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UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF MARINE ENGINEERING TECHNOLOGY

FINAL EXAMINATION
MARCH 2025 SEMESTER

COURSE CODE	:	LGB25103
COURSE TITLE	:	MECHANICS OF MATERIALS
PROGRAMME NAME	:	BACHELOR OF ENGINEERING TECHNOLOGY (NAVAL ARCHITECTURE AND SHIPBUILDING) WITH HONOURS
DATE	:	26 JUNE 2025
TIME	:	2:00PM - 5:00PM
DURATION	:	3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question paper consist of TWO sections.
4. Answer ALL questions for Section A.
5. Section B consist of four questions. Answer THREE (3) questions only.
6. Please write your answer on the answer booklet provided.
7. Please answer all questions in English only.
8. Please answer MCQ/EMQ questions using OMR sheet. ☐ *Tick if applicable*
9. Refer to the attached Formula/ Appendies. ☐ *Tick if applicable*

THERE ARE 11 PAGES OF QUESTIONS INCLUDING THIS PAGE

SECTION A (Total: 40 marks)

Answer ALL questions.

Please use the answer booklet provided.

Question 1

A plot of the results produces a curve called the stress–strain diagram can be effectively used for behaviours for all materials. This concept is important to know when deal with engineering materials field.

(a) From the sketch of Stress-Strain diagram given, explain the behaviour for A-B, B-C, C-D and D-E
Refer Below - Figure1 : Stress-Strain Diagram for Steel .

(10 marks)

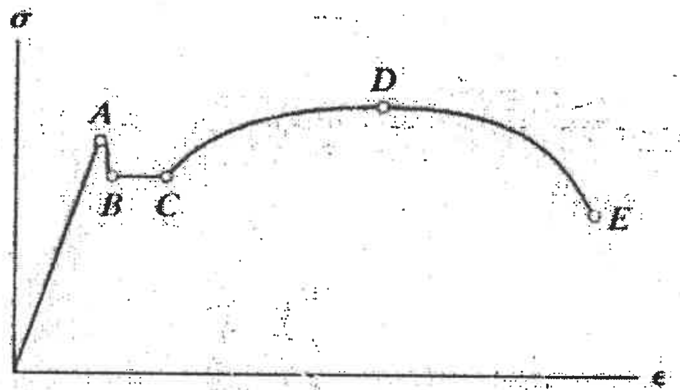


Figure 1: Stress-Strain Diagram for Steel

(b) The mechanical properties of a material have up to this point been discussed only for a static or slowly applied load at constant temperature. In some cases, however, a member may have to be used in an environment for which loadings must be sustained over long periods of time at elevated temperatures, or in other cases, the loading may be repeated or cycled. Describe with an example for items below;

- Creep failure
- Fatigue failure

(10 marks)

Question 2

One of the most important tests to perform in this regard is the tension or compression test. Although several important mechanical properties of a material can be determined from this test, it is used primarily to determine the relationship between the average normal stress and average normal strain in many engineering materials such as metals, ceramics, polymers, and composites. To perform a mechanical testing for tension or compression testing, a specimen of the material is made into a "standard" shape and size. Their mechanical properties need to be tested by using Universal Testing Machine (UTM).

Refer Below - Figure2 : Universal Testing Machine Overview.

