INTI International University & Colleges

FINAL
Examination Paper

(COVER PAGE)

Session	:	**August 2019**
Programme	:	Diploma In Mechanical Engineering (DMEN)
Course	:	**EGM1180 : Mechanics of Engineering Materials**
Date of Examination	:	December 10, 2019 (Tuesday)
Time	:	11:00 am – 1:00 pm Reading Time: Nil
Duration	:	2 Hours
Special Instructions	:	

This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Materials permitted :

Non-Programmable Calculator

Materials provided :

Fundamental Equation of Mechanics of Materials
Geometric Properties of Area Elements

Examiner (s) : **Lim Kah Hei** and Soo Swee Yoong

Moderator : Mr Abdolreza Toudehdehghan

*This paper consists of **6** printed pages, including the cover page.*

DIPLOMA IN MECHANICAL ENGINEERING PROGRAMME (DMEN)
EGM1180: MECHANICS OF ENGINEERING MATERIALS
FINAL EXAMINATION: AUGUST 2019 SESSION

Instruction: This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Question 1

(a) Figure 1(a) shows a structure under a load of 28 kN at point B. Members AB, AC and BC of the truss have dimension of 20×20mm square bar. Member AB, AC and BC have the same material properties and tested to have an ultimate load of 120kN. If a factor of safety of 3.2 is to be achieved for both bars. Determine the required cross-sectional area bar AB and AC. Draw out free body diagram and indicate the action and reaction of the structure.

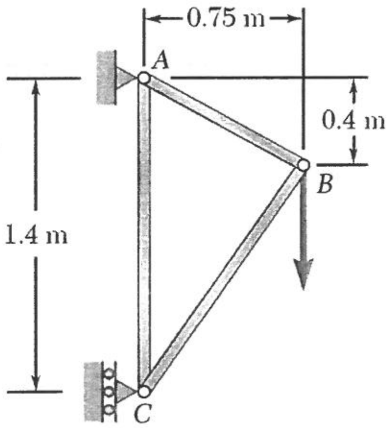


Figure 1(a)

(12 marks)

(b) The rod ABC as shown in Figure 1(b) is made of an aluminum for which E =70 GPa. Knowing that P = 6 kN and Q = 42 kN, determine the deflection of
(i) point A,
(ii) point B.

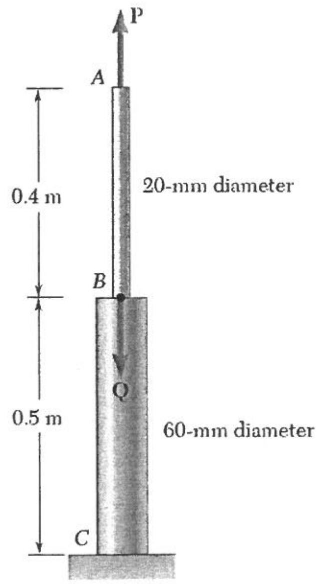


Figure 1(b) Connected rod

(13 marks)
(Total: 25 marks)

Question 2

(a) Figure 2(a) show an aluminum rod AB (G =27 GPa) is bonded to the brass rod BD (G =39 GPa). Knowing that portion CD of the brass rod is hollow and has an inner diameter of 40 mm, determine the angle of twist of AD.

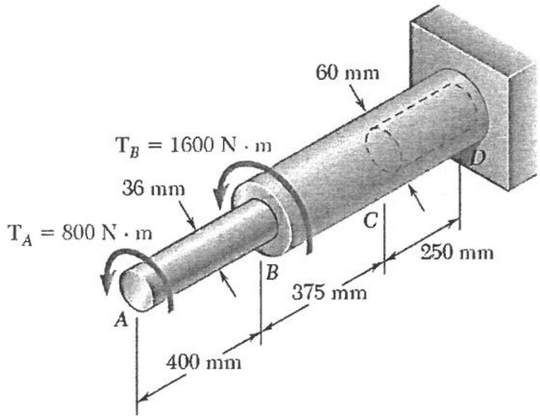


Figure 2(a) Connecting rod

(17 marks)

(b) A torque of magnitude T=1000 N.m is applied at D as shown in Figure 2(b) Knowing that the diameter of shaft AB is 56 mm and that the diameter of shaft CD is 42 mm, determine the maximum shearing stress in

(i) shaft AB,
(ii) shaft CD.

