UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2005/2006

November 2005

EMM 331/3 – Mekanik Pepejal

Masa : 3 jam

ARAHAN KEPADA CALON :

Sila pastikan bahawa kertas soalan ini mengandungi **LAPAN (8)** mukasurat bercetak, **2 (DUA)** mukasurat lampiran dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan.

Jawab **LIMA (5)** soalan sahaja.

Calon boleh menjawab semua soalan dalam **Bahasa Malaysia** ATAU **Bahasa Inggeris** atau kombinasi kedua-duanya.

Jawapan bagi setiap soalan hendaklah dimulakan pada mukasurat yang baru.

Lampiran

1. Principal slope and deflection for beams with basic loading [1 mukasurat]

2. Formula untuk rasuk melengkung [1 mukasurat]

S1. [a] **Satu pendakap pengandung tekanan akan direka supaya dapat menahan kitar beban tegangan sebanyak 0-500 MN/m^2 sekali setiap hari selama 25 tahun. Manakah jenis keluli berikut yang mempunyai toleransi kecacatan yang lebih besar dalam applikasi ini:**

A pressure vessel support bracket is to be designed so that it can withstand a tensile loading cycle of 0-500 MN/m^2 once every day for 25 years. Which of the following steels would have the greater tolerance to intrinsic defects in this application :

(i) **keluli penuaan (K_{Ic} = 82 MN/m$^{-3/2}$, C = 0.15 x 10^{-11}, m = 4.1), atau**

a maraging steel (K_{Ic} = 82 MN/m$^{-3/2}$, C = 0.15 x 10^{-11}, m = 4.1), or

(ii) **keluli kekuatan sederhana (K_{Ic} = 50 MN/m$^{-3/2}$, C = 0.24 x 10^{-11}, m = 3.3)?**
A medium strength steel (K_{Ic} = 50 MN/m$^{-3/2}$, C = 0.24 x 10^{-11}, m = 3.3)?

Untuk situasi bebanan ini, faktor geometri 1.12 boleh diandaikan. Nota: K_{Ic} = kekuatan patah kritikal mod I; C dan m = pemalar

For the loading situation a geometry factor of 1.12 may be assumed. Note: K_{Ic} = critical fracture toughness for mode I; C and m = constant.

(40 markah)

[b] **Disepanjang servis, satu silinder keluli bergaris pusat 320 mm akan dikenakan tekanan dalam yang berubah daripada 0 ke P MN/m^2. Kekuatan tegangan keluli ialah 440 MN/m^2 dan had ketahanan lesu dalam kitar balikan penuh ialah 210 MN/m^2. Jika tebal dinding silinder ialah 8 mm, anggarkan nilai maksima P yang dibenarkan supaya silinder tersebut dapat mengelak daripada mengalami kegagalan lesu.**
[Faktor pengurangan kekuatan lesu boleh diandaikan sebanyak 1.8 dan hubungkait pengubahsuai Goodman mesti digunakan untuk kesan purata].

During service a steel cylinder of 320 mm diameter, is to be subjected to an internal pressure which varies from 0 to P MN/m^2. The tensile strength of the steel is 440 MN/m^2 and the fatigue endurance limit in fully reversed cycling is 210 MN/m^2. If the wall thickness of the cylinder is 8 mm estimate the maximum permissible value of P to avoid fatigue failure in the cylinder.
[A fatigue strength reduction factor of 1.8 may be assumed and the modified Goodman relationship should be used for the mean effect].

(60 markah)

S2. [a] **Rajah S2[a] menunjukkan satu rasuk prisma AB dikenakan beban P pada D.**

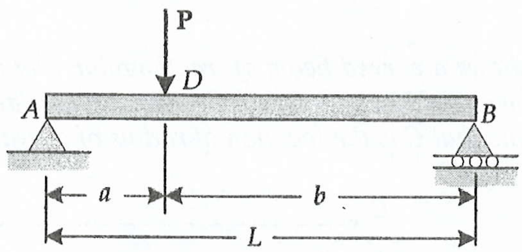
Figure Q2[a] shows a prismatic beam AB subjected to a load P at D.

(i) **Dengan mengambil kira hanya kesan tegasan normal disebabkan oleh lenturan, tentukan tenaga terikan rasuk prisma AB dalam ungkapan pembolehubah yang berkaitan.**

Taking into account only the effect of normal stresses due to bending, determine the strain energy of the prismatic beam AB in terms of the relevant variables.

