enthalpy potential, Analysis of Coil & Spray Equipment's Design of Cooling & Dehumidifying coils, Design of Air Washer & Cooling Towers. **Analysis of Complete Vapour Compression System:** Design and Balancing of System Components, Type of Refrigerant Compressors, Condensers, Evaporators & Expansion devices used in Vapour Compression Refrigeration Cycles, Designand Selection of individual components and their performance characteristics, Use of P-H charts for different Refrigerants in performance predication of the cycle, Analysis of the complete vapour-compression system and determination of' Balance Points using Graphical and Analytical methods, System simulation, Layout & selection of Refrigerant, Water and Brine pipings for the designed system, Selection of Refrigeration and Airconditioning Controls for the system.	**30**	**1**
III	**Design of Turbo machines:** Principles of Design of turbomachines, Design of axial flow turbine stage, Design of axial flow compressor stage, Design of centrifugal compressor. **Design of Heat Exchanger:** Study of design aspects, Fluid flow and heat transfer characteristics, Material requirement of heat exchange equipments, Liquid to liquid and Liquid to gas heat exchange systems, Familiarity with use of design related standards and codes, Design of Heat exchanger.	**30**	**1**

IV	**Design of Thermal System:** Optimization of design of thermal systems like condenser, evaporator, cooling tower for minimum cost and maximum performance, Development of computer program for design, Environmental consideration in design of thermal systems, Analysis of thermal systems using FEM.	**30**	**1**

Reference Books:

1. Refrigeration& Air Conditioning - By C.P. Arora.
2. Refrigeration& Air Conditioning - By Manohar Prasad.
3. Principles of Refrigeration (S.I. Units) –By Roy J. Dossat.
4. Air Conditioning Engineering – By P. Jones.
5. Ventilating and Air Conditioning- By McQuistion, Parker &Spitler.
6. Refrigeration& Air Conditioning Data Book – Manohar Prasad.
7. ASHRAE handbook – Fundamentals.
8. Refrigeration& Air Conditioning-Stoecker& Jones.
9. Refrigeration& Air conditioning – By P.L. Ballaney.

DESIGN FOR MANUFACTURING (GE33524)

Course Objective:

Purpose is to study how a design can be made suitable for various manufacturing processes.

Learning Outcome:

At the end of the course student should be able to:

1. To study the various factors influencing the manufacturability of components
2. To study the use of tolerances in manufacturing
3. Application of this study to machining and casting processes

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Introduction General design principles for manufacturability –strength and mechanical factor, mechanisms selection, evaluation method, Process capability – Feature tolerances – Geometric tolerances – Assembly limits – Datum features – Tolerance stacks.	**30**	**1**
II	**Factors Influencing Form Design:** Working principle, Material, Design – Possible solutions – Materials choice – Influence of materials on from design – from design of welded members, forgings and castings.	**30**	**1**
III	**Component Design – Machining Consideration**: Design of features to facilitate machining – drills – milling cutters – keyways – Doweling procedures, counter sunk screws – Reduction on machined area – simplification by separation – simplification by amalgamation – Design for assembly.	**30**	**1**
IV	**Component Design – Casting Considerations:** Redesign of castings based on parting line considerations – Minimizing core requirements, machined holes and redesign of cast members to obviate cores.	**30**	**1**

References:

1. Harry Peck, “Design for Manufacture”, Pittman Publication 1983.
2. Robert Matousek, “Engineering Design – A systematic approach”, Blackie & sons Ltd., 1963.
3. James G. Bralla, “Hand Book of Product Design for Manufacturing”, McGraw Hill Co., 1986

4. Swift K. G. “Knowledge based design for manufacture”, Kogan Page Ltd., 1987.

MECHANICAL VIBRATIONS (GE33531)

Course Objective:

1. To learn the basics of vibrations including causes and effects of vibrations.
2. To study the undamped and damped free vibration.
3. To study the forced vibrations and vibration measuring instrument.
4. To study multi degrees of freedom system.

