
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2008/2009

April/May 2009

EAS 152/3 – Strength Of Materials
[Kekuatan Bahan]

Duration: 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of **NINETEEN (19)** printed pages including appendix before you begin the examination.

*[Sila pastikan kertas peperiksaan ini mengandungi **SEMBILAN BELAS (19)** muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions: This paper consists of **SIX (6)** questions. Answer **FIVE (5)** questions only. All questions carry the same marks.

*[**Arahan:** Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan sahaja. Semua soalan membawa jumlah markah yang sama.]*

You are required to provide your answers for Question 2(a) and 2(b) on Attachment I and Attachment II which are attached together with the question book. Attachment I and Attachment II must be detached from the question book and submit together with your answer script.

*[**Arahan:** Anda dikehendaki memberikan jawapan kepada Soalan 2(a) and 2(b) diatas Lampiran I dan Lampiran II yang disertakan bersama buku soalan. Lampiran I dan Lampiran II hendaklah diasingkan daripada buku soalan dan dihantar sekali bersama dengan buku jawapan anda.]*

You may answer the question either in Bahasa Malaysia or English.

[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

All questions **MUST BE** answered on a new page.

*[Semua soalan **MESTILAH** dijawab pada muka surat baru.]*

Write the answered question numbers on the cover sheet of the answer script.

[Tuliskan nombor soalan yang dijawab di luar kulit buku jawapan anda.]

1. Figure 1 shows a vertical bar ABC which is pin supported at its upper end A and loaded by a force of 3.5kN at its lower end C. A horizontal rigid bar BDE is pinned to the vertical bar at joint B and supported by a pin joint at D. Pin at B is designed to be in single shear with diameter of 12.5mm. Figure 2 shows the detail of bolt connection at joint D. The beam is loaded by a force 6.5kN at end E. The vertical bar ABC is made of steel portion AB and aluminium portion BC with modulus of elasticity given as follows: for steel $E_S = 210\text{GPa}$ and for aluminium $E_A = 72\text{GPa}$. Sizes of cross-section for portion AB and BC of vertical bar are as follows: portion AB – 50mm (width) and 10mm (thickness); portion BC : 40mm (width) and 10mm (thickness). For beam BDE, the size of cross-section is as follows : 50mm (width) and 10mm (thickness).

Calculate:

- i) Normal stress in portion AB and BC of vertical bar ABC [6 Marks]
- ii) Shear stress in bolt at joint D [3 Marks]
- iii) Bearing stress between gusset plate and bolt at joint D [3 Marks]
- iv) Shear stress in pin at joint B [2 Marks]
- v) Vertical displacement of point E [6 Marks]

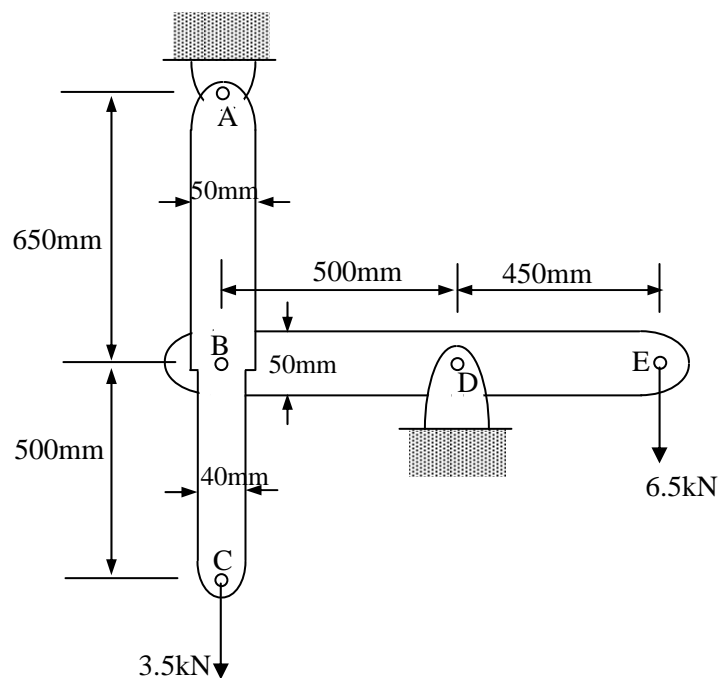


Figure 1

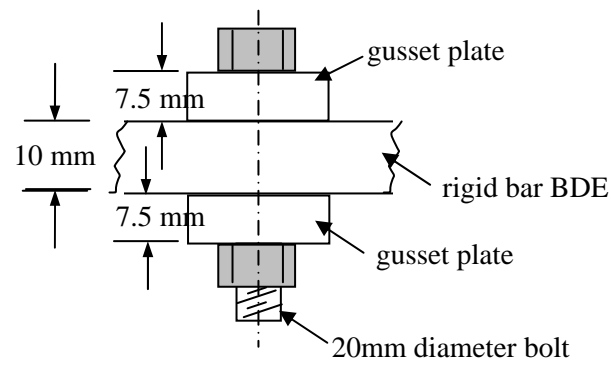


Figure 2

2. a) Figure 2(a) shows the Mohr's circle for the stressed element shown in Figure 2(b). Using the Mohr's circle given, determine the normal and shear stress on the inclined plane m-m indicated in Figure 2(b). Provide the solution to your answer on Attachment I.