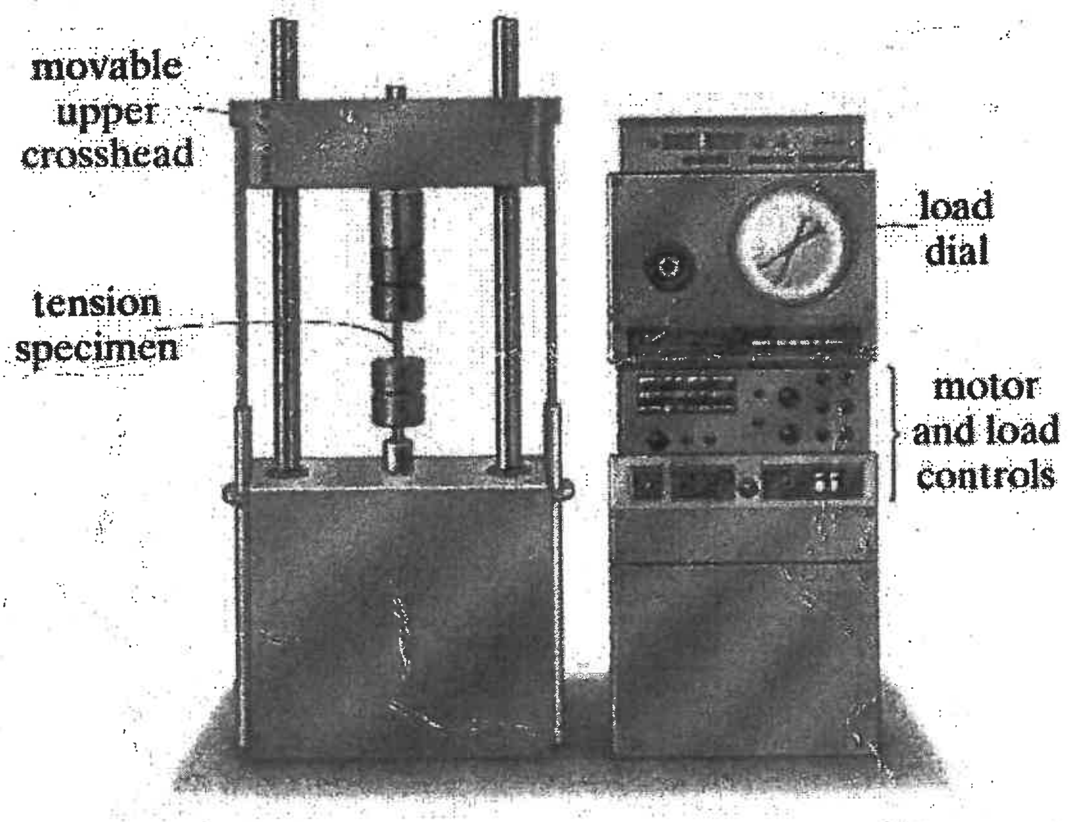


Figure 2: Universal Testing Machine Overview

(a) Explain the common term's in mechanical chracteristic of materials as follows with their formula;
- Engineering Stress
- Engineering Strain
- Ultimate Stress

(5 marks)

(b) Sketch the Stress - Strain diagram for steel material including indicate the elastic behaviour, plastic behaviour and ultimate strength before raptured.

(10 marks)

(c) From b) describe the characterstic for steel material including indicate the elastic behaviour, plastic behaviour and ultimate strength before raptured.

(5 marks)

SECTION B (Total: 60 marks)

Answer THREE (3) questions only.

Please use the answer booklet provided.

Question 1

Materials and metallurgical engineers, on the other hand, are concerned with producing and fabricating materials to meet service requirements as predicted by these stress analyses.This necessarily involves an understanding of the relationships between the microstructure (i.e., internal features) of materials and their mechanical properties. Materials are frequently chosen for structural applications because they have desirable combinations of mechanical characteristics. The present discussion is confined primarily to the mechanical behavior of metals; polymers and ceramics are treated separately because they are, to a large degree, mechanically different from metals.This chapter discusses the stress–strain behavior of metals and the related mechanical properties, and also examines other important mechanical characteristics.

(a) Describe the following mechanical testing for all materials with it application;
- Tensile testing properties
- Compressive testing properties

(8 marks)

(b) Another important property of a material is the modulus of toughness, μ_t. Sketch and describe the behaviour of modulus toughness.

(4 marks)

(c) An aluminum rod has a circular cross section and is subjected to an axial load of 10 kN. Determine the normal stress for each segment;
- AB
- BC

Refer Below - Figure3 : Aluminum Rod Cylinder .

(8 marks)

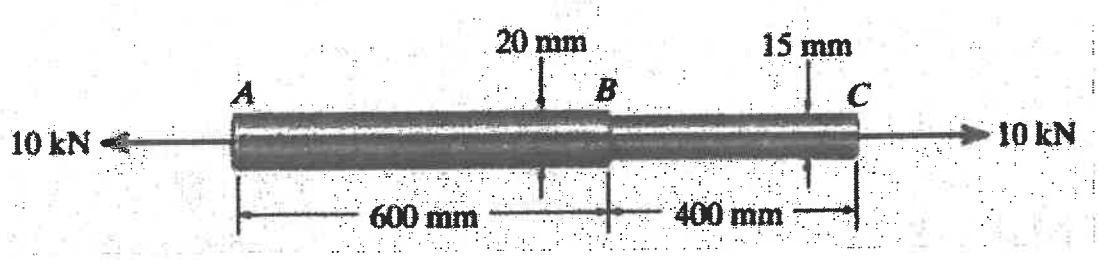


Figure 3: Aluminum Rod Cylinder

Question 2

It is important to choose the right material for any job that we pursue. Not choosing the right material can cause unintended consequences like metal whiskers growing on metallic parts. These consequences can lead to bigger disasters. Hence, it is important to understand the classification of materials. And understand their properties and applications. There are thousands of materials available for use in engineering applications. Most materials fall into one of three classes that are based on the atomic bonding forces of a particular material. These three classifications are metallic, ceramic and polymeric. Additionally, different materials can be combined to create a composite material. Within each of these classifications, materials are often further organized into groups based on their chemical composition or certain physical or mechanical properties..

