**TECHNICAL UNIVERSITY OF MOMBASA**

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**Faculty of Engineering and Technology**
**Department of Mechanical & Automotive Engineering**
**UNIVERSITY EXAMINATION FOR:**
**BSc. Mechanical Engineering**
**EMG 2411 : SOLIDS & STRUCTURAL MECHANICS IV**
**END OF SEMESTER EXAMINATION**
**SERIES: DECEMBER 2016**
**TIME: 2 HOURS**
**DATE: 5 Dec 2016**

**Instruction to Candidates:**

You should have the following for this examination

- *Answer booklet*
- *Non-Programmable scientific calculator*

This paper consists of **FIVE** questions. Attempt any **THREE** questions. All Questions carry equal marks.

Maximum marks for each part of a question are as shown.

**Do not write on the question paper.**

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**Question 1**

Fig Q1 shows a beam of length $'2a'$ metres fixed at the left-hand end and propped at the centre. The beam supports a uniformly distributed load of magnitude $wN/m$ over a span of $'a'$ metres as well as a point load of magnitude $'2wa'$ Newtons and a clockwise couple of magnitude $'2wa^2'N-m$ at the free end.

(i) Derive expressions for the reactions at the supports

(ii) Derive expressions for the slope and the deflection at the free end of the beam.

$E$ - Modulus of elasticity of the beam

$I$ - Second Moment of area of the beam cross-section

**Question 2**

Fig Q2 shows the cross-section of a two-celled tube subjected to a torque $T$. The dimensions of the sections are given as functions of $'a'$ and the thicknesses of the various sections are given as functions of $'t'$.

Derive in terms of the indicated parameters

(i) the Shear stresses in all the walls

(ii) the expression for the angle of twist per unit length

$G$ = Torsional Modulus of Rigidity of the material

**Question 3**

Fig Q3 shows a cross-section of a beam made from a material of thickness '$t$' and the rest of the dimensions are indicated as functions of '$a$'.

(i) Calculate the magnitude of the maximum Shear stress

(ii) Determine the position of the Shear centre

**Question 4**

Fig Q4 shows a strut fixed at the left-hand end and supporting a compressive load $P$ as well as a bending moment $M$ at the free end.

Show that :

$$M = \frac{PaCosnl}{(1 - Cosnl)}$$

where $l$ is the length of the strut and '$a$' the deflection at the free end

**Question 5**

A circular plate of radius $R$ and thickness '$t$' is fixed at the periphery and the plate supports a uniformly applied pressure '$p$' per unit area.

(i) Show that the maximum radial stress per unit arc $(\sigma_r \max)$ is given by

$$\sigma_r \max = \frac{3pR^2}{4Et^2}$$

And the maximum circumferential stress per unit radius $(\sigma_\theta \max)$ is given by

$$\sigma_\theta \max = \frac{3pR^2(1+\upsilon)}{8t^2}$$

(iii) show that at $r = 0$ the bending moment in the circumferential direction per unit length of radius is given by

$$M_\theta = \frac{pR^2(1+\upsilon)}{16}$$

And ( at $r = 0$ ) the bending moment in the radial direction per unit length of circumference is given by

$$M_r = \frac{pR^2(1+\upsilon)}{16}$$

Assume that at any radius '$r$' the bending moment in the radial direction per unit length of arc is given by

$$M_r = -D\left[\frac{d^2w}{dr^2} + \frac{\upsilon}{r}\frac{dw}{dr}\right]$$

And the bending moment in the circumferential direction per unit length of radius is given by

$$M_\theta = -D\left[\frac{1}{r}\frac{dw}{dr} + \upsilon\frac{d^2w}{dr^2}\right]$$

Also $$\frac{d}{dr}\left[\frac{1}{r}\frac{d}{dr}\left(r\frac{dw}{dr}\right)\right] = \frac{Q}{D}$$

Where $Q$ is the Shear Force per unit length and $D = \frac{Et^3}{12(1-\upsilon^2)}$

