POLITEKNIK
Jabatan Pengajian Politeknik

EXAMINATION AND EVALUATION DIVISION
DEPARTMENT OF POLYTECHNIC EDUCATION
(MINISTRY OF HIGHER EDUCATION)

MECHANICAL ENGINEERING DEPARTMENT

FINAL EXAMINATION

DECEMBER 2011 SESSION

J3009 : STRENGTH OF MATERIALS 1

DATE : 26 APRIL 2012 (THURSDAY)
DURATION : 2 HOURS (2.30 PM - 4.30 PM)

This paper consists of **ELEVEN (11)** pages including the front page.
Structured/Essay (6 questions – answer any **4 question**)

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DO NOT OPEN THIS QUESTION PAPER UNTIL INSTRUCTED BY THE CHIEF INVIGILATOR

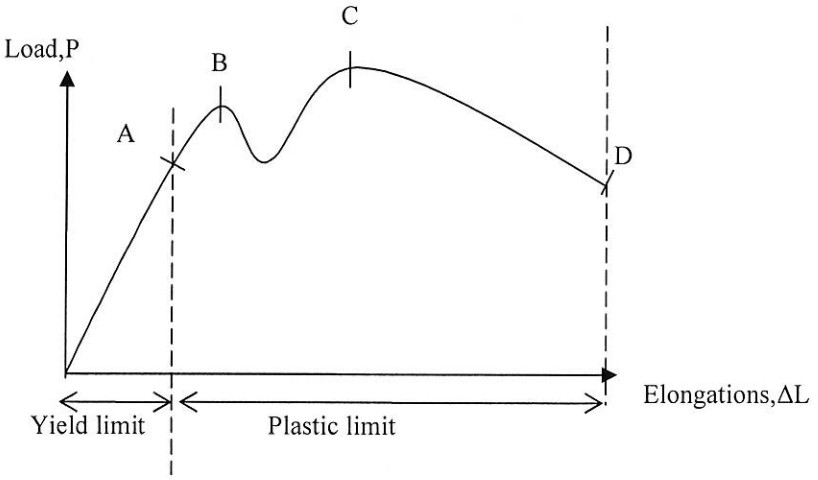
(CLO stated at the end of each question is referring to the learning outcome of the topic assessed. The CLO stated is only for lectures' references.)

STRUCTURED (100 marks)

Instruction: This section consists of 6 structured questions. Answer 4 questions only.

QUESTION 1

(a) Figure 1(a) is a resulting curve from tension test. Name points A, B, C, and D shown in the figure.



(2 marks)

Figure 1(a)

(b) Give the meaning of yield limit and plastic limit as indicated in Figure 1(a).

(4 marks)

(c) A composite bar A, B, C and D is subjected to an axial force of 40 kN, 50 kN and 100 kN in A, B and C respectively as in Figure 1(b). Calculate the stress developed at every bar section and the total elongation of the bar. Take E value for steel =207 kN / mm^2.

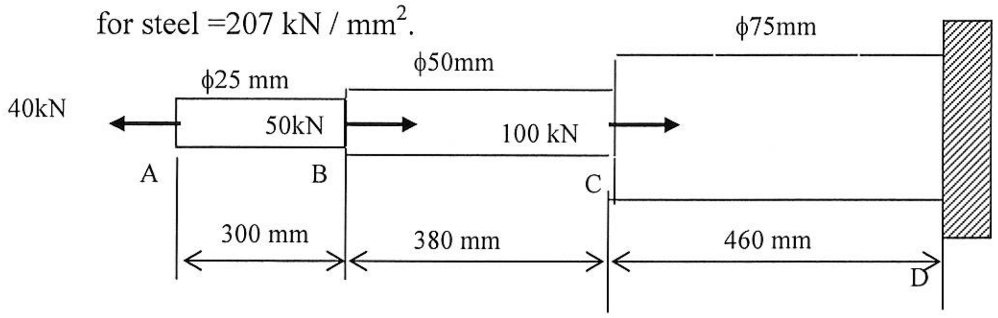


Figure 1(b)

(19 marks)

QUESTION 2

(a) Define the following terms:

i. Composite bar (2 marks)

ii. Coefficient of thermal expansion (2 marks)

(b) Figure 2 shows a composite bar ABC that is made of different materials. AB is made of steel while BC is made of copper. The external diameter of AB is 50 mm and BC is 30 mm. If the change in temperature is 100 ^{0}C, determine:

i. The internal force developed in the bar due to temperature change. (16 marks)

ii. The stress in steel and copper bar (5 marks)

