INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

TUTORIAL QUESTION BANK

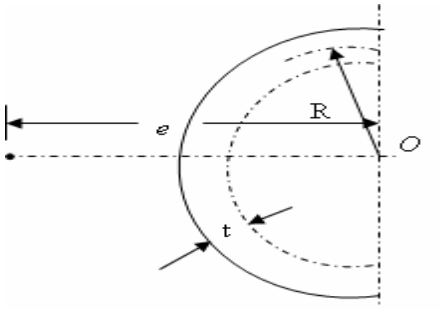
Course Name	:	**ADVANCED MECHANICS OF SOLIDS**
Course Code	:	**BCC206**
Class	:	I M. Tech I Semester
Branch	:	CAD-CAM
Year	:	2016 – 2017
Course Coordinator	:	Prof. U. S. P Rao
Course Faculty	:	Prof. U. S. P. Rao

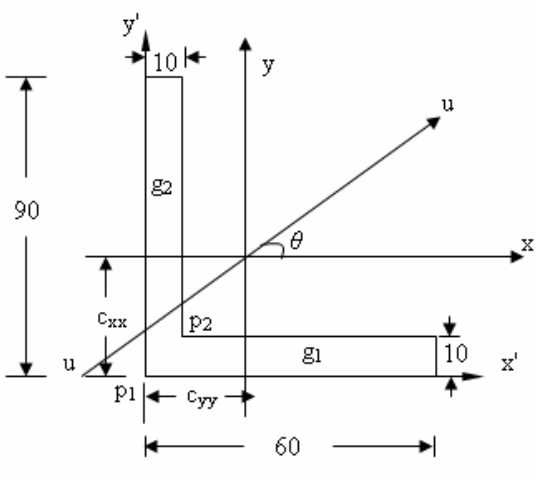
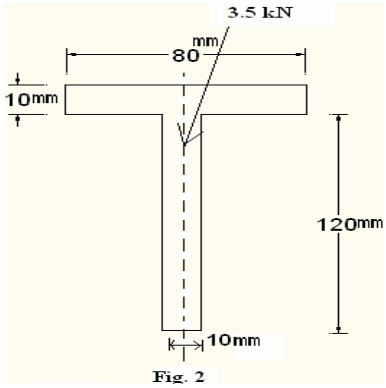
OBJECTIVES

The course should enable the students to:

1. Understand the theory of elasticity including stress, strain, displacement and Hooke's law and strain energy relationships.
2. Understand the shear force and bending moment diagrams of symmetrical beams.
3. Distinguish bending and shear stresses developed in beams of various sections.
4. Compare stresses in a shaft under torsion and in thin cylindrical members.

S No	QUESTION	Blooms taxonomy level	Course Outcomes
	UNIT – I SHEAR CENTER		
	Part - A (Short Answer Questions)		
1	Define neutral axis	Remember	1
2	Define symmetrical bending	Remember	1
3	Define unsymmetrical bending	Remember	1
4	Write about Un symmetrical beams.	Remember	1
5	Write about symmetrical beams.	Remember	1
6	Explain principal axes in case of unsymmetrical bending	Remember	1
7	Discuss about product of inertia	Remember	1
8	Indicate the axes for which Product of Inertia is zero.	Remember	1
9	Describe ellipse of Inertia	Understand	1
10	Discuss about momental ellipse	Remember	1
11	Write about middle third rule	Remember	1
12	State middle quarter rule	Remember	1
	Part - B (Long Answer Questions)		
1	Compare symmetrical bending and unsymmetrical bending using examples with a neat sketch.	Create	1