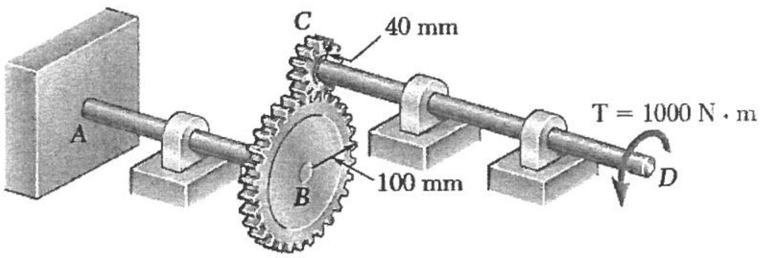


Figure 2(b)

(8 marks)
(Total: 25 marks)

Question 3

(a) Figure 3(a) show a T-beam subjected to a moment, M. It has allowable stress of 24 MPa in tension and 30 MPa in compression. Determine the largest couple M that can be applied to the beam.

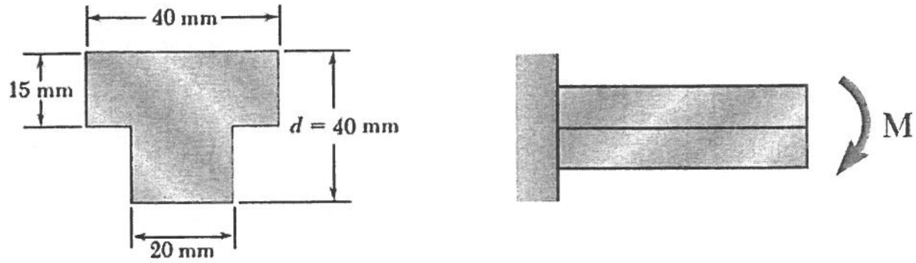


Figure 3(a)

(15 marks)

(b) Figure 3(b) showing a solid beam under force P. Knowing that the magnitude of the horizontal force P is 8 kN. Determine the stress at

(i) At point A
(ii) At point B

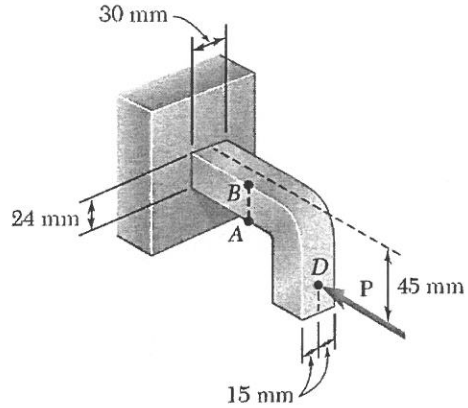


Figure 3(b) A solid beam under force P.

(10 marks)
(Total: 25 marks)

Question 4

(a) A point in a strained material is subjected to the stresses as shown in the Figure 4(a). Find,

(i) the normal stress on the section AB,
(ii) the shear stress on the section AB.

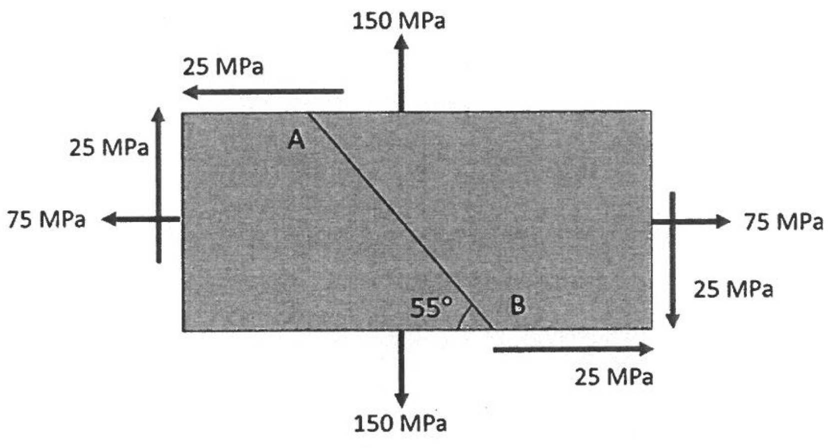


Figure 4(a)

(12 marks)

(b) Figure 4(b) show a beam AB under load P. Given load, P=160kN, L=3.6m, a=0.9 m, b=2.7 m and E=200 GPa. Area moment of inertia of the beam is $I = 104 \times 10^6 \text{mm}^4$.

(i) Determine the strain energy of the prismatic beam AB, taking into account only the effect of normal stress due to bending.

