The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Diploma in Technology/Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	**:**	**MEX5232 Strength of Materials II**
Academic Year	:	2012/13
Date	:	21 – 07 - 2013
Time	:	9.30 a.m – 12.30 p.m.
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **8** questions. All questions carry equal marks.
3. Answer any **5** questions only.
4. Formula sheet is provided at the end of the question paper.

Q1. A cantilever beam of length 2m having the cross section as shown in Figure Q1 is subjected two mutually perpendicular forces of 10kN each at the free end, passing through the centroid of the beam section.
Determine

(a) Position of the centre of area ($\bar{x}$) *4 marks*

(b) Second moment area about the axis Y-Y (I_{yy}) *4 marks*

(c) Bending stress at point A at the mid span of the beam assuming I_{xx} as $2.8 \times 10^{-6} m^4$. *8 marks*

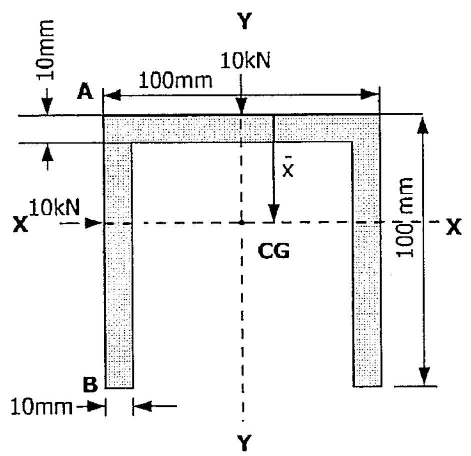

Figure Q1

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(d) If the vertical force is shifted from the axis of symmetry what would be effect on the stresses? *4 marks*

Q2. (a) State the first and the second moment- area theorems used to determine angular and vertical deflections of beams. *6 marks*

(b) A cantilever beam AB fixed at B carries two concentrated loads as shown in Figure Q2.

(i) Sketch the bending moment diagrams due to the two loads. *4marks*

(ii) Using moment area theorem, find out the deflection at A, in terms of W, L, a and EI. *8 marks*

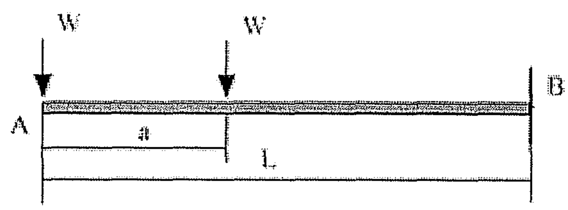

Figure Q2

(c) If a single load of 2W is applied at the free end, replacing the two loads determine the free end deflection. *2 marks*

Q3. A closed end thick cylinder has an internal radius of 150mm. A pressure of $20 MN/m^2$ is to be applied inside the cylinder.

(a) Determine the external radius of the cylinder, if the maximum hoop stress is to be $32 MN/m^2$. *8 marks*

(b) The outside of the cylinder is subjected to an external pressure of $30 MN/m^2$, in addition to the inside pressure.

(i) Sketch the radial and hoop stresses against $^1/r^2$. *8 marks*

(ii) Hence, determine the value of hoop stresses at internal and external radii. *4 marks*

Q4. A compound cylinder, made out of the same material having the modulus of elasticity $200 GN/m^2$, has the following radii.

Internal: 100mm
Intermediate: 200mm
External: 300mm

(a) Determine total shrinkage if the hoop stresses at the interface radius for the two cylinders are found to be as given below. **4 marks**

For outer cylinder (σ_{Ho}) = 80 MN/m^2 (tensile)
For inner cylinder (σ_{Hi}) = 60MN/m^2 (compressive)

(b) Sketch the stresses against $1/r^2$, hence find out interface pressure. **8 marks**

(c) A pressure equal to the interface pressure is applied inside the cylinder. Sketch the variation of stresses against $1/r^2$ on the same axes drawn in (b). **8 marks**

Q5 A compound cylinder is made of a brass inner cylinder and a steel outer cylinder as shown in Figure Q5. The interface pressure is 60MN/m^2.