Learning Outcome:

At the end of the course student should be able to:

1. Write differential equation of the given vibration model.
2. Calculate the frequencies of free or natural, damped and forced vibrations.
3. Find the response of a vibrating system.
4. Calculate the natural frequencies and mode shapes of multi degrees of freedom systems.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Periodic motion, Harmonic motion, Superposition of simple harmonic motions, Beats, Fourier analysis. **Single Degree Freedom System:** Free vibration, Natural frequency, Equivalent systems, Energy method for determining natural frequency, Response to an initial disturbance, Torsional vibrations, Damped vibrations, Vibrations of systems with viscous damping, Logarithmic decrement.	**30**	**1**
II	**Single Degree Freedom: Forced Vibration:** Harmonic excitation with viscous damping, Steady state vibrations, forced vibrations with rotating and reciprocating unbalance, support excitation, Vibration isolation, Transmissibility, Vibration measuring instruments, Displacement, velocity and acceleration measuring instruments.	**30**	**1**

III	**Two Degree Freedom systems:** Introduction, Principal modes, Double pendulum, Torsional system with damping, Coupled system, Undamped dynamic vibration absorbers, Centrifugal pendulum absorbers, Dry friction damper.	**30**	**1**
IV	**Multi Degree Freedom system: Exact Analysis:** Undamped free and forced vibrations of multi-degree freedom systems, Influence number, Reciprocal theorem, Torsional vibration of multi-degree rotor system, Vibration of gear system, Principal coordinates, Continuous systems- Longitudinal vibrations of bars, Torsional vibrations of circular shafts. **Multi Degree Freedom system: Numerical Analysis:** Rayleigh's methods, Dunkerely's methods, Holzer's ad Stodola methods, Rayleigh-Ritz method. **Critical speed of shafts:** Shaft with one disc with and without damping, Multi-disc shafts, Secondary critical speed.	**30**	**1**

Reference Books:

1. William T. Thomson, Theory of vibration with applications, 5th Edition, Pearson Education India.
2. R V Dukkipati, Advanced Mechanical Vibrations, Alpha Science.
3. G K Grover, Mechanical Vibrations, Nem Chand & Bros. Roorkee.

OPERATIONS RESEARCH (GE33532)

Course Objective:

1. To provide students the knowledge of optimization techniques and approaches.
2. To enable the students apply mathematical, computational and communication skills needed for the practical utility of Operations Research.
3. To introduce students to research methods and current trends in Operations Research.
4. To develop project management techniques using various theories.

Learning Outcome:

At the end of the course student should be able to:

1. Apply operations research techniques in industrial optimization problems.
2. Solve transportation problems using various OR methods.
3. Illustrate the use of OR tools in a wide range of applications in industries.
4. Explain current topics and advanced techniques of Operations Research for industrial solutions.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Basics of Operations Research. **Linear Programming:** Introduction & Scope, Problem formulation, Graphical Method, Simplex methods, Primal & dual problem sensitivity analysis.	**30**	**1**
II	**Transportation & Assignment problems.** **Deterministic Dynamic Programming:** Multistage decision problems & solution, Principle of optimality. **Decision theory:** Decision under various conditions. **Game Theory:** Two Person Zero sum game, Solution with / without	**30**	**1**

	Saddle point, Dominance Rule, Different Methods like Algebraic, Graphical, Liner Programming.		
III	**Sequencing:** Basic assumption, n Jobs through two / three machines, 2 Jobs on m machines. **Stochastic inventory models:** Single & multi period models with continuous & discrete demands, Service level & reorder policy. **Simulations:** Use, advantages & limitations, Monte-carlo simulation, Application to queuing, Inventory & other problems.	**30**	**1**
IV	**Queuing models:** Characteristics of Queuing Model, M/M/1 & M/M/S system, Cost consideration. **Project Management:** Basic concept, Rules for drawing the network diagram, Applications of CPM and PERT techniques in Project planning and control, Crashing of operations, Resource allocation.	**30**	**1**

Reference Books:

1. Operations Research by: Wangner.

2. Operations Research by: Taha.

3. Introduction to Management Science by: Hiller & Hiller.

4. Operations Research by: Wayne L. Winston.

MAINTENANCE ENGINEERING & MANAGEMENT (GE33533)

Course Objective:

1. To acquire skills to develop maintenance strategies.
2. To get aware with general maintenance engineering & management principles.
3. To understand about the different types of maintenance planning models.
4. To know about maintenance management and economics of management.

Learning Outcome:

At the end of the course student should be able to:

1. Explain maintenance engineering & management process and review strategies of existing product considering reliability.
2. Develop models according to requirement of product.
3. Incorporate the ergonomics into the maintenance engineering.
4. Develop production maintenance system and planning.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Operating lifecycle, Reliability, Failure data analysis, Failure rate curve, Hazard models, Elements in series, parallel & mix, Logic diagrams, improving reliability, Redundancy-element, unit, standby, Maintainability, Availability, reliability and maintainability trade off.	**30**	**1**
II	**Maintenance Strategies:** Break down maintenance, Planned maintenance, Preventive maintenance, design out maintenance, Planned lubrication, Total productive maintenance, zero breakdown, Preventive inspection of equipment used in emergency.	**30**	**1**
III	Replacement planning maintain or replace decision, Replacement of items that deteriorate identical equipment, Replacement of items that fail without deterioration individual, Group replacement,	**30**	**1**