[4 Marks]

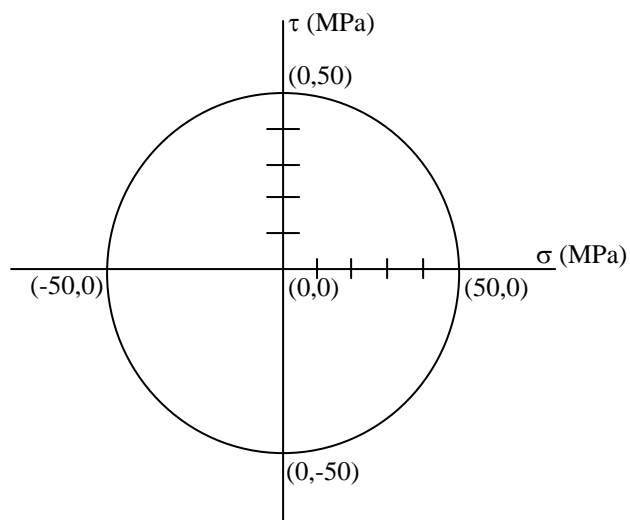


Figure 2(a)

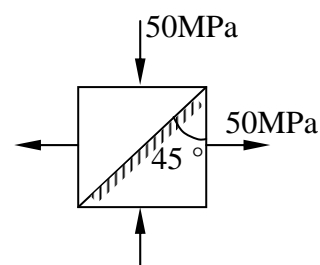


Figure 2(b)

- b) Figure 3(c) shows the Mohr's circle for the state of stress of the element shown in Figure 3(d). Show the stresses represented by points P(9,24) and S(9,-24) in a properly oriented element. Provide the solution to your answer on Attachment II.

[4 Marks]

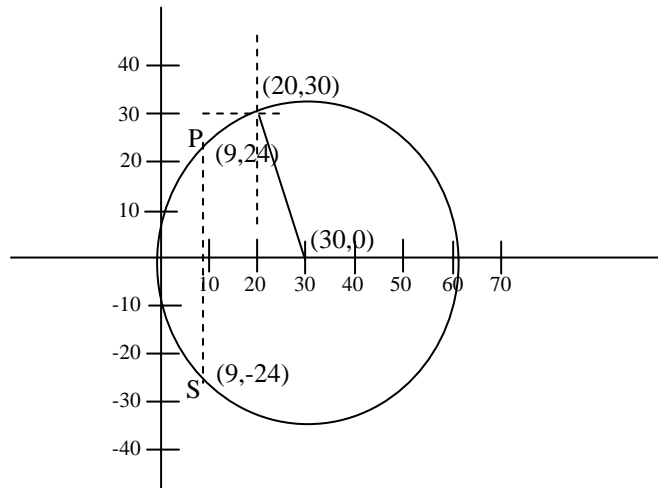


Figure 3(c)

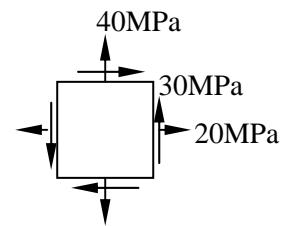


Figure 3(d)

- c) Draw the Mohr's circle for the state of stress shown in Figure 4. Using the Mohr's circle obtained, determine:

- i) The principal stresses and the principal planes.

[6 Marks]

- ii) The maximum and minimum shear stresses, the associated normal stresses and the planes.

[6 Marks]

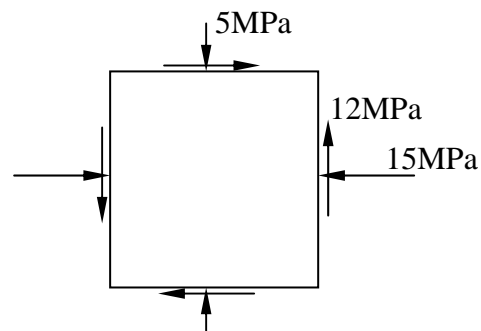
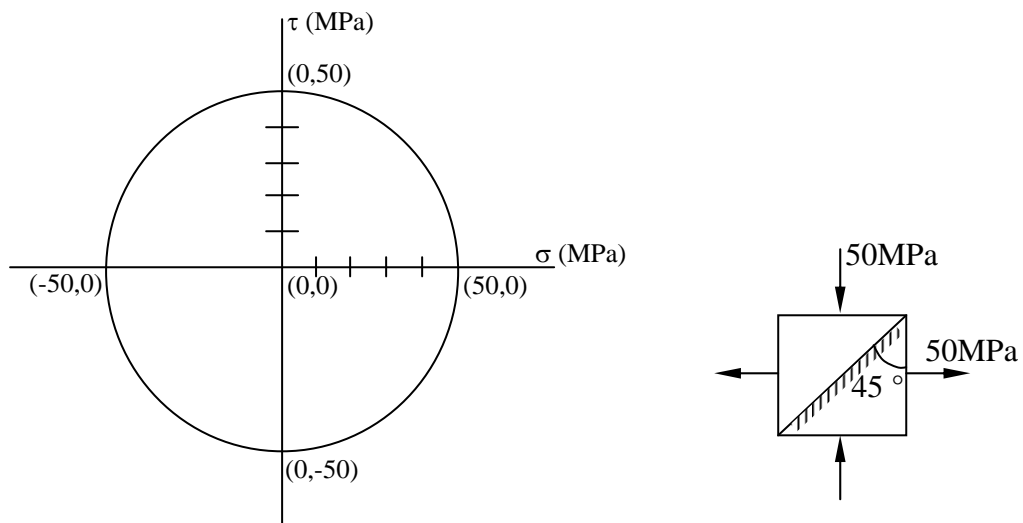