(ii) **Kirakan tenaga terikan dengan mengetahui parameter berikut: P = 178 kN, L = 3.6 m, a = 0.9 m, b = 2.7 m, I = 104 x 10^6 mm ^{4} dan E = 200 GPa.**

Evaluate the strain energy, knowing that the beam is a W250 x 67, P = 178 kN, L = 3.6 m, a = 0.9 m, b = 2.7 m, I = 104 x 10^6 mm ^{4} and E = 200 GPa.

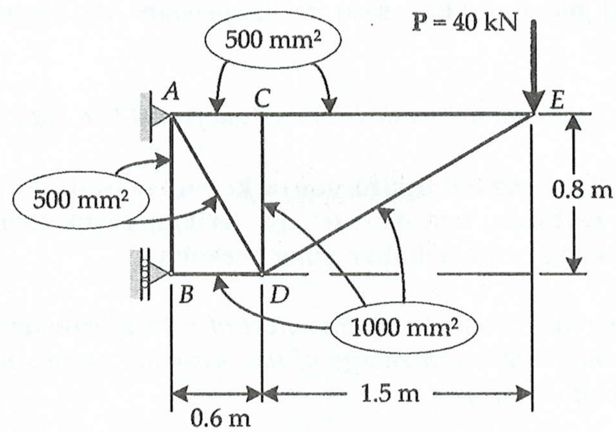


Rajah S2[a]
Figure Q2[a]

(30 markah)

[b] **Satu kekuda dikenakan beban seperti yang ditunjukkan dalam Rajah S2[b]. Tentukan pesongan menegak pada titik C. Guna modulus Young E = 73 GPa. Luas keratan rentas untuk setiap anggota adalah seperti berikut: AC=CE=AD=AB= 500 mm^2 and CD=BD=DE= 1000 mm^2.**

A truss is subjected to single loading at joint E as shown in Figure Q2[b]. Determine the vertical deflection at point C. Use Young modulus, E equals to 73 GPa. The cross-sectional areas for each member are as follows: AC=CE=AD=AB= 500 mm^2 and CD=BD=DE= 1000 mm^2.

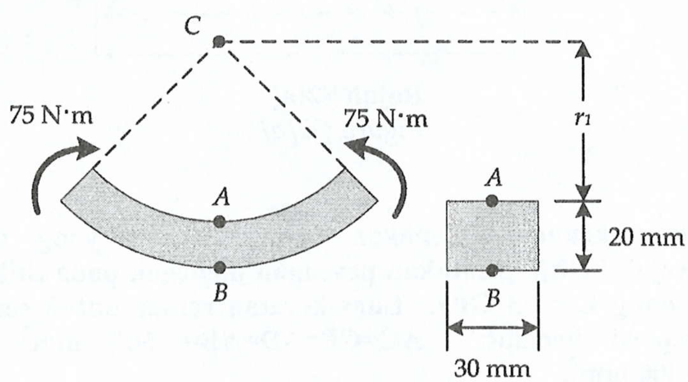


Rajah S2[b]
Figure Q2[b]

(70 markah)

S3. [a] **Rajah S3[a] menunjukkan rasuk melengkung berkeratan rentas segi empat dikenakan beban momen 75 N.m. Tentukan tegasan pada titik A dan B apabila r_1 = 40 mm. Ambil perhatian bahawa C ialah lokasi jejari lengkungan.**

Figure Q3[a] shows a curved beam of rectangular cross section subjected to end loading moment of 75 N.m. Determine the stresses at point A and B when r_1 = 40 mm. Note that C is the location of radius of curvature.

