UNIVERSITI SAINS MALAYSIA

First Semester Examination
2010/2011 Academic Session

November 2010

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

Duration : 3 hours
[*Masa : 3 jam*]

Please check that this examination paper consists of **TWENTY (20)** printed pages including appendix before you begin the examination.
*[Sila pastikan kertas peperiksaan ini mengandungi **DUA PULUH (20)** 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 any **TWO (2)** questions in Part B.
*[**Arahan**: Kertas ini mengandungi **SEVEN (7)** soalan. Jawab **THREE (3)** soalan wajib di Bahagian A dan mana-mana **DUA (2)** soalan di Bahagian B]*

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.]

PART A

1. (a) Check the statical determinacy for the structures shown in Figure 1a and 1b.

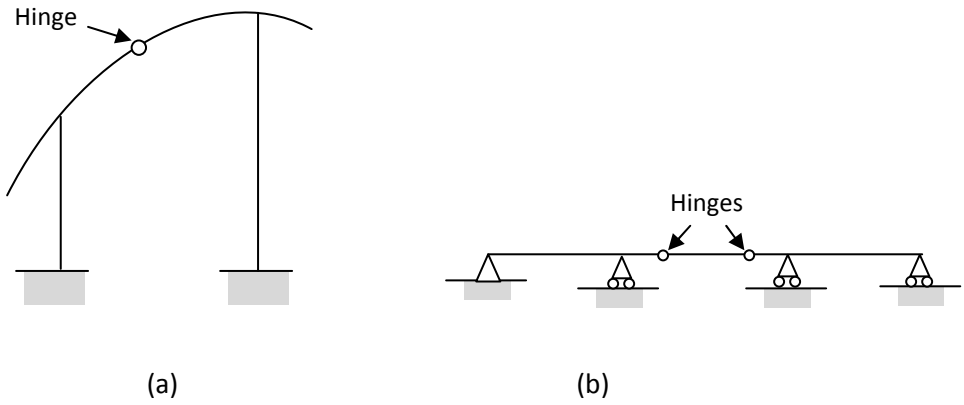


Figure 1

[2 marks]

(b) Figure 2 shows an analysis model of a two-member frame with member CD inclined at 25˚ from horizontal. The frame is supported by a pinned support at A and a roller support at D. Loading on the frame is as follows: a couple 50kNm at B, a horizontal concentrated load 25kN at C and a uniformly distributed load 5kN/m along the inclined member CD.

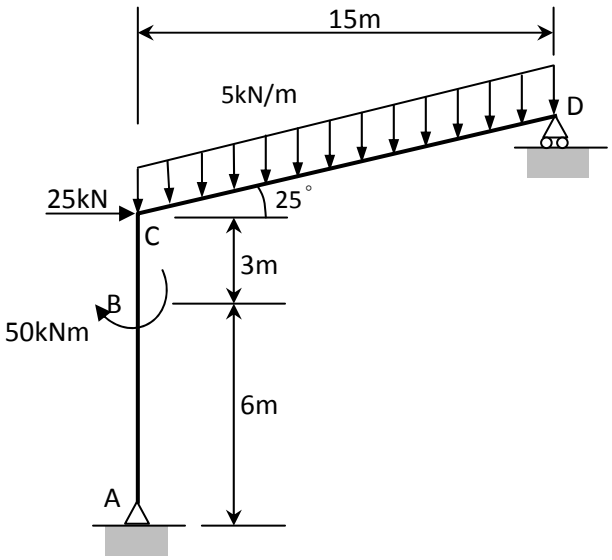


Figure 2

Determine the thrust, shear force and bending moment for portion AB, BC and CD of the frame. Subsequently, draw the shear force and bending moment diagrams for the frame. Sketch also the qualitative deflected shape.

[18 marks]

2. (a) (i) Various methods can be used to determine deflection of a beam. Conjugate-beam method is one of them. State the theorems related to the conjugate-beam method that is based on the similarity between the relationships among external applied load, internal shear force and bending moment and the relationships among *M/EI*, slope and deflection. Support your answer by comparing these two types of relationships with equations.

[4 marks]

(ii) Use the relationships in part (i) to draw the conjugate beam for the real beam as shown in Figure 3.

[2 marks]

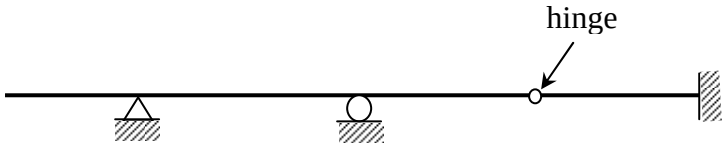


Figure 3

(b) Find the slope and deflection at point C for the beam of Figure 4. The variation of the second moment of area of the beam is as shown. Use either the moment-area method or conjugate-beam method. Take E = 200 GPa and I = 600(10^6) mm^4.