Given,

$E_{steel} = 200\ GN/m^2$

$E_{cuprum} = 93\ GN/m^2$

$\alpha_{steel} = 12 \times 10^{-6} / ^0C$

$\alpha_{cuprum} = 19.3 \times 10^{-6} / ^0C$

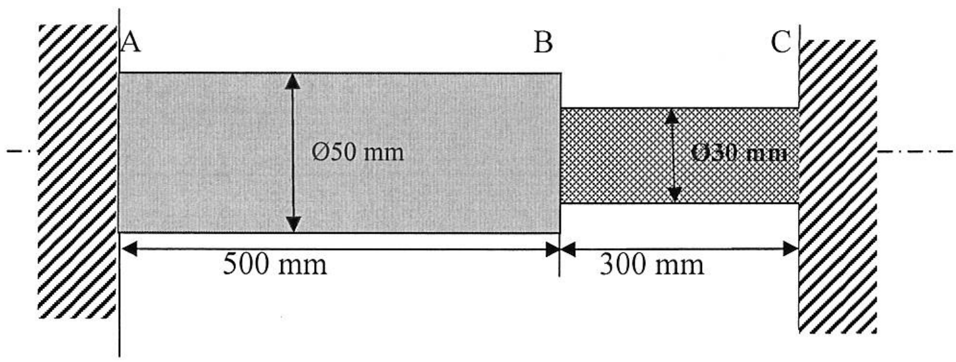


Figure 2

QUESTION 3

(a) State the meaning of contra flexure point.

(2 marks)

(b) A simply supported beam with a length of 8 m is subjected to a loading shown in Figure 3, below :

i. Sketch the shear force and bending moment diagram.

(15 marks)

ii. Determine the position and the magnitude of maximum bending moment.

(5 marks)

iii. Determine the point of contra flexure (if any)

(3 marks)

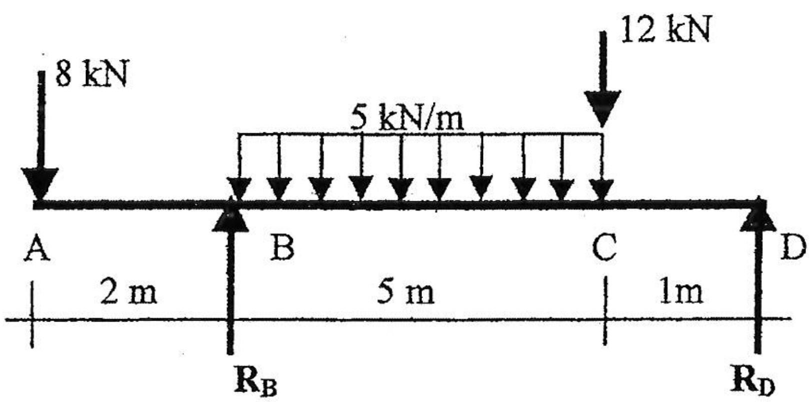


Figure 3

QUESTION 4

A T-section beam is shown in Figure 2 below. The beam carries a uniformly distributed load, w which is simply supported at both ends.

(a) Determine the position of neutral axis.

(11 marks)

(b) Calculate moment of inertia about the neutral axis.

(4 marks)

(c) Find the value of the uniformly distributed load, w which may be imposed on the beam so that the maximum tensile stress does not exceed 100 MN/m^2.

(6 marks)

(d) Calculate the maximum compressive stress developed in the beam.

(4 marks)

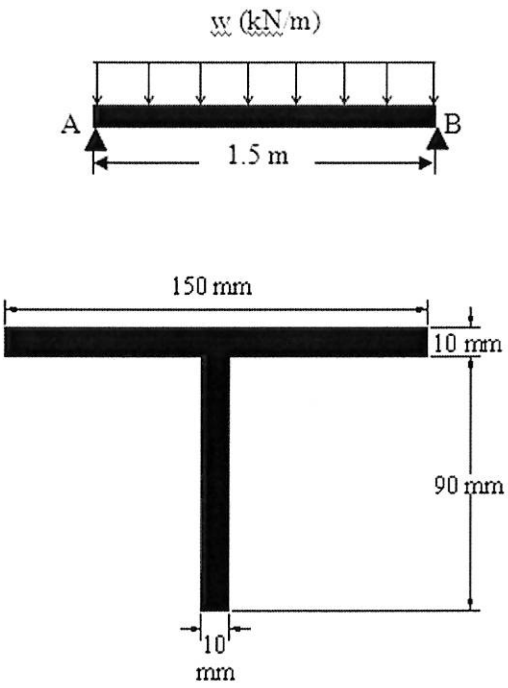


Figure 2

QUESTION 5

An I-beam is subjected to a 250kN shear force as shown in Figure 5. Calculate the :

(a) Moment of inertia.