2	An area has momemts of interia I_x=58.5cm^4 and I_y=56 cm^4 and I_{xy}=54 cm^4. Determine the momemts of interia and product of interia with respect to UV axes inclined at 30° anticlockwise to xy axes Also determine its principal axes of interia and principal moment of interia	Understand	1
3	Explain shear centre with the help of examples.	Understand	1
4	Determine I_u,I_v and I_{uv} for a rectangle 100mmx 250mm if uv axis are inclined at 30° anticlockwise to xy axes.	Understand	1
5	Determine the principal moments of interia for an unequal angle section 125mmx75mmx10mm I_X=304mm^4,I_y=88mm^4, C_x=17.8mm, C_y=42.8mm.	Understand	1
6	An area has momemts of interia I_x= 60cm^4 and I_y= 65cm^4 and I_{xy}= 60 cm^4. Determine the momemts of interia and product of interia with respect to UV axes inclined at 30° anticlockwise to xy axes also determine its principal axes of interia and principal moment of interia	Understand	1
7	Determine I_u,I_v and I_{uv} for a rectangle 120mmx 280mm if uv axis are inclined at 30° anticlockwise to xy axes.	Understand	1
8	OX and OY are two perpendicular axes through the centroid and ou and ov are principal axesprove $I_U+I_V=I_X+I_Y$.		
Part - C (Problem Solving and Critical Thinking Questions)			
1	Show that the shear centre for the section shown in fig. 1 is at $e = 4R/\pi$ measured from point O. 		1
2	Determine the approximate positions of shear centre for a channel section of 60mmx60mm and 5mm thickness. When it is loaded by a vertical force with its web vertical.	Create	1
3	"A single channel when used as a beam with its web vertical and acted upon by vertical load will be in torsion unless the load is applied through a particular point outside the section". Justify the statement.	Create	1
4	Determine the position of the shear centre for an 80mm x 40mm x 5mm thick channel when it is subjected to a vertical load F with the web in vertical position.	Create	1
5	Why shear force is zero in flanges when a vertical force is applied through shear centre in the case of a channel loaded with its web vertical? Explain with a neat sketch.	Create	1

6	A 90mm × 60mm × 10mm unequal angle is placed with the larger leg vertical as shown in fig.1. It is subjected to a sagging bending moment of 700N-m on the horizontal axis. Determine the stresses induced at points P1 and P2.  	Create	1
7	A simply supported beam of length 1.8m carries a central load of 3.5K.N inclined at 30^0 to the vertical and passing through the centroid of the section as shown in fig.2. The thickness is 10mm throughout the section. Determine a) Maximum tensile stress. b) Maximum compressive stress. All dimensions are in mm.  Fig. 2	Create	1

UNIT - II CURVED BEAMS

Part – A (Short Answer Questions)

1	Write the equation for neutral axis distance of a curved beam.	Remember	2
2	Compare the stresses induced in a curved beam and straight beam.	Remember	2
3	Indicate the stresses induced in a curved beam.	Remember	2
4	Explain deflection of a curved beam.	Remember	2
5	"Is flexural stress distribution in a curved beam is linear", Explain.	Remember	2
6	Write an equation for p^2 and explain the parameters.	Remember	2
7	Indicate the variation of boundary stress in a curved beam.	Remember	2
8	What is the shape of the cross section of a crane hook. Why	Remember	2

Part - B (Long Answer Questions)			
1	A frame has a 50mmx50mm square cross section. The load P located 100mm from the center of curvature of the curved portion of the frame. The radius of curvature of the inner surface of the curved beam is 30mm. For P=9.5KN, Determine the values for the maximum tensile and compressive stresses.		2
2	A curved bar of square section 75mmx75mm and of mean radius of curvature 112.5mm is initially unstressed if a bending moment of 7500N-m is applied to the bar and tends to straighten it, find the stresses at the inner and outer faces.	Remember	2
3	A semi circular curved bar of trapezoidal cross section with a diametrical load 25KN. Calculate the minimum and maximum stress at the critical section.	Remember	2
4	A hook has a isosceles triangular section with a base 40mm and height 50mm. the load 10KN is applied along a line 40mm from the inner edge of the shank. The base of the triangle is inside of the hook. Radius of curvature of inside surface is 30mm. Compute the stresses on the inner and outer fibers.	Create	2
5	A curved bar of rectangular section initially unstressed is subjected to a bending moment of 900Nm, which tends to straighten the bar. The section is 30mm wide and 40mm deep in the plane of bending, Mean radius of curvature is 80mm. Find the bending stresses.	Remember	2
6	A semi circular curved bar of trapezoidal cross section with a diametrical load 20KN. Calculate the minimum and maximum stress at the critical section.	Remember	2
7	A hook has a isosceles triangular section with a base 30mm and height 40mm. the load 10KN is applied along a line 40mm from the inner edge of the shank. The base of the triangle is inside of the hook. Radius of curvature of inside surface is 30mm. Compute the stresses on the inner and outer fibers	Remember	2
8	A curved bar of rectangular section initially unstressed is subjected to a bending moment of 900Nm, which tends to straighten the bar. The section is 25mm wide and 30mm deep in the plane of bending mean radius of curvature is 80mm. Find the bending stresses.	Create	2
9	A frame has a 60mmx60mm square cross section. The load P located 120mm from the center of curvature of the curved portion of the frame. The radius of curvature of the inner surface of the curved beam is 30mm. For P=12KN, Determine the values for the maximum tensile and compressive stresses.	Evaluate	2
Part – C (Problem Solving and Critical Thinking)			
1	Derive an equation for the value of p^2 for a trapezoidal section.		2
2	A crane hook having a trapezoidal horizontal cross section is 60mm wide inside and 40mm wide outside. Thickness of the section is 60mm. the Crane hook caries a vertical load of 30KN whose line of action is 50mm from the inside edge of the section. The centre of curvature is 60mm from the inside edge. Determine the maximum tensile and compressive stresses in the section.		2
3	Derive an expression for the stresses developed in a curved bar of circular cross section when it is subjected to a tensile load. Explain each parameter including units		2

