Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

Course Contents (Syllabus) for

First Year M. Tech.
(Mechanical Design Engineering)
Sem – I to II

AY 2020-21

Professional Core (Theory) Courses

Title of the Course: Research Methodology 4IC501	L	T	P	Cr
	2	-	-	2

Pre-Requisite Courses:

Textbooks:

1. C. R. Kothari, "Research Methodology", New Age international, 2nd edition, 2004.
2. Deepak Chopra and Neena Sondhi, "Research Methodology: Concepts and cases", Vikas Publishing House, New Delhi, 1998
3. Stuart Melville and Wayne Goddard, "Research Methodology: An Introduction for Science & Engineering Students", Tata MacGraw Hill, 2000

References:

1. E. Philip and Derek Pugh, "How to get a Ph. D. – a handbook for students and their supervisors", open university press, 2001
2. Kumar R., "Research Methodology- A step by step guide for beginners", SAGE, 3rd Edition, 2012.
3. G. Ramamurthy, "Research Methodology", Dream Tech Press, New Delhi, 2009.

Course Objectives: The objective of the course is

1. To prepare the students to identify and formulate the research problems,
2. To impart the Knowledge of planning and execution of research project, IPRs, Patents etc
3. To develop the student to prepare and write papers for publications to Conferences and Journals.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Classify the research problem and research plan.	III	Apply
CO2	Analyze the research problem, literature and methodology.	IV	Analyze
CO3	Interpret the research papers, reports, case studies, patent information and database, etc.	V	Evaluate

CO-PO Mapping:

	1	**2**	**3**	**4**	**5**	**6**
CO1	3			2	3	
CO2				1	3	
CO3				1	2	3

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first two modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last two modules) covered after MSE.

Course Contents:

Module 1:	**5 Hrs.**
Meaning of research problem, Sources of research problem, Criteria, Characteristics of a good research problem, and Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	
Module 2:	**4 Hrs.**
Effective literature studies approaches, analysis. Plagiarism, Research ethics.	
Module 3	**5 Hrs.**
Effective technical writing, how to write report, Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	
Module 4:	**4 Hrs.**
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	
Module 5:	**4 Hrs.**
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	
Module 6:	**4 Hrs.**
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	

Module wise Measurable Students Learning Outcomes:

Students will able to

1. Explain the research problem and research plan.
2. Propose methodology for their research topic and understand various analysis techniques.
3. Analyze and interpret the research data.
4. Prepare the conference papers, dissertation report and understand patent related aspects.
5. Handle issues related to IPR.
6. Process and interpret the research data.

Title of the Course: Advanced Stress Analysis 4DE501	L	T	P	Cr
	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. Sadd, Martin H., Elasticity: Theory, applications and Numeric, Academic Press, 2005
2. Boresi, A.P. and K. P. Chong, Elasticity in Engineering Mechanics, Second Edition, John Wiley & Sons, 2000
3. Budynas, R. G. Advance strength and Applied Stress Analysis, Second Edition, WCB/McGraw Hill 1999

References:

1. Dally, J. W. and W.F. Riley, Experimental Stress Analysis, McGraw Hill International, third Edition, 1991
2. Theory of Elasticity – Timoshenko and Goodier, McGraw Hill
3. Advanced Strength of Materials, Vol. 1,2 – Timoshenko, CBS
4. Advanced Strength of Materials – Den Harteg

Course Objectives:

1. To prepare the students to succeed as designer in industry/technical profession.
2. To provide students with a sound foundation in solid mechanics required to solve the problems in Industry.
3. To train the students with good design engineering breadth required for safe and efficient design, Construction, installation, inspection and testing of structural parts of the mechanical system.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Verify basic field equations such as equilibrium equations, compatibility and constitutive relationship	V	Evaluating
CO2	Study basic field equations to torsion, bending and two-dimensional elasticity problems, and energy methods.	IV	Analyzing
CO3	Solve problems in unsymmetrical bending and shear center, contact stresses and pressurized cylinders and rotating discs.	III	Applying

CO-PO Mapping:

PO	1	2	3	4	5	6
CO1			1	3	2	
CO2			2	3		1
CO3	1		1	3		

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Theory of Elasticity	**7 Hrs.**
Analysis of stress, Analysis of stain, Elasticity problems in two dimension and three dimensions, Mohr's circle for three dimensional stresses. Stress tensor, Air's stress function in rectangular and polar coordinates.	
Module 2: Energy Methods	**7 Hrs.**
Energy method for analysis of stress, strain and deflection The three theorem's -theorem of virtual work, theorem of least work, Castiglioni's theorem, Rayleigh Ritz method, Galekin's method, Elastic behavior of anisotropic materials like fiber reinforced composites	
Module 3: Theory of Torsion	**7 Hrs.**
Torsion of prismatic bars of solid section and thin walled section. Analogies for torsion, Membrane analogy, fluid flow analogy and electrical analogy. Torsion of conical shaft, bar ofvariable diameter, thin walled members of open cross section in which some sections areprevented from warping, Torsion of noncircular shaft.	
Module 4: Unsymmetrical Bending and Shear Centre	**6 Hrs.**
Concept of shear center in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending, shear center for thin wall beam cross section, open section with one axis of symmetry, general open section, and closed section.	
Module 5: Pressurized Cylinders and Rotating Disks	**6 Hrs.**
Governing equations, stress in thick walled cylinder under internal and external pressure, shrink fit compound cylinders, stresses in rotating flat solid disk, flat disk with central hole, disk with variable thickness, disk of uniform strength, Plastic action in thick walled cylinders and rotating disc.	
Module 6: Contact stresses	**7 Hrs.**
Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point contact, stress for two bodies in line contact with load normal to contact area and load normal and tangent to contact area. Introduction to Analysis of low speed impact	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1) Analyse stresses in 2D problems
2) Analyse stresses using energy methods
3) Solve problems related to torsional loads
4) Calculate stresses in unsymmetric bending problems
5) Calculate stresses in pressure vessels and discs
6) Formulate problem for contact stresses.

Title of the Course: Advanced Vibration and Acoustics 4DE502	L	T	P	Cr
	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. Thomson W.T., "Theory of Vibrations with applications", George Allen and Unwh Ltd. London, 1981.
2. S.S. Rao, Addison, "Mechanical Vibrations", Wesley Publishing Co., 1990.
3. Leonard Meirovitch, "Fundamentals of vibrations", McGraw Hill International Edition.

References:

1. S. Timoshenko, "Vibration problems in Engineering", Wiley, 1974.
2. Lawrence E. Kinsler and Austin R.Frey, "Fundamentals of acoustics", Wiley Eastern Ltd., 1987.
3. Michael Rettinger, "Acoustic Design and Noise Control", Vol. I & II. , Chemical Publishing Co., New York, 1977.

Course Objectives:

1. To teach the fundamental concept of dynamic analysis of machines.
2. To train students to prepare mathematical model of discrete and continuous mass system and to find response of models for different types of excitations.
3. To introduce students to fundamental concepts of acoustics and its measurement.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Evaluate response of a SDOF system, damped or undamped, subjected to simple arbitrary base or force excitations.	V	Evaluating
CO2	Apply technique of decoupling and orthogonal properties of natural modes to solve differential equations of motion for MDOF systems	III	Applying
CO3	Explain various terminologies used in acoustics and acoustic wave transmission, derive plane and spherical wave equations, and obtain sound pressure level at a given distance from a simple sound source of known strength	IV	Analyzing

CO-PO Mapping:

PO	1	2	3	4	5	6
CO1			2	1	1	3
CO2	1			1	2	3
CO3	1		2			3

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1	**7 Hrs.**
Transient Vibrations, Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel's) integral, impulse response function	
Module 2	**7 Hrs.**
Multi degree of freedom systems, Free, damped and forced vibrations of two degree of freedom systems, Eigen values and Eigen vectors, normal modes and their properties, mode summation method, use of Lagrange's equations to derive the equations of motion,	
Module 3	**7 Hrs.**
Continuous Systems, Natural Vibrations of beams – Differential equation of motion, solution by the method of separation of variables, frequency parameter, natural frequencies and mode shapes, forced vibration of simply supported beam subjected to concentrated harmonic force at a point, Mode summation method, discretized models of continuous systems and their solutions using Rayleigh – Ritz method	
Module 4	**6 Hrs.**
Vibration Control, Methods of vibration control, principle of superposition, Numerical and computer methods in vibrations: Rayleigh, Rayleigh-Ritz and Dunkerley's methods, matrix iteration method for Eigen-value calculations, Holzer's method	
Module 5	**7 Hrs.**
Plane acoustic waves, Sound speed, characteristic acoustic impedance of elastic media, sound intensity, dB scale, Transmission Phenomena, transmission from one fluid medium to another, normal incidence, reflection at the surface of a solid, standing wave patterns, Symmetric Spherical waves, near and far fields, simple models of sound sources, sound power, determination of sound power and intensity levels at a point due to a simple source	
Module 6	**6 Hrs.**
Psychoacoustics, Speech, mechanism of hearing, thresholds of the ear – sound intensity and frequency, loudness, equal loudness levels, loudness, pitch and timbre, beats, masking by pure tones, masking by noise.	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Calculate system response to transient vibrations
2. Determine motion response for multi degree systems.
3. Find natural frequency for continuous system
4. Select appropriate methods for vibration control
5. Understand concept of sound propagation
6. Appreciate sound characteristics and relation with human hearing

Professional Core (Lab) Courses

Title of the Course: Design Engineering Lab 1, 4DE551	L	T	P	Cr
	-	-	4	2

Pre-Requisite Courses:

Textbooks:

1. Kumar D.S Mechanical Measurement and Control, Metropolitan Book Co. Pvt. Ltd., New Delhi, 4th Edition, 2007.
2. Beckwith and Buck, Mechanical Measurement, Pearson Education Asia, 5th Edition, 2001.
3. Rao S. S. Mechanical Vibrations, Pearson education, 5th edition, 2010.

