UNIVERSITI SAINS MALAYSIA

First Semester Examination
2012/2013 Academic Session

January 2013

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 1 appendix before you begin the examination.

[*Sila pastikan bahawa kertas peperiksaan ini mengandungi* ***LAPAN BELAS (18)*** *muka surat yang bercetak termasuk 1 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* ***TUJUH (7)*** *soalan. Jawab* ***TIGA (3)*** *soalan wajib di Bahagian A dan pilih* ***DUA (2)*** *soalan di Bahagian B]*

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

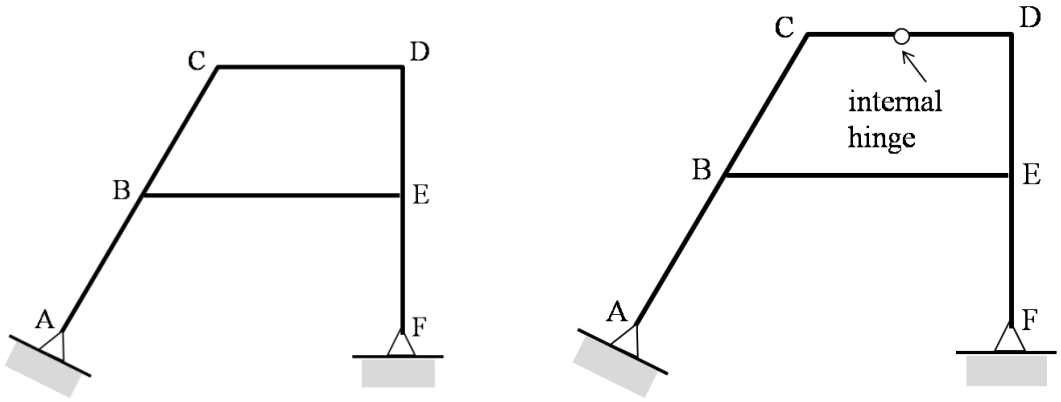
[*Semua soalan* ***MESTILAH*** *dijawab pada muka surat baru*].

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

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

PART A : Answer all THREE (3) questions

1. (a) Figure 1 shows a frame which has been changed from one without an internal hinge (Case I) to one with internal hinge (Case II). Verify the truth of the following statement : "*By introducing an internal hinge, the statical indeterminacy of the frame is changed from 4 to 3*".



Case I Case II

Figure 1

[3 marks]

(b) Figure 2 shows an intermediate stage of the frame shown in Figure 1 (case II) where member BE has not been connected. Verify that this frame is statically determinate. The frame carries uniformly distributed load of 3.5kN/m acting perpendicular to member AC, a uniformly distributed load of 2.5kN/m acting along member CD, a linearly distributed load with intensity varying from 5kN/m to 0 kN/m acting along vertical member DF and a point load 25kN acting at D.

(i) Draw the shear force and bending moment diagrams for the frame.

(ii) Sketch the qualitative deflected shape.

(iii) Compute the axial force in member DF.

[17 marks]

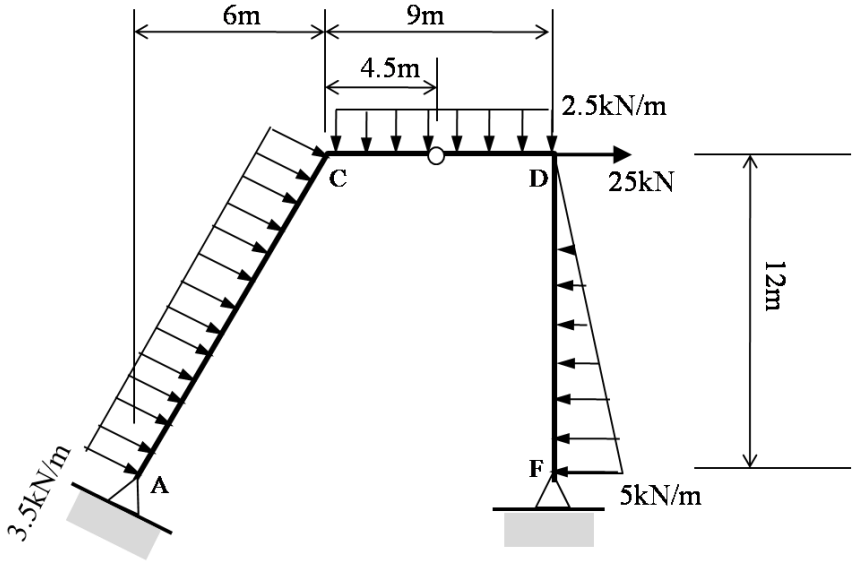


Figure 2

2. (a) Based on the differential equation for the deflection of beams derived from the elastic beam theory and with the help of appropriate sketches, explain the moment-area theorems.

