



UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF MARINE ENGINEERING TECHNOLOGY

FINAL EXAMINATION
MARCH 2025 SEMESTER

COURSE CODE : LGD21103
COURSE TITLE : STRENGTH OF MATERIALS
PROGRAMME NAME : DIPLOMA OF ENGINEERING TECHNOLOGY IN SHIP DESIGN
DATE : 23 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. Section A consist total of 60 marks. Answer **ALL** questions.
5. Section B consist of three questions. Answer **TWO (2)** questions only.
6. Please write your answer on the answer booklet provided.
7. Please answer all questions in English only.
8. Refer to the attached Formula/ Appendices. *Tick if applicable*

THERE ARE 9 PAGES OF QUESTIONS INCLUDING THIS PAGE

SECTION A (Total: 60 marks)

Answer ALL questions.

Please use the answer booklet provided.

Question 1

The following questions relate to forces and equilibrium.

- (a) If the magnitude of the resultant force is to be 9kN directed along the positive x-axis, determine the following:

Refer Below - Figure1 : Forces acting on an eyebolt .

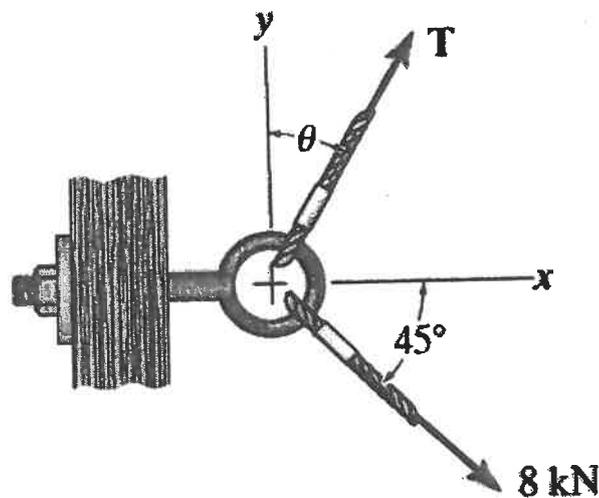


Figure 1: Forces acting on an eyebolt

- i. Draw a free body diagram of the forces acting on the eyebolt. (4 marks)
 - ii. Determine the magnitude of force T acting on the eyebolt and its angle θ . (6 marks)
- (b) Force F_A and F_B acts on a gusset plate as shown. If θ is 60° , determine the following:
Refer Below - Figure2 : Forces acting on a gusset plate .