References:

1. Doebel in Emesto, Measurement Systems, McGraw Hill International Publication Co. New York,4th Edition,1990
2. Reddy J. N , An Introduction to Finite Element Method; 2/e, McGraw Hill International Editions, 3rd Edition, 2008
3. Rettinger Michael, "Acoustic Design and Noise Control", Vol. I &II, Chemical Publishing Co. New York, 1st edition, 1977

Course Objectives:

At the end of the course:

1. Students will be able to use various experimental techniques relevant to the subject.
2. Students will acquire hands on experience on the various test-rigs, Experimental set up.
3. Students will be able to function as a team member
4. Students will develop communication skills.
5. Students will be able to write technical reports.
6. Students will be able to use different software's.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Solve field problems by using different vibration controlling techniques.	III	Applying
CO2	Measure transmissibility characteristics of a system	V	Evaluating
CO3	Identify different measurement techniques	IV	Analyzing

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	3	2				3
CO2	2		3			3
CO3	1		3			2

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25

LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

Course Contents:

List of Experiments for Advanced Stress Analysis (Minimum eight experiments) 1. To calibrate the Bourdon Tube Pressure Gauge. 2. To carry out the speed measurement. 3. To carry out the strain measurement. 4. To measure the displacement by using LVDT. 5. To measure vacuum by using pressure gauge. 6. To find out stress-strain curve by using Tensile Test. 7. To find out impact energy of the specimen by Impact Test 8. To find out the surface hardness by Hardness Test. 9. To measure the overall vibration of a rotary machine.	**20 Hrs**
List of Experiments for Advanced Vibrations and Acoustics (Minimum ten experiments) 1. To determine natural frequency of single degree of freedom spring mass system. 2. To determine natural frequency of two degree of freedom spring mass system. 3. To determine natural frequency of double pendulum system 4. To plot response curve of system under forced vibration 5. To determine mode shapes of a thin plate. 6. To perform noise measurement and addition /subtraction of noise levels. 7. To carry out 1/3rd octave band analysis of machine noise. 8. To write matlab programme for eigen value solutions. 9. To find motion transmissibility curve for given setup. 10. To find out force transmissibility for given setup. 11. To design dynamic vibration absorber for given spring mass damper system. 12. To carry out the lumped mass system analysis (Building Model). 13. To write matlab programme for phase plane plot 14. To draw Simulink matlab model for single degree freedom spring mass damper system 15. To draw Simulink matlab model for double degree freedom spring mass damper system 16. Industrial visit	**24 Hrs**

Professional Elective (Theory) Courses

Title of the Course: Advanced Machine Design 4DE511 Professional Elective 1	L 3	T -	P -	Cr 3

Pre-Requisite Courses:

Textbooks:

1. Ulrich K.T. and Eppinger S., Product Design and Development, McGraw-Hill Education; 5th edition, 2011
2. Dieter G.E., Engineering Design, McGraw-Hill Education 5th edition, 2012
3. Prashant Kumar, Product Design, Creativity, Concepts and Usability, PHI New Delhi, 1st edition, 2011

References:

1. John J.C., Design Methods, Wiley Inter science, 2nd edition, 1970
2. Law A. M. and Kelton W.D, Simulation, Modelling and Analysis, McGraw Hill Education, 4th edition, 2017
3. Pahl G. and W. Beitz, Engineering Design- a Systematic Approach, Springer, 2nd edition, 1996.

Course Objectives:

1. To prepare the students to succeed as designer in industry /technical profession.
2. To provide students the knowledge of steps involved in design and developments of industrial product.
3. To prepare the students to use knowledge of ergonomics, aesthetics for development of industrial Product.
4. To prepare the students to use knowledge of rapid prototyping, value analysis, standardization for development of industrial Product.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Bloom's Cognitive Descriptor
CO1	Demonstrate an ability to recognize the need of society to design the products as per their requirements	III	Applying
CO2	Recommend appropriate changes to apply aesthetic and ergonomic concepts to product	V	Evaluating
CO3	Design and develop the products by using principles of DFMA, rapid prototyping, reliability and economy	VI	Creating

CO-PO Mapping:

PO	1	2	3	4	5	6
CO1	3		2	3	1	
CO2	1		1	2		
CO3	3					2

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Product Development Process	**7 Hrs.**
Development processes and organizations, Product Planning Product development management establishing the architecture, clustering geometric layout development - Fundamental and incidental interactions - related system level design issues	
Module 2: Concept Generation	**6 Hrs.**
Need Identification and problem definition, product specification, concept generation and selection, evaluation, creativity methods, Concept testing	
Module 3: Ergonomics and Aesthetics	**6 Hrs.**
Industrial design, Design for Emotion and experience, Introduction to retrofit and Eco design, Human behavior in design, ergonomics and aesthetics	
Module 4: Robust Design	**7 Hrs.**
Design for Reliability, strength based reliability, parallel and series systems, robust design, Integrate process design, Managing costs, Robust design, Integrating CAE, CAD, CAM tools, Simulating product performance and manufacturing processes electronically, Need for industrial design-impact	
Module 5: Design for Manufacturing and Assembly	**7 Hrs.**
Design for manufacture, assembly, maintenance, casting, forging, Estimation of Manufacturing cost, reducing the component costs and assembly costs, Minimize system complexity	
Module 6: Rapid Prototyping	**7 Hrs.**
Rapid Prototyping Liquid based processes, Powder based processes and Solid based processes; Classes of RP systems: 3D Printers, Enterprise Prototyping centers, Direct digital tooling, Direct digital manufacturing, system classification, RP Applications	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Demonstrate that creativity, manufacturability, assembly, maintainability, emotions, reliability are also important aspects of design other than finding dimensions and stresses in the highly competitive, dynamic and customer centered market.
2. Demonstrate the ability to identify needs of the customer and convert them into technical specifications of a product.
3. Recommend the changes in existing design while designing for manufacture, assembly, emotions and maintenance.
4. Design the components considering strength based reliability.
5. Design a product after identifying the need and determining the specifications and constraints of a product for a particular purpose.
6. Recommend various methods of rapid prototyping the products to test and modify the designs.

Title of the Course: Design for Manufacturing and Assembly 4DE512 **Professional Elective 1**	L	T	P	Cr
	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. Rao S. S., Engineering Optimization: theory and practice, John Wiley, 2nd edition, 1996.
2. Ashby M. F. and Johnson K, Materials and Design - the art and science of material selection in product design, Pearson publications,3rd edition, 2002.
3. G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, 2nd edition, 2006.

References:

1. Bralla J G, Handbook for Product Design for Manufacture, McGraw Hill, 2nd edition, 2003.
2. ASTM Design handbook.
3. Courtney T H, Mechanical Behavior of Materials, McGraw Hill, 4th edition, 2008.
4. Swift K G and Booker J D, Process selection: from design to manufacture, London: Arnold,1997

Course Objectives:

1. To provide the students the knowledge of different steps involved in Product Development Cycle.
2. To prepare the students to use knowledge of manufacturing process.
3. To prepare the students to succeed as designer in industry /technical profession.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Explain the product development cycle	IV	Analyzing
CO2	Study the principles of assembly to minimize the assembly time	V	Evaluating
CO3	Interpret the effect of manufacturing process and assembly operations on the cost of product	III	Applying

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1		2	2		3	
CO2	3			2	2	
CO3		2	3		2	

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1	**6 Hrs.**
Introduction Need Identification and Problem Definition, Concept Generation and Evaluation, Embodiment Design, Selection of Materials and Shapes	
Module 2	**6 Hrs.**
Properties of Engineering Materials, Selection of Materials – I, Selection of Materials – II, Case Studies – I, Selection of Shapes, Co-selection of Materials and Shapes, Case Studies – II,	
Module 3	**6 Hrs.**
Selection of Manufacturing Processes, Review of Manufacturing Processes, Design for Casting, Design for Bulk Deformation Processes, Design for Sheet Metal Forming Processes,	
Module 4	**6 Hrs.**
Design for Machining, Design for Powder Metallurgy, Design for Polymer Processing, Co-selection of Materials and Processes, Case-Studies – III	
Module 5	**10 Hrs.**
Design for Assembly, Review of Assembly Processes, Design for Welding – I, Design for Welding – II, Design for Brazing and Soldering, Design for Adhesive Bonding, Design for Joining of Polymers, Design for Heat Treatment, Case-Studies - IV	
Module 6	**6 Hrs.**
Design for Reliability, Failure Mode and Effect Analysis and Quality, Design for Quality, Design for Reliability, Approach to Robust Design, Design for Optimization,	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Explain the product development cycle
2. Solve the manufacturing issues that must be considered in the mechanical engineering design Process
3. Study the principles of assembly to minimize the assembly time
4. Explain the effect of manufacturing process and assembly operations on the cost of product
5. Be familiar with tools and methods to facilitate development of manufactural mechanical designs
6. Know Reliability approach of design.

Title of the Course: Mathematical Methods in Engineering 4DE513 **Professional Elective 1**	L	T	P	Cr
	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. Ronald E, Walpole, Sharon L. Myers, Keying Ye, *Probability and Statistics for Engineers and Scientists* (8th Edition), Pearson Prentice Hall, 07

2. J. B. Doshi, *Differential Equations for Scientists and Engineers*, Narosa, New Delhi, 10

References:

1. Douglas C. Montgomery, *Design and Analysis of Experiments* (7th Edition), Wiley Student Edition, 09.

2. S. P. Gupta, *Statistical Methods*, S. Chand & Sons, 37th revised edition, 08

3. William W. Hines, Douglas C. Montgomery, David M. Goldsman, *Probability and Statistics for Engineering*, (4th Edition), Willey Student edition, 06.

4. Advanced Engineering Mathematics (9th Edition), Erwin Kreyszig, Wiley India (13)

Course Objectives:

1. To make students to organize systems of equations, their algebraic and graphical representations, and their use in practical applications.
2. To prepare students to outline the physical systems and formulate mathematical models for them.
3. To make students to solve differential equations using numerical techniques and transform technique.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Apply statistical techniques to analyze multivariate functions.	III	Applying
CO2	Evaluate solution of engineering problems by applying the knowledge of ordinary and partial differential equations	V	Evaluating
CO3	Analyze nature of a given wave equation and obtain solution from the perspective of D'Alembert principle and/or by method of separation of variables	IV	Analyzing

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	3		1	2		3
CO2	2			1	1	2
CO3	1		1	2		

Assessments:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Introduction to Probability Theory	**5 Hrs.**
Probability Theory and Sampling Distributions. Basic probability theory along with examples.	
Module 2: Probability distributions and theorems	**5 Hrs.**
Standard discrete and continuous distributions like Binomial, Poisson, Normal, Exponential etc. Central Limit Theorem and its significance. Some sampling distributions like x^2, t, F.	
Module 3: Testing of Statistical Hypothesis	**8 Hrs.**
Testing a statistical hypothesis, tests on single sample and two samples concerning means and variances. ANOVA: One – way, Two – way with/without interactions.	
Module 4Ordinary Differential Equations:	**7 Hrs.**
Ordinary linear differential equations solvable by direct solution methods; solvable nonlinear ODE's;	
Module 5: Partial Differential Equations and Concepts in Solution to Boundary Value Problems:	**7 Hrs.**
Solution methods for wave equation, D'Alembert solution, potential equation, properties of harmonic functions, maximum principle, solution by variable separation method	
Module 6: Major Equation Types Encountered in Engineering and Physical Sciences	**8Hrs.**
Solution methods for wave equation, D'Alembert solution, potential equation, properties of harmonic functions, maximum principle, solution by variable separation method	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Use appropriate sampling technique for given application
2. Analyse different methods for testing statistical hypothesis.
3. Solve ODE for linear systems
4. Solve partial differential equation
5. Select correct solution method for solving various problems.

Title of the Course: Reliability Engineering 4DE514	L	T	P	Cr
Professional Elective 1	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. Balagurusmy E., "*Reliability Engineering"*, Tata McGraw-Hill Publishing Co. Ltd., 1984.
2. Birolini Alessandro, "*Reliability Engineering",* Springer, Seventh Edition, 2013.
3. Modarres M, Kaminskiy M, "*Reliability Engineering and Risk Analysis-A Practical Guide",* CRC Press, Second Edition, 2010.

References:

1. Ebiting Charles E., "*Introduction to Reliability and Maintainability Engineering*", Waveland Pr Inc., Second edition, 2009.
2. Kapoor K.C., Lamberson L.R., "*Reliability in Engineering Design*", John Wiley & Sons, First edition, 1977.
3. Rao S.S., "*Reliability Based Design*", Tata McGraw Hills, 1st edition, 1980.

