THE OPEN UNIVERSITY OF SRI LANKA

FACULTY OF ENGINEERING TECHNOLOGY

Bachelor of Technology (Engineering)

FINAL EXAMINATION 2011/12

MEX5232 Strength of Materials II

Date: 20– 02 - 2012

Time: 9.30am – 12.30pm

Duration: 3 hours

Read the following instructions carefully before answering the questions.

1. This question paper consists of **8 questions**. All questions carry equal marks.
2. Answer **any 5 questions** only.

Q1. (a) A beam **ABCD**, 6m long, is simply supported at the right hand end **D**, and at point **B**. **AB** = 1m, **BC** = 2m.

The beam carries loads as given below:

(a) A vertical load of 10kN at **A**,
(b) A Vertical load of 20kN at **C**
(c) A uniformly distributed load of 10kN/m between **C** and **D**.

Determine,

(i) The values of support reactions at **B** and **D**. **(4 marks)**

(ii) The value of the bending moments at **B** and **C**. **(6 marks)**

(iii) The deflection at point **A**, if EI = 36MNm^2. **(10 marks)**

Q2. (a) State First and Second theorems of Moment-Area method used to determine the deflections of beams. **(6 marks)**

(b) A beam AB fixed at both ends is subjected to a bending moment, M_o at **C** as shown in Fig. Q2.

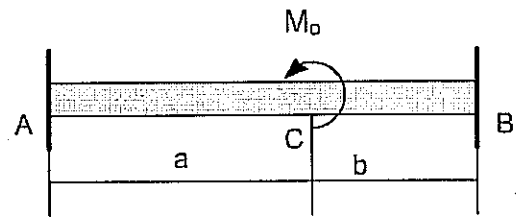


Fig. Q2

(i) Considering the beam as a cantilever, fixed at one end and with appropriate loads at the other end, sketch the bending moment diagram in parts. **(4 marks)**

(ii) Write down equations, by applying the First and the Second theorems of Moment-Area method. **(5 marks)**

(iii) Find out support reactions and fixing moments in terms of M_o, a, b, and EI. **(5 marks)**

Q3. (a) State Lame equations for the hoop and the radial stresses in thick cylinders. **(2 marks)**

(b) A thick cylinder with closed ends has internal and external radii 60mm and 100mm respectively. The cylinder is subjected an internal pressure, P_i. The cylinder is made of steel having a yield strength of 210MN/m².

Determine,

(i) Maximum value of Pi, assuming a safety factor of 2. **(5 marks)**

(ii) Longitudinal stress. **(5 marks)**

(iii) Maximum shear stress at the outer surface. **(5 marks)**

(c) The above cylinder is subjected to an external pressure of P_o in addition to the internal pressure P_i. Sketch the radial and hoop stress variations against $1/r^2$. **(3 marks)**

Q4. (a) Show that the shrinkage allowance (δ) for a compound cylinder is given by the following formula. **(4 marks)**

$$\delta = \frac{r}{E}(\sigma_{Ho} - \sigma_{Hi})$$

Where

$r = common\ radius$
$\sigma_{Ho} = hoop\ stress\ at\ the\ common\ radius\ for\ outer\ cylinder$
$\sigma_{Hi} = hoop\ stress\ at\ the\ common\ radius\ for\ inner\ cylinder$

(b) Fig. Q 4 shows the variation of stresses with $1/r^2$ for a compound cylinder. The compound cylinder has been made by shrinking a tube of 125mm internal radius and 25mm wall thickness on to another tube of 125mm external radius and 25mm wall thickness. Both cylinders are made of the same material having modulus elasticity of 200GN/m².

