Code No: RT21032 **R13** SET - 1

II B. Tech I Semester Regular Examinations, Jan - 2015
MECHANICS OF SOLIDS
(Com. to ME, AME, AE, MTE)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **THREE** Questions from **Part-B**

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PART-A

1. a) What are the limitations of Euler's formula for buckling of columns?
   b) Mention the assumptions in the theory of simple bending.
   c) Define the terms: i) Bulk modulus ii) Principal stresses iii) Resilience
   d) What is point of contraflexure? Give relatio between shear force and rate of loading for a beam.
   e) Give the value of the ratio of maximum shear stress to average shear stress in a beam having i) circular cross section ii) rectangular cross section iii) traingular cross section
   f) State the first Moment-area thoerem.
   g) How do you differentiate between thin and thick cylinders? Express the volumetric strain in thin cylinders in terms of longitudinal and circumferential strains.
   h) State the assumptions made in the theory of torsion.

(3M+3M+3M+3M+3M+2M+2M+3M)

PART-B

2. a) The stresses on two mutually perpendicular planes through a point in a body are 90 MPa and 60 MPa, both being tensile. Determine the maximum value of shear stress which can be applied so that the maximum value of permissible principal stress is limited to 140 MPa. What will be the direction of the principal stress and the magnitude of the maximum shear stress?
   b) A load of 900 kN is applied to a reinforced concrete column of 600 mm diameter which has rods of 40 mm diameter embedded in it. Determine the stress in the concrete and steel. Take young's modulus for steel as 210 GPa and that for concrete as 15 GPa. (10M+6M)
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3. a) Draw S.F.D and B.M.D for the cantilever beam shown in Figure 1.

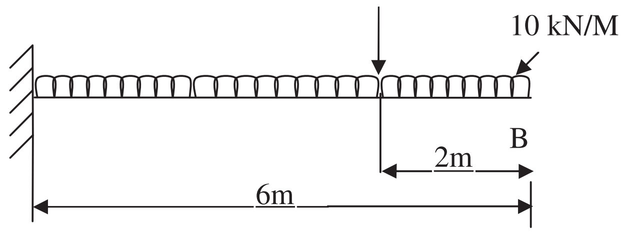

Figure 1

b) A simply supported beam of 10 m span carries uniformly distributed load of 8 kN/m over the left half and a counter clockwise couple at 7.5 m from the left end. The reaction at the left support is found to be 60 kN. Draw the shear force and bending moment diagrams.(8M+8M)

4. a) A beam of traphezoidal section is subjected to sagging bending moment with the larger side at the bottom. Determine the ratio of lengths of parallel sides for maximum economy. The permissible stresses in tension and compression are 50 MPa and 62.5 MPa respectively.

b) A hollow steel shaft transmits 250 kW of power at 160 r.p.m. The total angle of twist in a length of 5 m of the shaft is 3 degrees. Determine the inner and outer diameters of the shaft if the permissible shear stress is 60 MPa. Take modulus of rigidity as 80 GPa. (8M+8M)

5. A simply supported beam of 10 m span carries a concentrated load of 40 kN at a distance of 7.5 m from one end. Determine the deflection at the load point and the slopes at the load point and at the two ends. **Use moment area method**. Take moment of inertia of area I= 2 x 10^9 mm^4 and young's modulus of elasticity as 200 GPa. (16M)

6. A cylindrical boiler drum has hemispherical end. The cylindrical portion is 1.2 m long and 600 mm in diameter with 16 mm thick. After filling it with water at atmospheric pressure, it is put on a hrdraulic test and the pressure is raised to 10 MPa.Determine the additional vol;ume of water required to be filled in the drum at this pressure. Assume that the hoop strain at the junction of the cylinder and the hemisphere to be the same for both. Take young's modulus as 200 GPa, bulk modulus of water as 2100 MPa and poisson's ratio as 0.3. (16M)

7. a) A tubular strut pin jointed at both ends has outer and inner diameters as 50 mm and 45 mm respectively and is 2.6 m long. Compare the crippling loads given by Euler's and Rankine's formulae. Take young's modulus as 200 GPa, yield strength as 310 MPa and Rankine's constant as 1/7500. If the elastic limit stress is taken as 230 MPa, determine the length below which the Euler's formula ceases to apply.

