B.Tech (Four Years)

Course Structure

Department of Mechanical Engineering

Indian Institute of Engineering Science and Technology, Shibpur

भारतीय अभियांत्रिकी विज्ञान एवं प्रौद्योगिकी संस्थान, शिबपुर

ভারতীয় প্রকৌশল বিজ্ঞান এবং প্রযুক্তিবিদ্যা প্রতিষ্ঠান, শিবপুর

Howrah 711103, West Bengal, India

COURSE STRUCTURE

B. TECH. (MECHANICAL)

(REFER TO ANNEXURE-1 FOR COURSES OFFERED BY ME DEPT TO OTHERS)

FIRST SEMESTER

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load/ week	Marks
			L	T	P			
1.	Mathematics-I	MA 1101	3	1	0	4	4	100
2.	Chemistry	CH 1101	3	0	0	3	3	100
3.	Introduction to Computing	CS 1101	3	0	0	3	3	100
4.	Mechanics	AM 1101	4	0	0	4	4	100
5.	Professional Communication in English	HU 1101	3	0	0	3	3	100
	Theory Sub-total		**16**	**1**	**0**	**17**	**17**	**500**
6.	Chemistry Lab	CH 1171	0	0	3	2	3	50
7.	Computer Lab	CS 1171	0	0	3	2	3	50
8.	Drawing Practice	AM 1171	0	1	3	3	4	50
9.	NSS/NCC/PT/Yoga	SA 1171				R*		
	Practical Sub-total		**0**	**1**	**9**	**7**	**10**	**200**
	First Semester Total					**24**	**27**	**700**

*R: Required (Non-credit but with grade)

NB. No departmental subject in this Semester.

SECOND SEMESTER

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load/ week	Marks
			L	T	P			
1.	Mathematics – II	MA 1201	3	1	0	4	4	100
2.	Physics	PH 1201	4	0	0	4	4	100
3.	Basic Electrical Engineering	EE 1201	4	0	0	4	4	100
4.	Environment and Ecology	CE 1201	3	0	0	3	3	100
5.	Sociology & Professional Ethics	HU 1201	3	0	0	3	3	100
	Theory Sub-total		**17**	**1**	**0**	**18**	**18**	**500**
6.	Physics Lab	PH 1271	0	0	3	2	3	50
7.	Basic Electrical Engineering Lab	EE 1271	0	0	3	2	3	50
8.	Workshop Practice	WS 1271	0	0	3	2	3	50
9.	NSS/NCC/PT/Yoga	SA 1271				R*		
	Practical Sub-total		**0**	**0**	**9**	**6**	**9**	**200**
	Second Semester Total					**24**	**27**	**700**

*R: Required (Non-credit but with grade)

NB. No departmental subject in this Semester.

THIRD SEMESTER

Sl. No	Subject code	Course Name	Class Load/Week			Total Load (h)	Credit	Marks
			L	T	P			
1.	MA 2101	Mathematics – III	3	0	0	3	3	100
2.	AM 2101	Strength of Materials	4	0	0	4	4	100
3.	AM 2102	Dynamics	4	0	0	4	4	100
4.	ME2101	Basic Thermodynamics	3	0	0	3	3	100
5.	ME2102	Numerical Methods in Engineering	3	0	0	3	3	100
		Theory Sub-total	**17**	**0**	**0**	**17**	**17**	**500**
6.	AM 2171	Strength of Materials Laboratory	0	0	3	3	2	50
7.	AM 2172	Machine Drawing	0	0	3	3	2	50
8.	ME2171	Numerical Methods in Engineering Lab	0	0	3	3	2	50
9.	ME2191	Minor Project	0	0	0	0	2	50
		Sessional Sub-total	**0**	**0**	**9**	**9**	**8**	**200**
		3rd Semester Total				**26**	**25**	**700**

FOURTH SEMESTER

Sl. No	Subject code	Course Name	Class Load/Week			Total Load (h)	Credit	Marks
			L	T	P			
1.	AM 2201	Fluid Mechanics	4	0	0	4	4	100
2.	ME2201	Applied Thermodynamics	3	1	0	4	4	100
3.	ME2202	Kinematics of Mechanisms and Robots	3	0	0	3	3	100
4.	ME2203	Fundamentals of Machine Design	3	0	0	3	3	100
5.	ME2204	Engineering Materials and Processes	3	1	0	4	4	100
		Theory Sub-total	**16**	**2**	**0**	**18**	**18**	**500**
6.	AM 2271	Fluid Mechanics Laboratory	0	0	3	3	2	50
7.	ME2271	Applied Thermodynamics Lab	0	0	3	3	2	50
8.	ME2272	Machine Shop Practice	0	0	3	3	2	50
9.	ME2273	CAD Modelling and Simulation Lab	0	0	3	3	2	50
		Sessional Sub-total	**0**	**0**	**12**	**12**	**8**	**200***
		4th Semester Total				**30**	**26**	**700**

FIFTH SEMESTER

Sl. No	Subject code	Course Name	Class Load/Week			Total Load (h)	Credit	Marks
			L	T	P			
1.	ME3101	Heat Transfer	3	1	0	4	4	100
2.	ME3102	Steam and Gas Power Systems	3	0	0	3	3	100
3.	ME3103	Dynamics of Machines and Vibration	3	0	0	3	3	100
4.	ME3104	Design of Power Transmission Elements	3	0	0	3	3	100
5.	ME3105	Machine Tools and Metal Cutting	3	0	0	3	3	100
		Theory Sub-total	**15**	**1**	**0**	**16**	**16**	**500**
6.	ME3171	Heat Transfer Lab	0	0	3	3	2	50
7.	ME3172	Design of Power Transmission Elements Sessional	0	0	3	3	2	50
8.	ME3173	Metal Cutting and Metrology Lab	0	0	3	3	2	50
		Sessional Sub-total	**0**	**0**	**9**	**9**	**6**	**150**
		5th Semester Total				**25**	**22**	**650**

SIXTH SEMESTER

Sl. No	Subject code	Course Name	Class Load/Week			Total Load (h)	Credit	Marks
			L	T	P			
1.	AM 3201	Fluid Power Engineering	4	0	0	4	4	100
2.	ME3201	I.C. Engine and Jet Propulsion	3	1	0	4	4	100
3.	ME3202	Design of Frictional Machine Elements	3	1	0	4	4	100
4.	ME3203	Modelling and Control of Mechanical Systems	3	0	0	3	3	100
5.	ME3204	Manufacturing Technology	3	0	0	3	3	100
		Theory Sub-total	16	2	**0**	**18**	**18**	**500**
6.	AM 3271	Fluid Power Engineering Laboratory	0	0	3	3	2	50
7.	ME3271	Engine Lab	0	0	3	3	2	50
8.	ME3272	Design of Frictional Machine Elements Sessional	0	0	3	3	2	50
9.	ME3273	Seminar and Group Discussion.	0	0	3	3	2	50
		Sessional Sub-total	**0**	**0**	**12**	**12**	**8**	**200**
		6th Semester Total				**30**	**26**	**700**

SEVENTH SEMESTER

Sl. No	Subject code	Course Name	Class Load/Week			Total Load (h)	Credit	Marks
			L	T	P			
1.	ME4101	Refrigeration and Air conditioning	3	0	0	3	3	**100**
2.	ME4102	Advanced Manufacturing Technology	3	1	0	4	4	**100**
3.	ME4103	Industrial Engineering and Operations Research	3	0	0	3	3	**100**
4.		Core Elective -I (**LIST-I)**	3	0	0	3	3	**100**
		Theory Sub-total	**12**	**1**	**0**	**13**	**13**	**400**
5.	ME4171	Refrigeration and Air Conditioning Lab	0	0	3	3	2	**50**
6.	ME4172	Advanced Manufacturing Lab	0	0	3	3	2	**50**
7.	ME4191	B. Tech Project Part-I	0	0	2	2	4	**100**
8.	ME4192	Evaluation of 6th Semester Internship	0	0	0	0	2	**50**
		Sessional Sub-total	**0**	**0**	**8**	**8**	**10**	**250**
		7th Semester Total				**21**	**23**	**650**

LIST-I (Core Elective -I)

1. Automobile Engineering (ME4121)
2. Fundamentals of Tribology(ME4122)
3. Fatigue and Fracture Mechanics (ME 4123)
4. Computational Fluid Dynamics and Heat Transfer(ME4124)
5. Welding Technology (ME4125)
6. CNC Machining and Additive Manufacturing (ME4126)

EIGHTH SEMESTER

Sl. No	Subject code	Course Name	Class Load/Week			Total Load (h)	Credit	Marks
			L	T	P			
1.	HU4201	**HSS-III** FINANCE, ECONOMICS AND MANAGEMENT FOR ENGINEERS	3	0	0	3	3	**100**
2.	See the list below	Core Elective – II (**LIST-II)**	3	0	0	3	3	**100**
3.		Open –Elective	3	0	0	3	3	**100**
		Theory Sub-total	**9**	**0**	**0**	**9**	**9**	**300**
4.	ME4291	B. Tech Project Part-II	0	0	2	2	8	**200**
	ME4292	Project Seminar	0	0	0	0	2	**50**
5.	ME4293	Comprehensive Viva	0	0	0	0	2	**100**
		Sessional Sub-total	**0**	**0**	**2**	**2**	**12**	**350**
		8th Semester Total				**11**	**21**	**650**
		TOTAL CREDIT (All Semester) =					**191**	

List of Core Elective -II subjects (to be offered in the 8th-semster)

1. Power Plant Engineering(ME4221)
2. Manufacturing Automation(ME4222)
3. Finite Element Method for Engineering(ME4223)
4. Fluidized Bed Technology(ME4224)
5. Robotics (ME 4225)
6. Introduction to Biomechanics (ME 4226)

OPEN ELECTIVE

Students are to choose one OE from a list as declared and notified by the institute.

Annexure-1

A. Subjects offered by ME Department to the other specified departments

Sl. No.	Subject code	Course Name	Class Load/Week			Total Load (h)	Credit	Marks	Department
			L	T	P				
1.	ME2205	Heat Power and Machine Elements	3	1	0	4	4	100	Mining Engg. (4TH Sem)
2.	ME2274	Heat Power and Machine Elements Laboratory	0	0	3	3	2	50	Mining Engg. (4TH Sem)
3	ME 3106	Heat Power	3	0	0	3	3	100	Elec Engg. (5TH Sem)
4	ME 3174	Heat Power Lab	0	0	3	3	2	50	Elec Engg. (5TH Sem)

B. Subjects offered by ME Department as Open Electives (OE)

Sl. No.	Subject code	Course Name	Class Load/Week			Total Load (h)	Credit	Marks	Department
			L	T	P				
1.	ME4261	Energy Storage Technology	3	0	0	3	3	100	All Depts. (8TH Sem)
2.	ME4262	Solar and Wind Energy	3	0	0	3	3	100	All Depts (8TH Sem)

Annexure -A

4 Year UG (B.Tech)

Mechanical Engineering

Course Contents

(Syllabus)

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3rd SEMESTER
BASIC THERMODYNAMICS (ME-2101)

Contact hours per week : 3L + 0T **Credit : 3 (Marks :100)**

SYLLABUS:

Basic concepts: Thermodynamic system and its properties, Processes and cycles, Quasi-static process, Reversible process, Thermodynamic equilibrium. Zeroth law of thermodynamics, Work and heat interactions, Measurement of pressure and temperature. First law of thermodynamics: Statement, Corollaries and its application to closed and open systems, Steady and unsteady flow processes. Second law of thermodynamics: Concepts of heat reservoir and heat engine, Kelvin-Planck and Clausius statements of second law of thermodynamics, Carnot cycle, Carnot's theorem, Refrigerator and heat pump, Inequality of Clausius. Entropy: Principle of increase of entropy, Availability and Irreversibility, Concept of entropy generation and exergy analysis. Properties of gas and gas mixture: Ideal gas, Equation of state, Analysis of different processes undergone by a gas, Dalton's law and Amagats law, Characteristic gas constant and molecular weight of mixture of perfect gasses, Gibbs Dalton law and its applications. Maxwell's equations in thermodynamics, Thermodynamic relations. Reactive mixtures: Combustion equations, Stoichiometric and actual air-fuel ratios, Lean and rich mixtures, Analysis of actual combustion products. Properties of pure substance: Phase equilibrium, Diagram and related properties, Gibbs phase rule, Relevant properties of pure substance, Steam Table, Mollier diagram, T-s and p-h diagrams, Dryness fraction of steam and its measurement. Psychrometry: Relevant psychrometric properties, Measurement of DBT and WBT of moist air, Psychrometric chart, Psychrometric processes.

	Topics	No of Classes
1.	Basic concepts: Thermodynamic system and its properties, Processes and cycles, Quasi-static process, Reversible process, Thermodynamic equilibrium. Zeroth law of thermodynamics, Work and heat interactions, Measurement of pressure and temperature.	03
2.	First law of thermodynamics: Statement, Corollaries and its application to closed and open systems, Steady and unsteady flow processes.	04
3.	Second law of thermodynamics: Concepts of heat reservoir and heat engine, Kelvin-Planck and Clausius statements of second law of thermodynamics, Carnot cycle, Carnot's theorem, Refrigerator and heat pump, Inequality of Clausius.	06
4.	Entropy:Principle of increase of entropy, Availability and Irreversibility, Concept of entropy generation and exergy analysis.	03
5.	Properties of gas and gas mixture: Ideal gas, Equation of state, Analysis of different processes undergone by a gas, Dalton's law and Amagats law, Characteristic gas constant and molecular weight of mixture of perfect gasses,GibbsDalton law and its applications.	06
6.	Maxwell's equations in thermodynamics, Thermodynamic relations.	02
7.	Reactive mixtures: Combustion equations, Stoichiometric and actual air-fuel ratios, Lean and rich mixtures, Analysis of actual combustion products.	05
8.	Properties of pure substance: Phase equilibrium, Diagram and related properties, Gibbs phase rule, Relevant properties of pure substance, Steam Table, Mollier diagram, T-s and p-h diagrams of steam, Dryness fraction of steam and its measurement.	06
9.	Psychrometry: Relevant psychrometric properties, Measurement of DBT and WBT of moist air, Sling Psychrometer, Psychrometric chart, Psychrometric processes.	05

10.	Class Test/Viva-Voce	02
	Total number of classes	**42**

LESSON PLAN:

Text Books:

1. Engineering Thermodynamics by P. K. Nag
2. Fundamentals of Thermodynamics by Sonntag,Borgnakke and Van Wylen

Reference Books:

1. Engineering Thermodynamics: Work and Heat Transfer by Rogers and Mayhew
2. Principles of Engineering Thermodynamics by Moran and Shapiro

Numerical Methods in Engineering (ME2102)

Contact Period: 3-0-0 **Credit: 3 (Marks- 100)**

Introduction to Numerical Methods, Relevance of numerical methods in present day engineering. Numerical Error, Hartree's classification of iterative process. Solution of transcendental equations, Solution of Polynomial Equations, Solution of a set of linear algebraic equations. Curve fitting, Interpolation and Numerical Integration. Solution of ODE, Initial Value Problems, Solution of ODE, Boundary Value Problems.

Module	Topics	Number of Lectures
Introduction	Introduction to Numerical Methods, Relevance of numerical methods in present day engineering	2
Types of Errors	Truncation and Round-off Errors. Absolute error and relative error. Hartree's classification of iterative process	2
Solution of transcendental equations	Fixed point iterative methods; Method of iteration, Method of Bisection, Regula-Falsi method, Newton-Raphson method, Algorithm Development and determining order of convergence	3
Solution of Polynomial Equations	Roots of polynomial equation by Lin-Bairstow's method. Solution of a system of nonlinear equations by Newton-Raphson method	3
Solution of a set of linear algebraic equations	Direct Methods: Gaussian elimination method with partial pivoting, Evaluation of determinant of the coefficient matrix, Algorithm development, Examples. Gauss-Jordan method and LU-Decomposition (Doolittle's) method. Algorithm development, Examples. Matrix Inversion, Calculation of multiplication/division FLOPS for each method. Condition of an equation set: Condition Index, Condition number. Iterative Method: Gauss-Seidel method. Convergence criteria. Gauss-Seidel method with relaxation, Examples	7
Curve fitting	Meaning, importance and application. Difference with interpolation. Linear regression using the least square method. Matrix formulation of the least square procedure for linear forms, Weighting factors, Curve fitting with polynomials. Standard error, Curve fitting using non-linear forms. Examples	5
Interpolation	Interpolation using polynomials: Newton's forward difference and backward difference method, Lagrange's method. Examples. Interpolation using splines: Difference between polynomial interpolation and spline interpolation. Development of cubic splines for a set of data with different end conditions. Examples	5
Numerical Integration	Trapeziodal and Simpson's methods. Newton Cotes formula, composite forms, Gaussian quadrature using Legendre polynomials. Examples	4
Solution of ODE, Initial Value Problems	Definition of initial value problem. Solution of ordinary differential equation: Euler's method, Modified Euler's method, both self-starting type and non-self starting type.	5

	Midpoint method. Error estimation, Examples. Family of Runge-Kutta methods, Classical 4^{th} order Runge-Kutta method. Solution of simultaneous equations using 4^{th} Order Runge-Kutta method. Algorithm development, Examples.	
Solution of ODE, Boundary Value Problems	Definition of Boundary Value Problems, Solution of ODE depicting boundary value problems using Finite Difference method	4
	Total	40

Text books:

1. *Numerical methods for Engineers*, 4^{th}Edition, by Steven C. Chapra and Raymond P. Canale, McGraw-Hill Companies, 2002.
2. *Applied Numerical Methods for Digital Computation*, 4th Edition, by M.L. James, G.M. Smith and J.C. Wolford, Addison-Wesley Longman Publishing Co., Inc., 1984.
3. *Numerical Methods: Principles, Analyses, and Algorithms*, by Srimanta Pal, Oxford University Press, 2012.
4. Numerical Methods for Scientists and Engineers, by Richard Hamming, Dover Books Publications, 1987.