Course Objectives:

1. To prepare the students to compute reliability engineering parameters and estimates for applications in mechanical devices
2. To provide knowledge of reliability and maintainability of machines and systems.
3. To train the students to apply knowledge of probability for reliability analysis of machines and mechanisms.
4. To teach use reliability theory for product life calculation and for maintenance of machines and mechanical systems.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Apply various probability distributions theory for reliability analysis.	III	Applying
CO2	Evaluate reliability analysis of mixed and complex systems.	V	Evaluating
CO3	Design a machine element based on reliability theory.	VI	Creating

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	2		2			2
CO2	3		2			2
CO3	3		2			3

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1 Fundamental Concepts	**6 Hrs.**
Introduction to reliability, History, Reliability terminologies, Failure, Failure density, Failure Rate, Hazard Rate, Mean Time To Failure, MTBF, Maintainability, Availability, PDF, CDF, Safety and reliability, Quality, Cost and system effectiveness, Life characteristic phases, Modes of failure, Areas of reliability, Quality and reliability assurance rules, Product liability, Importance of reliability,	
Module 2 Probability and Reliability	**7 Hrs.**
Basic probability concepts, Laws of probability, Introduction to independence, mutually exclusive, conditional probability, Discrete and continuous probability distributions, Comparison of probability distributions - Binomial, Normal, Lognormal, Poisson, Weibull, Exponential. Standard deviation, Variance, Mean, Mode and Central limit theorem.	
Module 3 System Reliability and Modelling:	**7 Hrs.**
Series, Parallel, Mixed configuration, k- out of n structure, Complex systems- enumeration method, Conditional probability method, Cut set and tie set method, Redundancy, Element redundancy, Unit redundancy, Standby redundancy and its types, Parallel components, Single redundancy, Multiple redundancy.	
Module 4 Maintainability and Availability:	**6 Hrs.**
Objectives of maintenance, Types of maintenance, Maintainability, Factors affecting maintainability, System down time, Availability - inherent, achieved and operational availability. Introduction to Reliability Centered Maintenance.	
Module 5 Reliability in Design & Development	**7 Hrs.**
Failure mode effects analysis, Severity/Criticality analysis, FMECA examples, RPN, Ishikawa diagram for failure representation, Fault tree construction, Basic symbols development of functional reliability Block diagram, Fault tree analysis, Fault tree evaluation techniques, Minimal cut set method, Delphi methods, Monte Carlo evaluation.	
Module 6 Reliability Testing	**7 Hrs.**
Introduction to reliability testing, Stress strength interaction, Introduction to Markov model. Testing for Reliability and Durability- Accelerated Life Testing and Highly Accelerated Life Testing (HALT), Highly Accelerated Stress Screening (HASS).	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Explain concept of reliability and its terminologies.
2. Apply various probability distributions theory for reliability analysis.
3. Estimate reliability analysis of mixed and complex systems.
4. Discuss concept of reliability and maintainability of machines and systems
5. Perform failure mode analysis.
6. Design machine elements based on reliability theory and evaluate product life of machine components and system.

Title of the Course: Advanced Engineering Materials 4DE515	L	T	P	Cr
Professional Elective 2	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. Materials Science and Engineering, William D. Callister, Jr, John Wiley & sons, 07
2. Modern Physical Metallurgy and Material Engineering, Science, Process, application, Smallman R.E., Bishop R J, Butterworth Heinemann, Sixth Ed., 1999.
3. Essentials of Materials Science & Engineering,Donald R. Askeland, Wendelin J. Wright,PradeepFulay

References:

1 Sidney H. Avener, *Physical Metallurgy*, Tata McGraw Hill Education Private Limited, 2nd Edition, 1997

2 George E. Dieter, *Mechanical Metallurgy*, Tata McGraw Hill Publication, Si Metric Edition, 3rd Revised edition, 2013.

3 Ashok Sharma, Rajan, Heat Treatment: Principles & Techniques, Phi Learning Pvt. Ltd-New Delhi, 2nd edition, 2011.

Course Objectives:

1. To demonstrate understanding Mechanical properties of materials and influence of imperfections over mechanical properties.
2. To demonstrate understanding phase diagrams and their use in predicting phase transformation and microstructure also understand and predict various types of failures using concept of fracture mechanics, creep and effect of impact.
3. To recognize Electrical, Thermal, Optical and Magnetic Properties of metals, ceramics, polymers and composites and understand the economic considerations in usage and recycling of materials in human use.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Apply knowledge of mechanics, physical and chemical properties of materials including metals, ceramics, polymers and composites and imperfections and their effects on mechanical properties of materials and cause of failure.	III	Applying
CO2	Examine phase diagrams in predicting phase transformation and microstructure.	V	Evaluating
CO3	Recognize Electrical, Thermal, Optical and Magnetic Properties of metals, ceramics, polymers and composite.	VI	Creating

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	1		2	3	1	2
CO2			2	3	1	
CO3		1	2		3	1

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1	**7 Hrs.**
Introduction, Atomic Structure, Interatomic Bonding and Structure of Crystalline Solids: Historical perspective of Materials Science. Why study properties of materials? Classification of materials. Advanced Materials, Future materials and modern materials, Atomic structure. Atomic bonding in solids, Crystal structures, Crystalline and noncrystalline materials. Miller indices. Anisotropic elasticity. Elastic behaviour of composites. Structure and properties of polymers. Structure and properties of ceramics.	
Module 2	**7 Hrs.**
Imperfections in Solids and Mechanical Properties of Metals, Diffusion, Dislocations and Strengthening Mechanisms: Point defects. Theoretical yield point. Line defects and dislocations. Interfacial defects. Bulk or volume defects. Atomic vibrations; Elastic deformation. Plastic deformation. Interpretation of tensile stress-strain curves Yielding under multiaxial stress. Yield criteria and macroscopic aspects of plastic deformation. Property variability and design factors, Diffusion mechanisms. Steady and non-steady state diffusion. Factors that influence diffusion. Non-equilibrium transformation and microstructure, Dislocation and plastic deformation. Mechanisms of strengthening in metals. Recovery, recrystallization and grain growth. Strengthening by second phase particles. Optimum distribution of particles. Lattice resistance to dislocation motion.	
Module 3	**7 Hrs.**
Phase Diagrams Equilibrium phase diagrams. Particle strengthening by precipitation. Precipitation reactions. Kinetics of nucleation and growth. The iron-carbon system. Phase transformations. Transformation rate effects and TTT diagrams. Microstructure and property changes in iron-carbon system	
Module 4	**7 Hrs.**
Fracture. Ductile and brittle fracture. Fracture mechanics. Impact fracture. Ductile brittle transition. Fatigue. Crack initiation and propagation. Crack propagation rate. Creep. Generalized creep behaviour. Stress and temperature effects	
Module 5	**7 Hrs.**
Applications and Processing of Metals and Alloys, Polymers, Ceramics, and	

composites: Types of metals and alloys. Fabrication of metals. Thermal processing of metals. Heat treatment. Precipitation hardening. Types and applications of ceramics. Fabrication and processing of ceramics, Mechanical behaviour of polymers. Mechanisms of deformation and strengthening of polymers. Crystallization, melting and glass transition. Polymer types. Polymer synthesis and processing, Particle reinforced composites. Fibre reinforced composites. Structural composites	
Module 6	**5 Hrs.**
Electrical, Thermal, Optical and Magnetic Properties and economic Considerations: Electrical conduction. Semi conductivity. Super conductivity. Dielectric behaviour. Ferroelectricity. Piezoelectricity Heat capacity. Thermal expansion. Thermal conductivity. Thermal stresses Diamagnetism and Para magnetism. Ferromagnetism.Antiferromagnetism and ferrimagnetism. Influence of temperature on magnetic behaviour. Economic, Environmental and Social Issues of Material Usage - Economic considerations. Environmental and societal considerations. Recycling issues. Life cycle analysis and its use in design	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Understand Atomic Structure, Interatomic Bonding and Structure of Crystalline Solids
2. Understand Imperfections in Solids and Mechanical Properties of Metals, Diffusion, Dislocations and Strengthening Mechanisms.
3. Understand Phase Diagrams.
4. Understand Fracture mechanics and Creep behavior.
5. Understand Applications and Processing of Metals and Alloys, Polymers, Ceramics, and Composites.
6. Understand Electrical, Thermal, Optical and Magnetic Properties and economic Considerations in Materials Engineering.

Title of the Course: Mechanics of Composite Materials 4DE516 **Professional Elective 2**	L	T	P	Cr
	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. WD Callister, Materials Science and Engineering, An introduction., John Wiley & Sons, NY, Indian edition, 2007
2. Bhagwan D. Agarwal, Lawrence J. Broutman, Analysis and Performance of fiber composites, John Wiley and Sons, Inc. 1990.

References:

1. Isaac M. Daniels, OriIshai, Engineering Mechaincs of Composite Materials, Oxford University Press, 1994.
2. Mazumdar S. K., Composite Manufacturing – Materials, Product and Processing Engineering, CRC Press, Boca Raton, 2002
3. Robert M. Jones, Mechanics of Composite Materials, Taylor and Francis, Inc., 1999.

Course Objectives:

1. To teach students treatment of the classification and properties of composite materials, of the different ways composites can be laid up and how they can be analyzed, with emphasis on physical understanding.
2. To perform independent analysis of the composite materials which is increasing used in many fields e.g. in transportation (sea, land, air, space), the oil industry, civil engineering construction, sports equipment, biomechanics and medicine.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Identify the properties of fiber and matrix materials used in commercial composites, as well as some common manufacturing techniques.	V	Evaluating
CO2	Analyze a laminated plate in bending, including finding laminate properties from lamina properties and find residual stresses from curing and moisture.	IV	Analyzing
CO3	Predict the failure strength of a laminated composite plate Knowledge of issues in fracture of composites and environmental degradation of composites.	V	Evaluating

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	1			3		2
CO2	2		3			2
CO3	2		3	2		2

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1 Introduction to composite material	**7 Hrs.**
characteristics, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus	
Module 2 Basic Concepts and Characteristics	**7 Hrs.**
Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials	
Module 3 Reinforcements	**7 Hrs.**
Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.	
Module 4 Manufacturing of Metal Matrix Composites	**7 Hrs.**
Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.	
Module 5 Manufacturing of Polymer Matrix Composites	**7 Hrs.**
Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.	
Module 6 Strength	**6 Hrs.**
Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.	

Module wise Measurable Students Learning Outcomes:
After the completion of the course the student should be able to:

1. Elucidate to recent developments in composites, including metal and ceramic matrix composites.
2. Identify the properties of fiber and matrix materials used in commercial composites, as well as some common manufacturing techniques.
3. Predict the elastic properties of both long and short fiber composites based on the constituent

properties.

4. Explain the basic concepts and difference between composite materials with conventional materials.
5. Analyze a laminated plate in bending, including finding laminate properties from lamina properties and find residual stresses from curing and moisture.
6. Predict the failure strength of a laminated composite plate, knowledge of issues in fracture of composites and environmental degradation of composites.