b) A square of 30 mm side is used as a beam with its diagonal in the horizontal position. If the vertical shear force at a section is 3 kN, determine the value and the location of the maximum shear stress occuring in the cross section. Also, determine the shear stress at the bottom. (8M+8M)

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2. Answer **ALL** the question in **Part-A**
3. Answer any **THREE** Questions from **Part-B**

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PART-A

1. a) State the second Moment-area thoerem.
b) What is slenderness ratio of a column?
c) What are the assumptions in the analysis of thin cylinders?
d) State the Hooke's law.
e) What is complimentary shear stress?
f) Derive the relation between the shearforce and bending moment in a beam.
g) Define the terms for a beam, i) neutral axis ii) moment of resistance
h) What are the assumptions taken in the analysis of shear stress in beams?
i) What do you mean by compound tubes used as pressure vessels?
j) What do you mean by statically indeterminate beam?
(2M+2M+2M+2M+2M+4M+2M+2M+2M+2M)

PART-B

2. a) A steel bar of 30 mm square in section is subjected to an axial compressive load of 80 kN. Find the percentage change in volume if the bar is 400 mm long. What are the equal stresses that must be applied to the sides of the bar if the volumetric chage is to be zero? Young's modulus is 200 GPa and poisson's ratio is 0.3.
b) A hollow circular section of outside diameter 150 mm and 15 mm thick carries a shear force of 30 kN. Determine the maximum shear stress and the shear stress at the inner edge and draw the shear stress distribution diagram. (8M+8M)

3. a) The diameter of the circular cross section of a cantilever beam varies from 240 mm at the fixed end to 60 mm at the free end over a length of 12 m. Determine the maximum stress in the beam due to a uniform distributed load of 1.5 kN/m.
b) A beam of 10 m long is simply supported and carries a load of uniformly varying from 50 kN/m at the left end to 150 kN/m at the right end. Draw the shear force and bending moment diagrams. (8M+8M)
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4. a) A beam of 12 m long is supported at 2 m and 10 m from the left end. It carries uniformly distributed loads of 15 kN/m over both overhanging lengths along with a clockwise couple load of 220 kN-m at mid-span. Draw the shear force and bending moment diagrams for the beam. Find the position and magnitudes of maximum bending moment and the position of the point of contraflexure. (8M+8M)

 b) An element in a structure is subjected to a plane stress system that has the stress values σ_x=100 MPa, σ_y=140 MPa and τ_{xy}= 50 MPa. Draw a Mohr's circle and find (i) principal stresses and principal directions (ii) the maximum shear stress and the accompanying normal stress. (8M+8M)

5. A 10 m long horizontal cantilever ABC is built in at A and supported at B, 2 m from C by a rigid prop so that AB is horizontal. If the portions AB and BC carry uniformly distributed loads of 1.4 kN/m and 2 kN/m respectively, determine the load taken by the prop. Use moment-area method. (16M)

6. a) A steel hub of 75 mm inner radius and 125 mm outer radius is shrunk on a steel shaft with initial diameter of 150.1 mm. Determine the maximum hoop stress, contact pressure and the final diameter of the surface in contact. Take young's modulus as 200 GPa and poisson's ratio as 0.3.

 b) Find the diameter of a solid shaft carrying a design torque of 5 kN-m if the maximum shear stress is limited to 90 MPa and the angle of twist should not exceed 1 degree in a length of 20 diameters. Take modulus of rigidity as 85 GPa. (10M+6M)

7. a) A 5 m long hollow cast iron column with fixed ends, supports an axial load of 900 kN. If the external diameter of the column is 250 mm, determine the thichness of the column using the Rankine's formula with a constant of 1/6400. The working stress is 90 MPa.

 b) A spherical shell of 1.5 m inner diameter and 6 mm thick is filled with water under pressure until the volume is increased by 400 x 10^3 mm^3. Find the pressure exerted by water on the shell. Take young's modulus as 200 GPa and poisson's ratio as 0.3.

 c) Write short notes on shafts in series and parallel. (6M+6M+4M)

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2. Answer **ALL** the question in **Part-A**
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PART-A

1. a) Draw typical stress-strain diagrams for high tesile steel and cast iron?
 b) For a cantilever as shown in Figure 1, draw approximately the shape of the shear force and bending moment diagrams.