Figure 4

Attachment I**Subject : EAS152****Angka Giliran :**

For Question 2(a)

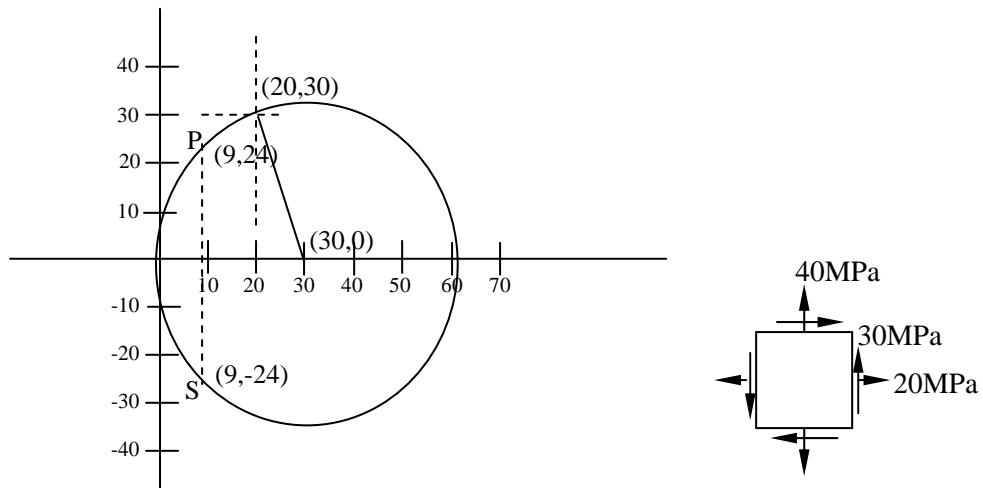
(This page must be submitted together with your answer scripts)



Attachment II**Subject : EAS152****Angka Giliran :**

For Question 2(b)

(This page must be submitted together with your answer scripts)



3. A moment load of 2400 N.m is applied at the free end of a hollow 1.5 m long cantilever shaft having inner diameter of 40 mm and outer diameter of 60 mm.
- Determine the maximum shearing stress developed in the shaft.
[10 Marks]
 - Find the diameter of a solid shaft under the maximum shearing stress condition in (i).
[5 Marks]
 - If the shaft is solid having a diameter of 65 mm, calculate the angle of twist under the same loading condition (Use $G = 77 \text{ GPa}$).
[5 Marks]
4. A beam as shown in Figure 5 is carrying a 20 kN concentrated load at B and three uniformly distributed loads of 15 kN/m, 5 kN/m and 10 kN/m along segment AB, BC and CD, respectively. The beam is pinned at A and supported by a roller at C.
- Derive the shear force and moment function in terms of x for segment AB, BC and CD of the beam. State clearly the origin point and the range of x taken, in order to derive the functions for each segment of the beam.
[12 Marks]
 - Draw the shear force and bending moment diagram for the beam.
[4 Marks]
 - If it is given that the allowable bending stress and shear stress of the material used for the beam are $\sigma_{b,all} = 8.0 \text{ MPa}$ and $\tau_{all} = 0.8 \text{ MPa}$, respectively, propose the height of rectangular beam which is safe to be used with a factor of safety 1.5 so that it can resist the highest bending moment of the beam. Take the width of the beam as 150 mm.
[4 Marks]

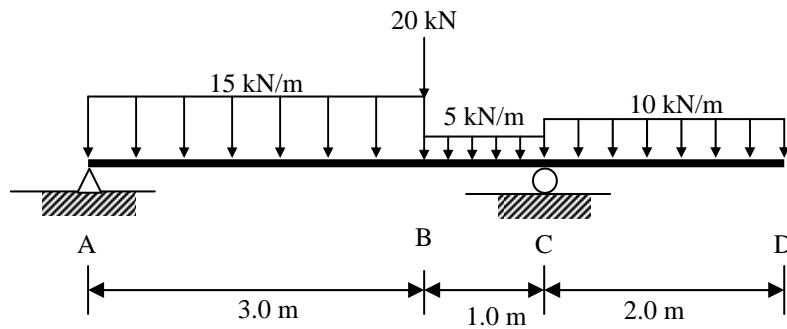


Figure 5

5. a) Define actual length, effective length and Euler buckling load.

[4 Marks]

- b) Columns can be categorized by their slenderness ratio. Define slenderness ratio and state **THREE (3)** types of column according to slenderness ratio as well as the range of each category.