Title of the Course: Analysis and Synthesis of Mechanism 4DE517	L	T	P	Cr
Professional Elective 2	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. R.S. Hartenberg and J. Denavit, “Kinematic Synthesis of Linkages”, McGraw-Hill, New York, 1980.
2. Robert L.Nortan ,"Design of Machinery',Tata McGraw Hill Edition
3. Hamilton H.Mabie,"Mechanisms and Dynamics of Machinery",John Wiley and sons New York

References:

1. A. Ghosh and A.K. Mallik, “Theory of Machines and Mechanisms”, Affiliated East-West Press, New Delhi, 1988.
2. A.G. Erdman and G.N. Sandor, “Mechanism Design – Analysis and Synthesis”, (Vol. 1 and 2), Prentice Hall India, 1988.
3. A.S. Hall, “Kinematics and Linkage Design”, Prentice Hall of India.
4. J.E. Shigley and J.J. Uicker, “Theory of Machines and Mechanisms”, 2nd Edition, McGraw-Hill, 1995

Course Objectives:

1. To provide students with a sound foundation in kinematic and synthesis of machines and mechanisms.
2. To train the students to apply complex number, matrices and algebra for analysis of mechanisms.
3. To prepare the students to use modern software for kinematic and dynamic analysis of the mechanisms.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom’s Cognitive	
		level	Descriptor
CO1	Select, configure, and synthesize mechanical components into complete systems. Use kinematic geometry to formulate and solve constraint equations to design linkages for specified tasks.	V	Evaluating
CO2	Formulate analytical equations describing the relative position, velocity and acceleration of all moving links.	VI	Creating
CO3	Analyze and animate the movement of planar and spherical four-bar linkages. Students will be able to apply modern computer-based techniques in the selection, analysis, and synthesis of components and their integration into complete mechanical systems	IV	Analyzing

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	1		2	3		1
CO2	1			3		
CO3	1		1	3		

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1	**7 Hrs.**
Basic Concepts; Definitions and assumptions; planar and spatial mechanisms; kinematic pairs; degree of freedom; equivalent mechanisms; Kinematic Analysis of Planar Mechanisms. Review of graphical and analytical methods of velocity and acceleration analysis of kinematically simple mechanisms, velocity-acceleration, analysis of complex mechanisms by the normal acceleration and auxiliary-point methods.	
Module 2	**7 Hrs.**
Curvature Theory: Fixed and moving centrodes, inflection circle, Euler-Savary equation, Bobillier constructions, cubic of stationary curvature, Ball's point, Applications in dwell mechanisms.	
Module 3	**7 Hrs.**
Kinematic Synthesis of planar mechanisms, accuracy (precision) points, Chebesychev spacing, types of errors, Graphical synthesis for function generation and rigid body guidance with two, three and four accuracy points using pole method, centre and circle point curves, Analytical synthesis of four-bar and slider-crank mechanisms.	
Module 4	**7 Hrs.**
Freudenstein's equation, synthesis for four and five accuracy points, compatibility condition, synthesis of four-bar for prescribed angular velocities and accelerations using complex numbers, three accuracy point synthesis using complex numbers.	
Module 5	**6 Hrs.**
Coupler Curves: Equation of coupler curve, Robert-Chebychev theorem, double points and symmetry.	
Module 6	**6 Hrs.**
Kinematic Analysis of Spatial Mechanisms, Denavit-Hartenberg parameters, matrix method of analysis of spatial mechanisms	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Analyse planar mechanisms for velocity and acceleration.
2. Use different techniques for synthesis of mechanisms
3. Synthesis 4 bar mechanisms for given application
4. Synthesis of 4 bar mechanism for velocity and acceleration
5. Determine coupler curves for mechanisms
6. Analyse spatial mechanisms.

Title of the Course: Process Equipment Design 4DE518 **Professional Elective 2**	L	T	P	Cr
	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. Mahajani V.V. and Umbrani S.B., *"Process Equipment Design",* Macmillan Publishing India Ltd., Fourth edition, 2009.
2. Bieuro of Indian standard *"Code for unfired pressure vessels IS:2825",* Indian Standard Institution, Revised Edition

References:

1. Brownell L. E and Young H, "*Process Equipment Design*", John Willey Publication, First Edition,2004.
2. Harvey J. F., *"Theory and Design of Pressure Vessel"* CBS Publisher, Third edition, 2004.

Course Objectives:

1. To prepare the students to succeed as designer in process industry/technical profession.
2. To provide students with a sound foundation in process equipment design required to solve the problems in process industry.
3. To train the students with good design engineering breadth required for safe and efficient design, construction, installation, inspection, testing and certification of unfired pressure vessels.
4. To aware the students about rules and regulations related to the operational safety of process equipment.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Distinguish types of equipment used in the process industry and their general procedure of design.	IV	Analyzing
CO2	Recommend the appropriate equipment for a process by considering process hazards and safety measures.	V	Evaluating
CO3	Design pressure vessels and its corresponding components using BIS and ASME codes of pressure vessels	VI	Creating

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	1					2
CO2			2			
CO3	3		2			3

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1 Introduction to Process Equipments	**6 Hrs.**
Introduction, Basic process requirement of plants and projects, Types and classification of equipments used in process industry, General design procedure, Materials of construction and corrosion prevention, Design codes required in process equipment design.	
Module 2 Pressure Vessels	**7 Hrs.**
Design parameters, Design criteria, Design of pressure vessel components – Shell, Head, Nozzle, flanged joint, Thermal stresses in cylindrical shell, Cylindrical pressure vessels under combined loading, Fabrication process, Inspection and testing of pressure vessels.	
Module 3 High Pressure Vessels	**7 Hrs.**
Constructional features, Stresses in thick walled shells, Multi-shell construction, Shrink fit construction, Stresses in shrink fit construction, Supports for pressure vessels. Discontinuity stresses in pressure vessel.	
Module 4 Storage Vessels	**7 Hrs.**
Storage vessels and its type, Fixed roof storage tanks, Variable volume tanks-vapor lift type and floating roof type, Accessories of storage tanks, column supported storage tanks, Design of rectangular tanks. Reaction vessel - Heating systems of reaction vessels, Design and construction of jackets.	
Module 5 Heat Exchangers	**6 Hrs.**
Types of heat exchangers and constructional features, Design of shell and tube heat exchangers, Arrangements of tubes, baffles, Expansion provisions for heat exchangers. Evaporators and crystallizers – Types and its constructional features.	
Module 6 Process Equipments	**7 Hrs.**
Agitators, Centrifugal machines, Filters and dryers used in process industries. Process hazards and safety in the process industry.	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Recognize the types of equipment used in the process industry and their general procedure of design.
2. Design pressure vessels and its corresponding component using BIS and ASME codes of pressure vessels.
3. Design High pressure vessels and its corresponding components using BIS and ASME codes of pressure vessels.
4. Design storage and reaction vessels and its corresponding components using BIS and ASME codes.
5. Design heat exchangers, evaporators and crystallizers required for process industry.
6. Differentiate the types of agitators, centrifugal machines, dryers and filters and their design and maintenance.

Professional Elective (Lab) Courses

Title of the Course: **Professional Elective -Design Engineering Lab 2**
4DE552

L	T	P	Cr
-	-	4	2

Text Books:
As per the course details

References:
As per the course details

Course Objectives:

1. To provide fundamental knowledge and expertise in order to produce competency in recent engineering fields.
2. To develop ability through the applications of the acquired knowledge, skills, and tools pertinent to design engineering.
3. To engage in continuous professional development in response to technological challenges in design engineering.

Course Learning Outcomes:

CO	**After the completion of the lab the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Demonstrate clearly and effectively for the practical utilization in day-to-day life	III	Applying
CO2	Analyze results using significant modern scientific methods	IV	Analyzing
CO3	Build ability to understand advanced technologies and research in design engineering	VI	Creating

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			2			
CO2					2	1
CO3						1

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25

Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.

Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

Students should perform experiments based on electives selected from PE 1 and 2

Professional Elective – 1 (Experiments from any one elective selected by student)

List of Experiments for course Advanced Machine Design 1. To perform ergonomic analysis of office chair. 2. To perform ergonomic analysis of a car. 3. To carry out aesthetic analysis of a bike. 4. To carry out aesthetic analysis of a home appliance. 5. To prepare 3D model of a product designed by student. 6. To make prototype of above product using 3D printer.	**20 Hrs.**
List of Experiments for course Design for Manufacturing and Assembly (Minimum eight experiments) 1. Life cycle of mechanical equipment design based on requirements of customer, management, marketing, manufacturing, transportation etc. - Case study. 2. Appropriate example of DFMA for improving product quality, cost and time to the market. 3. Case study based on design considerations for manual, automated and flexible assembly. 4. Realistic problem of geometric dimensioning and tolerance considerations for manufacturing and assembly. 5. Application of tools like lean manufacturing in the perspective of DFMA. 6. Application of tools like six sigma in the perspective of DFMA. 7. Use of DFMA for sand casting with example. 8. Use of DFMA for machining with example. 9. Use of DFMA for extrusion with example. 10. Use of DFMA for welding with example.	**20 Hrs.**
List of experiments for course Mathematical Methods in Engineering 1. Solve examples on probability 2. Case study on probability distribution functions 3. Case study on hypothesis testing 4. Prepare MATLAB program for solving ordinary differential equations using ODE function 5. Prepare MATLAB program for solving ordinary differential equations using dsolve function 6. Prepare MATLAB program for solving elliptic PDE 7. Prepare MATLAB program for solving linear/non linear algebraic equation	**20 Hrs.**
List of Experiments for course Reliability Engineering 1. Study of reliability engineering in mechanical design engineering. 2. Assignment on Probability and Reliability. 3. Study of system reliability and modeling. 4. Case study: Reliability in mechanical product design and development. 5. Case study: Reliability in maintenance and maintainability. 6. Case study: Testing of reliability of the product.	**20 Hrs.**

Professional Elective – 2 (Experiments from any one elective as selected by student)	
List of Experiments for course Advanced Engineering Materials 1. Tensile test of ferrous and nonferrous metals. 2. Hardness test. 3. Creep test at room temperature on Solder wire. 4. Impact test on steels samples and establish nil ductility temperature. 5. Fatigue test on Mild steel samples 6. Microstructural analysis of Ferrous base metals 7. Microstructural analysis of Non Ferrous base metals 8. Effect of work hardening on mechanical properties of materials	**20 Hrs.**
List of Experiments for course Mechanics of Composite Materials 1. Two assignments and case study discussion on Basic Concepts and Characteristics of composites. 2. Two assignments and case study discussion on Elastic Behaviour of Unidirectional Lamina of composites. 3. Two assignments and case study discussion on Strength of Unidirectional Lamina of composites. 4. Two assignments and case study discussion on Elastic Behaviour of Laminate of composites. 5. Two assignments and case study discussion on Stress Analysis of Laminates. 6. Two assignments and case study discussion on Failure analysis of Composites	**20 Hrs.**
List of experiments for course Analysis and Synthesis of Mechanisms 1. Solve examples on calculation of degree of freedom of mechanism 2. Case study on Euler Savary Equation 3. Case study on designing four bar mechanism using graphical method 4. Case study on designing slider crank mechanism using graphical method 5. Prepare 3D model in modeling software and simulate a mechanism 6. Case study on designing four bar mechanism using complex algebra method 7. Case study on designing slider crank mechanism using complex algebra method 8. Analyze mechanism using a simulation software such as Simulink, solidworks etc 9. Mini project on designing mechanism for path generation/function generation	**20 Hrs.**
List of Experiments for course Process equipment design 1. Study of materials of construction and corrosion prevention of process equipments. 2. Design calculations for pressure vessel design. 3. Drawing of pressure vessel in sheet or using any mechanical software 4. Design calculations for storage vessel design. 5. Drawing of storage vessel in sheet or using any mechanical software 6. Analysis of cylindrical pressure vessel using FEA Software.	**20 Hrs.**

Open Electives Courses

There are no courses under this category for this semester.

Mandatory Life Skill Courses

There are no courses under this category for this semester.

Value Added
Professional Courses

There are no courses under this category for this semester.