Numerical Methods in Engineering Laboratory (ME2171)

Contact Period: 0-0-3 **Credit: 2 (Marks- 50)**

Module	Topics	Lab Sessions
Introduction	1. Computer programming exercise to refresh knowledge in computer programming. (i) To read a set of numbers in an array and sort them according to the selection short and bubble short algorithm. (ii) To read a set of numbers in an array and find the values of the maximum element and its location in the array. (iii) To read the size of a square matrix and its elements and then calculate the sum of the elements on the (a) main diagonal and (b) auxiliary diagonals. (iv) To read the size and elements of two rectangular matrices and calculate the product matrix. Program must be able to check feasibility of such multiplication.	2
Solution of transcendental equations	2. Write a computer programme that will solve a transcendental equation f(x) =0 by the *bisection* method; Inputs: f(x), x_0, eps. 3. Write a computer programme that will solve a transcendental equation f(x) =0 by the *regula-falsi* method; Inputs: f(x), x_0, eps. 4. Write a computer programme that will solve a transcendental equation f(x) =0 by the *Newton-Raphson* method. Inputs: f(x), x_0, eps.	2
Solution of Polynomial Equations	5. Write a computer program to solve a system of non-linear equations by Newton-Raphson method; Inputs: Number of equations, $x_{i,0}$, eps.	1
Solution of a set of linear algebraic equations	6. Write a computer program to solve a set of n linear algebraic equations by the Gaussian elimination method with partial pivoting; Inputs; number of equations n, coefficient matrix [A], right hand vector {b}. 7. Write a computer program to solve a set of n linear algebraic equations by the LU decomposition method with partial pivoting; Inputs; number of equations n, coefficient matrix [A], right hand vector {b}. 8. Write a computer program to invert a square matrix of order n by the Gauss Jordan method: Inputs: n, [A], 9. Write a computer program to solve a set of n linear algebraic equations by the Gauss-Seidel iterative method; Inputs: number of equations n, coefficient matrix [A], right hand vector {b}. Initial guess vector $\{x_0\}$, eps.	3

Curve fitting and Interpolation	10. Write a computer program that will fit a set of x-y data in the least-square sense. Use matrix formulation for linear forms of the least –square procedure; Inputs: number of data n, vectors {x} and {y}, degree of the approximating polynomial m. 11. Write a computer program that will read a set of x-y data and obtain an interpolated value of y for a given x by the Lagrange interpolation formula. Input: n=size of {x} or {y}, {x}, {y} , value of x at which y has to be computed. 12. Write a computer program that will read a set of x-y data and obtain an interpolated value of y for a given x by natural cubic spline. Input: n=size of {x} or {y}, {x}, {y}, value of x at which y has to be computed.	2
Numerical Integration	13. Write a computer program that will calculate the definite integral $I = \int_a^b f(x)dx$ by the Simpson's 1/3rd rule. Input: a,b, f(x), n=number of intervals. 14. Write a computer program that will calculate the definite integral $I = \int_{-1}^{1}\int_{-1}^{1} f(r,s)drds$ by the Gauss-Quadrature formula. Inputs: f(r,s), n, m= number of gauss points in r and s directions respectively. Location of Gauss points in r and s directions with respective weight factors are to be incorporated in the program using appropriate statements.	1
Solution of ODE, Initial Value Problems	15. Write a computer program that will solve the initial value problem $\frac{dy}{dx} = f(x,y), subject\ to\ y\|_{x_o} = y_o$ by the predictor –corrector type modified Eulers's method with k corrections. Inputs: x_0, y_0, f(x,y), h= step size , n= number of steps and k. 16. Write a computer program that will solve the initial value problem $\frac{dy}{dx} = f(x,y), subject\ to\ y\|_{x_o} = y_o$ by the classical 4thorder Runge-Kutta method. Inputs: x_0, y_0, f(x,y), h= step size , n= number of steps. 17. Write a computer program that will solve a set of simultaneous ODE $\frac{dy_1}{dx} = f_1(x, y_1, y_2, \dots, y_m), \frac{dy_2}{dx} = f_2(x, y_1, y_2, \dots, y_m), \dots, \frac{dy_m}{dx} = f_m(x, y_1, y_2, \dots, y_m)$ subject to $\{y\}\|_{x_o} = \{y_o\}$ by the classical 4thorder Runge-Kutta method. .Inputs: x_0, $\{y_0\}$, f_1, f_2...f_m, h=step size, n = number of steps.	3
	Total	14

Text books:

1. *Numerical methods for Engineers*, 4thEdition, by Steven C. Chapra and Raymond P. Canale, McGraw-Hill Companies, 2002.
2. *Applied Numerical Methods for Digital Computation*, 4th Edition, by M.L. James, G.M. Smith and J.C. Wolford, Addison-Wesley Longman Publishing Co., Inc., 1984.
3. *Numerical Methods: Principles, Analyses, and Algorithms*, by Srimanta Pal, Oxford University Press, 2012.
4. Numerical Methods for Scientists and Engineers, by Richard Hamming, Dover Books Publications, 1987.

Minor Project (ME 2191)

Contact Period: 0-0-0 **Credit: 2 (Full Marks- 50)**

Students will be divided into small groups and any engineering or physics related problem may be selected in consultation with the supervisor. This is intended to enhance their outlook and problem-solving skill in a broader spectrum. The problem may not be directly related to mechanical engineering as they are only in 3rd Semester and no mechanical engineering subject is completed at the starting of the Semester. At the end of the Semester (3rd) they need to submit a report to the supervisor. Evaluation will be done by the supervisor on the basis of overall performance as well as on the report. Head examiner may need to keep parity of marks across the groups.

4th SEMESTER

APPLIED THERMODYNAMICS (ME2201)

Contact hours per week : 3 -1- 0 **Credit : 4 (Marks : 100)**

SYLLABUS:

Different gas power cycles: Carnot, Otto, Diesel, Dual, Stirling, Ericsson and Brayton cycles, Comparison of Otto, Diesel and Dual cycles. Vapour power cycles: Carnot and Rankine cycles, Effect of steam parameters on cycle performance, Reheat and Regenerative steam power cycles. Refrigeration cycle: Different methods of refrigeration, Refrigerants. Air cycle refrigeration (Bell-Coleman), Vapour compression refrigeration cycle. Boiler: Classification of boilers. Fire tube and water tube boilers, High pressure and low pressure boiler, Once-through boiler. Description and working of Cochran, Babcock-Wilcox, Stirling, Lamont and Benson boilers. Boiler mounting and accessories. Boiler performance analysis and heat balance of a boiler plant. Boiler specifications. Reciprocating compressor: Working principle, FAD, Single stage and multi-stage compression with intercooler, optimum inter-stage pressure, volumetric efficiency and isothermal efficiency of compressor. Introduction to rotary compressors: Roots blower, vane type compressors, screw type compressors, centrifugal and axial compressors. Introduction to nuclear power generation: Fundamentals of nuclear reactions and nuclear reactor, estimation of nuclear fuel required for power generation.

LESSON PLAN :

Sl.No.	Topics	No of Classes
1.	Different gas power cycles: Carnot, Otto, Diesel, Dual, Stirling, Ericsson and Brayton cycles, Comparison of Otto, Diesel and Dual cycles.	08
2.	Vapour power cycles: Carnot and Rankine cycles, Effect of steam parameters on cycle performance, Reheat and Regenerative steam power cycles.	08
3.	Refrigeration cycle: Different methods of refrigeration, Refrigerants. Air cycle refrigeration (Bell-Coleman), Vapour compression refrigeration cycle.	07
4.	Boiler: Classification of boilers. Fire tube and water tube boilers, High pressure and low pressure boiler, Once-through boiler. Description and working of Cochran, Babcock-Wilcox, Stirling, Lamont and Benson boilers. Boiler mounting and accessories.Boiler performance analysis and heat balance of a boiler plant. Boiler specifications.	08
5.	Reciprocating compressor: Working principle, FAD, Single stage and multi-stage compression with intercooler, optimum inter-stage pressure, volumetric efficiency and isothermal efficiency of compressor.	07
6.	Introduction to rotary compressors: Roots blower, vane type compressors, screw type compressors, centrifugal and axial compressors.	03
7.	Introduction to nuclear power generation: Fundamentals of nuclear reactions and nuclear reactor, estimation of nuclear fuel required for power generation.	05
8.	Class Test/Viva-Voce	02
Total number of classes		**48**

Text Books:

1. Engineering Thermodynamics by P. K. Nag
2. Thermodynamics: An Engineering Approach by Michael A Boles and YungusACengel
3. Principles of Engineering Thermodynamics by Moran and Shapiro

Reference Books:

1. Principles of Energy Conversion by A. W. Culp
2. Applied Thermodynamics for Engineering Technologists by T. D. Eastop and A. McConkey
3. Refrigeration and Air Conditioning by R C Arora

Kinematics of Mechanisms and Robots (ME2202)

Contact Period: 3+0+0 Credit - 03 (Marks: 100)

Syllabus:

Fundamental concepts of mechanisms, Position analysis of planar mechanisms, Graphical methods of velocity analysis, Graphical methods of acceleration analysis, Analytical methods of velocity and acceleration analysis, Dimensional Synthesis of mechanisms, Cam, Gear and Gear trains, Kinematics of Robotic manipulators.

Lesson Plan:

Module	Topics	No. of Lecture Periods
1.	**Fundamental concepts of mechanisms:** Introduction- Définitions, Classifications, Machine Vs. Mechanism, Kinematic pairs, Kinematic chains,Mobility of mechanisms(KutzbachandGrubler Criterion), Kinematic inversions,Number synthesis, Rotatability criterion of four bar mechanisms (Grashof's Criterion)	06
2.	**Position analysis of planar mechanisms:** Loop closure equations, Graphical and analytical solutions of loop closure equations	03
3.	**Graphical methods of velocity analysis:** Relative velocity method, velocity polygon, Instantaneous Centre (IC) of velocity,Aronhold-Kennedey theorem, Circle diagram, Velocity analysis by IC method	04
4.	**Graphical methods of acceleration analysis**: Relative acceleration method, acceleration polygon,Normal, Tangential and Coriolis component of acceleration- examples	03
5.	Analytical methods of velocity and acceleration analysis	02
6.	**Dimensional Synthesis of mechanisms:** Function generation, path generation and body guidance, Freudenstein's equation, Two and Three position synthesis	04
7.	**Cam:** Classifications, Analysis of follower motion, Cam profile	05

	synthesis	

8.	Gears and Gear trains: Fundamental law of gearing, Geometry of involute tooth profiles, interference, undercutting and contact ratio, Spur, helical, and bevel gears-nomenclatures, Epicyclic gear trains	05
9.	**Robotics Introduction:** Definition, Law of Robotics, Anatomy of a Robot, Degree of Freedom, Geometric Configurations, Robot Specifications	02
10.	**Robot Arm Kinematics:** Review of Rigid Body Rotation- Rotation Matrix, Axis-angle or Rodrigues' Rotation Formula, Successive Rotations, Forward Kinematics- Homogeneous Transformation, Representation of Joints and Link, Denavit-Hartenberg Parameters	06
Total		40

Text Book:

1. Theory of Mechanisms and Machines, Amitabha Ghosh and Asok Kumar Mallik, Affiliated East-west Press, 3rd ed.
2. Robotics and Control by R. K. Mittal and I. J. Nagrath, Tata McGraw-Hill, New Delhi, 2007.
3. Industrial Robotics: Technology, Programming and Applications by M. P. Groover, M. Weiss, R. N. Nagel and N. G. Odrey, Tata McGraw-Hill, New Delhi, 2008.

Reference books:

1. Theory of Machines and Mechanisms, J. J. Uicker, G. R. Pennock and J. E. Shigley, Oxford University Press (Oxford international student edition).
2. Theory of Machines, S. S. Rattan, Tata MaGraw Hill Education Private Limited, Third edition.

FUNDAMENTALS OF MACHINE DESIGN (ME2203)

L-T-P: 3-0-0 **Credit: 3 (Marks: 100)**

Syllabus

Basic principles and steps of machine design; Standardization (BIS)and preferred numbers; Limits, fits and tolerances; Stress concentration and factor of safety; Stress analysis in 3D, principal stresses, octahedral normal and shear stresses, Hydrostatic and deviatoric states of stresses, total strain energy and distortion energy; Theories of failure for ductile and brittle materials; Theories of failure for variable loading; Design of cotter joint; Design of leaf spring.

Lesson Plan

SL. No.	Topics	No of lectures
1.	**Introduction to mechanical design**: Basic steps	02
2.	Standardization (BIS) and preferred numbers	02
3.	Limits, fits and tolerances	04
4.	Stress concentration and factor of safety	03
5.	**Design of cotter joint:** Cotter joints and its purpose, Different parts, derivation of condition of self locking of the cotter, materials of cotter joint, Design and calculation of a spigot and socket type cotter joint dimensions based on possible modes of failure, Problem	04
6.	**Stress Analysis:** Stress at a point, State of stress and strain at a point in 3-dimensions, rectangular stress and strain components, sign conventions, Cauchy's equation, Normal and shear stress on any arbitrary plane	04
7.	Stress invariants, principal stresses in 3-dimensions and their directions, hydrostatic and deviatoric states of stress, expressions of strain energy, distortion energy in terms of principal stresses, Boundedness of stress components at a point: Mohr's circles in 3D.	06
8.	**Theories of failure in terms of 3-dimensional state of stress for ductile and brittle materials**: Maximum principal stress, maximum shear stress, maximum principal strain, total strain energy, distortion energy theories of failure; Variations of Mohr's theory, i.e., Coulomb Mohr theory and modified Mohr theory for brittle materials	05
9.	Theories of failures under variable loading: Concepts of variable loading and fatigue failure, endurance limit- Gerber, Goodman and Soderberg criteria for individual and combined loading, Modified Goodman Diagram Diagram, Application on bolted joints for pressure vessel.	06
10.	Design of leaf spring: Concepts of uniform beam and beam of uniform strength, Construction of leaf or laminated springs, Nipping, Laminated spring materials, Maximum stress and	04

	deflections, Design of important dimensions of a leaf spring with and without nipping, Problems.	
	Total	40

Text Books:

1. Advanced Mechanics of Solids, by L.S. Srinath, 3rd edition, McGraw Hill Education.
2. Mechanical Engineering Design (6th International Edition), by J.E. Shigley and C.R. Mischke, McGraw-Hill Publications, 2001
3. Machine Design: An Integrated Approach (3rd Edition), by Robert L. Norton, Prentice Hall, 2006.
4. Machine Design Data Book, by V.B. Bhandari, McGraw Hill Education (India) Private limited, 2014.

