# Fourth Semester

# BTME 401 Strength of Materials-II

**Course Objective/s and Outcome/s:** The course is designed to understand the concepts of strain energy, resilience, stress under impact loading; shear stress distribution in a beam of various cross sections; stress in curved cross sections; stresses in helical, spiral and leaf springs; stress and strain analysis of thin, thick cylinder and spheres subjected to internal pressure; and various failure theories. The outcome of the course is to enhance deep and vigorous understanding of stress analysis in various machine elements, so that a student can properly analyze and design a mechanical member from the strength point of view under various conditions.

**Unit –I**

**Strain energy:** Introduction to strain energy, energy of dilation and distortion. Resilience, stress due to suddenly applied loads. Castigliano's and Maxwell's theorem of reciprocal deflection.

**Unit –II**

**Theories of failure**: Maximum principal stress theory, maximum shear stress theory, maximum principal strain theory, total strain energy theory, shear strain energy theory. Graphical representation and derivation of equation for these theories and their application to problems related to two dimensional stress systems.

**Unit –III**

**Springs:** Open and closed coiled helical springs under the action of axial load and/or couple. Flat spiral springs- derivation of formula for strain energy, maximum stress and rotation. Leaf spring-deflection and bending stresses

**Unit –IV**

**Thin cylinders and spheres**: Calculation of Hoop stress, longitudinal stress in a cylinder, effects of joints, change in diameter, length and internal volume. Principal stresses in sphere, change in diameter and internal volume.

**Unit –V**

**Thick cylinders**: Derivation of Lame's equations, calculation of radial, longitudinal and hoop stresses and strains due to internal pressure in thick cylinders, compound cylinders, hub shrunk on solid shafts, shrinkage allowance and shrinkage stress.

**Unit –VI**

**Bending of curved beams**: Calculation of stresses in cranes or chain hooks, rings of circular and trapezoidal section, and chain links with straight sides.

**Unit –VII**

**Shear stresses in beams**: Shear stress distribution in rectangular, circular, I, T and channel section; built up beams. Shear centre and its importance.

**Unit –VIII**

**Rotational discs:** Stresses in rotating discs and rims of uniform thickness; disc of uniform strength.

**Suggested Readings / Books:**

- D.S. Bedi, Strength of materials, Khanna book publishing company.
- G.H. Ryder, Strength of materials, Macmillan India Ltd.
- R.S Lehri and A.S. Lehri, Strength of materials, vol. 2, S. K. Kataria and Sons.
- S.S.Rattan, Strength of materials, Tata McGraw Hills.
- Timoshenko and Gere, Mechanics of materials, CBS publishers.

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## BTME 402 Theory of Machines – II

**Course Objective/s & Outcome/s:** The students will understand the basic concepts of inertia forces & couples applied to reciprocating parts of a machine. Students should be able to understand balancing of masses and design of gears & gear trains. They will also gain knowledge of kinematic synthesis and different applications of gyroscopic effect.

**Unit –I**

**Static force analysis**:, Concept of force and couple, free body diagram, condition of equilibrium, static equilibrium of mechanism, methods of static force analysis of simple mechanisms. Power transmission elements, considerations of frictional forces

**Unit –II**

**Dynamic force analysis** Determination of forces and couples for a crank, inertia of reciprocating parts, dynamically equivalent system, analytical and graphical method, inertia force analysis of basic engine mechanism, torque required to overcome inertia and gravitational force of a four bar linkage.

**Unit –III**

**Balancing:** Necessity of balancing, static and dynamic balancing, balancing of single and multiple rotating masses, partial unbalanced primary force in an engine, balancing of reciprocating masses, and condition of balance in multi cylinder in line V-engines , concept of direct and reverse crank, balancing of machines, rotors, reversible rotors.

**Unit –IV**

**Gears:** Toothed gears, types of toothed gears and its terminology. Path of contact, arc of contact, conditions for correct gearing, forms of teeth, involutes and its variants, interference and methods of its removal. Calculation of minimum number of teeth on pinion/wheel for involute rack, helical, spiral, bevel and worm gears. Center distance for spiral gears and efficiency of spiral gears

**Unit –V**

**Gear Trains**: Types of gear trains, simple, compound and epicyclic gear trains, problems involving their applications, estimation of velocity ratio of worm and worm wheel.

**Unit –VI**

**Gyroscopic motion and couples**: Effect on supporting and holding structures of machines. stabilization of ships and planes, Gyroscopic effect on two and four wheeled vehicles and stone crusher.