EVEN Semester

Professional Core (Theory) Courses

Title of the Course: Finite Element Method 4DE521	L	T	P	Cr
	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. ,Klaus JurgenBathe, *"Finite Element Procedures"* Print ice Hall of India Pvt. Ltd. Fourth Print,2008

2. J.N.Reddy. *"Introduction to Finite Element",* Tata McGraw Hill Publishing Co. Ltd,1998

3. O.C. Zienkiewicz*"The Finite Element Method"*, Tata McGraw Hill Publishing Co. Ltd, 5th revised edition ,2000.

References:

1. T.R.Chandrupatla. *"Introduction to Finite Element in Engineering",* Prentice Hall, New Delhi, 2nd Edition-1997

2. David V. Hutton, Fundamentals of finite element analysis, Tata McGraw Hill Publishing Co. Ltd Second edition 2005.

3. S. S .Rao. *"Introduction to Finite Element in Engineering",Elsevier,5th edition,2012.*

4.Cook R.D. "Concepts and applications of finite element analysis" Wiley, New York, 4th Ed. 02.

5. Logan Deryl L., "A First Course in Finite Element Method", Thomson Brook/Cole,5th Ed.

Course Objectives: The objective of the course is

1. To teach the fundamentals of finite element method with emphasize on the underlying theory, assumption, and modeling issues.
2. To provide hands on experience using finite element software to model, analyze and design mechanical systems.

Course Learning Outcomes:

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

1. Classify a given problem on the basis of its dimensionality as 1-D, 2-D, or 3-D, time-dependence as Static or Dynamic, Linear or Non-linear.

2. Construct system level matrix equations from a given mathematical model of a problem following the Galerkin weighted residual method or principle of stationary potential.

3. Estimate three sources of errors in implementing FEM and suggest remedies to minimize the same for a given problem, viz. Modeling errors, Approximation errors, and numerical errors.

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Classify a given problem on the basis of its dimensionality as 1-D, 2-D, or 3-D, time-dependence as Static or Dynamic, Linear or Non-linear.	II	Understanding
CO2	Construct system level matrix equations from a given mathematical model of a problem following the Galerkin weighted residual method or principle of stationary potential.	III	Applying
CO3	Estimate three sources of errors in implementing FEM and suggest remedies to minimize the same for a given problem, viz. Modeling errors, Approximation errors, and numerical errors.	V	Evaluating

CO-PO Mapping:

	1	2	3	4	5	6
CO1	3					
CO2				3	2	2
CO3		2	2			3

Assessments:Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1:	**3 Hrs.**
Classification of problems – Dimensionality, time dependence, Boundary Value problems, Initial value problems, Linear/Non-linear, etc,	
Module 2:	**9 Hrs.**
Differential equation as the starting point for FEM, steps in finite element method, discretization, types of elements used, Shape functions, Linear Elements, Local and Global coordinates, Coordinate transformation and Gauss-Legendre scheme of numerical integration, Nodal degrees of freedom.	
Module 3:	**9 Hrs.**
Finite element formulation, variational, weighted residual and virtual work methods.	
Module 4:	**9 Hrs.**
1-D and 2-D problems from Structural Mechanics – Bar, Beam, Plane stress and plane Strain problems, Axisymmetric problems – Axi-symmetric forces and geometry.	
Module 5:	**6 Hrs.**
Computer implementation, higher order elements, iso-parametric formulation.	
Module 6:	**4 Hrs.**
Eigen-value problems, Natural vibration of bars and beams, Methods to find eigen-values andeigen-vectors.	

Module wise Measurable Students Learning Outcomes:

1. Students will be able to explain the Mathematical modeling and FEM.
2. Students will be able to use Design Engineering problems by using FEM. Students will develop confidence for self education and ability for lifelong learning.
3. Students will demonstrate an ability to formulate and solve Design Engineering problems by using variational formulation methods.
4. Students will have ability to design machines, systems, and projects required for industry based on the

static analysis of machine components.
5. Students will be able to organize experiments and analyze and interpret the data.
6. Students will be able to use modern tools, software, and equipments to analyze and solve the dynamic problems.

Title of the Course: Computer Aided Design 4DE522	L	T	P	Cr
	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. ZeidEbrahim, CAD/CAM Theory and Practice,TataMc.Graw Hills, 3rd edition,2009.
2. Radhakrishnan P., Subramanyan S., Raju V. ,CAD/CAM/CIM, , New Age International, 2nd edition, 2010.

References:

1. Lee Kunwoo, Principles of CAD/CAM/CAE systems, , Addison Wesley, 2nd edition,1999
2. Machover Carl ,The C4 handbook: CAD, CAM, CAE, CIM, Tab Professional and Reference Books, 3rd edition, 1998
3. Taraman Khalil ,CAD-CAM: Meeting Today's Productivity Challenge, University of Michigan, 6th edition, 2012

Course Objectives:

1. To introduce the students application of Geometric Dimensioning and Tolerancing
2. To impart the students modern CAD operations.
3. To prepare the students for use of modern FEA system

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Demonstrate various approaches of geometric modeling	III	Applying
CO2	Analyse geometric dimensioning and tolerancing based on ASME standard in design and generate proper engineering drawings	IV	Analyzing
CO3	Design parts using a modern parametric CAD system	VI	Creating

CO-PO Mapping:

PO	1	2	3	4	5	6
CO1	3		3		2	
CO2		3			2	
CO3		3		2		

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1	**6 Hrs.**
CAD Hardware and Software, Types of systems and system considerations, input and output devices, hardware integration and networking, hardware trends, Software modules	
Module 2	**7 Hrs.**
Computer Communications, Principle of networking, classification networks, network wring, methods, transmission media and interfaces, network operating systems,	
Module 3	**6 Hrs.**
Computer Graphics, Introduction, transformation of geometric models: translation, scaling, reflection, rotation, homogeneous representation, concatenated transformations; mappings of geometric models, translational mapping rotational mapping, general mapping, mappings as changes of coordinate system; inverse transformations and mapping	
Module 4	**7 Hrs.**
Projections of geometric models, orthographic projections, Geometric Modeling, curve representation: Parametric representation of analytic curves, parametric representation of synthetic curves, curve manipulations. Surface representation	
Module 5	**7 Hrs.**
Fundamentals of solid modeling, boundary representation (B-rep), Constructive Solid Geometry (CSF), sweep representation, Analytic Solid Modeling (ASM), other representations; solid manipulations, solid modeling based applications: mass properties calculations, mechanical tolerancing etc.	
Module 6	**7 Hrs.**
Finite Element Modeling and Analysis, Finite Element Analysis, finite element modeling, mesh generation mesh requirements, semiautomatic methods, fully automatic methods, design and engineering applications, System Simulation, Need of simulation, areas of applications, when simulation is appropriate tool / not appropriate, concept of a system, components of a system, discrete and continuous systems, model of a system, types of models, types of simulation approaches	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Have a conceptual understanding of the principles of CAD systems, the implementation of these principles, and its connections to CAM and CAE systems.
2. Interpret 2D, 3D transformations and projection transformations.
3. Compare mathematical representation of 2D and 3D entities
4. Demonstrate various approaches of geometric modeling
5. Design basic mechanical components.
6. Explain basic fundamentals of FEM

Professional Core (Lab) Courses

Title of the Course: Design Engineering Lab 3 4DE571	L	T	P	Cr
	-	-	4	2

Pre-Requisite Courses: Mechanical vibrations, Machine Tool Design.

Textbooks:

1. Adams M. L., Rotating Machinery Analysis - from Analysis to Troubleshooting, CRC Press, 2nd edition, 2009
2. Mohanty A. R., Machinery Condition Monitoring-Principles and Practices, CRC Press, 1st edition, 2015
3. Mehta N. K., Machine Tool Design, McGraw Hill Education, 3rd edition, 2017

References:

1. William J. H., Davis N., Drake P. R., Condition Based Maintenance and Machine Diagnostics, Springer Netherlands , 2nd edition, 1994
2. Rao S. S., Mechanical Vibrations, Pearson education, 5th edition, 2010
3. Koenigsberger F., Design Principles of Metal Cutting Machine Tool, The Macmillan Co, 1st edition, 1964

Course Objectives:

At the end of the course:

1. Students will be able to use various experimental techniques relevant to the subject.
2. Students will acquire hands on experience on the various test-rigs, Experimental set up.
3. Students will be able to function as a team member
4. Students will develop communication skills.
5. Students will be able to write technical reports.
6. Students will be able to use different software's

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Solve field problems by using different condition monitoring techniques.	III	Applying
CO2	Evaluate typical characteristics of dynamic systems by carrying out experiments in team. .	V	Evaluating
CO3	Design equipment according to the requirements specified.	VI	Creating

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	3	2				3
CO2			3	2	2	
CO3	2		3		2	1

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.

Course Contents: **List of experiments for course Computer Aided Design (Minimum eight experiments)** 1.To create 2D drawing using sketcher workbench – 2 drawings 2.To study 3D modeling and drafting using 3D features – 5 models 3.To study Assembling and drafting of 2D assemblies with interference checking. 4.To study Geometric modelling by using 3D transformation 5.To carry out Kinematic simulation of different mechanisms 6. To study surface modelling- exercise 1. 7. To study surface modelling- exercise 2. 8. To study surface modelling- exercise 3	**20 Hrs**
List of experiments for course Finite Element Method (Minimum ten experiments) 1. To carry out Drafting with geometrical dimensioning and tolerancing. 2. To carry out Structural analysis of complex truss using FEA software 3. To carry out Buckling analysis of beam using FEA software 4. To carry out Thermal analysis of chimney using FEA software 5. To carry out Transient Thermal analysis of fin using FEA software 6. To carry out Thermal analysis of Axi-symmetric plate using FEA software 7. To carry out 3D modelling and analysis of pulley using FEA software. 8. To carry out 3D modelling and analysis of rotating shaft using FEA software 9. To carry out Non Linear analysis using contact element using FEA software 10. To carry out 3D modelling and analysis of corner bracket using FEA software 11. To carry out 3D modelling and analysis of machine part using FEA software 12. To carry out Laminar Flow analysis in 2D duct using FEA software 13. To carry out Flow analysis around a cylinder using FEA software	**24 Hrs**

14. To carry out Structural analysis of book shelf bracket using FEA software 15 To carry out Structural analysis of balcony truss using FEA software	

Title of the Course: Industrial Project 4DE572	L	T	P	Cr
	-	-	4	2

Pre-Requisite Courses:

Textbooks: As per topic Selected and Journal papers, Conference papers, Handbooks.

References: As per topic Selected and Journal papers, Conference papers, Handbook.

Course Objectives:

1. To Review and increase students' understanding of the specific topics.
2. To induce Learning management of values.
3. To teach how research papers are written and read such papers critically and efficiently and to summarize and review them to gain an understanding of a new field, in the absence of a textbook.
4. To teach how to judge the value of different contributions and identify promising new directions in specified area.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		Level	Descriptor
CO1	Apply the existing knowledge on real life problems	III	Applying
CO2	Investigate the selected topic/ system.	IV	Analyzing
CO3	Verify the outcomes of the work have solved the specified problems.	V	Evaluating

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	2	2	1			
CO2	3				1	
CO3		3			2	

Assessment:

There are four components of assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Project Progress	Course Faculty/ Industrial Guide	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Project Progress	Course Faculty/ Industrial Guide	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Project Progress	Course Faculty/ Industrial Guide	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Project Progress	Course Faculty/ Industrial Guide	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.
Project activities/Project performance shall include literature review, problem statement, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the industrial project.

