B.E. PRODUCTION ENGINEERING

SECOND YEAR, FIRST SEMESTER EXAM 2024

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 a one place.
All the dimensions in the figures are in centimeters unless indicated otherwise.

GROUP—A

1.(a) The cylinder shown in Fig. 1(a) has inside diameter D=25 cm and is subjected to internal gas pressure of intensity p = 20 kg/cm^2 gauge. How many 12.5 mm diameter steel bolts will be required to fasten the top cover plate to the cylinder if the working stress for the bolts is 700 kg/cm^2?

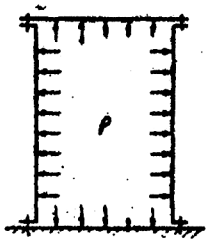

Fig.1 (a)

(b) A rigid steel plate is supported by three concrete posts each having a 10cm×10cm square cross-section as shown in Fig. 1(b). 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 $E_c = 12\times10^4$ kg/cm^2.

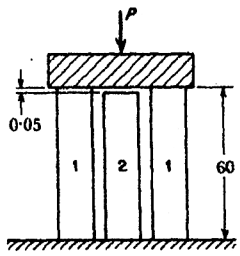

Fig.1 (b)

10+10

2.(a) For the simple structure shown in Fig. 2(a), member BC is a steel wire having diameter d = 3 mm and member AB is a wood strut of 2.5cm-square cross-section. Calculate the horizontal and vertical components of the displacement of point B due to a vertical load P = 200 kg acting as shown. For steel, $E_s = 2\times10^6$ kg/cm^2, for wood, $E_w = 10\times10^4$ kg/cm^2 .

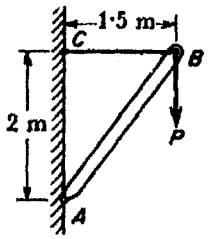

Fig.2 (a)

(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

3.(a) A prismatic steel bar having cross-sectional area A=3 sq cm is subjected to axial loading as shown, in Fig. 3(a).

(i) Neglecting localized irregularities in stress distribution near the points of application of the loads, find the net increase δ in the length of the bar. Assume E =2(10)^6 kg/cm^2.

(ii) At what distance *x* from the fixed end of the bar in Fig. A should the 2t force be applied in order that the net overall change in length of the bar will be zero?

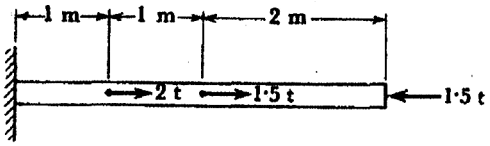

Fig.3 (a)

(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

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 prismatic shaft of diameter d has built-in ends and is subjected to the action of externally applied twisting moments T_1 and T_2, as shown in Fig. 4(b). Find the internal torques T_a, T_b, T_c in the three portions a, b, c, of the shaft. The following numerical data are given: a = 75 cm, b = 125 cm, c = 100 cm, T_1 = 12,000 kg-cm, and T_2 = 24,000kg-cm.

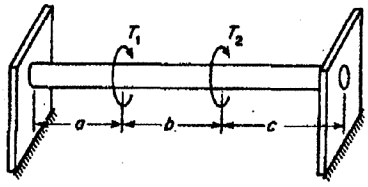

Fig. 4(b) 10+10

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.

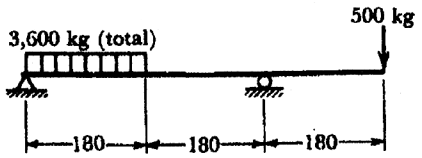

Fig. 5(a)

(b) A 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. 5(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 $G = 84\times10^4 Kg/cm^2$.

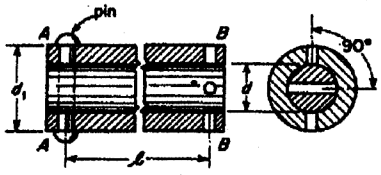

Fig. 5(b)

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

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

Where the symbols have the usual meaning.

(b)The member AB of the simple truss in Fig. is 1.5 m length of ISLC 75 steel channel section with pinned ends and the member BC is a steel rod of circular cross-section having diameter d = 2 cm. Find the largest value of the vertical load P that the structure can support if $\sigma_{y.p.}$ = 2,800 kg/cm^2 and E_s =2(10)^6 kg/cm^2. For ISLC 75: I_x= 66.1 cm^4, I_y= 11.5 cm^4 & A= 7.26 cm^2.

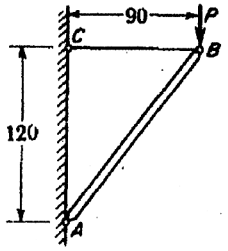

Fig. 6(b) 10+10

7.(a) Show that $\frac{d^2y}{dx^2} = -\frac{M}{EI}$

Each symbol holds its usual significance.

State clearly the different assumptions.

(b) For a rectangular element shown in Fig. 5(b), the following numerical data are given σ_x= 100 kg/cm^2, σ_y= 75 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 $\varphi = 30°$.

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

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

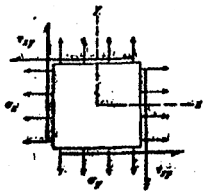

Fig. 7(b) 5+15

8.(a)A solid steel shaft is to be used as a standard to support a highway road sign as shown in Fig. 8(a). The maximum wind pressure on the face of the board is assumed to be 250 kg/m^2. The standard is unsupported laterally and its diameter is d. The allowable working stress in shear is given as τ_w = 600 kg/cm^2. Calculate the required diameter d of the shaft.

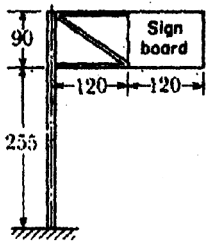

Fig. 8(a)

(b) A solid steel shaft with a flywheel at one end rotates at constant speed n = 120 rpm, Fig.8(b). If the bearing A suddenly freezes, what maximum shear stress τ will be produced in the shaft due to dynamic effects? Assume ℓ = 1.5 m, d = 5 cm, the weight of the flywheel W = 50 kg, and its radius of gyration i = 25 cm.

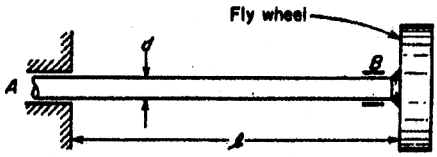

Fig. 8(b) 10+10