UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2009/2010

November 2009

EAS 253/3 – Theory of Structures
[Teori Struktur]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of **EIGHTEEN (18)** pages of printed material including appendices.
*[Sila pastikan kertas peperiksaan ini mengandungi **LAPAN BELAS (18)** muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

[Instructions: This paper contains **SEVEN (7)** questions. Answer **THREE (3)** compulsory questions in Part A and choose **TWO (2)** questions in Part B.
*[**Arahan**: Kertas ini mengandungi **SEVEN (7)** soalan. Jawab **THREE (3)** soalan wajib di Bahagian A dan pilih **DUA (2)** soalan di Bahagian B]*

You may answer the questions 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.]

In the event of any discrepancies, the English version shall be used

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai]

PART A : Answer all THREE   (3) questions

1.(a)   Sketch qualitative deflected shape for the frames shown together with their corresponding bending moment diagrams in Figure 1 and Figure 2 below. Bending moment diagram for each of the frame is drawn on the compression side. Write your answers on Attachment 1.
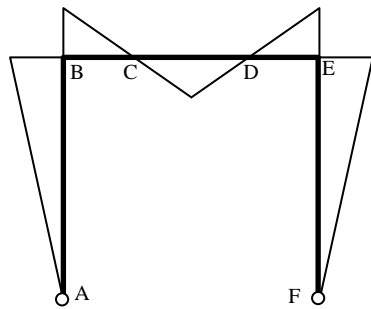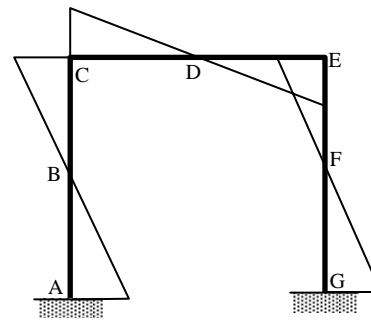
(3 marks)

Figure 1   **Figure 2**

b)   Figure 3 shows a beam structure with pinned support at A, roller supports at B, D and hinge joint at C. The beam is loaded with a uniformly distributed load 10kN/m and 20kN/m along spans AB and BCD, respectively; a linearly distributed load varying from 20kN/m at D until 0kN/m at E along overhang span DE; and a couple 20kNm at free end E. Draw the shear force and bending moment diagrams for the beam.   Sketch also the qualitative deflected shape.
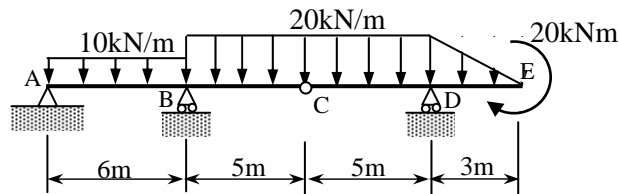
(17 marks)

Figure 3

ATTACHMENT 1

EAS253

Angka Giliran:

Write your answer to Question 1(a) on this page. Sketch the qualitative deflected shape on the figure given below the bending moment diagram of each frame. You are required to indicate clearly all points shown in the bending moment diagram on the qualitative deflected shape. This page must be separated from the question book and submitted together with your answer booklet.
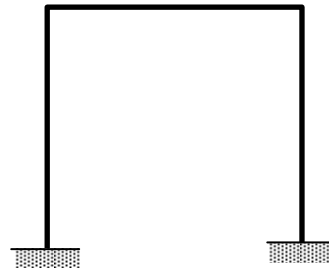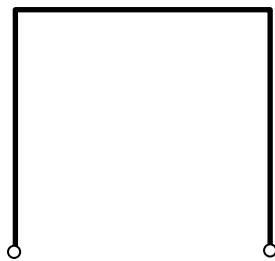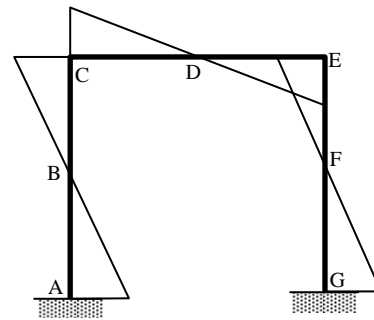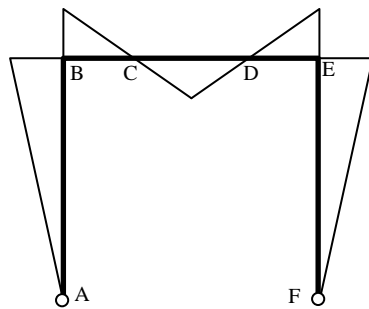
2. (a) Without any calculation, state the   analysis procedures to determine the angle of rotation at a specified point on the elastic curve of a cantilever beam using moment-area method

(8 marks)