Reference Books:

1. Machine Design (Schaum's Outline Series), by Hall, Holowenko and Laughlin, McGraw-Hill International Book Company, 1980.
2. Engineering Design (3rd International Edition), by George E. Dieter, McGraw-Hill International Book Company, 2000.
3. Introduction to Solid Mechanics (2nd Edition), by I.H. Shames, Prentice-Hall of India Pvt. Ltd., 1990.
4. Mechanical Behavior of Materials (4th Edition), by Norman E. Dowling, Pearson Education Limited, 2013

Engineering Materials and Processes (ME2204)

Weekly contact: 3L+1T **Credit: 4 (Marks: 100)**

Syllabus :

Mechanical properties and their testing: Engineering and true stress-strain diagram, ductile and brittle fracture, hardness, toughness, endurance limit and fatigue testing, creep.
Phase diagrams: solid solutions, binary alloy system, lever rule, Iron-carbon equilibrium diagram, TTT diagrams
Heat treatment: Annealing, normalizing, tempering, hardening (case hardening and surface hardening).
Engineering materials: A brief overview on metals, alloyed steel, cast iron, nonferrous alloy, ceramics, polymers and composite materials
Casting: Types of patterns and allowances; Mould materials and their properties; Solidification; Gating and Risering; Special casting processes: Investment casting, Die casting, Centrifugal casting, Continuous casting; Casting defects.
Metal forming processes: Terminology and classification; Fundamentals of hot and cold working processes; Load estimation for bulk deformation (forging, rolling, extrusion, drawing); Metal forming defects
Joining process: Terminology and types; DC and AC welding; Arc length & power calculation; Edge preparation; Shielded Metal Arc welding and Resistance welding; Welding defects and detection methods. Brazing, soldering and adhesive bonding

Lesson Plan :

Sl. No.	Topic	No. of Periods
1.	**Mechanical properties and their testing**: Engineering and true stress-strain diagram, ductile and brittle fracture, hardness, toughness, endurance limit and fatigue testing, creep.	05
2.	**Phase diagrams:** solid solutions, binary alloy system, lever rule, Iron-carbon equilibrium diagram, TTT diagrams.	07
3.	**Heat treatment:** Annealing, normalizing, tempering, hardening (case hardening and surface hardening).	08
4.	**Engineering materials:** A brief overview on metals, alloyed steel, cast iron, nonferrous alloy, ceramics, polymers and composite materials.	06
5.	**Casting:** Types of patterns and allowances; Mould materials and their properties; Solidification; Gating and Risering; Special casting processes: Investment casting, Die casting, Centrifugal casting, Continuous casting; Casting defects.	10
6.	**Joining process:** Terminology and types; DC and AC welding; Arc length & power calculation; Edge preparation; Shielded Metal Arc welding and Resistance welding; Welding defects and detection	08

	methods.Brazing, soldering and adhesive bonding	
7.	**Metal forming processes:**Terminology and classification; Fundamentals of hot and cold working processes;Load estimation for bulk deformation (forging, rolling, extrusion, drawing); Metal forming defects.	08
	TOTAL	52

Text book

1. Manufacturing processes for engineering materials : by S. Kalpakjian, S.R. Schmid, Pearson Pub. India.

Reference book

1. Fundamentals of Modern Manufacturing by M.P. Groover, John Wiley & Sons Inc.
2. Manufacturing Science by A. Ghosh & A.K. Mullick, East-West Publication
3. Manufacturing Technology by P.N.Rao, Tata McGraw-Hill Publication
4. Welding Technology by JF Little, Tata McGraw-Hill Publication

Heat power and Machine Elements (ME2205)
(For Mining Engineering)

Contact hours per week : 3-1-0 **Credit : 4 (Marks :100)**

SYLLABUS

Heat Power:

Fundamental concepts of thermodynamics: Thermodynamic Systems, surroundings, properties, process, cycle, internal energy, enthalpy, flow work, Zeroth law of thermodynamics, heat, work.
First law of thermodynamics: statement, application to open and closed systems.
Second law of thermodynamics: Concepts of heat reservoir and heat engine, Kelvin-Planck and Clausius statements of second law of thermodynamics, Refrigerator and heat pump, Carnot cycle, Carnot's theorem, basic concept of entropy.
Power Cycles: Otto Cycle, Diesel, Rankine cycles.
I.C.Engines: Classifications, two and four-stroke engines, fuels, Carburetor, injector, engine performance analysis; engine systems-cooling, and lubrication.
Refrigeration and air conditioning: Introduction, Vapour compression refrigeration systems.
Reciprocating Compressor: Single and multi-staging, power and efficiency

***Machine Elements*:**

Shaft, keys and coupling: Types of keys. Types of couplings; muff coupling, clamp coupling, flange coupling and flexible coupling.
Hydraulic coupling: types, components and applications.
Clutches: Types of clutches, friction clutches, single disc and multiple disc plate clutches.
Gears: Classification; Spur, Helical, Bevel and Worm gears and their applications;Gear train; gear materials,

LESSON PLAN:

	Topics	No. of Classes
1.	Basic concepts: Thermodynamic system and its properties, Processes and cycles, Quasi-static process, Reversible process, Thermodynamic equilibrium. Zeroth law of thermodynamics, Work and heat interactions.	02
2.	**First law of thermodynamics**: statement, application to open and closed systems.	04
3.	**Second law of thermodynamics:**Concepts of heat reservoir and heat engine, Kelvin-Planck and Clausius statements of second law of thermodynamics, Refrigerator and heat pump, Carnot cycle, Carnot's theorem, basic concept of entropy.	04

4.	Power Cycles: Otto, Diesel, and Rankine cycles	04
5.	**Refrigeration and air conditioning:** Introduction, Vapour compression refrigeration systems	03
6.	I.C.Engines: Classifications, two and four-stroke engines, fuels, Carburetor, injector, engine performance analysis; engine systems-cooling, and lubrication.	05
7.	Reciprocating Compressor: Single and multi-staging, power and efficiency.	04
8.	Introduction to machine elements	02
9.	Shaft, keys and coupling: Types of keys. Types of couplings; muff coupling, clamp coupling, flange coupling and flexible coupling. **Hydraulic coupling**: types, components and applications	06
10.	Clutches: Types of clutches, friction clutches, single disc and multiple disc plate clutches, applications	04
11.	Gears: Classification; Spur, Helical, Bevel and Worm gears and their applications; Gear train; gear materials	06
12.	Class Test/Viva-Voce	02
	Total no. of classes	46

Text Books:

1.Applied Thermodynamics and engineering, Fifth Edition By T.D Eastop and A. McConkey
2. Engineering Thermodynamics by P.K.Nag.
3. Machine Design by PC Sharma & DK Aggarwal

Applied Thermodynamics Laboratory (ME2271)

Contact Period: 0-0-3 **[Credit – 02] (Marks: 50)**

Sl No.	Name of experiments	No. of Classes
1	Study of fire tube and water tube boiler models	03
2	Study of reciprocating IC engine models	03
3	Calibration and use of planimeter.	03
4	Study of double-acting steam engine model.	03
5	Determination of coefficient of discharge of different orifices at various Reynolds Number.	03
6	Experimental determination of the values of polytropic index (n) for compression & expansion processes.	03
7	Determination of dryness fraction of steam by throttling calorimeter.	03
8	Flue gas analysis by Orsat apparatus.	03
9	Boiler Trial	03

Machine Shop Practice (ME2272)

Cont. hr. – 3 **Credit – 2**

Experiments:

1. Development of a shaft using simple turning operation in a lathe machine
2. Development of a key way using milling machine of the developed shaft in Experiment no. 1
3. Grinding of the developed shaft (Experiment no. 1) using cylindrical grinding machine
4. Development of a stepped shaft using taper turning attachment in a lathe machine
5. Thread cutting of a cylindrical job in a lathe machine
6. Slot cutting in a Shaping machine
7. Spur gear cutting in a milling machine using indexing methods

CAD Modelling and Simulation Laboratory (ME2273)

Contact Period: 0-0-3 **Credit: 2 (Marks: 50)**

Syllabus: Part modelling and assembly using SolidWorks, and basic simulation using Ansys and Simulink.

Serial No.	Topics	No. of lab hours
1.	CAD Modelling using SolidWorks: Introduction to Solid Modelling Demonstration of Sketch, Plane, Boss Extrude, Cut Extrude, Loft, Sweep, Fillet, Chamfer, Pattern, Dimensioning, etc.)	03
2	CAD Modelling using SolidWorks: Part Modelling 3D part modelling of various geometries	12
3.	CAD Modelling using SolidWorks: Assembly Assembly of parts such as Flange Coupling, Universal Coupling, and Plummer Block	09
4.	Simulation using Ansys: Structural Problem Beams and Frames	06
5.	Introduction to Simulink	03
6.	Simulation using Simulink: Simulation of a bouncing ball, inverted pendulum with animation, and solving collision problem	09
	Total	**42**

Heat Power Laboratory (ME2274)
(For Mining Engineering)

Contact Period: 0 – 0 – 3 Full Marks: 50 [Credit:02]

Sl. No.	Name of the experiments	No. of classes
1.	Study of four stroke SI and CI engine model	06
2.	Study of fire tube and water tube boiler model	06
3.	Calibration and use of Planimeter	06
4.	Measurement of air flow using standard Orifice meter and estimation of coefficient of discharge	06
5.	Lister Engine trial	06
6.	Study of Vapour Compression Refrigeration Test Rig	06
	Viva Voce (including interim and repeat viva)	03
	Total Classes	39

5th SEMESTER
HEAT TRANSFER (ME3101)

Contact hours per week: 3L+1T Credit : 4 (Marks:100)

Syllabus :

TOPIC
One-Dimensional, Steady-State Conduction: The plane wall, Temperature distribution, Thermal resistance, The composite wall Contact resistance, Radial Systems; Summary of One-Dimensional Conduction Results, Conduction with thermal energy generation; The plane wall; Radial Systems, Heat Transfer from Extended Surfaces; A general conduction analysis, Fins of uniform cross-sectional area; Fin performance; Fins of non-uniform cross-sectional area; overall surface efficiency
Two-Dimensional, Steady-State Conduction: The method of separation of variables, The graphical method, Methodology of constructing a flux plot; Determination of the heat transfer rate, The conduction shape factor, Finite-Difference equations; The nodal network; Finite-difference form of the heat equation; the energy balance method; Finite-difference solutions; The matrix inversion method; Gauss-Seidel iteration
Transient Conduction: The lumped capacitance method, Validity of the lumped capacitance method, General lumped capacitance analysis, Spatial effects ,The plane wall with convection, Exact solutions, Approximate solutions, Total energy transfer, Radial Systems with convection, Exact solutions, Approximate solutions, The semi-infinite solid Multidimensional effects, Finite-difference Methods, Discretization of the heat equation: The explicit method, Discretization of the heat equation: The implicit method
Introduction to convection: The convection transfer problem, The Convection boundary layers, The velocity boundary layer, The thermal boundary layer, Significance of the boundary layers, Laminar and turbulent flow, The convection transfer equations, The velocity boundary layer, The thermal boundary layer, The concentration boundary layer, Approximations and special conditions, Boundary layer similarity: The normalised convection transfer equations, Boundary layer similarity parameters, Functional forms of the solutions, Physical significance of the dimensionless parameters, Boundary layer analogies, Evaporative cooling ,The Reynolds analogy, The effects of turbulence, The convection coefficients
External flow: The Empirical Method , The Flat Plate in Parallel Flow, Laminar Flow over an Isothermal Plate: A Similarity Solution, Turbulent Flow over an Isothermal Plate, Unheated Starting Length, Flat Plates with Constant Heat Flux Conditions, Limitations on Use of Convection Coefficients, Methodology for a Convection Calculation, The Cylinder in Cross Flow, Flow Considerations, The Sphere, Flow Across Banks of Tubes, Impinging Jets
Internal flow: Hydrodynamic Considerations , Flow Conditions, The Mean Velocity, Velocity Profile in the Fully Developed Region, Pressure Gradient and Friction Factor in Fully Developed Flow: Thermal Considerations, The Mean Temperature, Newton's Law of Cooling, Fully Developed Conditions, The Energy Balance, General Considerations, Constant Surface Heat Flux, Constant Surface Temperature, Laminar

Flow in Circular Tubes: Thermal Analysis andConvection Correlations, The Fully Developed Region, The Entry Region, Convection Correlations: Turbulent Flow in Circular Tubes, Convection Correlations: Noncircular Tubes ,The Concentric Tube Annulus
Free Convection, Boiling and Condensation, Heat Exchangers
Radiation: Fundamental Concepts, Radiation Heat Fluxes, Radiation Intensity, Mathematical Definitions, Radiation Intensity and Its Relation to Emission, Relation to Irradiation, Relation to Radiosity for an Opaque Surface, Relation to the Net Radiative Flux for an Opaque Surface, Blackbody Radiation , The Planck Distribution, Wien's Displacement Law, The Stefan–Boltzmann Law , Band Emission, Emission from Real Surfaces, Absorption, Reflection, and Transmission by Real Surfaces, Absorptivity, Reflectivity, Transmissivity, Special Considerations, Kirchhoff's Law, The Gray Surface, Environmental Radiation, Solar Radiation, The Atmospheric Radiation Balance, Terrestrial Solar Irradiation
Radiation Exchange between Surfaces: The View Factor, The View Factor Integral, View Factor Relations , Blackbody Radiation Exchange, Radiation Exchange Between Opaque, Diffuse, Gray Surfaces in an Enclosure, Net Radiation Exchange at a Surface, Radiation Exchange between Surfaces, The Two-Surface Enclosure , Two-Surface Enclosures in Series and Radiation Shields, The Reradiating Surface, Multimode Heat Transfer, Implications of the Simplifying Assumptions, Radiation Exchange with Participating Media, Volumetric Absorption, Gaseous Emission and Absorption

Lesson plan :

(Conduction 16 L + Convection 14 L + Radiation 12 L) = (42 L) + (14 T) = 56 hrs	
TOPIC	Hours
One-Dimensional, Steady-State Conduction	(8 L)
Two-Dimensional, Steady-State Conduction	(5 L)
Transient Conduction	(3L)
Introduction to convection	(4 L)
External flow	(3 L)
Internal flow	(3L)
Free Convection, Boiling and Condensation, Heat Exchangers	(4 L)
Radiation	(6L)
Radiation Exchange between Surfaces	(6L)

Text book :

1. Heat Transfer - F P Incropera and D P De Witt, T L Bergeman, A S Lavine, J Wiley & Sons

Reference books :

2. Heat Transfer J H Lienhard, Cambridge, Massachusetts, USA
3. Heat Transfer J P Holman, McGraw-Hill

4. Heat Transfer S P Sukhatme, Universities Press (India) Pvt Ltd.

STEAM AND GAS POWER SYSTEMS (ME3102)

Weekly Contact Period: 3 L + 0 T **Credit: 3 (Marks: 100)**

Syllabus:

Advanced steam cycle: Superheat, Reheat and Regeneration, Open and closed type heaters, Drip diversion systems, Boiler, Steam drum, Modern high pressure boilers, Water wall, Superheater, Reheater, Economiser and air preheater, Circulation, Void fraction, Slip ratio, Heat transfer characteristics of heating elements, Fuels and firing System, Burners,Steam Generator ControlDraft system: Natural draft system, Forced draft system, Induced draft system, Balanced draft system, Computation of draft.Steam Nozzles : Stagnation Properties- Function of nozzle, Types, Flow through nozzles, Velocity at exit, Ideal and actual expansion in nozzle- Velocity coefficient, Condition for maximum discharge and critical pressure ratio, Criteria to decide nozzle shape- Super saturated flow, its effects, Degree of super saturation and Degree of under cooling - Wilson line.SteamTurbines: History, Impulse, Optimum velocity ratio, Compounding of steam turbines, Impulse-reaction principle and 50% Reaction turbines, Reheat factor and condition line, Losses in steam turbines, Steam turbine governing.Condenser: Classification and construction,Jet and Surface condensers, Air-ingress and its effect, Air removal, Vacuum efficiency, Relatedcalculations.Gas turbines and improved Brayton cycle configurations, Regeneration, Inter cooling and Reheating, Closed and Semi-closed cycles, Performance parameters, Actual cycle and losses, Merits and Demerits of gas turbine plants, Components and materials.

Lesson Plans

Sl. No.	Topics	No. of periods
1.	Advanced steam cycle: Superheat, Reheat and Regeneration, Open and closed type heaters, Drip diversion systems	4
	Boiler, Steam drum, Modern high pressure boilers, Water wall, Superheater, Reheater, Economiser and air preheater, Circulation, Void fraction, Slip ratio, Heat transfer characteristics of heating elements, Fuels and firing System, Burners,Steam Generator Control	8
2.	Draft system: Natural draft system, Forced draft system, Induced draft system, Balanced draft system, Computation of draft.	3
	Steam Nozzles : Stagnation Properties- Function of nozzle, Types, Flow through nozzles, Velocity at exit, Ideal and actual expansion in nozzle- Velocity coefficient, Condition for maximum discharge and critical pressure ratio, Criteria to decide nozzle shape- Super saturated flow, its effects, Degree of super saturation and Degree of under cooling - Wilson line.	5
3.	Steam Turbines: History, Impulse, Optimum velocity ratio, Compounding of steam turbines, Impulse-reaction principle and 50% Reaction turbines, Reheat factor and condition line, Losses in steam turbines, Steam turbine governing.	8
4.	Condenser: Classification and construction, Jet and Surface condensers, Air-ingress and its effect, Air removal, Vacuum efficiency, Related calculations.	4
5.	Gas turbines and improved Brayton cycle configurations, Regeneration, Inter cooling and Reheating, Closed and Semi-closed cycles, Performance parameters, Actual cycle and losses, Merits and Demerits of gas turbine plants, Components and materials	8
Total		**40**

Text Books:

1. Power Plant Engineering by P. K. Nag, Tata McGraw Hill
2. Power Plant Technology by M. M. Ei. Wakil, McGraw Hill Education (India) Pvt.Ltd.

Reference Books:

1. Principles of Energy Conversion by A. W. Culp, McGraw Hill Education Pvt.Ltd
2. Power Plant Engineering and Economy by B. G. A. Skrotzki and W. A. Vopat, McGraw Hill Education (India) Pvt.Ltd.

Dynamics of Machines and Vibration (ME3103)

Contact Period: 3L Credit - 03 (Marks: 100)

Content: Static and Dynamic Force analysis of planar mechanisms, Design of Flywheels, Balancing of rotating and reciprocating machines, Gyrodynamics, Vibration analysis

Lesson Plan

Module	Topics	No. of Lecture Periods
1. Static and Dynamic Force analysis of planar mechanisms	Force analysis of four bar mechanisms Engine force analysis Dynamically equivalent system Turning Moment on crankshafts, turning moment diagram	5
2. Design of Flywheels	Fluctuation of energy and speed Design and analysis of flywheels for engines and punching press	5
3. Balancing	Static unbalance and static balancing Dynamic Unbalance and its analysis Balancing machines Field Balancing- balancing of thin discs, balancing of rigid rotors Balancing of reciprocating parts Balancing of single-cylinder engines Balancing of multi-cylinder engines Analytical technique of balancing of reciprocating engines Balancing of linkages Balancing standards and codes	10
4. Gyrodynamics	Euler Equations for 3-D rigid body dynamics Tops and conventional Gyroscopes Gyroscopic Moment Optical and MEMS gyroscopes	8
5. Vibration Analysis	Lumped parameter models of elastic machine members, differential equations of motion, natural frequency. Free and forced vibration of single degree-of-freedom systems Viscous and dry friction damping, measurement of damping Vibration Isolators Two Degrees-of-Freedom systems Vibration absorber	14
Total		42

Text Book:

Theory of Machines and Mechanisms, Amitabha Ghosh and Asok Kumar Mallik, Affiliated East-west Press, 3rd ed.