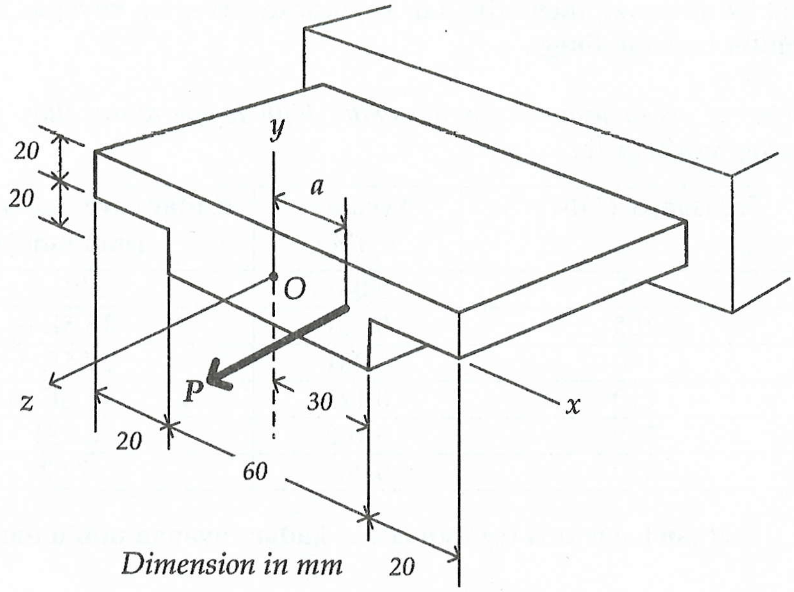


Rajah S3[a]
Figure Q3[a]

(40 markah)

[b] **Bebań mengufuk P dikenakan ke atas rasuk seperti yang ditunjukkan dalam Rajah S3[b]. Dengan mengetahui a = 20 mm dan tegasan dalam rasuk tidak melebihi 75 MPa, tentukan beban P yang paling besar.**

*A horizontal load **P** is applied to the beam as shown in Figure Q3[b]. Knowing that a = 20 mm and the stress in the beam does not exceed 75 MPa, determine the largest permissible load **P**.*



Rajah S3[b]
Figure Q3[b]

(60 markah)

S4. [a] (i) Lakarkan graf bagi menunjukkan tahap-tahap rayapan dalam logam seperti berikut ketika berlakunya:

Plot a creep curve for metal illustrating instantaneous deformation, primary stage, steady state (secondary), and tertiary stage.

- **ubah bentuk**
  deformation
- **primer**
  primary
- **sekunder**
  secondary
- **dan tahap tertiari**
  and tertiary level

(ii) Jelaskan ciri-ciri penting bagi setiap tahap-tahap rayapan tadi.

Explain the characteristic behavior for each curve.

(20 markah)

[b] **Jadual S4 di bawah menunjukkan keputusan siri ujian rayapan bagi aloi austenitik bersuhu tinggi.**

A series of creep tests on an austenitic high temperature alloy gave the following results in Table Q4:

Tegasan, σ (MN/m^2)	**Terikan, ε_o (%)**	**Kadar rayapan minimum $\dot{\varepsilon}$ (mm/mm/jam)**
70	0.041	27E-8
105	0.061	15.5E-6
140	0.081	27.5E-5
210	0.122	15.8E-3
280	0.162	0.281
350	0.203	2.62

(i) **Plotkan logaritma tegasan lawan kadar rayapan minimum.**

Plot a graph of log σ against $\dot{\varepsilon}_{min}$.

(30 markah)

(ii) **Carikan nilai pemalar B dan n dalam hubungan $\Delta\varepsilon/\Delta t = B\sigma^n$.**

From the graph obtained, calculate values of constants B and n in the relationship $\Delta\varepsilon/\Delta t = B\sigma^n$.

(20 markah)

(iii) **Berapa lamakah masa yang diperlukan sebelum tegasan stabil 125 MN/m^2 mengakibatkan terikan sebanyak 2% pada bahan ini.**

Calculate how long would elapse before a steady stress of 125 MN/m^2 would cause a strain of 2% in this material.

(30 markah)

S5. [a] **Nyatakan dengan ringkas tiga kaedah bagi mengurangkan kesan penumpuan tegasan ke atas plat atau aci yang keluasannya berkurangan.**

Briefly explain any three ways to reduce stress concentration effect for a plate or shaft with area reduction.

