UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER 2
SESSION 2011/2012

COURSE	:	SOLID MECHANICS II
COURSE CODE	:	BDA30303
PROGRAMME	:	BACHELOR OF MECHANICAL ENGINEERING WITH HONOURS
EXAMINATION DATE	:	JUNE 2012
DURATION	:	3 HOURS
INSTRUCTIONS	:	ANSWER ONLY **FIVE(5)** OUT OF SIX(6) QUESTIONS

THIS PAPER CONSIST OF NINE (9) PAGES

Q1 **Figure Q1** shows a 60° strain rosette attached on the mechanical component to measure surface strains. The reading of the strains measured by this gauge is as follows:

$$\varepsilon_a = 1000\mu, \quad \varepsilon_b = 750\mu, \quad \varepsilon_c = -650\mu$$

Determine:

(a) The principal strains and its corresponding planes

(b) The maximum shearing strain,

(c) The principal stress and its corresponding planes

Given, the component's modulus of elasticity E = 200 GPa and $\nu = 0.3$

(20 marks)

Q2 A cantilever beam *ABCDE* as shown in **Figure Q2** has a length of 4 m rigidly attached at *A*. If the beam's modulus of elasticity, E = 200 GPa, determine:

(a) The deflection of the beam at point *C*,

(b) The slope of the beam at point *C*, and

(c) The value of vertical force must be applied at point *C* so that the deflection at this point becomes zero.

(20 marks)

Q3 (a) **Figure Q3 (a)** shows a handle used to crush cans. Determine the maximum force P that can be applied to the handle so that the rod BC does not buckle. The rod is made of steel and has a diameter of 10 mm. It is pin connected at its ends. Given, E_{st} = 210 GPa, σ_Y = 250 MPa.

(10 marks)

(b) A tube column is made from cast iron that has a modulus of elasticity, E = 100 GPa, fixed at both ends and subjected to axial force 1000 kN. If the column has a length of 6.0 m and outer diameter of 270 mm, by taking a factor of safety 4, determine the thickness of this column to prevent the failure in the form of buckling.

(10 marks)

Q4 A bent cantilever shown in **Figure Q4** has a diameter of 12 mm rigidly attached at point A. Point B is forced to move only in vertical direction by applying 10 kg load. If the material's modulus of elasticity, E = 200 GPa, determine the displacement of point B.

(20 marks)

Q5 The aluminium bar in **Figure Q5** is made from two segments having diameters of 5 mm and 10 mm. Determine the maximum height, h from which the 5-kg collar should be dropped so that it not permanently damage the bar after striking the flange at A. E_{al} = 70 GPa, σ_Y = 410 MPa. Also, determine the stress in the bar if the weight is dropped from:-

(a) Height of h = 250 mm

(b) Released from a height, $h = 0$

(c) Placed slowly on the flange at A

(20 marks)

Q6. The pipe assembly shown in **Figure Q6** is fixed at A. The pipe has an inner diameter of 40 mm and outer diameter of 60 mm. The material of the metal is made of steel and has a yield strength, σ_Y = 290 MPa and ν = 0.25. Determine the maximum magnitude of P that could be applied so that it does not fail according to following theories:-

(a) Maximum-shear-stress theory; Tresca

(c) Maximum-principal-strain theory; St. Venant

(b) Distortion-energy theory; Von Mises

(20 marks)

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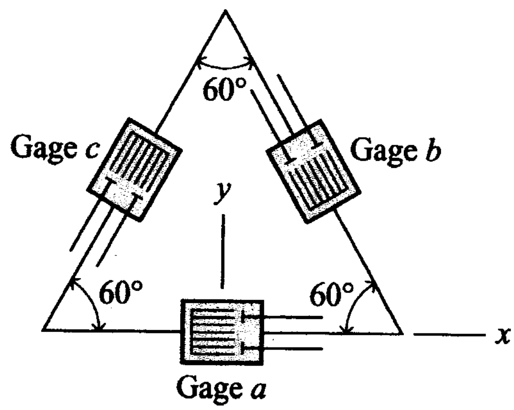