(b) A cantilever beam as shown in Figure 4 is subjected to a concentrated load of P at point B. The moment of inertia of segments AB and BC of the beam is 2I and I, respectively. Prove that the angle of rotation and deflection at point C is P/EI and 7P/3EI respectively . Modulus of elasticity of the beam is constant. Use moment – area method
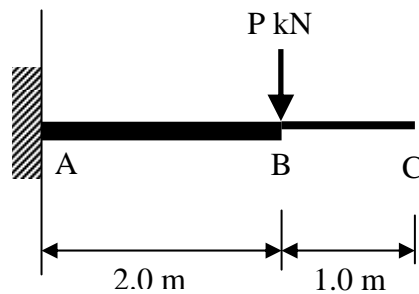
(12 marks)

P kN

A   B   C

2.0 m   1.0 m

Figure 4

3. (a) Figure 5(a) shows **FOUR (4)** different types of plane trusses. Check the statical determinacy of the trusses. All supports and member connections are pinned.

(8 marks)

(b) Figure 5(b) shows a plane truss with pinned support at G and roller support at F. Find the reactions at supports G and F. Identify any zero force members , if any.

(6 marks)

(c) Determine forces in member EG, ED, CD and BD for the truss shown in Figure 5(b) by using section method and classify whether they are in tension or compression.

(4 marks)

(d) Determine forces in member GD   and FD for the truss shown in Figure 5(b) by using joint method. Classify whether they are in tension or compression.
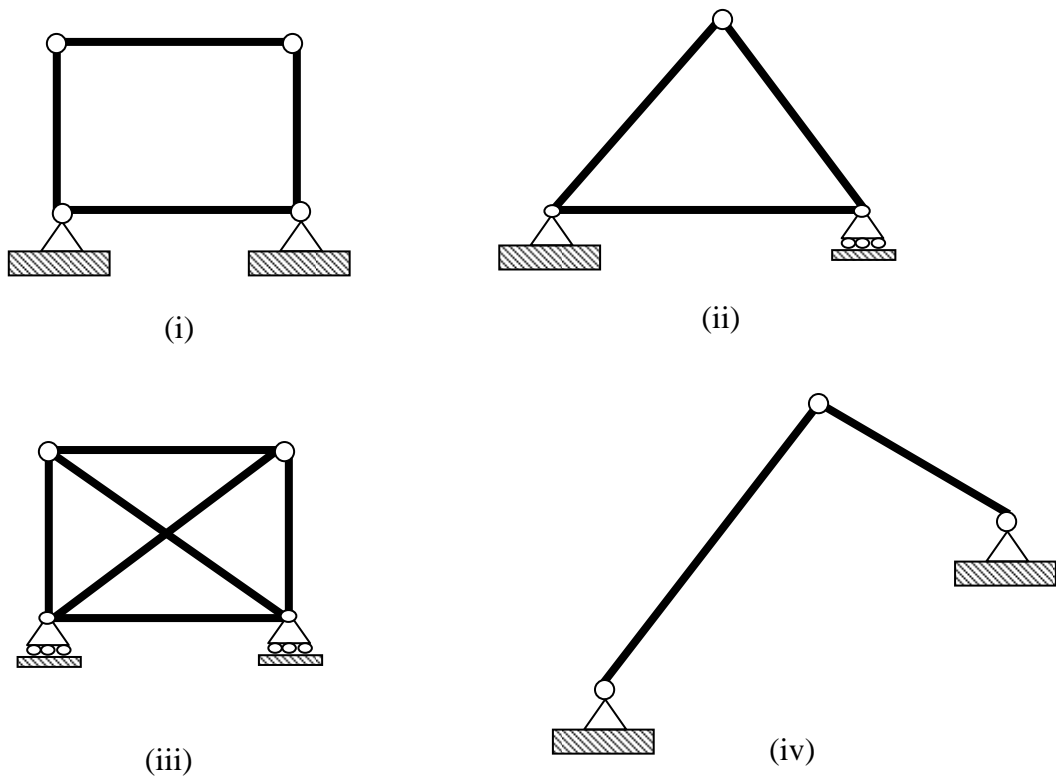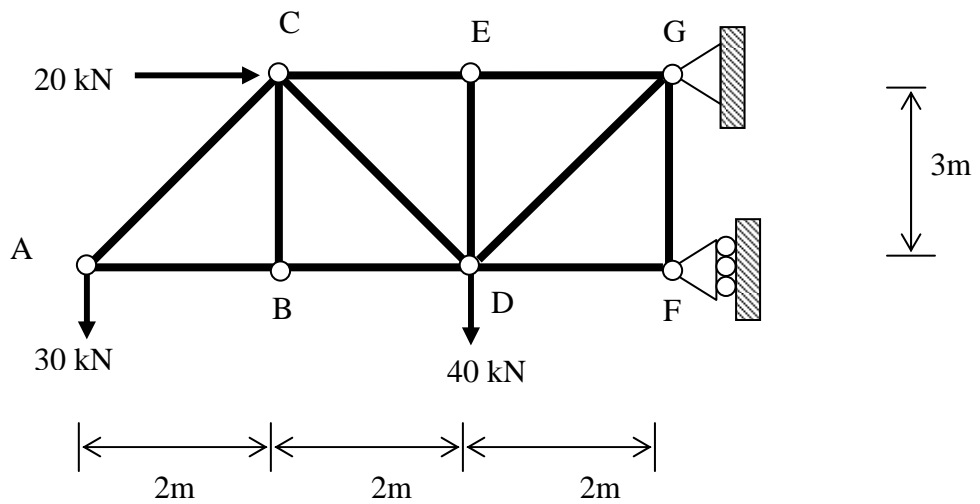
(2 marks)

