EL-MANSOURA UNIVERSITY
FACULTY OF ENGINEERING
DPT. OF PROD. & MECH. DESIGN

FINAL EXAM., JUNE 2010
1st YEAR, MECH. ENGINEERING
STRENGTH OF MAT. & STRESS ANALYS
TIME ALLOWED: (3) HOURS

IMPORTANT NOTES: (PLEASE READ CAREFULLY)

* Solve all problems.
* Arrange solution steps in clear & neat fashion.
* Free-body diagrams, when applicable, are important part of the solution.
* Always support your answers with the proper units

PROBLEM # 1: (16 %)

It has been found that a plane stress condition exists at a point on a part, where:

$$\sigma_x = -700\ MPa;\quad \sigma_y = -300\ MPa;\quad \sigma_z = 0;\quad \tau_{xy} = 200\ MPa;\quad \tau_{xz} = \tau_{yz} = 0$$

Draw, to a scale 1cm = 100 MPa, the three-dimensional Mohr's circles *and find the following:*

(a) The three principal stresses, σ_1, σ_2, & σ_3
(b) The(largest) maximum shear stress at the point.
(c) The corresponding normal & shear strains; assuming that E=200 GPa and $\nu = 0.30$

PROBLEM # 2: (22 %)

The simply-supported beam, shown in Fig. 1, carries a uniform load, a concentrated load, and a concentrated moment; all acting as shown. The beam is made of aluminum (E= 80 GPa) and has the cross-section shown in the Figure. It is required to:

(a) determine the magnitude and location of the maximum tensile and compressive bending stresses.
(b) determine the magnitude and location of the maximum transverse shear stress.
(c) determine the magnitude and sign of the slopes of the beam ends.
(d) determine the magnitude and sign of left-end and mid-point deflection, point (C).

(Use method of superposition- several cases are given at end of exam.)

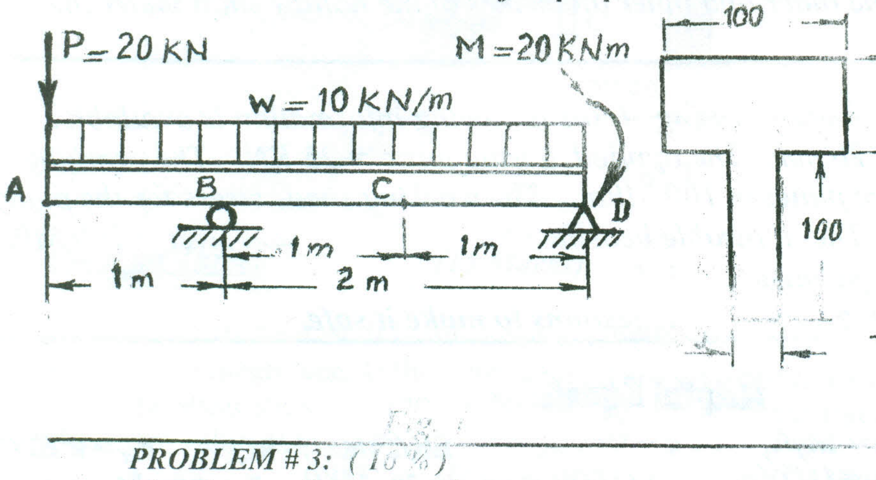


Fig. 1

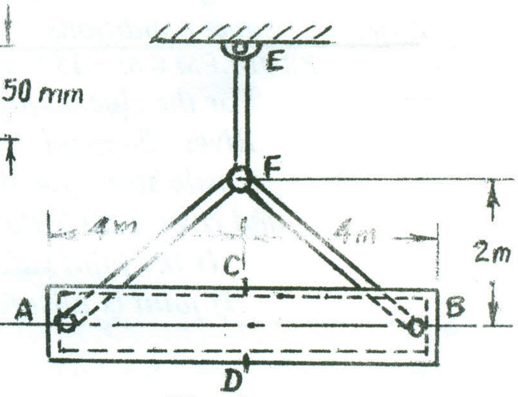


Fig. 2

PROBLEM # 3: (16 %)

The thin-walled pipe shown in Fig. 2 weighs 200 KN and is having a mean diameter 0.6m and a wall thickness 0.0... The pipe is hanged in a horizontal position using a steel wire, as shown, and it contains a fluid under a pressure of 2 MPa. It is required to calculate:

(a) *the total normal stresses at points (C) and (D),*

(b) *the downward deflection of point (D).*

***(Hint:** The pipe is subjected to: its **weight**, the internal **pressure**, and the **tensions** in the wire)*

PROBLEM # 4: (16 %)

