CONFIDENTIAL

UNIVERSITI KUALA LUMPUR
Malaysian Institute of Marine Engineering Technology

FINAL EXAMINATION
MARCH 2025 SEMESTER SESSION

SUBJECT CODE	:	**LGB22103**
SUBJECT TITLE	:	**STRENGTH OF MATERIALS**
PROGRAMME NAME (FOR MPU: PROGRAMME LEVEL)	:	**BET (NAVAL ARCHITECTURE AND SHIPBUILDING) WITH HONOURS** **BET (OFFSHORE) WITH HONOURS**
TIME / DURATION	:	**2.00 PM - 5.00 PM (3 HOURS)**
DATE	:	**30 JUNE 2025**

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper **CAREFULLY**.
2. This question paper has information printed on both sides of the paper.
3. This question paper consists of **ONE (1)** section with FIVE (5) questions, answer **FOUR (4)** questions **ONLY**.
4. Please write your answer on the answer booklet provided.
5. Answer **ALL** questions in English language **ONLY**.
6. Graph paper is provided together with the answer sheets.
7. Formula sheet and stress concentration charts are attached with the question paper.
8. Answer should be written in blue or black ink except for sketching, graphic and illustration.

THERE ARE 6 PAGES OF QUESTIONS, INCLUDING THIS PAGE.

SECTION A (Total: 100 marks)

INSTRUCTION: Answer FOUR (4) questions only.
Please use the answer booklet provided.

Question 1

With reference to the mechanical properties of materials;

(a) Data taken from stress-strain for ceramic are given in Table 1. The curve is linear between the origin and the first point.

i. Plot the stress-strain diagram for ceramic.
ii. Determine the rupture stress.
iii. Determine the modulus of elasticity.
iv. Determine the modulus of resilience.
v. Determine the modulus of toughness.

Table 1

σ(MPa)	ε (mm/mm)
0	0
232.4	0.0006
318.5	0.0010
345.8	0.0014
360.5	0.0018
373.8	0.0022

(25 marks)

Question 2

With reference to the mechanical properties of materials;

(a) Figure 1 shows an acrylic rod 200 mm long and 15 mm in diameter. An axial load of 300 N is applied to the rod and E_p is given by 2.70 GPA and v_p = 0.4. Determine the change in its length and diameter.

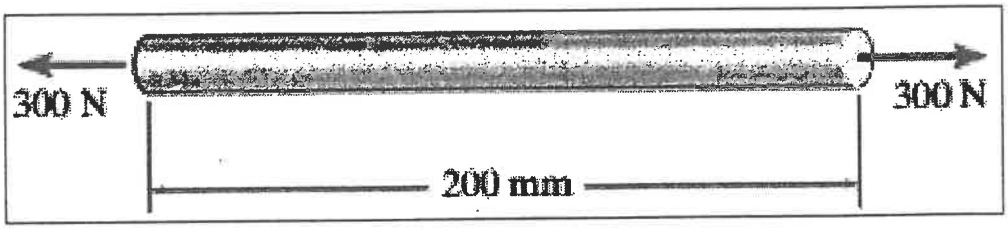

Figure1

(10 marks)

(b) The lap joint is connected using 30 mm diameter bolt. The bolt is made from materials having a shear stress-strain diagram as shown in Figure 2. Determine the shear strain developed in the shear plane of the bolt when P= 340 kN.

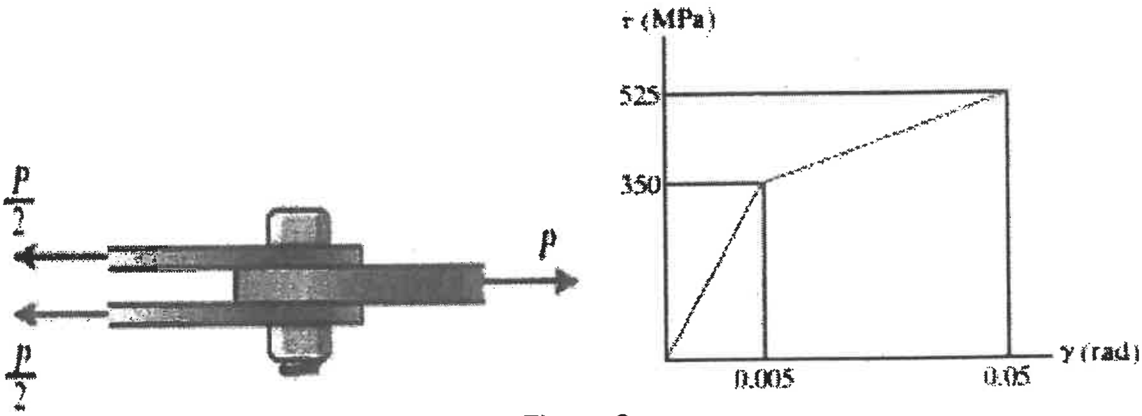

Figure 2

(15 marks)