[14 marks]

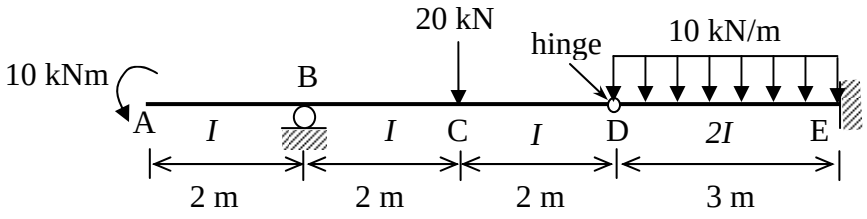


Figure 4

3. a) Figure 5(a) shows four (4) different types of plane trusses. Check for the statical determinacy of the trusses. All members are pinned connected.

[4 marks]

b) Figure 5(b) shows a plane truss with roller support at A and pinned support at F. Find the reactions at supports A and F. Identify any zero force members , if any. Determine forces in member AB, BE and ED for the truss shown in Figure 5(b) by using section method. Then find the forces in member CB, CD and DB using joint method. Classify whether they are in tension or compression.

[12 marks]

c) If point load at D of 10 kN in Figure 5(b) is acting upward, calculate the new forces in member DE and DB. Specify if there is any changes.

[4 marks]

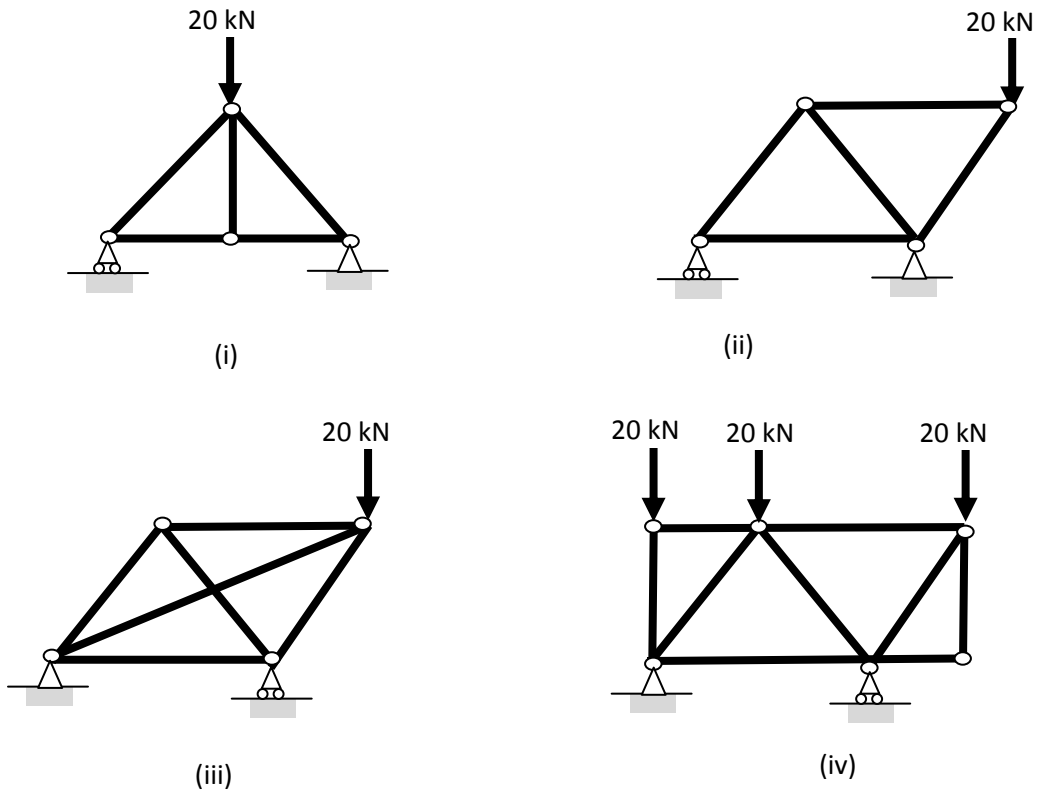


Figure 5 (a)

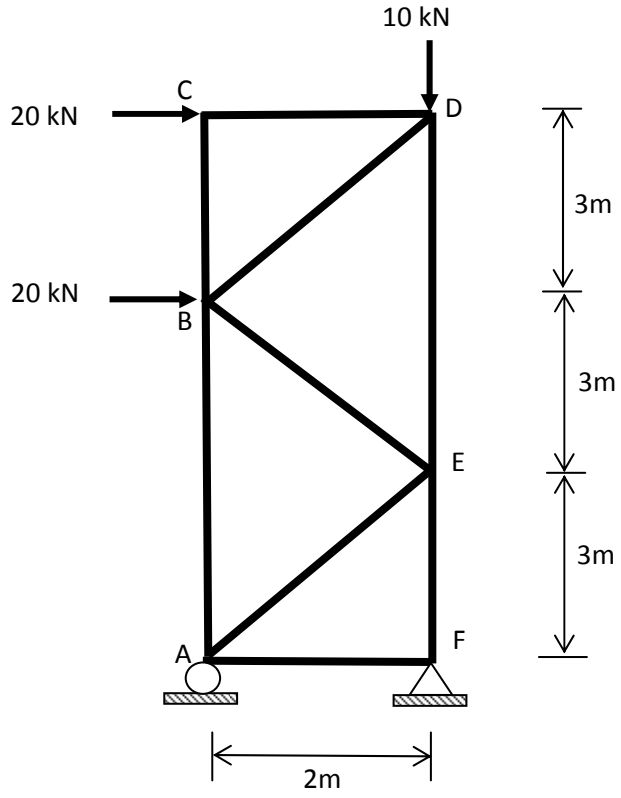


Figure 5 (b)