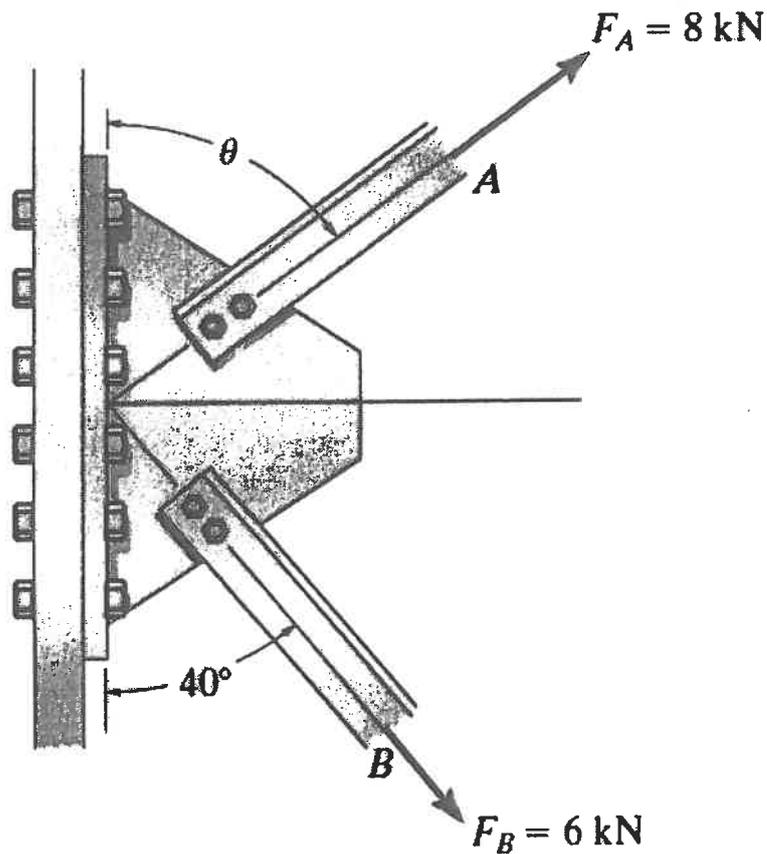


Figure 2: Forces acting on a gusset plate

- i. Determine the magnitude and direction of the resultant force (F_R) created by these two forces F_A and F_B .
(6 marks)
- ii. Draw the free body diagram for the gusset plate showing all forces.
(4 marks)

Question 2

The following questions relate to forces and stress.

(a) Define the following terms:

i. Surface Forces

(2 marks)

ii. Body Forces.

(2 marks)

(b) The two aluminum rods support the vertical force of $P=20\text{kN}$. Determine their required diameters if the allowable tensile stress for the aluminum is $\sigma_{\text{allow}} = 150\text{MPa}$.

Refer Below - Figure3 : Aluminium rods support system .

(8 marks)

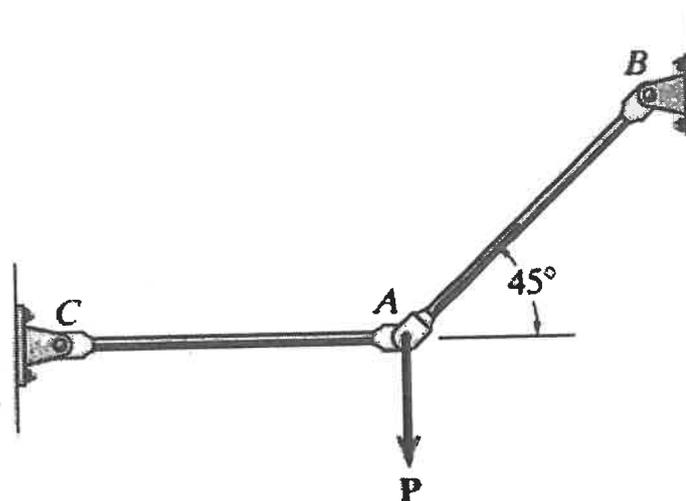


Figure 3: Aluminium rods support system

- (c) The thrust bearing consists of a circular collar A fixed to the shaft B. Determine the maximum axial force P that can be applied to the shaft so that it does not cause the shear stress along a cylindrical surface a or b to exceed an allowable shear stress of $\tau_{\text{allow}} = 170\text{MPa}$.

Refer Below - Figure4 : Thrust bearing system .

(8 marks)

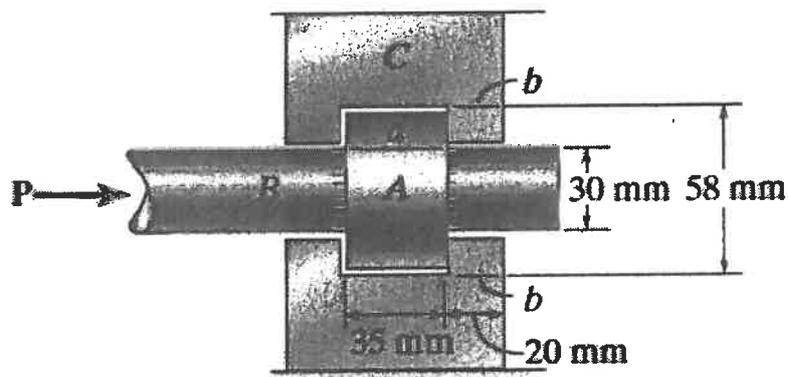


Figure 4: Thrust bearing system

Question 3

The following questions relate to strain.

(a) Define the following terms.

i. Normal Strain

(2 marks)

ii. Shear Strain

(2 marks)

(b) The force applied at the handle of the rigid lever causes the lever to rotate clockwise about the pin B through an angle of 2° . Determine the average normal strain developed in each wire. The wires are unstretched when the lever is in the horizontal position.