[4 Marks]

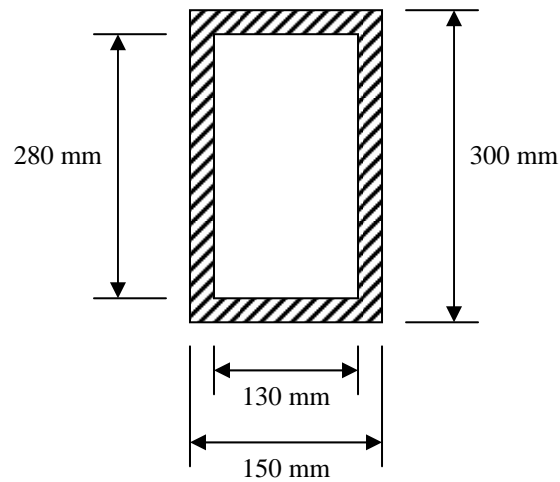
- c) A rectangular hollow section as shown in Figure 6 is to be used as a column with one end fixed and another end pin jointed. The actual length of the column is 5.5 m. Take modulus of elasticity as 210 GPa.

- (i) Calculate the radius of gyration for the section.
- (ii) Calculate the slenderness ratio of the column.
- (iii) Determine the Euler buckling load.
- (iv) Determine the maximum load that can be supported by the column with a factor of safety of 2.0.

[10 Marks]

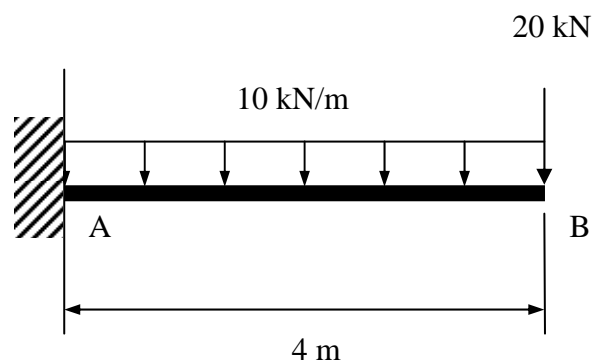
- d) Suggest one way to increase the column load carrying capacity without changing the cross section of the column. No calculation is needed.

[2 Marks]

**Figure 6**

6. a) Figure 7 shows a beam carrying a uniformly distributed load of 10 kN/m along segment AB and a concentrated load of 20 kN at B. Compute the deflection of the beam at B. Use the double integration method. Given the modulus of elasticity and second moment of inertia of the beam are 200GPa and $3.125 \times 10^6 \text{ mm}^4$, respectively

[10 Marks]

**Figure 7**

- b) Figure 8 shows a structure consisting of two members, ACD and BC, which is used to support a horizontal load P . Link BC is 4mm thick and 12.5mm wide. Link BC is connected to support B and joint C using pin with diameter 5mm. Given that the allowable bearing stress between the link and pin at B, C is 200N/mm^2 and the allowable maximum tensile stress in link BC is 175N/mm^2 , determine the maximum load P_{max} that the structure is able to carry.

[10 Marks]