Course Contents:

The industrial project work will start in semester II and should be an industrial problem with research potential and should involve scientific research review, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution. Student should undergo industrial project in registered company/organization after consulting with faculty guide assigned by the department. Industrial project should be based preferably in the area in which the candidate is interested to undertake the dissertation work. The student has to be in regular contact with guide and the topic of industrial project must be mutually decided. The examination shall consist of the preparation of report consisting literature review, detailed problem statement, methodology, etc, according to type of work carried out. The work has to be presented in front of the examiners panel formed by DPGC for evaluation.

Professional Elective (Theory) Courses

Title of the Course: Tribology in Design 4DE531 **Professional elective 3**	L	T	P	Cr
	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. Basu, Sengupta and Ahuja, *"Fundamentals of Tribology",* PHI Learning, First edition, 2011.
2. Sushil Kumar Srivatsava, *"Tribology in Industry",* S. Chand Publisher, Revised edition, 2001

References:

1. Majumdar B.C., *"Introduction to Tribology of Bearings",* S. Chand and Company Ltd., First Edition, 2010.
2. Bharat Bhushan, *"Handbook of Tribology*", Krieger Publishing Company, First Edition, 1997.
3. Mervin H. Jones and Douglas Scott, *"Industrial Tribology - The Practical Aspects of Friction, Lubrication and Wear"*, Elsevier Scientific Publishing Company Amsterdam-Oxford-New York, 1991.
4. PrasannaSahoo, *"Engineering Tribology"*, PHI Learning Pvt. Ltd., First Edition, 2011.

Course Objectives:

1. To create an awareness of the importance of tribology in design.
2. To describe the material selection for minimizing friction and wear in machinery.
3. To select bearing and bearing arrangement in machines

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Apply the basic theories of friction, wear and lubrication to predictions about the frictional behavior of commonly encountered sliding interfaces.	III	Applying
CO2	Select materials and lubricants to suggest a tribological solution to a particular situation.	V	Evaluating
CO3	Design a hydrodynamic bearing using various bearing charts.	VI	Creating

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	2		1			2
CO2			2			3
CO3	1		2			3

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1 Lubrication Theory	**6 Hrs.**
Introduction to Tribology, Tribology in design – bearing materials - its properties, Bearing construction, Tribology in industry, Lubrication – introduction, basic modes of lubrication, Lubricants properties, Lubricants standards, Types of additives, Bearing Terminology - Sliding contact bearings and Rolling contact bearings, Comparison between sliding and rolling contact bearings.	
Module 2 Friction and Wear	**6 Hrs.**
Friction - Laws of friction, Friction classification, Causes of friction, Theories of dry friction, Friction measurement, Stick-Slip motion and friction instabilities. Wear - Wear classification, Wear between solids, Wear between solid and liquid, Factors affecting wear, Measurement of wear, Theories of Wear.	
Module 3 Lubrication of Bearings	**8 Hrs.**
Theory of hydrodynamic lubrication, Mechanism of pressure development in oil film, Two dimensional Reynolds's equation and its limitations, Designing of journal bearing by using Raimondi and Boyd method, Petroff's Solution, Parameters of bearing design - Unit bearing pressure, Temperature rise, Length to diameter ratio, Radial clearance, Minimum oil-film thickness.	
Module 4 Hydrodynamic Thrust Bearing	**7 Hrs.**
Introduction, Types of hydrodynamic thrust bearing, Analysis of flat plate thrust bearing, Tilting pad thrust bearing and Rayleigh step bearing.	
Module 5 Hydrostatic and Squeeze Film Lubrication	**7 Hrs.**
Hydrostatic Lubrication – Basic concept, Advantages and limitations, Viscous flow through rectangular slot, Load carrying capacity and flow requirement, Energy losses, Optimum design. Hydrostatic conical thrust bearing Squeeze Film Lubrication - Basic concept, Squeeze action between circular and rectangular plates.	
Module 6 Elasto-Hydrodynamic Lubrication	**6 Hrs.**
Principles and Applications, Pressure viscosity term in Reynolds's equation, Hertz' theory, Ertel - Grubin equation, lubrication of spheres, gear teeth and rolling element bearings, Gas (Air-) Lubricated Bearings: Introduction, Merits, Demerits and Applications.	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Apply basic theory of lubrication to design a bearing.
2. Recognize the laws of friction, mechanisms of friction and appreciate the various modes of wear.
3. Design journal bearing and select suitable grade lubricant for specific application.
4. Design hydrodynamic thrust bearing.
5. Select hydrostatic and squeeze film lubrication.
6. Analyze elasto-hydrodynamic lubrication.

Title of the Course: Robotics 4DE532	L	T	P	Cr
Professional elective 3	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. John J. Craig, Introduction to Robotics (Mechanics and Control), Addison-Wesley, 2nd Edition, 04
2. Mikell P. Groover et. Al., Industrial Robotics: Technology, Programming and Applications, McGraw – Hill International, 1986.
3. Shimon Y. Nof , Handbook of Industrial Robotics , John Wiley Co, 01.

References:

1. Richard D. Klafter , Thomas A. Chemielewski, Michael Negin, Robotic Engineering: AnIntegrated Approach , Prentice Hall India, 02.
2. Handbook of design, manufacturing & Automation: R.C. Dorf, John Wiley and Sons.

Course Objectives:

1. To introduce students to fundamentals of robot working, programming and integration in a manufacturing process.
2. To make students understand basic working components of an industrial robot
3. To introduce recent technology as machine vision

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Understand basic terminologies and concepts associated with Robotics and Automation	II	Understanding
CO2	Demonstrate comprehension of various Robotic sub-systems	III	Applying
CO3	Analyse kinematics and dynamics to explain exact working pattern of robots	IV	Analyzing

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1			1	1		
CO2	1			2		1
CO3	1		2			2

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: **Introduction**	**7 Hrs.**
Basic Concepts such as Definition, three laws, DOF, Misunderstood devices etc., Elements of Robotic Systems i.e. Robot anatomy, Classification, Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device, etc. Automation - Concept, Need, Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations, introduction to automation productivity.	
Module 2: **Robot Grippers:**	**7 Hrs.**
Types of Grippers , Design aspect for gripper, Force analysis for various basic gripper system. Sensors for Robots:- Characteristics of sensing devices, Selections of sensors, Classification and applications of sensors. Types of Sensors, Need for sensors and vision system in the working and control of a robot.	
Module 3: **Drives and control systems:**	**7 Hrs.**
Types of Drives, Actuators and its selection while designing a robot system. Types of transmission systems, Control Systems -Types of Controllers, Introduction to closed loop control Control Technologies in Automation:- Industrial Control Systems, Process Industries Verses Discrete-Manufacturing Industries, Continuous Verses Discrete Control, Computer Process and its Forms. Control System Components such as Sensors, Actuators and others.	
Module 4: **Kinematics**	**7 Hrs.**
Transformation matrices and their arithmetic, link and joint description, Denavit - Hartenberg parameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics calibration, inverse kinematics, solvability, algebraic and geometrical methods. Velocities and Static forces in manipulators:-Jacobians, singularities, static forces, Jacobian in force domain. Dynamics:- Introduction to Dynamics , Trajectory generations	
Module 5: Machine Vision System	**6 Hrs.**
Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques , Noise reduction methods, Edge detection, Segmentation. Robot Programming:- Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Introduction to various types such as RAIL and VAL II etc, Features of type and development of languages for recent robot systems.	
Module 6: Modeling and Simulation for manufacturing Plant Automation:	**6 Hrs.**
Introduction, need for system Modeling, Building Mathematical Model of a manufacturing Plant, Modern Tools- Artificial neural networks in manufacturing automation, AI in manufacturing, Fuzzy decision and control, robots and application of robots for automation. Artificial Intelligence:- Introduction to Artificial Intelligence, AI techniques, Need and application of AI. Other Topics in Robotics:- Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and associated mass, New Trends & recent updates in robotics	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Understand basic concepts of robotics
2. Select appropriate grippers and sensors

3. Analyze different drives and controllers for their performance.
4. Formulate transformation matrices for kinematics
5. Learn different machine vision systems
6. Simulate plant automation using neural network and fussy logic.

Title of the Course: Fracture Mechanics 4DE533	L	T	P	Cr
Professional elective 3	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. Prashant Kumar, *"Elements of Fracture Mechanics",* Tata McGraw Hill, New Delhi, India,2009.
2. K. Ramesh, e-Book on Engineering Fracture Mechanics, IIT Madras, 2007. URL: http://apm.iitm.ac.in/smlab/kramesh/book_4.htm
3. K. R.Y. Simha*, "Fracture Mechanics for Modern Engineering Design",* Universities Press (India) Limited, 2001.

References:

. 1 D. Broek, *"Elementary Engineering Fracture Mechanics",* Kluwer Academic Publishers, Dordrecht, 1986.

2. T.L. Anderson,"*Fracture Mechanics - Fundamentals and Applications*", 3rd Edition, Taylor and Francis Group, 2005.

Course Objectives:

1. To describe the near field equations to determine the stress-strain and load-displacement fields around a crack tip for linear elastic cases.
2. To recognize and formulate the stress intensity factor ((K) for typical crack configurations.
3. To identify and formulate the strain energy release rate (G) .
4. To find and formulate J-integral and the stress and strain fields around a crack tip for non linear and elastoplastic materials.
5. To explain fracture toughness of materials using Kc, Gc and Jc.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Relate the basic concepts regarding solid materials	III	Applying
CO2	Check the procedures to carryout analysis of failure	V	Evaluating
CO3	Design of Failure analysis template	VI	Creating

	1	**2**	**3**	**4**	**5**	**6**
CO1		1	3	2	1	2
CO2		2	1	3	2	
CO3	1	2	1		1	2

Assessments:

ISE1 and ISE2 can be based on quiz, assignments, oral, presentation, survey, surprise test, mini project etc. ISE assessment scheme will be declared by teacher at start of the course. ISE1 marks are open to students. ISE2 marks are hidden component for students.

MSE (generally on module 1-3) and ESE (30-40% weightage for modules 1-3 and 60-70% weightage for modules 4-6) may have 0-20% optional questions.

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1:	**6 Hrs.**
Introduction to Material Behavior, overview of dislocation theory and plastic deformation, strengthening mechanisms.	
Module 2:	**7 Hrs.**
Overview of Engineering Fracture Mechanics: Kinds of failures, Historical aspects, Fracture, Fatigue, Creep, Modes of fracture failure	
Module 3	**7 Hrs.**
Energy Release Rate: Dilemma of Griffith, surface energy, Griffith's realization and analysis, Energy release rate, Energy release rate of DCB specimen, inelastic deformation at crack tip, Crack resistance stable and unstable crack growth, R curve, thin and thick plate, Critical energy release rate. Stress intensity factor, relation between G_I and K_I , critical stress intensity factor	
Module 4	**7 Hrs.**
Anelastic deformation at the crack tip, Modeling of Plastic Deformation, Irwin's Model, Dugdale Model, effective crack length, effect of plate thickness.	
Module 5:	**7 Hrs.**
Elastic plastic analysis, J-integral, definition and engineering approach of J-integral, applications. Fracture Toughness Testing	
Module 6	**7 Hrs.**
Crack tip opening displacement, relationship between CTOD, K_I and G_I for small scale yielding, Failure analysis- Spectacular Failures case studies.	