PART B (ANSWER ANY TWO QUESTIONS)

4. a) Derive the horizontal forces, H occurs in both symmetrical and unsymmetrical cables when subjected to uniformly distributed loads, w in term of span, $L = l_1 + l_2$ and vertical distance from the lowest point to support, h. Specify any assumption made with the aid of sketches.

[4 marks]

b) The cable system shown in Figure 6 carries a uniformly distributed load of 10kN/m between the supports and two point loads of 40kN and 60kN at 10m away from supports A and B respectively. The horizontal distance between supports is 50m and the vertical distance between the lowest point and the left hand support is 3m. The right hand support is 6m higher than the left support.

Determine:

(i) the lowest point of the cable (x).

(ii) the maximum and minimum tension between A and B (T_{max} and T_{min}).

(iii) the tension in anchor cables (T_A' and T_B').

(iv) vertical and horizontal reactions at supports (R_{vA}, R_{HA} and R_{vB}, R_{HB}).

(v) minimum size of the cable, if the allowable stress is 15500 kN/m^2.

[16 marks]

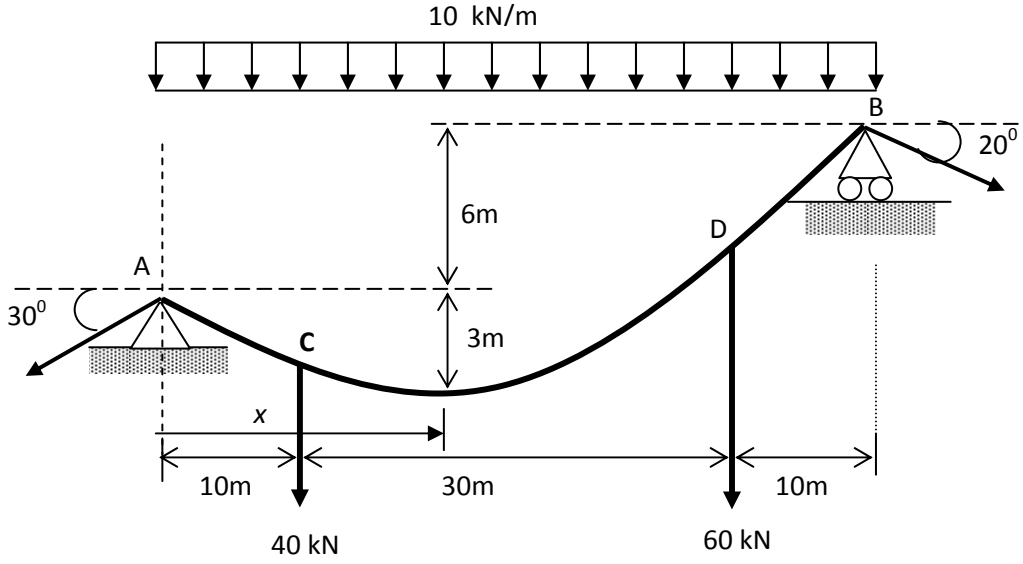


Figure 6

5. a) Check statical determinacy of the two arches shown in Figure 7 (a).

[4 marks]

Figure 7 (a)

b) An unsymmetrical three pinned arch in the form of parabolic arch is designed to carry a uniformly distributed load of 10 kN/m throughout the bridge deck as shown in Figure 7(b) and point loads of 100kN and 80 kN at point D and E. Joint A, B and C are hinged.

Determine:

i. support reactions at A and C.

[8 marks]

ii. bending moment at D and E. Sketch the bending moment diagram of the arch for a span ADBEC.

[4 marks]

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

[4 marks]