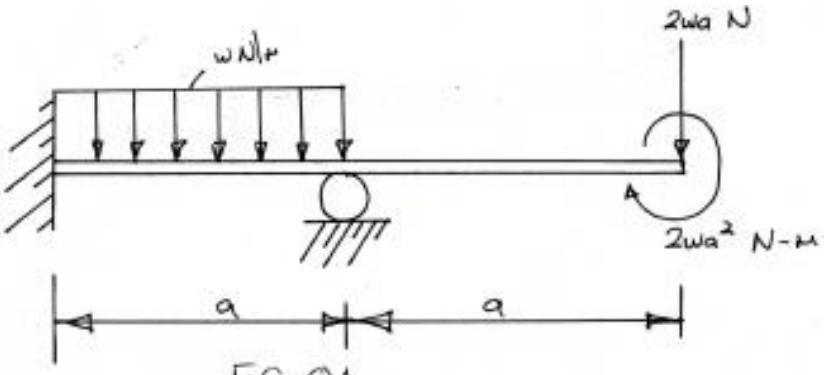


FIG Q1

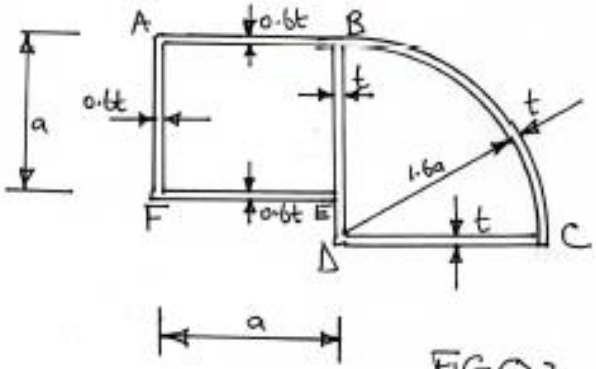


FIG Q2

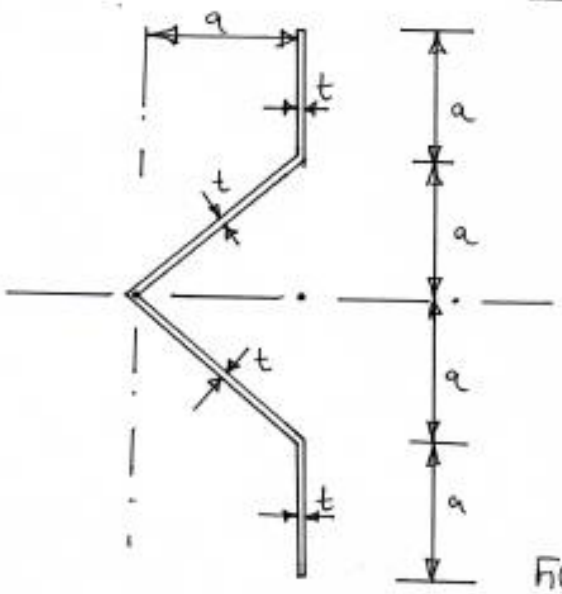


FIG Q3

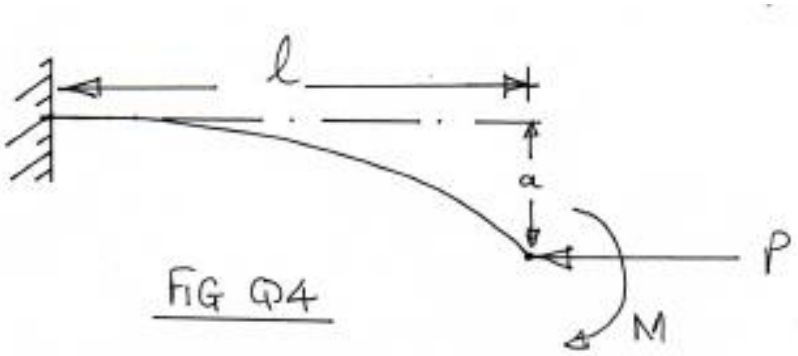


FIG Q4