Reference books:

1. Theory of Machines and Mechanisms, J. J. Uicker, G. R. Pennock and J. E. Shigley, Oxford University Press (Oxford international student edition).
2. Principles of Vibration, B. H. Tongue, Oxford University Press (Indian edition).

DESIGN OF POWER TRANSMISSION ELEMENTS (ME3104)

Contact Hours: 3-0-0 **Credit :3 (Marks: 100)**

Syllabus

Design of helical spring(s); Design of power transmission shaft based on strength, stiffness and stability; Force analysis of spur gear trains and design of spur gear tooth; Force analysis and design of helical gears; Force analysis and design of bevel gears; Introduction to various types of rolling contact bearings and specifications, Selection of rolling contact bearings for different applications from standard catalogues.

Lesson Plan

Sl. No.	Topics	No. of. Lectures
1.	**Design of Helical Spring:** Classification, Construction of a helical spring, nomenclatures and definitions; Derivation of maximum shear stress expression including Wahl's correction factor, deflection. Design of spring dimensions based on both strength and stiffness under static and dynamic loading, Spring surge, Design of cluster springs.	05
2.	**Design of power transmission shaft:** Definition of shaft and axle, Properties of shaft material, Design of shaft based on strength under torsional moment, bending moment and axial load as per ANSI/ASME standard B106.1M-1985; Design of shaft based on stiffness considering transverse deflection, slope and torsional rigidity, Design of shaft based on critical speed using Rayleigh Ritz method. **Design of keys:** types of keys and applications, key material, Design of key based on different failure types.	09
3.	**Spur Gear:** purpose, Classifications and Applications, Nomenclatures of spur gears, law of gearing and interference; Forces induced on each gear of compound and epicyclic gear train, Gear materials, Derivation of Lewis equation based on strength and design of module, checking of design using Buckingham's dynamic load. Wear on a gear tooth, Possible causes in the light of Hertzian contact state of stress. Derivation of Buckingham's wear load formula from Hertz's contact stress formula for a pair of spur gear teeth and its use in further checking of design.	09
4.	**Helical Gear:** Purpose, Classifications and Applications, Nomenclatures of helical gear, Speed ratio and interference, Concept of virtual number of teeth of a helical gear, Force analysis of a helical gear drive, Modified Lewis equation in designing a helical gear tooth, Modified dynamic load and wear load formula of Buckingham. Problems on force Analysis and design of helical gears.	05
5.	**Design of Bevel Gear:** Purpose, Classifications and Applications, Nomenclatures of bevel gear and definition of	05

	various parameters of a bevel tooth, derivation of virtual number of teeth of a bevel gear, force analysis of bevel gear drive, Modified Lewis equation for bevel gear tooth, modified dynamic load and wear load formula of Buckingham.	
6.	**Design of rolling contact bearings:** Construction and designation , Basic static load and Basic Dynamic load Capacities Rated Life , Equivalent dynamic load, Selectionof ball bearings based on SKF catalogue, Selection of cylindrical and taper roller bearings.	06
7.	**Class Test**	01
	Total	**40**

Text Books:

1. Mechanical Engineering Design (6th International Edition), by J.E. Shigley and C.R. Mischke, McGraw-Hill Publications, 2001
2. Machine Design: An Integrated Approach (3rd Edition), by Robert L. Norton, Prentice Hall, 2006.
3. Fundamentals of Machine Component Design (3rd Edition), by Robert C. Juvinall and Kurt M. Marshek, Wiley Student Edition, 2007.
4. Machine Design Data Book, by V.B. Bhandari, McGraw Hill Education (India) Private limited, 2014.

Reference Books

1. Shigley's Mechanical Engineering Design (8th Special Indian Edition), by J.E. Shigley, Charles R. Mischke, Richard G. Budynas and Keith J. Nisbett, The McGraw-Hill Companies, 2008.
2. Machine Design (Schaum's Outline Series), by Hall, Holowenko and Laughlin, McGraw-Hill International Book Company, 1980.
3. Design of Transmission Systems, by P. Kannaiah, SCITECH Publications Pvt. Ltd., 2007.

Machine Tools and Metal Cutting (ME3105)

Contact hours per week : (L+T+P : 3+0+0) Credit : 3 (Marks: 100)

Syllabus :

Machine tools:Concept and definition of machining and machine tools, Concept of generatrix and directrix, Kinetic chains and structures of conventional machine tools, Various mechanisms for transformation and transfer of motion in machine tools, Classification of machine tools, Lathe – specifications, types, functions of various parts, various operations, Shapers and Planers: specifications, types, functions of various parts, Accuracy, alignment and inspection of machine tools.

Metal cutting: Mechanics of machining, tool geometry in orthogonal and ASA systems, tool angles, conversion of tool angles from one system to the other, mechanism of chip formation, chip morphology, types of chip and formation of Built-Up-Edge (BUE), forces in machining operation, merchants diagram, velocity relationship, derivation of specific energy terms, cutting temperature and cutting fluid, failure, wear and life of cutting tools, Taylor's tool life equations, basic concepts of on-line tool condition monitoring, cutting tool materials.

Lesson plan :

Serial No.	Topics	No. of Lectures
1.	Concept and definition of machining and machine tools, Concept of generatrix and directrix.	02
2.	Kinetic chains and structures of conventional machine tools.	02
3.	Various mechanisms for transformation and transfer of motion in machine tools. Differential mechanisms.	04
4.	Classification of machine tools. Fixed automation.	02
5.	Lathe – specifications, types, functions of various parts, various operations.	04
6.	Shapers and Planers: specifications, types, functions of various parts.	04
7.	Accuracy-Alignment-Inspection of machine tools.	02
8.	Metal cutting: mechanics of machining.	02
9.	Tool geometry in Orthogonal and ASA systems. Tool angles. Conversion of tool angles from one system to other.	04
10.	Mechanism of chip formation, chip morphology, types of chip, and formation of Built-Up-Edge (BUE).	04

11.	Forces in machining operation, Merchants diagram, velocity relationship, derivation of specific energy terms.	04
12.	Cutting temperature and cutting fluid.	02
13.	Failure, wear and life of cutting tools. Taylor's tool life equations. Basic concepts of on-line tool condition monitoring.	04
14.	Cutting tool materials.	02
	Total:	**42**

Text books :

1. Materials and Processes in Manufacturing by E.P. DeGarmo, J.T. Black, R.A Kohser, Prentice Hall of India Pvt. Ltd.
2. Manufacturing Technology by P. N. Rao, Tata McGraw-Hill Publishing Company Limited.
3. A Textbook of Manufacturing Technology by P. C. Sharma, S. Chand and Company Limited.
4. Principles of Metal Cutting, GC Sen, A Bhattacharyya , New Central Book Agency.

Reference books :

1. Manufacturing Processes for Engineering Materials by S. Kalpakjian and S.R. Schmid, Pearson Education India Ltd.
2. Manufacturing Science by A. Ghosh and A. K. Mallik, Affiliated East-West Press Pvt. Ltd.
3. Workshop Technology by W.A.J. Chapman, Viva Books Pvt. Ltd.
4.Production Technology, HMT, Tata McGraw-Hill Education.

Heat Power (ME-3106)
(Only for EE Department)

Weekly Contact Period: 3 L + 0T **Full Marks: 100 (Credit: 3)**

Thermodynamic system, surroundings, properties; processes and cycles; 1st and 2nd laws of thermodynamics, applications to open and closed systems. Ideal and real gases, non-reactive gas mixtures, properties of pure substance (steam); air-water vapour mixture and psychrometry; Power Cycles: Refrigeration Cycles: Heat Transfer Basics; Air Compressors; I.C.Engines; Steam Power Plant cycle and major components; Nuclear Power Plant: principles and types of reactors.

Sl No	Topics	Periods
1.	Introduction to thermodynamics and heat power. Need and objective of the course.	01
2.	Thermodynamics: Thermodynamic system, surroundings, properties; processes and cycles; thermodynamic equilibrium, heat and work, internal energy, enthalpy, 1st and 2nd laws of thermodynamics, applications to open and closed systems.	06
3.	Ideal and real gases: Equation of state, non-reactive gas mixtures, properties of pure substance (steam), steam tables and charts, air-water vapour mixture and psychrometry.	05
4.	Power Cycles: Carnot, Otto, Diesel, Dual, Brayton, and Rankine.	06
5.	Refrigeration Cycles: Air and Vapour Refrigeration Cycles.	04
6.	Heat Transfer: Conduction, Convection and Radiation.	02
7.	Air Compressors: Reciprocating, Centrifugal and Axial flow compressors.	05
8.	I.C.Engines: Principles of SI and CI engines, Four-stroke and two-stroke engines, ideal and actual indicator diagrams, mean effective pressure, power and efficiency.	05
9.	Steam Power Plant: Modified Rankine cycle, superheat, reheat, regeneration and feed water heaters, Boilers, nozzles and turbines, condenser, cooling tower, deaerator.	06
10.	Nuclear Power Plant: Nuclear fission and fusion, types of reactors.	02
Total		**42**

Text Books:

1. Engineering Thermodynamics by P.K.Nag.
2. Thermal Engineering by P.L.Ballaney.
3. I,C. Engines by Ganasan
4. Thermal Engineering by R K Rajput

Reference Books:

1. Applied Thermodynamics for Engineers by Eastop & McConky
2. Power Plant Engineering by P K Nag
3. Power Plant Technology by M. El Wakil

Heat Transfer Laboratory (ME3171)

Contact hours per week : 3 Credit : 2 (Marks: 50)

Sl No.	Name of experiments	No. of Classes
1	Trial and Heat Balance of a Reciprocating Air Compressor.	03
2	Heat Transfer in Forced Convection.	03
3	Determination of Thermal Conductivity of a Metal Bar.	03
4	Heat Transfer in Natural Convection.	03
5	Measurement of Emissivity of a Test Body.	03
6	Heat Pipe Demonstration.	03
	Viva Voce	03
	Total	21

Design of Power Transmission Elements Sessional (ME3172)

Contact hours:0-0- 3 Credit : 2 (Marks: 50)

Sessional Plan

Sl. No.	Topic	No. of Hours
01	**Design of Helical Spring:** Problems on design of single and cluster helical springs under static load, design of heical spring under variable load	06
02	**Design of power transmission shaft:** Problems on **d**esign of shaft based on strength under torsional moment, bending moment and axial load as per ANSI/ASME standard B106.1M-1985, design of shaft based on various design criteria viz. Strength, deflection, slope, torsional rigidity and critical speed	06
03	**Spur Gear:** Problems on compound and epicyclic gear trains, design of spur gears with same and different materials combination	06
04	**Helical Gear:** Problemsonforce analysis and design of helical gear	06
05	**Bevel Gear:** Problems on force analysis and design of bevel gear	06
06	**Rolling contact bearings:** Problemsonthe selection of ball bearings and taper roller bearings as per the catalogue	06
07	Viva – voce	04

Total: 40

Reference Books:

1. Shigley's Mechanical Engineering Design (8th Special Indian Edition), by J.E. Shigley,
2. Machine Design (Schaum's Outline Series), by Hall, Holowenko and Laughlin, McGraw-Hill International Book Company, 1980.
3. Machine Design by R.C.Sharma and D.K.Aggarwal, Kataria Publication

4. Machine Design Data Book, by V.B. Bhandari, McGraw Hill Education (India) Private limited, 2014.

Metal Cutting and Metrology Laboratory (ME3173)

Contact hours per week : 3 Credit : 2 (Marks: 50)

Serial No.	Name of Experiments	No. of Classes
1.	Measurement of chip thickness ratio, shear angle and shear strain in cylindrical turning operation, performed on lathe.	06*
2.	Study of a column and knee type milling machine and calculation of specific power consumption and frictional power loss during slab milling operation.	06
3.	Study of a radial drilling machine and measurement of torque and thrust during drilling operation.	06
4.	Measurement of diameter of a cylindrical hole by two- ball and four-ball method.	06
5.	Measurement of internal taper angle of a tapered hole.	06
6.	Measurement of radii of curvatures of external and internal radius gauges.	06
7.	Measurement of angles by Sine devices.	06
	Total:	**42**

* Considering TWO groups in a section.

HEAT POWER LABORATORY (ME 3174)

(Only for E.E. Department)

Contact Period: 3P **Full Marks: 50 [Credit – 02]**

l No.	Name of experiments	No. of Classes
1	Study of 2-S and 4-S S.I.	03
2	Study of 4-S C.I. Engine	03
3	Study of Fire tube and Water tube boiler.	03
4	Study of vapour compression refrigeration system.	03
5	Measurement of airflow by standard orifice meter.	03
6	Trial of a double acting reciprocating air compressor.	03
7	Diesel engine trial.	03
8	Determination of Relative Humidity of moist air.	03
	Viva Voce	03
	Total	27

6th SEMESTER

INTERNAL COMBUSTION ENGINES AND JET PROPULSION (ME3201)

Contact hours per week: 3L+0T Credit: 3 (Marks: 100)

Basic engine nomenclature and classification, 2 stroke and 4 stroke engine. Actual cycles, valve timing diagram for 2 stroke and 4 stroke SI as well as CI engines.Carburetor: Simple carburetor, its working, mixture requirements of a SI engine, derivation of air fuel ratio for simple carburetor, complete carburetor with attachments, limitation of carburetor basics of petrol injection, Types of fuel injection in SI and CI engines. Ignition system basic principles - Battery and Magneto ignition system, working principle and operation, limitations of conventional breaker operated ignition system, introduction to electronic ignition system. Combustion in SI and CI engines, stages of combustion, factors influencing the combustion phenomenon, abnormal combustion or detonation/knocking, factors responsible for abnormal combustion, types of combustion chamber. Fuels and rating of fuels for internal combustion engine, Fuels for the jet engines, basic overview of alternative fuels, Environmental pollution from vehicles, its measurement and control. Testing and performance characteristics of internal combustion engine and heat balance, engine performance parameters, indicator card. Supercharging and Turbo-charging. Basics of jet propulsion system, Air Breathing engines: Turboprop, Turbojet, Ramjet, Pulse jet. Basics of Rocket and types of propellants used in the rockets.

Lesson plan:

Topics	No. of lecture periods
Basic engine nomenclature and classification, 2 stroke and 4 stroke engine. Actual cycles, valve timing diagram for 2 stroke and 4 stroke SI as well as CI engines.	04
Carburetor: Simple carburetor, its working, mixture requirements of a SI engine, derivation of air fuel ratio for simple carburetor, completecarburetor with attachments, limitation of carburetor basics of petrol injection, Types of fuel injection in SI and CI engines	07
Ignition system basic principles - Battery and Magneto ignition system, working principle and operation, limitations of conventional breaker operated ignition system, introduction to electronic ignition system	06
Combustion in SI and CI engines, stages of combustion, factors influencing the combustion phenomenon, abnormal combustion or detonation/knocking, factors responsible for abnormal combustion, types of combustion chamber	05
Fuels and rating of fuels for internal combustion engine. Fuel used in the jet engines. basic overview of alternative fuels, Environmental pollution from vehicles, its measurement and control	04
Testing and performance characteristics of internal combustion engine and heat balance, engine performance parameters, indicator card.	07
Supercharging and Turbo-charging, Their effect on the engine performance	03
Basics of jet propulsion system, Air Breathing engines: Turboprop, Turbojet, Ramjet, Pulse jet. Basics of Rocket and types of propellants used in the rockets	06
	42

***Text Books**:*

1. Internal Combustion Engines -V. Ganesan- Tata McGraw-Hill Education Private Limited - Fourth edition, printing 2013.
2. Internal Combustion Engines by M.L. Mathur and R.P.Sharma-Dhanpat Rai Publications-printing 2016.
3. A course in Internal Combustion Engines by V.M. Domkundwar and A.V. Domkundwar-Dhanpat Rai and Co.-printing 2013.
4. Gas Turbines - V. Ganesan- Tata McGraw-Hill Education Private Limited –Third edition, printing 2010.

Reference books:

1. Fundamentals of Internal Combustion Engines-Paul W Gill and James H Smith-Oxford and Ibh Publishing Company Pvt. Limited, printing 2007.
2. Internal Combustion Engine Fundamentals – John B. Heywood- McGraw Hill, Inc.-2011.
3. Introduction to Internal Combustion Engines - Richard Stone-Palgrave Macmillan -Fourth Edition, printing 2012.
4. Gas Turbine Theory-H I H Sarvanamutto, H.Cohen, G F C Rogers- Pearson (India) Private Limited-Fifteenth Edition printing 2016.