(i)

(ii)

(iii)

(iv)

Figure 5 (a)

Figure 5 (b)

…6/-

PART B : Choose TWO (2) questions

4. (a) Describe briefly **TWO (2)** characteristics of cables .

(2 marks)

(b) The 60m cable shown in Figure 6 is loaded with point loads. Supports A and B are pinned. Assuming that the self weight of the cable is negligible, determine:

(i) Support reactions at A and B   (3 marks)

(ii) Tension forces in segments AC, CD, DE and EB   (8 marks)

(iii)Total length of cable, S   (2 marks)

(iv)Tension forces at supports A and B   (3 marks)

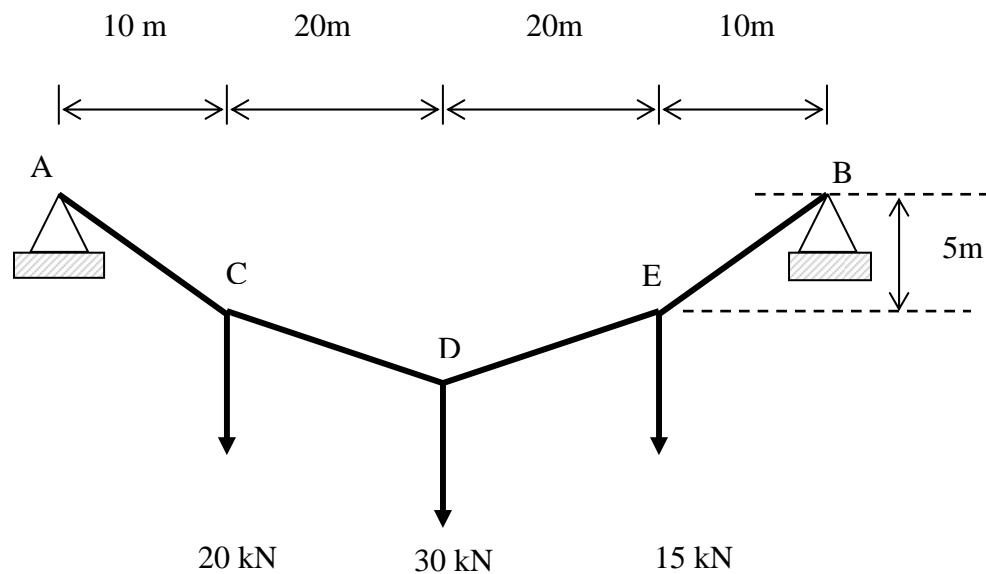(v) Size of the cable, if the allowable stress is 15500 kN/m^2 (2 marks)

Figure 6

5. (a) State **TWO (2)** types of equation for arch structures.

(2 marks)

(b) An unsymmetrical three pinned arch is in the form of semicircle with radius R= 10 m. It is designed to carry a uniformly distributed load of 20 kN/m from support A to E and a point load of 100 kN and 80 kN at points B and D, respectively. Joints A, C and E are hinged.

Determine:

   i.   support reactions at A and E.   (10 marks)

   ii.   bending moment at B and D.   (2 marks)

   iii.   shear force, Q and thrust, N at point D (with loading)   (4 marks)

Sketch the bending moment diagram of the arch.   (2 marks)
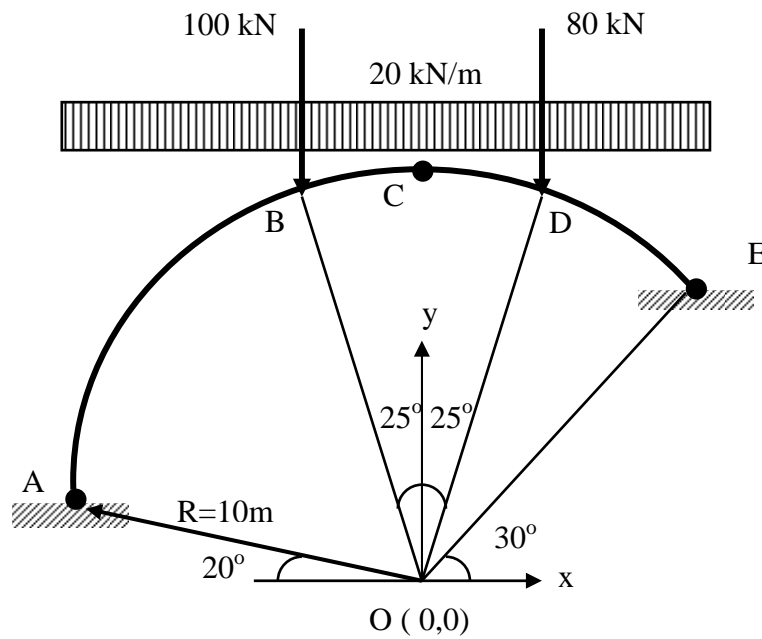