**Unit –VII**

**Kinematic synthesis of Mechanism**: Freudenstien equation, Function generation errors in synthesis, two and three point synthesis, Transmission angles, least square techniques.

**Suggested Readings / Books:**

- S.S. Rattan, Theory of Machines, Tata Mc. Graw Hill.
- John, Gordon, and Joseph, Theory of Machines and Mechanisms, Oxford University Press.
- Hams Crone and Roggers, Theory of Machines.
- Shigley, Theory of Machines, Mc Graw Hill.
- V.P. Singh, Theory of Machines, Dhanpat Rai and Sons.

## BTME 403 Fluid Mechanics

**Course Objective/s and Expected Outcome/s:** This course is designed for the undergraduate mechanical engineering students to develop an understanding of the behavior of fluids at rest or in motion and the subsequent effects of the fluids on the boundaries as the mechanical engineers has to deal with fluids in various applications. This course will also develop analytical abilities related to fluid flow. It is expected that students will be able to have conceptual understanding of fluids and their properties, apply the analytical tools to solve different types of problems related to fluid flow in pipes, design the experiments effectively and do the prototype studies of different types of machines and phenomenon.

**Unit –I**

**Fundamentals of Fluid Mechanics**: Introduction; Applications; Concept of fluid; Difference between solids, liquids and gases; Concept of continuum; Ideal and real fluids; Fluid properties: density, specific volume, specific weight, specific gravity, viscosity (dynamic and kinematic), vapour pressure, compressibility, bulk modulus, Mach number, surface tension and capillarity; Newtonian and non-Newtonian fluids.

**Unit –II**

**Fluid Statics:** Concept of static fluid pressure; Pascal's law and its engineering applications; Hydrostatic paradox; Action of fluid pressure on a plane submerged surface (horizontal, vertical and inclined): resultant force and centre of pressure; Force on a curved surface due to hydrostatic pressure; Buoyancy and flotation; Stability of floating and submerged bodies; Metacentric height and its determination; Periodic time of oscillation; Pressure distribution in a liquid subjected to : (i) constant acceleration along horizontal, vertical and inclined direction (linear motion), (ii) constant rotation.

**Unit –III**

**Fluid Kinematics:** Classification of fluid flows; Lagrangian and Euler flow descriptions; Velocity and acceleration of fluid particle; Local and convective acceleration; Normal and tangential acceleration; Path line, streak line, streamline and timelines; Flow rate and discharge mean velocity; One dimensional continuity equation; Continuity equation in Cartesian (x,y,z), polar (r,θ) and cylindrical (r,θ,z) coordinates; Derivation of continuity equation using the Lagrangian method in Cartesian coordinates; Rotational flows: rotation, vorticity and circulation; Stream function and velocity potential function, and relationship between them; Flow net.

**Unit –IV**

**Fluid Dynamics:** Derivation of Euler's equation of motion in Cartesian coordinates, and along a streamline; Derivation of Bernoulli's equation (using principle of conservation of energy and equation of motion) and its applications to steady state ideal and real fluid flows; Representation of energy changes in fluid system (hydraulic and energy gradient lines); Impulse momentum equation;

Kinetic energy and momentum correction factors; Flow along a curved streamline; Free and forced vortex motions.

**Unit –V**

**Dimensional Analysis and Similitude:** Need of dimensional analysis; Fundamental and derived units; Dimensions and dimensional homogeneity; Rayleigh's and Buckingham's π - method for dimensional analysis; Dimensionless numbers (Reynolds, Froudes, Euler, Mach, and Weber) and their significance; Need of similitude; Geometric, kinematic and dynamic similarity; Model and prototype studies; Similarity model laws.

**Unit –VI**

**Internal Flows:** Laminar and Turbulent Flows: Reynolds number, critical velocity, critical Reynolds number, hydraulic diameter, flow regimes; Hagen – Poiseuille equation; Darcy equation; Head losses in pipes and pipe fittings; Flow through pipes in series and parallel; Concept of equivalent pipe; Roughness in pipes, Moody's chart.

**Unit –VII**

**Pressure and Flow Measurement:** Manometers; Pitot tubes; Various hydraulic coefficients; Orifice meters; Venturi meters; Borda mouthpieces; Notches (rectangular, V and Trapezoidal) and weirs; Rotameters.

