

**SAVITRIBAI PHULE PUNE UNIVERSITY**



**FACULTY OF ENGINEERING**

**SYLLABUS FOR  
T. E. (MECHANICAL ENGINEERING)  
(2015 Course)**

**WITH EFFECT FROM YEAR 2017-2018**

**Savitribai Phule Pune University**  
**T.E. Mechanical Engineering 2015 – Course**  
**T. E. (Mechanical) (2015 Course) Semester – I**

Code	Subject	Teaching Scheme Hrs / week			Examination Scheme					Total Marks	Credits	
		Lecture	Tut	Pract	In-Sem	ESE	TW	PR	OR		Th	TW / PR / OR
302041	Design of Machine Elements-I	4	-	2	30@	70@	50	-		150	4	1
302042	Heat Transfer*	4	-	2	30	70		50	-	150	4	1
302043	Theory of Machines-II <sup>§</sup>	3	1		30	70	25	-	25	150	3	1
302044	Turbo Machines	3	-	2	30	70	-	-	25	125	3	1
302045	Metrology and Quality Control <sup>§</sup>	3	-	2	30	70	-	-	25	125	3	1
302046	Skill Development	-	-	2	-	-	25	25	-	50	-	1
<b>Total</b>		<b>17</b>	<b>1</b>	<b>10</b>	<b>150</b>	<b>350</b>	<b>100</b>	<b>75</b>	<b>75</b>	<b>750</b>	<b>17</b>	<b>6</b>
											<b>23</b>	

**T. E. (Mechanical) (2015 Course) Semester – II**

Code	Subject	Teaching Scheme Hrs / week			Examination Scheme					Total Marks	Credits	
		Lecture	Tut	Pract	In-Sem	ESE	TW	PR	OR		Th	TW / PR / OR
302047	Numerical Methods and Optimization*	4	-	2	30	70	-	50	-	150	4	1
302048	Design of Machine Elements-II	4	-	2	30@	70@	25	-	25	150	4	1
302049	Refrigeration and Air Conditioning	3	-	2	30	70	-	-	25	125	3	1
302050	Mechatronics <sup>%</sup>	3	1		30	70	-	-	25	125	3	1
302051	Manufacturing - Process-II <sup>§</sup>	3	-	-	30	70	-	-	-	100	3	-
302052	Machine Shop-II <sup>§</sup>	-	-	2	-	-	50	-	-	50	-	1
302053	Seminar <sup>§</sup>	-	-	2	-	-	25	-	25#	50	-	1
302054	Audit Course*	--	--	--	--	--	-	-	-	-	-	-
<b>Total</b>		<b>17</b>	<b>1</b>	<b>10</b>	<b>150</b>	<b>350</b>	<b>100</b>	<b>50</b>	<b>100</b>	<b>750</b>	<b>17</b>	<b>6</b>
											<b>23</b>	

# Though it is under Oral head Internal Panel to be appointed by Principal and HOD.

Examination schedule will not be prepared at University level.

\* Marked subjects are common with TE (Auto. Engg.) and TE Mech. Sandwich

§ Marked subjects are common with TE (Auto. Engg.) only

% Marked subjects are common with TE Mech. Sandwich only

@ Examination time for Insem examination 1 Hr 30 Min. and Endsem examination 3Hrs.

**Savitribai Phule Pune University, Pune**  
**Third Year of Mechanical**  
**(2015 Course)**

**Course Code: 302041**

**Course Name : Design of Machine Elements – I**

<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme:</b>
<b>TH: -- 4 Hrs/ Week</b>	<b>TH:--04</b>	<b>TH In-Sem: -- 30</b>
<b>PR: - 2 Hrs/ Week</b>	<b>TW:--01</b>	<b>End-Sem: -- 70</b>
		<b>TW: -- 50</b>

**Course Objective:**

1. Student shall gain appreciation and understanding of the design function in Mechanical Engineering, different steps involved in designing and the relation of design activity with manufacturing activity.
2. The student shall learn to choose proper materials for different machine elements depending on their physical and mechanical properties. They will learn to apply the knowledge of material science in real life situations.
3. Student shall gain a thorough understanding of the different types of failure modes and criteria. They will be conversant with various failure theories and be able to judge which criterion is to be applied for a particular situation.
4. Student shall gain design knowledge of the different types of elements used in the machine design process, for e.g. fasteners, shafts, couplings etc. and will be able to design these elements for each application.

**Course Outcome:**

1. Ability to identify and understand failure modes for mechanical elements and design of machine elements based on strength.
2. Ability to design Shafts, Keys and Coupling for industrial applications.
3. Ability to design machine elements subjected to fluctuating loads.
4. Ability to design Power Screws for various applications.
5. Ability to design fasteners and welded joints subjected to different loading conditions.
6. Ability to design various Springs for strength and stiffness.

**Course Contents****UNIT 1: Design of Simple Machine Elements (10 hrs)**

Machine Design, Design cycle, Design considerations - Strength, Rigidity, Manufacture, Assembly and Cost, Standards and codes, Use of preferred series, Factor of safety, Service factor. Design of Cotter joint, Knuckle joint, Levers - hand / foot lever, lever for safety valve, bell crank lever, and components subjected to eccentric loading.

**UNIT 2: Design of Shafts, Keys and Couplings (08 hrs)**

Shaft design on the basis of strength, torsional rigidity and lateral rigidity, A.S.M.E. code for shaft design. Transmission shaft:- Theoretical treatment only. Design of keys and splines. Design of Flange Coupling and Flexible Bushed Pin Coupling.

**UNIT 3: Design for Fluctuating Load (08 hrs)**

Stress concentration - causes & remedies, fluctuating stresses, fatigue failures, S-N curve, endurance limit, notch sensitivity, endurance strength modifying factors, design for finite and infinite life, cumulative damage in fatigue failure, Soderberg, Gerber, Goodman, Modified Goodman diagrams, Fatigue design of components under combined stresses:- Theoretical treatment only.

**UNIT 4: Power Screws (06 hrs)**

Forms of threads, multiple start screws, Torque analysis and Design of power screws with square and trapezoidal threads, Self locking screw, Collar friction torque, Stresses in power screws, design of a C-Clamp. Design of screw jack, Differential and Compound Screw and Re-circulating Ball Screw (Theoretical treatment only).

**UNIT 5: Threaded joints and Welded joints s** **(10 hrs)**

Basic types of screw fasteners, Bolts of uniform strength, I.S.O. Metric screw threads, Bolts under tension, eccentrically loaded bolted joint in shear, Eccentric load perpendicular and parallel to axis of bolt, Eccentric load on circular base, design of Turn Buckle. Welding symbols, Stresses in butt and fillet welds, Strength of butt, parallel and transverse fillet welds, Axially loaded unsymmetrical welded joints, Eccentric load in plane of welds, Welded joints subjected to bending and torsional moments.

**UNIT 6: Mechanical Springs** **(06 hrs)**

Types, applications and materials for springs, Stress and deflection equations for helical compression Springs, Style of ends, Design of helical compression and tension springs, Springs in series and parallel, Concentric helical springs, Surge in springs, Design of Multi-leaf springs. Helical torsion Spring (Theoretical treatment only).

**Books:**

**Text:**

- 1) Bhandari V.B., Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd.
- 2) Shigley J.E. and Mischke C.R., Mechanical Engineering Design, McGraw Hill Publication Co. Ltd.
- 3) Spotts M.F. and Shoup T.E., Design of Machine Elements, Prentice Hall International.
- 4) Juvinal R.C., Fundamentals of Machine Components Design, John Wiley and Sons

**References:**

- 1) Black P.H. and O. Eugene Adams, Machine Design, McGraw Hill Book Co. Inc.
- 2) William C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House.
- 3) Hall A.S., Holowenko A.R. and Laughlin H.G, Theory and Problems of Machine Design, Schaum's Outline Series.
- 4) C. S. Sharma and Kamlesh Purohit, Design of Machine Elements, PHI Learning Pvt. Ltd.
- 5) D. K. Aggarwal & P. C. Sharma, Machine Design, S.K Kataria and Sons
- 6) P. C. Gope, Machine Design: Fundamentals and Applications, PHI Learning Pvt. Ltd.
- 7) Design Data - P.S.G. College of Technology, Coimbatore.
- 8) Bhandari, V. B. Machine Design data book, Tata McGraw Hill Publication Co. Ltd.
- 9) K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers.
- 10) Kanhhia, Design of Machine Elements-1, Scitech Publications

## Term-Work

Term work shall consist of

### 1. Two design projects on Assemblies covering above syllabus.

The design project shall consist of half imperial sheets (A2 size) involving assembly-drawing with a bill of material and overall dimensions and drawings of individual components. The Project should be assigned to a group of three to five students.

#### **Project 1 shall be based on any one of the following topics-**

- i) Cotter joint/ knuckle joint/turn buckle for a specified application.
- ii) Transmission Shaft/Machine tool spindles/coupling for specified application.
- iii) Hand or foot operated levers/lever for safety valve.

#### **Project 2 shall be based on any one of the following topics-**

- i) Bench vice/Machine vice for specified applications.
- ii) Bottle type/toggle jack for vehicles.
- iii) Lead screw for machine tool/other applications.

Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified for important surfaces. A design report giving all necessary calculations of the design of components and assembly should be submitted in a separate file. Design data book shall be used wherever necessary for selection of standard components.

Drawings of design project should be done manually.

### 2. Assignments

The assignment shall be internally presented in the form of power point presentation, by a group of three to five students. A report of assignment (Max 8 to 10 pages) along with print out of ppt is to be submitted. Each student shall complete any two of the following assignments, with Assignment

(a) compulsory.

a. Use of dimensional tolerances, Geometrical tolerances and surface finish symbols in machine component drawings.

A. Selection of materials using weighted point method.

B. Selection of manufacturing methods for machine elements designed in any one of the above design projects.

C. Theories of failures and their applications.

**Savitribai Phule Pune University, Pune**  
**Third Year of Mechanical, Mechanical Sandwich & Automobile**  
**(2015 Course)**

**Course Code: 302042**

**Course Name : HEAT TRANSFER**

<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme:</b>
<b>TH: - 4 Hrs/ Week</b>	<b>TH:--04</b>	<b>TH In-Sem: -- 30</b>
		<b>End-Sem: -- 70</b>
<b>PR: - 2 Hrs/ Week</b>	<b>PR:--01</b>	<b>PR: -- 50</b>

**Course Objectives:**

1. Identify the important modes of heat transfer and their applications.
2. Formulate and apply the general three dimensional heat conduction equations.
3. Analyze the thermal systems with internal heat generation and lumped heat capacitance.
4. Understand the mechanism of convective heat transfer
5. Determine the radiative heat transfer between surfaces.
6. Describe the various two phase heat transfer phenomenon. Execute the effectiveness and rating of heat exchangers.

**Course Outcomes:**

CO 1: Analyze the various modes of heat transfer and implement the basic heat conduction equations for steady one dimensional thermal system.

CO 2: Implement the general heat conduction equation to thermal systems with and without internal heat generation and transient heat conduction.

CO 3: Analyze the heat transfer rate in natural and forced convection and evaluate through experimentation investigation.

CO 4: Interpret heat transfer by radiation between objects with simple geometries.

CO 5: Analyze the heat transfer equipment and investigate the performance.