Figure 7

6. (a) Sketch the corresponding bending moment diagrams (to be drawn on compression side) for the beams shown in Figure 8 and 9 below. Neglect the self-weight of the beam. Provide your answers on Attachment 2.
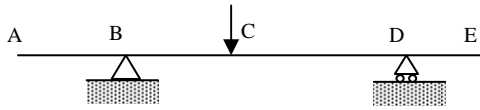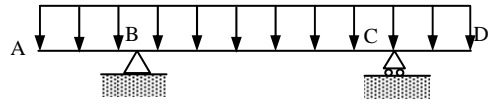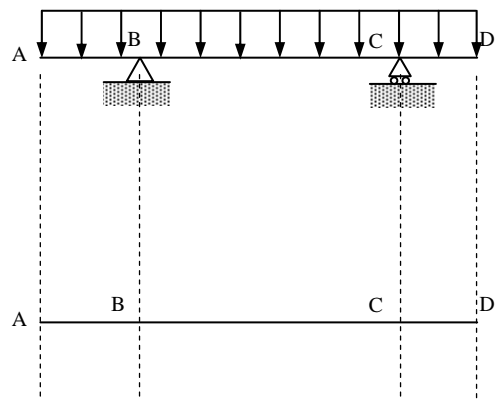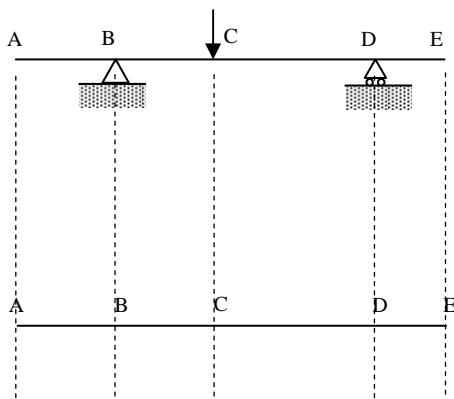
(3 marks)

Figure 8   **Figure 9**

ATTACHMENT 2

EAS253

Angka Giliran:

Write your answer to Question 2(a) on this page. Sketch the corresponding bending moment diagram on the figure below each beam. This page must be separated from the question book and submitted together with your answer book.

(b) Figure 10 shows a frame with pinned and roller supports at A and D, respectively. It is loaded by a uniformly distributed load 10kN/m along vertical member AB, a uniformly distributed load 15kN/m along inclined members BCD, a horizontal concentrated load 25kN at joint B and a vertical concentrated load 30kN at point C. Draw the shear force and bending moment diagrams for the frame. Sketch also the qualitative deflected shape.
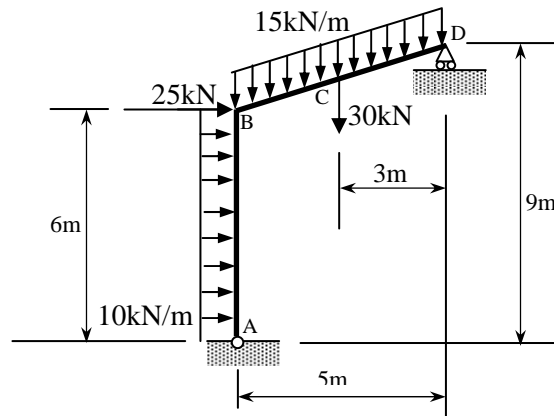
(17 marks)

Figure 10

7. A simply supported beam as shown in Figure 11 is subjected to a moving load which travels from A to C. The beam is pin supported at A and supported by a roller at C.

(a) Derive the influence line equation for reactions at A and C.

(4 marks)

(b) Derive the influence line equation for shear and moment at point B for segment AB and BC of the beam. State clearly the range of x (limit for each equations) taken, in order to derive the equations for each segment of the beam

(10 marks)