**Suggested Readings / Books:**

- D.S. Kumar, Fluid Mechanics and Fluid Power Engineering, S.K. Kataria and Sons Publishers.
- S.K. Som, G. Biswas and S. Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw Hill.
- C.S.P. Ojha, R. Berndtsson and P.N. Chandramouli, Fluid Mechanics and Machinery, Oxford University Press.
- Y.A. Cengel and J.M. Cimbala, Fluid Mechanics - Fundamentals and Applications, Tata McGraw Hill.
- B.R. Munson, D.F. Young, T.H. Okiishi and W.W. Huebsch, Fundamentals of Fluid Mechanics, John Wiley and Sons.
- J.F. Douglas and J.M. Gasiorek, J.A. Swaffield and L.B. Jack, Fluid Mechanics, Pearson.
- V.L. Streeter, E.B. Wylie and K.W. Bedford, Fluid Mechanics, Tata McGraw Hill.

## BTME 404 Applied Thermodynamics-II

**Course Objectives and Expected Outcomes:** This course is designed for providing comprehensive understanding and thermodynamic analysis of positive displacement air compressors and thermal turbo machines used in power generation, aircraft, spacecraft and rocket propulsion. The students will be able to understand the thermodynamic working as well as performance of thermal turbo power machinery. They will also be able to select various thermal devices required for aforesaid applications.

**Unit –I**

**Air Compressors- Introduction**: Classification of Air Compressors; Application of compressors and use of compressed air in industry and other places; Complete representation of compression process on P-v and T-s coordinates with detailed description of areas representing total work done and polytropic work done; Areas representing ***energy lost*** in internal friction, *energy carried away by cooling water* and ***additional flow work*** being done for un-cooled and cooled compression on T-S coordinates; Best value of index of compression; Isentropic, polytropic and isothermal efficiencies and their representation in terms of ratio of areas representing various energy transfers on T-s coordinates.

**Unit –II**

**Reciprocating Air Compressors**

Single stage single acting reciprocating compressor (with and without clearance volume): construction, operation, work input and best value of index of compression, heat rejected to cooling medium, isothermal, overall thermal, isentropic, polytropic, mechanical efficiency, **Clearance Volumetric efficiency**, Overall volumetric efficiency, effect of various parameters on volumetric efficiency, free air delivery; Multistage compressors: purpose and advantages, construction and operation, work input, heat rejected in intercoolers, minimum work input, optimum pressure ratio; ***isothermal***, ***overall thermal***, ***isentropic***, ***polytropic*** and ***mechanical*** efficiencies; Performance curves.

**Unit –III**

**Positive Displacement Rotary Compressors Introduction:** Comparison of rotary positive displacement compressors with reciprocating compressors; Classification of rotary compressors; Construction, operation, work input and efficiency of positive displacement type of rotary compressors like Roots blower, Lysholm compressor and Vane type Blower.

**Unit –IV**

**Thermodynamics of Dynamic Rotary Compressors:** Applications of Steady Flow Energy Equation and thermodynamics of dynamic(i.e., *centrifugal* and *axial flow m/cs*) compressors; Stagnation and static values of pressure, Temperature and enthalpy etc. for flow through dynamic rotary machines; Complete representation of compression process on T-S coordinates with detailed description of areas representing total work done, polytropic work done; ideal work required for compression process, areas representing energy lost in internal friction, energy carried away by cooling water on TS coordinates for an uncooled and cooled compression; ***isentropic***, ***polytropic***, and ***isothermal efficiencies*** as ratios of the areas representing various energy transfers on T-S coordinates.

**Unit –V**

**Centrifugal Compressors**:- Complete thermodynamic analysis of centrifugal compressor stage; Polytropic, isentropic and isothermal efficiencies; Complete representation of compression process in the centrifugal compressor starting from ambient air flow through the suction pipe, Impeller, Diffuser and finally to delivery pipe on T-S coordinates; Pre-guide vanes and pre-whirl; Slip factor; Power input factor; Various modes of energy transfer in the impeller and diffuser; Degree of Reaction and its derivation; Energy transfer in backward, forward and radial vanes; Pressure coefficient as a function of slip factor; Efficiency and out-coming velocity profile from the impeller; Derivation of non-dimensional parameters for plotting compressor characteristics; Centrifugal compressor characteristic curves; Surging and choking in centrifugal compressors.