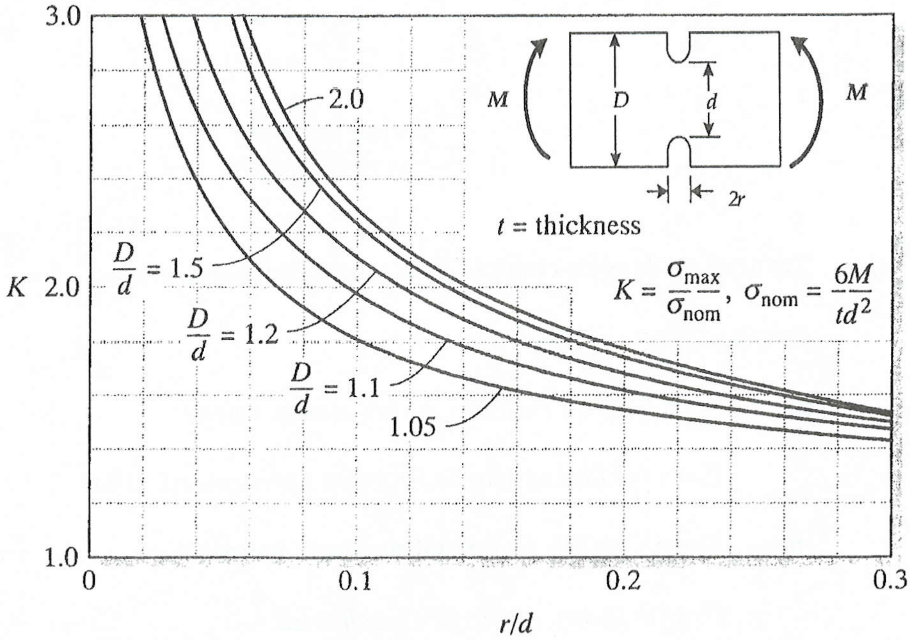
(30 markah)

[b] **Bar rata dalam graf S5[b] berada dalam keadaan lentur tulin. Berapakah peratusan momen maksimum pada bar perlu ditingkatkan setelah bahannya dikurangkan dengan menukarkan alur dalam pada Rajah S5[b](i) kepada alur separa dalam seperti pada Rajah S5[b](ii)**

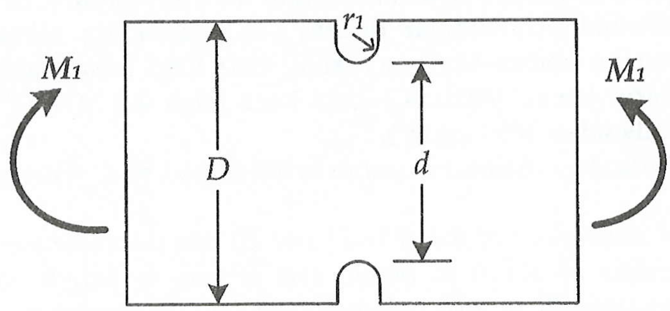
Andaikan kedua-dua bar mempunyai ketebalan, *t* dan sifat bahan yang sama. (Nilai tegasan yang dikenakan adalah sama).

The flat bars in graph Q5 [b] are subjected to pure bending. By what percentage can the maximum moment in the bar be increased by removing material in order to convert the deep grooves of Figure Q5[b][i] to the semicircular grooves as shown in Figure Q5[b][ii]?

Assume that both bars have the same thickness t and are made of the same material. (They have the same allowable stress).

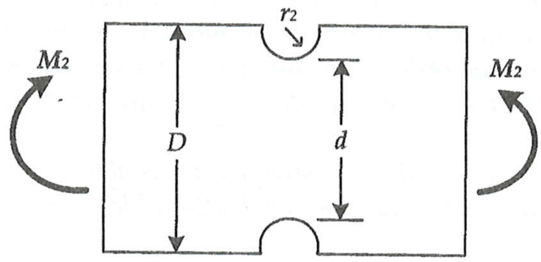


Graf S5[b]
Graph Q5[b]



$$\frac{D_1}{d_1} = 1.5, \frac{d_1}{r_1} = 8, t_1 = t$$

Rajah S5[b][i]
Figure Q5[b][i]



$$\frac{D_2}{d_2}=1.5, \frac{d_2}{r_2}=4, t_2=t$$

Rajah S5[b][ii]

Figure Q5[b][ii]

(70 markah)

S6. [a] Terangkan dengan ringkas perkara-perkara berikut:

Briefly explain the followings:

(i) Asas kepada mekanik patah elastik linear.

Basis for Linear Elastic Fracture Mechanics(LEFM).

(ii) Teori Griffith mengenai mekanik kepatahan.

Griffith theory of fracture mechanics.