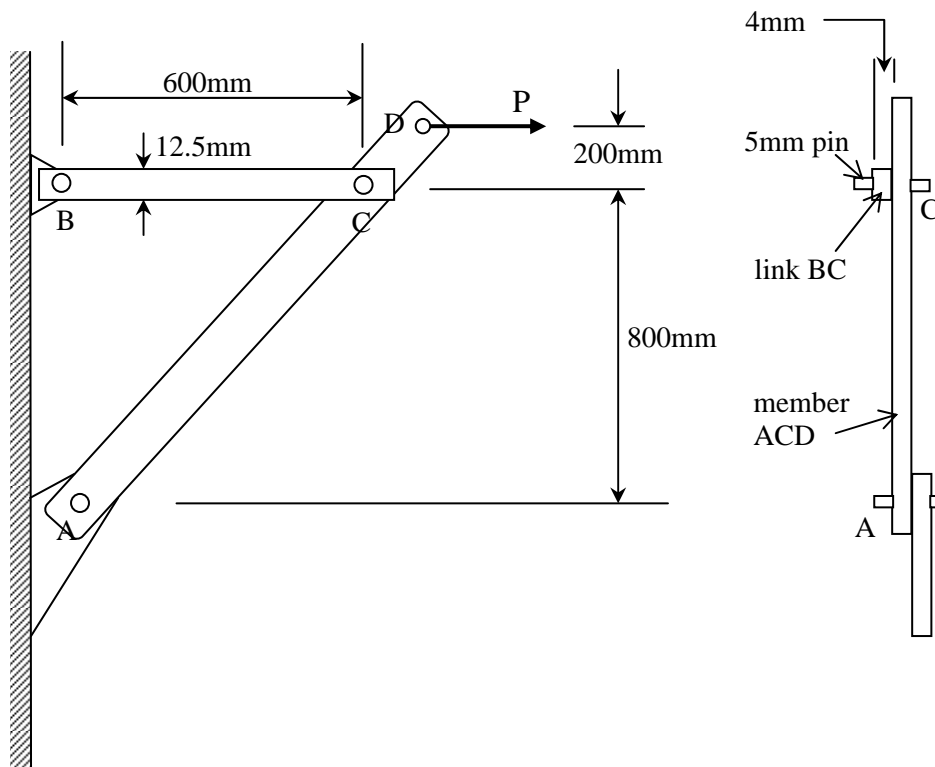


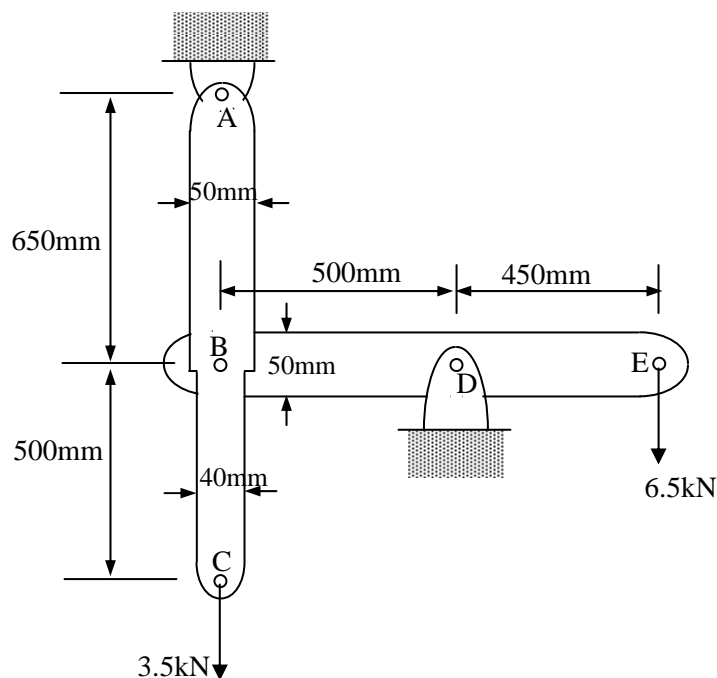
Figure 8

(TERJEMAHAN)

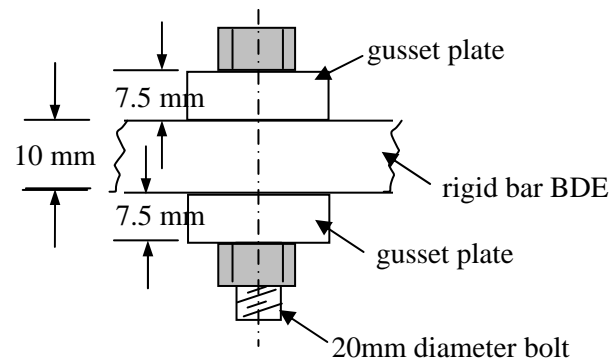
1. Rajah 1 menunjukkan satu bar pugak ABC yang disokong dengan sambungan jenis pin pada hujung atas A dan dikenakan satu beban 3.5kN pada hujung bawah C. Satu bar ufuk tegar BDE yang disambung kepada bar pugak pada sambungan B dan disokong melalui satu sambungan bolt pada D. Pin pada sambungan B direkabentuk sebagai pin dalam keadaan ricih tunggal dengan garispusat 12.5mm. Butir sambungan bolt pada D ditunjukkan dalam Rajah 2. Bar ufuk tegar berkenaan dikenakan satu beban 6.5kN pada hujung E. Bar pugak terdiri daripada bahagian keluli AB dan bahagian aluminium BC. Nilai modulus keanjalan adalah seperti berikut: untuk keluli $E_S = 210\text{GPa}$ dan untuk aluminium $E_A = 72\text{GPa}$. Saiz keratan bahagian AB dan BC bar pugak ABC adalah seperti berikut: bahagian AB – 50mm (lebar) dan 10mm (tebal); bahagian BC – 40mm (lebar) dan 10mm (tebal). Untuk bar ufuk tegar BDE, saiz keratan adalah seperti berikut: 50mm (lebar) dan 10mm (tebal).

Kirakan :

- i) Tegasan normal dalam bahagian AB dan BC bar pugak ABC [6 Markah]
- ii) Tegasan ricih dalam bolt pada sambungan D [3 Markah]
- iii) Tegasan ricih dalam pin pada sambungan B [3 Markah]
- iv) Tegasan galas antara plat gusset dan bolt pada sambungan D [2 Markah]
- v) Anjakan pugak titik E [6 Markah]



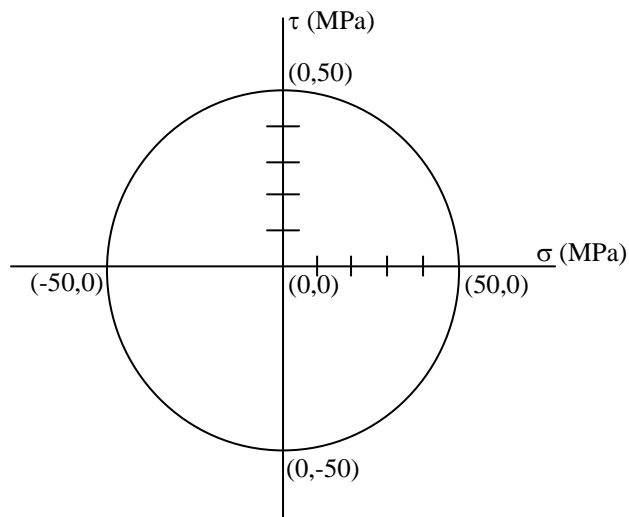
Rajah 1



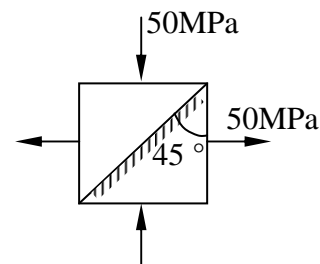
Rajah 2

2. a) Rajah 2(a) menunjukkan bulatan Mohr untuk elemen tertegas dalam Rajah 2(b). Dengan menggunakan bulatan Mohr yang diberi, tentukan tegasan normal dan ricih atas satah condong $m-m$ yang ditunjukkan dalam Rajah 2(b). Berikan penyelesaian anda di atas Lampiran I.