**Course Contents**

<b>UNIT 1:</b>	<b>(10 hrs)</b>
<p><b>Introduction and Basic Concepts:</b> Application areas of heat transfer, Modes and Laws of heat transfer, Three dimensional heat conduction equation in Cartesian coordinates and its simplified equations, thermal conductivity, Thermal diffusivity, Thermal contact Resistance</p>	
<p><b>Boundary and initial conditions:</b> Temperature boundary condition, heat flux boundary condition, convection boundary condition, radiation boundary condition.</p>	
<p><b>One dimensional steady state heat conduction without heat generation:</b> Heat conduction in plane wall, composite slab, composite cylinder, composite sphere, electrical analogy, concept of thermal resistance and conductance, three dimensional heat conduction equations in cylindrical and spherical coordinates (no derivation) and its reduction to one dimensional form, critical radius of insulation for cylinders and spheres, economic thickness of insulation.</p>	
<b>UNIT 2:</b>	<b>(08 hrs)</b>
<p><b>One dimensional steady state heat conduction with heat generation:</b> Heat conduction with uniform heat generation in plane wall, cylinder &amp; sphere with different boundary conditions.</p>	
<p><b>Heat transfer through extended surface:</b> Types of fins and its applications, Governing Equation for constant cross sectional area fins, solution for infinitely long &amp; adequately long (with insulated end) fins, efficiency &amp; effectiveness of fins.</p>	
<b>UNIT 3:</b>	<b>(06 hrs)</b>
<p><b>Thermal Insulation – Types and selection, Economic and cost considerations, Payback period</b></p>	
<p><b>Transient heat conduction:</b> Validity and criteria of lumped system analysis, Biot and Fourier number, Time constant and response of thermocouple, Transient heat analysis using charts.</p>	
<b>UNIT4:</b>	<b>(08hrs)</b>
<p><b>Convection</b></p>	
<p><b>Fundamentals of convection:</b> Mechanism of natural and forced convection, local and average heat transfer coefficient, concept of velocity &amp; thermal boundary layers.</p>	
<p><b>Forced convection:</b> Dimensionless numbers and their physical significance, empirical correlations for external &amp; internal flow for both laminar and turbulent flows.</p>	
<p><b>Natural convection:</b> Introduction, dimensionless numbers and their physical significance, empirical correlations for natural convection.</p>	
<b>UNIT 5: Radiation</b>	<b>(08 hrs)</b>
<p>Fundamental concepts, Spectral and total emissive power, real and grey surfaces, Stefan Boltzmann law, Radiation laws – Planks, Wiens, Kirchoff's and Lambert's cosine law with simple applications, Irradiation and radiosity, Electrical analogy in radiation, Radiation shape factor, radiation heat exchange between two black and diffuse gray surfaces, radiation shield.</p>	



**UNIT 6: Heat Transfer Equipments****(08 hrs)**

**Condensation and Boiling:** Boiling heat transfer, types of boiling, pool boiling curve and forced boiling phenomenon, condensation heat transfer, film wise and drop wise condensation (simple numerical treatment).

**Heat exchangers:** Classification and applications, heat exchanger analysis – LMTD for parallel and counter flow heat exchanger, effectiveness– NTU method for parallel and counter flow heat exchanger, cross flow heat exchanger, LMTD correction factor, design criteria for heat exchanger, Introduction to TEMA standards.

Introduction to heat pipe, Introduction to electronic cooling - Discussion on active and passive methods.

**Books:****Text:**

1. F.P. Incropera, D.P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley.
2. Y. A. Cengel and A.J. Ghajar, Heat and Mass Transfer – Fundamentals and Applications, Tata McGraw Hill Education Private Limited.
3. S.P. Sukhatme, A Textbook on Heat Transfer, Universities Press.
4. R.C. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New Age Science.
5. P.K. Nag, Heat & Mass Transfer, McGraw Hill Education Private Limited.
6. M. M. Rathod, Engineering Heat and Mass Transfer, Third Edition, Laxmi Publications, New Delhi
7. V. M. Domkundwar, Heat Transfer,

**References:**

1. A.F. Mills, Basic Heat and Mass Transfer, Pearson.
2. S. P. Venkatesan, Heat Transfer, Ane Books Pvt. Ltd.
3. Holman, Fundamentals of Heat and Mass Transfer, McGraw – Hill publication.
4. M. Thirumaleshwar, Fundamentals of Heat and Mass Transfer, Pearson Education India.
5. B.K. Dutta, Heat Transfer-Principles and Applications, PHI.
6. C.P. Kothandaraman, S. V. Subramanyam, Heat and Mass Transfer Data Book, New Academic Science.
7. Databook, SPPU provided by the Exam Center

## **LIST OF EXPERIMENTS**

**Any eight experiments (1-11) and two assignments (12-14) from the following list**

1. Determination of Thermal Conductivity of metal rod
2. Determination of Thermal Conductivity of insulating powder
3. Determination of Thermal Conductivity of Composite wall
4. Determination of Thermal Contact Resistance
5. Determination of heat transfer coefficient in Natural Convection
6. Determination of heat transfer coefficient in Forced Convection
7. Determination of temperature distribution, fin efficiency in Natural / Forced Convection
8. Determination of Emissivity of a Test surface
9. Determination of Stefan Boltzmann Constant
10. Determination of effectiveness of heat exchanger
11. Study of pool boiling phenomenon and determination of critical heat flux
12. Assignment on 1-D transient heat transfer program using finite difference methods.
13. Assignment to solve transient heat transfer problem using Heisler and Grober charts.
14. Assignment on multi-pass / cross-flow heat exchanger using effectiveness charts.

**Savitribai Phule Pune University, Pune**

**TE Mechanical and TE Automobile (2015 course)**

**Course Code: 302043**

**Course Name : Theory of Machine – II**

<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme:</b>	
<b>TH: -- 03 Hrs/week</b>	<b>TH:--03</b>	<b>TH</b>	<b>In-Sem: -- 30</b>
			<b>End-Sem: --70</b>
<b>Tut.:- 01 Hr /week</b>	<b>TW/OR:--01</b>		
			<b>OR: -- 25</b>
			<b>TW: -- 25</b>

**Course Objectives:**

1. To develop competency in understanding of theory of all types of gears.
2. To understand the analysis of gear train.
3. To develop competency in drawing the cam profile.
4. To make the student conversant with synthesis of the mechanism.
5. To understand step-less regulations.
6. To understand mechanisms for system control – Gyroscope.

**Course Outcomes:**

1. Student will be able to understand fundamentals of gear theory which will be the prerequisite for gear design.
2. Student will be able to perform force analysis of Spur, Helical, Bevel, Worm and Worm gear.
3. The student to analyze speed and torque in epi-cyclic gear trains which will be the prerequisite for gear box design.
4. Student will be able to design cam profile for given follower motions and understand cam Jump phenomenon, advance cam curves.
5. The student will synthesize a four bar mechanism with analytical and graphical methods.
6. *a.* The student will analyze the gyroscopic couple or effect for stabilization of Ship  
Aeroplane and Four wheeler vehicle.  
*b.* Student will choose appropriate drive for given application (stepped / step-less).

**Course Contents**

**Unit – I: Spur Gear**

**(08 hrs)**

Classification, Spur gear: definition, terminology, fundamental law of toothed gearing, involute and cycloidal profile, path of contact, arc of contact, conjugate action, contact ratio, interference and under cutting – Methods to avoid interference. Minimum number of teeth on gear and pinion only, Force analysis and Friction in gears.

<b>Unit – II: Helical, Bevel, Worm and Worm Wheel</b>	<b>(06 hrs)</b>
<p>Helical and Spiral Gears: terminology, geometrical relationships, tooth forces, torque transmitted and efficiency, virtual number of teeth for helical gears          Bevel Gear &amp; Worm and worm wheel: terminology, geometrical relationships, tooth forces, torque transmitted.          Bevel Gear: Theoretical treatment only</p>	
<b>Unit – III Gear Trains</b>	<b>(06 hrs)</b>
<p>Types of Gear Trains, analysis of epicyclic gear trains, Holding torque – Simple, compound and epicyclic gear trains, torque on sun and planetary gear train, compound epicyclic gear train, Bevel epicyclic Gear train.</p>	
<b>Unit –IV Cam and Follower</b>	<b>(08 hrs)</b>
<p>Types of cams and followers, analysis of standard motions to the follower, Determination of cam profiles for different follower motions, Methods of control: pressure angle, radius of curvature and undercutting. Jump phenomenon of Eccentric cam, Introduction to advanced cam curves (up to 3-4-5 Polynomial cam only)</p>	
<b>Unit –V Synthesis of Mechanism</b>	<b>(06 hrs)</b>
<p>Steps in synthesis process: Type, number and dimensional synthesis. Tasks of Kinematic synthesis: Path, function and motion generation (Body guidance). Precision Positions, Chebychev spacing, Mechanical and structural errors. Three position synthesis of four bar mechanism using Freudenstein’s equation. Analytical synthesis using kinematic coefficient in four bar mechanism.</p>	
<b>Unit –VI Step–Less-Regulation (Theoretical Treatment only) &amp; Gyroscope</b>	<b>(06 hrs)</b>
<p>Continuous Variable Transmissions - Geometry, Velocity and torque analysis of Faceplate variators, conical variators, Spheroidal and cone variators, Variators with axially displaceable cones, PIV drives. Gyroscopes, Gyroscopic forces and Couples, Gyroscopic stabilisation for ship and Aeroplane, Stability of four wheel vehicle moving on curved path.</p>	
<b>Books:</b>	
<b>Text:</b>	
<ol style="list-style-type: none"> <li>1. S. S. Rattan, Theory of Machines, Third Edition, McGraw Hill Education ( India) Pvt. Ltd. New Delhi.</li> <li>2. Bevan T, Theory of Machines, Third Edition, Longman Publication.</li> <li>3. A. G. Ambekar, Mechanism and Machine Theory, PHI.</li> <li>4. N. K. Mehta, Machine Tool Design and Numerical Control, Tata McGraw Hill Publication,</li> <li>5. J. J. Uicker, G. R. Pennock, J. E. Shigley, Theory of Machines and Mechanisms, Third Edition, International Student Edition, OXFORD.</li> </ol>	

**References:**

1. Ghosh Malik, Theory of Mechanism and Machines, East-West Pvt. Ltd.
2. Hannah and Stephans, Mechanics of Machines, Edward Arnold Publication.
3. R L Norton, Kinematics and Dynamics of Machinery, First Edition, McGraw Hill Education (India) P Ltd. New Delhi
4. Sadhu Singh, Theory of Machines, Pearson
5. D.K. Pal, S.K. Basu, Design of Machine Tools, Oxford & Ibh Publishing Co Pvt. Ltd.
6. Dr. V. P. Singh, Theory of Machine, Dhanpatrai and sons.
7. C. S. Sharma & Kamlesh Purohit, "Theory of Machine and Mechanism", PHI.

**Tutorial (Term-work) shall consist of****Part A: Compulsory**

1. To study manufacturing of gear using gear generation with rack as a cutter and to generate involute profile
2. Kinematic analysis of synchromesh, machine tool gear box, differential gear box (Self Study)
3. Speed and torque analysis of epicyclic gear train to determine holding torque
4. To draw the cam profile and study variation in pressure angle with respect to change in base circle diameter and draw pitch circle for both the cases. ( Half imperial drawing sheet)
5. To synthesize the four bar and slider crank mechanism using relative pole and inversion method with three accuracy points. ( Half imperial drawing sheet)
6. To determine the effect of active gyroscopic couple on a spinning disc and verify the gyroscopic effect.
7. Study of Continuous Variable Transmission and Infinite Variable Transmission.

**Part B: Any two from the following**

1. To draw conjugate profile for any general type of gear tooth. ( Half imperial drawing sheet)
2. To verify the cam jump phenomenon for an eccentric cam.
3. Synthesis a four bar mechanism based on Freudenstein's equation using any programming Language.
4. To measure the range of speeds obtained using any one type of continuously variable transmission device.
5. Industrial visit to understand Machines and Mechanisms.

**Savitribai Phule Pune University, Pune**

**T.E Mechanical (2015 course)**

**Course Code: 302044**

**Course Name : Turbo Machines**

<b>Teaching Scheme:</b>	<b>Credits:</b>	<b>Examination Scheme:</b>
TH: -- 03 hrs/week PR: -- 02 hrs/week	TH:-- 03 OR:-- 01	TH In-Sem: -- 30 End-Sem: -- 70  OR: -- 25

**Course Objectives:**

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

**Course Outcomes:**

On successful completion of the course, the student will be able to,

1. Apply thermodynamics and kinematics principles to turbo machines.
2. Analyze the performance of turbo machines.
3. Ability to select turbo machine for given application.
4. Predict performance of turbo machine using model analysis.