Module wise Measurable Students Learning Outcomes:

Students should be able to

1. Be familiar with fundamentals of plastic deformation and strengthening mechanisms.
2. Describe different modes of fracture.
3. Analyze concept of energy release rate and stress intensity factor.
4. Formulate and solve plastic deformation models and be able to calculate effective crack length.
5. Study the role of plastic zone in the metals, J-integral approach and Fracture Toughness Testing.
6. Formulate failure analysis process by understanding few Spectacular Failures case studies

Title of the Course: Advanced Metallurgy 4DE535	L	T	P	Cr
Professional Elective 4	3	-	-	3

Pre-Requisite Courses:

1. V. Raghvan, "Solid State Phase Transformations", PHI Publication, 1st Edition, 2004.
2. V. Raghvan, "Physical Metallurgy: Principles and Practice", PHI Publication, 3rd Edition, 2015.
3. William D. Callister, "Fundamentals of Materials Science and Engineering", Wiley India Pvt. Ltd, 7th Edition, 2009.
4. Engineering Metallurgy, R. A. Higgins, Viva Books Pvt. Ltd.4th Edition,1998.

References:

1. Sidney H. Avener, "*Physical Metallurgy",* Tata McGraw Hill Education Private Limited, 2nd Edition, 1997
2. George E. Dieter, "*Mechanical Metallurgy",* Tata McGraw Hill Publication, Si Metric Edition, 3rd Revised edition, 2013
3. Biomaterials and Bioengineering Handbook, Donald L. Wise, Marcel Dekker Inc.
4. Smithells Metals Reference Book, E. A. Brandes and G. B. Brook, Butterworth Heinemann.

Course Objectives:

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive level	Descriptor
CO1	Apply various aspects of crystal and lattice structure and their imperfection, and also acquisition of knowledge of composites, ceramics, orthodontal and biomaterials	III	Applying
CO2	Discuss importance of equilibrium diagrams and their uses in developing materials	V	Evaluating
CO3	Explain the process of heat treatment of different nonferrous alloys and tool steel and decide a heat treatment to acquire their desired properties	II	Understanding

CO-PO Mapping:

PO	**1**	**2**	**3**	**4**	**5**	**6**
CO1	2	3	1	2	1	2
CO2		2	1	3	2	
CO3		2	2		3	1

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1	**7 Hrs.**
Aspects of Physical Metallurgy: Crystal structure, systems and Barvias lattices, Indexing of lattice planes (Miller's Indices), Indexing of lattice directions, Co-ordination Number (Ligency), Density calculations and imperfections in crystals	
Module 2	**7 Hrs.**
Study of Equilibrium diagrams for Fe-C systems, Cu - Bronze alloys i.e. Cu:Zn, Cu:Sn, Cu:Al etc., Developments in metallic materials like HSLA state, maraging steels, dual phased steels, creep resisting steels, materials for high and low temperature applications, Nimerics, Inconels, Haste Alloys etc., Al, Ni alloys, Ti, Mg alloys.	
Module 3	**7 Hrs.**
Heat Treatment of Nonferrous alloys, Heat Treatment of Tool steels	
Module 4	**7 Hrs.**
Orthodental materials, Bio material, Prosthetic materials, Nano materials, super conducting materials, sports materials.	
Module 5	**7 Hrs.**
Composites, ceramics, cermets, shape memory alloys their manufacturing techniques, advantages and limitations.	
Module 6	**7 Hrs.**
Surface coatings and their tribological aspects. PVD, CVD, IVD ion implantation method.	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Apply knowledge of Physical Metallurgy, imperfections in crystals in Materials Engineering field.
2. Importance of Equilibrium diagrams in Materials Engineering field.
3. Summarize various heat treatment processes.
4. Summarize applications various advanced materials and their properties.
5. Explain properties and applications Composites, ceramics, shape memory alloys.
6. Classify types of coatings and their processes.

Title of the Course: Condition Based Monitoring 4DE536	L	T	P	Cr
Professional Elective 4	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. Adams M. L., Rotating Machinery Analysis - from Analysis to Troubleshooting, CRC Press, 2nd edition, 2009
2. Cornelius S., Paresh G., Practical Machinery Vibration Analysis and Predictive Maintenance, Newnes, 1st edition, 2004
3. Mohanty A. R., Machinery Condition Monitoring-Principles and Practices, CRC Press, 1st edition, 2015

References:

1. William J. H., Davis N., Drake P. R., Condition Based Maintenance and Machine Diagnostics, Springer Netherlands , 2nd edition, 1994
2. L.L. Faulkner, Handbook of Industrial Noise Control, Industrial press, 1st edition 1976
3. Rao S. S., Mechanical Vibrations, Pearson education, 5th edition, 2010

Course Objectives:

1. To make students aware of some methods and procedures applied for general Condition Monitoring.
2. To make students appreciate and understand the basic idea behind vibration-based structural health
   monitoring and vibration-based condition monitoring, know the general stages of CM
3. To prepare students capable to apply some basic techniques for analysis of random and periodic signals
4. To prepare students aware of some basic instrumentation used for machinery and structural vibration-based monitoring

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Calculate the characteristic of problems related to vibrations	V	Evaluating
CO2	Apply knowledge for preventive maintenance	III	Applying
CO3	Investigate the data for troubleshooting vibration problems in the mechanical machines	IV	Analyzing

CO-PO Mapping:

PO	1	2	3	4	5	6
CO1			3		2	3
CO2	2					1
CO3				2	3	

Assessments:

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)
ESE: Assessment is based on 100% course content with 70-80% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1: Types of Maintenance	**7 Hrs.**
Types of maintenance, basic idea of health monitoring and condition monitoring of structures and machines. Critical speed of shafts, Some basic techniques.	
Module 2: Signal Processing	**6 Hrs.**
Basics of signal processing: Study of periodic and random signals, probability distribution, statistical properties, auto and cross correlation and power spectral density functions of commonly found systems, spectral analysis.	
Module 3: Fourier Transform	**7 Hrs.**
Fourier transform: the basic idea of Fourier transform, interpretation and application to real signals. Response of linear systems to stationary random signals: FRFs, resonant frequencies, modes of vibration	
Module 4: Vibration Based Fault Diagnosis	**7 Hrs.**
Introduction to vibration-based monitoring, Machinery condition monitoring by vibration analysis: Use and selection of measurements, analysis procedures and instruments	
Module 5: Applications of Condition Monitoring	**6 Hrs.**
Typical applications of condition monitoring using vibration analysis to rotating machines, unbalance, misalignment, faulty gears and bearings, vibration problem related to the foundation. Transmissions of vibration and its isolation	

Module 6: Other Health Monitoring Techniques	**7 Hrs.**
Other health monitoring techniques, acoustic emission, oil debris and temperature analysis, Applications.	

Module wise Measurable Students Learning Outcomes:

After the completion of the course the student should be able to:

1. Calculate the critical speed of rotor system.
2. Investigate the vibration signal for faults.
3. Apply fast Fourier transform to get the frequency domain signal.
4. Calculate fundamental parameters of vibration measurement.
5. Investigate the problem in machine using condition monitoring techniques.
6. Apply other techniques to identify faults.

Title of the Course: Optimization Techniques in Design, 4DE537	L	T	P	Cr
Professional Elective 4	3	-	-	3

Pre-Requisite Courses:

Textbooks:

1. S. S. Stricker, "Optimising performance of energy systems" Battelle Press, New York,1985.
2. R.C. Johnson, "Optimum Design of Mechanical Elements", Willey, New York, 1980.
3. J. S. Arora, "Introduction to Optimum Design", McGraw Hill, New York, 1989.
4. Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India, New Delhi, 05

References:

1. Rao S, "Engineering optimization, Theory and Practice, New Age International Publishers,1996.
2. R.J. Duffin, E.L. Peterson and C.Zener "Geometric Programming-Theory and Applications", Willey, New York, 1967.
3. G.B. Dantzig "Linear Programming and Extensions Princeton University Press", Princeton, N. J., 1963.

Course Objectives:

- To design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability, and sustainability.
- To use the operations research techniques and tools for necessary engineering practice.
- To use mathematical methods and computers to make rational decisions in solving a variety of optimization problems.

Course Learning Outcomes:

CO	**After the completion of the course the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Develop algorithms for design optimization.	III	Applying
CO2	Evaluate and interpret solution of an optimization problem.	V	Evaluating
CO3	Formulate and construct the optimum solution of the problems using optimization techniques.	VI	Creating

CO-PO Mapping:

	1	**2**	**3**	**4**	**5**	**6**
CO1	2		2	1	1	3
CO2	3		1		3	
CO3	2	1	2		1	

Assessments:

ISE1 and ISE2 can be based on quiz, assignments, oral, presentation, survey, surprise test, mini project etc. ISE assessment scheme will be declared by teacher at start of the course. ISE1 marks are open to students. ISE2 marks are hidden component for students.

MSE (generally on module 1-3) and ESE (30-40% weight age for modules 1-3 and 60-70% weight age for modules 4-6) may have 0-20% optional questions

Teacher Assessment:

Two components of In Semester Evaluation (ISE), One Mid Semester Examination (MSE) and one End Semester Examination (ESE) having 20%, 30% and 50% weights respectively.

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

ESE: Assessment is based on 100% course content with60-70% weightage for course content (normally last three modules) covered after MSE.

Course Contents:

Module 1:	**7 Hrs.**
Introduction to optimization, classification of optimization problems, classical optimization techniques	
Module 2:	**7 Hrs.**
Linear programming, simplex method and Duality in linear programming, sensitivity or post-optimality analysis, Karmarkar's methods,	
Module 3:	**7 Hrs.**
Non-Linear Programming: - One dimensional minimization, unconstrained and constrained minimization, direct and indirect methods,	
Module 4:	**7 Hrs.**
Geometric programming, Optimum design of mechanical elements like beams, columns, gears, shafts, etc.	
Module 5:	**7 Hrs.**
Introduction to Genetic Algorithms, Operators, applications to engineering optimization Problems.	
Module 6:	**7 Hrs.**
Optimum selection of material and processes in mechanical design using material selection charts and optimization	

Module wise Measurable Students Learning Outcomes:

1. Introduction to optimization techniques and understand its classification.
2. Able to understand the linear programming, Duality and sensitivity analysis.
3. Understand non-linear programing.
4. Use Geometric programming for optimum design of mechanical elements.
5. Able to understand Genetic Algorithms and its use in industrial design.
6. Select materials and processes related to optimization.

Professional Elective (Lab) Courses

Title of the Course: **Professional Elective - Design Engineering Lab 4- 4DE573**

L	T	P	Cr
-	-	4	2

Text Books:
As per the course details

References:
As per the course details

Course Objectives:

1. To provide advanced knowledge and expertise in order to produce creative and imaginative engineers with a strong scientific acumen.
2. To develop ability through hands-on experience for implementing modern methods, techniques and best practices in manufacturing
3. To make aware about current scenario and facilitate with modern trends which are tending towards their own area of interest

Course Learning Outcomes:

CO	**After the completion of the lab the student should be able to**	Bloom's Cognitive	
		level	Descriptor
CO1	Validate technological solutions to defined problems.	III	Applying
CO2	Acquire knowledge developed by scholarly predecessors and critically assess the relevant technological issues.	IV	Analyzing
CO3	Create skills towards research oriented fields.	VI	Creating

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1			1			2
CO2				2	1	
CO3	1					1

Lab Assessment:

There are four components of lab assessment, LA1, LA2, LA3 and Lab ESE.

IMP: Lab ESE is a separate head of passing.