DESIGN OF FRICTIONAL MACHINE ELEMENTS (ME3202)

Contact Hours: 3-1-0 **Credit:3 (Marks:100)**

Syllabus

Introduction to sliding contact bearings, Classifications, Design of short journal bearings, Thermal effects; Force analysis and design of worm gears, Introduction to braking system, classifications and applications, Design of band, shoe and disc brakes with thermal considerations; Design of frictional clutches with thermal considerations; Design of power screw, Optimization in design: Role and importance, Analytical and numerical optimization procedures, Introduction to software tools for implementation of optimization on design problems.

Lesson Plan

SL. No.	Topics	No. of lectures
1.	Design of infinitely short journal bearings: Basic Assumptions, Petroff's equation of frictional coefficient, Sommerfeld number, Solutions of numerical problems, McKee's coefficient of friction for thermal effect.	06
2.	Design of Worm Gears: Purpose, Classifications and Applications, Nomenclatures and Proportions of Worm Gears, Force Analysis, Friction in Worm Gears, Efficiency of Worm Gear Drive, Selection of Materials, Strength and Wear Rating of Worm Gears, Thermal Considerations	07
3.	Design of Brakes: Purpose, Classifications and Applications, Energy Equations, Block Brake with Short Shoe, Pivoted Block Brake with Long Shoe, Internal Expanding Double Shoe Brake, External Contracting Double Shoe Brake, Band and Disk Brakes, Thermal Considerations.	07
4.	Design of Friction Clutches:Single disc clutch, multiple disc clutch, cone clutch and centrifugal clutch. Calculation of slipping time, energy lost in slipping due to disengagement and re-engagement, temperature rise.	07
5.	Design of power screw: Application and material of power screw, Types of threads, condition for self-locking, maximum efficiency, design of components of a power screw based on strength and lubrication aspects.	05
6.	Design of V-belt drive (Problems with data are to be done by charts in sessional classes)	05
7.	Optimization in design: Multivariable optimization using Lagrange multiplier method, Kuhn-Tucker conditions for solving generalized optimization problems, Global optimality, Numerical methods of optimization of unconstrained and constrained design problems, Use of OPTIMIZATION toolbox in MATLAB in solving problems on Shaft, Spring, Clutch, Gear Boxes, Flag pole etc.	12
8	Class test	01
	Total	50

Text Books:

1. Mechanical Engineering Design (6th International Edition), by J.E. Shigley and C.R. Mischke, McGraw-Hill Publications, 2001
2. Machine Design: An Integrated Approach (3rd Edition), by Robert L. Norton, Prentice Hall, 2006.
3. Introduction to Optimum Design (4th Edition), by J.S. Arora, Academic Press (Elsevier), 2017.
4. Machine Design Data Book, by V.B. Bhandari, McGraw Hill Education (India) Private limited, 2014.

Reference Books

1. Shigley's Mechanical Engineering Design (8th Special Indian Edition), by J.E. Shigley, Charles R. Mischke, Richard G. Budynas and Keith J. Nisbett, The McGraw-Hill Companies, 2008.
2. Machine Design (Schaum's Outline Series), by Hall, Holowenko and Laughlin, McGraw-Hill International Book Company, 1980.
3. Design of Machine Elements, by V.B. Bhandari, Tata McGraw-Hill Publishing Company Limited, 1995.
4. Optimization: Algorithms and Applications, by R.K. Arora., CRC Press (Taylor and Francis), 2015

Modelling and Control of Mechanical Systems (ME3203)

Weekly Contact Period: 3-0-0 **Credit: 3 (Marks: 100)**

Content: Newtonian and Lagrangian Dynamics, Introduction to control systems, Time and frequency response of systems, Characteristics of closed-loop control systems, Stability of systems, Root Locus, State-space formulation of control systems, Computer numerical control of machine tools, Active control of vibration, Active Vibration isolator.

Sl. No.	Topics	No. of periods
1.	**Newtonian and Lagrangian Dynamics:** Generalized coordinates, Generalized force, Euler-Lagrange equation of motion	03
2.	**Introduction to control systems:** System modeling, transfer function, blocks diagram, closed-loop and open-loop systems, actuators and sensors for controlled mechanical systems.	04
3.	**Time and frequency response of systems:** Impulse, step and ramp response, time constant, overshoot in second-order systems, bode plot.	05
4.	**Characteristics of closed-loop control systems:** Sensitivity to modeling errors, disturbance rejection, steady-state errors.	05
5.	**Stability of systems:** Asymptotic stability, bounded input bounded output stability, Routh-Hurwitz stability criterion, Nyquist stability criterion.	05
6.	**Root Locus**	03
7.	**State-Space formulation of Control systems**	03
8.	**Computer Numerical Control of Machine Tools**	05
9.	**Active control of Vibration**	04
10.	**Active Vibration Isolator**	03
		40

Text Books:

1. Control System Engineering by Norman S. Nise, Wiley International Publication.
2. Principles of Passive and Active Vibration Control by Asok Kumar Mallik and Shyamal Chatterjee, Affiliated East West Press, 2014

Manufacturing Technology (ME3204)

Contact hours per week : 3-0-0 Credit : 3 (Marks:100)

Syllabus :

Basic activities of a manufacturing industry and its requirement; Milling machine: specifications, types, functions of various parts, various operations, indexing methods – simple compound and differential indexing. Gear cutting, Grinding machine: types of grinding machines, various grinding operations; grinding wheels, preparation for wheel operation, Multipoint machining - Broaching and Reaming, Finishing operations - Honing and Lapping. Fundamentals of plasticity, yield and flow, anisotropy, instability, limit analysis, slipline field theory. Metal forming processes: Types of forming, mechanism of forming. Fundamentals of metal working processes, Sheet metal forming operations, Defects in metalworking processes.

Lesson plan :

Serial No.	Topics	No. of Lectures
1.	Basic activities of a manufacturing industry and its requirement	02
2.	Milling machine: specifications, types, functions of various parts, various operations.	06
3.	Indexing methods – simple compound and differential indexing. Gear cutting.	04
4.	Grinding machine - types of grinding machines, various grinding operations; Grinding wheels, preparation for wheel operation.	06
5.	Multipoint Machining - Broaching and Reaming.	04
6.	Finishing Operations - Honing and Lapping.	04
7.	Fundamentals of plasticity, yield and flow, anisotropy, instability, limit analysis, slipline field theory.	04
8.	Metal forming processes: Types of forming, mechanism of forming.	02
9.	Fundamentals of metal working processes and Sheet metal forming operations.	08
10.	Defects in metalworking processes.	02
	Total:	**42**

Text books :

1. Manufacturing Science by A. Ghosh and A. K. Mallik, Affiliated East-West Press Pvt. Ltd.
2. Manufacturing Process for Engineering Materials, by S Kalpakjian& SR Schmidt, Pearson Education India, New Delhi, 2009.
3. Fundamentals of Metal Forming Processes by B. L. Juneja, 1e, New Age International Publishers.
4. Mechanical Metallurgy, GE Dieter, McGraw Hill Company.

Reference books :

1. Materials and Processes in Manufacturing by E.P. DeGarmo, J.T. Black, R.A Kohser, Prentice Hall of India Pvt. Ltd.
2. Workshop Technology by W.A.J. Chapman, Viva Books Pvt. Ltd.
3. Modelling Techniques for Metal Forming Processes by GK Lal, PM Dixit, N Venkata Reddy, Narosa Publication, 2011.
4. Principle of Industrial Metal Working Process, GW Rowe, CBS Publication, New Delhi.

Engine Laboratory (ME3271)

ContactHours : 0-0-3 Credit : 2 (Marks:50)

List of Experiments:

Sl No.	Topics
1	Trial of a Lister Engine (Two cylinder diesel engine).
2	Trial of a variable compression ratio engine (Ricardo Engine).
3	Analysis of petrol sample by distillation and to plot the ASTM distillation curve.
4	Measurement of emission level from a spark ignition engine using exhaust gas analyzer
5	Measurement of smoke level (in HSU) from a diesel engine using smoke-meter
6	Study of a MPFI engine model
7	Morse Test on a conventional spark ignition engine.
8	Performance analysis of a compound steam engine
9	Determination of off design performance of a steam nozzle.

DESIGN OF FRICTIONAL MACHINE ELEMENTS SESSIONAL (ME3272)

Contact Hours: (L-T-P) 0-0-3 **Credit:2 (Marks:50)**

Sessional Contents

Design and applications of journal bearings, Force analysis and design of worm gears, Design of band, shoe and disc brakes with thermal considerations; Design of frictional clutches with thermal considerations; Design of power screw, Optimization in design - Analytical and numerical optimization procedures, Use of software tools for implementation of optimization on design problems.

Sessional Plan

SL. No.	Topics	No. of Hours
1.	**Design of Journal Bearings of I.C. Engine**: Design calculation of Forces in the slider crank mechanism at various crank angles, drawing of polar diagram, bearing and oil temperatures, minimum film thickness and oil flow rate for various values of Sommerfeld Number,& graphical plottings.	09
2.	**Design of Worm Gears** based on Strength and Wear Rating of Worm Gears, Gear box design based on thermal considerations	06
3.	**Design of Brakes** - Block Brake with Short Shoe, Pivoted Block Brake with Long Shoe, Internal Expanding Double Shoe Brake, External Contracting Double Shoe Brake, Band and Disk Brakes	03
4.	**Design of Friction Clutches** - Design of cone and disc clutches, calculation of slipping time, energy lost in slipping due to disengagement and re-engagement, temperature rise.	06
5.	**Design of power screw** - design of components of a power screw based on strength and lubrication aspects.	06
6.	**Design of V-belt drive** - Selection of type of V-belt profile and design of pulleys, belt length , centre distance and no of belts required for power transmission as per BIS code	06
7.	Optimization in design: Optimization problems on mechanical components and its solution by using of OPTIMIZATION toolbox in MATLAB	06
8	Sessional Viva Voce Examination	04
	Total	46

Text Books:

1. Mechanical Engineering Design (6th International Edition), by J.E. Shigley and C.R. Mischke, McGraw-Hill Publications, 2001
2. Machine Design: An Integrated Approach (3rd Edition), by Robert L. Norton, Prentice Hall, 2006.

3. Introduction to Optimum Design (4th Edition), by J.S. Arora, Academic Press (Elsevier), 2017.
4. Machine Design Data Book, by V.B. Bhandari, McGraw Hill Education (India) Private limited, 2014.

Reference Books

1. Shigley's Mechanical Engineering Design (8th Special Indian Edition), by J.E. Shigley, Charles R. Mischke, Richard G. Budynas and Keith J. Nisbett, The McGraw-Hill Companies, 2008.
2. Machine Design (Schaum's Outline Series), by Hall, Holowenko and Laughlin, McGraw-Hill International Book Company, 1980.
3. Design of Machine Elements, by V.B. Bhandari, Tata McGraw-Hill Publishing Company Limited, 1995.
4. Optimization: Algorithms and Applications, CRC Press (Taylor and Francis), 2015

Seminar and Group Discussion (ME3273)

Contact Hours : 0-0-3 **Credit : 2 (Marks:50)**

This course is mainly designed to enhance the performance of the students for

(a) Interview preparedness
(b) Group discussion.

Instructors may decide suitable ways to improve the performance of a student depending on his/her strength and weakness. For interview preparedness, mock interview and seminar presentation on a selected topic may be conducted. Special emphasis to be given on self introduction.

Group Discussion is an important skill for placement of the students and it is observed that many students are weak in this section despite their good academic performance.The students be divided in a small groups and they may be allowed to speak within the group on a selected topic as given by the instructor.

Students may be evaluated based on their overall performance or as decided by the instructor.

7th SEMESTER

Refrigeration and Air-Conditioning(ME4101)

Contact Period :3-0-0 **Credit – 3 (Marks : 100)**

Sl No.	Topics	No. of lecture periods
1	Introduction; History of Refrigeration and AC;Applications	1
2	Reverse Carnot cycle and COP of refrigeration and heat pump;	1
3	Vapour compression refrigeration (VCR): Simplesaturatedcycle, Actual VCR cycle, Improvement options: liquid sub-cooling, superheated vapor at suction; Liquid-suction heat exchange; Multistage, multi-evaporator and cascade systems	3
4	Vapour absorption refrigeration systems; Water-Lithium Bromide and Ammonia-Water Pairs.	2
5	Air cycle refrigeration: Reversed Brayton Cycle, Ram Compression, Boot Strap with its variation, Reduced Ambient with its variation	3
6	Refrigerants: Properties, nomenclature and designation	1
7	System components: Compressors, condensers, expansion valves and evaporators.	4
8	Review of Psychrometry; Moist air properties	1
9	Psychrometric Processes inair-conditioning, Room sensible heat factor (RSHF), Cooling coil and bypass factor	2
10	Air washer	1
11	Human comfort; Inside and outside design conditions	2
12	Psychrometry of Air Conditioning Systems: Summer air conditioning with 100% recirculation and partial recirculation, Room load Vs coil load	2
13	Evaporative Air Conditioning Systems; direct, indirect and cascade	2
14	Winter Conditioning and All-Year Air Conditioning Systems	2
15	Cooling And Heating Load Calculations -Solar Radiation Through Fenestration, Fabric Heat Gain/Loss, Ventilation And Infiltration, Estimation of Required Cooling/Heating Capacity Balance point outdoor temperature and its relevance	4
16	Types of Air Conditioning Systems and their selection	2
17	Air Transmission and Distribution: Air handling units (AHU), Ducts and blowers	2
18	Safety in air conditioning systems	1
Total		**36**

Text Books/References :

1. Refrigeration and Air-Conditioning, NPTEL online resources
2. Refrigeration and Air-Conditioning, C P Arora,
3. Refrigeration and Air-conditioning, P L Ballaney
4. Refrigeration and Air Conditioning, W F Stoecker

Advanced Manufacturing Technology (ME4102)

Contact hours per week :3-1-0 Credit : 4 (Marks:100)

Syllabus :

Introduction to Non-traditional manufacturing processes, Differences between traditional and Non-traditional manufacturing, Classification of Non-traditional manufacturing processes, Abrasive Water Jet Machining (AWJM): Equipment, Process principles, Operating parameters, Modelling of Material Removal Rate (MRR), Advantages, Limitations, Different applications, Ultrasonic Machining (USM): Equipment, Process principles, Operating parameters, Advantages, Limitations, Different applications, Chemical Machining (CHM): Equipment, Process principles, Maskants and etchants, Photo-Chemical Machining Advantages, Limitations, Different applications,Electro-Chemical Machining (ECM): Equipment, Process principles, Operating parameters, Modelling of Material Removal Rate (MRR), Advantages, Limitations, Different applications, Electro-Discharge Machining (EDM): Equipment, Process principles, Operating parameters, Modelling of Material Removal Rate (MRR), Wire-Electro-Discharge Machining Process (WEDM), Advantages, Limitations, Different applications, Laser Beam Machining (LBM): Fundamentals of lasing process, Lasing materials, Solid-state and gas lasers, Processing with lasers – cutting, drilling, welding, heat treatment, cladding engraving, marking etc.,Electron Beam Machining (EBM): Equipment, Process principles, Operating parameters, Advantages, Limitations, Different applications, Hybrid and Micro Machining Processes: Introduction to Hybrid Machining, Different Hybrid Machining Processes, Equipment, Process principles, Operating parameters, Advantages, Limitations, Different applications.

Lesson plan :

Serial No.	Topics	No. of Lectures
1.	Introduction to Non-traditional manufacturing processes, Need of Non-traditional manufacturing in the present industrial scenario. Differences between traditional and Non-traditional manufacturing, Classification of Non-traditional manufacturing processes.	04
2.	Abrasive Water Jet Machining (AWJM): Equipment, Process principles, Operating parameters, Modelling of Material Removal Rate (MRR), Advantages, Limitations, Different applications.	06
3.	Ultrasonic Machining (USM): Equipment, Process principles, Operating parameters, Horn design, Modelling of Material Removal Rate (MRR), Advantages, Limitations, Different applications.	04
4.	Chemical Machining (CHM): Equipment, Process principles, Maskants and etchants, Photo-Chemical Machining Advantages, Limitations, Different applications.	04
5.	Electro-Chemical Machining (ECM): Equipment, Process principles, Operating parameters, Modelling of Material Removal Rate (MRR), Advantages, Limitations, Different applications.	04
6.	Electro-Discharge Machining (EDM): Equipment, Process principles, Operating parameters, Modelling of Material Removal Rate (MRR), numerical problems on EDM, Wire-Electro-Discharge Machining Process (WEDM), Advantages, Limitations, Different applications.	06

7.	Laser Beam Machining (LBM): Fundamentals of lasing process, Lasing materials, Solid-state and gas lasers, Processing with lasers – cutting, drilling, welding, heat treatment, cladding engraving, marking etc.	06
8.	Electron Beam Machining (EBM): Equipment, Process principles, Operating parameters, Advantages, Limitations, Different applications.	04
9.	Hybrid and Micro Machining Processes: Introduction to Hybrid Machining, Different Hybrid Machining Processes, Equipment, Process principles, Operating parameters, Advantages, Limitations, Different applications.	04
	Total	**42**

Text books :

1. Nonconventional Machining by P. K. Mishra, Narosa Publishing House.
2. Nontraditional Manufacturing by G. F. Benedict, Marcel Dekkar Inc.
3. Modern Machining Technology Advanced, Hybrid, Micro Machining and Super Finishing Technology – B. Bhattacharyya and B.N. Doloi, Academic Press (Elsevier), USA.