**Course Contents**

**Unit – I: Introduction to Turbo Machinery****(08hrs)**

Turbo machines (Hydraulic & Thermal), Classification of Turbo machines, Comparison with positive displacement machines, Fundamental equation governing turbo machines, Different losses associated with turbo-machinery, Applications of Turbo machines.

**Impact of Jet**

Impulse momentum principle and its applications, Force exerted on fixed and moving flat plate, hinged plate, curved vanes, series of flat plates and radial vanes, velocity triangles and their analysis, work done equations, vane efficiency.

**Unit –II: Impulse Water Turbines****(06hrs)**

Introduction to Hydro power plant, classification of hydraulic turbines construction, principle of working, velocity diagrams and analysis, design aspects, performance parameters, performance characteristics, specific speed, selection of turbines, multi-jet Pelton wheel.

**Unit –III: Reaction Water Turbines****(08 hrs)**

Classifications, Francis, Propeller, Kaplan Turbines, construction features, velocity diagrams and analysis, degree of reaction, performance characteristics.

Draft tubes: types and analysis, causes and remedies for cavitation phenomenon

Governing of turbines, Similitude and dimensional analysis of hydraulic turbines

**Unit –IV: Steam Turbines****(08 hrs)**

**Steam nozzles:** types and applications, Equation for velocity and mass flow rate [No numerical treatment].

**Steam Turbines:** Classifications, construction details, compounding of steam turbines, velocity diagrams and analysis of Impulse and reaction turbines (single & multi stage), governing, dimensional analysis, performance characteristics. Losses in steam turbines, selection of turbines.

**Unit –V: Centrifugal Pumps****(08 hrs)**

Classification of rotodynamic pumps, components of centrifugal pump, types of heads, velocity triangles and their analysis, effect of outlet blade angle, cavitation, NPSH, Thoma's cavitation factor, priming of pumps, installation, specific speed, performance characteristics of centrifugal pump, series and parallel operation of pumps, system resistance curve, selection of pumps.

Dimensional and Model analysis of hydraulic machines

**Unit –VI: Centrifugal & Axial Compressor****(07 hrs)**

**Centrifugal compressor:** Classification of compressors, Construction, velocity diagram, flow process on T-S Diagram, Euler's work, actual work input, performance characteristics, various losses in centrifugal compressor.

**Axial Compressor:** Construction, stage velocity triangles and its analysis, enthalpy entropy diagram, stage losses and efficiencies, performance characteristics. [No numerical treatment]

**Books:****Text:**

1. Turbines, Compressors & Fans, S.M. Yahya, Tata-McGraw Hill
2. Turbomachines, B. U. Pai, Wiley India
3. Fluid mechanics and hydraulic machines, Dr. R.K. Bansal
4. Hydraulic Machines, Dr. J. Lal, Metropolitan Book Co. Pvt. Ltd., Delhi.
5. Hydraulics, Fluid Mechanics and Machinery, Modi P N & Seth S N, Standard Book House, New Delhi.
6. R. Yadav, Steam and Gas Turbines and Power Plant Engineering, VII edition, Central Publ. house

**References:**

1. William W. Perg, Fundamentals of Turbomachinery, John Wiley & Sons.
2. Thermal Turbomachines, Dr. Onkar Singh, Wiley India
3. V. P. Vasandani, Theory of Hydraulic Machinery, Khanna Publishers, Delhi.
4. Karassik, Hand Book of Pumps, Tata McGraw Hills Ltd., New Delhi.
5. S.L. Dixon, Fluid Mechanics, Thermodynamics of Turbomachinery, IV edition, Butterworth-Heinemann Publ., 1966.



## **Term-Work**

### **List of Experiments**

1. Verification of impulse momentum principle
2. Study and trial on impulse water turbine (Pelton wheel) and plotting of main and operating characteristics
3. Study and trial on any one hydraulic reaction turbine (Francis/Kaplan) and plotting of main and operating characteristics
4. Study and trial on centrifugal pump and plotting operating characteristics
5. Study and trial on centrifugal air compressor and plotting its characteristics
6. Visit to hydro/steam power plant and report to be submitted.
7. Study of different types of nozzles and trial on convergent-divergent air/steam nozzle.
8. Study of axial flow compressors/ centrifugal air blower.
9. Study of multi-staging of steam turbines.
10. Design of pumping system installation using manufacturers' catalogue, specific to housing or industrial application.
11. Visit to pumping station and report to be submitted.

### **Notes**

1. Eight experiments from above list should be performed; out of which at least four trials should be conducted. Data from any one trial performed should be analyzed by using suitable software.
2. One Experiment out of Expt. no. 10 and 11 is compulsory.
3. Visit to Hydro or Steam power plant is compulsory.

**Savitribai Phule Pune University, Pune**

**TE Mechanical and TE Automobile (2015 course)**

**Course Code: 302045**

**Course Name : Metrology And Quality Control**

<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme:</b>
<b>TH: 03 Hrs/week</b>	<b>TH:--03</b>	<b>TH In-Sem: -- 30</b>
<b>PR: 02 Hrs/week</b>	<b>OR:--01</b>	<b>End-Sem: -- 70</b>
		<b>OR: -- 25</b>

**Course Objectives:**

**Students are expected to –**

1. Select suitable instrument / gauge / method of inspection for determining geometrical and dimensional measurements.
2. Calibrate measuring instruments and also design inspection gauges.
3. Understand the advances in Metrology such as use of CMM, Laser, Machine Vision System for Metrology etc.
4. Select and apply appropriate Quality Control Technique for given application.
5. Select and Apply appropriate Quality Management Tool and suggest appropriate Quality Management System (QMS).

**Course Outcomes:**

**The student should be able to –**

1. Understand the methods of measurement, selection of measuring instruments / standards of measurement, carryout data collection and its analysis.
2. Explain tolerance, limits of size, fits, geometric and position tolerances and gauge design
3. Understand and use/apply Quality Control Techniques/ Statistical Tools appropriately.
4. Develop an ability of problem solving and decision making by identifying and analyzing the cause for variation and recommend suitable corrective actions for quality improvement.

## Course Contents

### Unit – I Measurement standards and Design of gauges

(06 hrs)

**Introduction:** Principles of Engineering metrology, Measurement standards, Types and sources of errors, Accuracy and Precision, Calibration: Concept and procedure, traceability,

**Geometric Form Measurement:** Straightness, Flatness, Roundness - Straight edge, use of level beam comparator, autocollimator testing of flatness of surface plate.

**Design of Gauges:** Tolerances, Limits and Fits [IS 919-1993], Taylor's principle, Types of gauges, Wear allowance on gauges, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials, Considerations of gauge design (numerical).

### Unit –II Comparators, Thread and Gear Metrology, Surface Roughness Measurement

(08 hrs)

**Comparators:** Mechanical, Pneumatic, Optical, Electrical (LVDT).

**Measurement of Thread form:** Thread form errors, Measurement of Minor, Major and Effective diameter (Three Wire Method), Flank angle and Pitch, Floating Carriage Micrometer (Numerical).

**Gear Metrology:** Errors in Spur Gear form, Gear tooth Vernier, Constant chord, Base tangent (Numerical), Gear Rolling Tester. Profile Projector, Tool maker's microscope and their applications

**Surface Roughness Measurement:** Introduction to Surface texture, Parameters for measuring surface roughness, Surface roughness measuring instrument: TalySurf.

### Unit – III Advances in Metrology

(06 hrs)

**Coordinate Measuring Machine (CMM):** Fundamental features of CMM – development of CMMs – role of CMMs – types of CMM and Applications, – types of probes

**Machine Vision Systems:** vision system measurement – Multisensory systems.

**Interferometer:** Principle, NPL Interferometer

**Laser Metrology:** Basic concepts of lasers, advantages of lasers, laser interferometers, types, applications

**Unit – IV Introduction to Quality and Quality Tools****(06 hrs)**

**Concept of Quality:** Various Definitions and Quality Statements, Cost of quality & value of quality, Deming's cycles & 14 Points, Juran Trilogy approach, Old New Seven Tools, Quality Circles.

**Importance of Quality deployment at Design and Manufacturing Engineering:** Opportunities for improvement product design, Importance of– initial planning for quality, concept of controllability: self-controls – defining quality responsibilities on the factory flow – self inspection.

**Unit –V Statistical quality control****(08 hrs)**

**Statistical quality control:** Statistical concept, Frequency diagram, Concept of variance analysis, Control Chart for Variable (**X & R** Chart) & Attribute (**P & C** Chart), Process capability(Indices: cp, cpk, ppk), Statistical Process Control (Numerical). Production Part Approval Method (PPAP).

**Acceptance Sampling:** Sampling Inspection, OC Curve and its characteristics, sampling methods, Sampling Plan: Single, Double (Numerical), Multiple, Comparison of Plan, calculation of sample size, AOQ, Probability of Acceptance (Numerical)

**Unit –VI Total Quality Management****(06 hrs)**

**TQM:** Introduction, Quality Function Deployment, 5S, Kaizen, Poka yoke, Kanban, JIT, FMECA, Zero defects, TPM. Six Sigma: DMAIC - Concept and Applications.

**Quality Management System**

Need for quality management system – design of quality management system - quality management system requirements – ISO 9001, TS-16949, ISO-14000, Quality Audit.

**Books:****Text:**

1. Jain R.K., Engineering Metrology, Khanna Publication.
2. I. C. Gupta, Engineering Metrology, Dhanpath Rai.
3. Bewoor A. K. and Kulkarni V. A., Metrology and Measurements, Tata McGraw hill Publication.
4. Juran J. M., Quality Handbook, McGraw Hill Publications.
5. Grant S.P., Statistical Quality Control, Tata McGraw hill Publication.

**References:**

1. Narayana K.L., Engineering Metrology.
2. Galyer J.F & Shotbolt C.R., Metrology for engineers
3. Gupta I.C., Engineering Metrology, Dhanpatrai Publiartions
4. Judge A.W., Engineering Precision Measurements, Chapman and Hall
5. Francis T. Farago, Mark A. Curtis, Handbook of dimensional measurement.
6. ASTME, Handbook of Industrial Metrology, Prentice Hall of India Ltd.
7. Connie Dotson, Fundamentals of Dimensional Metrology, Thamson Publ., 4th Edition.
8. Basterfield D. H., Quality control, Pearson Education India, 2004.
9. Kulkarni V. A. and Bewoor A. K., Quality Control, John Wiley Publication.
10. Harrison M. Wordsworth, Stefeen Godfrey, Modern Methods for Quality control and Improvement, Willy Publication.

**Online Education resources: viz. NPTEL web site:**

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

## **Term-Work**

### **LIST OF EXPERIMENTS**

**Part: A] Experiment no. 1, 4 and 6 are mandatory. Perform any three from experiment no. 2 to 5 & any three from experiment no. 7 to 10.**

1. Demonstration of linear and angular measuring instruments, slip gauges and their applications.
2. Error determination of linear / angular measuring instruments and determination of linear and angular dimensions of given part, (MSA: Gauge R & R).
3. Calibration of measuring instrument. Example – Dial gauge, Micrometer, Vernier (any one) (Refer ISO 17025).
4. Verification of dimensions and geometry of given components using Mechanical /Pneumatic comparator. [An assignment with this experiment write-up as, Introduction to use of Standard CODE viz. ASME-Y14.5, ISO-1101].
5. Machine tool alignment testing on machine tool – Lathe / Drilling / Milling.
6. Demonstration of surfaces inspection using optical flat/interferometers. / Demonstration of surface roughness measurement using surface roughness tester.
7. Determination of geometry and dimensions of given composite object / single point tool, using profile projector and tool maker's microscope.
8. Measurement of thread parameters using floating carriage diameter measuring machine.
9. Measurement of spur gear parameters using Gear Tooth Vernier / Span Micrometer / Gear Rolling Tester.
10. Determination of given geometry using coordinate measuring machine (CMM).