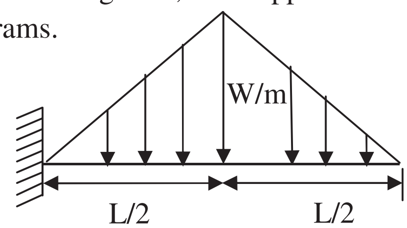

Figure 1

 c) Make a rough sketch for shear stress distribution for the section shown in Figures 2 and 3.

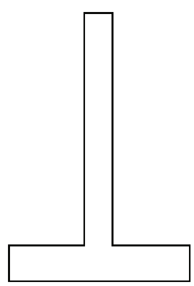
Figure 2

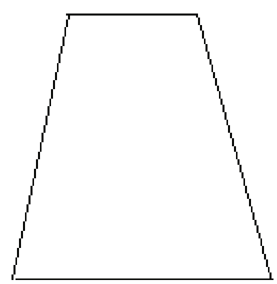
Figure 3

 d) A cantilever of 4 m span carries a uniformly distributed load of 12 kN/m length over the entire span. Determine the deflection of the free end. Young's modulus is 200 GPa and moment of inertia is 90 x 10^6 mm^4.
 e) Ratio of diameters of two shafts joined in series is 2. If the two shafts have the same material and the same length, what is the ratio of their shear stresses?
 f) A pipe of 800 mm diameter is used to carry water under a head of 50 m. Determine the thickness of the pipe if the permissible stress is to be 18 Mpa.
 g) What is meant by equivalent length of columns? What are its values for different end conditions? (2M+4M+4M+3M+2M+3M+4M)
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PART-B

2. a) Determine the safe load that can be carried by a timber column of 400 mm diameter and 4 m long with its both ends fixed. Factor of safety is 2.5. If the proportionality limit is 35 MPa, determine the minimum length up to which Euler's formula can apply. Take young's modulus as 15 GPa.

   b) The resultant stress on a plane BC at a point in a material under stress is 100 MPa inclined at 30 degrees to the normal to the plane BC as shown in Figure 4. The normal component of stress on another plane AB at right angle to the first plane BC is 70 MPa. Determine the resultant stress on the plane AB, the principal stresses and their planes and the maximum shear stresses and their planes. (6M+10M)

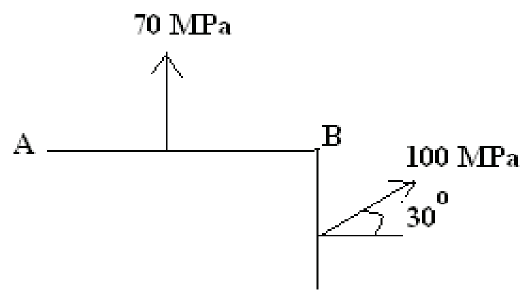

Figure 4

3. a) A simply supported overhanging beam is load as shown in the Figure 5. Draw the shear force and bending moment diagrams.

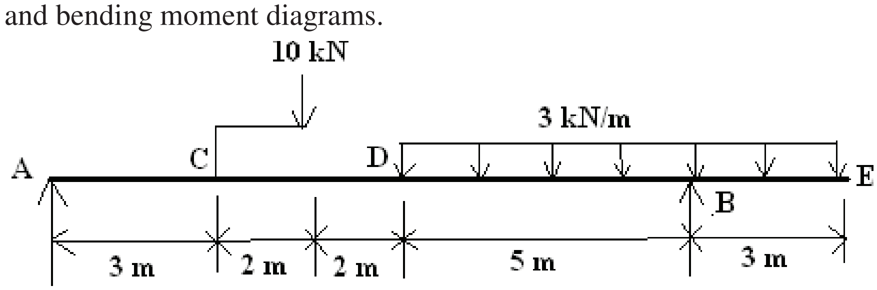

Figure 5

   b) A hollow cylinder of 900 mm diameter and 12 mm thick is 1.5 m long. When it is subjected to an internal pressure of 6 Mpa, the volume is increased by 1500 ml. Calculate the poisson's ratio of the material of the cylinder. Young's modulus is 210 Gpa. (10M+6M)