Reference books :

1. Laser Material Processing by W.M. Steen, Springer.
2. Modern Machining Processes by P.C. Pandey and H.S. Shan, Tata McGraw-Hill Publishing Company Limited.
3. Nano systems: Molecular Machinery, manufacturing, and computation by K. Eric Drexler, John Wiley & Sons.

Industrial Engineering and Operations Research (ME4103)

Contact Hours : 3-0-0 Credit : 3 (Marks: 100)

Syllabus :

Introduction to Industrial Engineering and Operation Management. Plant layout, Production planning and control, MRP-I, Aggregate Production Planning. Work study, Motion study, Replacement analysis, Value engineering, Incentive plans, Break-even analysis, Project Management.

Statistical Quality Control, Maintenance and reliability.

Forecasting models, Inventory control, Scheduling and sequencing, Queuing models.

Linear programming problem Formulation of minimization and maximization problems, Simplex and Big-M methods, some special cases of LPP, Concept of duality, primal and dual problem,

Transportation problems, Assignment problems, Network models, PERT, CPM.

Industry 4.0 and Smart Factory: Basic concepts

Serial no	Topics	No. of lecture periods
1.	Introduction to (a) Industrial Engineering and (b) Operation Management with historical references.	02
2.	Plant layout, Production planning and control,	02
3.	Forecasting models.	03
4.	Inventory control: Deterministic Inventory control, Safety stock inventory control system, Materials Requirement Planning,Aggregate Production Planning.	04
5.	Work study, Motion study, Replacement analysis, Value engineering,	03
6.	Statistical Quality Control, Maintenance and reliability.	03
7.	Scheduling and sequencing, Simple queuing models.	03
8.	Incentive plans, Break-even analysis, Project Management.	02
9.	**Linear programming problem**: Introduction to linear programming, linear programming models, algorithms, minimization and maximization problems, Simplex and Big-M methods, some special cases of LPP	05
10.	**Dual-simplex method:** Concept of duality, primal and dual problem, algorithm, problems on dual-simplex methods.	04

11.	**Transportation problems:** Algorithm, North-west corner rule, Vogel's approximation method, U-V method, degeneracy, some special cases on transportation problems	04
12.	**Network models:** Algorithm, problems on Network models.	03
13.	**Industry 4.0 and Smart Factory:** Basic concepts ,	03
	Total	**41**

Text Books:

1. Industrial Engineering and Management by Dr.O.P.Khanna
2. Production Systems: Planning, Analysis, and Control by James L. Riggs, John Willey and Sons.
3. Operations Research - by Hamdy A. Taha, Prentice-Hall of India Private Limited

Reference Books:

1. Operations Research Principles and Practice – by **A. Ravindran, Don T.Phillips and James J. Solberg**- John Wiley & Sons.
2. Quantitative Techniques in Management – by **N.D.Vora** – Tata McGraw- Hill Publishing Company Limited – New Delhi
3. **AmitavaMitra,**Findamentals of Quality Control and Improvement – PHI
4. Factory and Production Management by **K.G.Lockyer** – Publisher – The English Language Book Society and Pitman Publishing.
5. Production and Operations Management by **S.N.Chary** - Tata McGraw – Hill Publishing Company Limited – New Delhi
6. Production systems : planning, analysis, and control / [by] **James L**. **Riggs**. Author. Riggs, James L. Published. New York : Wiley, [1970].
7. Introduction to operations research / **Frederick S. Hillier, Gerald J. Lieberman**.

AUTOMOBILE ENGINEERING (ME4121)
Core Elective -I (Common for all 3 Specializations)

Contact Period :3-0-0 **Credit – 3**

Syllabus:

Introduction- Engine classification, frame, chassis and materials for construction. Automotive electrical system- battery (Lead acid and Alkaline), maintenance free battery, starter system, details of components of conventional ignition system, limitations of conventional ignition system and modern ignition system (Electronic ignition system). Combustion chambers in Spark Ignition and Compression Ignition Engines, Concept of Swirl, Squish and Turbulence. Injection system in Spark Ignition and Compression Ignition Engines- Limitation of Carburetors, TBI Systems, MPFI Engines and its various sub-systems. Engine friction, sources of engine friction, need for lubrication, properties of lubricants, classification of lubricants, types of lubrication systems for automobiles. Heat transfer in engines, engine cooling system- need, types and components. Automotive Steering system-components and functions, manual and power steering. Wheels, wheel alignment parameters, tyres, types of tyre construction and materials. Vehicle transmission system- components and types of drives used. Modern terminologies used in automobiles like ASFS, APDV, ATFT, CVT, ABS. Introduction to Hybrid Electric Vehicles

Topics	No. of lecture periods
Introduction- Engine classification, frame, chassis and materials for construction	01
Automotive electrical system- battery (Lead acid and Alkaline), maintenance free battery, starter system, details of components of conventional ignition system, limitations of conventional ignition system and modern ignition system (Electronic ignition system)	03
Future fuels for Automobiles and their effect on the engine performance	02
Combustion chambers in Spark Ignition and Compression Ignition Engines, Concept of Swirl, Squish and Turbulence	07
Injection system in Spark Ignition and Compression Ignition Engines- Limitation of Carburetors, TBI Systems, MPFI Engines and its various sub-systems	06
Engine friction, sources of engine friction, need for lubrication, properties of lubricants, classification of lubricants, types of lubrication systems for automobiles	04
Heat transfer in engines, engine cooling system- need, types and components	04
Automotive Steering system-components and functions, manual and power steering	03
Wheels, wheel alignment parameters, tyres, types of tyre construction and materials	03
Vehicle transmission system- components and types of drives used	03
Introduction to Hybrid Electric Vehicles, Power and its Propulsion System and Energy management of such vehicles.	05
Modern terminologies used in automobiles like ASFS, APDV, ATFT, CVT, ABS.	01

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Text Books

5. Automobile Engineering - K.K. Ramalingam- Scitech Publications (India) Pvt. Limited-printing 2011
6. A textbook of Automobile Engineering - R.K.Rajput – Laxmi Publications(P) Ltd. – Second edition , printing 2015 .
7. Internal Combustion Engines -V. Ganesan- Tata McGraw-Hill Education Private Limited - Fourth edition, printing 2013.
8. A textbook of Automobile Engineering I and II - P.S.Gill- S.K. Kataria and Sons-Second edition 2012, reprint 2014.

Reference Books

5. Automotive Mechanics by William Crouse and Donald Anglin 10th Edition Tata McGraw Hill Publishing House.
6. Automotive Engineering-An Introduction by Vincent Parese, Clanrye International Publishers, 2018.
7. Automotive Engineering Fundamentals by Richard Stone and Jeffrey K Ball, SAE International Publishers, 2004.
8. Automotive Handbook by Robert Bosch GmbH, SAE International Publishers 10th Edition, 2018.
9. Hybrid Electric Vehicles-Principles and Applications with Practical Perspectives by Chris Mi and M. Abul Masrur, Wiley, 2017.
10. Internal Combustion Engine Fundamentals – John B. Heywood- McGraw Hill, Inc.-2011.
11. Introduction to Internal Combustion Engines - Richard Stone-Palgrave Macmillan -Fourth Edition, printing 2012.

Fundamentals of Tribology (ME4122)

Core Elective -I

Contact Period :3-0-0 **Credit – 3 (Marks:100)**

Syllabus:

Terminology, Engineering surfaces and roughness measurement; Non-conforming surface contact geometry; Adhesion at Solid-Solid Contact, Factors influencing adhesion; Different Wear Mechanisms and Modelling; Tribo-testers; Wear resistance materials; Liquid Lubricants - Properties and Measurement; Lubrication Regimes Versus Film Thickness Ratio

Sl No.	Topics	No. of lecture periods
01	Tribology - Introduction, A brief history of tribology, Industrial importance	02
02	Engineering Surfaces - Properties and Measurement, Contact and Non-contact type surface roughness measuring instruments, Optical & Electron Microscope, Centre Line Average (CLA) and Root Mean Square (RMS) Roughness, Abbott-Firestone Bearing Area Curve, Probability Distribution Function, Skewness, Kurtosis, Auto-correlation Function (ACF), Asperity slope and curvature, Power Spectral Density Function, Fractal Description	06
03	Non-conforming surface contact geometry, Surface and sub-surface stress distributions of point and line contact, Greenwood and Williamson's model for contact between two rough flat surfaces - expected number of asperity contacts, real area of contact and concept of plasticity index	05
04	Adhesion at Solid-Solid Contact, Factors influencing adhesion, E. Rabinowicz's Compatibility Chart of Solid Solubility Versus Work of Adhesion, Genesis of Solid Friction, Amontons laws of friction, Bowden and Tabor's Simple Adhesion Theory, Modified Adhesion Theory - Junction Growth, Deformation Theory - Ploughing	04
05	Wear Mechanisms and Modelling - Adhesive Wear, Abrasive Wear, Erosive Wear, Cavitational Wear, Chemical Wear, Surface Fatigue Wear	07
06	Tribo-testers - Pin/Ball-on-Disc Machine, Talysurf (Surtronic 3^{+}), Optical Profilometer, Electronic Weighing Balance, Ultrasonic Vibro-cleaning Bath, Micro-Hardness Indenter	03
07	Wear Resistant Materials	02
08	Liquid Lubricants - Properties and Measurement, SAE Classifications, Effect of Temperature, Pressure and Shear Rates on	06

	Viscosity, Flash Point, Pour Point, Specific Heat and Thermal Conductivity, Oxidation Stability, Solid Lubricants, Additives	
09	Lubrication Regimes Versus Film Thickness Ratio - Hydrodynamic Hydrostatic Lubrication, Elasto-Hydrodynamic Lubrication (EHL), micro-EHL, Boundary Lubrication Applications	04
10	Class Test	01
	Total	**40**

Text Book :

1. Engineering Tribology - J. A. Williams, Oxford University Press, Reprint 1996

Reference Books :

1.Fundamentals of Fluid Film Lubrication - B. J. Hamrock (McGraw Hill International)
2.The principles of lubrication - A . Cameron, Longman Publication, 1966
3. Engineering Tribology – Prasanta Sahoo, Prentice-Hall of India Pvt. Ltd., 2005
4.Friction and Lubrication of Solids – Part I & Part II , F. P. Bowden and D. Tabor, Oxford University
5.Contact Mechanics – K. L. Johnson, Cambridge University Press
6.Tribophysics – Nam P. Suh, Prentice-Hall INC Press.

Fatigue and Fracture Mechanics (ME4123)

Core Elective -I

Contact Period :3-0-0 **Credit – 3 (Marks:100)**

Syllabus :

High cycle fatigue:- Definition of stress cycles, Stress based fatigue experimentation and presentation of data, Fatigue Life and Endurance limit. The S-N curve and Wohler Diagram. The effect of Mean stress and stress ratio on fatigue life. Effect of notch in fatigue life. Basquin equation for stress based fatigue life calculation. Low cycle fatigue :-Hysteresis loop, cyclic hardening and softening phenomena. Cyclic stress- strain curve. Coffin Masson equation .Total strain life curve. Mean stress correction. Fatigue damage accumulation and Life Exhaustion, Linear damage rule (Palmgren Miner rule). Linear Elastic Fracture Mechanics:- Theoretical Cohesive strength of Material (An Atomic View), Stress concentration effect of Flaws, Griffith Energy Balance. Energy Release Rate, Instability, R - curve .Crack tip stress field , Stress Intensity Factor. Crack tip plastic zone, Plane stress / plane strain fracture Mechanics.Fatigue crack growth. Elastic Plastic Fracture Mechanics:-J Contour Integral . Crack Tip opening displacement (CTOD), J_ R curve , Ductile crack growth and Instability. Determination of critical stress intensity factor (K_{IC}) [ASTM E-399]. Determination of J-R curve (ASTM-1821)

Lesson Plan

Sl.No	Module	Content	Lectures
1.	**Fatigue of Metal**	Concept of Fatigue failure, High Cycle Fatigue, Low cycle fatigue (a)High cycle fatigue(stress based fatigue), Definition of stress cycles, Stress based fatigue experimentation and presentation of data, Fatigue Life and Endurance limit. The S-N curve and Wohler Diagram. The effect of Mean stress and stress ratio on fatigue life. The Soderberg , Goodman and Gerber Plots. Effect of notch in fatigue life. Basquin equation for stress based fatigue life calculation, fatigue strength coefficient and fatigue strength exponent.	**15**
		(b) Low cycle fatigue (strain based fatigue) Hysteresis loop, cyclic hardening and softening phenomena. Steady state loop. Masing and non masing loop. Cyclic stress-strain curve. Coffin Masson equation, Fatigue ductility coefficient and fatigue ductility exponent. Total strain life curve (Morrow' s equation). Mean stress correction i) Morrow's method ii) SWT (Smith Watson Topper) Method.	
		© Fatigue damage accumulation and Life Exhaustion , Linear damage rule (Palmgren Miner rule), Cycle counting methods	

2.	**Linear Elastic Fracture Mechanics (LEFM)**	(a)Theoretical Cohesive strength of Material (An Atomic View), Stress concentration effect of Flaws , Griffith Energy Balance. Energy Release Rate, Instability, R - curve	**07**
		(b)Crack tip stress field analysis , Stress Intensity Factor, K- dominated field , Crack tip plastic zone (Irwin model/ Dugdale model), Plane stress / plane strain fracture Mechanics	**10**
3.	**Fatigue Crack growth**	Paris Law and its modifications, over loading effect, Variable amplitude loading Determination of FCGR Curve	**04**
4.	**Elastic Plastic Fracture Mechanics (EPFM)**	**J** Contour Integral , Path independent of J-integral - Example, Crack Tip opening displacement (CTOD), **J_ R** curve , Ductile crack growth and Instability, Tearing Modulus	**05**
		Total	**41**

Text Books :-

1. Fatigue of Materials – S. Suresh
2. Fracture Mechanics (Fundamental and Application) -- T.L. Anderson

Reference book:-

1. Elementary Fracture Mechanics ---- David Broek
2. Elements of Fracture Mechanics ----- Prasant Kumar

Supplementary Books

1. Theory of Elasticity ------ S.P. Timoshenko & J.N. Goodier
2. Mechanical Behaviour of Materials----- Marc Meyers & Krishna Chawla
3. Mechanical Metallurgy -------George E Dieter

Computational Fluid Dynamics and Heat Transfer(ME4124)

Core Elective -I

Contact Period :3-0-0 **Credit – 3 (Marks:100)**

Syllabus:

Introduction to Computational Fluid Dynamics and Principles of Conservation: Continuity Equation, Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations, Classification of Partial Differential Equations and Physical Behaviour, Fundamentals of Discretization: Finite Difference and Finite Volume Method, Finite Volume Method: Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems, Boundary Condition Implementation and Discretization of Unsteady State Problems, Important Consequences of Discretization of Time Dependent Diffusion Type Problems and Stability Analysis : Consistency, Stability and Convergence, Grid independent and time independent study, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): FTCS (Forward time central space) scheme, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): CTCS scheme (Leap frog scheme), Dufort-Frankel scheme, Stability analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes, Finite Volume Discretization of 2-D unsteady State Diffusion type Problems, Discretization of Convection-Diffusion Equations: A Finite Volume Approach, Discretization of Navier Stokes Equations: Stream Function Vorticity approach and Primitive variable approach, SIMPLE Algorithm, SIMPLER Algorithm.

Lesson Plan

SL. NO.	Topic	No of Lecture
1.	Computational Fluid Dynamics: What, When, and Why?, CFD Applications, Numerical vs Analytical vs Experimental, Modelling vs Experimentation, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation	5
2.	Mathematical classification of Partial Differential Equation, Illustrative examples of elliptic, parabolic and hyperbolic equations, Physical examples of elliptic, parabolic and hyperbolic partial differential equations	4
3.	Fundamentals of Discretization: Preprocessing, Solution, Postprocessing, Finite difference method, Well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples: 1-D steady state heat conduction without and with constant source term	4
4.	Finite Volume Method: Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems: Physical consistency, Overall balance, FV Discretization of a 1-D steady state diffusion type problem, Composite material with position dependent thermal conductivity, Four basic rules for FV Discretization of 1-D steady state diffusion type	5

	problem, Source term linearization, Implementation of boundary condition	
5.	Discretization of Unsteady State Problems	2
6.	Consequences of time-discretization in finite discretization, Consistency, Stability, Convergence, LAX Equivalence theorem, Grid independent and time independent study, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): FTCS (Forward time central space) scheme, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): CTCS scheme (Leap frog scheme), Dufort-Frankel scheme, Stability 4 analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes, Stability analysis of 2nd order hyperbolic equations: CTCS scheme	6
7.	FVM for 2-D unsteady state diffusion problems	2
8.	Discretization of Convection-Diffusion Equations: A Finite Volume Approach: Finite volume discretization of convection-diffusion problem: Central difference scheme, Upwind scheme, Exponential scheme and Hybrid scheme, Power law scheme, Generalized convection-diffusion formulation, Finite volume discretization of two-dimensional convection-diffusion problem, The concept of false diffusion, QUICK scheme	5
9.	Discretization of Navier Stokes Equations: Discretization of the Momentum Equation: Stream Function-Vorticity approach and Primitive variable approach, Staggered grid and Collocated grid, SIMPLE Algorithm, SIMPLER Algorith	5
10	Class Test Viva Voce	02
	Total Number of Classes	40

Text Books:

1. S.V.Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill.
2. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press.
3. John C. Tannehill, Dale A.Anderson and Richard H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor &Francis
4. H.K.Versteeg& W. Malalasekera,An Introduction to Computational Fluid Dynamics, Longman Scientific & Technical.