(5 marks)

(b) Shear stress at the neutral axis.

(11 marks)

(c) Shear stress at point A.

(9 marks)

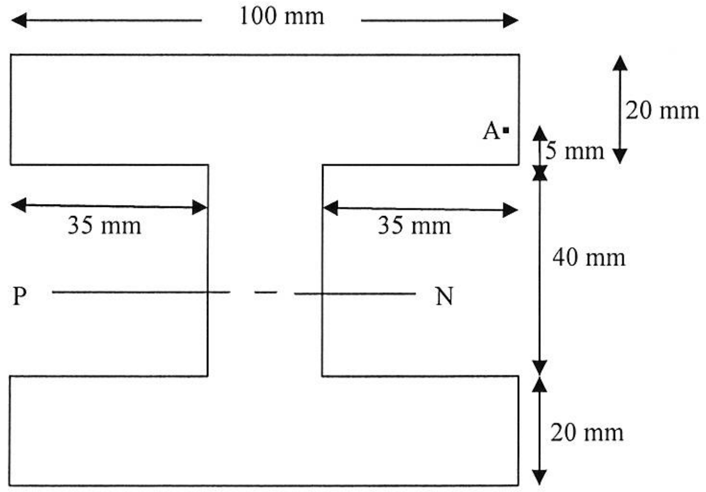


Figure 5

QUESTION 6

(a) A steel shaft with a diameter of 60 mm is rigidly fixed into a aluminium shaft with external diameter of 130 mm. Calculate the polar moment of inertia, J of both shafts.

(5 marks)

(b) A solid shaft, 100 mm in diameter, transmits 75 kW power at 150 rev/min. Determine the value of the shear stress induced in the shaft and the angle of twist of the shaft if G =80 GN/m^2.

(9 marks)

(c) A hollow shaft, 750 mm long, has an external diameter of 150 mm and an internal diameter of 100 mm. If the maximum allowable shear stress is 75 MN/m^2 and the modulus of rigidity for steel is 80 GN/m^2, calculate :

i. The torque transmitted by the shaft.

(5marks)

ii. The power that can be transmitted at a speed of 1200 r.p.m

(3 marks)

iii. The angle of twist.

(3 marks)

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FORCES ON MATERIALS

1. Safety factor $= \dfrac{\text{Maximum Stress}}{\text{Work Stress}}$

2. Poisson's Ratio, $\nu = \dfrac{\text{laterial strain}}{\text{longitudinal strain}}$

3. Percent Elongation $= \dfrac{\text{Elongation}}{\text{Length}} \times 100\ \%$

4. Percent reduction in area $= \dfrac{\text{original cross - sectional - area at fracture}}{\text{original cross sectional area}} \times 100\ \%$

5. Strain Energy, $U = \dfrac{1}{2} P \Delta L$

THERMAL STRESSES AND COMPOSITE BARS

1. Equation of a parallel composite bar subjected to a temperature change.

$$\frac{\sigma_1}{E_1} + \frac{\sigma_2}{E_2} = (\alpha_2 - \alpha_1)\,\Delta t$$

2. Equation of a series composite bar subjected to a temperature change.

$$\frac{P_1 L_1}{A_1 L_1} + \frac{P_2 L_2}{A_2 L_2} = \Delta t(\alpha_1 L_1 + \alpha_2 L_2)$$

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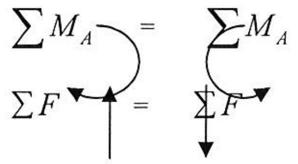
J 3009 - STRENGTH OF MATERIALS 1