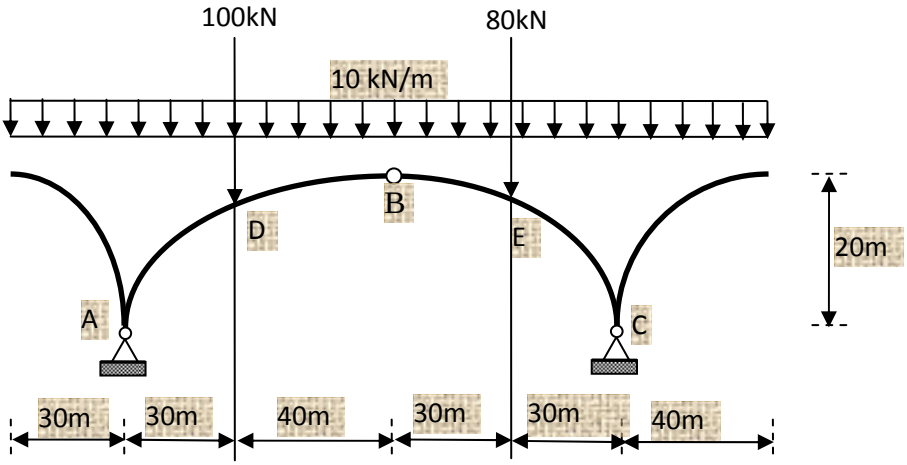


Figure 7 (b)

6. (a) Define without using any equation the concept of statical determinacy. Check the statical determinacy of the frame shown in Figure 8.

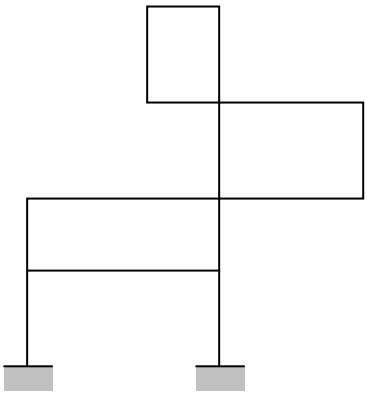


Figure 8

[2 marks]

(b) Figure 9 shows an analysis model of a beam with hinge at C. The beam is supported by a roller at B and a fixed support at D. Loading on the beam is as follows: a concentrated load 75kN at free end A, a couple 50kNm at B and a uniformly distributed load 20kN/m along portion CD.

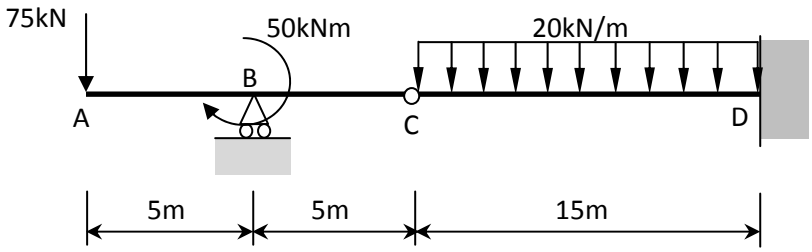


Figure 9

Draw the shear force and bending moment diagrams for the beam. Sketch also the qualitative deflected shape.

[18 marks]

7. (a) List **TWO (2)** differences between the diagrams of influence lines and structural response such as shear force and bending moment diagrams.

[2 marks]

(b) Figure 10 shows a bridge frame which is constructed to allow a moving truck to travel on it. Draw the influence lines for:

(i) the vertical and horizontal reactions at support A,

(ii) the vertical reaction at support B,

(iii) the shear at point F which is just to the left of the beam to column connection, and

(iv) the bending moment at point E.

Next, determine the maximum bending moment at point E.

[14 marks]

(c) If point E is a hinge as shown in Figure 11, draw the influence lines for:

(i) the vertical and horizontal reactions at support A, and

(ii) the vertical reaction at support B.

Comment on the results of the horizontal reaction force obtained from parts (b) and (c).

[4 marks]