(c) Draw the influence lines diagram for the shear and moment at point B. Plot numerical values at every 1 m interval.
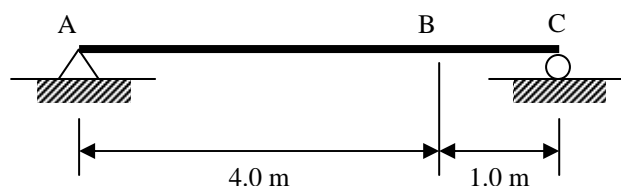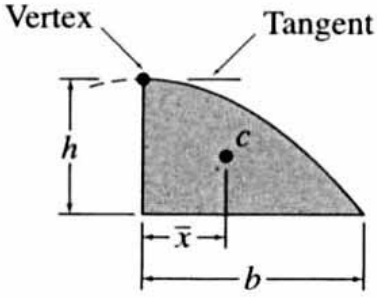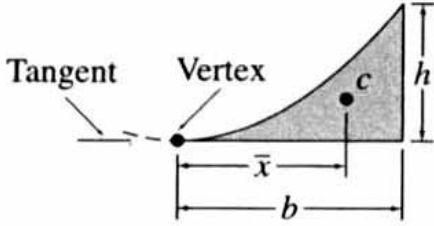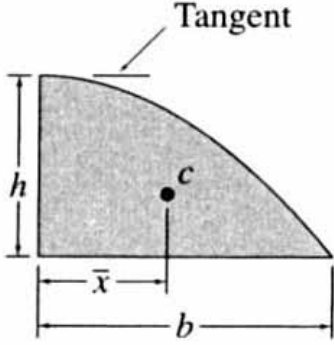
(6 marks)
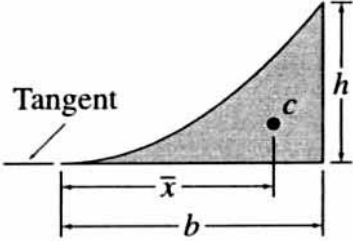
Figure 11

Areas and Centroids of Geometric Shapes

Shape	Area	Centroid
Semi-parabola Vertex — Tangent h ... c $\bar{x}$ ... b	$A = \dfrac{2bh}{3}$	$\bar{x} = \dfrac{3b}{8}$
Parabolic spandrel Tangent — Vertex — c — h $\bar{x}$ ... b	$A = \dfrac{bh}{3}$	$\bar{x} = \dfrac{3b}{4}$
Cubic Tangent h ... c $\bar{x}$ ... b	$A = \dfrac{3bh}{4}$	$\bar{x} = \dfrac{2b}{5}$
Cubic spandrel Tangent ... c — h $\bar{x}$ ... b	$A = \dfrac{bh}{4}$	$\bar{x} = \dfrac{4b}{5}$

Bahagian A

1. a)   Lakarkan   bentuk   terpesong   kualitatif untuk kerangka bersama

dengan gambarajah momen lentur yang berkaitan seperti yang ditunjukkan

dalam Rajah 1 dan 2 di bawah.   Gambarajah momen lentur untuk setiap

kerangka dilakarkan di sisi mampatan.   Berikan jawapan anda di Lampiran 1.
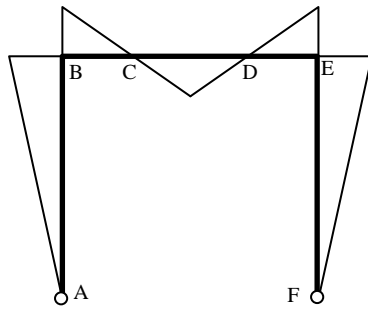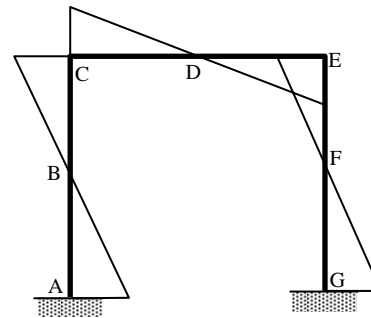
Rajah 1   **Rajah 2**

b)   Rajah 3 menunjukkan satu struktur rasuk dengan penyokong pin di A,

penyokong rola di B, D dan sambungan sendi di C.   Rasuk berkenaan membawa

satu beban teragih seragam 10kN/m di sepanjang rentang AB, satu beban teragih

seragam 20 kN/m disepanjang rentang BCD; satu beban teragih lelurus yang

berubah dari 20kN/m pada D sehingga 0 kN/m pada E di sepanjang rentang

terjulur DE; dan satu gandingan 20kNm pada hujung bebas E.   Lukiskan

gambarajah daya ricih dan momen lentur untuk rasuk berkenaan. Lakarkan juga

bentuk terpesong kualitatif.
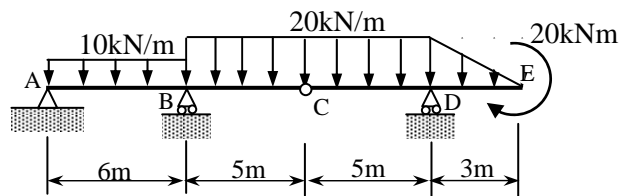
Rajah 3

2. a) Tanpa sebarang pengiraan, nyatakan tatacara analisis untuk menentukan sudut putaran di titik tertentu di atas lengkok anjal rasuk julur menggunakan kaedah momen-luas.

