

**SULIT**



**KEMENTERIAN PENDIDIKAN TINGGI  
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI**

**BAHAGIAN PEPERIKSAAN DAN PENILAIAN  
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI  
KEMENTERIAN PENDIDIKAN TINGGI**

**JABATAN KEJURUTERAAN MEKANIKAL**

**PEPERIKSAAN AKHIR**

**SESI II : 2023/2024**

**DJJ30103 : STRENGTH OF MATERIALS**

**TARIKH : 13 JUN 2024**

**MASA : 8.30 PAGI - 10.30 PAGI (2 JAM)**

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Kertas ini mengandungi **SEPULUH (10)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Formula

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**JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN**

(CLO yang tertera hanya sebagai rujukan)

**SULIT**

**INSTRUCTION:**

This section consists of **FOUR (4)** structured questions. Answer **ALL** questions.

**ARAHAN:**

*Bahagian ini mengandungi EMPAT (4) soalan berstruktur. Jawab SEMUA soalan.*

**QUESTION 1****SOALAN 1**

- CLO1 (a) Elaborate the following terms along with their formulas.  
*Huraikan istilah-istilah berikut berserta formula masing-masing.*
- i. Normal stress  
*Tegasan normal*  
[2 marks]  
[2 markah]
- ii. Normal strain  
*Terikan normal*  
[2 marks]  
[2 markah]
- iii. Modulus of elasticity  
*Modulus keanjalan*  
[2 marks]  
[2 markah]
- iv. Factor of safety  
*Faktor keselamatan*  
[2 marks]  
[2 markah]
- v. Poisson's ratio  
*Nisbah Poisson*  
[2 marks]  
[2 markah]

- CLO1 (b) A tensile test was conducted on a steel specimen with a diameter of 42 mm and a length of 675 mm. When a load of 500 kN was applied, an elongation of 0.095 mm was observed. Calculate:

*Ujian tegangan telah dilakukan pada sampel keluli dengan diameter 42 mm dan panjang 675 mm. Jika suatu beban dikenakan adalah 500 kN, pemanjangan yang diperhatikan adalah 0.095 mm. Kirakan:*

- i. the Young's modulus of the specimen.

*Modulus Young bagi sampel tersebut.*

[4 marks]

[4 markah]

- ii. the factor of safety when the ultimate stress reaches 200 MPa.

*Faktor keselamatan apabila tegasan maksimum mencapai 200 MPa.*

[3 marks]

[3 markah]

CLO1

- (c) A compound bar, consisting of aluminum and steel materials, is rigidly fixed in series between walls at a temperature of  $90^{\circ}\text{C}$  as illustrated in Figure 1(c). If the temperature drops to  $35^{\circ}\text{C}$ , compute:

*Sebatang bar campuran yang terdiri daripada bahan aluminium dan keluli dipasang secara kukuh berturutan di antara dinding pada suhu  $90^{\circ}\text{C}$  seperti yang ditunjukkan dalam Rajah 1(c). Jika suhu turun kepada  $35^{\circ}\text{C}$ , hitungkan:*

Given that:	$E_{\text{al}} = 75 \text{ GPa}$	$E_{\text{st}} = 270 \text{ GPa}$
Diberi	$\alpha_{\text{al}} = 21.8 \times 10^{-6} /^{\circ}\text{C}$	$\alpha_{\text{st}} = 11.9 \times 10^{-6} /^{\circ}\text{C}$

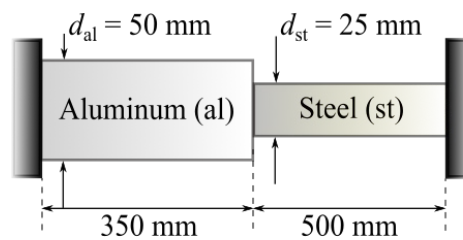


Figure 1(c) / Rajah 1(c)

- i. the thermal stress induced in the steel bar.  
*tegasan haba yang terhasil dalam bar keluli.*

[6 marks]

[6 markah]

- ii. the thermal stress developed in the aluminum bar.  
*tegasan haba yang terbentuk dalam bar aluminium.*

[2 marks]

[2 markah]

**QUESTION 2****SOALAN 2**

A combined beam, denoted as  $ABCD$  and measuring 5 meters in length, is supported at  $A$  and  $D$ , as illustrated in Figure 2.