Assessment	Based on	Conducted by	Conduction and Marks Submission	Marks
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 4 Submission at the end of Week 5	25
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 5 to Week 8 Submission at the end of Week 9	25
LA3	Lab activities, attendance, journal	Lab Course Faculty	During Week 10 to Week 14 Submission at the end of Week 14	25
Lab ESE	Lab Performance and related documentation	Lab Course faculty	During Week 15 to Week 18 Submission at the end of Week 18	25

Week 1 indicates starting week of Semester.

Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course.	
Students should perform experiments based on electives selected from PE 3 and 4	
Professional Elective – 3 (Experiments from any one elective as selected by student)	
List of Experiments for course Tribology in Design 1. Design calculations for journal bearing. 2. Design calculations for hydrodynamic thrust bearing. 3. Design calculations for hydrostatic lubrication and 4. Design calculations squeeze film lubrication. 5. Study of recent development in industrial tribology. 6. Case Study: Lubrication system used in specific application.	**20 Hrs.**
List of Experiments for course Robotics (Minimum eight experiments) 1. Study of Automation - Concept, Need, 2. Assignment on Automation in Production System. 3. Study of robot grippers. 4. Study of Sensors – types, classification, selection. 5. Study of drives in robots – electric, pneumatic, hydraulic. 6. Prepare MATLAB program for calculating Denavit Hartenberg parameters 7. Prepare Simulink Model of Four Bar mechanism for forward kinematics analysis 8. Prepare Simulink Model of Four Bar mechanism for inverse kinematics analysis 9. Case study on sampling and quantization in signals and systems 10. Case study on motion interpolation in robotic manipulators 11. Study of Artificial Neural Networks and its application in automation 12. Study of Socio-Economic aspect of robotisation 13. Study of economical aspects for robot design	**20 Hrs.**
List of experiments for course Fracture Mechanics 1. Case study discussion on Spectacular Failures case studies- Failure Analysis of Engineering Structures Methodology 2. Case study discussion on Spectacular Failures case studies- Overview of the Mechanisms of Failure in Heat Treated Steel Components. 3. Case study discussion on Spectacular Failures case studies- Failure in Steel Forging. 4. Case study discussion on Spectacular Failures case studies- Failures from the Casting Process. 5. Case study discussion on Spectacular Failures case studies- Sources of Failures in Carburized and Carbonitrided Components. 6. Case study discussion on Spectacular Failures case studies- Steel Component Failures in Aerospace Applications. 7. Case study discussion on Spectacular Failures case studies- Failure Analysis of Steel Welds. 8. Case study discussion on Spectacular Failures case studies- Analysis and Prevention of Corrosion-Related Failures	**20 Hrs.**

Professional Elective – 4 (Experiments from any one elective as selected by student)	
List of experiments for course Advanced Metallurgy 1. Two assignments on Model preparation of Bravis lattices. 2. Effect of low alloy steels on Mechanical properties of materials-Tensile test, hardness test, Impact test. 3. Manufacturing of Al alloys and development of precipitation hardening cycle for strength improvements. 4. Study of dual phase steels-effect of dual phase on forming properties of materials. 5. Study of high temperature properties of materials: - high temperature tensile test. 6. Study of Heat Treatment steels: carry out different trials of heat treatment for the optimization of properties 7. Study of Heat Treatment of tool steels: carry out different trials of heat treatment for the optimization of properties	**20 Hrs.**
List of experiments for course Condition Based Monitoring (Minimum eight experiments) 1. Measurement of overall vibration of a rotary machine. 2. Frequency analysis of a rotary machine using FFT analyser. 3. Detect of the fault by frequency analysis. 4. Single plane balancing of rotor using FFT analyser 5. Two plane balancing of a rotor using FFT analyser. 6. Analysis and performance of the alignment of shaft of rotary machine. 7. Measurement of sound levels using sound meter 8. One-third octave band analysis of machine noise. 9. Identification of soft foot of machine installed on four foundation bolts by using virtual lab simulator. 10. Analysis of vibration levels caused by cavitation in centrifugal pump by using virtual lab simulator.	**20 Hrs.**
List of experiments for course Optimization Techniques in Design 1. Two assignments and case study discussion on classical optimization techniques. 2. Two assignments and case study discussion on in linear programming. 3. Two assignments and case study discussion on Non-Linear Programming. 4. Two assignments and case study discussion on Geometric programming. 5. Two assignments and case study discussion on Introduction to Genetic Algorithms. 6. Two assignments and case study discussion on Optimum selection of material and processes in mechanical design	**20 Hrs.**

Mandatory Life Skill Courses

Title of the Course: Constitution of India 4IC601 **Mandatory Life Skill Course**	L	T	P	Cr
	02	-	-	-

Pre-Requisite Courses: -

Textbooks:

1. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
2. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
3. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

References:

1. The Constitution of India, 1950 (Bare Act), Government Publication

Course Objectives :

The objectives of the course are:

1. To review and create awareness on various provisions in the constitution of India.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Explain the premises informing the twin themes of liberty and freedom from a civil rights perspective.	2	Understanding
CO2	Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.	2	Understanding
CO3	Address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.	2	Understanding

CO-PO Mapping :

	1	**2**	**3**	**4**	**5**	**6**
CO1						
CO2						
CO3						

Assessments :

Teacher Assessment:

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

Course Contents:

Module 1	**4 Hrs.**
History of Making of the Indian Constitution Drafting Committee, (Composition & Working)	
Module 2 Philosophy of the Indian Constitution	**4 Hrs.**
Preamble, Salient Features	
Module 3 Contours of Constitutional Rights & Duties	**5 Hrs.**
Fundamental Rights; Right to Equality; Right to Freedom; Right against Exploitation; Right to Freedom of Religion; Cultural and Educational Rights; Right to Constitutional Remedies; Directive Principles of State Policy; Fundamental Duties.	
Module 4 Organs of Governance	**5 Hrs.**
Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions	
Module 5 Local Administration	**5 Hrs.**
District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy	
Module 6 Election Commission	**5 Hrs.**
Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.	

Title of the Course: Pedagogy Studies 4IC602 **Mandatory Life Skill Course**	L	T	P	Cr
	02	-	-	-

Pre-Requisite Courses: -

Textbooks:

1. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
2. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
3. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
4. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
5. www.pratham.org/images/resource%20working%20paper%202.pdf.

References: 1. Alexander RJ, 2001, Culture and pedagogy: International comparisons in primary education, Oxford and Boston: Blackwell.
2. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.

Course Objectives :

The objectives of the course are:

1. To discuss pedagogical practices being used by teachers in formal and informal classrooms in developing countries.
2. To provide the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners.
3. To explain teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive level	Descriptor
CO1	Outline pedagogical practices, and existing evidence on the review topic to inform programme design and policy making undertaken.	2	Understanding
CO2	Explain critical evidence gaps to guide the development	2	Understanding

CO-PO Mapping :

	1	**2**	**3**	**4**	**5**	**6**
CO1						
CO2						
CO3						

Assessments :

Teacher Assessment:

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)

Course Contents:

Module 1 Introduction and Methodology	**5Hrs.**
Aims and rationale, Policy background, Conceptual framework and Terminology, Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions**,** Overview of methodology and Searching.	
Module 2	**5 Hrs.**
Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.	
Module 3	**5 Hrs.**
Evidence on the effectiveness of pedagogical practices, Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches, Teachers' attitudes and beliefs and Pedagogic strategies.	
Module 4	**5 Hrs.**
Professional development: alignment with classroom practices and follow-up support Peer support, Support from the head teacher and the community, Curriculum and assessment, Barriers to learning: limited resources and large class sizes	
Module 5	**5 Hrs.**
Research gaps and future directions Research design, Contexts, Pedagogy, Teacher education, Curriculum and assessment Dissemination and research impact.	

Title of the Course: Disaster Management 4IC603 **Mandatory Life Skill Course**	L	T	P	Cr
	02	-	-	-

Pre-Requisite Courses: -

Textbooks:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep &Deep

Course Objectives :

The objectives of the course are:

1. To impart knowledge for critical understanding of key concepts in disaster risk reduction and humanitarian response, and disaster management approaches
2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. Critically understand the strengths and weaknesses of, planning and programming in different countries, particularly their home country or the countries they work in

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Explain disaster risk reduction and humanitarian response policy and practice from multiple perspectives	2	Understanding
CO2	Summarize standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.	2	Understanding
CO3	Outline the strengths and weaknesses of disaster management approaches, planning and programming in different countries.	2	Understanding

CO-PO Mapping :

	1	**2**	**3**	**4**	**5**	**6**
CO1						
CO2						
CO3						

Assessments :

Teacher Assessment:

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.
MSE: Assessment is based on 50% of course content (Normally first three modules)

Module 1 Introduction	**4 Hrs.**
Disaster: Definition, Factors and Significance; Difference Between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.	
Module 2 Repercussions Of Disasters And Hazards	**4 Hrs.**
Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	
Module 3 Disaster Prone Areas In India	**4 Hrs.**
Study Of Seismic Zones; Areas Prone To Floods and Droughts, Landslides and Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics	
Module 4 Disaster Preparedness And Management	**4 Hrs.**
Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.	
Module 5 Risk Assessment	**4 Hrs.**
Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment and Warning, People's Participation In Risk Assessment. Strategies for Survival.	
Module 6 Disaster Mitigation	**4 Hrs.**
Meaning, Concept and Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.	

Title of the Course: Value Education 4IC604 **Mandatory Life Skill Course**	L	T	P	Cr
	02	-	-	-

Pre-Requisite Courses: -

Textbooks:

1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

Course Objectives :

The objectives of the course are:

1. To impart knowledge on value of education and self- development.
2. To imbibe good values in students.
3. To highlight importance of character.

Course Learning Outcomes:

CO	After the completion of the course the student should be able to	Bloom's Cognitive	
		level	Descriptor
CO1	Explain value of education and self- development.	2	Understanding
CO2	Summarize importance of good character, and Behavior development.	2	Understanding

CO-PO Mapping :

	1	**2**	**3**	**4**	**5**	**6**
CO1						
CO2						
CO3						

Assessments :

Teacher Assessment:

Assessment	Marks
ISE 1	10
MSE	30
ISE 2	10
ESE	50

ISE 1 and ISE 2 are based on assignment/declared test/quiz/seminar etc.

MSE: Assessment is based on 50% of course content (Normally first three modules)

Module 1	**6Hrs.**
1. Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. 2. Moral and non- moral valuation. Standards and principles. 3. Value judgments	
Module 2	**6 Hrs.**
1. Importance of cultivation of values 2. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. 3. Honesty, Humanity. Power of faith, National Unity. 4. Patriotism. Love for nature, Discipline	
Module 3	**7 Hrs.**
1. Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. 2. Punctuality, Love and Kindness. 3. Avoid fault Thinking. 4. Free from anger, Dignity of labour. 5. Universal brotherhood and religious tolerance. 6. True friendship. 7. Happiness Vs suffering, love for truth. 8. Aware of self-destructive habits. 9. Association and Cooperation. 10. Doing best for saving nature	
Module 4	**7 Hrs.**
1. Character and Competence –Holy books vs Blind faith. 2. Self-management and Good health. 3. Science of reincarnation. 4. Equality, Nonviolence, Humility, Role of Women. 5. All religions and same message. 6. Mind your Mind, Self-control. 7. Honesty, Studying effectively	

Value Added
Professional Courses

There are no courses under this category for this semester.

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