Ex/ME/T/123/2017

B.E. MECHANICAL ENGINEERING EXAMINATION, 2017
(1st Year, 2nd Semester)
ENGINEERING MECHANICS - II

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

Any missing data may be assumed with suitable justification
Marks are indicated in the square bracket against each question
For question Q4(a), the figure should be drawn in graph paper

PARTS OF THE SAME QUESTION MUST BE ANSWERED TOGETHER

ANSWER TOTAL FIVE QUESTIONS BY TAKING ATLEAST ONE QUESTION FROM *GROUP B*

GROUP – A

Q1. **[7+10+3]**

(a) 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.

(b) Before the 400 kN load is applied, the rigid platform rests on two steel bars, each of cross-sectional area 1400 mm^2, as shown in **Fig. Q1b.** The cross-sectional area of the aluminum bar is 2800 mm^2. Compute the stress in the aluminum bar after the 400 kN load is applied. Use E =200 GPa for steel and E =70 GPa for aluminum. Neglect the weight of the platform.

(c) If the elongation of a bar of weight W hanging vertically under its own weight is δ_W, and if the elongation of the same bar subjected to a free end load P is δ_P, (neglecting self-weight), then show that $\delta_P = 2\,\delta_W$, if $P = W$.

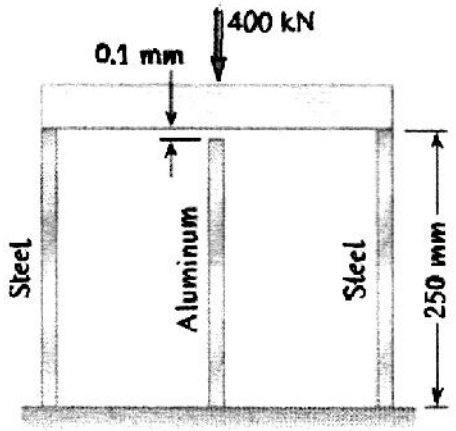

Fig. Q1b

Q2. **[10+7+3]**

(a) A 2.5 m long steel shaft is to transmit 10 kW at a frequency of 25 Hz. Determine the required diameter of the shaft, knowing that that the allowable shear stress is 30 MPa, and that the angle of twist must not exceed 4°. Take G=77.2 GPa.

(b) Compute the maximum shear stress developed (considering Wahl's correction) in a close-coiled helical spring having mean coil diameter of 200 mm and consisting of 24 turns of 20 mm diameter wire when the spring is stretched 200 mm. Take G=42 GPa.

(c) Explain the fact that the maximum shear stress is developed at the inner fibre of a close-coiled helical spring under axial loading.

[Turn over

Q3. **[8+8+4]**

(a) For beam loaded as shown in **Fig. Q3**, draw the complete shear force and bending moment diagrams.

(b) Considering the beam shown in **Fig. Q3** has the T-shaped cross section as shown in the figure, determine the values and locations of the maximum tensile and compressive bending stresses.

(c) For a beam of rectangular cross section, prove that the maximum shear stress at any section is 50 percent higher than the average shear stress.

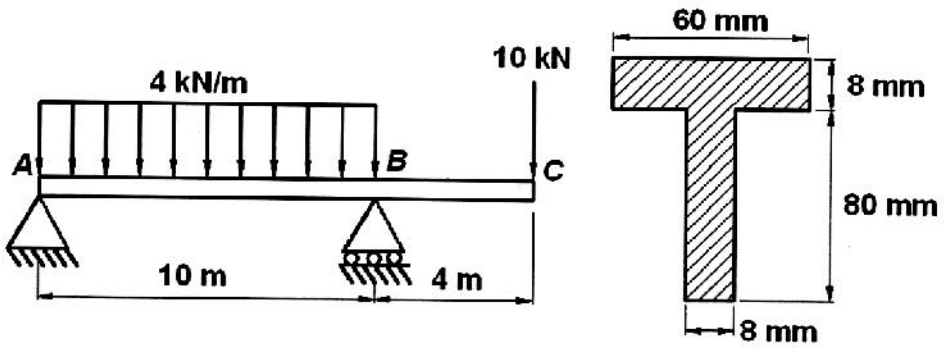

Fig. Q3

Q4. **[10+10]**

(a) **Fig. Q4a** 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 45^0 counterclockwise from the x-plane. Show the principal stresses on a properly rotated element in body plane.