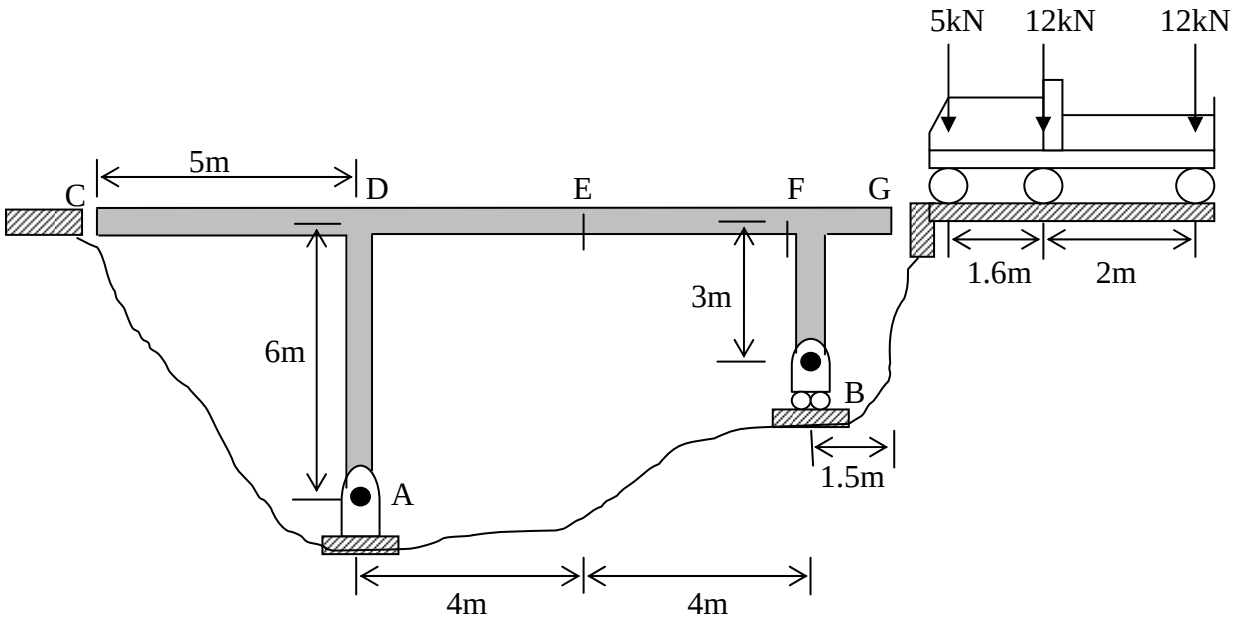


Figure 10

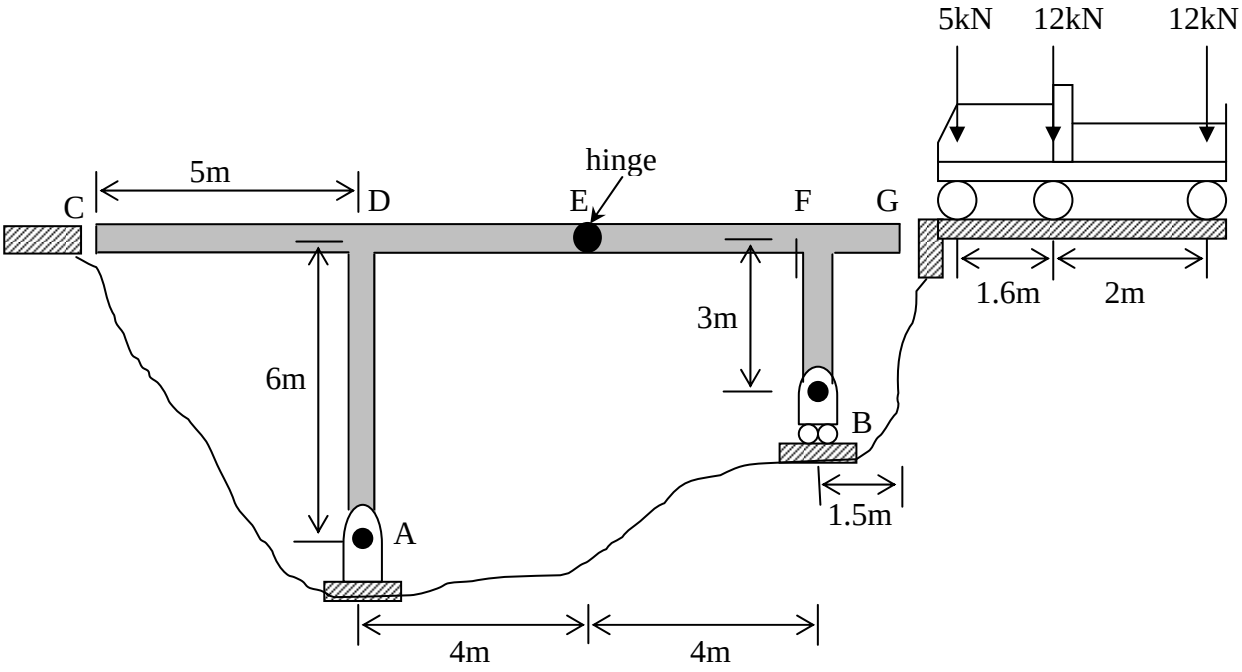
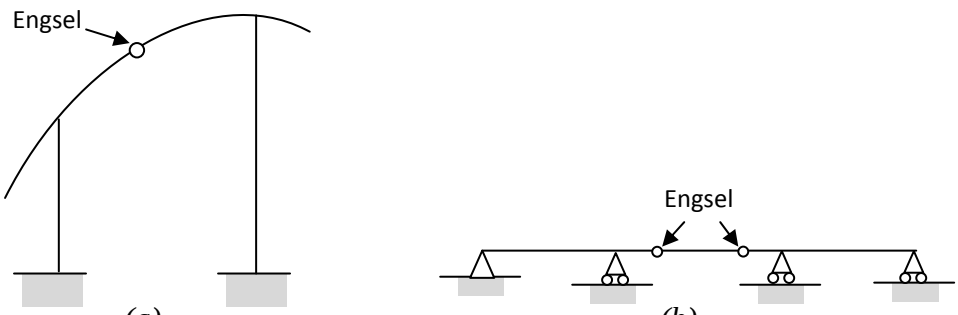


Figure 11

BAHAGIAN A

1. *(a)* *Semak kebolehtentuan statik untuk struktur yang ditunjukkan dalam Rajah 1(a) dan 1(b).*