Question 3

With reference to the concept of stress, strain, axial load, bending and torsion;

(a) Figure 3 shows a C83400-red-brass rod AB and a 2014-T6-aluminum rod BC which are joined at the collar B and fixed connected at their ends. The cross-sectional area of each member is 1130 mm². If there is no load in the members when T_1= 10 °C, determine the following; (Refer to Appendix B)

i. the average normal stress in each member when T_2 = 50 °C. (10 marks)

ii. the collar displacement. (5 marks)

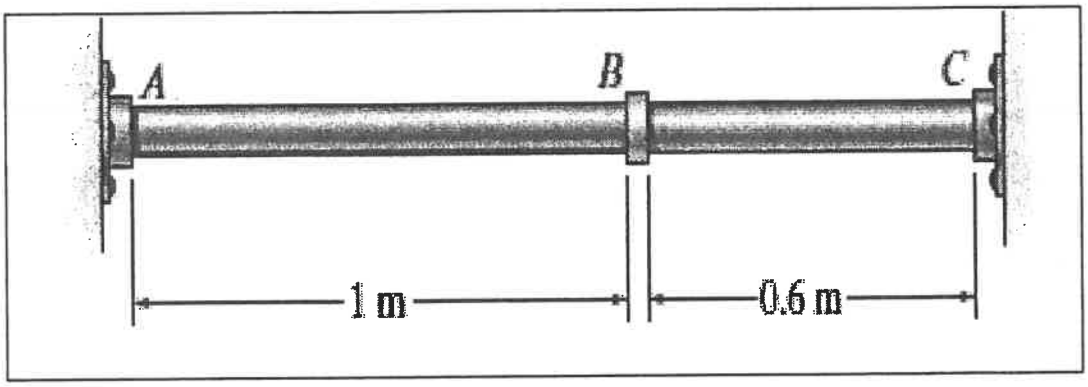

Figure 3

(b) Figure 4 shows a bar subjected to axial force P. The allowable stress is σ_{allow} = 150 MPa. Determine the maximum axial force P that can be applied to the steel plate. (Refer to Appendix A)

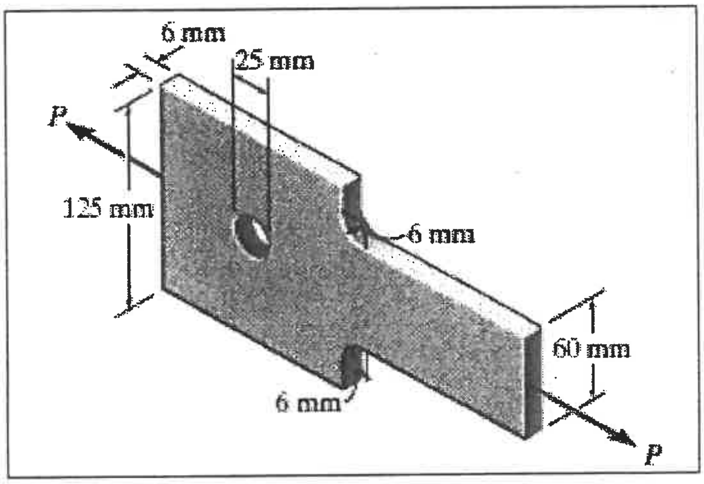

Figure 4

(10 marks)

Question 4

With reference to the concept of stress, strain, axial load, bending and torsion;

(a) Figure 5 shows A-36 hollow steel shaft is 2 m long and has an outer diameter of 40 mm. The shaft is rotating at 80 rad/s and transmits 32 kW of power from engine *E* to generator *G*. If the allowable shear stress is τ_{allow} = 140 MPa and the shaft is restricted not to twist more than 0.05 rad, determine the smallest thickness of the shaft.

