B. E. ELECTRICAL ENGINEERING EXAMINATION, 2018
(1st Year, 2nd Semester)
STRENGTH OF MATERIALS

Time: Three Hours **Full Marks: 100**

Any missing data may be assumed with suitable justification
For question Q6a, the figure should be drawn in graph paper
PARTS OF THE SAME QUESTION MUST BE ANSWERED TOGETHER

ANSWER ANY FIVE QUESTIONS

Q1. **[15+5]**

(a) **Fig. Q1a** shows a rigid bar *ABC* which is pinned at *O* by means of a pin of diameter ***d***. Flexible strings *AB* and *AC* are attached to the bar and each having cross-sectional area 100 mm^2. The bar is subjected to a load P_0 at end *C*. If P_0 =50 kN, then calculate the following:

(i) Tensions developed in the strings *AB* and *AC*.

(ii) Stresses developed in the strings *AB* and *AC*.

(iii) Deflection at point *C* of the bar *ABC*.

(iv) Pin diameter *d*.

Assume *L* = 2.0 m, Young's modulus of elasticity of the string material as 200 GPa and allowable shear stress for pin as 100 MPa.

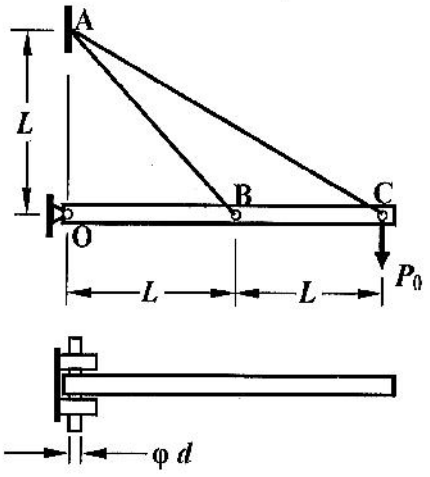
(b) In order to produce a uniform stress distribution due to an axial force *P* in a prismatic member, prove that the line of action of the force must pass through the centroid of its cross-section.

Q2. **[10+5+5]**

(a) A rod (**Fig. Q2a**) consisting of two cylindrical portions *AB* and *BC* is restrained at both ends. The portion *AB* is made of steel (E =200 GPa and α =11.7×10^{-6} /°C) and the portion *BC* is made of brass (E =105 GPa and α =20.9×10^{-6} /°C). Knowing that the rod is initially unstressed, determine the stresses induced in each portion for a temperature rise of 50°C.

(b) If a solid shaft transmitting certain torque is made hollow with the inner diameter as half the outer diameter, the maximum shear stress will rise by about 6%, while the weight reduction will be by about 25%.

(c) Show that the shear stress in the bending of beams varies parabolically over rectangular cross-sections.



Top View of Bar

Fig. Q1a

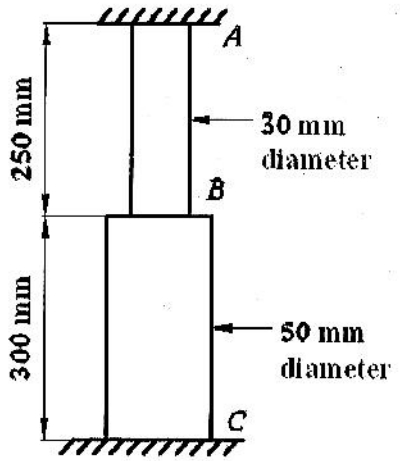


Fig. Q2a

Q3. **[10+10]**

(a) A 2.5 m long steel shaft (G=77.2 GPa) of 30 mm diameter rotates at a frequency of 30 Hz. Determine the maximum power that the shaft can transmit, knowing that the allowable shear stress is 60 MPa, and that the angle of twist must not exceed 7.5^0.