[4 Markah]



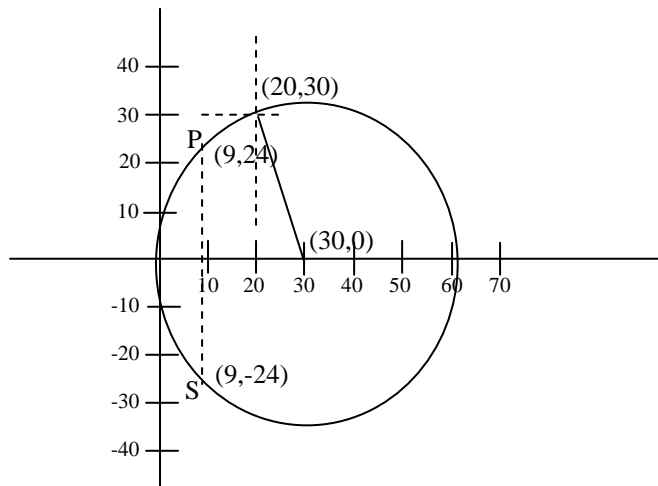
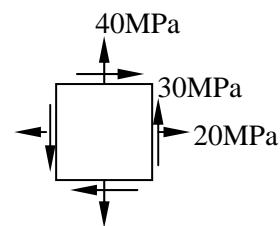
Rajah 2(a)



Rajah 2(b)

- b) Rajah 3(c) menunjukkan bulatan Mohr untuk keadaan tegasan untuk elemen dalam Rajah 3(d). Tunjukkan tegasan yang diwakili oleh titik $P(9,24)$ dan $S(9,-24)$ dalam satu elemen dengan orientasi yang bersesuaian. Berikan penyelesaian anda di atas Lampiran II.

[4 Markah]

**Rajah 3(c)****Rajah 3(d)**

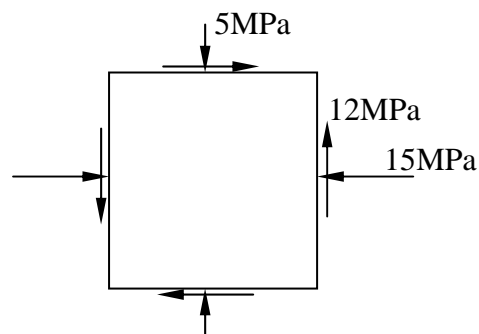
- c) Lukiskan bulatan Mohr untuk keadaan tegasan yang ditunjukkan dalam Rajah 4. Dengan menggunakan bulatan Mohr yang diperolehi, tentukan:

- i) Tegangan utama dan satah utama

[6 markah]

- ii) Tegangan ricih maksima dan minima, tegasan normal yang berkaitan dan satah yang berkaitan.

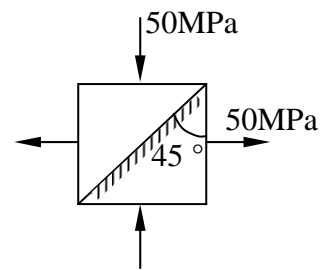
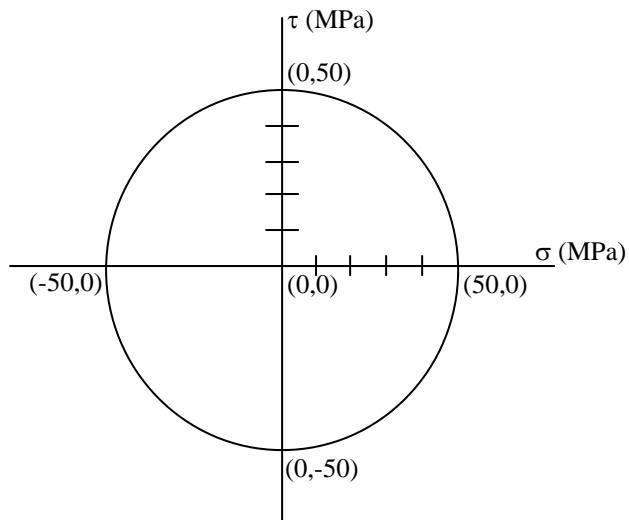
[6 markah]

**Rajah 4**

Lampiran I**Kursus** : EAS152**Angka Giliran** :

Untuk Soalan (a)