	Replacement in anticipation of failure.		
IV	Break down maintenance planning, Assignment model, waiting time models expected waiting time, Minimum cost service rate., PERT, Maintenance Management, Production maintenance system, Objectives and functions: forms, policy, planning, organization, Economics of maintenance, Man power planning, Materials planning, Spare parts planning and control, Evaluation of maintenance management, Introduction to online maintenance record.	**30**	**1**

Reference Books:

1. Management of systems – R.N. Nauhria& R. Prakash.

2. Operations Research –Wangner.

INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS (GE33534)

Course Objective:

Purpose to study the components of Industrial robotics and Expert systems.

Learning Outcome:

At the end of the course student should be able to:

1. Basics about Robotics and Robot manipulation in space.
2. The controlling of Robots and devices system.
3. Sensor technology
4. Robot programming and Expert system.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction and Robotic Kinematics:** Definition need and scope of industrial robots – Robot anatomy – work volume – Precision movement – End effectors – sensors. Robot kinematics – Direct and inverse kinematics – Robot trajectories – Control of robot manipulators – Robot dynamics – Methods for orientation and location of objects.	**30**	**1**
II	**Robot Drives and Control:** Controlling the robot motion – Position and velocity sensing devices – Design of drive systems – Hydraulic and Pneumatic drives – Linear and rotary actuators and control valves –Electro hydraulic servo valves, electric drives – Motors – designing of end effectors – Vacuum, magnetic and air operated grippers.	**30**	**1**
III	**Robot Sensors:** Transducers and sensors – Sensors in robot – Tactile sensor – Proximity and range sensors – Sensing joint forces – Robotic vision system – Image processing and analysis – Image segmentation – Pattern recognition – Training of vision system.	**30**	**1**
IV	**Robot Cell Design and Application Robot Programming, Artificial Intelligence and Expert Systems:** Robot work cell design and control – Safety in Robotics – Robot cell layouts – Multiple robots and machine interference – Robot cycle time analysis – Industrial applications of robots. Methods of robot programming. Artificial intelligence – Basics – Goals	**30**	**1**

	of artificial intelligence – AL and KBES in robots.		

References:

1. Fu. K.S., Gonzalez R. and Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence" McGraw hill, 1987.
2. Kozyrey, Yu. "Industrial Robotics" MIR Publishers Moscow, 1985.
3. Richar. D., Klafter, Thomas, A, Chmielewski, Michale Negin "Robotics Engineering – An Integrated Approach", Prentice Hall of India Pvt., Ltd., 1984.
4. Deb, S.R. "Robotics Technology and Flexible Automation", Tata Mc Graw Hill, 1994.
5. Mikell, P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas G. Odrey "Industrial Robotics Technology, Programming and Applications", Mc Graw Hill, Int., 1986. 6. Timothy Jordonides et.al, "Expert Systems and Robotics", Springer – Verlag, New York, May 1991.

ADVANCED SYNTHESIS OF MECHANISM (GE33541)

Course Objective:

At the end of the course student should be able to:

1. To familiarize students with advanced types of mechanisms, joints and degrees of freedom to perform position, velocity and acceleration analysis using graphical and analytical methods.
2. To provide students an understanding of different types of mechanisms.
3. To teach the basics of synthesis of advanced mechanisms.
4. To teach students the Algebraic Methods of Synthesis.

Learning Outcome:

1. Demonstrate an understanding of the concepts of various mechanisms and pairs.
2. Conduct various analyses of advanced mechanisms.
3. Design a layout of crank for specified motion.
4. Synthesize advanced mechanisms for slider crank and four bar link mechanism.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Mechanisms, Classifications, Relative & absolute motion, Degree of freedom, 4-bar mechanisms-planar & spatial mechanisms, Inversion and equivalent linkage, Transmission deviation and pressure angles, Kinematic analysis of Planer motion, Relative velocity and velocity difference, Instantaneous Centre, Poles and centroids, Relative acceleration, Acceleration difference.	**30**	**1**
II	**Kinematic Synthesis:** Kinematic Synthesis type, Number and dimensional synthesis, Spacing of accuracy points, Chebyshev polynomials. **Four bar coupler point curves:** Four bar linkage, Equation of coupler curves, Double points and symmetry, Robert Chebyshev theorem, Approximate and exact straight-line mechanisms.	**30**	**1**

