Ex/PROD/PC/B/T/213/2025

B.E. PRODUCTION ENGINEERING
SECOND YEAR, FIRST SEMESTER EXAM 2025
DEFORMATION OF SOLIDS

Time: 3 hours. Full Marks 100

Answer any FIVE questions, taking any THREE from group A and any TWO from group B.

All parts of a question (a, b, etc) should be answered in one place.

All the dimensions in the figures are in centimeters unless indicated otherwise.

GROUP—A

1.(a) A rigid bar AB is hinged to a vertical wall and supported horizontally by a tie-bar CD as shown in Fig. 1(a). The tie-bar has a cross-sectional area A = 0.5 sq cm and its allowable stress in tension is σw = 1,500 kg/cm2. Find the safe value of the magnitude of the load P and the corresponding vertical deflection of point B. The tie-bar has modulus of elasticity E =2(10)6 kg/cm2.

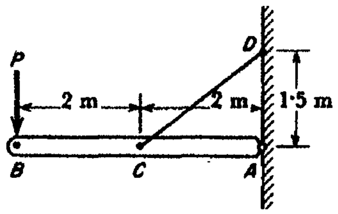

Fig.1 (a)

(b) A rigid steel plate is supported by three concrete posts each having a 10cm×10cm square cross-section as shown in Fig. 1(a). By accident, the middle post is 0.05cm shorter than the other two before load P is applied. Find the safe value of load P if the working stress for the concrete in compression is 200kg/cm^2 and the modulus of elasticity E_c = 12×10^4 kg/cm^2.

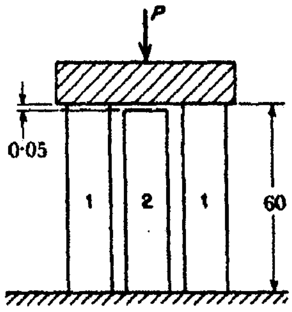

Fig.2 (b) 10+10

[Turn over

2.(a) Consider a vertical bar of uniform cross-section with a flange at the lower end as shown in Fig. 2(a). Weight 'W' is released from a height 'h' and falls freely along the bar until it strikes the flange. Determine the maximum deflection 'δ' of the bar and also calculate the maximum stress

(*i*) when 'h' is large compared to the elongation of the bar &

(*ii*) when 'h' is zero.

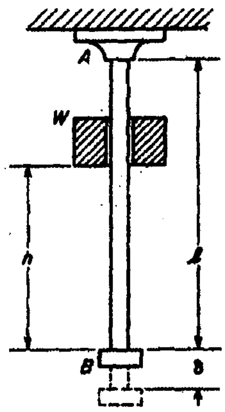

Fig.2 (a)

(b) A prismatic steel rod of length l, modulus of elasticity E and cross-sectional area A hangs vertically under its own weight. How much strain energy is stored in the bar if its weight per unit volume is γ?

15+5

3.(a) Show that bending stress can be expressed as

$$\sigma = My/I$$

Where each symbol holds its usual significance.

(b) A shaft of diameter d, bent in the form of a semicircle AB of radius R, is built-in at A and loaded at B by a force P acting perpendicular to the plane of the ring as shown in Fig.3 (b). Thus any cross-section C of the ring is subjected to both bending and torsion. Assuming that d is small compared with R so that the theory of bending of straight bars may be used, find the value of Φ for which the principal stress σ will be a maximum.

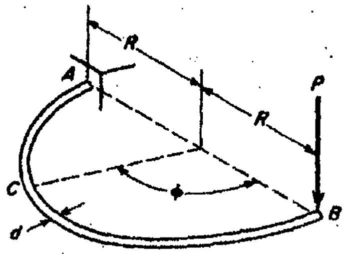

Fig.3 (b) 10+10

4.(a) Show that the angle of twist for a shaft subject to torsion, can be represented by the following relation

$$\Phi = TL/GJ$$

Where the symbols have the usual meaning.

(b) A solid steel shaft of diameter d= 6mm fits loosely inside a hollow steel shaft of inside diameter d = 6 mm and outside diameter d_1 = 9 mm as shown in Fig. 4(b). A pin AA prevents relative rotation between the ends of the shafts at the left. Pinholes at the right are initially at right angles to each other as shown. The two shafts are now twisted in opposite directions until the pinholes at B line up and a pin BB is then inserted. How much strain energy will be locked in the system if l= 250 cm? Assume $G = 84\times10^4 Kg/cm^2$.

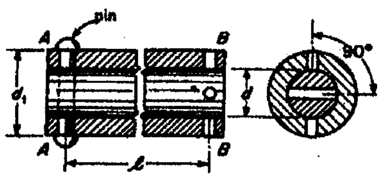

Fig. 4(b)

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5.(a) Construct the complete shear force and bending moment diagram for the beam shown in Fig. 5(a). Also determine the maximum bending moment and the point of contra-flexure.