(ii) Evaluate the strain energy

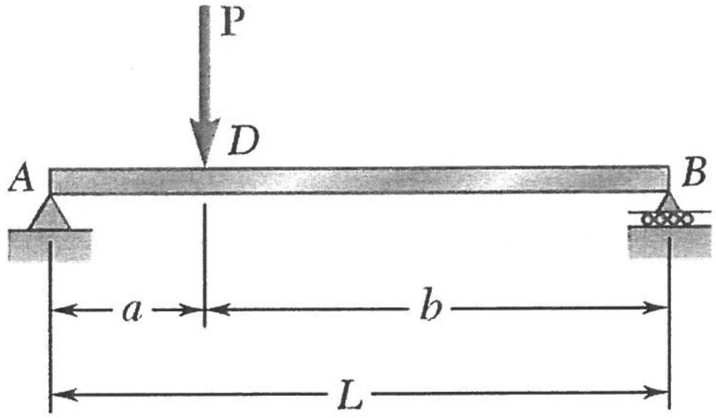


Figure 4(b)

(13 marks)

(Total: 25 marks)

Question 5

A 'T' shape cross-section of a beam shown in the Figure 5, is subjected to a vertical shear force of 100 kN and a moment of inertia $I_{NA} = 113.4 \times 10^6 \text{ mm}^4$. Calculate

(i) the shear stress at points a, b, c, d (22 marks)

(ii) draw the shear stress distribution diagram (3 marks)

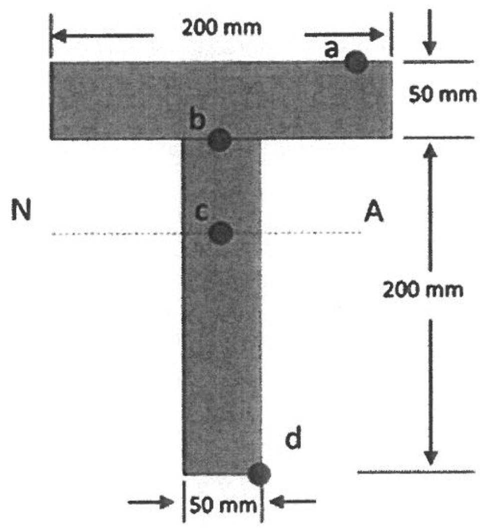


Figure 5

(Total: 25 marks)

Question 6

A horizontal steel girder having uniform cross-section is 14 m long as shown in Figure 6, is simply supported at its ends. It carries two concentrated loads as shown in the Figure 6. Taking E = 200 GPa and moment of inertia, $I = 160 \times 10^6$ mm^4. Calculate the

(a) Reactions at points A and B,

(4 marks)

(b) Deflections of the beam under the load C and

(18 marks)

(c) Deflections of the beam under the load D.

(3 marks)

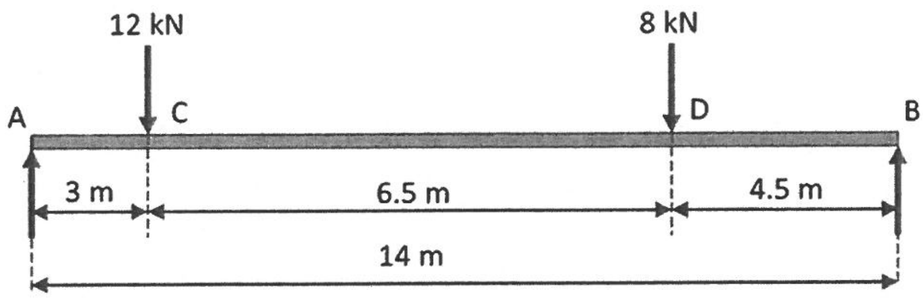


Figure 6

(Total: 25 marks)

-THE END -

Fundamental Equations of Mechanics of Materials

Axial Load

Normal Stress

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

Displacement

$$\delta = \int_0^L \frac{P(x)dx}{A(x)E}$$

$$\delta = \Sigma \frac{PL}{AE}$$

$$\delta_T = \alpha \, \Delta T L$$

Torsion

Shear stress in circular shaft

$$\tau = \frac{T\rho}{J}$$

where

$$J = \frac{\pi}{2} c^4 \text{ solid cross section}$$

$$J = \frac{\pi}{2}(c_o^4 - c_i^4) \text{ tubular cross section}$$

Power

$$P = T\omega = 2\pi f T$$

Angle of twist

$$\phi = \int_0^L \frac{T(x)dx}{J(x)G}$$

$$\phi = \Sigma \frac{TL}{JG}$$

Average shear stress in a thin-walled tube

$$\tau_{avg} = \frac{T}{2tA_m}$$

Shear Flow

$$q = \tau_{avg} t = \frac{T}{2A_m}$$

Bending

Normal stress

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

Unsymmetric bending

$$\sigma = -\frac{M_z y}{I_z} + \frac{M_y z}{I_y}, \qquad \tan \alpha = \frac{I_z}{I_y} \tan \theta$$