III	**Geometrical Method of Synthesis:** Poles and relative poles of four bar linkage, Poles and relative poles of slider crank mechanism, Synthesis with three accuracy points, Pole triangle, Four position synthesis.	**30**	**1**
IV	**Algebraic Methods of Synthesis-I:** Displacement equation of four bar linkage, Crank and follower synthesis with three accuracy points, Four bar function generator with three accuracy points, Crank and follower synthesis: angular velocities and accelerations. **Algebraic Methods of Synthesis-II:** Syntheses of slider crank mechanism with three accuracy points, Synthesis of slider crank mechanism with four accuracy points, Five accuracy points synthesis of crank and follower mechanism, Analysis of mechanical errors in linkage, Mechanical error in four bar linkage.	**30**	**1**

Reference Books:

1. Kinematic Synthesis of Linkages R. S. Hartenberg and J. Denavit McGraw Hill, New York.
2. Kinematic and Linkage Design A.S Hall Jr Prentice Hall India Ltd.
3. Mechanism and Machine Theory Amitabh Ghosh and AK Mallick.

SIX SIGMA METHODS & APPLICATIONS (GE33542)

Course Objective:

1. To understand the Differences between Conventional and Six Sigma concept of quality.
2. To know about the six sigma success stories, Statistical foundation and methods of quality improvement.
3. To understand the different methodology of Six Sigma.
4. To get aware with six sigma organizations and software for six sigma.

Learning Outcome:

1. Understand six sigma concepts.
2. Describe models of implementation of six sigma.
3. Select proper methods for six sigma implementations.
4. Describe the advantages of six sigma concept of quality over conventional method.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Quality Perception, Quality in Manufacturing, Quality in Service Sector, Differences between Conventional and Six Sigma concept of quality, Six Sigma success stories, Statistical foundation and methods of quality improvement, Descriptive statistics: Data Type, Mean, Median, Mode, Range, Variation, Standard Deviation, Skewness, Kurtosis, Probability Distribution: Normal, Binomial, Poisson distribution.	**30**	**1**
II	Basics of Six Sigma, Concept of Six Sigma, Defects, DPMO, DPU, Attacks on X'S, Customer focus, Six Sigma for manufacturing, Six Sigma for service, Understanding Six Sigma organizations, Leadership council, Project sponsors and champions, Master Black Belts, Green Belts.	**30**	**1**

III	Methodology of Six Sigma, DMAIC, DFSS, Models of Implementation of Six Sigma, Selection of Six Sigma Projects, Six Sigma Tools, Project Charter, Process mapping, Measurement system analysis, Hypothesis Testing, Quality Function deployment, Failure mode effect analysis, Design of Experiments.	**30**	**1**
IV	Sustenance of Six Sigma, Communication plan, Company culture, Reinforcement and control, Introduction to software's for Six Sigma, Understanding Minitab, Graphical analysis of Minitab plots.	**30**	**1**

Reference Books:

1. Six Sigma: SPC and TQM in manufacturing and service, Geoff Tennant, Gower Publishing Co.
2. Six Sigma for managers, Greg Brue, TMH.
3. What is Six Sigma, Pete Pande, TMH.
4. The Six Sigma Way, Peter S. Pande, TMH Team Field book.
5. The Six Sigma way, Peter S. Pande, TMH.

FINITE ELEMENT METHOD (GE33543)

Course Objective:

1. To enable the students, understand the mathematical and physical principles underlying the Finite Element Method (FEM) as applied to solid mechanics and thermal analysis.
2. To understand the characteristics of various finite elements.
3. To develop finite element equations for simple and complex domains.
4. To understand various numerical methods of FEM.

Learning Outcome:

At the end of the course student should be able to:

1. Apply the knowledge of mathematics and engineering to solve problems in structural and thermal engineering by approximate and numerical methods.
2. Design a new component or improve the existing components using FEA.
3. Solve the problems in solid mechanics and heat transfer using FEM.
4. Use commercial FEA packages like ANSYS and modern CAD/CAE tools for solving real life problems.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Introduction to finite difference method and finite elements method, Advantages and limitations, Mathematical formulation of FEM, Different approaches in Finite Element Method, Direct Stiffness approach, Simple examples, Variational approach, Elements of variational calculus, Euler Lagrange equation, Rayliegh Ritz method, Weighted Residual methods, Point Collocation method, Galarkin method, Steps involved in FEM.	**30**	**1**
II	**Types of Elements Used:** Interpolation Polynomials, Linear elements Shape function, Analysis of simply supported beam, Element and Global matrices, Two-dimensional elements, Triangular and rectangular elements, Local and Natural	**30**	**1**