*Sebatang rasuk gabungan  $ABCD$ , dengan panjang 5 meter, disokong secara mudah di hujung  $A$  dan  $D$ , seperti yang digambarkan dalam Rajah 2.*

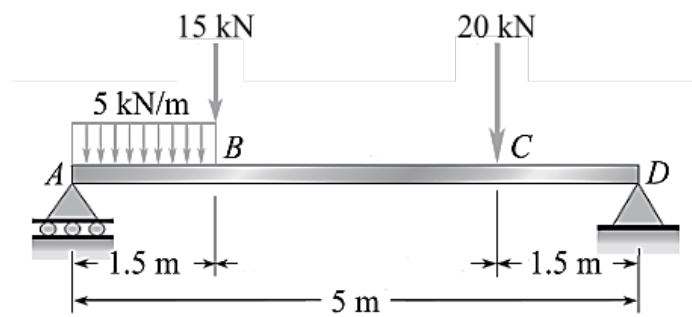


Figure 2 / Rajah 2

CLO1

- (a) Express the value of reaction force at the supported  $A$  and  $D$ , with the aid of free body diagram.

*Nyatakan nilai daya yang bertindak balas pada penyokong  $A$  dan  $D$ , dengan bantuan gambarajah badan bebas.*

[5 marks]

[5 markah]

CLO1

- (b) Based on the value of reaction force in (a):

*Berdasarkan nilai daya tindak balas di (a):*

- i. Calculate the magnitude of shear force along the beam.

*Kirakan magnitud daya ricih di sepanjang rasuk.*

[4 marks]

[4 markah]

CLO1

- ii. Draw to scale the shear force diagram of the beam.

*Lukiskan skala gambarajah daya ricih bagi rasuk.*

[4 marks]

[4 markah]

- CLO1 (c) Referring to the shear force diagram in (b)(ii):  
*Merujuk kepada gambarajah daya ricih di (b)(ii):*
- i. Calculate the magnitude of bending moment along the beam.  
*Kirakan magnitud momen lentur di sepanjang rasuk.*
- [6 marks]  
[6 markah]
- ii. Draw to scale the bending moment diagram of the beam.  
*Lukiskan skala gambarajah momen lentur bagi rasuk.*
- [4 marks]  
[4 markah]
- iii. Show the point position and value of maximum bending moment based on the diagram plotted in (c)(ii).  
*Tunjukkan kedudukan titik momen lentur maksimum dan nilainya berdasarkan gambarajah yang dilukis di (c)(ii).*
- [2 marks]  
[2 markah]

## QUESTION 3

## SOALAN 3

- CLO2 (a) Based on the following equation for bending stress, define the meaning of each symbol and its units.

*Berdasarkan persamaan tegangan lenturan yang berikut, jelaskan makna setiap simbol dan unitnya.*

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

[6 marks]

[6 markah]

- CLO2 (b) A symmetrical composite beam, 6 m long as depicted in Figure 3(b), is simply supported at both ends *A* and *B*.

*Sebatang rasuk komposit simetri, sepanjang 6 m seperti yang ditunjukkan dalam Rajah 3(b), disokong secara mudah di kedua-dua hujung *A* dan *B*.*

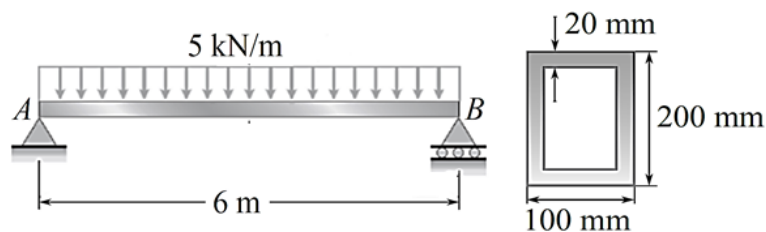


Figure 3(b) / Rajah 3(b)

Calculate the following:

*Kirakan yang berikut:*

- i. Centroid of the beam on the neutral axis. [2 marks]  
*Pusat graviti bagi keratan rasuk pada paksi neutral.* [2 markah]
- ii. Moment of inertia of the beam section on the neutral axis. [3 marks]  
*Momen inersia bagi keratan rasuk pada paksi neutral.* [3 markah]
- iii. Maximum bending stress of the beam. [4 marks]  
*Tegasan lentur maksimum bagi rasuk.* [4 markah]

- CLO2 (c) A cantilever beam 3m long is subjected to a uniformly distributed load of 200 kN/m as illustrated in Figure 3(c). Given the Young's modulus,  $E = 483 \text{ GN/m}^2$  and the second moment of area,  $I = 6.21 \times 10^{-5} \text{ m}^4$ , determine:

*Sebatang rasuk cantilever sepanjang 3 m terdedah kepada beban teragih seragam sebanyak 200 kN/m seperti yang ditunjukkan dalam Rajah 3(c). Diberi modulus Young,  $E = 483 \text{ GN/m}^2$  dan momen kedua kawasan,  $I = 6.21 \times 10^{-5} \text{ m}^4$ . Tentukan:*

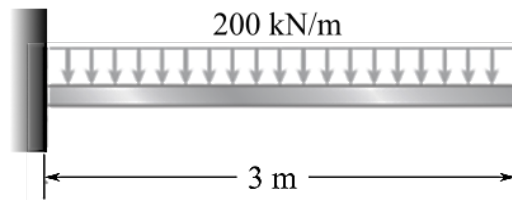


Figure 3(c) / Rajah 3(c)

- i. the deflection of the beam.  
*pesongan rasuk.*
- ii. the slope at the free end of the beam.  
*kecerunan di hujung bebas rasuk.*

[5 marks]

[5 markah]

[5 marks]

[5 markah]



**QUESTION 4****SOALAN 4**

- CLO2 (a) Describe the equation and its corresponding units used to calculate the Polar Moment of Inertia for the cross sections of both a solid rod and a hollow rod.  
*Terangkan persamaan dan unit yang sepadan yang digunakan untuk mengira Momen Inersia Kutub bagi keratan rentas kedua-dua rod terpadu dan rod berongga.*
- [5 marks]  
[5 markah]
- CLO2 (b) A hollow shaft with an inner diameter of 40 mm and an outer diameter of 80 mm transmits a power of 225 kW at a speed of 2700 revolutions per minute. Calculate:  
*Sebatang aci berongga dengan diameter dalam 40 mm dan diameter luar 80 mm memindahkan kuasa sebanyak 225 kW pada kelajuan 2700 pusingan seminit. Kirakan:*
- i. the torque transmitted by the shaft.  
*tork yang dipindahkan oleh aci.*
- [4 marks]  
[4 markah]
- ii. the maximum shear stress induced in the shaft.  
*tegasan ricih maksimum yang terinduksi dalam aci.*
- [4 marks]  
[4 markah]
- CLO2 (c) Figure 4(c) depicts aluminum rods with a diameter of 30 mm and a length of 400 mm connected in series to a bronze pipe. The bronze pipe has an outer diameter of 30 mm, a length of 200 mm, and carries a torsional load of 225 Nm. It is known that the angle of twist for the bronze pipe is double then the angle of twice for aluminum rod. Determine:  
  
[Consider the modulus of rigidity:  $G_{\text{bronze}} = 45 \text{ GN/m}^2$  and  $G_{\text{aluminum}} = 27 \text{ GN/m}^2$ ].

Rajah 4(c) menunjukkan batang aluminium dengan diameter 30 mm dan panjang 400 mm yang disambung secara bersiri dengan paip gangsa. Paip gangsa itu mempunyai diameter luar 30 mm, panjang 200 mm, dan membawa beban torsion sebanyak 225 Nm. Diketahui bahawa sudut puntiran untuk paip gangsa adalah dua kali ganda sudut puntiran batang aluminium. Tentukan:

[Pertimbangkan modulus kekakuan:  $G_{\text{gangsa}} = 45 \text{ GN/m}^2$  dan  $G_{\text{aluminium}} = 27 \text{ GN/m}^2$ ]