Figure Q1

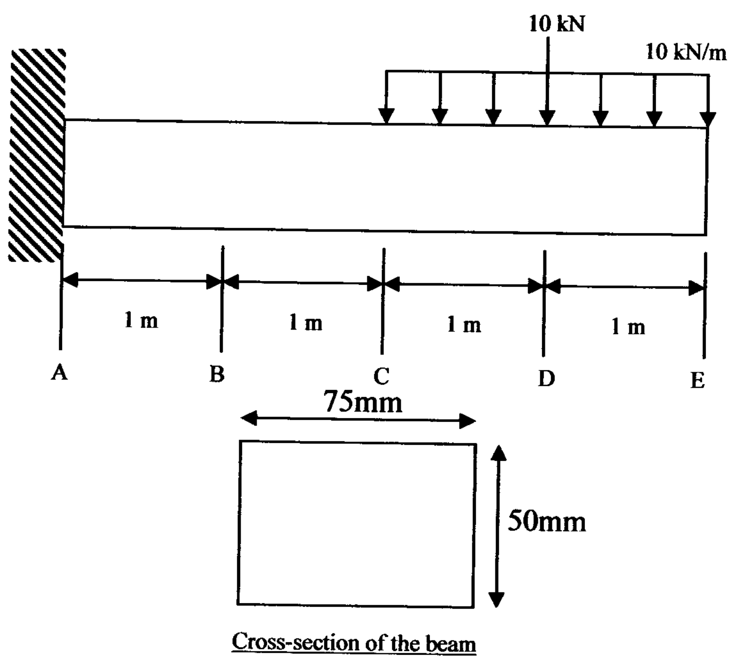

Figure Q2

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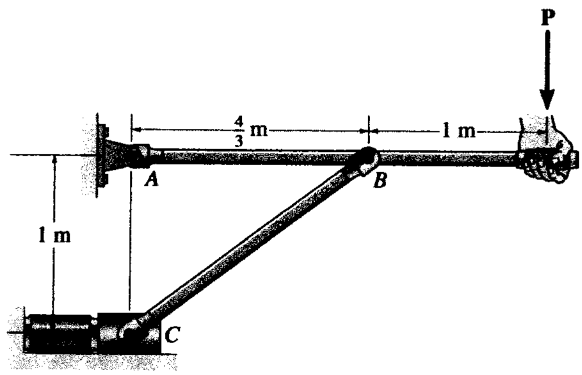

Figure Q3 (a)

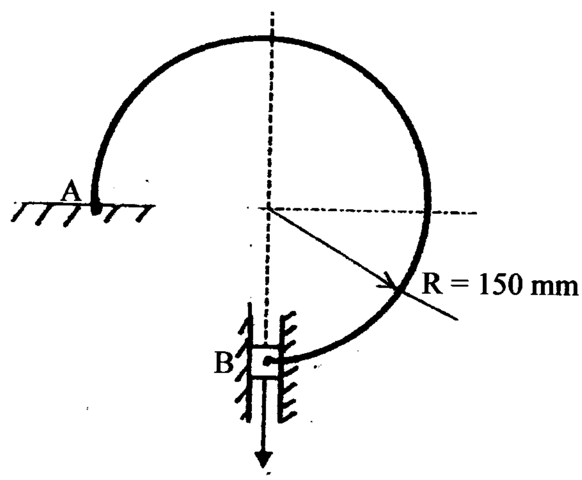

Figure Q4

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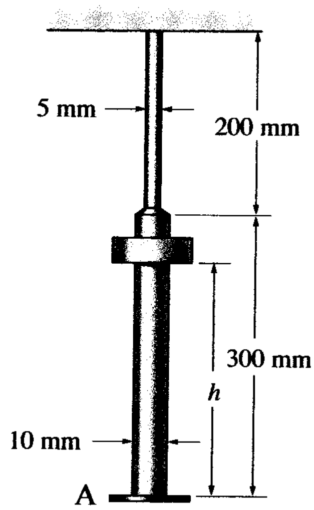