Welding Technology(ME4125)

Core Elective -I

Contact Period :3-0-0 **Credit – 3 (Marks:100)**

Syllabus:

Fundamentals of arc welding processes, Types of welding, physics ofarc, arc forces, arc blow, selection of power sources fordifferent arc welding processes, principles of weld joint design,welding symbols, metallurgical aspects in welding of steel, heatflow in welding and its effect on the performance of weldjoints, residual stress and distortion in weld joints andassessing the quality and uitability of weld joints, destructiveand non-destructive testing method.

Lesson Plan :

Sl. No.	Topic	Lectures
1.	**Introduction:** Evolution of welding; classification ofwelding processes; heat sources andshielding methods	6
2.	**Physics of Welding Arc** Welding arc; voltage distribution along thearc; hermionic and non-thermioniccathodes; theories of cathode and anodemechanism; arc characteristics and itsrelationship with power source; arcefficiency; heat generation; effect of type ofshielding gas on arc; isotherms of arcs	4
3.	**Welding Power Sources** Conventional welding power sources;constructional features; static and dynamiccharacteristics; duty cycle; influence ofinductance on arc and power source characteristics; internal and externalregulation; specific power sourcerequirements; special welding power sources	3
4.	**Arc Welding Processes** Consumable electrode welding processes.Manual metal arc (MMA) welding; Gasmetal arc welding; pulsed MIG welding;Submerged arc welding, Significance of flux-metal combination; Electroslagwelding: heat generation; principle; Gastungsten arc welding; selection of polarity,Plasma arc welding; transferred and non-transferred plasma arc welding;selection of gases; welding parameters;keyhole technique.	5
5.	**Heat flow in welding** Effect of welding parameter on heatdistribution; calculation of peaktemperatures; thermal cycles; cooling rateand solidification; Residual stresses andtheir distribution in welds; influence ofresidual stresses in static and dynamicloading, distortion	5
6.	**Design of weld joints** Introduction to design; engineeringproperties of steels; Type of welds andweld joints; description of welds:	6

	terminology, definitions and weld symbols;edge preparation; sizing of welds instructure; Design for Static loading, WeldCalculations in lap, butt and fillet welds; design for fatigue loading, Introduction toFatigue; nature of the fatigue process;fatigue strength; factors affecting fatiguelife; improvement methods for fatiguestrength; reliability analysis and safetyfactors applied to fatigue design.	
7.	**Testing and inspection of weld joints** Chemical tests; Metallographic tests;Hardness tests; Mechanical test for grooveand fillet welds-full section, reduced sectionand all-weld- metal tensile tests, root, faceand side bend tests, fillet weld break tests,creep& fatigue testing. Non-DestructiveTesting of Weldments; Visual inspection;Dye-penetrant inspection; Magneticparticle inspection; Ultrasonic inspectionprincipleof ultrasonic testing, Radiographicinspection –principle of radiography, X-raytubes, gamma-ray sources, defect discernibility; Eddy current inspection; Leaktests: N.D.T. Standard procedure forspecification and qualification of weldingprocedure; WPS and PQR, WPQ	6
8.	**Weldability of metals** Solidification of weld metal; heat affectedzone (HAZ), factors affecting properties ofHAZ; gas-metal, slag-metal and solid state reactions in welding and their influence onsoundness of weld joint; lamellar tearingand hydrogen damage; weldability; definition, factor affecting the weldability ofsteel Carbon equivalent. weldablityofsteel, cast iron and aluminium alloys of commercial importance, failure analysis ofwelded joints.	6
	TOTAL	41

Text Book:

Welding Technology & Design – by V.M. Radhakrisnan; New Age International

References:

1. The Metallurgy of Welding, 6th Edition , Lancaster, William Andrew Publishing, NY.
2. Principles of Welding (Processes, Physics, Chemistry and Metallurgy), Robert and Messler, Wiley Interscience Publishers.
3. Welding Hand Book Vol. 5; 7th edition, AWS, 1984.
4. Welding METALLURGY, S Kou, John Wiley, USA, 2003.

CNC Machining and Additive Manufacturing (ME4126)

Core Elective -I

Contact Period :3-0-0 **Credit – 3 (Marks:100)**

Syllabus :

Introduction : Working of CNC machines, Difference between CNC and conventional machine tools, Basic architecture, Classification of CNC systems

Construction : DC/AC Servomotors, Feed drive with recirculating ball screw, Feedback system, Encoders

Interpolation: Basic objectives of interpolation, Principle of Digital Differential Analyzer, DDA Hardware Interpolator- Linear and Interpolators, Stair Approximation Interpolator Direct Search Interpolator,Reference Word Interpolation

Modelling and Design of Control Loop Unit (CLU): Different control loops,Basic Design of CLU

Adaptive Control of Machine Tools: Acceleration and Deceleration control

Part Programming with G-M Code: CNC Lathe & CNC Milling

Additive Manufacturing: General overview; Reverse engineering; AM process chain : CAD to CAM; Application level: Direct processes - Prototyping, Rapid Tooling. Rapid Manufacturing; Indirect Processes - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing; AM technologies; Mathematical models for AM; Parameter control, defects and remedy

Lesson Plan :

Sl. No.	Topic	Lectures
1.	**Introduction :**Working of CNC machines, Difference between CNC and conventional machine tools, Basic architecture, Classification of CNC systems	03
2.	**Construction :**DC/AC Servomotors, Feed drive with recirculating ball screw, Feedback system, Encoders	04
3.	**Interpolation**: Basic objectives of interpolation, Principle of Digital Differential Analyzer,DDA Hardware Interpolator- Linear and Interpolators, Stair Approximation Interpolator Direct Search Interpolator,Reference Word Interpolation	06
4.	**Modelling and Design of Control Loop Unit (CLU):**Different control loops,Basic Design of CLU	04
5.	**Adaptive Control of Machine Tools:**Acceleration and Deceleration control	04
6.	**Part Programming with G-M Code:** CNC Lathe & CNC Milling	06
7.	**Additive Manufacturing:** General overview; Reverse engineering; AM process chain : CAD to CAM; Application level: Direct processes - Prototyping, Rapid Tooling. Rapid Manufacturing; Indirect Processes - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing	04
8.	**AM Technologies:**Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, electron beam melting. involvement). Printing processes (drop!et based 3D Solid-based AM processes - extrusion based fused deposition ;Stereolithography Micro- and nano-additive	04

9.	**Mathematical models for AM:** Transport phenomena models:	03
10.	**AM Parameter control, defects and remedy**	02
	TOTAL	40

Text books

1. Computer Aided Manufacturing: By T.C. Chang, R.A. Wysk, H.P. Wang Prentice Hall International Inc.
2. Introduction to Robotics: By S.K.Saha. Tata McGraw Hill.
3. Robotics and Control: By R. K. Mittal and I. J. Nagrath. Tata McGraw-Hill, New Delhi, 2007.
4. Additive manufacturing technologies: rapid prototyping to direct digital manufacturing - I. Ian Gibson, David W. Rosen, Brent Stucker; Springer, 2010

Reference books

1. Manufacturing Automation: By Y Altintas, Cambridge University Press.
2. Robotics: By S.B. Niku, Wiley Publication, Delhi.
3. Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, - Andreas Gebhardt ;Hanser Publishers, 2011.

Refrigeration and Air-Conditioning Laboratory (ME4171)

Contact Hours : 0 – 0 - 3 Credit:2 (Marks: 50)

List of Experiments

Sl No.	Topics
1	Study of a domestic air-conditioning unit
2	Study of a water chilling plant.
3	Determination of COP of a Vapour Compression Refrigeration (VCR) system.
4	Determination of saturation efficiency of an Air Washer
5	Determination of COP of an aqua ammonia Vapour Absorption Refrigeration (VAR) system.
6	Study of a Lithium Bromide Water Absorption system model.
7	Determination of performance characteristic of a centrifugal blower.
8	Verification of fan laws.
9	Determination of COP of a cascade refrigeration system.

Advanced Manufacturing Laboratory (ME4172)

Contact Hours : 0 – 0 - 3 Credit:2 (Marks: 50)

1. Study of a die-sinking EDM and machining of a blind circular hole. Parametric analysis.
2. Study of Wire-Electro Discharge Machine and performance of 'Machine referencing', 'Edge finding' and 'Centre finding' operations. Actual programming for a real job.
3. CNC Lathe: Study of machine axes and machine parameters.
4. CNC Lathe programming.
5. CNC Milling: Study of machine axes, ATC, Tool magazine and machine parameters.
6. CNC Milling programming.
7. Machining of Spur Gear in a gear hobbing machine.
8. Measurement of face width, pitch circle diameter and backlash in a spur gear manufactured in the above gear hobbing machine.
9. Measurement of force components during cylindrical turning operation using piezoelectric dynamometer.

B.Tech Project Part-I (ME4191)

Contact Hours : 0 – 0 - 2 Credit:4 (Marks: 100)

B.Tech Project (Part-I & II) is of full one year duration. So an involved industry problem or numerical modelling/ simulation may be formulated. For problems relating to industry , students may have to visit plant or company to collect data or for manufacturing some components. Such data may be further analysed to improve the process, to rectify some problem or to find out some important parameter like efficiency. Purely numerical problems also can be taken up on frontier research areas and the same may be validated with the results of similar models in published papers. But only study kind of project, in which the students can not carry out the calculations (or model development etc.) on their own, is not allowed.

Evaluation of Sixth Semester Internship (ME4192)

Contact Hours : 0 – 0 - 0 Credit:2 (Marks: 50)

Students need to submit a Report on Vocational Training which they undergo during the summer vacation after 6th Semester. The report should be signed by the competent authority of the company or the institute where the student had performed the work. At the end of 7th Semester, the students also have to make a presentation before a board constituted by the department and the board will evaluate the presentation as well as the Report submitted.

8th SEMESTER

POWER PLANT ENGINEERING (ME4221)

Core Elective -II

Contact hours per week: 3 – 0 – 0 Credit : 3 (Marks : 100)

Syllabus:

Thermal: Site selection, layout and material estimation.Team power plant performance and auxiliaries, Plant control systems, Coal& ash handling systems. Water chemistry. Binary vapour and Combined cycles. Fluctuating loads in power plants, Economic analysis of power plants and Tariffs. Hydel: Hydro electric power plant. Site selection, Hydrograph, Classification. Dam-Type, Storage type, Mini and Micro Hydel plants. Nuclear reactors andnuclear power plants, Environmental aspects of power generation.

Lesson plan:

Topic	Hours
Thermal: Site selection and Plant layout, Material estimation for thermal power plant	02
Steam Power Plant: Heat balance, Heat rate and Efficiency, plant auxiliaries such as pulverizers, boiler feed pump, vacuum pump and ejector, ID/FD/PA fans etc.coal handling systems, Ash handling systems, Dust collecting devices.	06
Operation and control of thermal power plant: Drum level control, Steam temperature control, Deaerator and H/W level control, Combustion control and FSSS (Furnace Safeguard Supervisory System), Turbine control; Fixed pressure and sliding pressure controls	06
Cooling tower: Classification. Principles of operation, circulation. Wet cooling Tower and cooling fans.	03
Water chemistry and water treatment.	03
Binary vapour and Combined cycles. Ideal working fluid. CHP.	03
Fluctuating loads in power plants and terminologies involved in connection to fluctuating load, Economic analysis of power plants and Tariffs	03
Hydel: Basics of Hydro electric power plant. Site selection and plant layout. Run off and measurement, Hydrograph, Flow duration curve and mass curve.	04
Classification. Storage type power plant, pump storage plant, Mini and Micro Hydel plants. Components of hydel plants, Dam-Types, Spillways and hydraulic turbines.	04
Nuclear reactions, Recapitulation of nuclear reactor, Nuclear power plant-Types of reactors PWR, BWR, PHWR, Liquid metal cooled reactor, Fast Breeder Reactor	04

Environmental aspects of power generation: Emission norms for fossil fuel power plants and emission control systems: SOx and NOx control, Carbon capture and storage,	04
	42

Text Books:

9. Power Plant Engineering by P.K. Nag. (Tata Mc Graw Hill Publishing Company Limited, New Delhi).
10. Power Plant Engineering by V.M. Domkundwar and S.C Arora (Dhanpat Rai and Company Limited).

Reference books:

1. Principles of Energy Conversion by A. W. Culp, McGraw Hill Education Pvt.Ltd
2. Power Plant Technology by M. M. Ei. Wakil, McGraw Hill Education (India) Pvt. Ltd.
3. Power Plant Engineering and Economy by B. G. A. Skrotzki and W. A. Vopat, McGraw Hill Education (India) Pvt.Ltd.

Manufacturing Automation (ME4222)

Core Elective -II

Contact Period :3-0-0 **Credit – 3 (Marks:100)**

Serial No.	Topics	No. of Lectures
1.	An introduction on Manufacturing Automation. Review of the development of machine tools. An introduction on the application of CNC programming on automation.	06
2.	Capstan and Turret lathe. Single-spindle and multi-spindle automatic lathes. Machining centre.	10
3.	Gear Hobbing: Different types of gear manufacturing processes, their advantages, limitations and comparison, principle of spur and helical gear hobbing, characteristics features, kinematics of gear hobbing operation, numerical problems on gear hobbing	12
4.	Computer Integrated Manufacturing (CIM) and Flexible Manufacturing Systems (FMS): Definitions, characteristic features, various components, classification of manufacturing system, different configuration, typical layout of FMS, automated storage and material handling system, comparison between conventional and automated material handling system, a brief introduction on conveyor, pellet, automated guided vehicle system and industrial robot and their specific applications, application of FMS in manufacturing, numerical problems on FMS.	14
	Total	**42**

Text Books:

1. Principle of Machine Tools by G. C. Sen and A. Bhattacharya, New central book agency (P) limited.
2. Automation, Production systems and Computer-integrated manufacturing by M. P. Groover, Prentice Hall of India Pvt. Ltd.

Reference Books:

1. Computer Aided Manufacturing – T.C. Chang, R.AWysk, , H.P.Wang
2. Computer Integrated Design and Manufacturing - D.D. Bedworth, M.R. Henderson, P.M.Wolfe ; Mc Graw Hill Inc.
3. Introduction to Robotics : S.K. Saha, Tata Mc Graw Hill

CAD/CAM Principles and applications : P.N. Rao ; Tata Mc Graw Hill

Finite Element Method for Engineering(ME4223)

Core Elective -II

Contact Period :3-0-0 **Credit – 3 (Marks:100)**

Fundamental concepts of FEM. Direct Stiffness Method for solution of problems on assemblage of 1-D springs/axial bars. Direct Stiffness Method for solution of problems on plane/space truss. Weighted residual method (WRM) for approximate solution of ODE based boundary value problems using point collocation, sub-domain collocation, least square, Rayleigh-Ritz, Galerkin procedures. FE Solution of 1-D boundary value scalar field problems. FE solution of beam (1D vector field) problems under general loading and support conditions. FE formulation and solution of 2D steady state scalar field problems (such as heat transfer, torsion of non-circular shafts). Intrduction to the variational method, Concept of functional, Derivation of functional for different field problems leading to element equation. FE formulation and solution of 2D steady state vector field (plane stress/strain) problems using variational methods.

Lesson Plan

Sl. No.	Topics	Number of Lectures
1.	Introduction to Numerical Methods, Difference between Finite Difference (FD) and Finite Element (FE) Methods. Basic steps of the Finite Element Method. Versatility of FEM and its use in different applications. Review of matrix theory and numerical solution of linear algebraic equations.	3
2.	FE solution of assemblage of linear springs arranged in 1D by direct stiffness method: Discretization, derivation of element equations, assembly rule and imposition of boundary conditions. Solution nodal displacements and calculation of support reactions. Problems.	3
3.	Extension of direct stiffness method from 1D to 2D: Analysis of Plane truss. Derivation of element equations, assembly rule and imposition of BC. Solution for displacements, member forces and support reactions. Special case of inclined roller supports. Problems on plane truss.	5
4.	Approximate solution of boundary value problems involving ODE by the weighted residual method. Weighted integral statement. Point collocation, Least-square, Rayleigh-Ritz and Galerkin procedure. Weak form: primary variables, secondary variables, essential BC, natural BC. Advantages of weak form over strong form. Examples.	5
	Solution of boundary value scalar field problems (such as heat transfer with conduction, surface convection in presence of heat generation) depicted by ODE in 1-D. Deriving Shape functions of a 1-	

5.	D linear and higher order elements, Natural coordinates. Derivation of equation of a finite element from its weak form. Assembly, imposition of BC and solution for primary and secondary variables (PV and SV). Problems.	5
6.	Review of Euler-Bernoulii beam equations. FE formulation of 1D beam problem governed by Euler-Bernoulli equation: Weak form, Galerkin procedure. Introduction to C^1 continuous elements. Isoparametric and sub-parametric formulation, Derivation of element equations, Assembly, Examples under general loading with different cases of supports. Introduction to Frame elements.	5
7.	FE formulation of 2D scalar field problem, Weak form, Galerkin procedure, Area coordinates, 3-node, 6-node triangular elements,. Conforming and non-conforming elements while introducing 4-node and 8-node quadrilateral elements. Coordinate transformation, Jacobian, Parent and child elements. Problems involving 2-D steady state heat transfer with conduction, surface and edge convection, and heat generation, Problems on torsion of non-circular shafts.	8
8.	Stress analysis problems: Plane stress and plane strain type in 2D. Review of equilibrium equation, stress-strain and strain-displacement relation. Introduction to variational formulation, Meaning and derivation of functional in standard form. Variational formulation of 2D stress analysis problems under general loading and heart transfer problems and derivation of their functional. Problems.	5
	CClass test	1
	Total	40

Text Books:

1. Fundamentals of Finite Element Analysis, by David V. Hutton, Tata McGraw-Hill Publishing Co. Ltd., 2005.
2. A First Course in the Finite Element Method (5th Edition), by Daryl L. Logan, Cengage Learning, 2012

Reference Books:

1. An introduction to the Finite Element Method (3rd Edition), by J.N. Reddy, Tata McGraw-Hill, 2005.
2. Introduction to Finite Elements in Engineering, by T.R. Chandrupatla and A.D. Belegundu, Prentice-Hall of India Pvt. Ltd., 1991.