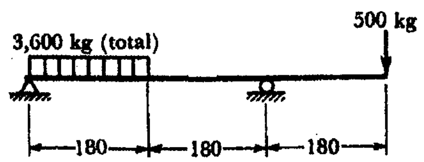

Fig. 5(a)

(b) A steel tube 1 in. external diameter and 3/4 in. internal diameter encloses a copper rod 5/8 in. diameter to which it is rigidly joined at each end. If, at a temperature of 60 °F there is no longitudinal stress, calculate the stress in the rod and tube when the temperature is raised to 400 °F. For steel $E_s=30\times10^6$ lb/sq.in. and for copper $E_c=14\times10^6$ lb/sq.in, coefficient of linear expansion for steel and copper is $\alpha_s= 6\times10^{-6}/$ °F and $\alpha_c= 10\times10^{-6}/$ °F respectively. 10+10

GROUP—B

6.(a) Show that the Euler's column formula for the case of a slender column built in at one end and free at the top is

$$P_{cr} = \pi^2EI/4\ell^2$$

Where the symbols have the usual meaning.

(b) A temporary dam in a water channel is formed by setting vertical 7.5x30 cm planks between guide rails AA and BB as shown in Fig. G. Assuming no support at D, calculate the maximum bending stress induced in each plank when the water depth on the left side of the dam is 1.8m as shown.

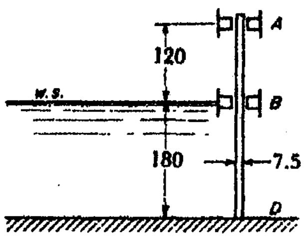

Fig. 6(b) 10+10

7.(a)Pre-stressed concrete beams are made in the following manner: Steel wires are stretched between rigid end plates to a tensile stress σ_0 as shown in Fig. 7(a). Concrete is then poured around them to form the beam as shown in Fig. 6(a)$_2$. After the concrete sets, the external forces Q are removed and the beam is left in a pre-stressed condition. If the moduli of elasticity of steel and concrete are in the ratio 12:1 and their cross-sectional areas are in the ratio 1:15, what are the final residual stresses in the two materials?

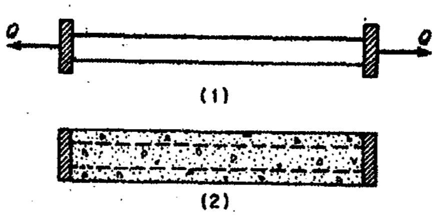

Fig 7(a)

(b) For a rectangular element shown in Fig. 7(b), the following numerical data are given σ_x= -75 kg/cm^2, σ_y= 100 kg/cm^2 and τ_{xy}= -50 kg/cm^2. Determine

(i) The values of σ_x and τ on the plane whose normal is defined by φ = 30°.

(i) The magnitude and direction of the principal stresses σ_1 and σ_2.

(ii) The stress component and planes on which shear stress is the maximum.

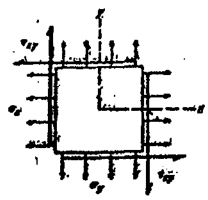

Fig. 7(b)

10+10

8.(a) A simply supported prismatic beam AB carries a concentrated load P as shown in Fig. 8(a). Locate the point of maximum deflection on the elastic line and find the value of this deflection. The following numerical data are given: a = 6 m, b = 2 m, P= 10 t, E = 2(10)^6 kg/cm^2, I = 93,750 cm^2.

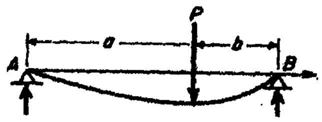

Fig. 8(a)

(b) A steel shaft supported in bearings at A and B and carrying pulleys at C and D, is to transmit 100 hp at 500 r.p.m. from the drive pulley D to the offtake pulley C as shown in Fig. 7. The following numerical data are given P_1 = 2P_2, Q_1 = 2Q_2, R_d =15cm, R_c = 20cm, l = 1.2 m, a = 30cm, and the working stress in shear τ_w= 420 kg/cm^2. Calculate the required diameter d of the shaft.

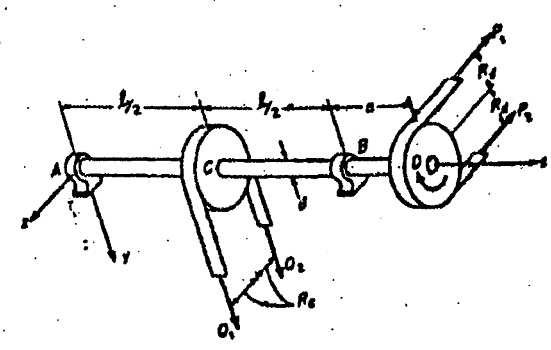

Fig. 8(b)

10+10