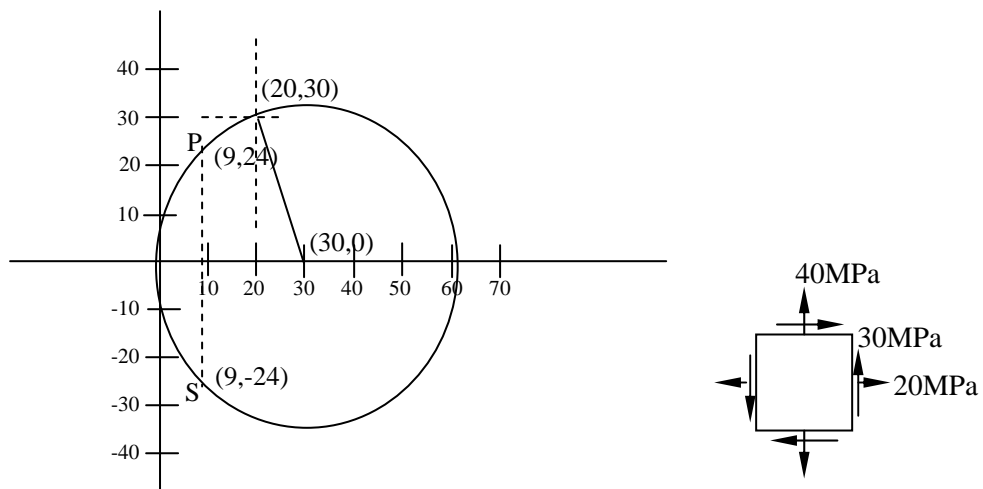
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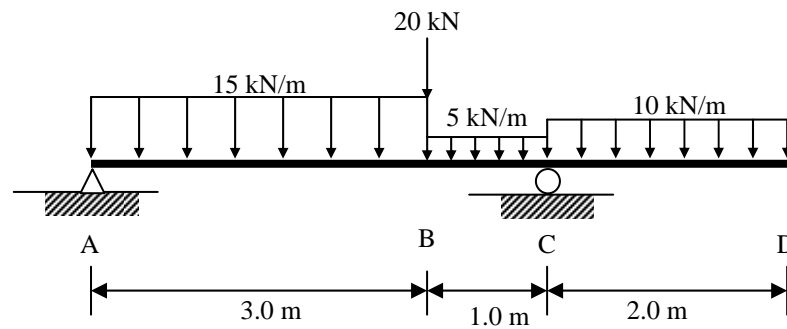
Lampiran II**Kursus** : **EAS152****Angka Giliran** :

Untuk Soalan 2(b)

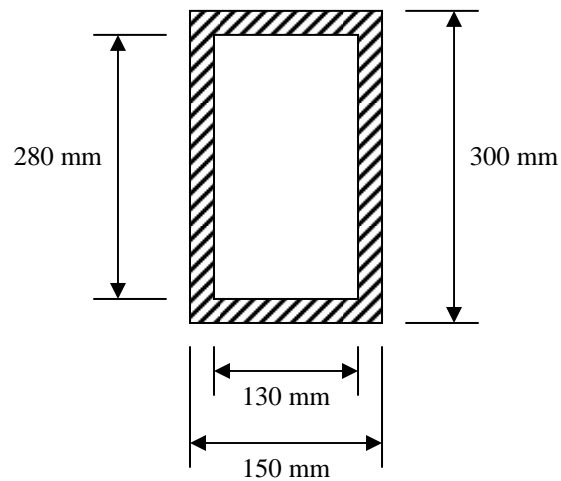
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3. Satu beban momen 2400Nm dikenakan di hujung bebas satu aci julur geronggang sepanjang 1.5m yang mempunyai garis pusat dalam 40 mm dan garis luar 60 mm.
- i) Tentukan tegasan ricih maksimum yang terhasil dalam aci tersebut.
[10 Markah]
- ii) Cari garis pusat untuk satu aci di bawah nilai tegasan ricih maksimum seperti dalam (a).
[5Markah]
- iii) Sekiranya aci ialah padu dan mempunyai garis pusat 65 mm, kira sudut piuh di bawah keadaan beban yang sama. (Guna $G = 77 \text{ Gpa}$).
[5Markah]
4. Satu rasuk ditunjukkan dalam Rajah 5 menanggung beban titik 20 kN dan tiga beban teragih seragam 15 kN/m, 5 kN/m and 10 kN/m masing-masing di sepanjang rentang AB, BC dan CD. Rasuk tersebut disokong pin di A dan disokong rola di C.
- a) Terbitkan fungsi daya ricih dan momen dalam sebutan x bagi bahagian AB, BC dan CD rasuk tersebut. Nyatakan dengan jelas titik asalan dan had nilai x yang digunakan untuk menerbitkan fungsi-fungsi tersebut bagi setiap bahagian rasuk.
[12 Markah]
- b) Lukiskan gambarajah daya ricih dan momen lentur bagi rasuk tersebut.
[4 Markah]
- c) Jika tegasan lentur dan tegasan ricih yang dibenarkan bagi bahan yang digunakan untuk rasuk tersebut masing-masing ialah $\sigma_{b,all} = 8.0\text{MPa}$ and $\tau_{all} = 0.8\text{MPa}$, cadangkan ketinggian rasuk segiempat tepat yang selamat digunakan dengan faktor keselamatan 1.5 supaya ia dapat menanggung nilai momen tertinggi rasuk tersebut. Lebar rasuk ialah 150 mm
[4 Markah]