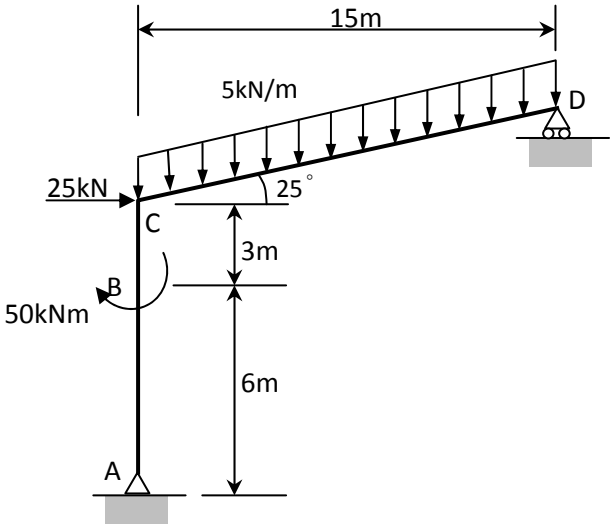


(a) *(b)*

Rajah 1

[2 markah]

(b) *Rajah 2 menunjukkan model analisis untuk satu kerangka dua-anggota dengan anggota CD dalam kedudukan condong 25^0 dari ufuk. Kerangka berkenaan disokong oleh penyokong pin di A dan penyokong rola di D. Beban yang bertindak keatas kerangka adalah seperti berikut: Satu momen tertumpu 50kNm pada B, satu beban tertumpu ufuk 25kN pada C dan satu beban teragih seragam 5kN/m sepanjang anggota condong CD.*



Rajah 2

Tentukan daya tujah, daya ricih dan momen lentur untuk bahagian AB, BC dan CD kerangka berkenaan. Seterusnya, lukiskan gambarajah daya ricih dan momen lentur untuk kerangka berkenaan. Lakarkan juga bentuk pesongan kualitatif.

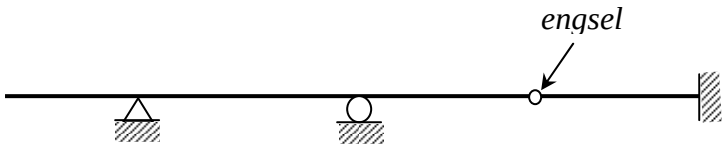
[18 markah]

2. (a) (i) *Pelbagai kaedah boleh digunakan untuk menentukan pesongan satu rasuk. Kaedah rasuk konjugat merupakan salah satu daripadanya. Berikan teorem yang berkaitan kaedah rasuk konjugat yang berasaskan kesamaan antara hubungan di antara beban luar, daya ricih dan momen lentur dan M/EI, kecerunan dan pesongan. Sokong jawapan anda dengan membandingkan dua jenis hubungan ini dengan persamaan.*

[4 markah]

(ii) *Gunakan hubungan-hubungan di bahagian (i) untuk melakar rasuk konjugat untuk beban sebenar seperti yang ditunjukkan dalam Rajah 3.*

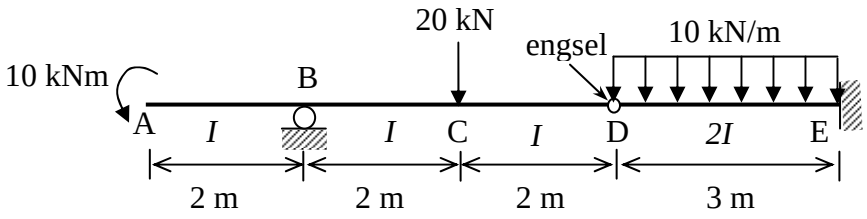
[2 markah]



Rajah 3

(b) *Cari putaran dan pesongan di titik C untuk rasuk yang diberikan dalam Rajah 4. Perubahan momen luas kedua adalah seperti yang ditunjukkan. Guna sama ada kaedah momen luas atau kaedah rasuk konjugat. Guna E = 200 GPa dan I = 600(10^6) mm^4.*

[14 markah]



Rajah 4

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

[4 markah]

(b) *Rajah 5(b) menunjukkan satu kekuda satah dengan penyokong cemat F dan penyokong sola di A. Kira nilai daya tindakbalas di penyokong A dan F. Kenalpasti anggota kekuda yang mungkin mempunyai daya sifar, sekiranya ada.*

Kira daya dalam anggota AB, BE, dan ED bagi kekuda dalam Rajah 5(b) menggunakan kaedah keratan. Kemudian kira nilai daya dalam anggota CB , CD dan DB. Nyatakan sama ada anggota tersebut mengalami mampatan atau tegangan.