(30 markah)

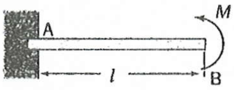
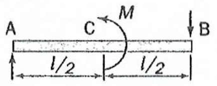
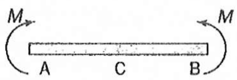
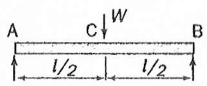
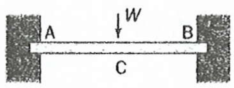
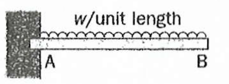
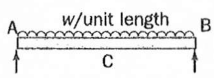
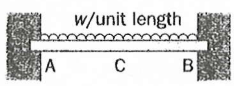
[b] Sekeping kaca yang lebarnya 0.4 m dan 20 mm tebal mengalami retak permukaannya sedalam 5 mm dan sepanjang 10 mm. Jika kaca itu diletakkan mendatar di atas dua penyokong, kirakan jarak maksimum antara kedua-dua penyokong tadi bagi mengelakkan keretakan akibat berat kaca. (Nilai K_{IC} bagi kaca ialah 0.3 $MNm^{-3/2}$ dan ketumpatannya pula ialah 2600 kg/m^3).
Nota: K_{Ic} = kekuatan patah kritikal mod I; C = pemalar.

A sheet glass of 0.4 m wide and 20 mm thickness have a number of surface cracks of 5 mm in depth, and 10 mm in length. If the glass is placed horizontally on two supports, calculate the maximum spacing of the supports to avoid fracture on the glass due to its own weight. Given the value of K_{IC} = 0.3 $MNm^{-3/2}$ and the density, ρ = 2600 kg/m^3.
Note: K_{Ic} = critical fracture toughness for mode I; C = constant.

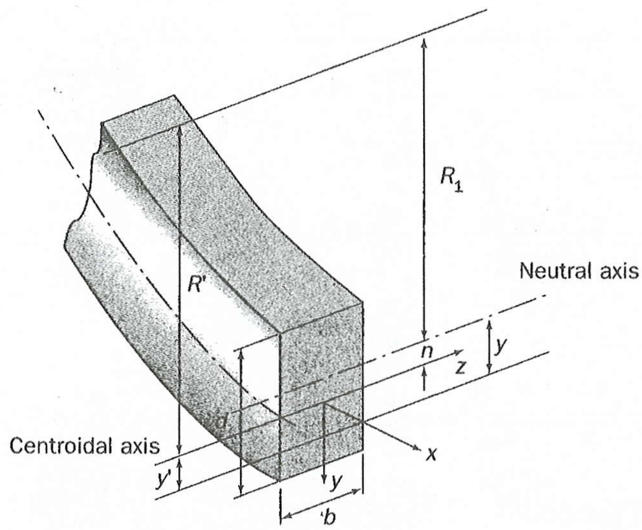
(70 markah)

-oooOOooo-

Principal slope and deflection for beams with basic loading

		Slope	Deflection
(*a*)		$-\dfrac{Ml}{EI}$ at B	$-\dfrac{Ml^2}{2EI}$ at B
(*b*)		$-\dfrac{Ml}{12EI}$ at C $+\dfrac{Ml}{24EI}$ at A, B	0 at C
(*c*)		$\pm\dfrac{Ml}{2EI}$ at A, B	$+\dfrac{Ml^2}{8EI}$ at C
(*d*)		$+\dfrac{Wl^2}{2EI}$ at B	$+\dfrac{Wl^3}{3EI}$ at B
(*e*)		$\pm\dfrac{Wl^2}{16EI}$ at A, B	$+\dfrac{Wl^3}{48EI}$ at C
(*f*)		0 at A, B, C	$+\dfrac{Wl^3}{192EI}$ at C
(*g*)		$+\dfrac{wl^3}{6EI}$ at B	$+\dfrac{wl^4}{8EI}$ at B
(*h*)		$\pm\dfrac{wl^3}{24EI}$ at A, B	$+\dfrac{5wl^4}{384EI}$ at C
(*i*)		0 at A, B, C	$+\dfrac{wl^4}{384EI}$ at C

Formula untuk rasuk melengkung



Rectangular section

$$n = R' - \frac{d}{\log_e[(R' + d/2)/(R' - d/2)]}$$

Circular section of radius r

$$n = R' - \frac{r^2}{2[R' - (R'^2 - r^2)^{1/2}]}$$