	Co-ordinate systems.		
III	**Finite Element Formulation of Field Problems:** 1-D and 2-D heat transfer, Fluid flow (incompressible and non-viscous fluid) in ducts, Simple electrical and magnetic field problems, Simple Numerical examples. **Finite Element Formulation of Solid Mechanics Problems:** 1-D problem of shaft, Truss element analysis of pinned truss, Plane stress/strain problems, Axi-symmetric problems, Thin plate problems, Vibration of shafts & beams.	**30**	**1**
IV	**Numerical Methods in FEM:** Evaluation of shape functions, One dimensional & triangular elements, Quadrilateral elements, Isoperimetric elements, Numerical Integration, Gauss Legendre quadrature, Solution of finite element equations, Gauss Elimination Method, Cholesky decomposition.	**30**	**1**

Reference Books:

1. The Finite Element Method O.C. Sienkiewicz and R.L. Taylor McGraw Hill.
2. An Introduction to Finite Element Method J. N. Reddy McGraw Hill.
3. Finite Element Procedure in Engineering Analysis K.J. Bathe McGraw Hill.
4. Finite Element Analysis C.S. Krishnamoorthy Tata McGraw Hill.
5. Concepts and Application of Finite Element Analysis R.D. Cook, D.S. Malcus and M.E. Plesha John Wiley.
6. Introduction to Finite Elements in Engineering T.R Chandragupta and A.D. Belegundu Prentice Hall India.
7. Numerical Methods E Balagurusamy Tata McGraw Hill.

MECHATRONICS (GE33544)

Course Objective:

To study about various, sensors, transducers, microprocessors and PLC

Learning Outcome:

At the end of the course student should be able to:

1. To study the sensors and transducers, used in mechanical engineering
2. To study how microprocessors can be used to do simple applications in mechanical engineering
3. To study about PLC and its applications

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Introduction to Mechatronics Systems, Mechatronics in products - Measurement systems, control systems - traditional design and Mechatronics Design.	**30**	**1**
II	**Sensors and Transducers:** Introduction - performance terminology - displacement position and proximity - velocity and motion - fluid pressure - temperature sensors - light sensors - selection of sensors - signal processing - servo systems.	**30**	**1**
III	**Microprocessors in Mechatronics:** Introduction - Architecture - pin configuration - instruction set - programming of microprocessor using 8085 instructions - interfacing input and output devices - interfacing D/A converters and A/D converters - applications - temperature control - stepper motor control - traffic light controller.	**30**	**1**
IV	**Programmable Logic Controllers:** Introduction - basic structure - input and output processing - programming - Mnemonics timers, internal relays and counters - data handling - analog input and output - selection of PLC. Possible design solution - case studies of Mechatronics systems.	**30**	**1**

References:

1. Michael B. Histan and David G. Alciatore, “Introduction and Mechatronics and Measurement systems”, McGraw Hill International Edn. 1999.

2. Bradley, D.A., Dawson, D, Buru, N.C. and Loader, A.J. “Mechatronics”, Chapman and Hall,1993.
3. Ramesh S. Gaonkar, ‘Microprocessors Architecture, Programming and Applications”, Wiley Eastern, 1998.
4. Lawrence J. Kamm, “Understanding Electro-Mechanical Engineering, An Introduction to Mechatronics”, Prentice Hall 2000.
5. Ghosh. P.K and Srithar, P.R.8000 to 8085 “Introduction to Microprocessors for Engineers and Scientists” Second Edition Prentice Hall, 1CONCURRENT ENGINEERING

ADVANCED MATERIALS TECHNOLOGY (GE33551)

Course Objective

1. To have knowledge of different types of Advanced Materials.
2. To be aware about the importance of advanced materials.
3. To understand the various ways in which we can use the various types of advanced material in latest technologies**.**
4. To have knowledge of Biomaterials & Nuclear material.