**Part: B] Statistical Quality Control (SQC) (Any Two)**

**Note - Use of computational tools [such as Minitab / Matlab / MS Excel] are recommended**

1. Analyze the fault in given batch of specimens by using seven quality control tools for engineering application. Submission of these assignments USING STANDARD FORMATS.
2. Determination of process capability from given components and plot variable control chart/ attribute chart.
3. Case study on various tools in Total Quality Management (TQM).

**Part: C] Industrial visit to:**

Calibration lab /Quality control lab / CMM Lab / Gear Inspection Unit

**OR**

QA/QC Unit of Automotive Industry / Engineering Industry.

**Savitribai Phule Pune University, Pune**  
**Third Year of Mechanical**  
**(2015 Course)**

**Course Code: 302046**

**Course Name: Skill Development**

**Teaching Scheme:**

**Credits**

**Examination Scheme:**

**PR: -- 2 Hrs/ Week**

**TW/PR:--01**

**TW:-- 25**

**PR:-- 25**

**COURSE OBJECTIVES**

1. To develop the skill for required in shop floor working.
2. To have knowledge of the different tools and tackles used in machine assembly shop.
3. Use of theoretical knowledge in practice.
4. Practical aspect of the each component in the assembly of the machine.

**Course Contents**

## **List of Experiments**

1. Tail stock assembly
2. Valve Assembly ( PRV, Sluice valve, Steam stop valve)
3. IC engine of Two Wheeler (4 stroke single cylinder)
4. Hermetically sealed compressor
5. Hydraulic actuator
6. Industrial Gear box
7. Sheet drawing (Sheet will be given per group and a group consist of 04 students. The sheet will be drawn manually by every student)

**Note: 1-6 experiments are for assembly and disassembly only**

### **Term-Work**

1. Sheet drawing of assembly, which should contain the display of Geometric tolerances, Limits, Fits, BOM, Dimensional measurements techniques. Special Operations.. Students should make process sheet of each assembly. (One topic per four students group will be given for sheet drawing and each student should draw the sheet manually)

### **Practical Examination**

Practical examination will be based on opening and closing of any assembly. In addition to this some questioning will be asked to the student based on assembly drawing, GD&T Sequencing and tools and tackles. For this the assemblies and their drawings should be provided to students for examination

**Note:** Term work will carry 25 Marks and practical examination will carry 25 marks.

- A. The assessment has to be carried out based on close monitoring of involvement and intellectual contribution of student.
- B. The student should maintain the record of work in the form of diary and has to be submitted at the end of semester.
- C. The batch teacher should assess the concerned student



# **SEM-II**

**Savitribai Phule Pune University, Pune**

**TE Mechanical, Mechanical Sandwich and Automobile (2015 course)**

**Course Code: 302047      Course Name : Numerical Methods and Optimization**

<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme:</b>	
<b>TH: -04 hrs/week</b>	<b>TH:--04</b>	<b>TH</b>	<b>In-Sem: -- 30</b>
			<b>End-Sem: --70</b>
<b>PR: 02 hrs /week</b>	<b>PR:--01</b>	<b>PR:</b>	<b>-- 50</b>

**Course Objectives:**

**Students are expected to –**

- 1 Recognize the difference between analytical and Numerical Methods.
- 2 Effectively use Numerical Techniques for solving complex Mechanical engineering Problems.
- 3 Prepare base for understanding engineering analysis software.
- 4 Develop logical sequencing for solution procedure and skills in soft computing.
- 5 Optimize the solution for different real life problems with available constraints.
- 6 Build the foundation for engineering research.

**Course Outcomes:**

**The student should be able to –**

1. Use appropriate Numerical Methods to solve complex mechanical engineering problems.
2. Formulate algorithms and programming.
3. Use Mathematical Solver.
4. Generate Solutions for real life problem using optimization techniques.
5. Analyze the research problem

**Course Contents**

**Unit – I: Roots of Equation and Error Approximations (08 hrs.)**

**Roots of Equation**

Bisection Method, Newton Raphson method and Successive approximation method.

**Error Approximations**

Types of Errors: Absolute, Relative, Algorithmic, Truncation, Round off Error, Error Propagation, Concept of convergence-relevance to numerical methods.

**Unit – II: Simultaneous Equations (08 hrs.)**

Gauss Elimination Method with Partial pivoting, Gauss-Seidal method and Thomas algorithm for Tri-diagonal Matrix, Jacob iteration method.

<p><b>Unit – III: Optimization</b> <span style="float: right;"><b>(08 hrs.)</b></span></p> <p>Introduction to optimization, Classification, Constrained optimization (maximum two constraints): Graphical and Simplex method, One Dimensional unconstrained optimization: Newton’s Method. Modern Optimization Techniques: Genetic Algorithm (GA), Simulated Annealing (SA).</p>
<p><b>Unit – IV: Numerical Solutions of Differential Equations</b> <span style="float: right;"><b>(10 hrs.)</b></span></p> <p><b>Ordinary Differential Equations [ODE]</b> Taylor series method, Euler Method, Runge-Kutta fourth order, Simultaneous equations using RungeKutta2nd order method.</p> <p><b>Partial Differential Equations [PDE]: Finite Difference methods</b> Introduction to finite difference method, Simple Laplace method, PDEs- Parabolic explicit solution, Elliptic-explicit solution.</p>
<p><b>Unit – V: Curve Fitting and Regression Analysis</b> <span style="float: right;"><b>(08 hrs.)</b></span></p> <p><b>Curve Fitting</b> Least square technique- Straight line, Power equation, Exponential equation and Quadratic equation.</p> <p><b>Regression Analysis</b> Introduction to multi regression analysis, Lagrange’s Interpolation, Newton’s Forward interpolation, Inverse interpolation (Lagrange’s method only).</p>
<p><b>Unit – VI: Numerical Integration</b> <span style="float: right;"><b>(06 hrs.)</b></span></p> <p><b>Numerical Integration (1D only)</b> Trapezoidal rule, Simpson’s 1/3<sup>rd</sup>Rule, Simpson’s 3/8<sup>th</sup>Rule, Gauss Quadrature 2 point and 3 point method.</p> <p><b>Double Integration</b> Trapezoidal rule, Simpson’s 1/3<sup>rd</sup>Rule.</p>
<p><b>Books:</b></p>
<p><b>Text:</b></p> <ol style="list-style-type: none"> <li>1. Steven C. Chapra, Raymond P. Canale, Numerical Methods for Engineers, 4/e, Tata McGraw Hill Editions</li> <li>2. Dr. B. S. Garewal, Numerical Methods in Engineering and Science, Khanna Publishers,.</li> <li>3. Steven C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientist, Tata Mc-Graw Hill Publishing Co-Ltd</li> <li>4. Rao V. Dukkipati, Applied Numerical Methods using Matlab, New Age International Publishers</li> </ol>

**References:**

1. Gerald and Wheatley, Applied Numerical Analysis, Pearson Education Asia
2. E. Balagurusamy, Numerical Methods, Tata McGraw Hill
3. P. Thangaraj, Computer Oriented Numerical Methods, PHI
4. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI.

**Term-Work**

1. Program on Roots of Equation (Validation by suitable solver, all three compulsory)  
a) Bisection Method, b) Newton Raphson method c) Successive approximation method
2. Program on Simultaneous Equations (Validation by suitable solver, all three compulsory)  
a) Gauss Elimination Method, b) Thomas algorithm for tridiagonal matrix, c) Gauss-Seidal method.
3. Demonstration of optimization technique using suitable solver.
4. Program on ODE(Validation by suitable solver, all three compulsory)  
a) Euler Method, b) Runge-Kutta Methods- fourth order, c) Simultaneous equations.(Runge-Kutta 2nd order: *One step only*).Simple pendulum equation or Spring mass damper equation
5. Program on PDE(Validation by suitable solver): Laplace equation
6. Program on Curve Fitting using Least square technique (Validation by suitable solver, all four compulsory)  
a) Straight line, b) Power equation, c) Exponential equation, d) Quadratic equation
7. Program on Interpolation(Validation by suitable solver, all three compulsory)  
a) Lagrange's Interpolation, b) Newton's Forward interpolation,
8. Program on Numerical Integration(Validation by suitable solver, all four compulsory)  
a) Trapezoidal rule, b) Simpson's Rules (1/3rd, 3/8th) [In one program only], c) Gauss Quadrature Method- 2 point, 3 point. [In one program only], d) Double integration: Trapezoidal rule

**NOTE:**

1. Solver is compulsory for all above programs and compared with actual solution.
2. Manual solution for each problem.
3. Algorithms and Flowcharts are compulsory for all programs.

**GUIDELINES TO CONDUCT PRACTICAL EXAMINATION**

Any one program from each set A & B with flowchart and solver: **Duration: 2 hrs.**

**Set A: (Weightage – 60 %)**

- a) Simultaneous Equation,
- b) Partial Differential Equation (Laplace equation with solver)
- c) Interpolation: Lagrange's interpolation, Newton's Forward interpolation (Any one)

**Set B: (Weightage – 40 %)**

- a) Roots of Equations, b) Curve Fitting, c) Ordinary Differential Equations, d) Integration

**Savitribai Phule Pune University, Pune**  
**Third Year of Mechanical (2015 Course)**

**Course Code: 302048**

**Course Name : Design of Machine Elements – II**

<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme:</b>
<b>TH: -- 4 Hrs/ Week</b>	<b>TH:--04</b>	<b>TH: In-Sem: -- 30</b>
<b>PR: - 2 Hrs/ Week</b>	<b>TW/OR:--01</b>	<b>End-Sem: -- 70</b>
		<b>TW: -- 25</b>
		<b>OR: -- 25</b>

**Course Objective:**

1. Enable students to attain the basic knowledge required to understand, analyze, design and select machine elements required in transmission systems.
2. Reinforce the philosophy that real engineering design problems are open-ended and challenging
3. Impart design skills to the students to apply these skills for the problems in real life industrial applications
4. Inculcate an attitude of team work, critical thinking, communication, planning and scheduling through design projects
5. Create awareness amongst students about safety, ethical, legal, and other societal constraints in execution of their design projects
6. Develop an holistic design approach to find out pragmatic solutions to realistic domestic and industrial problems

**Course Outcome:****The student should be able to –**

CO 1: To understand and apply principles of gear design to spur gears and industrial spur gear boxes.

CO 2 : To become proficient in Design of Helical and Bevel Gear

CO 3: To develop capability to analyse Rolling contact bearing and its selection from manufacturer's Catalogue.

CO 4: To learn a skill to design worm gear box for various industrial applications.

CO 5: To inculcate an ability to design belt drives and selection of belt, rope and chain drives.

CO 6: To achieve an expertise in design of Sliding contact bearing in industrial applications.

**Course Contents****Unit –I Spur Gears****(08 hrs)**

**Introduction to gears:** Gear Selection, material selection, Basic modes of tooth failure, Gear Lubrication Methods.

**Spur Gears:** Number of teeth and face width, Force analysis, Beam strength (Lewis) equation, Velocity factor, Service factor, Load concentration factor, Effective load on gear, Wear strength (Buckingham's) equation, Estimation of module based on beam and wear strength, Estimation of dynamic tooth load by velocity factor and Buckingham's equation.

**Unit –I Helical and Bevel Gears****(08 hrs)**

Types of helical and Bevel gears, Terminology, Virtual number of teeth, and force analysis of Helical and Straight Bevel Gear. Design of Helical and Straight Bevel Gear based on Beam Strength, Wear strength and estimation of effective load based on Velocity factor ( Barth factor) and Buckingham's equation. Mountings of Bevel Gear. ( **No numerical on force analysis of helical & Bevel Gear**)

**Unit – III Rolling Contact Bearings****(08 hrs)**

Types of rolling contact Bearings, Static and dynamic load carrying capacities, Stribeck's Equation,

Equivalent bearing load, Load- life relationship, Selection of bearing life Selection of rolling contact bearings from manufacturer's catalog, Design for cyclic loads and speed, bearing with probability of survival other than 90%

Taper roller bearing: Force analysis and selection criteria. (Theoretical Treatment only)

**Unit - IV:**

Worm and worm gear terminology and proportions of worm and worm gears, Force analysis of worm gear drives, Friction in Worm gears, efficiency of worm gears, Worm and worm gear material, Strength and wear ratings of worm gears (Bending stress factor, speed factor, surface stress factor, zone factor) IS 1443-1974, Thermal consideration in worm gear drive, Types of failures in worm gear drives, Methods of lubrication

**Unit - V:**

**Belt drive:** Materials and construction of flat and V belts, geometric relationships for length of belt, power rating of belts, concept of slip & creep, initial tension, effect of centrifugal force, maximum power condition,

Selection of Flat and V-belts from manufacturer's catalog, belt tensioning methods, relative advantages and limitations of Flat and V- belts, construction and applications of timing belts.