(8 markah)

b) Satu rasuk julur seperti ditunjukkan dalam Rajah 4 menanggung beban tumpu P di titik B. Momen inersia untuk bahagian AB dan BC rasuk tersebut masing-masing ialah 2I dan I. Buktikan bahawa sudut putaran dan pesongkan di titik C masing-masing ialah P/EI dan 7P/3EI. Modulus keanjalan rasuk tersebut ialah malar. Guna kaedah momen-luas.

(12 markah)
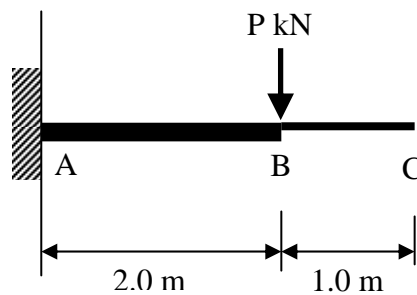
Rajah 4

3. a) Rajah 5(a) menunjukkan **EMPAT (4)** kekuda satah yang berbeza. Semak kebolehtentuan statik kekuda berkenaan. Semua penyokong dan sambungan adalah pin.

(8 markah)

b) Rajah 5(b) menunjukkan satu kekuda satah dengan penyokong cemet di G dan penyokong rolla di F. Kira nilai daya tindakbalas di penyokong G dan F. Kenalpasti anggota kekuda yang mungkin mempunyai daya sifar, sekiranya ada.
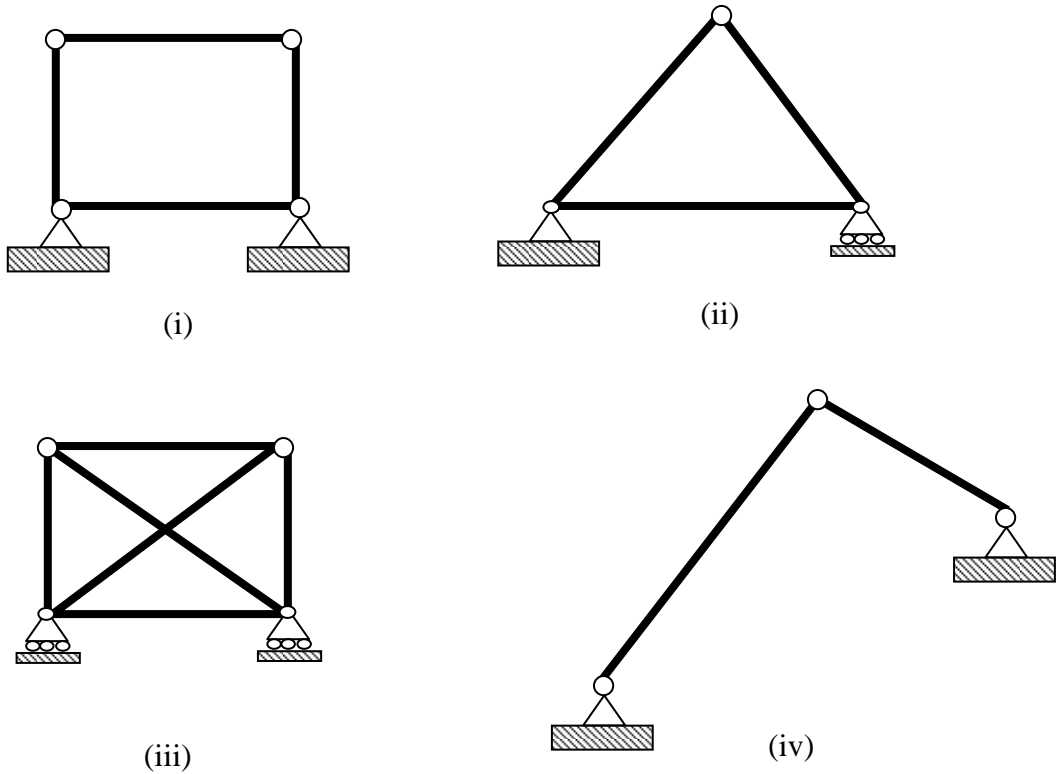
(6 markah)

c) Kira daya dalam anggota EG, ED, CD dan BD bagi kekuda dalam Rajah 5(b) menggunakan kaedah keratan. Nyatakan sama ada anggota tersebut mengalami daya mampatan atau tegangan.
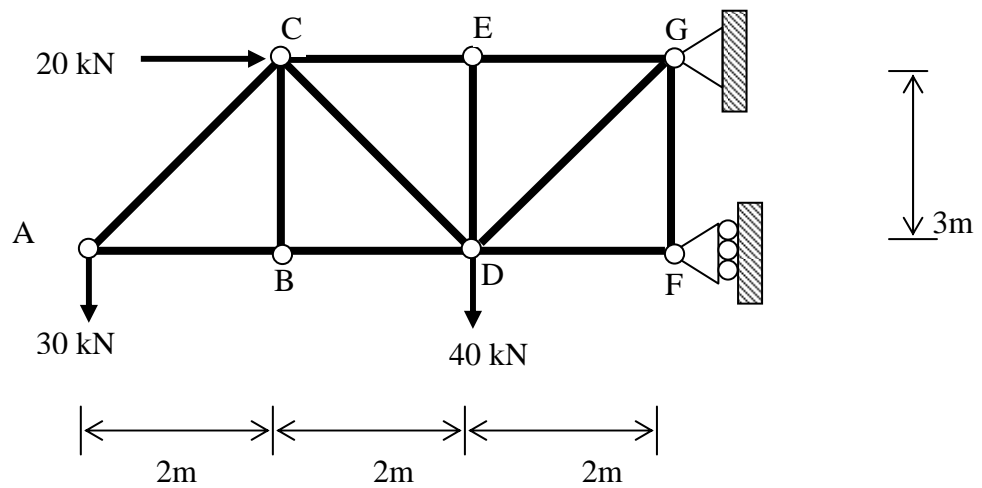
(4 markah)