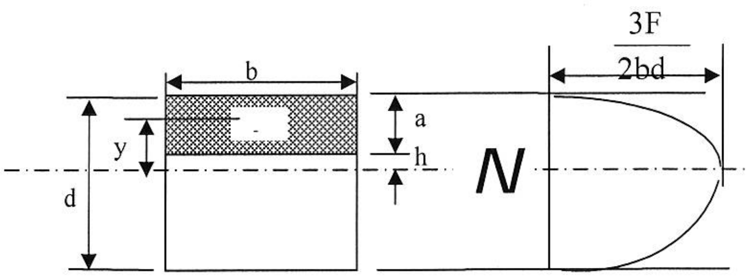
FORCES ON MATERIALS



BENDING MOMENT

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

SHEAR STRESS



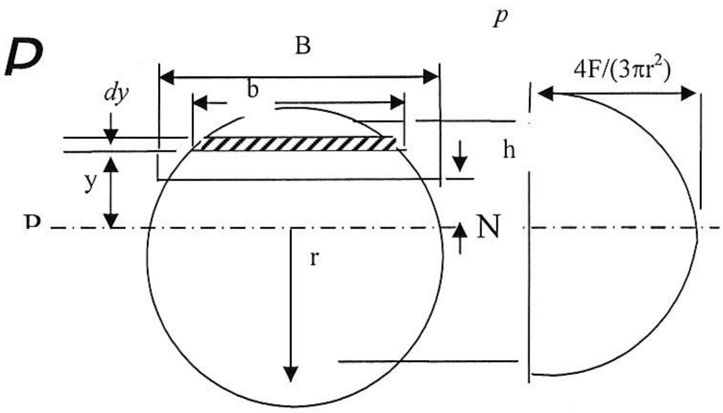
1. $\sigma = \frac{P}{A} = \frac{My}{I}$; $A = (bdy)$

2. $P = \frac{My}{I}(bdy)$

3. Rectangular cross section:

$$A = b \times a = b\left(\frac{d}{2} - h\right)$$

$$\bar{y} = \left(\frac{\frac{d}{2} + h}{2}\right) = \frac{1}{2}\left(\frac{d}{2} + h\right)$$



If $B = b$ dan $I = \frac{bd^3}{12}$

4. Circular cross section

$$\tau = \frac{4F}{3\pi r^4}\left(r^2 - h^2\right)$$

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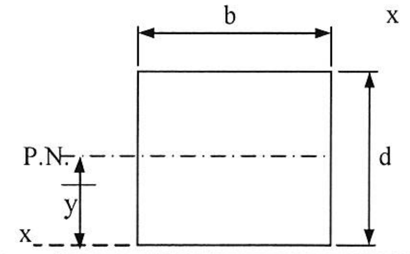
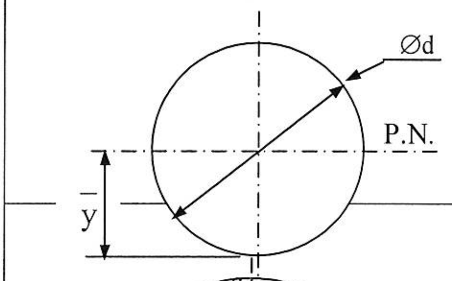
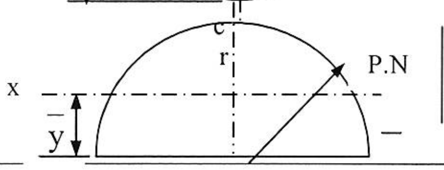
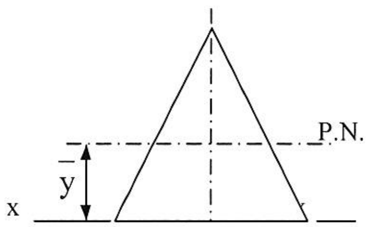
SHAPE	CENTROID	MOMENT OF INERTIA
	$\bar{x} = b/2$ $\bar{y} = d/2$	$I_{P.N.} = \frac{bd^3}{12}$ $I_{xx} = \frac{bd^3}{3}$
	$\bar{x} = d/2$ $\bar{y} = d/2$	$I_{P.N.} = \frac{\pi d^4}{64} = \frac{\pi r^4}{4}$
	$\bar{y} = \frac{4r}{3\pi}$	$I_{P.N} = 0.11r^4$ $I_{xx} = \frac{\pi r^4}{8}$
	$\bar{y} = h/3$	$I_{P.N.} = \frac{bh^3}{36}$ $I_{xx} = \frac{bh^3}{12}$ $I_{yy} = \frac{hb^3}{48}$

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TORSION OF SHAFT

1. TORSION FORMULA

$$\frac{\tau}{G} = \frac{R\theta}{L} \quad \text{atau} \quad \frac{\tau}{R} = \frac{G\theta}{L}$$

2. POLAR MOMENT OF INERTIA

$$J = \frac{\pi d^4}{32}$$

3. SERIES COMPOSITE SHAFT

$$T = \frac{G_1 \theta J_1}{L_1} = \frac{G_2 \theta_2 J_2}{L_2}$$

$$\begin{aligned} \theta_{AC} &= \theta_{AB} + \theta_{BC} \\ &= \frac{T_1 L_1}{G_1 J_1} + \frac{T_2 L_2}{G_2 J_2} \\ &= T\left(\frac{L_1}{G_1 J_1} + \frac{L_2}{G_2 J_2}\right) \end{aligned}$$

4. PARALLEL COMPOSITE SHAFT

$$T = T_1 + T_2$$

$$\theta = \left(\frac{T_1 L_1}{G_1 J_1}\right) = \left(\frac{T_2 L_2}{G_2 J_2}\right)$$