Learning Outcome:

At the end of the course student should be able to:

1. Know the importance of each of each of advanced material.
2. Get the knowledge of the various type's properties of advanced materials and the methods to further enhance these properties.
3. Get an idea of new types of advanced materials which can be developed in near future and its application.
4. Apply the best suitable material according to the application.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction to Ferrous Materials:** Plain carbon steels, their properties and application, Plain carbon steels, Effect of alloying elements in plain carbon steels, Alloy steels, tools steels, stainless steels, Low and high temperature resisting steels, High strength steels, selections, Specifications form and availability of steel.	**30**	**1**
II	**Heat Treatment of Steels:** TTT diagrams, annealing Normalizing, hardening and tempering of steel, Austempering and martempering of steel, Surface hardening of steel, Induction hardening, Depth of hardening.	**30**	**1**
III	**Nonferrous materials:** Ultra-light materials, Properties and application, Brasses, bronzes, copper-nickel alloys, Aluminum, magnesium and titanium alloys, bearing materials, Heat treatment of	**30**	**1**

	nonferrous material, Aging, Precipitations hardening. **Composites:** PMC, MMC, CMC, Ceramic-polymer, Metal-ceramic, Metal-polymer, composites, Dispersion reinforced, Particle reinforced, Laminated and fiber reinforced composites.		
IV	**Biomaterials:** Stress strain behavior of bone, The mechanical properties, Fatigue properties of skin, Biocompatible materials and its applications, The effects of degradation and corrosion. **Nuclear Materials:** Introduction to nuclear materials, Materials of nuclear fuel in fission & fusion reactors, Fissile and fertile materials, Control & Construction Materials for Nuclear reactors, Moderators, Heat Exchangers, Radiation proof materials, Brief discussion of safety, Radioactive waste disposal.	**30**	**1**

Reference Books:

1. Biomaterials Science- An Introduction to Materials in Medicine. Buddy D. Rattner, A.S. Hoffman, F.J. Sckoen, and J.E.L Emons, Academic Press, second edition, 2004.
2. Biomaterials: An Introduction (second edition) JoonB.Park&RodericS.Lakes, Plenum Press, 1992.
3. Handbook of Materials for Medical Devices, Edited by J. R. Davis, ASM international, 2003.
4. Introduction to Nuclear Engineering, by J.R Lamarsh.
5. W.D. Callister, Jr, - Material Science & Engineering Addition-Wesly Publishing Co.
6. Van Vlash - Elements of Material Science & Engineering John Wiley & Sons.

PRODUCTION & OPERATIONS MANAGEMENT (GE33552)

Course Objective:

1. To have knowledge about basic concept of production & operation management.
2. To be aware about the various tools used in production & operation management.
3. To know about scheduling production and service system.
4. To get an idea how to manage in a world class competition.

Learning Outcome:

At the end of the course student should be able to:

1. Able to know about various Managing operations.
2. Compare the different types of Production & Operation Management Techniques and can use the best suitable Technique.
3. Develop new types of Methods which can be used in Production & Operation Management**.**
4. Able to know about material requirement planning.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Managing Operations:** Operations Management, Function, Evolution, Definition, Systems view of P&OM, Operations Strategies for Competitive Advantage.	**30**	**1**
II	**Planning (Designing) the conversion System:** Designing Products, Services and Processes, Operations Capacity, Locating production and servicing facilities, Layout Planning.	**30**	**1**
III	**Organizing the conversion System:** Job design, Production and Operations standards, Work measurement, Project Management. **Scheduling Production and Service System:** Scheduling systems, Aggregate Planning for Production and service system, Operation scheduling.	**30**	**1**

IV	**Material Requirements Planning:** Planning for needs, Applying MRP, Detailed capacity planning, MRP II. **Managing for World class Competition:** World class Manufacturing practices, Managing for Quality, Conversion Process in change.	**30**	**1**

Reference Books:

1. Adam Jr Everett E. R J – Production and Operations Management (Prentice-Hall, 2000, 5th Edition).
2. Russell & Taylor III – Operations Management (Pearson, 4th Edition).
3. Hill T- Operations Management (Palgrave, 2000).
4. McGregor D – Operations Management (McGraw-Hill, 1960).

OPTIMIZATION TECHNIQUES IN ENGINEERING (GE33553)

Course Objective:

1. To have knowledge about Unconstrained & constrained Optimization.
2. To have knowledge of different types of Optimization Techniques.
3. To be aware, how the Optimization Techniques can be used in research.
4. To get an idea about Optimization and Functions of a Complex Variable and Numerical analysis.

Learning Outcome:

At the end of the course student should be able to:

1.Know how to practically apply Unconstrained & constrained Optimization.