4	A ring of steel bar has a diameter of 22mm and carries a pull of 5KN. Determine the stresses along line of action of load and on a section perpendicular to line of action of load. The mean radius of the rim is 100mm.		2
5	Indicate the formula for position of neutral axis as per Winker-Bach theory and explain each term with a suitable neat sketch.		2
6	A curved bar of rectangular section of 30mm width, 40mm depth and mean radius of curvature of 60mm. is subjected to a bending moment 400Nm. Determine the stresses at the inner and outer surfaces. Sketch the variations of stress across the section and find positions of neutral axis.	Remember	2
7	Find the load carrying capacity of a hook of rectangular cross section 100x75mm.The thickness of hook is 75mm, the radius of inner fiber is 150mm while that of outer fiber is 250mm. The line of action of force passes at a distance of 75mm from the inner fibers. The allowable stress is 70 N/mm^2	Remember	2
8	A ring having a saw cut along the horizontal diameter is made from a circular cross section bar of 60mm diameter. The inside diameter of the circular ring is 80mm. It is subjected to a vertical compressive load of 15KN. Find the stresses at the inside and the outside points along the horizontal sections opposite to the saw cut. Also find the position of the neutral axis.	Remember	2
UNIT-III TORSION			
Part – A (Short Answer Questions)			
1	Write an equation for the power transmitted by a shaft. Explain each term.	Remember	3
2	Write the power transmission equation for a hollow circular shaft.	Remember	3
3	Write an equation for angle of twist of a shaft.	Remember	3
4	What is torsional rigidity.	Remember	3
5	Distinguish between torsional moment of resistance and torsional rigidity.	Remember	3
6	A solid shaft transmits 100KW at 150 rpm. Determine torque.	Remember	3
7	A shaft is required to transmit a torque 8KN-m. Find suitable diameter of shaft if allowable stress is 60Mpa.	Remember	3
8	Find the maximum torque transmitted by a shaft 50mm diameter at 150 rpm if the maximum permissible stress is $80N/mm^2$.	Remember	3
9	Derive the equations for applicable for composite shaft.	Remember	3
10	A stepped steel shaft made out of same metal has two diameter d_1 and d_2. If $d_1>d_2$ write the equation for the maximum torque transmitted by the shaft.	Remember	3
11	Derive an equation for the principal stress induced in a shaft subjected to bending moment M and torque. T.	Remember	3
12	Indicate Bredt-Batho equation, for an angle of twist of thin tubular section.	Remember	3
13	Indicate the variation of shear stress from the centre of a circular solid shaft to the surface when it is subjected to a torque.	Remember	3
14	A solid shaft of same cross sectional area and of same material as that of hollow shaft can resist more torque, Explain.	Remember	3
15	The ratio of maximum bending stress to maximum shear stress on the cross section when a shaft is simultaneously subjected to a torque T and bending moment M is 2M/T. Prove	Remember	3