(b) Two close-coiled helical springs wound from the same wire with same number of coils but with different mean coil radii are coaxially assembled as shown in **Fig. Q3b** and compressed between rigid plates at their ends. Calculate the maximum shear stress induced in each spring if the wire diameter=12 mm and P=500 N. The mean coil diameters for the outer and inner springs are 100 mm and 75 mm respectively.

Q4. **[12+8]**

(a) For the prismatic beam loaded as shown in **Fig. 4a**, draw the shear force and bending moment diagrams, neatly marking all the important points and the corresponding values.

(b) A simply supported prismatic beam of span 5m, carries a uniformly distributed load of intensity 10 kN/m. The beam is of rectangular cross section having width 120 mm. Determine the minimum required depth h of the cross section, knowing that for the beam material, σ_{all}=12 MPa and τ_{all}=0.9 MPa.

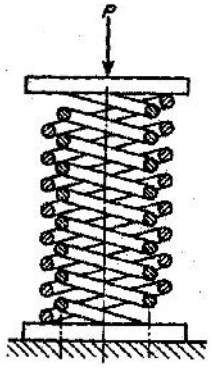


Fig. Q3b

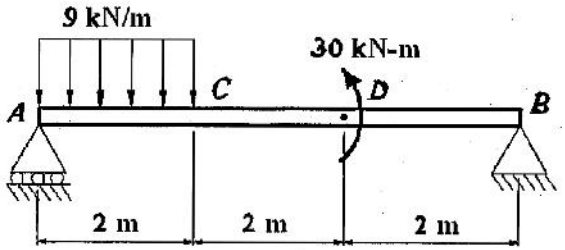


Fig. Q4a

Q5. **[10+10]**

(a) For the simply supported prismatic beam AB (**Fig. Q5a**) subjected to uniformly varying load of maximum intensity ω_0, derive the equation of the elastic curve. Also find the maximum deflection.

(b) Derive Euler's critical load for the fundamental mode of a pinned-pinned column of length L. Take EI=constant.

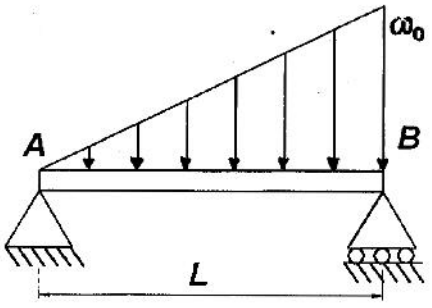


Fig. Q5a

Q6. **[10+10]**

(a) Fig. Q6a shows a differential bi-axial stress element. Draw Mohr's circle for stresses of the element [should be drawn in graph paper and in scale]. Using Mohr's circle, (i) find the principal stresses and the corresponding principal planes, (ii) find the stress components on a plane, which is 15^0 counterclockwise from the x-plane. Show the principal stresses on a properly rotated element in body plane.

(b) Drawing suitable neat figures, derive the governing equation involving membrane stresses for an axi-symmetric thin-walled pressure vessel subjected to internal pressure.

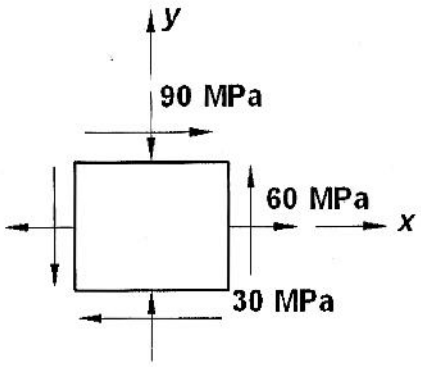


Fig. Q6a

Q7. Answer any four. **[5×4]**

(a) What do you mean by double shear? Explain with an example.

(b) Discuss Wahl's corrections for close-coiled helical springs.

(c) Using appropriate sign convention, prove that $dV/dx = \pm\omega$.

(d) Explain pure bending of beam.

(e) Prove that for a beam with rectangular cross-section and subjected to transverse loading, the maximum transverse shear stress is 1.5 times the average shear stress developed in the section..

(f) Draw and explain the stress-strain diagram of mild steel.

---------- X ----------