2. To understand the various ways in which we can use the Optimization Techniques in various fields.
3. To apply the Optimization Techniques in various processes in industry.
4. To apply the function of a complex variable and Numerical analysis in practical purposes.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Unconstrained Optimization:** Optimizing Single-Variable Functions, Conditions for Local Minimum and Maximum, Optimizing Multi-Variable Functions.	**30**	**1**
II	**Constrained Optimization:** Optimizing Multivariable Functions with Equality Constraint, Terminology, Direct Search Method, Lagrange Multipliers Method, Kuhn-Tucker Necessary conditions, Kuhn Tucker Sufficient Condition.	**30**	**1**
III	**Optimization:** Quasi-Newton Methods and line search, Least squares optimization, Gauss-Newton, Levenberg- Marquartd, The Newton Algorithm, Non Linear Least Square, Sequential Quadratics Programming (SQP), Constrained Optimization, SQP Implementation, Multi-Objective	**30**	**1**

	Optimization, Branch and Bound Approaches, Genetic Algorithms and Genetic Programming , Singular Based Optimization, On- Line Real-Time Optimization, Optimization in Econometrics Approaches–Blue.		
IV	**Optimization and Functions of a Complex Variable and Numerical Analysis:** The Finite Difference Method for Poisson`s Equation in two Dimensions and for the Transient Eulers Method, The Modified Eulers Method and the Runga –Kutta Method, Gaussian Quadrative Trapezoidal Rule and Simpson`s 1/3 and 3/8 Rules, The Newton Raphson in one and two Dimensions, Jacobi`s Iteration Method. **Optimization in Operation Research:** Transportation–Linear Optimization Simplex, Hitchcock Algorithms, Minimax and Maximum Algorithm, Discrete Simulation, Integer Programming–Cutting Plane Methods, Separable Programming, Stochastic Programming.	**30**	**1**

Reference Books:

1. Winston W L: Operations Research: Applications and Algorithms.
2. Rao S.S., Optimization: Theory and Applications.
3. Walsh G R: M methods of Optimization.
4. Williams H.P.: Model Building in Mathematics Programming.
5. Williams H.P.: Model Solving in Mathematics Programming.

PRINCIPLES OF COMPUTER INTEGRATED MANUFACTURING (GE33554)

Course Objective:

PURPOSE To enable the students to understand the basic principles of CIM and its elements.

Learning Outcome:

At the end of the course student should be able to:

1. The basic components of CIM and its hardware and software.
2. FMS and its applications.
3. Principles of computer aided process planning, JIT and GT.
4. Different monitoring systems used in CIM.
5. Computer Aided Quality Control and FIS.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction to CIM:** Manufacturing - Types, Manufacturing Systems, CIM Definition, CIM wheel, CIM components, Evolution of CIM, needs of CIM, Benefits of CIM, basic components of NC system, NC motion control system, applications of NC ,advantages and disadvantages of NC, computer Numerical control, advantages of CNC, functions of CNC, Direct Numerical Control, components of a DNC system, functions of DNC, advantages of DNC.	**30**	**1**
II	**Flexible manufacturing systems:** FMS concept, Components of FMS, FMS Layouts, FMS planning and implementation. Tool Management Systems-Tool monitoring, Work holding devices-Modular fixturing, flexible fixturing, flexibility, quantitative analysis of flexibility, application and benefits of FMS, automated material handling system –AGVs, Guidance methods, AS/RS.	**30**	**1**
III	**Automated process planning:** Group Technology, Part families, Part classification and coding, Production flow analysis, Machine cell design, Applications and Benefits of Group	**30**	**1**

	Technology, Structure of a Process Planning, Process Planning function, CAPP - Methods of CAPP, CAD based Process Planning, Inventory management - Materials requirements planning - basics of JIT		
IV	**Monitoring and quality control:** Types of production monitoring system, process control & strategies, direct digital control - Supervisory computer control - computer aided quality control - objectives of CAQC, QC and CIM, contact, non-contact inspection methods, CMM and Flexible Inspection systems. Integration of CAQC with CIM.	**30**	**1**

References:

1. Kant Vajpayee. S., 'Principles of Computer Integrated Manufacturing', Prentice Hall of India, 1999
2. Radhakrishnan.P, Subramanyan. S, 'CAD/CAM/CIM', New Age International publishers, 200.
3. Scheer.A.W., 'CIM- Towards the factory of the future' Springer - Verlag, 1994
4. Daniel Hunt.V., 'Computer Integrated Manufacturing Hand Book', Chapman & Hall, 1989
5. Groover M.P, 'Computer Aided Design and Manufacturing', Prentice Hall of India, 1987
6. Yorem Koren, 'Computer Control of Manufacturing System', McGraw Hill, 1986
7. Ranky Paul. G., 'Computer Integrated Manufacturing', Prentice Hall International, 1986

QUALITYMANAGEMENT (OE33501)

Course Objective:

1. To have knowledge of Quality concept & Quality Management.
2. To be aware about the importance Quality Management.
3. To have knowledge about Control charts.
4. To have knowledge of ISO9000series.