[5 marks]

(b) Calculate the slope and deflection at points B and D for the beam shown in Figure 3. Use either the moment-area method or conjugate-beam method. Take E = 200 GPa and I = 500(10^6) mm^4.

[12 marks]

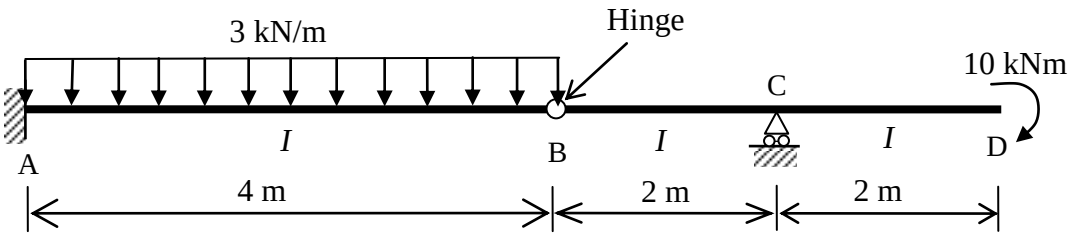


Figure 3

(c) The second moment of area of the beam for segment AB is to be increased to double of the present value. Determine the deflection at point D of the beam.

[3 marks]

3. (a) Figure 4 shows a plane truss used for a gantry of a crane of capacity 100kN. Check for the statical determinacy of the truss. The plane truss is supported by roller and pin supports at F and J, respectively. All member are pinned connected. Find the reactions at both supports and identify zero force members, if any. Determine forces in members EI, DI and DH by using section method and members FG, JK and FJ by using joint method. Classify whether the forces are in tension or compression.

[16 marks]

(b) If two members MI and ML of the truss shown in Figure 4 are removed, state change in the overall stability of the truss and changes in the forces for members EI, DI and DH, if any.

[4 marks]

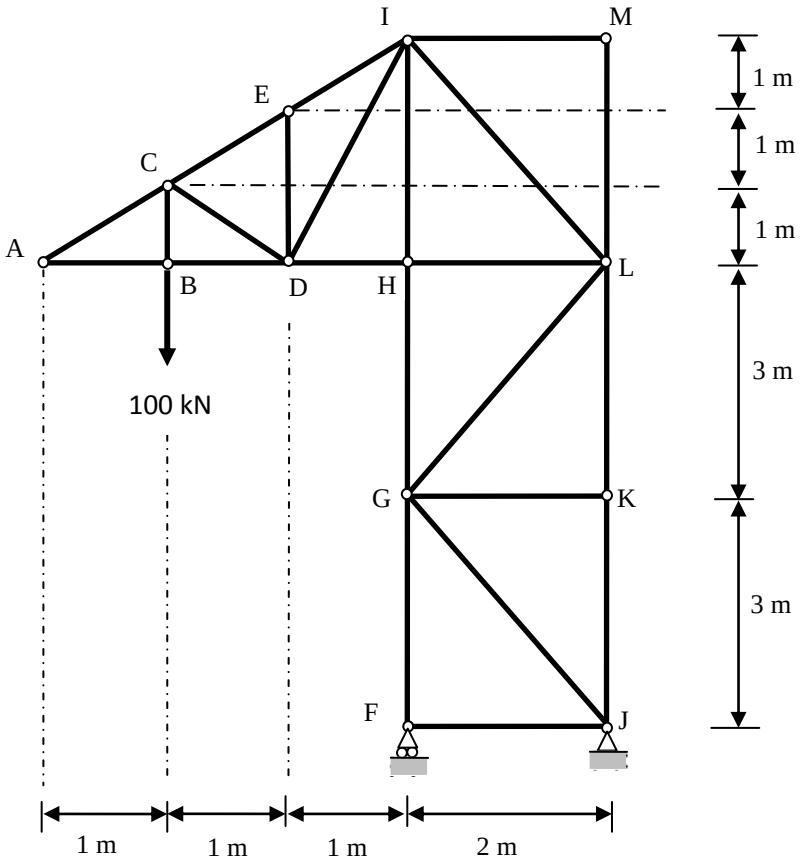


Figure 4

PART B : Choose TWO (2) questions

4. (a) The cable-supported foot bridge shown in Figure 5 is composed of 6 equally spaced hangers of 12 m apart. Each hanger can be assumed to provide a simple support for the suspended beam with a 50 kN load at both end hangers and 30 kN for intermediate hangers. Determine the tension forces in each segment of the cables, the total length of cable and the tension forces at both supports. Assume the self weight of the suspended beam to be negligible.