16	The Ratio of diameters of two shafts joined in series is 2. If the two shaft have the same material and the same length find the ratio of angle of twist.	Remember	3
Part – B (Long Answer Questions)			
1.	A solid shaft transmits 100KW at 150 rpm. Determine the suitable diameter of the shaft if the maximum torque transmitted exceeds the mean by 20%. The shear is not to exceed 60MPa. Also find the maximum angle of twist in a length of 4m of shaft. G=80GPa.	Understand	3
2.	A hollow shaft transmits 200KW of power at 150rpm. The total of twist in a length 5m of the shaft is 3°. Find the inner and outer diameters of the shaft if the permissible shear stress is 60MPa. Take G=80GPa	Understand	3
3.	A shaft transmits 220KW of power at 140 rpm. a. Determine the diameter of the solid shaft, b. The inner and outer diameter of a hollow circular shaft if the ratio of the inner to the outer diameter is 3/4. c. The percentage saving in the material on using hollow shaft. Take the allowable stress as 90MPa and density of a material is $84KN/m^3$.	Understand	3
4.	A hollow shaft transmits 100KW of power at 130rpm. The total of twist in a length 4m of the shaft is 3°. Find the inner and outer diameters of the shaft if the permissible shear stress is 60MPa. Take G=80GPa.	Understand	3
5.	Give the procedure to analyse a thin rectangular member subjected to torque T.	Understand	3
6.	Discuss the Bredt-Batho theory as applicable .	Understand	3
7.	In what way the shear stress and the angle of twist can be found in the case of a thin walled twin-celled section when a torque T is applied.	Understand	3
Part – C (Problem Solving and Critical Thinking)			
1	Derive an expression for the allowable twisting moment for a thin walledtube. Also derive an appropriate expression for strength-weight ratio of such a tube. Take τ_s as an allowable shear stress.	Create	3
2	The thickness of all walls of a thin-walled rectangular tube is 2mm and it is subjected to a torque of 10Nm. Determine the maximum shear stress and angular twist per m length take G=102Gpa.Outside dimensions of tube are 40x80mm.	Create	3
3	A thin uniform steel disc of radius 28cm is rotating about its axis at 3200R.p.m.Draw the radial and circumferential stress distribution diagram along the radius of the disc. What are the maximum and minimum values of circumferential and radial stresses? weight density $\rho = 0.078N/cm^3$,g= $9.81m/sec^2$, poison's ratio= 0.3.	Understand	3
4	A thin walled rectangular tube 30x60 mm is subjected to torque of 10Nm.The thickness of all walls is 2mm.Find the stress induced and angle of twist per metre. Take G= 80Gpa.	Create	3
5	Derive an equation for the torque transmitted by thin tubular section.	Create	3
6	Determine maximum torque a thin walled 800mm long tube outside diameter 50mm and inside diameter 46mm can transmit if the maximum angle of twist is 4^0. Also find the maximum shear stress for the maximum torque.	Understand	3
UNIT-IV THEORY OF PLATES			
Part – A (Short Answer Questions)			
1	Indicate bending equation and discuss the parameters of the equation,	Understand	4
2	What is flexural rigidity.	Understand	4
3	The line of action of the force must pass through the shear centre of a cross-section, otherwise the beam is subjected to both bending and torsion. Explain.	Understand	4

4.	Define neutral axis.	Understand	4
5	Sketch the variation of bending stresses in a beam from bottom to top.	Understand	4
6.	Why the bending stress variation in a beam is independent of the variation in width of a beam section	Understand	4
	Part – B (Long Answer Questions)		
1.	A solid plate of 400mm diameter and 20mm thick is acted upon by a uniformly distributed load of 1000KN/m^2 .Calculate the central deflection and the values of maximum stresses in the radial and tangential directions when 1. The edges are freely supported. 2. The edges are firmly supported Take E=205Gpa and poison's ratio= 0.3.	Apply	4
2	A solid flat circular plate of 800mm diameter and 15mm thickness is acted upon by a concentrated load of 40KN at the centre of the plate. Calculate the central deflections and the maximum radial stress at the edge when the plate is clamped at the edge E= 205Gpa and poison's ratio=0.3.	Apply	4
3.	A solid plate of 600mm diameter and 10mm thickness is acted upon by a concentrated load 5KN at the centre of the plate. Calculate the central deflection and the values of radial and tangential stresses at a radial distance of 5mm from the centre. When the plate is simply supported at the edges. Take E = 205Gpa Poison's ratio= 0.3.	Apply	4
4.	A square structural steel trap door (E= 200Gpa, Poison's ratio= 0.29 and Yield= 240Mpa) has a side length of 1.5m and thickness 15mm. The plate is simply supported and subjected to uniform pressure. Determine yield pressure P_r and maximum deflection when the pressure is applied.	Apply	4
5.	A 10mm thick plate covers a circular opening of diameter 200mm. The plate is fixed at the edges and subjected to a pressure p. Determine yield pressure. Deflection at centre when yield pressure is applied. Take E= 200GPa, μ= 0.29, yield stress = 315GPa. Factor of safety = 2. Also calculate working pressure	Apply	4
6.	A square door has a side of 1.8m and thickness of 15mm. The plate is simply supported and subjected to a uniform pressure. Determine yield pressure. find out maximum deflection when this pressure is applied. Take E= 200GPa, μ = 0.29, yield stress = 315GPa.	Apply	4
7.	A square structural steel trap door (E= 200Gpa, Poison's ratio= 0.29 and Yield=240Mpa) has a side length of 1.5m and thickness 15mm. The plate is simply supported and subjected to uniform pressure. Determine yield pressure P_r and maximum deflection when the pressure is applied.	Apply	4
	Part – C (Problem Solving and Critical Thinking)		
1	A water 3.6 m deep and 2.7 m in square is to be made of structural steel plate .The sides of the tank are divided into nine panels by two vertical stiffness and two horizontal support that is each panel is 0.9 m circle and 1.2 m high and the average head of water on a lower panel is 3m. (a) Determine the required thickness of the plate for the lower panels, using a working stress limit of 124mpa. (b) Calculate the maximum deflection of the panel.	Create	4
2	A plate made of mild steel (E=200Gpa, μ =0.29, yield stress =315Mpa) has a thickness 10mm and covers a circular opening having a diameter of 200mm. The plate is fixed at the edges and is subjected to a uniform pressure 'p'. (a) Determine the magnitude of the yield pressure P_r and deflection y_{max} at the center of the plate when this pressure is applied. (b) Determine a working pressure based on a factor of safety of shear failure 2 relative to P_r	Create	4
	UNIT-V **CONTACT STRESSES**		