[12 markah]

(c) *Sekiranya daya tumpu local di D sebanyak 10kN seperti dalam Rajah 5 (b) bertindak ke atas, kira nilai baru daya dalam anggota DE dan DB. Nyatakan sama ada anggota tersebut mengalami sebarang perubahan.*

[4 markah]

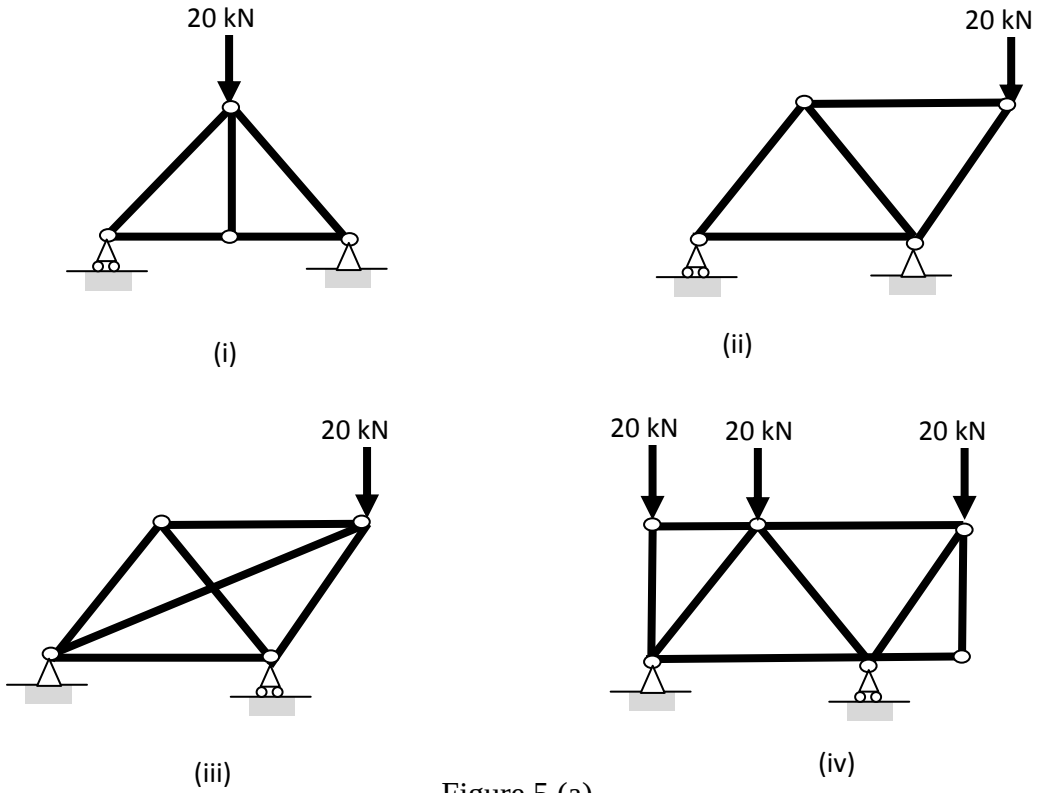


Figure 5 (a)

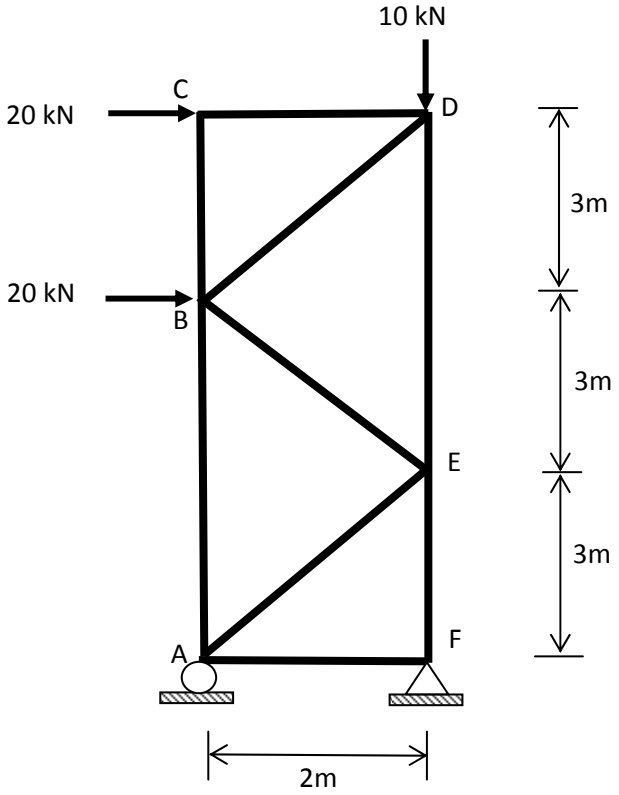


Figure 5 (b)

BAHAGIAN B (PILIH MANA-MANA DUA SOALAN)

4. *(a)* *Terbitkan nilai daya ufuk, H yang terhasil dalam kabel simetri dan tidak simetri apabila dikenakan beban teragih seragam , w dalam terma rentang, L = l_1 + l_2 dan jarak menegak dari titik trebawah ke penyokong, h . Nyatakan sebarang anggapan yang digunakan berbantukan lakaran.*

[4 markah]