Refer Below - Figure5 : Rigid lever system .

(16 marks)

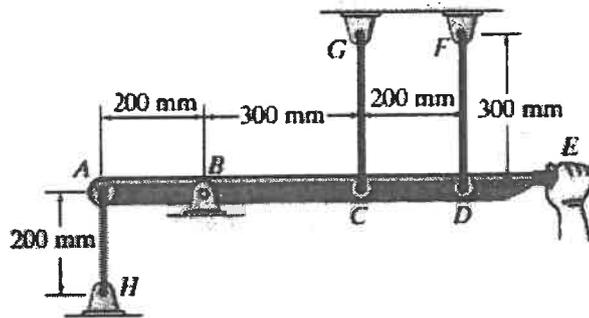


Figure 5: Rigid lever system

SECTION B (Total: 40 marks)

Answer TWO (2) questions only.

Please use the answer booklet provided.

Question 1

A reinforced concrete pier is used to support the stringers for a bridge deck. Draw the shear and moment diagrams for the pier when it is subjected to the stringer loads shown. Assume the columns at A and B exert only vertical reactions on the pier.

Refer Below - Figure 6 : Concrete pier .

(20 marks)

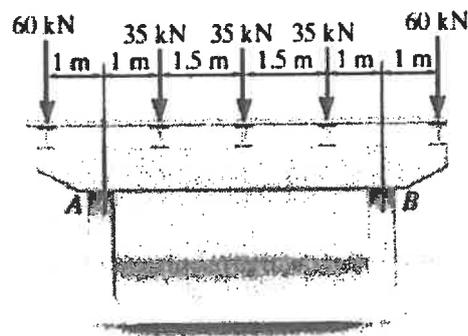


Figure 6: Concrete pier

Question 2

The following questions relate to axial load problems.

- (a) In your own words and with the aid of diagrams, describe Saint Venant's Principle. (10 marks)

- (b) The assembly consists of two 10mm diameter red brass C83400 copper rods AB and CD, a 15mm diameter 304 stainless steel rod EF, and a rigid bar G. Load $P = 5\text{kN}$.

Refer Below - Figure7 : Rod assembly system .

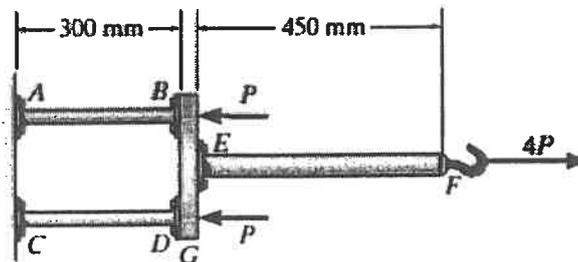


Figure 7: Rod assembly system

- i. Draw the free body diagram for each of the rod segments using method of section. (4 marks)
- ii. Determine the horizontal displacement of end F of rod EF (δ_F). (6 marks)

Question 3

The following questions relate to problems on torsion.

- (a) Describe in your own words with the aid of diagrams, the principle of superposition applied to shaft subjected to multiple torques to determine the total angle of twist (ϕ). Hint: in addition to the definition, include diagrams on the application of method of sections and a total angle of twist equation as example.

(10 marks)

- (b) The turbine develops 150kW of power, which is transmitted to the gears such that both C and D receive an equal amount. If the rotation of the 100mm diameter A-36 steel shaft is $\omega = 500\text{rev/min.}$, determine the absolute maximum shear stress in the shaft (τ_{max}) and the rotation of end B of the shaft relative to E ($\phi_{B/E}$). The journal bearing at E allows the shaft to turn freely about its axis. Take $G_{\text{steel}} = 75\text{GPa}$.

Refer Below - Figure8 : Turbine with output gears .