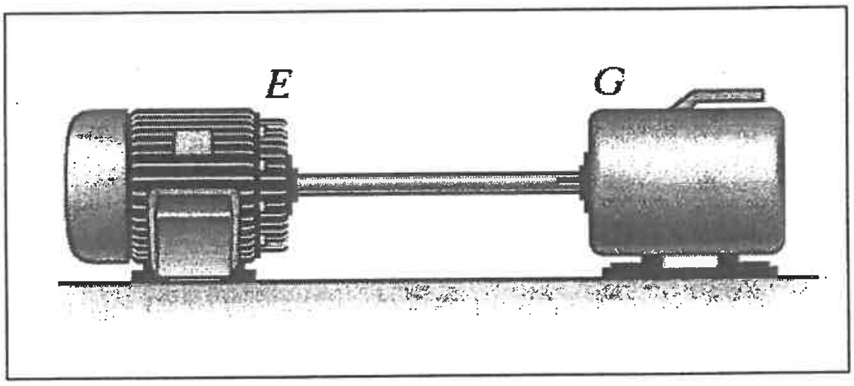

Figure 5

(10 marks)

(b) Figure 6 shows the journal bearing at A and B only support vertical forces that are subjected to the concentrated forces with allowable bending stress is σ_{allow} = 150MPa.

i. Calculate and sketch shear and moment diagrams. (10 marks)

ii. Determine the smallest allowable diameter of the shaft. (5 marks)

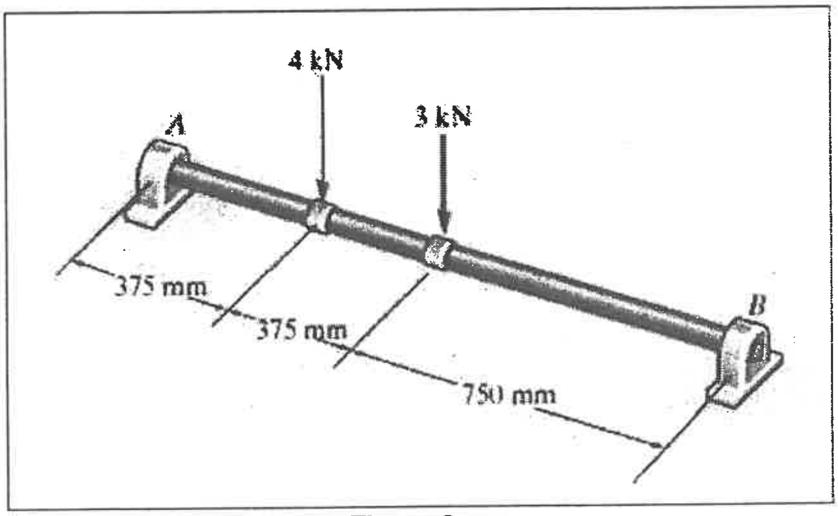

Figure 6

Question 5

With reference to the concept of stress, strain, axial load, bending and torsion;

(a) Figure 7 shows a turbine developing 150 kW of power and transmitted to the gears with C and D receives 70% and 30%, respectively. The journal bearing at *E* allows the shaft to turn freely about its axis. If the rotation of the 100 mm diameter A-36 steel shaft is ω = 800 rev/min, calculate;

i. the absolute maximum shear stress in the shaft and

ii. the angle of twist of end *E* of the shaft relative to *B*.

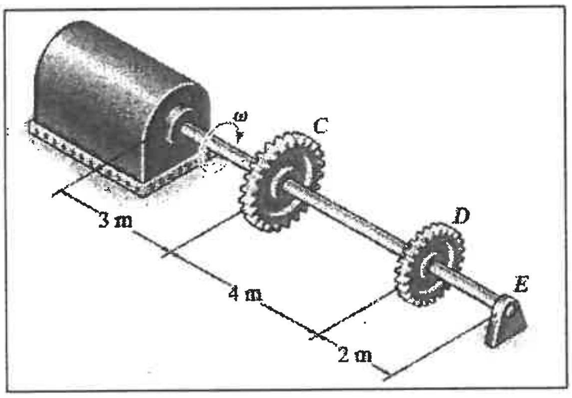

Figure 7

(10 marks)

(b) Figure 8 shows bearings at *A* and *D* exert only vertical reaction on the shaft. Loading is applied to the pulleys at *B* (360 N) and *C* (500 N) and *E* (160 N). Sketch;

i. the shear diagrams of the shaft.

ii. the moment diagrams of the shaft.