Learning Outcome:

At the end of the course student should be able to:

1. Know the importance of Quality Management Tools and their applications.
2. Increase the productivity and efficiency of organization with the help of Quality Management Tools.
3. Can develop new types Quality Management Techniques.
4. Apply Taguchi method & JIT method for various applications.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Quality Concepts:** Evolution of Quality control, Concept change, TQM Modern concept, Quality concept in design, Review off design, Evolution of prototype. **Control on Purchased Product:** Procurement of various products, Evaluation of supplies, Capacity verification, Development of sources, Procurement procedure. **Manufacturing Quality:** Methods and Techniques for manufacture, Inspection and control of product, Quality in sales and services, Guarantee, analysis of claims.	**30**	**1**
II	**Quality Management:** Organization structure and design, Quality function, Decentralization, Designing and fitting organization for different types products, Economics of quality value and contribution, Quality cost, Optimizing quality cost.	**30**	**1**

	Human Factor in Quality: Attitude of top management, Co-operation, of groups, Operators attitude, responsibility, Causes of operator's error and corrective methods.		
III	**Control Charts:** Theory of control charts, Measurement range, Construction and analysis of R charts, Process capability study, Use of control charts. **Attributes of Control Charts:** Defects, Construction and analysis off-chart, Improvement by control chart, Variable sample size, Construction and analysis of C-chart.	**30**	**1**
IV	**Defects Diagnosis and Prevention:** Defect study, Identification and analysis of defects, Corrective measure, Factors affecting reliability, MTTF, Calculation of reliability, Building reliability in the product, Evaluation of reliability, Interpretation of test results, Reliability control, Maintainability, Zero defects, quality circle. **IS0-9000anditsconceptofQualityManagement:** ISO9000series, Taguchi method, JIT in some details	**30**	**1**

Reference Books:

1. Concurrent Engineering Kusiak John Wiley.

2. Concurrent Engineering Menon Chapman & hall.

PRODUCT DEVELOPMENT (OE33502)

Course Objective:

1. To acquire skills to develop products in a structured way.
2. To get aware with general product development principles for manufacturability.
3. To understand the incorporation of ergonomics in product development.
4. To develop need analysis techniques and morphology of design.

Learning Outcome:

At the end of the course student should be able to:

1. Explain product development process and review design of existing product considering reliability.
2. Develop a product according to requirement of market.
3. Incorporate the ergonomics into the product development.
4. Explain morphological techniques and technological design.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	Concept of product, Definition and scope, Applications, Relevance, Product Definition, Scope, Terminology, Design definitions, the role and nature of design, Old and new design methods, Design by evolution, need based development, Technology based developments.	**30**	**1**
II	Morphology of Design, Divergent, Transformation and convergent phases of product design, Identification of need, Analysis of need, Aesthetics, Ergonomics, Form (structure) Shape, size, color, Mental blocks, Removal of blocks, Ideation Techniques, Creativity, Checklist.	**30**	**1**
III	Transformations, Brainstorming & Synectics, Morphological techniques, Utility concept, Utility value, Utility index, Decision making under multiple criteria, Economic aspects of design, Fixed and variable costs, Break-even analysis.	**30**	**1**
IV	Reliability considerations, Bath tub curve, Reliability of systems in series and parallel, Failure rate, MTTF and MTBF, Optimum spares from reliability consideration,	**30**	**1**

	Patents, Standards and codes, Environment and safety considerations, Existing techniques such as work-study, SQC etc. which could be used to improve method & quality of product, Innovation versus Invention, Technological Forecasting.		

Reference Books:

1. Product Design & Manufacturing - A.K. Chitab & R.C. Gupta, PHI (EEE).
2. The Technology of Creation Thinking - R.P. Crewford – Prentice Hall.
3. The Art of Thought – Grohem Walls – Bruce & Co., New York.
4. Product Design & Decision Theory - M.K. Starr - Prentice Hall.
5. Engineering. Product Design -C.D. Cain, Business Books.
6. Industrial design for Engineers –W.H. Mayall, Itiffe. Design Methods – seeds of human futures – J. Christopher Jones, John Wiley & Sons.
7. Human Factor Engineering. – Mccormick E.J., McGrawHill.
8. Engineering: An Introduction to Creative profession – G.C. BeakleyH W leach, Macmillan.
9. Industrial Design in Engineering – A marriage of Techniques – Charles H. Flurscheim, The Design Council - London.
10. Quality Control & Reliability Analysis – Bijendra Singh, Khanna Publications