(a) Define the mechanical characteristics below with it examples;
- Ductile materials
- Brittle materials

(6 marks)

(b) A tension test was performed on a steel specimen having an original diameter of 0.503 mm. and gauge length of 2.00 mm. Using the data listed in the table, plot the graph using a graph paper for the stress–strain diagram and determine approximately the modulus of toughness

Refer Below - Table1 : Tensional Test Result for Steel .

(14 marks)

Table 1: Tensional Test Result for Steel

Load (kN)	Elongation(mm)
0	0
2.50	0.0009
6.50	0.0025
8.50	0.0040
9.20	0.0065
9.80	0.0098
12.0	0.0400
14.0	0.1200
14.5	0.2500
14.0	0.3500
13.2	0.4700

Question 3

The **three-point bending flexural test** provides values for the modulus of elasticity in bending E_f, flexural stress σ_f, flexural strain, and the flexural stress–strain response of the material. This test is performed on a universal testing machine (tensile testing machine or tensile tester) with a three-point or four-point bend fixture. The main advantage of a three-point flexural test is the ease of the specimen preparation and testing. However, this method has also some disadvantages: the results of the testing method are sensitive to specimen and loading geometry and strain rate.

(a) Data taken from a stress–strain test for a ceramic are given in the table. The curve is linear between the origin and the first point. Plot the graph Stress-Strain diagram and determine approximately the modulus of toughness. The rupture stress is σ_r = 53.4 kPa.

Refer Below - Table2 : Stress-Strain Ceramic Data .

(10 marks)

Table 2: Stress-Strain Ceramic Data

σ (kPa)	ϵ (mm/mm)
0	0
33.2	0.0006
45.5	0.0010
49.4	0.0014
51.5	0.0018
53.4	0.0022

(b) The acrylic plastic rod is 200 mm long and 15 mm in diameter. If an axial load of 300 N is applied to it, determine the change in its length and the change in its diameter. Modulus elasticity, Ep = 2.70 GPa, Poisson Ratio's, υ_p = 0.4.

Refer Below - Figure4 : Acrylic Plastic Rod .

(10 marks)

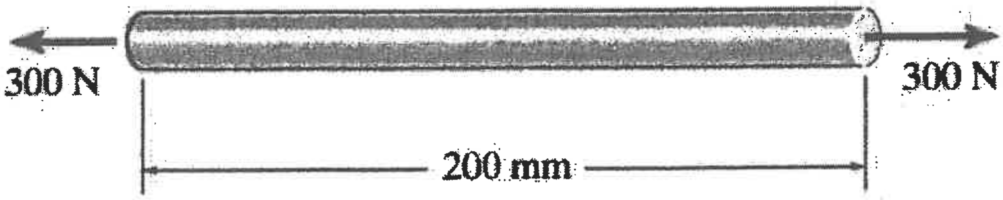


Figure 4: Acrylic Plastic Rod

Question 4

Elastic properties describe the reversible deformation (elastic response) of a material to an applied stress. Elastic solids behave like springs, and it always takes the same amount of force to displace the material the same amount. The two parameters that determine the elasticity of a material are its elastic modulus and its elastic limit.

(a) Define the Poisson's ratio in terms of lateral and axial strains using tension testing condition.

(10 marks)

(b) Explain the term for Shear Stress using Stress-Strain diagram

(5 marks)

(c) Explain the term for Shear Strain using Stress-Strain diagram

(5 marks)

END OF EXAMINATION PAPER

Fundamental Equations of Mechanics of Materials

Axial Load

Normal Stress

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

Displacement

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

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

$$\delta_T = \alpha \Delta TL$$

Torsion

Shear stress in circular shaft

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

where

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

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

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

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

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

$$\tau_{\substack{abs\\max}} = \frac{\sigma_{max}}{2} \quad \text{for } \sigma_{max}, \sigma_{min} \text{ same sign}$$

$$\tau_{\substack{abs\\max}} = \frac{\sigma_{max} - \sigma_{min}}{2} \quad \text{for } \sigma_{max}, \sigma_{min} \text{ opposite signs}$$

Material Property Relations

Poisson's ratio

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

Generalized Hooke's Law

$$\epsilon_x = \frac{1}{E}\left[\sigma_x - \nu(\sigma_y + \sigma_z)\right]$$
$$\epsilon_y = \frac{1}{E}\left[\sigma_y - \nu(\sigma_x + \sigma_z)\right]$$
$$\epsilon_z = \frac{1}{E}\left[\sigma_z - \nu(\sigma_x + \sigma_y)\right]$$
$$\gamma_{xy} = \frac{1}{G}\tau_{xy},\quad \gamma_{yz} = \frac{1}{G}\tau_{yz},\quad \gamma_{zx} = \frac{1}{G}\tau_{zx}$$