Shear

Average direct shear stress

$$\tau_{avg} = \frac{V}{A}$$

Transverse shear stress

$$\tau = \frac{VQ}{It}$$

Shear flow

$$q = \tau t = \frac{VQ}{I}$$

Stress in Thin-Walled Pressure Vessel

Cylinder $\qquad \sigma_1 = \frac{pr}{t} \qquad \sigma_2 = \frac{pr}{2t}$

Sphere

$$\sigma_1 = \sigma_2 = \frac{pr}{2t}$$

Stress Transformation Equations

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

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

Principal Stress

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

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

Maximum in-plane shear stress

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

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

$$\sigma_{avg} = \frac{\sigma_x + \sigma_y}{2}$$

Absolute maximum shear stress

$$\tau_{\substack{abs\\max}} = \frac{\sigma_{max} - \sigma_{min}}{2}$$

$$\sigma_{avg} = \frac{\sigma_{max} + \sigma_{min}}{2}$$

Material Property Relations

Poisson's ratio

$$\nu = -\frac{\epsilon_{\text{lat}}}{\epsilon_{\text{long}}}$$

Generalized Hooke's Law

$$\epsilon_x = \frac{1}{E}[\sigma_x - \nu(\sigma_y + \sigma_z)]$$

$$\epsilon_y = \frac{1}{E}[\sigma_y - \nu(\sigma_x + \sigma_z)]$$

$$\epsilon_z = \frac{1}{E}[\sigma_z - \nu(\sigma_x + \sigma_y)]$$

$$\gamma_{xy} = \frac{1}{G}\tau_{xy},\quad \gamma_{yz} = \frac{1}{G}\tau_{yz},\quad \gamma_{zx} = \frac{1}{G}\tau_{zx}$$

where

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

Relations Between *w, V, M*

$$\frac{dV}{dx} = -w(x), \qquad \frac{dM}{dx} = V$$

Elastic Curve

$$\frac{1}{\rho} = \frac{M}{EI}$$

$$EI\frac{d^4v}{dx^4} = -w(x)$$

$$EI\frac{d^3v}{dx^3} = V(x)$$

$$EI\frac{d^2v}{dx^2} = M(x)$$

Buckling

Critical axial load

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

Critical stress

$$\sigma_{\text{cr}} = \frac{\pi^2 E}{(KL/r)^2},\ r = \sqrt{I/A}$$

Secant formula

$$\sigma_{\max} = \frac{P}{A}\left[1 + \frac{ec}{r^2}\sec\left(\frac{L}{2r}\sqrt{\frac{P}{EA}}\right)\right]$$

Energy Methods

Conservation of energy

$$U_e = U_i$$

Strain energy

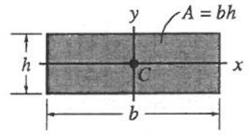
$$U_i = \frac{N^2L}{2AE} \quad \textit{constant axial load}$$

$$U_i = \int_0^L \frac{M^2dx}{EI} \quad \textit{bending moment}$$

$$U_i = \int_0^L \frac{f_sV^2dx}{2GA} \quad \textit{transverse shear}$$

$$U_i = \int_0^L \frac{T^2dx}{2GJ} \quad \textit{torsional moment}$$

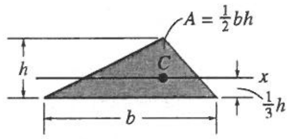
Geometric Properties of Area Elements



$I_x = \frac{1}{12}bh^3$

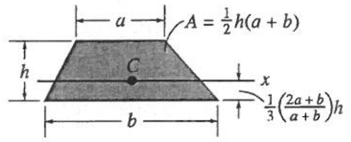
$I_y = \frac{1}{12}hb^3$

Rectangular area

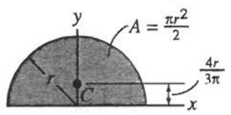


$I_x = \frac{1}{36}bh^3$

Triangular area



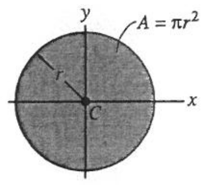
Trapezoidal area



$I_x = \frac{1}{8}\pi r^4$

$I_y = \frac{1}{8}\pi r^4$

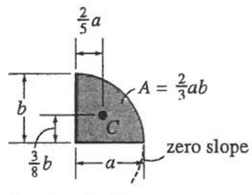
Semicircular area



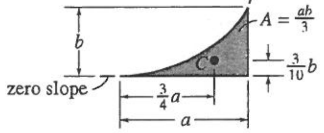
$I_x = \frac{1}{4}\pi r^4$

$I_y = \frac{1}{4}\pi r^4$

Circular area



Semiparabolic area



Exparabolic area