4. a) The tension flange of a cast iron I-section beam is 200 mm wide and 40 mm deep, the compression flange is 80 mm and 20 mm deep and the web is 300 mm x 30 mm. Determine the load per meter run which can be carried over a span of 3 m by a simply supported beam if the maximum permissible stresses are 80 MPa in compression and 30 MPa in tension.

   b) A beam of triangular cross-section with a base of 120 mm and 150 mm, the lower surface being horizontal. If the shear force on a section is 30 kN, draw the distribution of shear stress in the beam. (8M+8M)

5. A simply supported of 11 m length is loaded as shown in Figure 6. Determine the deflection under the load at point C and maximum deflection. Take young's modulus as 200 GPa and moment of inertia as 20 x 10^7 mm^4. Use Macaulay's method. (16M)

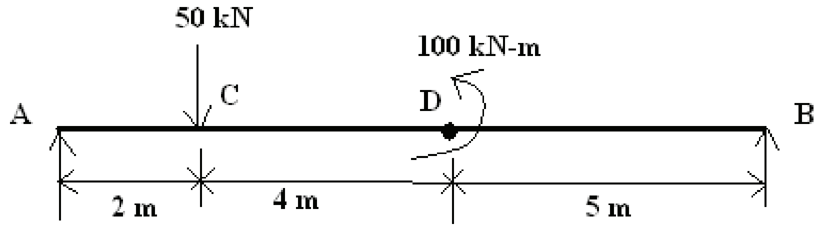

Figure 6

6. a) A compound cylinder is made by shrinking an outer tube of 500 mm external diameter on to an inner tube of 250 mm internal diameter. Find the common diameter at the junction if the maximum hoop stress in the inner tube is to be two thirds of the maximum hoop stress in the outer tube.

   b) A steel flat of dimensions 15 mm x 2 mm is bent into a circular arc of radius 2m by applying end couples . If young's modulus of elasticity is 210 GPa, determine the end couples applied and the maximum stress in the bar. (10M+6M)

7. a) For the shaft shown in figure7, find the maximum vlaue of torque T so that the stress in steel shaft is with in 100 MPa and that in brass is with in 55 MPa. The diameters of the steel and brass shafts are, respectively, 30 mm and 40 mm. Take the rigidity modulus for steel and brass as 90 GPa and 40 GPa, respectively.

   b) At what depth in sea water will a cube of 1 m side, made of steel, change the volume by 0.05%? Take young's modulus of elasticity as 210 GPa and poisson's ratio as 0.3. Specific weight of sea water is 10.1 kN/m^3. (10M+6M)

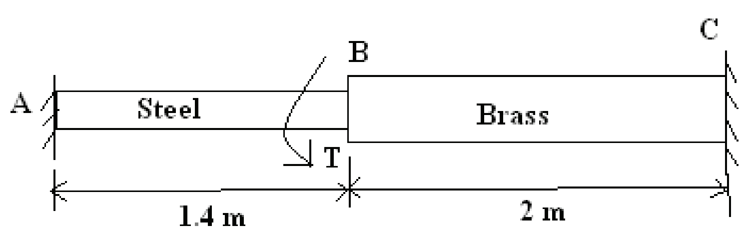

Figure 7

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PART-A

1. a) Define the terms: principal planes and principal stresses.
b) Obtain an expression for strain energy stored in a body when the load is applied gradually.
c) Draw the shapes of shear force and bending moment diagrams for a cantilever beam of length L carrying an end point load.
d) Find an expression for section modulus of a rectangular section of a beam.
e) Show approximately the shear stress distribution across the T-cross section of a beam.
f) Give the relation ship between the deflection of a beam and (i) rate of loading (ii) shear force.
g) Define torsional rigidity of a shaft and express it in terms of angle of twist per unit length.
h) Find an expression for maximum shear stress in a thin cylinder of diameter d and thickness t subjected to internal pressure P.
i) Define the terms: column, strut and crippling load.
(3M+2M+2M+2M+2M+2M+3M+3M+3M)

PART-B

2. a) A hollow cast iron column has an outside diameter of 250 mm and a thickness of 25 mm. It is 5 m long and is fixed at both ends. Calculate the safe load by Rankine's formula assuming a factor of safety of 4. Determine the slenderness ratio and the ratio of Euler's load to the Rankine's load.
b) Determine the contraction of a 12 mm thick flat aluminium plate of trapezoidal section which tapers uniformly from a width of 60 mm to 40 mm in a length of 300 mm when an axial compressive load of 90 kN is applied? Take young's modulus as 78 GPa. (10M+6M)