[16 marks]

(b) Determine the required area of the cable if the allowable stress is 16000 kN/m^2. If the number of hanger is reduced from 6 to 4, state whether there is any change in cable size.

[4 marks]

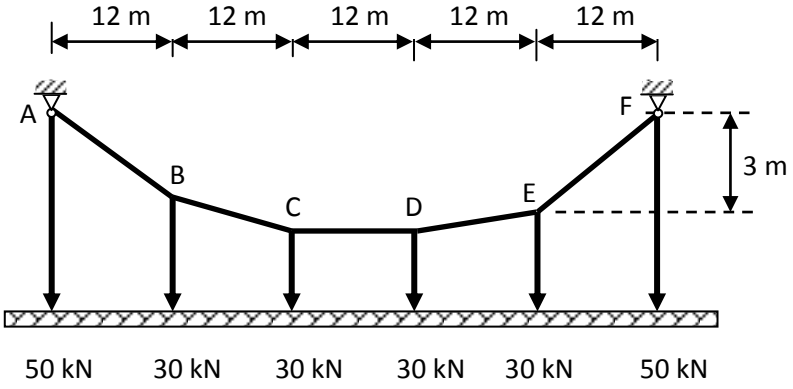


Figure 5

5. (a) Explain the main difference between two-pinned and three-pinned arch structures.

[4 marks]

(b) The three-pinned parabolic arch in Figure 6 supports horizontal loads of 10 kN and 5 kN at points B and D, respectively; and vertical loads of 20 kN at points B, C and D. It also carries a uniformly distributed load of 8 kN/m on span ABC. Determine the support reactions, bending moment at B and D, shear force, Q and thrust, N at point D (with loading). Sketch the bending moment diagram of the arch.

[16 marks]

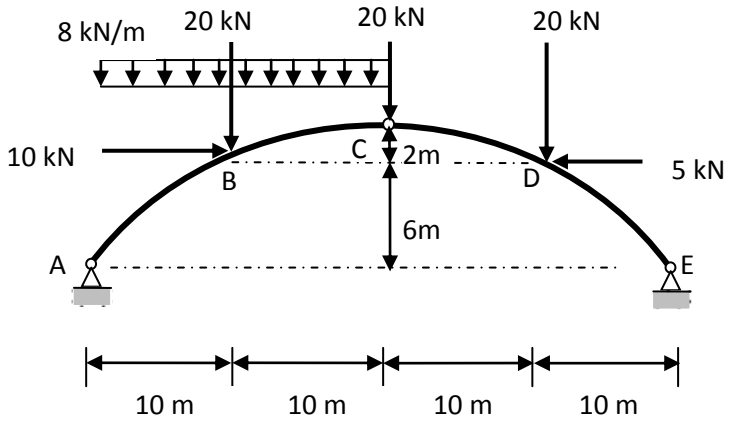


Figure 6

6. (a) Figure 7 shows an analytical model of a three-span beam. Show that the statical indeterminacy of the beam is 3. Suggest a way by means of a suitable diagram to lower the degree of statical indeterminacy from 3 to 2 without changing the support condition. Justify your suggestion with proof.

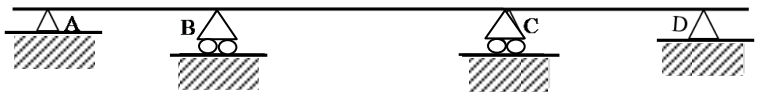


Figure 7

[3 marks]

(b) A three-span beam shown in Figure 8 carries a uniformly distributed load of 7.5kN/m along spans BC and CD, a linearly distributed load along span AB and a concentrated moment 50kNm at point D. Draw the shear force and bending moment diagram. Sketch the qualitative deflected shape.

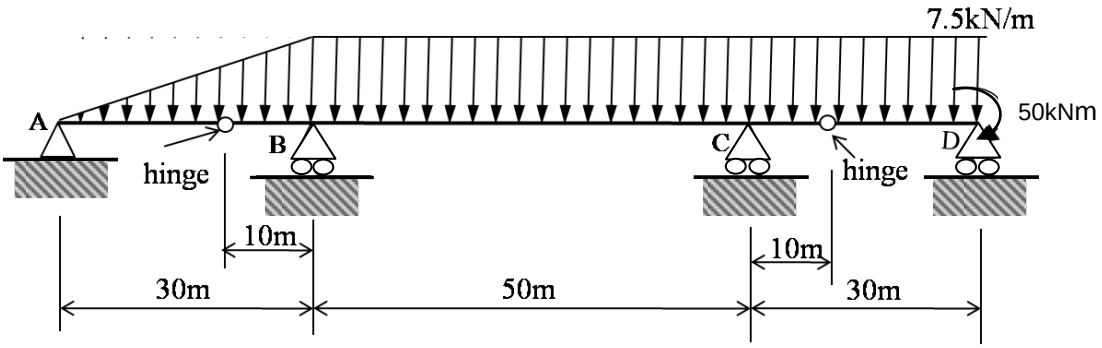


Figure 8

[15 marks]

(c) If location of action of concentrated moment changes from point D to point C, determine the reaction force at support D.