The system shown in Fig. 3 consists of three rods, A, B, & C having rectangular cross-sectional area, 60mm x 30mm each. Rods A & C are made of brass (E = 100 GPa); while rod B is made of steel (E = 200 GPa). A compressive load, P = 160 KN, is applied to the rods through a rigid horizontal cover. It is required to:

(a) *Calculate the stress and strain in each rod,*

(b) *Investigate the possibility of rods buckling, i.e. determine safety factor.*

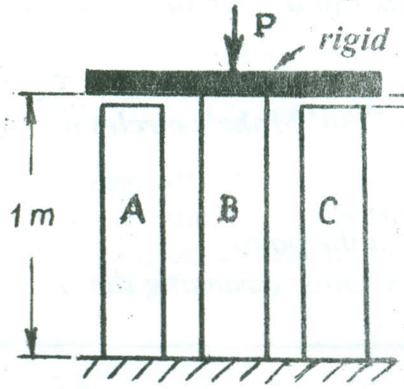


Fig. 3

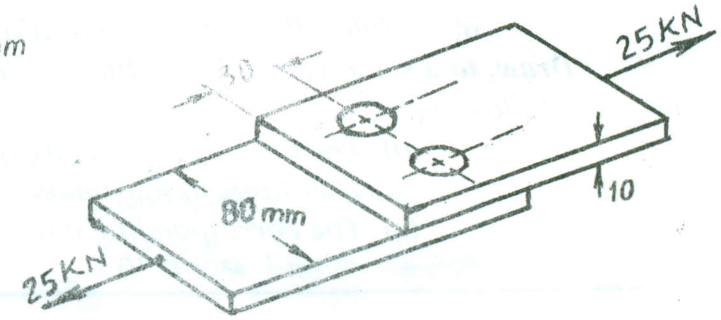


Fig. 4

PROBLEM # 5: (15 %)

Consider a solid circular shaft transmitting 1600 HP at 400 rpm. Determine the necessary diameter of the shaft so that the following conditions are met:

(a) *the torsional shear stress in the shaft does not exceed 80 MPa; and*

(b) *the angle of twist for a length of one meter of the shaft does not exceed 1°.*

(Take G for the shaft material = 80 GPa)

*If it is desired to replace the solid shaft with a hollow one having **one-half** its weight, calculate the outer and inner diameters of the hollow shaft under the same conditions.*

PROBLEM # 6: (15 %)

For the riveted joint shown in Fig. 4, the following information is available: Rivet diameter = 20 mm, The applied tensile force = 25 KN, The working tensile stress for the plates = 100 MPa, The working shear stress for the plates and rivet = 30 MPa, The allowable bearing stress for plates and rivet = 100 MPa.

Is the joint safe or unsafe ? Why ?

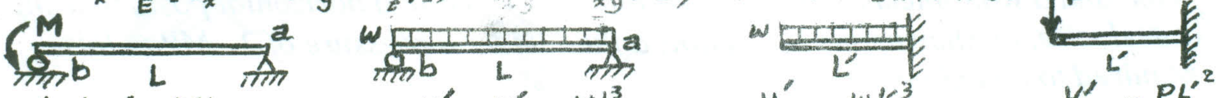
If joint is unsafe, give three suggestions to make it safe.

Helpful Equations

$\sigma = F/A$, $\tau = Tr/J$, $\sigma = My/I$, $\tau = VQ/Ib$, $EI(d^2y/dx^2) = M$, $F_{cr} = \pi^2 EI/CL^2$,

$\delta = \alpha L \Delta T$, $\delta = FL/AE$, $\sigma_1 = (1/2)(\sigma_x + \sigma_y) + (1/2)[(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2]^{(1/2)}$, $J = 2\pi r^3 t$, $A = 2\pi r t$

$\varepsilon_x = \frac{1}{E}[\sigma_x - \nu(\sigma_y + \sigma_z)]$, $\gamma_{xy} = \tau_{xy}/G$, Power $= 2\pi NT/60$



{ • f.e ≡ free-end ; • m.p ≡ mid-point }

$y'_a = \frac{1}{2} y'_b = \frac{ML}{6EI}$, $y_{m.p.} = \frac{ML^2}{16EI}$

$y'_a = y'_b = \frac{wL^3}{24EI}$, $y_{m.p.} = \frac{5wL^4}{384EI}$

$y'_{f.e.} = \frac{wL'^3}{6EI}$, $y_{f.e} = \frac{wL'^4}{8EI}$

$y'_{f.e} = \frac{PL'^2}{2EI}$, $y_{f.e} = \frac{PL'^3}{3EI}$

BEST WISHES