(b) Using a 60^0 strain rosette (**Fig. Q4b**), the following strains have been measured at point Q on the surface of a steel machine base: $\varepsilon_1 = 40\,\mu$, $\varepsilon_2 = 980\,\mu$ and $\varepsilon_3 = 330\,\mu$. Determine at point Q, (a) the principal strains, (b) the principal stresses and the principal planes. Use $E = 200$ GPa and $\upsilon = 0.3$.

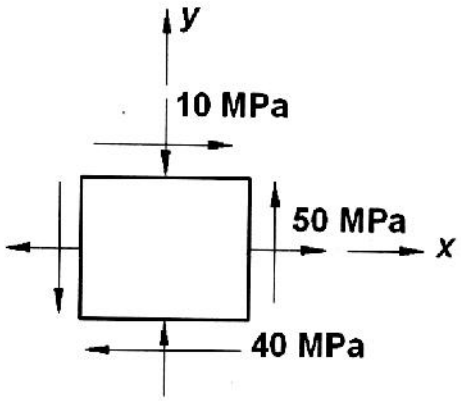

Fig. Q4a

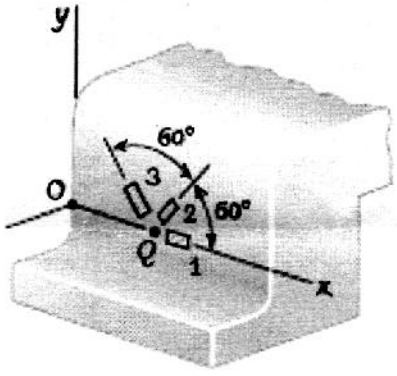

Fig. Q4b

Q5. **[10+10]**

(a) A thin-walled cylinder of thickness t and mean radius r, with closed ends, is subjected to a constant internal pressure p. Derive the expressions of circumferential and longitudinal stresses developed in the cylinder.

(b) A 60 mm diameter shaft supported in bearings carries a 750 mm diameter pulley weighing 2500 N at an overhanging end of the shaft as shown in **Fig. Q5b**. Calculate the principal tensile stress at the section mn if the horizontal belt tensions are as shown in the figure.

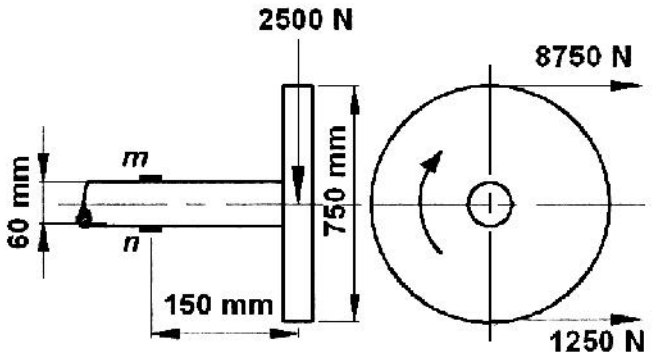

Fig. Q5b

GROUP - B

Q6. **[10+7+3]**

(a) Show that the path followed by a body under central force motion is a conic section. Take $h = r^2\dot{\theta}$ =constant, where r and θ are the radial and transverse coordinates with origin at the centre of the attracting body.

(b) An artificial satellite, after being launched from the earth surface, is inserted into an elliptical orbit at the perigee altitude of 500 km with a velocity of 36900 km/h. Determine (a) the maximum altitude reached by the satellite, and (b) the periodic time of the satellite.

(c) Explain the significance of coefficient of restitution for problems involving impact of two particles.

Q7. Answer any four: **[5 × 4 = 20]**

(a) Briefly explain generalized Hooke's law.

(b) Explain the fact that an I-section beam is more economical than a rectangular cross section beam of the same cross sectional area.

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

(d) Briefly discuss the significance of damping ratio.

(e) Define and explain logarithmic decrement.

(f) Show that the kinetic energy is conserved during a perfectly elastic impact.

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