[2 marks]

7. (a) Explain briefly the importance of determining influence lines for structures.

[2 marks]

(b) Figure 9 shows a beam which is constructed to allow a moving truck to travel on it. Draw the influence lines for:

(i) the vertical reaction forces at supports A, B and D,

(ii) the shear just to the right of support B,

(iii) the bending moment at mid span AB.

Determine the maximum values of the shear just to the right of support B and bending moment at mid span AB when a truck moves from point D to point A.

[14 marks]

(c) Determine the maximum values of the shear just to the right of support B and bending moment at mid span AB when the same truck moves from point A to point D.

[4 marks]

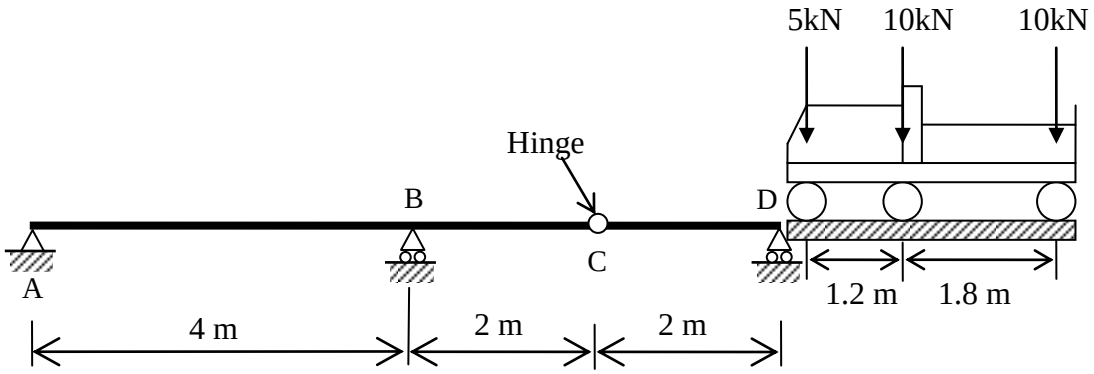
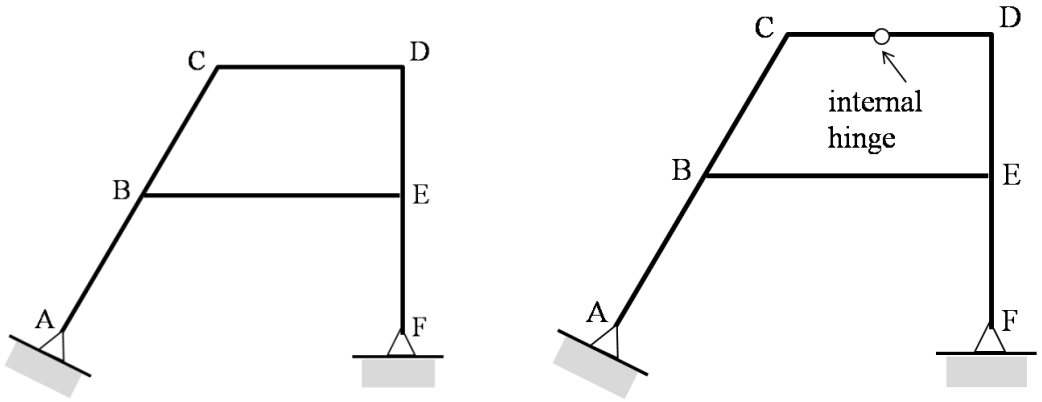


Figure 9

BAHAGIAN A : Jawab semua TIGA (3) soalan

1. (a) *Rajah 1 menunjukkan satu kerangka yang telah ditukar dari satu kerangka tanpa sambungan engsel dalaman (Kes I) ke satu kerangka dengan sambungan engsel dalaman (Kes II). Sahkan kesahihan keterangan di bawah: "Dengan memperkenalkan satu sambungan engsel dalaman, kebolehtentuan statik struktur kerangka telah bertukar dari 4 ke 3."*



Kes I Kes II

Rajah 1

[3 markah]