**Unit –VI**

**Axial Flow Compressors**

Different components of axial flow compressor and their arrangement; Discussion on flow passages and simple theory of aerofoil blading; Angle of attack; coefficients of lift and drag; Turbine versus compressor blades; Velocity vector; Vector diagrams; Thermodynamic analysis; Work done on the compressor and power calculations; Modes of energy transfer in rotor and stator blade flow passages; Detailed discussion on work done factor, degree of reaction, blade efficiency and their derivations; ***Isentropic***, ***polytropic*** and ***isothermal efficiencies***; Surging, Choking and Stalling in axial flow compressors; Characteristic curves for axial flow compressor; flow parameters of axial flow compressor like Pressure Coefficient, Flow Coefficient, Work Coefficient, Temperature-rise Coefficient and Specific Speed; Comparison of axial flow compressor with centrifugal compressor and reaction turbine; Field of application of axial flow compressors.

**Unit –VII**

**Gas Turbines Classification** and comparison of the Open and Closed cycles; Classification on the basis of combustion (at ***constant volume*** or ***constant pressure***); Comparison of gas turbine with a steam turbine and IC engine; Fields of application of gas turbines; Position of gas turbine in power industry; Thermodynamics of constant pressure gas turbine cycle (Brayton cycle); Calculation of net output, work ratio and thermal efficiency of ideal and actual cycles; Cycle air rate, temperature ratio;

Effect of changes in specific heat and that of mass of fuel on power and efficiency; Operating variables and their effects on thermal efficiency and work ratio; Thermal refinements like regeneration, inter-cooling and re-heating and their different combinations in the gas turbine cycle and their effects on gas turbine cycle i.e. gas turbine cycle. Multistage compression and expansion; Dual Turbine system; Series and parallel arrangements; Closed and Semi-closed gas turbine cycle; Requirements of a gas turbine combustion chamber; Blade materials and selection criteria for these materials and requirements of blade materials; Gas turbine fuels.

**Unit –VIII**

**Jet Propulsion** Principle of jet propulsion; Description of different types of jet propulsion systems like rockets and thermal jet engines, like **(i) Athodyds**(ramjet and pulsejet), **(ii)** Turbojet engine, and **(iii)** Turboprop engine. Thermodynamics of turbojet engine components; Development of thrust and methods for its boosting/augmentation; Thrust work and thrust power; Propulsion energy, Propulsion and thermal (internal) efficiencies; Overall thermal efficiency; Specific fuel c onsumption**;** Rocket propulsion, its thrust and thrust power; Propulsion and overall thermal efficiency; Types of rocket motors (e.g. solid propellant and liquid propellant systems); Various common propellant combinations (i.e. fuels) used in rocket motors; Cooling of rockets; Advantages and disadvantages of jet propulsion over other propulsion systems; Brief introduction to performance characteristics of different propulsion systems; Fields of application of various propulsion units.

**Suggested Readings / Books:**

- R. Yadav, Sanjay and Rajay, Applied Thermodynamics, Central Publishing House.
- J.S. Rajadurai, Thermodynamics and Thermal Engineering New Age International (P) Ltd. Publishers.
- D.S. Kumar and V.P. Vasandani, Heat Engineering, Metropolitan Book Co. Pvt. Ltd.
- K. Soman, Thermal Engineering, PHI Learning Pvt. Ltd.
- G. Rogers and Y. Mayhew, Engineering Thermodynamics, Pearson.
- D.G. Shephered, Principles of Turbo machinery Macmillan.
- H. Cohen, G.F.C. Rogers and M. Sarvan, Gas Turbine Theory, Longmans.

## BTME 405 Manufacturing Processes-II

**Course Objective/s and Outcome/s:** This course is designed to make students learn principles, operations and capabilities of various metal machining and metal forming processes. They will understand the importance of process variables controlling these processes. They will also recognize the inter-relationships between material properties and manufacturing processes. Upon completion of the course, the students should have the ability to select different types of the metal machining and forming processes needed for the manufacturing of various geometrical shapes of products.

**Unit –I**

**Metal Forming:** Introduction and classification. Rolling process: introduction, classification, rolling mills, products of rolling, rolling defects and remedies. Forging: open and closed die forging, forging operations, hammer forging, press forging and drop forging, forging defects, their causes and remedies. Extrusion: classification, equipment, defects and remedies. Drawing: drawing of rods, wires and tubes, draw benches, drawing defects and remedies. Sheet metal forming operations: piercing, blanking, embossing, squeezing, coining, bending, drawing and deep drawing, and spinning. Punch and die set up. Press working: press types, operations, press tools, progressive and combination dies. Process variables and numerical problems related to load calculation in Rolling, Forging, Extrusion, Drawing and Sheet metal forming. High velocity forming of metals: introduction, electro-hydraulic forming, mechanical high velocity forming, magnetic pulse forming and explosive forming. **Powder Metallurgy:** Introduction, advantages, limitations, and applications methods of producing metal powders, briquetting and sintering.