**Wire Ropes (Theoretical Treatment Only):** Construction of wire ropes, lay of wire rope, stresses in wire rope, selection of wire ropes, rope drums construction and design.

**Chain Drives (Theoretical Treatment Only):** Types of chains and its Geometry, selection criteria for chain drive, Polygon effect of chain, Modes of failure for chain, Lubrication of chains

**UNIT VI:**

Classification of sliding contact bearing.

**Lubricating oils:** Properties, additives, selection of lubricating oils, Properties & selection of bearing materials.

**Hydrodynamic Lubrication:** Theory of Hydrodynamic Lubrication, Pressure Development in oil film, 2D Basic Reynolds Equation, Sommerfeld number, Raimondi and Boyd method, Thermal considerations, Parameters of bearing design, Length to Diameter ratio, Unit bearing Pressure, Radial Clearance, minimum oil film thickness.

**Books:****Text:**

- 1) Bhandari V.B, Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd.
- 2) Shigley J.E. and Mischke C.R., Mechanical Engineering Design, McGraw Hill Publication Co. Ltd.
- 3) Spotts M.F. and Shoup T.E., Design of Machine Elements, Prentice Hall International.
- 4) Juvinal R.C, Fundamentals of Machine Components Design, John Wiley and Sons.

**References:**

1. Black P.H. and O. Eugene Adams, Machine Design, McGraw Hill Book Co. Inc.
2. Willium C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House.
3. Hall A.S., Holowenko A.R. and Laughlin H.G, Theory and Problems of Machine Design, Schaum's Outline Series
4. C.S. Sharma and Kamlesh Purohit, Design of Machine Elements, PHI Learning Pvt. Ltd.
5. D. K. Aggarwal & P.C. Sharma, Machine Design, S.K Kataria and Sons
6. P. C. Gope, Machine Design: Fundamentals and Applications, PHI Learning Pvt. Ltd.
7. Design Data - P.S.G. College of Technology, Coimbatore.
8. Bhandari, V. B. Machine Design data book, Tata McGraw Hill Publication Co. Ltd.
9. K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers



**Term-Work**

Term work shall consist of

1. One design project based on either Design of a Two Stage Gear Box (the two stages having different types of gear pair) or single stage worm gear box.

The design project shall consist of two full imperial (A1) size sheets involving assembly drawing with a part list and overall dimensions and drawings of individual components.

Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified for important surfaces. A design report giving all necessary calculations of the design of components and assembly should be submitted in a separate file. Design data book shall be used wherever necessary to achieve selection of standard components

Note:

1. Design project should be assigned to group of 5 to 7 students.
2. Assembly drawing of project should be drawn using any CAD software.
3. Detailed parts of project should be drawn manually.

Design projects should be practical oriented, below is the list of practical applications:

- i) Design of gearbox for wind mill application
  - ii) Design of gearbox for sluice gate application.
  - iii) Design of gearbox for machine tool applications like Lathe, Drilling, Milling machines etc.
  - iv) Design of in-line gearbox for Automobile application.
  - v) Design of gearbox for building Elevator
  - vi) Design of gearbox for Hoist.
  - vii) Design of gearbox for 2 wheeler .
  - viii) Design of gearbox for Tumbling barrel (Mixer).
  - ix) Design of gearbox for Cannon adjustment mechanism (Military application).
  - x) Design of gearbox for Worm gear box for Sugar Industry.
2. Presentation (PPT/slides) (on following topics (Any Two):
    - i) Application of belt drive and its selection method for Industrial application. (By using Manufacturer's Catalog).
    - ii) Application of chain drive and its selection method for Automobile application. (By using Manufacturer's Catalog).
    - iii) Mounting of machine elements on transmission shaft (like Bearings, gears, Pulley, Sprocket, etc).
    - iv) Selection of Bearing from Manufacturer's Catalog.
    - v) Construction and details of Gears.

**Savitribai Phule Pune University, Pune**

**TE Mechanical (2015 course)**

**Course Code: 302049**

**Course Name : Refrigeration and Air Conditioning**

<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme:</b>
<b>TH : 03 hrs/week</b>	<b>TH:-- 03</b>	<b>TH In-Sem: -- 30</b>
<b>PR : 02 hrs/ week</b>	<b>OR:- 01</b>	<b>End-Sem: -- 70</b>
		<b>OR: -- 25</b>

**Prerequisites:**

Basic Thermodynamics- Laws of thermodynamics, Ideal gas processes, Thermodynamic cycles, Properties of pure substance, Mollier Charts, Basic Psychrometry terms and process, Fluid properties, Fluid dynamics, Modes of heat transfer, Governing Equations in Heat Transfer, Extended Surfaces, Condensation and Boiling, Heat Exchangers.

**Course Objectives:**

- Learning the fundamental principles and different methods of refrigeration and air conditioning.
- Study of various refrigeration cycles and evaluate performance using Mollier charts and/ or refrigerant property tables.
- Comparative study of different refrigerants with respect to properties, applications and environmental issues.
- Understand the basic air conditioning processes on psychometric charts, calculate cooling load for its applications in comfort and industrial air conditioning.
- Study of the various equipment-operating principles, operating and safety controls employed in refrigeration air conditioning systems

**Course Outcomes:**

At the end of this course the students should be able to

- Illustrate the fundamental principles and applications of refrigeration and air conditioning system
- Obtain cooling capacity and coefficient of performance by conducting test on vapour compression refrigeration systems
- Present the properties, applications and environmental issues of different refrigerants
  - Calculate cooling load for air conditioning systems used for various
  - Operate and analyze the refrigeration and air conditioning systems.

**Course Contents****Unit I: Applications of Refrigeration and Air Conditioning and Refrigerants [8 hrs]****Applications**

Domestic Refrigerator, Domestic Air Conditioners, Automotive Air Conditioners, Evaporative coolers, water coolers, Commercial Refrigeration- Dairy, Cold storage, Ice plant, Commercial Air Conditioning-Multiplex, Hospitals.

**Refrigerants**

Classification of refrigerants, Designation of refrigerants, Desirable properties of refrigerants, environmental issues, Ozone depletion and global warming, ODP, GWP & LCCP, selection of environment friendly refrigerants, secondary refrigerants, anti-freeze solutions, Zeotropes and Azeotropes, refrigerant: recovery reclaims, recycle and recharge.

**Unit II: Vapour Refrigeration Systems [8 hrs]****Vapour compression systems**

Working of simple vapour compression system, representation of vapour compression cycle (VCC) on T-s and P-h diagram, COP, EER, SEER, IPLV, NPLV, effect of operating parameters on performance of VCC, actual VCC, methods of improving COP using flash chamber, sub-cooling, liquid vapour heat exchanger, comparison of VCC with Reverse Carnot cycle.

**Vapour absorption systems**

Introduction, Working of simple vapour absorption system (VAS), desirable properties of binary mixture (aqua-ammonia), performance evaluation of simple VAS (simple numerical treatment), actual VAS, Li-Br absorption system, three fluid system (Electrolux refrigeration), applications of VAS, comparison between VCC and VAC

**Unit III: Multiple pressure Refrigeration Systems [8 hrs]**

Introduction, need of multistage system, Intermediate pressure, two stage compression with flash gas removal and liquid intercooler, single compressor with multiple evaporator: individual and multiple expansion valves, individual compressors, cascade system: application and numerical(numerical only by using p-h chart),

Introduction to cryogenics (Linde - Hampson cycle) and applications (no numerical treatment)

<p><b>Unit IV: Psychrometry and Air conditioning load estimation</b> <span style="float: right;"><b>[8 hrs]</b></span></p> <p><b>Psychrometry</b> Basic Psychrometry and processes, BPF of coil, ADP, adiabatic mixing of two air streams, SHF, RSHF, GSHF, ESHF. Factors contributing to cooling load, Numerical based on load analysis</p> <p><b>Human Comfort</b> Thermodynamics of human body, comfort and comfort chart, factors affecting human comfort, concept of infiltration and ventilation, indoor air quality requirements,</p>
<p><b>Unit V: Air Conditioning Systems</b> <span style="float: right;"><b>[8 hrs]</b></span></p> <p><b>Air Conditioning Systems</b> Working of summer, winter and all year round AC systems, all air system, all water system, air water system, variable refrigerant flow and variable air volume systems, unitary and central air conditioning.</p> <p><b>Components of refrigeration and air conditioning systems</b> Working of reciprocating, screw and scroll compressors, working of air cooled, water cooled and evaporative condensers, working of DX, Flooded, Forced feed evaporators, Expansion devices – Capillary tube, TXV, EXV, operating and safety controls.</p>
<p><b>Unit VI</b> <span style="float: right;"><b>[8 hrs]</b></span></p> <p><b>Air Distribution Systems</b></p> <p><b>Part A] Ducts</b> Classification of ducts, duct material, pressure in ducts, flow through duct, pressure losses in duct (friction losses, dynamic losses), air flow through simple duct system, equivalent diameter, Methods of duct system design: equal friction, velocity reduction, static regain method (numerical on duct system design)</p> <p><b>Part B] Air handling unit</b> Air handling unit, Fan coil unit, types of fans used air conditioning applications, fan laws, filters, supply and return grills, sensors (humidity, temperature, smoke).</p>
<p><b>Books:</b></p>
<p><b>Text:</b></p> <ol style="list-style-type: none"> <li>1. Arora C. P., Refrigeration and Air Conditioning, Tata McGraw-Hill</li> <li>2. Manohar Prasad, Refrigeration and Air Conditioning, Willey Eastern Ltd, 1983</li> <li>3. McQuiston, — Heating Ventilating and air Conditioning: Analysis and Design  6th Edition, Wiley India</li> <li>4. Arora and Domkundwar, Refrigeration &amp; Air Conditioning, Dhanpatrai &amp; Company, New Delhi</li> <li>5. Khurmi R.S. and Gupta J.K., Refrigeration and Air conditioning, Eurasia Publishing House Pvt. Ltd, New Delhi, 1994.</li> <li>6. Ballaney P.L., Refrigeration and Air conditioning, Khanna Publishers, New Delhi, 1992</li> </ol>

**References:**

1. Dossat Ray J, Principles of refrigeration, S.I. version, Willey Eastern Ltd, 2000
2. Stockers W.F and Jones J.W., Refrigeration and Air conditioning, McGraw Hill International editions 1982.
3. Threlkeld J.L, Thermal Environmental Engineering, Prentice Hall Inc., New Delhi4.
4. Aanatnarayan, Basics of refrigeration and Air Conditioning, Tata McGraw Hill Publications
5. Roger Legg, Air Conditioning System Design, Commissioning and Maintenance
6. ASHRAE & ISHRAE handbook

**Term-Work**

The term work shall consist of minimum eight experiments out of the following (It should include the visit to cold storage plant or central air-condition plant) :

1. Test on Domestic Refrigerator for evaluation of EER
2. Test on vapour compression test rig
3. Test on air conditioning test rig
4. Test on ice plant test rig
5. Test on Heat Pump test rig
6. Test/visit on Vapour absorption refrigeration test rig
7. Estimation of cooling load of simple air conditioning system (case study)
8. Visit to cold storage plant.
9. Visit to any air conditioning plant
10. Thermal analysis of refrigeration cycle using suitable software
11. Installation and servicing of split air conditioner.

