UNIVERSITY OF GHANA

BSC. AGRICULTURAL ENGINEERING FIRST SEMESTER EXAMINATIONS: 2015/2016

FAEN 203: STRENGTH OF MATERIALS (3 Credits)

INSTRUCTION: *ANSWER FOUR (4) QUESTIONS*
TIME ALLOWED: *THREE (3) HOURS*

Marks

1.

(a) Define the terms *moment of inertia* and *section modulus.* 4

(b) State the parallel axis theorem for moment of area of a finite area. 2

(c) The beam in Fig. 1 carries a uniformly distributed load intensity w of 7500 N/m over the overhang. If the overall length of beam is 1.5 m and the cross-sectional dimensions B, H and h are respectively 100 mm, 5 mm and 20 mm, calculate the following:

i. The proper width b of the upper flange of the beam in order that extreme fibre stresses in bending will be in the ratio 4:2.5. 6

ii. The two section moduli Z_1 and Z_2. 6

iii. The shear force and bending moment at B. 4

iv. The maximum tensile stress at B due to bending moments. 3

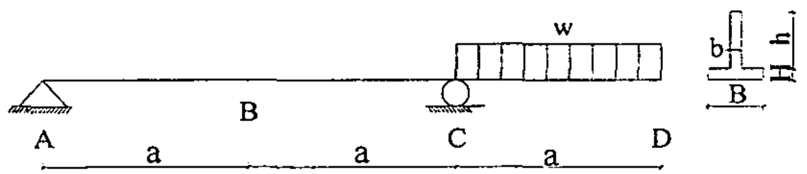


Fig. 1

2.

(a) For a rectangular beam in bending:

i. Where in its section does maximum shear stress occur? 2

ii. What is the shear stress at the extreme top and bottom fibres of the section? 2

(b) A simply supported beam has a rectangular cross-section of dimension b = 5 cm and h = 15 cm as shown in Fig. 2 below, and carries a uniformly distributed dead load of intensity ω N/cm. Allowable working stresses in tension or compression and in shear parallel to the grain are given as follows: σ_w = 750 N/cm^2, τ_w = 150 N/cm^2 respectively.

i. Derive the expression for maximum shear force, *Vmax*. 6

ii. Derive the expression for maximum bending moment, *Mmax*. 6

Marks

iii. Determine the critical span length L of the beam below which the shear stress will govern and above which the bending stress will govern the safe intensity of load ω. 6

iv. Sketch the shear force and bending moment diagrams indicating all turning points. 3

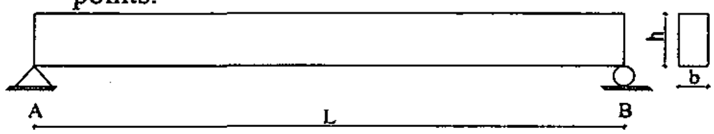


Fig. 2

3.

(a) In the case of bi-axial stress, state the relationships between 3

i. The two complementary normal stresses.
ii. The two complementary shear stresses.
iii. Shear stress and bi-axial normal stresses.

(b) For a thin spherical pressure vessel of thickness t, mean diameter D and allowable stress in tension, σ_w, derive the expression for safe external gas pressure p. 5

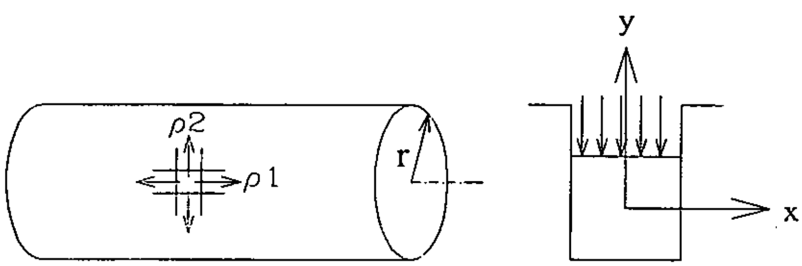
(c) The thin-walled cylindrical tank in Fig. 3(a) is subjected to internal pressure, $p = 70$ N/cm^2. If the mean radius r of the tank is 50 cm and wall thickness $t = 3$ cm,

i. Determine the principal stresses σ_1 and σ_2. 5

ii. Determine the shear stress τ along a 45° helix. 4

iii. Sketch the Mohr circle for this state of stress. 4

(d) A hard rubber block completely confined in the x-direction but free in both the y- and z-directions is subjected to compressive stress $\sigma_y = -200$ N/cm^2 in the y-direction as shown in Fig. 3(b). If Young's Modulus E = 200 N/cm^2 and Poisson's ratio $\mu = 0.5$, calculate the stress, σ_x in the x-direction. 4



(a) (b)

Fig. 3

4.

(a) Define the terms "strain energy" and "modulus of resilience". 4

(b) Derive the Strain Energy stored in a hanging 'weightless' prismatic bar of length l, cross-sectional area A, made of a material with Young's Modulus, E, and having a load P at its lower end. 7

(c) If the same bar above hangs vertically under its own weight (weight per unit volume = γ), derive the formula for:

i. Its elongation and 7

ii. How much strain energy is stored in the bar. 7

Marks

5.

(a) State any two assumptions underlying the derivation of the relationship between uniformly distributed radial loading on thin rings and internal stresses generated; 2

(b) Define the terms "thin ring" and "hoop tension/compression". 2

(c) What is the relationship between circumferential strain and strain along the diameter of a thin ring? 1

(d) A laminated pressure vessel is composed of two thin co-axial steel cylinders as shown in Fig. 4. The mean diameter of the assembly is 150 mm, the thickness of the inner shell is 3 mm and that of the outer shell 2 mm. Prior to assembly there is a 0.2 mm interference (of diameter) between these shells i.e. the inner one is too large to slide into the outer. The outer shell is therefore heated, placed on the inner and allowed to cool, providing a "shrink fit". With the aid of appropriate sketches/diagrams:

i. Determine the pressure generated between the two shells and 10

ii. The tangential stress in each shell arising from the shrinking. 10

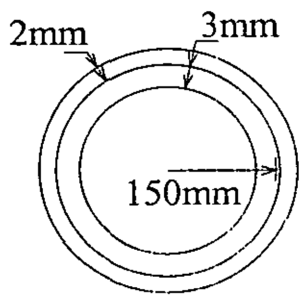


Fig. 4

Formulae Aid

(1) $\sigma = \frac{My}{I}$; $\tau = \frac{V}{Ib}\int_{y1}^{c_1} y\, dA$

(2) $\delta = \frac{Fl}{AE}$

(3) $\varepsilon_x = \frac{\sigma_x}{E} - \frac{\sigma_y}{E}$

(4) $I_G(\text{rectangle}) = \frac{1}{12} bh^3$

(5) $\frac{\sigma_1}{r_1} + \frac{\sigma_2}{r_2} = \frac{p}{t}$; $\sigma = \frac{q \cdot r}{A}$