SULIT

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESION 2011/2012

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|---|---|---|
| COURSE NAME | : | SOLID MECHANICS 2 |
| COURSE CODE | : | BDA 30303/ BDA 3033 |
| PROGRAMME | : | SARJANA MUDA KEJURUTERAAN MEKANIKAL DENGAN KEPUJIAN |
| DATE | : | JANUARY 2012 |
| DURATION | : | 2 HOURS 30 MINUTE |
| INSTRUCTIONS | : | ANSWER ALL QUESTIONS |

THIS PAPER CONTAINS (6) PAGES

**Q1** The strain rosette is mounted on a beam, and the strain gauge arrangement is shown in **FIGURE Q1**. The readings are obtained for each gauge: $\varepsilon_a = 200 \times 10^{-6}$, $\varepsilon_b = 100 \times 10^{-6}$, and $\varepsilon_c = -75 \times 10^{-6}$.

(a) Determine the stresses: $\varepsilon_x$ , $\varepsilon_x$ , and $\gamma_{xy}$

(5 marks)

(b) Draw the Mohr's circle to calculate the principle strains

(5 marks)

(c) Determine the average normal strain and the maximum in-plane shear strain

(5 marks)

(d) Illustrate the deformed element due to the strain conditions

(5 marks)

**Q2** A pin supported vertical rod with a horizontal spring attachment is shown in **FIGURE Q2**.

(a) Proof that the critical buckling load for the column shown in **FIGURE Q2** is equal $P_{cr} = kL/4$ (assume angle of deflection $\theta$ is small).

(5 marks)

(b) Explain the behaviour of the column if $P < kL/4$

(5 marks)

(c) Explain the behaviour of the column if $P > kL/4$

(5 marks)

**Q3** In a thick cylinder problem,

(a) Illustrate the type of stresses can be developed when a thick cylinder is under internal pressure condition. Write down the basic Lame's equations used in thick cylinder

(5 marks)

(b) A thick spherical shell of 400 mm internal diameter is subjected to an internal fluid pressure of 1.5 N/mm$^2$. If the permissible tensile stress in the shell material is 3 N/mm$^2$, find the necessary thickness of the shell.

(10 marks)

**Q4** A beam structure with a constant $EI$ along the span is under concentrated loads as shown in **FIGURE Q4.**

You are requested to implement the conservation energy method with virtual force to determine the deflection at point C. The following steps will guide you to find the deflection:

(a) Find the reaction forces at point A and E

(1 marks)

(b) Write down the Macaulay moment function of real loads for sections AB, BC, CD and ED

(7 marks)

(c) Write down the Macaulay moment function of virtual (dummy) unit load at C for sections AB, BC, CD and ED

(7 marks)

(d) By implementing the conservation energy, calculate the deflection at point C.

(10 marks)

**Q5** (a) A solid shaft shown in **FIGURE Q5** has a radius $r$=15 mm and is made of steel having a yield stress, $\sigma_Y = 360MPa$.

Determine the maximum torsion $T$ so that shaft does not fail according to following theories:

- maximum-shear-stress theory

(5 marks)

- maximum-distortion-energy theory

(10 marks)

(b) If a solid shaft having a diameter $d$ is subjected to a torque $T$ and moment $M$, show that by considering the maximum-principal-stress theory, the maximum allowable stress is $\sigma_{allow} = \left(16/\pi d^3\right)\left(M + \sqrt{M^2 + T^2}\right)$.

(10 marks)

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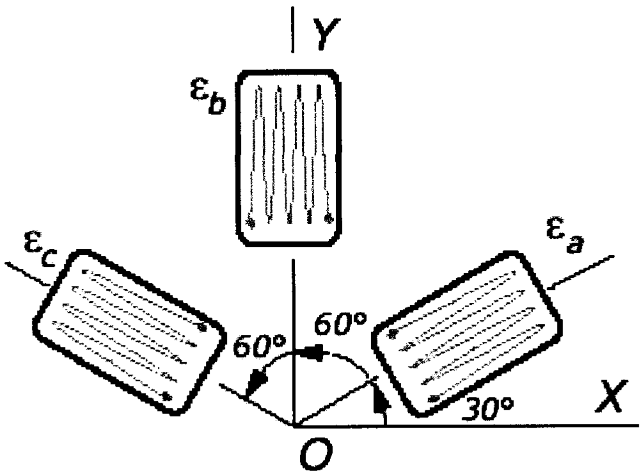