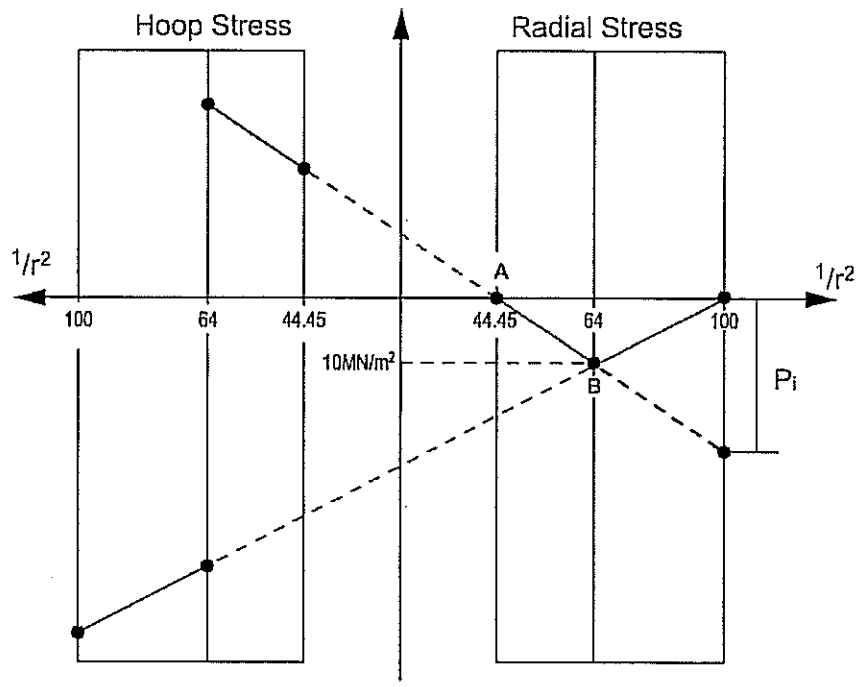


Fig. Q4

(i) If the interface pressure is 10MN/m², determine the hoop stresses at the interface radius for the two tubes with aid of graphical sketch of stresses given in Fig. Q4. **(4 marks)**

(ii) Calculate the shrinkage allowance. **(4 marks)**

(iii) If the compound cylinder is now subjected to an internal pressure of Pi such that the radial stress variation with $1/r^2$ coincides with **AB** as shown in Fig. Q4, determine the new values of hoop stresses at the interface radius. **(6 marks)**

(iv) What is the new interface pressure? **(2 marks)**

Q5 (a) Briefly explain the following theories of elastic failure. **(8marks)**

a. Maximum principal stress theory
b. Maximum shear stress theory

(b) A shaft of diameter 100mm is used to transmit a torque, while it is subjected to an axial load of 20kN. Calculate the toques that can be transmitted with a safety factor of 3 according to above failure theories. Yield stress of shaft material is 200MN/m². **(12 marks)**

Q6 (a) When a thin walled closed tube is subjected to a torque, the stress induced is given by the following formula.

$$\tau = \frac{T}{2At}$$

(i) With a suitable sketch explain the different variables in the above equation. **(4 marks)**

(ii) A tube of 3mm wall thickness carries a torque 100Nm. Calculate the shear stress induced in the section. **(2 marks)**

(iii) The same torque as in (ii) is applied to a **square** section. What should be the side of the square, if shear stress is the same? **(4 marks)**

(b) A rectangular steel bar having a cross section of 25mm wide and 38mm deep is subjected to a torque of 450Nm. Calculate the maximum shear stress and the angle of twist per unit length. **(10 marks)**

You may use the formulae and data given below with their usual notations. Modulus of rigidity for steel can be assumed as 30GN/m².

$$\tau_{max} = \frac{T}{k_1 bd^2} \qquad \frac{\theta}{L} = \frac{T}{k_2 db^3 G}$$

d/b	1.0	1.5	1.75	2.0	2.5	3.0	4.0	6.0	8.0
k_1	0.208	0.231	0.239	0.246	0.258	0.267	0.282	0.299	0.307
k_2	0.141	0.196	0.214	0.229	0.249	0.263	0.281	0.299	0.307

Q7 (a) Show that the Bending Moment M_{PP} carried by a rectangular beam section having a width B and depth 2B, when the plastic yielding has taken place to a depth $B/2$, measured from the neutral axis, is given by the following equation. **(8 marks)**

$$M_{PP} = \frac{25B^3}{12}\sigma_y$$

Where, σ_y = yield stress

(b) A steel beam having a rectangular section of 50mm width by 100mm depth is simply supported over a length of 3m, 100mm side being vertical.

Find,

(i) The value of the central point load that gives the plastic yielding to a depth of 25mm from the neutral axis. **(6 marks)**

(ii) The location of the beam at which yielding is just commencing under the load found in (i) **(6 marks)**

Assume yield stress of steel as 200MN/m².

Q 8 A turbine has a rotor disc of uniform thickness of 40mm with a central hole of 100mm diameter. The outer diameter of the disc is 600mm. On the periphery of the rotor, 200 blades of 150g each have been fixed having a uniform pitch. The centre of mass of each blade lies at a radius of 320mm. The rotor is to rotate at a maximum speed of 10,000rpm.

Determine

(i) The radial stress at the outer periphery of the rotor **(8 marks)**

(ii) Hoop stress values at inner and outer surfaces of the rotor **(12 marks)**

You may use the following equations with usual notation:

[ρ and ν of rotor material are 7470kg/m^3 and 0.3 respectively]

$$\sigma_r = A - \frac{B}{r^2} - (3+\nu)\frac{\rho r^2 \omega^2}{8}$$

$$\sigma_H = A + \frac{B}{r^2} - (1+3\nu)\frac{\rho r^2 \omega^2}{8}$$