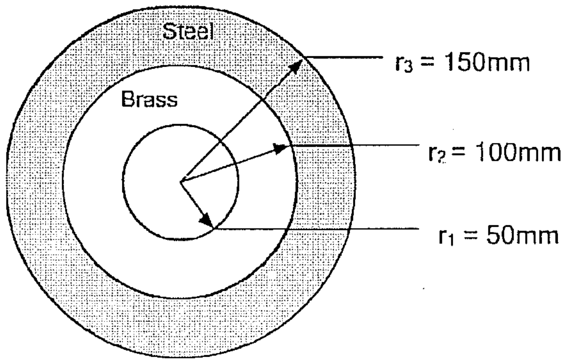

Figure Q5

(a) Determine the total shrinkage. **8 marks**

(b) The compound cylinder is heated which results in a temperature increase of 50°C. Determine the interface pressure due the thermal expansion of the cylinders. **12 marks**

Modulus of Elasticity (E), Poisson's ratio(ν), and coefficient of linear expansion(α) for brass and steel are:

For brass E_b = 100 GN/m^2, ν_b = 0.33, α_b = 18 x 10^{-6} °C^{-1}
For steel E_s = 200 GN/m^2, ν_s = 0.30, α_s = 13 x 10^{-6} °C^{-1}

Q6. (a) Write down the expression for the shear stress induced when a thin walled tube is subjected to a torque and identify its terms. **4 marks**

(b) A tube of 2mm thick has the shape as shown in Figure Q6. A torque of 600Nm is applied about the axis of the tube. Find the shear stress on the surface. **8 marks**

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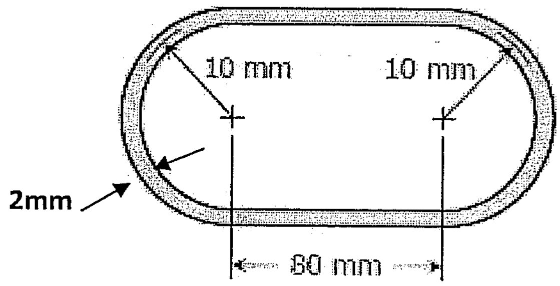

Figure Q6

(c) The tube is replaced with a square tube having the same thickness and effective area (carrying shear stress) which would carry the same torque. Find,

(i) The side dimension of the section. ***4 marks***

(ii) Shear stress carried by the section. ***4 marks***

Q7 (a) A beam of length 2m is simply supported at its ends and carries a concentrated load of W at the mid span. The beam section is 20mm deep and 50mm wide. Take yield stress of the beam material as $225MN/m^2$. Determine

(i) The value of load W which will produce initiation of yield at the outer fibres of the beam. ***5 marks***

(ii) The distance from the neutral axis up to which yielding will take place, if the load W is increased by 10%. ***5 marks***

(iii) The value of the load W which will produce fully plastic state at the mid span. ***5 marks***

(b) Briefly explain how the load W for fully plastic state is determined, if the beam is of a T-Section. ***5 marks***

Q8 (a) State

(i) Maximum shear stress theory, and ***4 marks***

(ii) Maximum principle stress theory, used in the prediction of failure of structural components.

(b) A shaft of 50mm diameter is used to transmit a torque, T. The yield stress of the shaft material is $240MN/m^2$.

(i) Determine the maximum value of torque, T that can be transmitted with a factor of safety 3 according to **maximum shear stress theory**. ***8 marks***

(ii) If the above shaft is subjected to a tensile axial load of 0.2kN, what would be the value of T, according to the **maximum principle stress theory** of failure, with the same factor of safety? ***8 marks***

Formula sheet

Thick cylinders

Lame equations

$$\sigma_r = A - \frac{B}{r^2}$$

$$\sigma_H = A + \frac{B}{r^2}$$

Compound cylinder with same material

$$\delta = \frac{r_2}{E}(\sigma_{Ho} - \sigma_{Hi})$$

Compound cylinder with different materials

$$\delta = \frac{r_2}{E_s}(\sigma_{H/s} + \nu_s p) - \frac{r_2}{E_b}(\sigma_{H/b} + \nu_b p)$$

$$\frac{1}{E_s}[\sigma_{H/s} + \nu_s p] - \frac{1}{E_b}[\sigma_{H/b} + \nu_b p] = \Delta T(\alpha_b - \alpha_s)$$

$\sigma_r = radial\ stress$
$\sigma_H = Hoop\ stress$
$\delta = Total\ shrinkage$
$\sigma_H = Hoop\ stress\ at\ the\ interface\ radius, r_2$
$E = Modulus\ of\ Elasticity$
$p = Interface\ pressure$
$\nu = Poission's\ Ratio$
$\Delta T = Temperature\ change$
$\alpha = Coefficient\ of\ Linear\ Expansion$
*Suffixes **o** and **i** refer to outer and inner cylinders*
*Suffixes **s** and **b** refer to steel and brass*

Strain beyond elastic limit

The bending moment M_{pp} that gives yielding up to a depth, a distance d from the Neutral Axis for rectangular section of width B and depth D is given by the following formula.

$$M_{PP} = \frac{B\sigma_y}{12}[3D^2 - d^2]$$