**Savitribai Phule Pune University, Pune**

**TE Mechanical and Mechanical Sandwich (2015 course)**

**Course Code: 302050**

**Course Name : Mechatronics**

<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme:</b>
<b>TH: -- 03 hrs/week</b>	<b>TH:--03</b>	<b>TH In-Sem: -- 30</b>
<b>Tut.: - 01 hr/week</b>	<b>OR:- 01</b>	<b>End-Sem: --70</b>
		<b>OR: --25</b>

**Course Objectives:**

- Understand key elements of Mechatronics system, representation into block diagram
- Understand concept of transfer function, reduction and analysis
- Understand principles of sensors, its characteristics, interfacing with DAQ microcontroller
- Understand the concept of PLC system and its ladder programming, and significance of PLC systems in industrial application
- Understand the system modeling and analysis in time domain and frequency domain.
- Understand control actions such as Proportional, derivative and integral and study its significance in industrial applications

**Course Outcomes:**

On completion of the course, students will be able to –

- Identification of key elements of mechatronics system and its representation in terms of block diagram
- Understanding the concept of signal processing and use of interfacing systems such as ADC, DAC, digital I/O
- Interfacing of Sensors, Actuators using appropriate DAQ micro-controller
- Time and Frequency domain analysis of system model (for control application)
- PID control implementation on real time systems
- Development of PLC ladder programming and implementation of real life system.

<b>Course Contents</b>	
<p><b>UNIT 1: Introduction to Mechatronics, Sensors &amp; Actuators</b></p> <p>Introduction to Mechatronics and its Applications; Measurement Characteristics: Static and Dynamic; Sensors: Position sensors- Potentiometer, LVDT, incremental Encoder; Proximity sensors-Optical, Inductive, Capacitive; Temperature sensor-RTD, Thermocouples; Force / Pressure Sensors-Strain gauges; Flow sensors-Electromagnetic; Actuators: Stepper motor, Servo motor, Solenoids; Selection of Sensor &amp; Actuator.</p>	<b>(08 Hrs)</b>
<p><b>UNIT 2: Block Diagram Representation</b></p> <p>Introduction to Mechatronic System Design; Identification of key elements of Mechatronics systems and represent into Block Diagram; Open and Closed loop Control System; Concept of Transfer Function; Block Diagram &amp; Reduction principles; Applications of Mechatronic systems: Household, Automotive, Industrial shop floor.</p>	<b>(08 Hrs)</b>
<p><b>UNIT 3: Data Acquisition</b></p> <p>Introduction to Signal Communication &amp; Types-Synchronous, Asynchronous, Serial, Parallel; Bit width, Sampling theorem, Aliasing, Sample and hold circuit, Sampling frequency; Interfacing of Sensors / Actuators to Data Acquisition system; 4 bit Successive Approximation type ADC; 4 bit R-2R type DAC; Current and Voltage Amplifier.</p>	<b>(08 Hrs)</b>
<p><b>UNIT 4: Programmable Logic Control</b></p> <p>Introduction to PLC; Architecture of PLC; Selection of PLC; Ladder Logic programming for different types of logic gates; Latching; Timers, Counter; Practical examples of Ladder Programming.</p>	<b>(08 Hrs)</b>
<p><b>UNIT 5: Frequency Domain Modelling and Analysis</b></p> <p>Transfer Function based modeling of Mechanical, Thermal and Fluid system; concept of Poles &amp; Zeros; Stability Analysis using Routh Hurwitz Criterion; Bode Plots: Introduction to Bode Plot, Gain Margin, Phase Margin, Relative Stability Analysis, Frequency Domain Parameters-Natural Frequency, Damping Frequency and Damping Factor; Mapping of Pole Zero plot with damping factor, natural frequency and unit step response.</p>	<b>(08 Hrs)</b>
<p><b>UNIT VI: Control System</b></p> <p>Proportional (P), Integral (I) and Derivative (D) control actions; PI, PD and PID control systems in parallel form; Unit step Response analysis via Transient response specifications: Percentage overshoot, Rise time, Delay time, Steady state error; Manual tuning of PID control; Linear Quadratic Control (LQR).</p>	<b>(08 Hrs)</b>
<b>Books:</b>	
<b>Text:</b>	
<ul style="list-style-type: none"> <li>• K.P. Ramchandran, G.K. Vijayaraghavan, M.S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Willey Publication, 2008</li> <li>• Bolton, Mechatronics - A Multidisciplinary approach, 4th Edition, Prentice Hall, 2009.</li> </ul>	

**References:**

- Alciatore & Hristand, Introduction to Mechatronics and Measurement system, 4th Edition, Mc-Graw Hill publication, 2011
- Bishop (Editor), Mechatronics – An Introduction, CRC Press, 2006
- Mahalik, Mechatronics – Principles, concepts and applications, Tata Mc-Graw Hill publication, New Delhi
- C. D. Johnson, Process Control Instrumentation Technology, Prentice Hall, New Delhi

**Term Work shall consist of following assignments:**

The common minimum submission mentioned in point 1 and 2 should comprise of the following. From the table below: Submission No. 04, 05, 10, 11 and 12 are mandatory; any one from 01 to 03, any one from 06 or 07, any one from 08 or 09.

Submission No	Title
01	Measurement of Load / Force using a suitable sensor
02	Measurement of Temperature using a suitable sensor
03	Measurement of Position using a suitable sensor
04	Demonstration of <b>any one</b> of the following applications: <ul style="list-style-type: none"><li>• Water Level Indicator</li><li>• Bottle Filling Plant</li><li>• Pick and Place Robot</li><li>• Any other suitable application which comprises of components of Mechatronic system</li></ul>
05	Interfacing of suitable sensor with Data Acquisition system
06	Ladder Diagram simulation, using suitable software, for logic gates
07	Real time application of PLC using Ladder logic
08	Real time control of Temperature / Flow using PID control
09	Real time control of speed of DC motor using PID control
10	PID control Design, Tuning using suitable Simulation Software
11	Study of Modeling and Analysis of a typical Mechanical System (Estimation of poles, zeros, % overshoot, natural frequency, damping frequency, rise time, settling time)
12	Case Study: Design of Mechatronic System (to be performed in a group of 4)



**Savitribai Phule Pune University, Pune  
Third Year of Mechanical & Automobile  
(2015 Course)**

**Course Code: 302051**

**Course Name : MANUFATCURING PROCESS – II**

**Teaching Scheme:**

**Credits**

**Examination Scheme:**

**TH: -- 3 Hrs/ Week**

**TH:03**

**TH In-Sem: -- 30**

**End-Sem: -- 70**

**Course Objective:**

1. To analyze and understand the metal cutting phenomena.
2. To select process parameter and tools for obtaining desired machining characteristic
3. To understand principles of manufacturing processes.

**Course Outcome:**

1. Student should be able to apply the knowledge of various manufacturing processes.
2. Student should be able to identify various process parameters and their effect on processes.
3. Student should be able to figure out application of modern machining.
4. Students should get the knowledge of Jigs and Fixtures for variety of operations.

**Course Contents**

**Unit – I Theory of Metal cutting**

**(07hrs)**

**Single point cutting tool:** Tool geometry, Mechanics of shearing (orthogonal and oblique), Shear plane angle, Shear stress, strain and Shear strain rate. Process parameters and their effect on machining.

**Merchant's circle of forces (analytical)** Estimation of shear force, Normal shear force, Friction force, Normal friction force, Material Removal Rate (MRR), Cutting power estimation, Calculation of Total power and Specific energy. Introduction to tool dynamometers.

**Machinability** - Factors affecting machinability, Tool life, Tool wear, Types of tool wear and remedial actions, Cutting fluid and their types, Effect of process parameters on tool life, Taylor's tool life equation (Derivation along with numerical).

**Unit – II Machine tools and their application**

**(07 hrs)**

**Drilling machine:** Types of drills and operations. Twist drill geometry, Types of drilling machine, Tool holder. Machining time calculations.

**Milling machine:** Types of milling machines, Cutter-types and geometry and their applications. Universal dividing head, Methods of Indexing: Simple, Compound, Differential. (Numericals based on simple and compound Indexing).Machining time calculations

**Broaching:** Introduction to broaching, Broach tool geometry, Planner and Boring Machines: Introduction.

<p><b>Unit – III Finishing processes</b> <span style="float: right;"><b>(07hrs)</b></span></p> <p><b>Grinding machines</b></p> <p><b>Introduction:</b> Types and Operations of grinding machines.</p> <p><b>Grinding wheel</b> – Shapes, Designation and selection, Mounting, Balancing and Dressing of grinding wheels, Machining time calculation for cylindrical and plunge grinding.</p> <p><b>Super-finishing processes</b> – Introduction to Honing, Lapping, Buffing and Burnishing. (Construction, working and controlling parameters)</p>
<p><b>Unit – IV Advanced Machining Processes</b> <span style="float: right;"><b>(07 hrs)</b></span></p> <p>Introduction, classification of advanced machining processes.</p> <p>Principles, Working, Process Parameters, Advantages, Limitations and Application for following processes:</p> <p>Electric Discharge Machining (EDM), LASER Beam Machining (LBM), Abrasive Jet Machining (AJM), Ultra Sonic Machining (USM) and Electro Chemical Machining (ECM)</p> <p>Introduction to micro machining.</p>
<p><b>Unit –V CNC Technology</b> <span style="float: right;"><b>(07 hrs)</b></span></p> <p>Introduction, Classification, Construction and working of NC, CNC, DNC and machining center. CNC axes and drives. Automatic Tool Changer (ATC) and Automatic pallet changer (APC)</p> <p><b>CNC Programming:</b> Word address format (WAF) –ISO Standards, G &amp; M codes, Type of CNC Control systems, Manual part programming (plain milling and Turning ), Subroutine, Canned cycles.</p>
<p><b>Unit –VI Jigs and fixtures</b> <span style="float: right;"><b>(07 hrs)</b></span></p> <p>Concept of degree of freedom, 3-2-1 principle of location, General guidelines to design Jigs and fixtures, advantages of jig and fixtures</p> <p><b>Jigs:</b> Definition. Elements of jig with the types, Location guidelines, Principles of clamping, Principles of guiding element, Channel jig, Template jig, Plate jig, Angle plate jig, Turn over jig, Box jig, and Latch type jig.</p> <p><b>Fixtures:</b> Definition. Elements of fixtures, Location guidelines, Principles of clamping, Principles of setting element, Turning fixture, Welding fixture, Milling fixture, Introduction to Assembly and Inspection fixtures. Indexing fixtures.</p> <p>Concept, elements and advantages of modular fixture, Pokayoke concept in jigs and fixtures.</p>
<p><b>Books:</b></p>
<p><b>Text:</b></p> <ol style="list-style-type: none"> <li>1. S. K Hajra Choudhury , Elements of workshop technology – Vol. II,, Media Promoters And Publishers, Mumbai</li> <li>2. Amitabh Ghosh and Asok kumar Mallik, Manufacturing science, Ellis Horwood Ltd</li> <li>3. Mikell. P. Grover, Fundamentals of Modern Manufacturing, Pearson Publications</li> <li>4. P. C. Sharma, Production Engineering, S. Chand Publication.</li> </ol>

**References:**

1. Production technology –HMT, Tata McGraw Hill publication
2. Lindberg, Roy A., Processes and materials of manufacture, P H I Learning
3. Serope Kalpakjian and Steven R. Schmid, Manufacturing Processes for Engineering Materials, Pearson Education, Fourth Edition.
4. G. K Lal, Fundamentals of Design and Manufacturing, Alpha Science International Ltd(2005)
5. M.C Shaw, Metal Cutting Principles, Oxford university press
6. Yoram Koren , Numerical Control of Machine Tools Khanna Publication
7. P. K Mishra, Non- conventional machining, Narosa Publishing House
8. V. K Jain, Advanced machining processes , Allied Publisher, New Delhi
9. M. H. A Kempster, An Introduction to Jig and Tool Design, ELBS
10. P. H. Joshi, Jigs and fixtures , Tata McGraw Hill
11. P. N. Rao, CAD/CAM Principles and Applications, McGraw Hill Education, Third Edition.
12. Cyrll Donaldson, George H. LeCain and V. C. Goold, Tool design, Tata McGraw- Hill. Third Edition

**Savitribai Phule Pune University, Pune**  
**Third Year of Mechanical & Automobile**  
**(2015 Course)**

**Course Code: 302052**

**Course Name : MACHINE SHOP – II**

<b>Credits</b>	<b>Examination Scheme:</b>
<b>PR: -2 Hrs/ Week</b>	
<b>TW:-01</b>	<b>TW: 50</b>

**Course Objective:**

1. To set the manufacturing set-up appropriately and study the corresponding set up parameters.
2. To select appropriate process parameter for obtaining desired characteristic on work piece.
3. To understand the operational problems and suggest remedial solution for adopted manufacturing process.