d) Kira daya bagi anggota GD dan   FD menggunakan kaedah sambungan. Nyatakan samada anggota tersebut mengalami daya mampatan atau tegangan.

(2 markah)

(i)

(ii)

(iii)

(iv)

Rajah 5 *(a)*

Rajah 5 *(b)*

…15/-

BAHAGIAN B : Jawab 2 sahaja dari 4   soalan

4. (a)   Jelaskan secara ringkas **DUA(2)** ciri kabel .

(2 markah)

b)   Satu sistem kabel sepanjang 60m seperti yang ditunjukkan dalam Rajah 6, menanggung beban tumpu. Penyokong A dan B ialah pin. Anggap berat kendiri kabel boleh diabaikan. Kira:
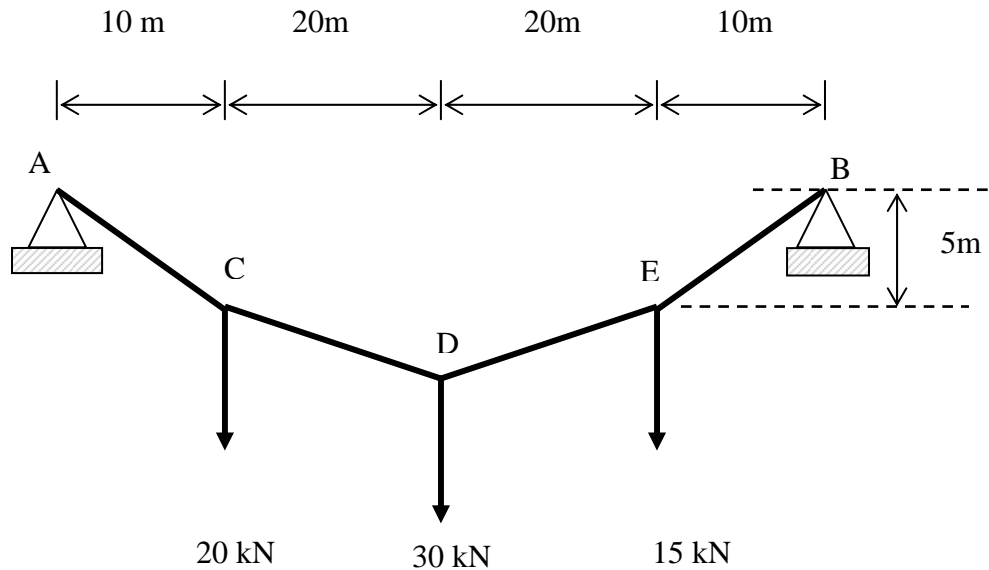
i.   Daya tindakbalas di penyokong A dan B.   (3 markah)

ii.   Daya tegangan untuk segmen AC, CD, DE dan EB.   (8 markah)

iii.   Panjang keseluruhan kabel, S   (2 markah)

iv.   Nilai daya tegangan di penyokong A dan B (T_A dan T_B)   (3 markah)

v.   Saiz kabel yang diperlukan sekiranya tegasan kabel tersebut ialah 15500 kN/m^2.   (2 markah)

Rajah 6

…16/-

5. a) Nyatakan   **DUA**   **(2)**   jenis   persamaan untuk struktur gerbang.

(2 markah)

b) Gerbang tiga engsel tidak simetri dalam Rajah 7 dibentuk dari persamaan separa bulat dengan radius R = 10 m. Ia direkabentuk untuk membawa beban teragih seragam sebanyak 20 kN/m dari penyokong A ke E dan beban tumpu 100 kN dan 80 kN di titik B dan D. Sambungan A, C dan E adalah engsel.

Tentukan:

   i.   daya tindakbalas di penyokong A dan E.