**Unit –II**

**Metal Cutting:** Introduction to machining processes, classification, Mechanics of chip formation process, concept of shear angle, chip contraction and cutting forces in metal cutting, Merchant theory, tool wear, tool life, machinability. Numerical problems based on above mentioned topics, Fundamentals of measurement of cutting forces and chip tool interface temperature. Cutting tools: types, geometry of single point cutting tool, twist drill and milling cutter, tool signature. Cutting tool materials: high carbon steels, alloy carbon steels, high speed steel, cast alloys, cemented carbides, ceramics and diamonds, and CBN. Selection of machining parameters. Coolants and lubricants: classification, purpose, function and properties.

**Unit III**

**Machine Tools** Lathe: classification, description and operations, kinematic scheme of lathe, and lathe attachments. Shaping and planing machine: classification, description and operations, drive mechanisms. Milling machine: classification, description and operations, indexing devices, up milling and down milling. Drilling machine: classification, description and operations. Boring machine: classification, description and operations. Grinding machines: classification, description and operations, wheel selection, grinding wheel composition and nomenclature of grinding wheels, dressing and truing of grinding wheels. Broaching machine: classification, description and operations. Speed, feed and machining time calculations of all the above machines.

**Suggested Readings / Books:**


- B. L. Juneja and G. S. Sekhon, Fundamentals of Metal Cutting & Machine Tools, New Age International (P) Ltd.
- H.S. Shan, Manufacturing Processes, Vol. I&II, , Pearson Publishers
- PC Sharma, A Text Book of Production Technology, S. Chand & Company Ltd.
- M. P. Groover, Fundamentals of Modern manufacturing, Wiley
- Serope Kalpakjian and Steven R. Schmid, Manufacturing Engineering and Technology, Pearson Publishers.


## BTME 406 Fluid Mechanics LAB

1. To determine the metacentric height of a floating vessel under loaded and unloaded conditions.
2. To study the flow through a variable area duct and verify Bernoulli's energy equation.
3. To determine the coefficient of discharge for an obstruction flow meter (venturi meter/ orifice meter)
4. To determine the discharge coefficient for a V- notch or rectangular notch.
5. To study the transition from laminar to turbulent flow and to ascertain the lower critical Reynolds number.
6. To determine the hydraulic coefficients for flow through an orifice.
7. To determine the friction coefficients for pipes of different diameters.
8. To determine the head loss in a pipe line due to sudden expansion/ sudden contraction/ bend.
9. To determine the velocity distribution for pipeline flow with a pitot static probe.
10. Experimental evaluation of free and forced vortex flow.

## BTME 407 Manufacturing Processes Lab

**Casting:**

1. To determine clay content, moisture content, hardness of a moulding sand sample.
2. To determine shatter index of a moulding sand sample.
3. To test tensile, compressive, transverse strength of moulding sand in green condition.
4. To determine permeability and grain fineness number of a moulding sand sample.

**Welding:**

1. To make lap joint, butt joint and T- joints with oxy- acetylene gas welding and manual arc welding processes
2. To study MIG, TIG and Spot welding equipment and make weld joints by these processes.

**Machining and Forming**

1. To study constructional features of following machines through drawings/ sketches:
   a. Grinding machines (Surface, Cylindrical)
   b. Hydraulic Press

c. Draw Bench
d. Drawing and Extrusion Dies
e. Rolling Mills

2. To grind single point and multipoint cutting tools
3. To prepare job on Lathe involving specified tolerances; cutting of V- threads and square threads.
4. To prepare job on shaper involving plane surface,
5. Use of milling machines for generation of plane surfaces, spur gears and helical gears; use of end mill cutters.
6. To determine cutting forces with dynamometer for turning, drilling and milling operations.

**Note: At least one industrial visit must be arranged for the students for the live demonstration of Casting, Welding, Forming and Machining processes.**

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## BTME 408 Theory of Machines Lab

1. To draw displacement, velocity & acceleration diagram of slider - crank and four bar mechanism.
2. To study the various inversions of kinematic chains.
3. Conduct experiments on various types of governors and draw graphs between height and equilibrium speed of a governor.
4. Determination of gyroscopic couple (graphical method).
5. Balancing of rotating masses (graphical method).
6. Cam profile analysis (graphical method)
7. Determination of gear- train value of compound gear trains and epicyclic gear trains.
8. To draw circumferential and axial pressure profile in a full journal bearing.
9. To determine coefficient of friction for a belt-pulley material combination.
10. Determination of moment of inertia of flywheel.

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