**Course Outcome:**

1. Ability to develop knowledge about the working and programming techniques for various machines and tools

**Term-Work**

Each student must complete and submit following term work:

**I. Jobs (Both the following jobs should be completed individually)**

- a. Any one marketable assembly consisting of at least three components with tolerance involving use of lathe, drilling, milling, grinding and any additional machine tool or processes as per requirement.
- b. Development and execution of one simple turning job on CNC (Trainer)

machine.

**II. Journal consisting of following assignments.**

- a. Two views of at least one jig and one fixture designed, for a component on a half imperial sheet.(manual drafting)
- b. Process planning sheets for job 1.a and 1.b.
- c. Report based on industrial visit to manufacturing plant.

**Note:** - Practical are to be performed under the guidance of concerned faculty member.  
Job drawing essentially consisting of Geometric Dimensioning and Tolerance

**Savitribai Phule Pune University, Pune**  
**Third Year of Mechanical & Automobile**  
**(2015 Course)**

**Course Code: 302053**

**Course Name : SEMINAR**

**Teaching Scheme:**

**Credits**

**Examination Scheme:**

**PR:-- 2 Hrs/Week**

**OR:--01**

**TH In-Sem: --**

**End-Sem: --**

**TW: -- 25**

**OR: -- 25**

**Prerequisites:**

**Course Objective:**

1. Identify and compare technical and practical issues related to the area of course specialization.
2. Outline annotated bibliography of research demonstrating scholarly skills.
3. Prepare a well organized report employing elements of technical writing and critical thinking.
4. Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

**Course Outcome:**

With this seminar report and presentation, the student is expected to learn/achieve the following:

- Establish motivation for any topic of interest and develop a thought process for technical presentation.
- Organize a detailed literature survey and build a document with respect to technical publications.
- Analysis and comprehension of proof-of-concept and related data.
- Effective presentation and improve soft skills.
- Make use of new and recent technology (e.g. Latex) for creating technical reports

**Course Contents:**

The evaluation of the seminar report is proposed with the following stages.

**Stage-I**

In this stage the student is expected to deliver the following:

1. Topic selection
2. Literature review
3. State of the art related to the topic of interest

**Stage-II**

1. Problem statement
2. Methodology
3. Scope and objectives

A review of the student's progress should be made after In-Sem examination, within a week. During this review, the student is expected to complete Stage-1 and Stage-2.

**Stage-III**

1. Quantification of results
2. Concluding remarks or summary

**Stage-IV**

3. Final report
4. Final presentation/viva

The final presentation/viva will be assessed by a committee including an expert (preferably from industry with minimum 5 years experience) and an internal panel. The internal panel will consist of the seminar guide and two subject experts, approved by the HOD and the principal of the institute.

Examination schedule will be prepared at institute level (and not at University level), though it is under Oral head. The appointment of the internal panel and the external (industrial) expert will be taken care by the respective institute. The seminar presentation will be held after the term end and before university external viva

**Contents of the Seminar report**

The contents of the seminar report as mentioned in section-3 are expected to include the following:

- Abstract/Summary
- Introduction: Scope and Methodology
- Literature review: The review should be conducted from at least five research papers published during last five year.
- Case study
- References

## Instructions for seminar report writing

It is important that the procedures listed below be carefully followed by all the students.

1. Prepare two spiral bound copies of your Seminar report.
2. Limit your seminar report to preferably 20 to 25 pages only.
3. Header For e.g. Title of the seminar.
4. The footer For e.g. page numbers
5. Institute Name, Mechanical Engineering and centrally aligned.
6. The report shall be prepared using LateX preferably (default font throughout) with double spacing throughout on A4 page.

Page	Left margin	Right margin	Top margin	Bottom margin
A-4 (8.5 11 inch)	1.5"	1"	1"	1"

7. Section titles should be bold typed in all capital letters and should be left aligned.
8. Sub-Section headings should be aligning at the left, bold and Title Case (the first letter of each word is to be capitalized).
9. Figure No. and Title at bottom with 10 pt; Legends below the title in 10 pt
10. Please use SI system of units only.
11. References should be either in order as they appear in the report or in alphabetical order by last name of first author.
12. Symbols and notations if any should be included in nomenclature section only

**The report will be made in the following order:**

1. Cover page and Front page as per specimen on separate sheet
2. Certificate from Institute as per specimen on separate sheet
3. Acknowledgement
4. List of Figures
5. List of Tables
6. Nomenclature
7. Contents
8. All section headings and subheadings should be numbered. For sections use numbers 1, 2, 3, .... and for subheadings 1.1, 1.2, .... etc and section subheadings 2.1.1, 2.1.2, .... etc.
9. References should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If figures and tables are taken from any reference then indicate source of it. Please follow the following procedure for references

**Reference Books:** Collier, G. J. and Thome, J. R., Convective boiling and condensation, 3 rd ed., Oxford University Press, UK, 1996, pp. 110 112.

**Papers from Journal or Transactions:**

1. Jung, D. S. and Radermacher, R., Transport properties and surface tension of pure and mixed refrigerants, ASHRAE Trans, 1991, 97 (1), pp. 90 98.
2. Bansal, P. K., Rupasinghe, A. S. and Jain, A. S., An empirical correction for sizing capillary tubes, Int. Journal of Refrigeration, 1996, 19 (8), pp.497 505.

**Papers from Conference Proceedings:**

1. Colbourne, D. and Ritter, T. J., Quantitative assessment of flammable refrigerants in room air conditioners, Proc. of the Sixteenth International Compressor Engineering Conference and Ninth International Refrigeration and Air Conditioning Conference, Purdue University, West Lafayette, Indiana, USA, 2002, pp. 34 40.

**Reports, Handbooks etc.**

1. United Nations Environmental Programme, Report of the Refrigeration, Air Conditioning and Heat Pumps, Technical Option Committee, 2002, Assessment - 2002. ASHRAE Handbook: Refrigeration, 1994 (Chapter 44)

**Patent:** Patent no, Country (in parenthesis), date of application, title, year.

**Web-links:** www.(Site) [Give full length URL]



**Savitribai Phule Pune University, Pune**  
**Third Year of Mechanical, Mechanical Sandwich & Automobile**  
**(2015 Course)**

**Course Code: 302054**

**Course Name : Audit Course I :- Fire & Safety Technology**

<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme: Audit (P/F)</b> Written and MCQ	
<b>PR:</b>	<b>Th/Tut:--</b>	<b>TH</b>	<b>In-Sem: --</b>
			<b>End-Sem: --</b>
<b>Tut:</b>	<b>TW:</b>		<b>PR: --</b>
			<b>OR: --</b>

**Description:**

To generate, develop and sustain a voluntary movement on Fire & Safety Engineering at the National Level aimed at educating and influencing society to adopt appropriate policies, practices and procedures that prevent and mitigate human suffering and economic loss arising from all types of accidents.

**Course Objective:**

On completion of this Basic Fire Safety Course, participants will be able to:-

- Describe the chemistry of fire
- Identify fire hazards in the workplace
- Follow evacuation procedures
- Select and use appropriate firefighting equipment

**Course Outcome:****• Students will be able**

1. To create and sustain a community of learning in which students acquire knowledge in fire, safety and hazard management and learn to apply it professionally with due consideration for ethical, human life & property safety issues.
2. To pursue research and development in fire safety engineering, hazard management and disseminate its findings.
3. To meet the challenges of today and tomorrow in the most effective, efficient and contemporary educational manner.
4. To help in building national capabilities in fire safety engineering, disaster management, hazard management, industrial safety education through practical training to ensure a fire safe nation.

## **Course Contents:**

### **1. Fire & Safety Overview**

Fire & safety legislation, Safety Personnel Supplier for construction sites/commissioning of plants. Understanding the physics and chemistry of fire. Development and spread of fire. Action in the event of fire

### **2. Fire Fighting Techniques**

Means of raising alarm, means of summoning the fire brigade, action on hearing the fire alarm  
Evacuation procedures Practical demonstration in the use of foam and CO<sub>2</sub> fire extinguishers using our state of the art gas fired training system.

### **3. Fundamentals of Fire Engineering Science**

Fire Tech & Design, Fire Risk Assessment, Fire Control Technology, Fire Fighting Drills, Fire Tender with Crew on Hire. Fire & Safety Audit. Fire & Safety Consultancy Services.

### **4. Industrial Aspects of Fire & Safety**

Industrial Training on Fire & Safety and Disaster Management. Repair of all kinds of Fire Equipment including Flooding System. Repair of Fire Tender including Pump and power take-off systems.

### **5. Maintenance of Fire Safety Equipments**

AMC of Fire System. Refilling of Fire Extinguishers. Ultrasonic Thickness Test of Extinguishers, Vessels and Pipe lines. Hydro Testing of Fire Extinguishers, Vessels and Pipe Lines. Supply of Fire & Safety Equipment and Spares.

**Case Study & Group Work:**

- Identification of fire & safety technology
- To study the Fire Fighting Properties of Foam Concentrate
- Case Studies of Salvage operations in different types of occupancy
- Design and drawing of parts contained in the syllabus
- Compilation of Results & Presentation
- Case Study on the projects (products or processes) carried out by your institution or an organization in your vicinity, for safety.

**Books:****References:**

1. Accident Prevention manual for Industrial Operations, NSC, Chicago 1982.
2. The manual of fire ship – 6 – A by HMSO
3. Electricity Fire Risks – G.S. Hodges
4. Fire Pumps and Hydraulics: I.E. Ditts and T. M. Harris.
5. Fire Service Manual (Volume 2) Fire Service Operations – Petrochemical Incidents
6. The Principles and Practice of Fire Salvage Operation by Fire Salvage association.

**Savitribai Phule Pune University, Pune**  
**Third Year of Mechanical, Mechanical Sandwich & Automobile**  
**(2015 Course)**

**Course Code: 302054**

**Course Name : Audit Course II - Entrepreneurship Development**

<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme: Audit (P/F)</b> Written and MCQ	
<b>PR:</b>	<b>Th/Tut:--</b>	<b>TH</b>	<b>In-Sem: --</b>
			<b>End-Sem: --</b>
<b>Tut:</b>	<b>TW:</b>		<b>PR: --</b>
			<b>OR: --</b>

**Description:**

EDP is a program meant to develop entrepreneurial abilities among the people. In other words, it refers to inculcation, development, and polishing of entrepreneurial skills into a person needed to establish and successfully run his enterprise. Thus, the concept of entrepreneurship development programme involves equipping a person with the required skills and knowledge needed for starting and running the enterprise.

This course will help in developing the awareness and interest in entrepreneurship and create employment for others. Students get familiar with the characteristics and motivation of successful entrepreneurs. Students learn how to identify and refine market opportunities, how to secure financing, how to develop and evaluate business plans and manage strategic partnerships. Students learn various concepts including the basics of management, leadership, motivation, decision-making, conflict management, human resource development, marketing and sustaining an organization. Students also get basic knowledge of accounting practices and finance. The core course in Entrepreneurship Development & Management equips students with skills and knowledge required to start and sustain their own business.

**Course Objective:**

- To impart basis managerial knowledge and understanding;
- Develop and strengthen entrepreneurial quality, i.e., motivation or need for achievement.
- To analyze environmental set up relating to small industry and promoting it.
- Collect and use the information to prepare project report for business venture.
- Understand the process and procedure involved in setting up small units.
- Develop awareness about enterprise management.