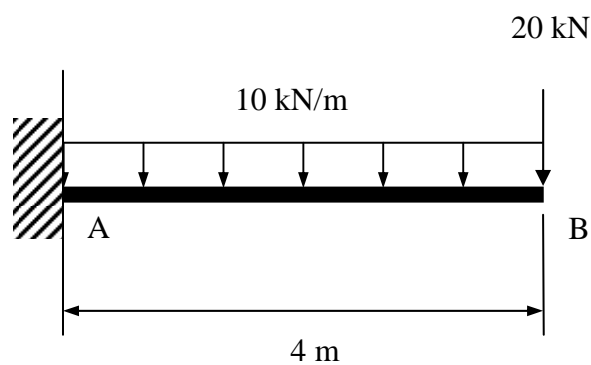
**Rajah 5**

5. a) Berikan takrif bagi panjang sebenar, panjang efektif dan beban lengkok Euler. [4 Markah]
- b) Tiang boleh dikategorikan berdasarkan nisbah kelangsingan. Berikan takrif nisbah kelangsingan dan nyatakan **TIGA (3)** jenis tiang berdasarkan nilai nisbah kelangsingan tersebut serta nyatakan julatnya untuk setiap kategori. [4 Markah]
- c) Satu keratan segiempat bergeronggang tepat seperti ditunjukkan dalam Rajah 6 akan digunakan sebagai tiang dengan satu hujungnya diikat tegar dan hujung yang lain disokong pin. Tinggi sebenar tiang tersebut ialah 5.5m. Ambil modulus keanjalan sebagai 210 GPa.
- (i) Kira jejari legaran bagi keratan
 - (ii) Kira nisbah kelangsingan tiang
 - (iii) Tentukan beban lengkok Euler
 - (iv) Tentukan beban maksimum yang boleh ditanggung tiang dengan faktor keselamatan 2.0
- [10 Markah]
- d) Berikan cadangan satu cara untuk meningkatkan keupayaan menanggung beban tiang tanpa mengubah keratan rentas tiang tersebut. Pengiraan tidak diperlukan. [2 Markah]

**Rajah 6**

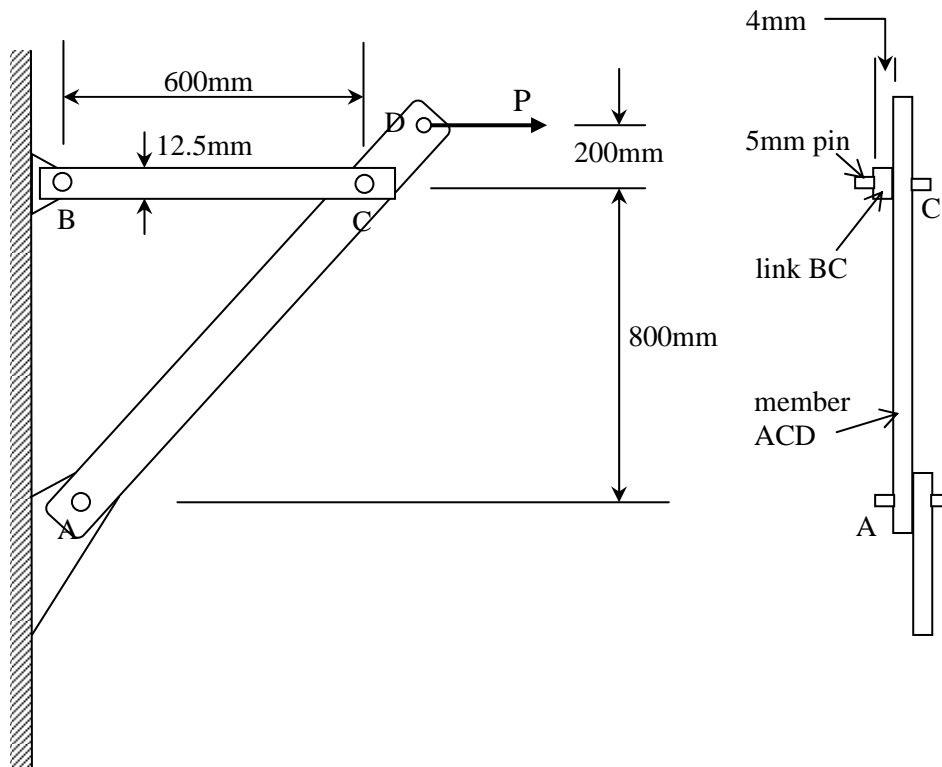
6. a) Rajah 7 menunjukkan satu rasuk yang ditindaki beban teragih seragam iaitu 10 kN/m disepanjang bahagian AB dan beban tumpu 20 kN di B. Kirakan lenturan di B rasuk tersebut. Guna kaedah kamiran berganda. Diberi modulus keanjalan dan momen inersia masing-masing adalah 200 GPa and $3.125 \times 10^6 \text{ mm}^4$.

[10 Markah]

**Rajah 7**

- b) Rajah 8 menunjukkan satu struktur terdiri daripada dua anggota, ACD dan BC, yang digunakan untuk menyokong satu beban ufuk P . Penghubung BC adalah 4mm tebal dan 12.5mm lebar. Penghubung BC disambung kepada penyokong B dan sambungan C dengan pin yang bergarispusat 5mm. Diberikan bahawa tegasan gelas dibenarkan antara penghubung BC dan pin pada B, C adalah 200N/mm^2 manakala tegasan tegangan maksima dibenarkan dalam penghubung BC adalah 175N/mm^2 , tentukan beban maksima P_{max} yang boleh ditanggung oleh struktur berkenaan.

[10 Markah]

**Rajah8**

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