(10 markah)

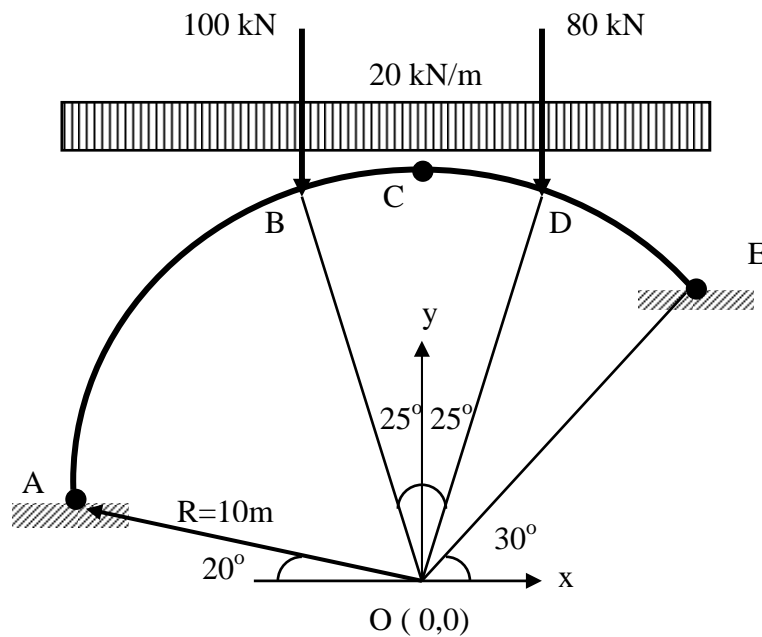   ii.   momen lentur di titik B dan D.

(2 markah)

   iii. daya ricih, Q dan daya paksi N di titik D (dengan beban kenaan)

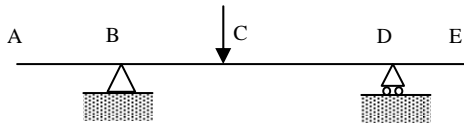(4 markah)

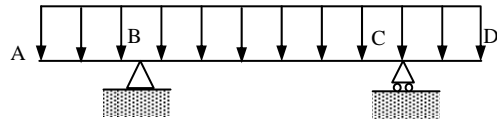Lakarkan rajah moment lentur untuk gerbang tersebut

(2 markah)

Rajah 7

6. a) *Lakarkan gambarajah momen lentur (dilukis pada sisi mampatan) untuk rasuk yang ditunjukkan dalam Rajah 8 dan 9 di bawah. Abaikan berat sendiri rasuk. Berikan jawapan anda di Lampiran 2.*

(3 markah)

Rajah 8

Rajah 9

b) *Rajah 10 menunjukkan satu kerangka dengan penyokong pin pada A dan penyokong rola pada D. Kerangka berkaitan dibebankan dengan beban teragih seragam 10kN/m di sepanjang anggota pugak AB, beban teragih seragam 15kN/m di sepanjang anggota condong BCD, beban tertumpu ufuk 25kN pada B dan beban tertumpu pugak 30kN pada C. Lukiskan gambarajah daya ricih dan momen lentur untuk kerangka berkenaan. Lakarkan juga bentuk terpesong kualitatif.*

(17 markah)
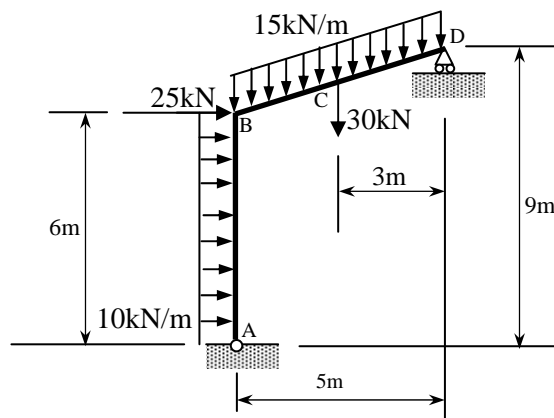
Rajah 10

7. *Satu rasuk disokong mudah seperti ditunjukkan dalam Rajah 11 dikenakan beban yang bergerak daripada titik A ke titik C. Rasuk tersebut disokong cemat di A dan disokong rola di C.*

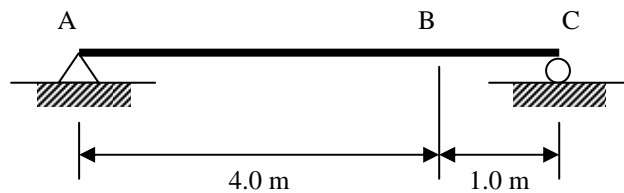a) *Terbitkan persamaan garis imbas bagi tindak balas di A dan C.*

(4 markah)

b) *Terbitkan persamaan garis imbas bagi ricih dan momen di titik B untuk bahagian AB dan BC rasuk tersebut. Nyatakan dengan jelas julat x (had untuk setiap persamaan) yang digunakan bagi menerbitkan persamaan tersebut untuk setiap bahagian rasuk.*

(10 markah)

c) *Lukiskan gambarajah garis imbas bagi ricih dan momen di titik B. Plotkan nilai berangka di setiap selaan 1 m.*

(6 markah)

Rajah 11

- ooo O ooo -