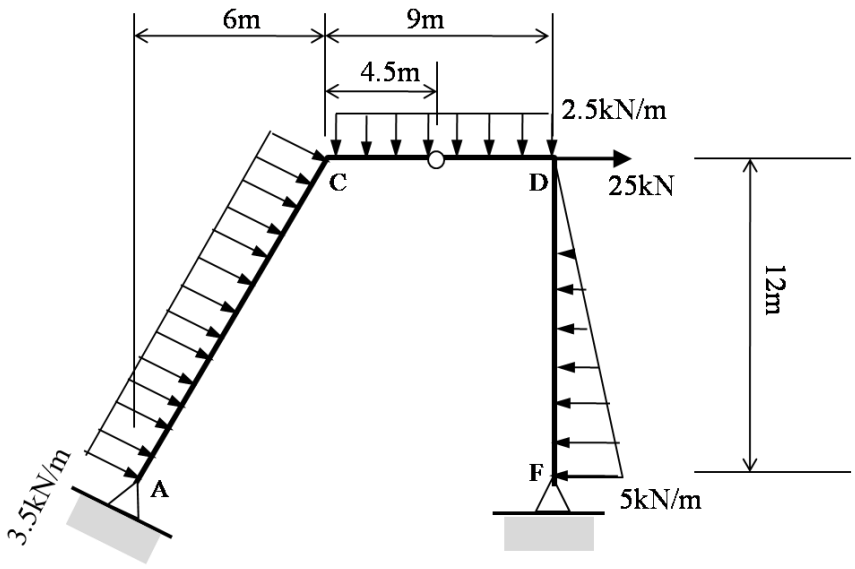
(b) *Rajah 2 menunjukkan peringkat perantaraan dalam proses pembinaan struktur kerangka seperti yang ditunjukkan dalam Rajah 1(Kes II) di mana anggota BE belum dipasang. Sahkan bahawa kerangka dalam Rajah 2 adalah struktur bolehtentu statik. Diberi bahawa satu beban teragih seragam 3.5kN/m bertindak dalam arah sudut tepat kepada anggota AC, satu beban teragih seragam 2.5kN/m bertindak di sepanjang anggota CD, satu beban teragih secara lelurus dengan keamatan berubah dari 5kN/m ke 0 kN/m bertindak di sepanjang anggota pugak DF dan satu beban tumpu bertindak pada titik D;*

(i) *lukiskan : gambar rajah daya paksi, gambar rajah daya ricih dan gambar rajah momen lentur untuk kerangka berkenaan.*

(ii) *Lakarkan juga bentuk pesongan kualitatif kerangka berkenaan.*

(iii) Kira nilai daya paksi anggota DF

[17 markah]



Rajah 2

2. *(a) Berasaskan persamaan kebezaan untuk pesongan bagi rasuk yang diterbitkan daripada teori rasuk elastik dan dengan bantuan lakaran yang bersesuaian, jelaskan teorem momen-luas.*

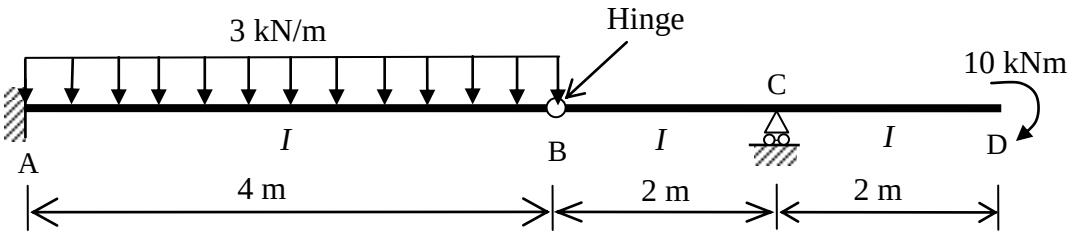
[5 markah]

(b) Kira putaran dan pesongan di titik B dan D untuk rasuk yang diberikan dalam Rajah 3. Guna sama ada kaedah momen luas atau kaedah rasuk konjugat. Guna E = 200 GPa dan I = 500(10^6) mm^4.