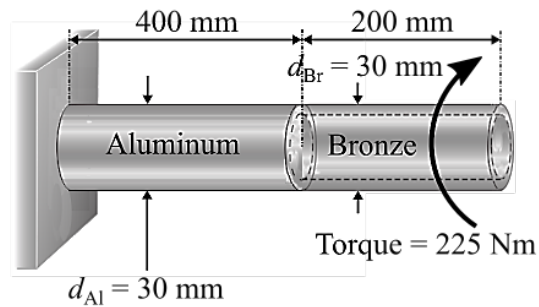


Figure 4(c) / Rajah 4(c)

- i. the allowable shear stress for the Aluminium bar.  
*tegasan ricih yang dibenarkan untuk bar Aluminium.*

[5 marks]

[5 markah]

- ii. the inner diameter of the bronze pipe.  
*diameter dalam bagi paip gangsa.*

[7 marks]

[7 markah]

**SOALAN TAMAT**

## DJJ30103: STRENGTH OF MATERIALS

### FORCES ON MATERIALS

$$P = \sigma A \quad \sigma = \varepsilon E$$

$$v = \frac{\varepsilon_y}{\varepsilon_x} \quad S.F = \frac{\sigma_{ult}}{\sigma_w}$$

$$\% \Delta L = \frac{L_f - L_o}{L_o} \times 100\%$$

$$\% A = \frac{A_o - A_f}{A_o} \times 100\%$$

### THERMAL STRESS AND COMPOSITE BAR

$$\Delta L = \frac{PL}{AE} = \frac{\sigma L}{E}$$

$$\Delta L = \alpha L \Delta t \quad \sigma = E \alpha \Delta t$$

Subjected to force:

#### **Series**

$$P_1 = P_2$$

$$\Sigma \Delta L = L_1 + L_2$$

#### **Parallel**

$$P = P_1 + P_2$$

$$\Delta L_1 = \Delta L_2$$

Subjected to temperature:

#### **Series**

$$\frac{P_1 L_1}{A_1 E_1} + \frac{P_2 L_2}{A_2 E_2} = \Delta t (\alpha_1 L_1 + \alpha_2 L_2)$$

#### **Parallel**

$$\frac{\sigma_1}{E_1} + \frac{\sigma_2}{E_2} = \Delta t (\alpha_b - \alpha_k)$$

### SHEAR FORCE AND BENDING MOMENT

$$\Sigma F \uparrow = \Sigma F \downarrow$$

$$Force = wL \text{ (unit: N)}$$

$$\Sigma M \cup = \Sigma M \cap$$

$$Moment = Fd \text{ (unit: Nm)}$$

### TORSION

$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L}$$

$$P = T\omega$$

$$\omega = \frac{2\pi N}{60}$$

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

#### Series compound

$$T_1 = T_2$$

$$\frac{G_1 \theta_1 J_1}{L_1} = \frac{G_2 \theta_2 J_2}{L_2}$$

$$\Sigma \theta = \theta_1 + \theta_2$$

#### Parallel compound

$$T = T_1 + T_2$$

$$\theta_1 = \theta_2$$

$$\frac{T_1 L_1}{G_1 J_1} = \frac{T_2 L_2}{G_2 J_2}$$

**BENDING STRESS AND BEAM DEFLECTION**

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

$$\bar{y} = \frac{\Sigma Ay}{\Sigma A}$$

$$I_{NA} = \Sigma(I + Ah^2)$$

Shape	Centroid, y	Second Moment of Area, I
	$y = \frac{d}{2}$	$I_{NA} = \frac{bd^3}{12}$
	$y = \frac{d}{2}$	$I_{NA} = \frac{\pi d^4}{64}$
	$y = \frac{4r}{3\pi}$	$I_{NA} = 0.11r^4$
	$y = \frac{h}{3}$	$I_{NA} = \frac{bh^3}{36}$

Beam	Moment, $M_{max}$	Slope, $\theta_{max}$	Deflection, $y_{max}$
	$PL$	$-\frac{PL^2}{2EI}$	$-\frac{PL^3}{3EI}$
	$\frac{wL^2}{2}$	$-\frac{wL^3}{6EI}$	$-\frac{wL^4}{8EI}$
	$\frac{PL}{4}$	$\pm \frac{PL^2}{16EI}$	$-\frac{PL^3}{48EI}$
	$\frac{wL^2}{8}$	$\pm \frac{wL^3}{24EI}$	$-\frac{5wL^4}{384EI}$