(10 marks)

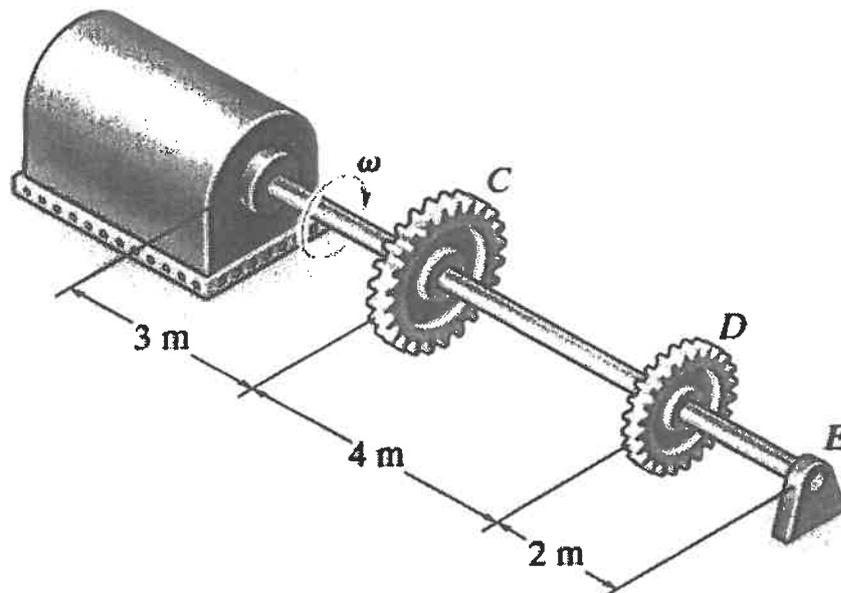


Figure 8: Turbine with output gears

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	$\nu = -\frac{\varepsilon_{lateral}}{\varepsilon_{longitudinal}}$
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	$G = \frac{E}{2(1+\nu)}$
Displacement (Axial Load)	$\delta = \frac{PL}{AE} = \sum \frac{PL}{AE}$

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)	$J = \frac{\pi}{2} (c_o^4 - c_i^4)$
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 (kg/m ³)	Modulus of Elasticity E (GPa)	Modulus of Rigidity G (GPa)	Yield Strength (MPa)	Tens. Comp. ¹ Shear	Ultimate Strength (MPa)	Tens. Comp. ² Shear	% Elongation in 50 mm specimen	Factor's Ratio ³	Cost of Therm. Expansion ⁴ (10 ³)/°C		
Metals												
Aluminum Wrought Alloys [2014-T6, 6061-T6]	279 271	73.1 68.9	27 26	414 255	414 255	172 131	469 290	469 290	186 186	10 12	0.35 0.35	23 24
Cast Iron [Grey ASTM 20, Malleable ASTM A-197]	718 728	67.0 172	27 68	- -	- -	- -	179 276	659 572	- -	0.6 5	0.28 0.28	12 12
Copper Alloys [Red Brass C83400, Bronze C86100]	8.74 8.83	101 103	37 38	70.0 345	70.0 345	- -	241 655	241 655	- -	35 30	0.35 0.34	18 17
Magnesium Alloy [AZ91EP-D]	183	44.7	18	152	152	-	276	276	152	1	0.30	26
Steel Alloys [Structural A36, Stainless 304, Tool L2]	785 785 8.16	200 193 200	75 75 75	250 207 703	250 207 703	- -	400 517 800	400 517 800	- -	30 40 22	0.32 0.27 0.32	12 17 12
Titanium Alloy [Ti-6Al-4V]	443	120	44	924	924	-	1000	1000	-	16	0.36	94
Nonmetals												
Concrete [Low Strength, High Strength]	238 238	22.1 29.0	- -	- -	- -	12 38	- -	- -	- -	- -	0.15 0.15	11 11
Plastic Reinforced [Kevlar 49, 30% Glass]	145 145	131 724	- -	- -	- -	- -	717 90	463 131	203 -	28 -	0.34 0.34	- -
Wood [Select Structural Grade, Douglas Fir, White Spruce]	0.47 360	13.1 9.65	- -	- -	- -	- -	2.1 ¹ 36 ²	26 ¹ 36 ²	6.2 ¹ 6.7 ¹	- -	0.29 ¹ 0.31 ¹	- -