[12 markah]

(c) *Sekiranya momen luas kedua rasuk di bahagian AB digandakan nilai yang asal, tentukan pesongan di titik D untuk rasuk.*

[3 markah]



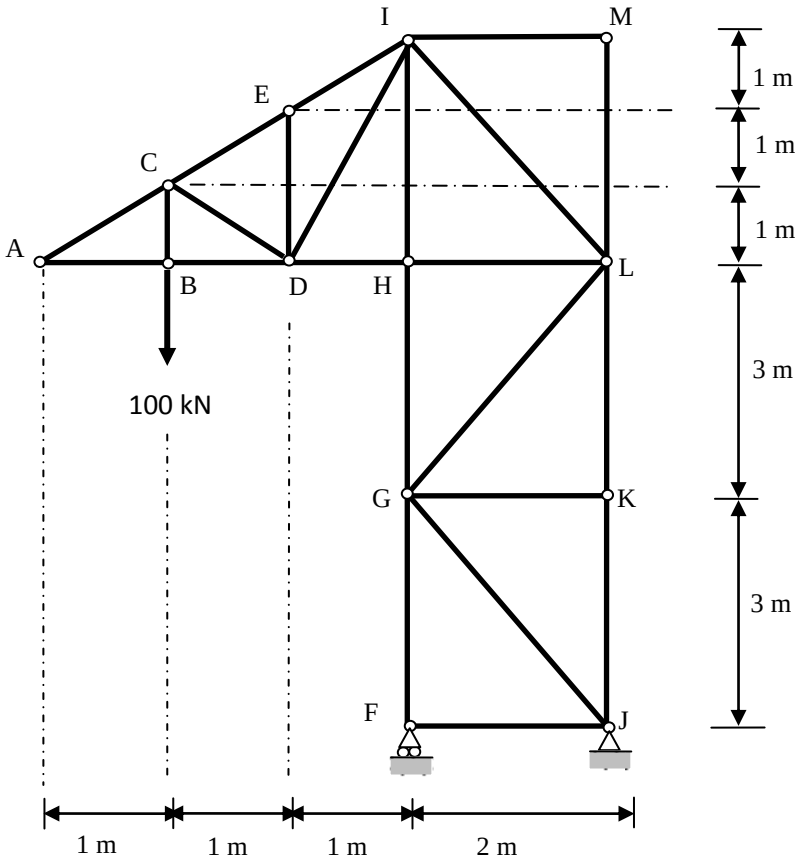
Rajah 3

3. (a) *Rajah 4 menunjukkan satu kekuda satah yang digunakan sebagai gantri kren dengan kapasiti 100 kN. Semak kebolehtentuan statik kekuda berkenaan. Penyokong F adalah rola dan penyokong J adalah pin. Semua sambungan anggota adalah pin. Kira nilai daya tindakbalas di kedua-dua penyokong dan kenalpasti anggota kekuda yang mungkin mempunyai daya sifar, sekiranya ada. Kira daya dalam anggota EI, DI and DH menggunakan kaedah keratan dan anggota FG, JK dan FJ menggunakan kaedah sambungan. Nyatakan sama ada anggota tersebut mengalami daya mampatan atau tegangan.*

[16 markah]

(b) *Sekiranya dua anggota MI dan ML kekuda dalam Rajah 4 dikeluarkan, nyatakan perubahan yang akan berlaku ke atas kestabilan kekuda tersebut dan perubahan dalam nilai daya dalam anggota EI, DI dan DH.*

[4 markah]



Rajah 4

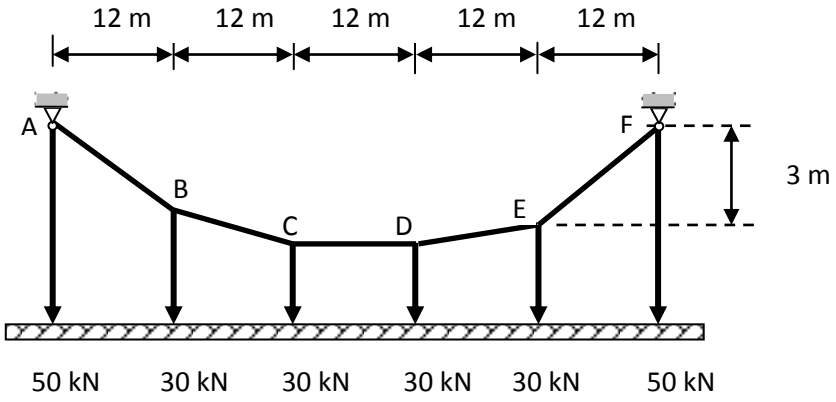
BAHAGIAN B : Pilih DUA (2) soalan

4. (a) *Kabel yang menyokong jambatan gantung seperti ditunjukkan dalam Rajah 5, terdiri daripada 6 tali pengantung yang berjarak sama sebanyak 12 m. Setiap tali penggantung dianggap sebagai penyokong mudah rasuk jambatan yang tergantung dengan beban 50 kN untuk hangar tepi dan 30 kN untuk tali penggantung bahagian perantaraan. Kira daya tegangan untuk setiap segmen kabel, panjang keseluruhan kabel dan nilai daya tegangan di kedua-dua penyokong. Anggap beban kendiri rasuk jambatan boleh diabaikan.*