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

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

Critical stress

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

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

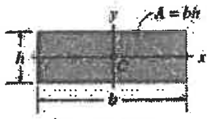
Conservation of energy

$$U_e = U_i$$

Strain energy

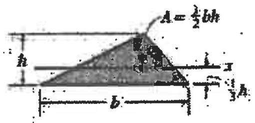
$$U_i = \frac{N^2L}{2AE}\quad \text{constant axial load}$$
$$U_i = \int_0^L \frac{M^2dx}{2EI}\quad \text{bending moment}$$
$$U_i = \int_0^L \frac{f_sV^2dx}{2GA}\quad \text{transverse shear}$$
$$U_i = \int_0^L \frac{T^2dx}{2GJ}\quad \text{torsional moment}$$

Geometric Properties of Area Elements



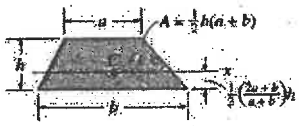
Rectangular area

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

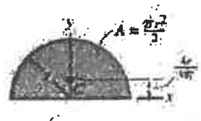


Triangular area

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

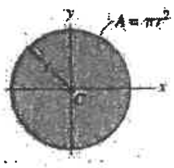


Trapezoidal area



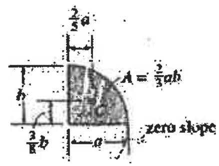
Semicircular area

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



Circular area

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



Semiparabolic area

Exparabolic area

Average Mechanical Properties of Typical Engineering Materials[a]
(SI Units)

Materials		Density ρ (Mg/m³)	Modulus of Elasticity E (GPa)	Modulus of Rigidity G (GPa)	Yield Strength (MPa) σ_y Tens.	Comp.[b]	Shear	Ultimate Strength (MPa) σ_u Tens.	Comp.[b]	Shear	% Elongation in 50 mm specimen	Poisson's Ratio ν	Coef. of Therm. Expansion α $(10^{-6})/°C$
Metallic													
Aluminum Wrought Alloys	2014-T6	2.79	73.1	27	414	414	172	469	469	290	10	0.35	23
	6061-T6	2.71	68.9	26	255	255	131	290	290	186	12	0.35	24
Cast Iron Alloys	Gray ASTM 20	7.19	67.0	27	–	–	–	179	669	–	0.6	0.28	12
	Malleable ASTM A-197	7.28	172	68	–	–	–	276	572	–	5	0.28	12
Copper Alloys	Red Brass C83400	8.74	101	37	70.0	70.0	–	241	241	–	35	0.35	18
	Bronze C86100	8.83	103	38	345	345	–	655	655	–	20	0.34	17
Magnesium Alloy	[Am 1004-T61]	1.83	44.7	18	152	152	–	276	276	152	1	0.30	26
Steel Alloys	Structural A-36	7.85	200	75	250	250	–	400	400	–	30	0.32	12
	Structural A992	7.85	200	75	345	345	–	450	450	–	30	0.32	12
	Stainless 304	7.86	193	75	207	207	–	517	517	–	40	0.27	17
	Tool L2	8.16	200	75	703	703	–	800	800	–	22	0.32	12
Titanium Alloy	[Ti-6Al-4V]	4.43	120	44	924	924	–	1,000	1,000	–	16	0.36	9.4
Nonmetallic													
Concrete	Low Strength	2.38	22.1	–	–	–	12	–	–	–	–	0.15	11
	High Strength	2.37	29.0	–	–	–	38	–	–	–	–	0.15	11
Plastic Reinforced	Kevlar 49	1.45	131	–	–	–	–	717	483	20.3	2.8	0.34	–
	30% Glass	1.45	72.4	–	–	–	–	90	131	–	–	0.34	–
Wood Select Structural Grade	Douglas Fir	0.47	13.1	–	–	–	–	2.1[c]	26[d]	6.2[d]	–	0.29[c]	–
	White Spruce	3.60	9.65	–	–	–	–	2.5[c]	36[d]	6.7[d]	–	0.31[c]	–

[a] Specific values may vary for a particular material due to alloy or mineral composition, mechanical working of the specimen, or heat treatment. For a more exact value, reference books for the material should be consulted.

[b] The yield and ultimate strengths for ductile materials can be assumed equal for both tension and compression.

[c] Measured perpendicular to the grain.

[d] Measured parallel to the grain.

[e] Deformation measured perpendicular to the grain when the load is applied along the grain.