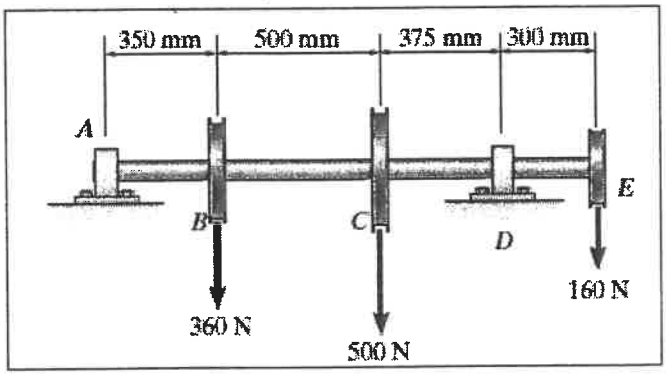

Figure 8

(15 marks)

END OF EXAMINATION PAPER

Normal Stress	$\sigma = \frac{P}{A}$
Shear Stress	$\tau = \frac{V}{A}$
Factor of Safety	$F.S. = \frac{F_{fail}}{F_{allow}} = \frac{\sigma_{fail}}{\sigma_{allow}} = \frac{\tau_{fail}}{\tau_{allow}}$
Normal strain	$\varepsilon = \frac{\Delta s' - \Delta s}{\Delta s} = \frac{\delta}{L_0}$
Shear strain	$\gamma = \frac{\pi}{2} - \theta'$
If θ (rad.) is small	$\sin\theta \approx \theta$ $\cos\theta \approx 1$ $\tan\theta \approx \theta$
Pythagoras theorem	$a^2 = b^2 + c^2$
Cosine rule	$a^2 = b^2 + c^2 - 2bc\cos\theta$
Hooke's Law (up to Proportional Limit)	$\sigma = E\varepsilon$
Hooke's Law (up to Proportional Limit)	$\tau = G\gamma$
Strain Energy	$u = \frac{1}{2}\sigma_{pl}\varepsilon_{pl} = \frac{1\sigma_{pl}^2}{2E}$
Poisson's Ratio	$\upsilon = -\frac{\varepsilon_{lateral}}{\varepsilon_{longitudinal}}$
Lateral strain	$\varepsilon_{lateral} = \frac{\delta}{r_0}$
Longitudinal strain	$\varepsilon_{longitudinal} = \frac{\delta}{L_0}$
Modulus of Elasticity	$E = \frac{\sigma_{pl}}{\varepsilon_{pl}}$
Modulus of Rigidity	$G = \frac{E}{2(1+\upsilon)}$
Displacement (Axial Load)	$\delta = \frac{PL}{AE} = \Sigma\frac{PL}{AE}$

Stress concentration factor	$K = \frac{\sigma_{max}}{\sigma_{allow}}$
Shear strain (torsion)	$\gamma = \frac{\pi}{2} - \theta'$
Shear strain (torsion)	$\gamma = \left(\frac{\rho}{c}\right)\gamma_{max}$
Shear stress (torsion)	$\tau = \left(\frac{\rho}{c}\right)\tau_{max}$
Shear stress (torsion)	$\tau = \frac{T\rho}{J}$
Maximum shear stress	$\tau_{max} = \frac{Tc_o}{J}$
Polar moment of inertia (solid shaft)	$J = \frac{\pi}{2}c^4$
Polar moment of inertia (hollow shaft)	$J = \frac{\pi}{2}\left(c_0^{\ 4} - c_i^{\ 4}\right)$
Power	$P = T\frac{d\theta}{dt} = T\omega$
Power	$P = 2\pi fT$
Angle of twist	$\phi = \int_0^L \frac{T(x)dx}{J(x)G} = \frac{TL}{JG} = \Sigma\frac{TL}{JG}$
Displacement of a point on an arc	$S = \phi \cdot r$

Materials		Density ρ (Mg/m^3)	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 A36	7.85	200	75	250	250	-	400	400	-	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	2.38	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[e]	-
	White Spruce	3.60	9.65	-	-	-	-	2.5[c]	36[d]	6.7[d]	-	0.31[e]	-

STRESS CONCENTRATION FACTOR (K) CHARTS