**FIGURE Q1**

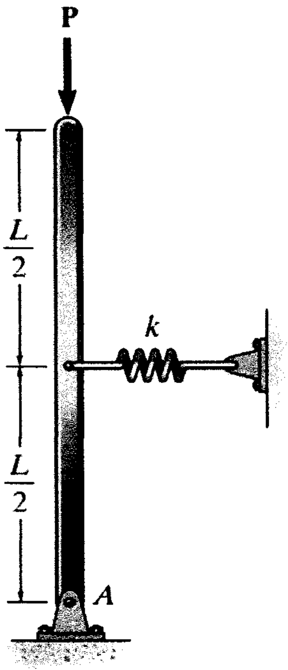


**FIGURE Q2**

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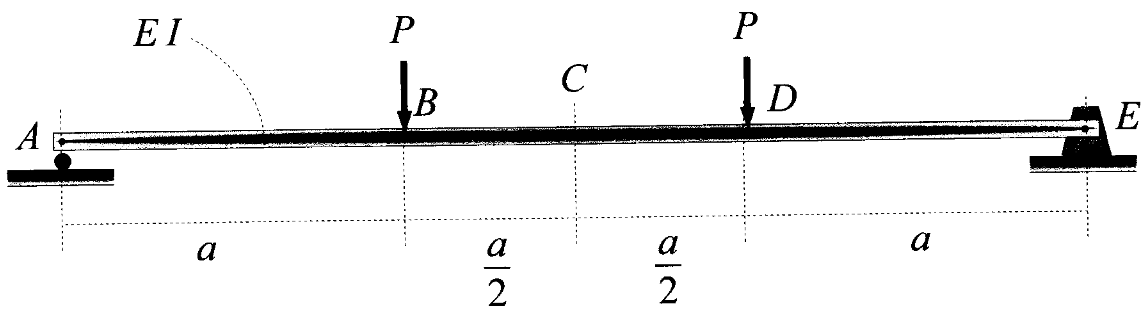


**FIGURE Q4**

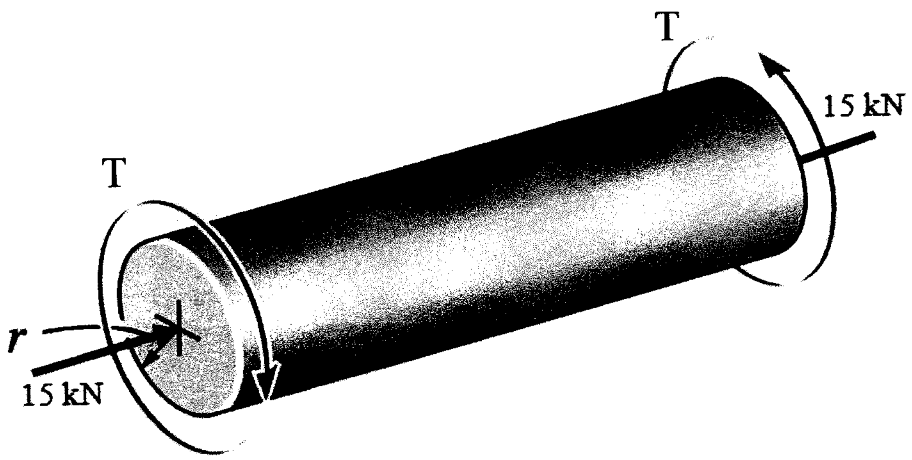


**FIGURE Q5**

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**Some useful formulas**

Strain rosettes:

$$\begin{Bmatrix}\varepsilon_a\\ \varepsilon_b\\ \varepsilon_c\end{Bmatrix}=\begin{bmatrix}\cos^2\theta_a & \sin^2\theta_a & \sin\theta_a\cos\theta_a\\ . & . & .\\ . & . & .\end{bmatrix}\begin{Bmatrix}\varepsilon_x\\ \varepsilon_y\\ \gamma_{xy}\end{Bmatrix}$$

Mohr's circle:

Mohr's circle: basic circle: locate C, locate A, radius of circle is CA
Mohr's circle: principle strains: $\varepsilon_1$ and $\varepsilon_2$ at the extreme values of $\varepsilon$ axis

Thick cylinder:

$$\sigma_r=\frac{p_a\,a^2-p_b\,b^2}{b^2-a^2}-\frac{a^2b^2}{r^2}\left(\frac{p_a-p_b}{b^2-a^2}\right)$$

$$\sigma_H=\frac{p_a\,a^2-p_b\,b^2}{b^2-a^2}+\frac{a^2b^2}{r^2}\left(\frac{p_a-p_b}{b^2-a^2}\right)$$

Macaulay's moment function for concentrated load:

$$M=\pm F(x-a)^1$$

Virtual (dummy) force for beam:

$$\frac{1}{2}(1F)\Delta=\int_0^L\frac{mM}{2EI}dx$$

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