[16 markah]

(b) *Tentukan saiz kabel yang diperlukan sekiranya tegasan kabel tersebut ialah 16000 kN/m^2. Pada pandangan anda, adakah pengurangan jumlah tali penggantung dari 6 ke 4 akan mengurangkan saiz kabel?*

[4 markah]



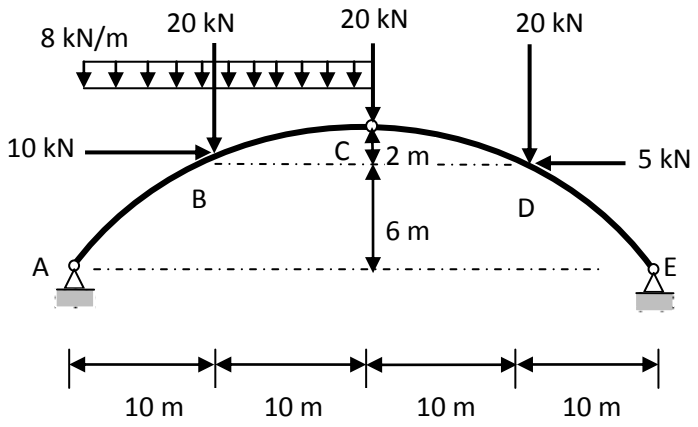
Rajah 5

5. (a) *Jelaskan perbezaan utama antara struktur gerbang dua-pin dan tiga pin?*

[4 markah]

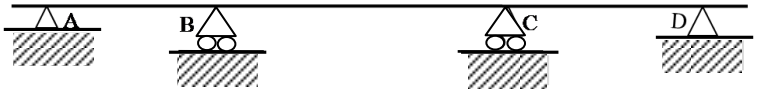
(b) *Gerbang tiga engsel berbentuk parabolik dalam Rajah 6 menyokong beban tumpu mendatar sebanyak 10 kN dan 5 kN di titik B dan D masing-masing dan beban tumpu menegak sebanyak 20 kN di titik B,C dan D. Ia juga membawa beban teragih seragam sebanyak 8 kN/m di rentang ABC. Tentukan daya tindakbalas di penyokong, momen lentur di titik B dan D daya ricih, Q dan daya paksi N di titik D (dengan beban kenaan). Lakarkan rajah momen lentur gerbang tersebut.*

[16 markah]



Rajah 6

6. (a) *Rajah 7 menunjukkan satu model analisa satu rasuk tiga-rentang. Tunjukkan bahawa darjah ketidakbolehtentuan statik rasuk berkenaan adalah 3. Cadangkan dengan bantuan satu gambar rajah yang sesuai satu cara untuk kurangkan darjah ketidakbolehtentuan statik rasuk berkenaan dari 3 kepada 2 tanpa menukar keadaan penyokong. Berikan justifikasi untuk menyokong cadangan anda.*

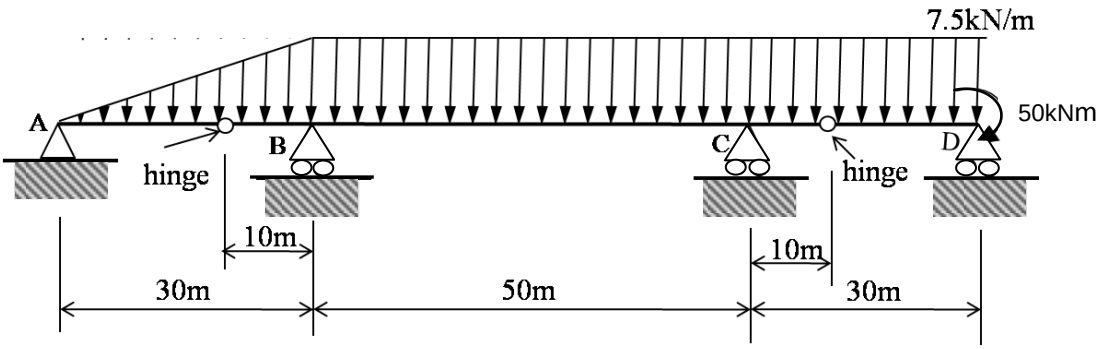


Rajah 7

[3 markah]

(b) Rajah 8 menunjukkan satu model analisa rasuk tiga-rentang seperti yang ditunjukkan dalam Rajah 7. Satu beban teragih seragam 7.5kN/m bertindak di sepanjang rentang BC dan CD, satu beban teragih secara lelurus bertindak di sepanjang rentang AB dan satu momen tertumpu 50kNm bertindak pada titik D. Lukiskan gambar rajah daya ricih dan gambar rajah momen lentur untuk rasuk berkenaan. Lakarkan juga bentuk pesongan kualitatif.