Part – A (Short Answer Questions)			
1	When two bodies having curved surface are pressed together what is the shape of contact area. Explain with a diagram	Remember	5
2.	Define contact area problems encountered in engineering.	Understand	5
3.	What is the boundary line of the area of contact when two curved surfaces are pressed together. Explain with a diagram.	Understand	5
4.	Express with an equation for the boundary line of the area of contact when two curved surfaces are pressed together.	Understand	5
5.	Total distance between corresponding points of any two surfaces which are pressed together equal to Ax^2+By^2. Explain with a sketch.	Understand	5
6	When two curved surfaces are pressed together perpendicular distance from the tangent plane to any point at the surface of body near the point of contact is $\frac{u}{2}tan\beta$. Explain with a sketch.	Understand	5
7.	Express the equation for octahedral shear stress.	Understand	5
Part – B (Long Answer Questions)			
1.	Find the contact stress area when a 10mm sphere is in contact with an internal spherical surface diameter 10.01mm and subjected to 5KN force subjected to 5KN for (a) Two cylinder of length l are in contact. (b) A cylinder of length l and plane. (c) A cylinder and an internal cylinder.	Understand	5
2.	Derive the expression for contact pressure on a single row ball bearing. If the ball diameter is 4cm, the radius of the groove is 2.5cm. The diameter of the outer race is 20cm and the greatest compressive force on one ball is 5KN. Calculate the contact pressure.	Understand	5
3.	A rail road uses steel rails (E = 200GPa) with a depth of 184mm. The distance from the top of the rail to its centroid is 9.91mm, and the moment of inertia of the rail is $36.9x10^6mm^4$ rail is supported by ties, ballast and a road bed that together are assumed to act as an elastic foundation with spring constant $K=14.0N/mm^2$. Determine the maximum deflection, maximum bending moment.	Understand	5
4.	A feed roll consists of two circular cylindrical steel rollers, each 200mm in diameter and arranged so that their longitudinal axes are parallel. A cylindrical steel shaft (60mm in diameter) is fed between the rollers in such a manner that its longitudinal axis is perpendicular to that of the rollers. The total load P between the shaft and rollers is 4.5KN. Determine the values of the maximum principal stress.	Understand	5
Part – C (Problem Solving and Critical Thinking)			
1	Two semicircular disks are made of steel ($E_1=E_2=200Gpa$, $r_1=r_2=0.29$). The radius of curvature of the two surfaces at the point of contact are $R_1=60mm$, $R_1^1=130mm$, $R_2=80mm$, $R_2^1=200mm$. The angle α between the planes of minimum curavature is 30˚. Find the ratio B/A.	Create	5
2.	A 150 mm diameter cast iron wheel, 50mm wide rolls on a flat surface carrying 3 KN (a) Find horizon stress σ_x, σ_y, σ_z and shear stress. (b) What happens to the stresses at a point A that is 0.25mm below the rim surface during one revolution.	Create	5
3.	In spherical ball bearing 10mm diameter roll on the inside surface of the outer race. The balls are arranged in a pitch circle of 65mm and the radius of contacting face of the outer race is 37.5mm in the plane of bearing width. Assuming E= 200Gpa and r= 0.3. Calculate the foot print area and the contact stresses. use load of 10N.	Create	5

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