**Course Outcome:****The students will be able to**

- Appreciate the concept of Entrepreneurship
- Identify entrepreneurship opportunity.
- Develop winning business plans

**Course Contents:**

**Entrepreneurship-** Definition; Growth of small scale industries in developing countries and their positions large industries; role of small scale industries in the national economy; characteristics and types of small scale industries; demand based and resources based ancillaries Government policy for small scale industry; stages in starting a small scale industry, requirements to be an entrepreneur, SWOT Analysis.

**Projects:** Identification and Selection of projects; project report: contents and formulation, concept of project evaluation, methods of project evaluation: internal rate of return method and net present value method.

**Market Assessment and Product feasibility**

Marketing -Concept and Importance Market Identification,  
Customer needs assessment, Market Survey Product feasibility analysis

**Business Finance & Accounts**

**Business Finance:** Costing basics, Sources of Finance, Break Even Analysis,

**Business Accounts:** Preparation of balance sheets and assessment of economic viability, decision, making, expected costs, planning and production control, quality control, marketing, Book Keeping, Financial Statements, Financial Ratios and its importance, Concept of Audit.

**Project Planning and control:**

The financial functions cost of capital approach in project planning and control. Economic evaluation, risk analysis, capital expenditures, policies and practices in public enterprises. Profit planning and programming, planning cash flow, capital expenditure and operations. Control of financial flows, control and communication.

**Institutional Support and Policies:** institutional support towards the development of entrepreneurship in India, technical consultancy organizations, E-Commerce: Concept and process, government policies for small scale enterprises.

**Case Study & Group Work:**

- Assess yourself-are you an entrepreneur?
- Prepare a Project Report for starting a small scale business.
- An Interview with an Entrepreneur.

**Books:****References:**

1. Ram Chandran, 'Entrepreneurial Development', Tata McGraw Hill, New Delhi
2. Saini, J. S., 'Entrepreneurial Development Programmes and Practices', Deep & Deep Publications (P), Ltd.
3. Khanka, S. S. 'Entrepreneurial Development', S Chand & Company Ltd. New Delhi
4. Badhai, B 'Entrepreneurship for Engineers', Dhanpat Rai & co. (p) Ltd.
5. Desai, Vasant, 'Project Management and Entrepreneurship', Himalayan Publishing House, Mumbai, 2002.
6. Gupta and Srinivasan, 'Entrepreneurial Development', S. Chand & Sons, New Delhi.



**Savitribai Phule Pune University, Pune**  
**Third Year of Mechanical, Mechanical Sandwich & Automobile**  
**(2015 Course)**

**Course Code: 302054**

**Course Name : Audit Course III - Intellectual Property Right**

<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme: Audit (P/F)</b> Written and MCQ	
<b>PR:</b>	<b>Th/Tut:--</b>	<b>TH</b>	<b>In-Sem: --</b>
			<b>End-Sem: --</b>
<b>Tut:</b>	<b>TW:</b>		<b>PR: --</b>
			<b>OR: --</b>

**Objective:**

Intellectual property refers to the rights which are attached to the creation of the mind and which take the form of a property. Though intangible in nature, intellectual property has become the driving force of many companies today. Fortune 500+ companies undoubtedly are the best examples of what a company can achieve through the proper understanding and management of IPR.

Thus the study of intellectual property rights is inevitable for managers, considering the fact that India is fast emerging as an economy with considerable investment in cutting-edge research and development. India is also emerging as an economy where foreign companies propose to invest considerably, both technically and financially, provided proper protection is guaranteed to their intangible assets which form the cornerstone of their business.

## **Topics:**

### 1. Introduction

- Concepts of IPR
- The history behind development of IPR
- Necessity of IPR and steps to create awareness of IPR

### 2. IP Management

- Concept of IP Management
- Intellectual Property and Marketing
- IP asset valuation

### 3. Patent Law

- Introduction to Patents
- Procedure for obtaining a Patent
- Licensing and Assignment of Patents
  - Software Licensing
  - General public Licensing
  - Compulsory Licensing
- Infringement of Patents
- Software patent US and Indian scenario

### 4. Copyrights

- Concept of Copyright Right
- Assignment of Copyrights
- Registration procedure of Copyrights
- Infringement (piracy) of Copyrights and Remedies
- Copyrights over software and hardware

### 5. Designs

- Concept of Industrial Designs
- Registration of Designs
- Piracy of registered designs and remedies

### 6. Trademark Law

- Concept of trademarks
- Importance of brands and the generation of “goodwill”
- Trademark registration procedure
- Infringement of trademarks and Remedies available
- Assignment and Licensing of Trademarks

**Case Study & Group Work:**

- Identify the projects (products or processes) carried out by your institution or an organization in your vicinity, which have been patented.
- A case study on significance of patents for a developing nation like India.
- Group discussion on creative / novel ideas and the feasibility of converting the idea into product or process.
- Discussion on Correlation between IPR and Entrepreneurship in the backdrop of Make in India Initiative.

**References:**

1. Ganguli Prabuddha, 'Intellectual Property Rights: Unleashing the knowledge economy', Tata McGraw Hill, New Delhi
2. Wadehra R. L., 'Law Relating to patents, trademarks, copyrights, designs and geographical indicators – 2<sup>nd</sup>', Universal Law Publishing.
3. Narayan P. S. 'Intellectual Property Law in India', Asia Law House Hyderabad.

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<b>Course Code: 302054</b>		<b>Course Name : Audit Course IV - Lean Management</b>	
<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme: Audit (P/F)</b> Written and MCQ	
<b>PR:</b>	<b>Th/Tut:--</b>	<b>TH</b>	<b>In-Sem: --</b>
			<b>End-Sem: --</b>
<b>Tut:</b>	<b>TW:</b>		<b>PR: --</b>
			<b>OR: --</b>
<b>Course Objective:</b>			
<ul style="list-style-type: none"> <li>• To learn Lean Thinking and its applications</li> <li>• To get knowledge of Tools &amp; Techniques used in Lean Management</li> <li>• To understand Business Impact of Lean Management</li> </ul>			
<b>Course Outcome: Students</b>			
<ul style="list-style-type: none"> <li>• Will be able to do practice Lean Management at the workplace</li> <li>• Will be able to contribute in Continuous Improvement program of the Organization</li> </ul>			
<b>Course Contents:</b>			
<ul style="list-style-type: none"> <li>• Brief History of Lean Thinking</li> <li>• Toyota Production System</li> <li>• Five Steps to Lean</li> <li>• Seven Types of MUDA – Waste in Manufacturing</li> <li>• MURA – Unevenness / Fluctuation</li> <li>• MURI – Overburden, Physical Strain</li> <li>• Lean Tools &amp; Techniques</li> <li>• Value Stream Mapping</li> <li>• Five ‘S’</li> <li>• Visual Management</li> <li>• Plan-Do-Check-Act (PDCA)</li> <li>• Kanban</li> <li>• Lean Distribution</li> <li>• Various Lean Management Systems</li> <li>• Just In Time Production</li> <li>• Total Quality Management (TQM)</li> <li>• Total Productive Maintenance (TPM)</li> <li>• Problem Solving Techniques</li> <li>• A3 Reporting Technique</li> </ul>			

**Books:****References:**

1. Lean Thinking: Banish Waste and Create Wealth in Your Corporation, Second Edition James P. Womack and Daniel T. Jones, Free Press, June 2003, ISBN: 0743249275
2. Learning to See: Value Stream Mapping to Create Value and Eliminate Muda Mike Rother and John Shook, Lean Enterprise Institute, June 2003, ISBN: 0966784308
3. Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System, Second Edition Pascal Dennis, Productivity Press Inc, September 2007, ISBN: 9781563273568
4. Gemba Kaizen: A Commonsense, Low-Cost Approach to Management Masaaki Imai, McGraw-Hill, March 1997, ISBN: 0070314462
5. World of Kaizen : By Shyam Talawadekar Paperback Publisher: Kaizen Publisher; 4 th edition (2016) ISBN-10: 819326780X ISBN-13: 978-8193267806

<p style="text-align: center;"><b>Savitribai Phule Pune University, Pune</b>  <b>Third Year of Mechanical, Mechanical Sandwich &amp; Automobile</b>  <b>(2015 Course)</b></p>		
<b>Course Code: 302054</b>		<b>Course Name : Audit Course V - Smart Manufacturing</b>
<b>Teaching Scheme:</b>	<b>Credits</b>	<b>Examination Scheme:</b> Audit(P/F) Written and MCQ
<b>PR:</b>	<b>Th/Tut:--</b>	<b>TH In-Sem: --</b>
		<b>End-Sem: --</b>
<b>Tut:</b>	<b>TW:</b>	<b>PR: --</b>
		<b>OR: --</b>
<b>Description:</b>		
<p>Smart Manufacturing is an amalgamation of Information Technology, Cloud Computing &amp; traditional Mechanical, Production Engineering towards achieving excellence in manufacturing. Maximum results with minimum resources being used. The course will introduce the concepts of Smart Manufacturing, how various technologies can be leveraged to achieve minimum breakdowns, First Time Right Production, 100% Delivery on Time with minimum turnaround time. Nine Pillars of Smart Manufacturing will be explained to the Students.</p> <p>The course will make the students aware of developments in Technology those are going to alter the Traditional Manufacturing scenario. The following topics may be broadly covered in the classroom. The practical will be in the form of Group Discussion based on Case Study.</p>		
<b>Course Objective:</b>		
<ul style="list-style-type: none"> <li>• To know more about Smart Manufacturing &amp; Industry 4.0</li> <li>• To get knowledge of various converging Technologies</li> <li>• To prepare ourselves for the ever changing Manufacturing Techniques</li> </ul>		
<b>Course Outcome: The students will be</b>		
<ul style="list-style-type: none"> <li>• Comfortable with terminology and practices in Smart Manufacturing</li> <li>• Able to face the challenges in Industry &amp; also contribute towards advancement.</li> <li>• Active part of Industry 4.0 (Fourth Industrial Revolution)</li> </ul>		

**Course Contents:**

- Introduction to Industry 4.0
- Historical Background
- Nine Pillars of Smart Manufacturing
- Big Data & analytics
- Autonomous Robots
- Simulation
- Universal System Integration
- IIOT – Industrial Internet of Things
- 3 D Printing – Additive Manufacturing
- Cloud Computing
- Augmented Reality
- Convergence of Nine Pillars
- Business Propositions delivered with Smart Manufacturing
- Adding Smartness to Manufacturing – Adoption & Scaling
- Economic Aspects
- Ecosystem Required for Smart Manufacturing
- Skill set Required for Smart Manufacturing
- Effects on 4 M- Man, Machine, Materials & Methods in Smart Manufacturing

**References:**

1. Smart Manufacturing by Shoukat Ali; Publisher: LAP LAMBERT Academic Publishing (10 August 2016)Language: EnglishISBN-10: 3659933554ISBN-13: 978-3659933554
2. Industry 4.0: The Industrial Internet of Things 2016by Alasdair Gilchrist (Author)  
Publisher: Apress; 1st ed. edition (30 July 2016)  
Language: English  
ISBN-10: 1484220463  
ISBN-13: 978-1484220467
3. Industry 4.0 Data Analytics31 July 2016 by Rajesh Agnihotri and Samuel New  
Publisher: CreateSpace Independent Publishing Platform (31 July 2016)  
Language: English  
ISBN-10: 1534778284  
ISBN-13: 978-1534778283
4. 3D Printing: The Next Industrial Revolution4 May 2013by Christopher Barnatt  
Publisher: Createspace Independent Publishing Platform (4 May 2013)  
Language: English  
ISBN-10: 148418176X  
ISBN-13: 978-1484181768
5. Augmented Reality: Principles and Practice by Dieter Schmalstieg and Tobias Hollerer  
Publisher: Pearson Education; First edition (5 October 2016)  
Language: English  
ISBN-10: 9332578494  
ISBN-13: 978-9332578494

## **LIST OF EXPERIMENTS / CASE STUDIES**

### **Case Study & Group Work:**

- Identification of areas where Smart Manufacturing can flourish
- Business Goals achieved through Smart Manufacturing
- Compilation of Results & Presentation