[15 markah]



Rajah 8

(c) Sekiranya kedudukan tindakan momen tertumpu bertukar dari titik D ke titik C, tentukan magnitud daya tindak balas pada penyokong D.

[2 markah]

7. *(a) Jelaskan secara ringkas kepentingan untuk menentukan garis imbas bagi struktur.*

[2 markah]

(b) Rajah 9 menunjukkan satu rasuk yang dibina untuk trak bergerak melaluinya. Lakarkan garis impas untuk:

(i) daya tindakbalas menegak di penyokong A, B dan D,

(ii) daya ricih sebelah kanan penyokong B,

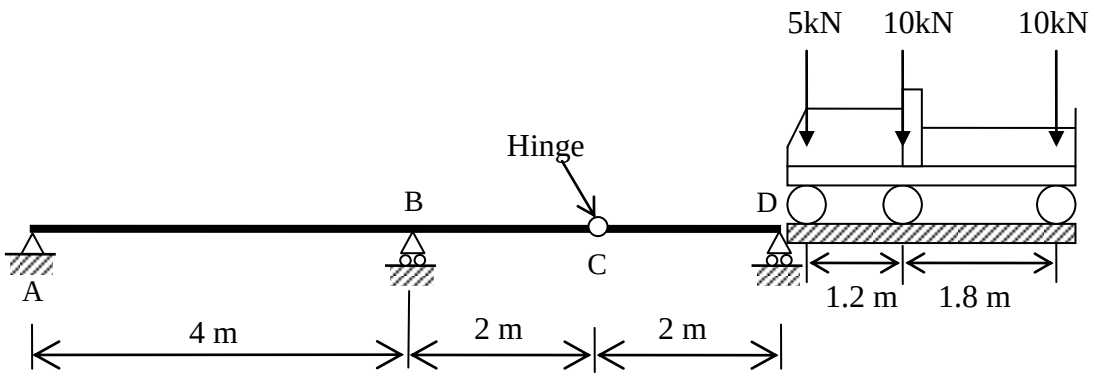
(iii) momen lentur di pertengahan AB.

Tentukan nilai maksimum untuk daya ricih di sebelah kanan penyokong B dan momen lentur di pertengahan AB apabila trak bergerak dari titik D ke titik A.

[14 markah]

(c) Tentukan nilai maksimum untuk daya ricih betul-betul kanan penyokong B dan momen lentur di pertengahan AB apabila trak yang sama bergerak dari titik A ke titik D.

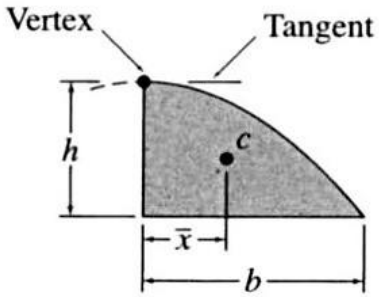
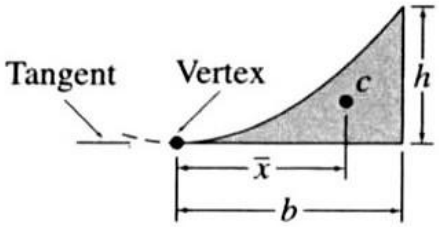
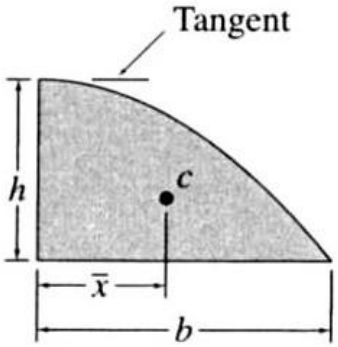
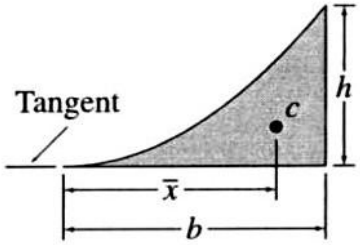
[4 markah]



Rajah 9

APPENDIX
LAMPIRAN

Areas and Centroids of Geometric Shapes

Shape	Area	Centroid
Semi-parabola 	$A=\frac{2bh}{3}$	$\bar{x}=\frac{3b}{8}$
Parabolic spandrel 	$A=\frac{bh}{3}$	$\bar{x}=\frac{3b}{4}$
Cubic 	$A=\frac{3bh}{4}$	$\bar{x}=\frac{2b}{5}$
Cubic spandrel 	$A=\frac{bh}{4}$	$\bar{x}=\frac{4b}{5}$

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