Fluidized Bed Technology(ME4224)

Core Elective -II

Contact Period :3-0-0 **Credit – 3 (Marks:100)**

Syllabus:

Introduction: Fluidized BedBoilers, its features, comparison of technologies
Hydrodynamics: Fluidization regimes, fast fluidized bed and its structure, gas-solid mixing
Heat Transfer: Gas to particle and bed to wall heat transfer, external fluid bed heat exchanger, heat transfer tubes immersed in fast beds, heat transfer and part load operations
Combustion: Stages of combustion, combustion processes in FB boilers, design and performance modelling of FB combustors
Emissions: Air pollution, Sulphur dioxide, nitrogen oxide, nitrous oxide, carbon monoxide emissions
Design Considerations and Design of FB Components: Stoichiometric calculations, heat and mass balance, furnace design, design of heating surfaces, thermal design of a FB boiler, types of nonmechanical valves, L-valve, loop-seal, distributor plates
Gas-Solid Separators: Cyclones, inertial separators

Lesson Plan

Sl. No.	Topics	No. of periods
1.	Introduction: CFB boilers, its features, comparison of technologies	03
2.	Hydrodynamics: Fluidization regimes, fast fluidized bed and its structure, gas-solid mixing	12
3.	Heat Transfer: Gas to particle and bed to wall heat transfer, external fluid bed heat exchanger, heat transfer tubes immersed in fast beds, heat transfer and part load operations	12
4.	Combustion: Stages of combustion, combustion processes in FB boilers, design and performance modelling of FB combustors	03
5.	Emissions: Air pollution, sulphur dioxide, nitrogen oxide, nitrous oxide, carbon monoxide emissions	03
6.	Design Considerations and Design of FB Components: Stoichiometric calculations, heat and mass balance, furnace design, design of heating surfaces, thermal design of a FB boiler, types of nonmechanical valves, L-valve, loop-seal, distributor plates	05
7.	Gas-Solid Separators: Cyclones, inertial separators	04
TOTAL		**42**

Recommended Book:

1. Fluidization Engineering, D. Kunii and O. Levenspiel, Butterworth and Heinemann
Circulating Fluidized Bed Boilers: Design and Operations, P. Basu and S. A. Fraser, Butterworth Heinemann

Robotics (ME4225)

Core Elective -II

Contact Period :3-0-0 **Credit – 3 (Marks:100)**

Contents: Introduction, Robot Arm Kinematics, Differential Motion and Velocity, Robot Dynamics, Robotic Vision System, Trajectory Generation, Robot Programming and Languages.

Lesson Plan:

Module	Topics	Number of Lectures
Introduction	Definition, Law of Robotics, Anatomy of a Robot, Degree of Freedom, Robot Classifications, Geometric Configurations, Robot Specifications.	2
Robot Arm Kinematics	Rigid Body Rotation: Rotation Matrix, Axis-angle or Rodrigues' Rotation Formula, Successive Rotations, Euler Angles. Forward Kinematics: Homogeneous Transformation, Representation of Joints and Link, Denavit-Hartenberg Parameters. Inverse Kinematics: Solvability and Solution Techniques.	10
Differential Motion and Velocity	Differential Motions of Frames and Robot Joints, Robot Jacobian, Inverse Differential Kinematics.	4
Robot Dynamics	Generalized Coordinates, Configuration Space, Holonomic and Non-holonomic constraints, Virtual Work, Lagrange's Equation, Kinetic Energy of a Rigid Body, Kinetic Energy for an n-Link Robot, Equation of Motion for an n-Link, Some Examples.	12
Robotic Vision System	Process of Imaging: Architecture of Vision system, Image Acquisition. Image Digitization and Storage. Image Processing and Analysis: Data reduction, Segmentation, Feature extraction and Object recognition.	5
Trajectory Generation	Joint Space Schemes: Polynomial Trajectories. Cartesian Space Scheme: Straight Line Path, Circular Path.	4
Robot Programming and Languages	Methods of Robot Programming: Lead through Programming Methods, Textual Robot Languages. Elements and Functions of Robot Language, Variable Assembly Language (VAL).	5
	Total	42

References:

1. R. K. Mittal and I. J. Nagrath, Robotics and Control, Tata McGraw-Hill, New Delhi, 2007.
2. M. W. Spong, S. Hutchinson, M. Vidyasagar, Robot Modeling and Control, Wiley, New York, 2005.

3. T. C. Chang, R. A. Wysk, H. P. Wang, Computer aided Manufacturing, Pearson Prentice Hall, 2006.
4. S. B. Niku, Introduction to Robotics: Analysis, Control, Applications, Wiley, New York, 2011.
5. K. S. Fu, C. S. G. Lee and R. Gonzalez, Robotics: Control, Sensing, Vision and Intelligence, Tata McGraw-Hill Education, 1987.
6. M. P. Groover, M. Weiss, R. N. Nagel and N. G. Odrey, Industrial Robotics: Technology, Programming and Applications, Tata McGraw-Hill, New Delhi, 2008.

INTRODUCTION TO BIOMECHANICS (ME4226)

Core Elective -II

Contact Period: 3-0-0 **Credit – 3 (Full Marks: 100)**

Syllabus

Introduction to Biomechanics - Basic terminologies, applications, review of Mechanical Engineering concepts related to Biomechanics. Musculoskeletal system – musculoskeletal anatomy, function ofhuman musculoskeletal system, composition and structure of hard-tissues and soft-tissues. Mechanical properties and biomechanical behaviour of hard- and soft-tissues, bone adaptation, viscoelasticity and anisotropy of bone. Basic biomechanics of human joints – structure, range of motions andmusculoskeletal model of forces for human joints (e.g. hip, knee, and spine). Basic biomechanics oforthopaedic implants: biomaterials for orthopaedic implants, design considerations of artificial joints (e.g. hip, knee, and spine), failure mechanisms, computational and experimental approach for analysis of implants. Bio-Tribology of natural and implanted joints, wear and lubrications.

Lesson Plans

Serial No.	Topics	No. of lecture periods
1.	Introduction to Biomechanics - Basic terminologies, applications, review of Mechanical Engineering concepts related to Biomechanics	03
2	Musculoskeletal system – musculoskeletal anatomy, function of human musculoskeletal system, composition and structure of hard-tissues and soft-tissues	07
3.	Mechanical properties and biomechanical behaviour of hard- and soft-tissues, bone adaptation, viscoelasticity and anisotropy of bone	07
4.	Basic biomechanics of human joints – structure, range of motions and musculoskeletal model of forces for human joints (e.g. hip, knee, and spine).	09
5.	Basic biomechanics of orthopaedic implants: biomaterials for orthopaedic implants, design considerations of artificial joints (e.g. hip, knee, and spine), failure mechanisms, computational and experimental approach for analysis of implants	09
6.	Bio-Tribology of natural and implanted joints, wear and lubrications	05
	Total	**40**

Text Books

1. Basic Biomechanics of the Musculoskeletal System, 4th Edition, M Nordin and VH Frankel, Lippincott Williams and Wilkins, 2012.
2. Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation. 4th Edition, N Ozkaya, D Leger, D Goldsheyder, M Nordin, Springer, 2017.

Reference Books

1. Biomechanics - Mechanical Properties of Living Tissue, YC Fung, Springer Verlag, 1993.
2. Fundamentals of Biomechanics, 2nd Edition, D Knudson, Springer, 2017.

Energy Storage Technology (ME4261)

Open Elective (For other engineering department students, not for M.E.)

Contact Hours : 3-0-0 Credit:3 (Marks:100)

Syllabus:

Need for energy storage, Electrical energy storage system- Battery types and parameters, Lead Acid battery cycle VLRA Battery, Battery charging, Lithium ion battery, Mathematical modeling of lead acid battery, Designer's choice of battery, ultra and super capacitor. Mechanical energy storage device- flywheel, compressed air storage system. Pump storage plants. Hydrogen storage and fuel cell system. Fuel cell types and thermodynamics., efficiency and voltage. Chemical Energy storage- Sensible heat storage system, Latent heat storage system, Thermo-chemical energy storage. Energy storage in phase change material.

Topics	No. of periods
Need for energy storage, Electrochemical energy storage system and Battery, classification and different types: Metal air, Lead Acid, Nickel Cadmium, Sodium Sulphur and Lithium ion battery; Battery characteristics and performance parameters, Secondary battery; charging-discharging cycle, Designer's choice of battery, Electrical energy storage and capacitor: ultra and super capacitors	09
Super conducting Magnetic Energy Storage (SMES)	02
Mechanical energy storage device- flywheel, compressed air storage system. Pump storage plants, merits and demerits.	07
Hydrogen production and storage: Different methods of hydrogen production; chemical, thermo-chemical, photochemical, electro-chemical; electrolyzer and fuel cell. Fuel cell types and thermodynamics, efficiency and voltage. Reversible fuel cell; Thermal splitting of water	08
Other chemical Energy storage- Bio-fuels and Hydrated Salts, Accumulators with internal and external storage. Graphene based composites for electrochemical energy storage	05
Thermal Energy Storage System- Sensible heat storage system, Latent heat storage system, Thermo-chemical energy storage. Concept of solar Pond. Basics of Thermo-electric generator. Heat Pipes and Vapour Chambers.	05
Economics of the Energy Storage, Special considerations for automotive and traction applications	06
	42

Text Books:

1. Energy Storage Systems by David Elliott, IOP Publishing Ltd. Bristol, UK, 2017. ISBN 978-0-7503-1531-9 (ebook).

2. Storing Energy Ist Edition by Trevor Letcher, Imprint Elsevier, 2016, Hardcover ISBN: 9780128034408,eBook ISBN: 9780128034491.

3. Solar Energy: Principles of Thermal Collection and Storage by S. P. Sukhatme and J.K.Nayak, Tata Mc Graw-Hill Publishing Company Limited.

Reference Books:

1. Energy Storage Fundamentals, Materials and Applications by Robert Huggins, Springer US, 2010,ISBN 978-1-4899-9031-0.
2. Energy Storage in Power Systems by Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt, Wiley Publications, 2016, ISBN: 978-1-118-97130-7.
3. Engineering Energy Storage Ist Edition by OdneStokkeBurheim, Academic Press 2017, Paperback ISBN: 9780128141007 and eBook ISBN:9780128141014.

Solar and Wind Energy (ME4262)

Open Elective (For other engineering department students, not for M.E.)

Contact Hours : 3-0-0 Credit:3 (Marks:100)

Syllabus:

Solar radiation: Introduction, Sun as the source of radiation, Solar constant, Spectral distribution of extraterrestrial radiation, Variation of extraterrestrial radiation. Classification of solar radiation: Beam solar radiation, Diffuse solar radiation, Global solar radiation. Solar radiation geometry: Latitude of location, Declination, Hour angle, Slope of surface, Altitude angle, Zenith angle, Solar azimuth angle, Local solar time, Equation of time. Estimation of solar radiation: Average daily global radiation, Average daily diffuse radiation, Hourly global radiation, Hourly diffuse radiation, Angle of incidence on horizontal surface, Angle of incidence on inclined surface, Computation of solar radiation on tilted surface. Measurements of solar radiation: Pyranometer, Pyrheliometer, Sunshine recorder, Spectral measurements, Calibration and standardization of measuring instruments. Solar thermal applications: Basic overview of solar collectors, Flat Plate Collector and its performance analysis, Solar water heating, Solar cooking, Solar desalination, Solar drying of food products, Solar energy for industrial process heat, Solar active heating of buildings, Solar passive heating of buildings, Solar greenhouses, Solar refrigeration, Solar photovoltaic: Fundamentals of photovoltaic conversion, Efficiency of solar cells, Solar modules and array, Balance of system (BOS). Wind Energy Conversion System, Classification of WEC systems, Advantages and Disadvantages of WECS, Types of Wind Machines (Wind Energy Collectors), Analysis of Aerodynamic Forces Acting on the Blade, Performance of Wind- machines, Generating Systems, Applications of Wind Energy and its Environmental Aspects.

Topics	**No. of periods**
Solar radiation: Introduction, Sun as the source of radiation, Solar constant, Spectral distribution of extraterrestrial radiation, Variation of extraterrestrial radiation.	03
Classification of solar radiation: Beam solar radiation, Diffuse solar radiation, Global solar radiation.	02
Solar radiation geometry: Latitude of location, Declination, Hour angle, Slope of surface, Altitude angle, Zenith angle, Solar azimuth angle, Local solar time, Equation of time.	04
Estimation of solar radiation: Average daily global radiation, Average daily diffuse radiation, Hourly global radiation, Hourly diffuse radiation, Angle of incidence on	05

horizontal surface, Angle of incidence on inclined surface, Computation of solar radiation on tilted surface.	
Measurements of solar radiation: Pyranometer, Pyrheliometer, Sunshine recorder.	01
Basic overview of solar collectors, Flat Plate Collector and its Performance Analysis. Solar thermal applications: Solar water heating, Solar cooking, Solar desalination, Solar drying of food products, Solar energy for industrial process heat, Solar active heating of buildings, Solar passive heating of buildings, Solar greenhouses, Solar refrigeration. Introduction to the concentrating collectors	08
Solar photovoltaic: Fundamentals of photovoltaic conversion, Efficiency of solar cells, Solar modules and array, Balance of system (BOS), Standalone system, Grid independent system, Grid interactive system, Photovoltaic applications.	05
Wind Energy Conversion System, Classification of WEC systems, Advantages and Disadvantages of WECS, Types of Wind Machines (Wind Energy Collectors), Basic analysis of Aerodynamic Forces Acting on the Blade, Performance of Wind- machines, Generating Systems, Applications of Wind Energy, Environmental Aspects.	10
Overview of other renewable energy system like Tidal Energy. Ocean Thermal Energy Conversion System. Biomass Energy	02
	40

Text Books:

1. Solar Energy Fundamentals and Applications by H. P. Garg and J. Prakash, Tata Mc Graw-Hill Publishing Company Limited.
2. Solar Energy Fundamentals, Design, Modelling and Applications by G. N. Tiwari, Narosa Publishing House.
3. Wind energy Conversion Systems – Freris L.L. (Prentice Hall1990).
4. Wind Energy Systems – G.L. Johnson (Prentice Hall, 1985)

Reference Books:

1. Solar Energy: Principles of Thermal Collection and Storage by S. P. Sukhatme and J.K.Nayak, Tata Mc Graw-Hill Publishing Company Limited.
2. Solar Engineering of Thermal Processes by John A. Duffie and William A. Beckman, John Wiley and Sons, Inc.
3. Wind Energy Explained – J.F.Manwell, J.G. McGowan and A.L. Rogers (John Wiley & Sons Ltd.)

B.Tech Project Part-II (ME4291)

Contact Period : 0-0-2 **Credit – 8 (Marks:200)**

B.Tech Project Part-I of 7th Semester will be continued and finished in 8th Semester. A Project Report as per the format circulated by the department, has to be prepared and submitted. The report should contain the main sections as below:

1. Introduction and background of the work
2. Literature review
3. Theoretical background and mathematical formulation (if any)
4. Detail description of the work (step-by-step)
5. Results and discussion
6. Conclusions
7. References

As high marks is allotted for this, the all the supervisors of the B.Tech Projects, while evaluating the Project Report, need to check the performance of the students in the Project Seminar.

Project Seminar (ME4292)

Contact Period : 0-0-0 **Credit – 2 (Marks: 50)**

All students need to make a presentation before a board constituted by the department. Presentation should be conducted group-wise but within a group each student will get approximately equal time to present. Once the presentation is complete the board members may ask question on the presentation.

Comprehensive Viva(ME4293)

Contact Period : 0-0-0 **Credit – 2 (Marks:100)**

A board of faculty members will be constituted by the department for the Comprehensive Viva to judge the overall performance of an individual student in the whole engineering course curriculum. This may enhance the performance of the students for the preparedness to face any interview in future.

----------END OF COURSE CONTENT ----------