Figure Q5

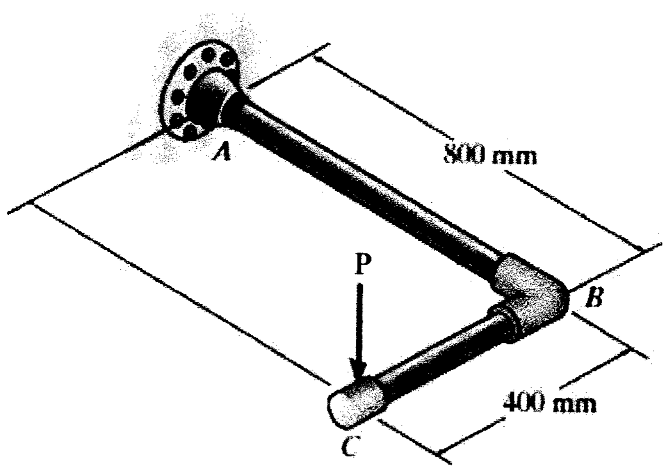

Figure Q6

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ATTACHMENT

Strain Transformation Equation

$$\varepsilon_{x'} = \frac{\varepsilon_x + \varepsilon_y}{2} + \frac{\varepsilon_x - \varepsilon_y}{2}\cos 2\theta + \frac{\gamma_{xy}}{2}\sin 2\theta$$

$$\frac{\gamma_{x'y'}}{2} = -\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)\sin 2\theta + \frac{\gamma_{xy}}{2}\cos 2\theta$$

$$\varepsilon_{1,2} = \frac{\varepsilon_x + \varepsilon_y}{2} \pm \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$\tan 2\theta_p = \frac{\gamma_{xy}}{\varepsilon_x - \varepsilon_y}$$

$$\left(\frac{\gamma_{in-plane}}{2}\right)_{max} = \sqrt{\left(\frac{\varepsilon_x - \varepsilon_y}{2}\right)^2 + \left(\frac{\gamma_{xy}}{2}\right)^2}$$

$$\tan 2\theta_s = -\left(\frac{\varepsilon_x - \varepsilon_y}{\gamma_{xy}}\right)$$

Material-Property Relationship

$$E = \frac{\sigma}{\varepsilon}$$

$$G = \frac{\tau}{\gamma}$$

$$G = \frac{E}{2(1+\upsilon)}$$

$$\sigma_x = \frac{E}{1-v^2}\left[\varepsilon_x + v\varepsilon_y\right]$$

Stress Transformation Equation

$$\sigma_{x'} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\tau_{x'y'} = -\left(\frac{\sigma_x - \sigma_y}{2}\right)\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + (\tau_{xy})^2}$$

$$\tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x - \sigma_y)/2}$$

$$(\tau_{in-plane})_{max} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + (\tau_{xy})^2}$$

$$\tan 2\theta_s = -\frac{(\sigma_x - \sigma_y)/2}{\tau_{xy}}$$

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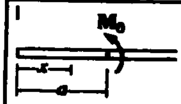
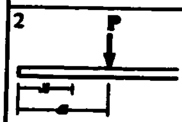
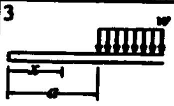
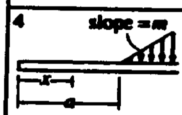
Macaulay's Function

Loading	Loading Function $w=w(x)$	Shear $V=-\int w(x)dx$	Moment $M=\int Vdx$
1 	$w = M_0<x-a>^{-2}$	$V = -M_0<x-a>^{-1}$	$M = -M_0<x-a>^0$
2 	$w = P<x-a>^{-1}$	$V = -P<x-a>^0$	$M = -P<x-a>^1$
3 	$w = w_0<x-a>^0$	$V = -w_0<x-a>^1$	$M = -\frac{w_0}{2}<x-a>^2$
4 	$w = m<x-a>^1$	$V = \frac{-m}{2}<x-a>^2$	$M = \frac{-m}{6}<x-a>^3$

Buckling

$$P_{cr} = \frac{\pi^2 EI}{(KL)^2}$$

Axial Load

$$\sigma = \frac{P}{A}$$

Torsion

$$\tau = \frac{Tr}{J}$$

Bending

$$\sigma = \frac{My}{I}$$

Thick Cylinder

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

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

Failures Theories

Maximum-principal-stress theory

$$\sigma_1 = \sigma_Y$$

Maximum-principal-strain theory

$$\sigma_1 - v\sigma_2 = \sigma_Y$$

Maximum-shear-stress theory

$$\sigma_1 - \sigma_2 = \sigma_Y$$

Strain-energy theory

$$\sigma_1^2 + \sigma_2^2 - 2v\sigma_1\sigma_2 = \sigma_Y^2$$

Maximum-distortion-energy theory

$$\sigma_1^2 + \sigma_2^2 - \sigma_1\sigma_2 = \sigma_Y^2$$