3. a) A weight of 15 kN falls by 25 mm on a collar rigidly attached to a vertical bar 3 m long and 1200 mm^2 in cross-section. Find the instantaneous expansion of the bar. Take young's modulus as 210 Gpa.
b) A steel cylinder of 350 mm external diameter is to be shrunk to another steel cylinder of 175 mm internal diameter. After shrinking, the diameter at the junction is 250 mm and radial pressure at the common junction is 30 N/mm^2. Find the original difference in radii at the junction. Take young's modulus as 2×10^5 MPa. (6M+10M)
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4. a) A cantilever of 2 m length carries a uniformly varying load of 20 kN/m at the free end to 70 kN/m at the fixed end. If young's modulus is 1 x 10^5 MPa and moment of inertia is 10^8 mm^4, determine the slope and deflection of the cantilever at the free end.

   b) Draw the shear force and bending moment diagrams for the over hanging beam carrying uniformly distributed load of 3 kN/m over the entire length and a point load of 3 kN as shown in Figure 1. Locate the point of contraflexure. (8M+8M)

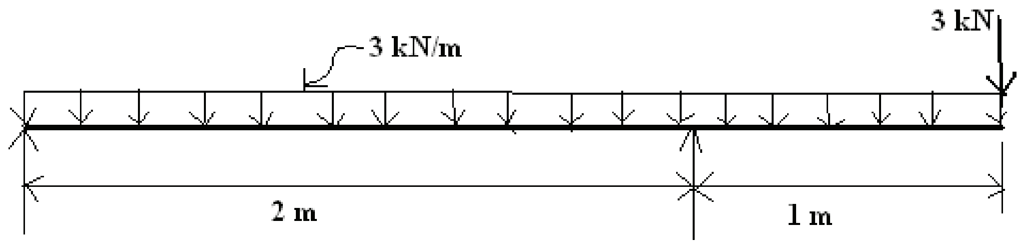

Figure 1

5. a) Show that the ratio of depth to width of the strongest beam that can be cut from a circular log of diameter d is $\sqrt{2}$. Hence calculate the ratio for the diameter d = 400 mm.

   b) A solid circular shaft of 15 cm diameter of length 3 m is transmitting 115 kW power at 180 r.p.m. Determine the maximum shear stress induced in the shaft and the strain energy stored in the shaft. Assume rigidity modulus as 8 x 10^4 Mpa. (8M+8M)

6. a) A simply supported beam carrying a uniformly distributed load ***w*** rests on two supports symmetrically placed at the same level and has overhangs on both ends. The distance between the supports is 2L and the length of each overhang is ***a.*** Determine the ratio of L to ***a*** when the greatest downward deflection has the least value.

   b) A thin cylindrical shell of 90 mm internal diameter and 6 mm thick, is closed at the ends and is subjected to an internal pressure of 7 MPa. A torque of 2 kN-m is also applied to the tube. Find the maximum and minimum principal stresses and maximum shear stress. (8M+8M)

7. a) The shear force acting on a beam at a section is V. The section of the beam is a triangule with base b and hieght h. The beam is placed with its base horizontal. Find the maximum shear stress.

   b) Draw the shear force and bending moment diagrams for the two beams joined together by a frictionless higne joint to form beam ABC as shown in the Figure 2. (8M+8M)

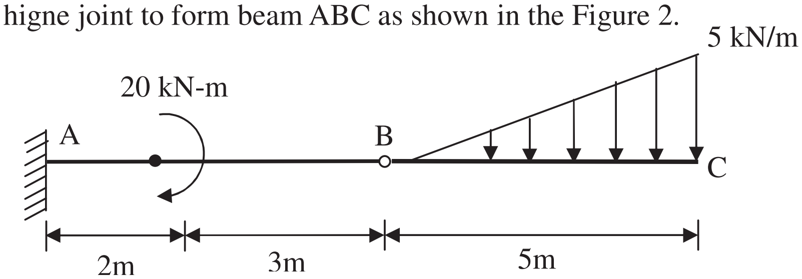

Figure 2