(b) *Satu sistem kabel seperti yang ditunjukkan dalam Rajah 6, menanggung beban teragih seragam sebanyak 10 kN/m di sepanjang rentang antara kedua-dua penyokong dan dua beban tumpu 40 kN dan 60 kN yang berjarak 10m dari kedua-dua penyokong. Jarak ufuk antara penyokong ialah 50 m dan jarak menegak dari titik terendah dan penyokong di sebelah kiri ialah 3m. Penyokong di sebelah kanan berada 6 m lebih tinggi daripada penyokong kiri.*

Kira:

(i) *Kedudukan titik terendah kabel (x).*

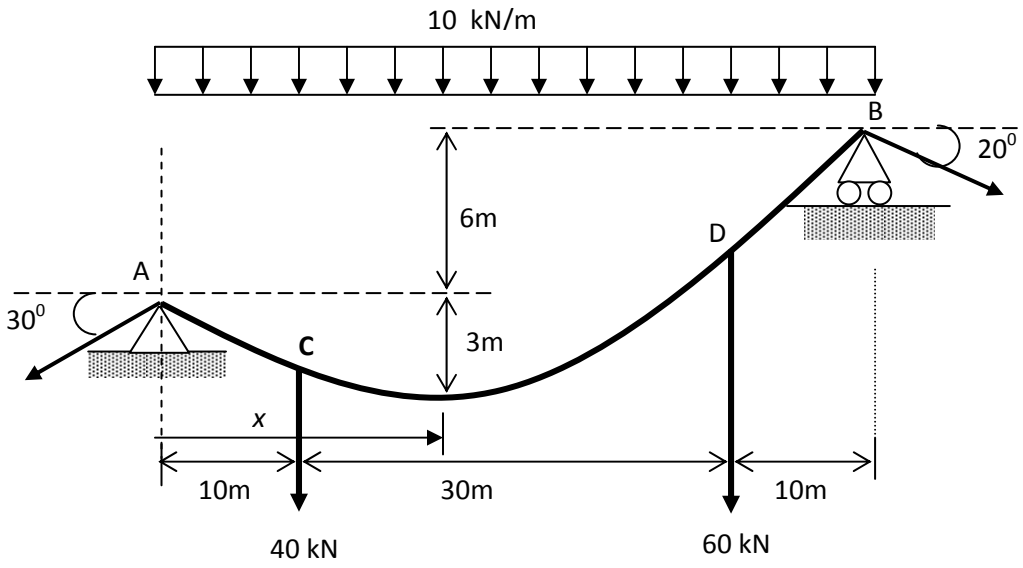
(ii) *nilai tegangan maksimum dan minimum kabel antara penyokong A dan B (T_{max} dan T_{min})*

(iii) *tegangan kabel sauh (T_A' dan T_B')*

(iv) *tindakbalas menegak dan mengufuk di penyokong (R_{vA}, R_{HA} dan R_{vB} , R_{HB})*

(v) *saiz minima kabel yang diperlukan sekiranya tegasan kabel tersebut ialah 15500 kN/m^2.*

[16 markah]



Rajah 6

5. *a)* *Semak kebolehtentuan statik untuk kedua-dua gerbang seperti di Rajah 7 (a).*

[4 markah]

Rajah 7 (a)

b) *Gerbang tiga engsel tidak simetri berbentuk parabolik dalam Rajah 7(b) direkabentuk untuk membawa beban teragih seragam sebanyak 10 kN/m sepanjang geledak jambatan dan beban tumpu 100 kN dan 80 kN di titik D dan E. Sambungan A, B dan C adalah engsel.*

Tentukan:

i) daya tindakbalas di penyokong A dan C.

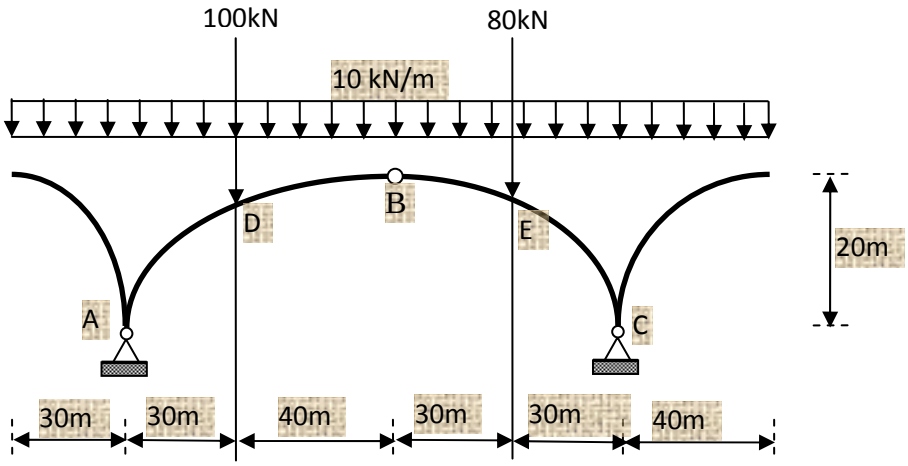
[8 markah]

ii) momen lentur di titik D dan E. Lakarkan rajah momen lentur untuk gerbang tersebut untuk rentang ADBEC.

[4 markah]

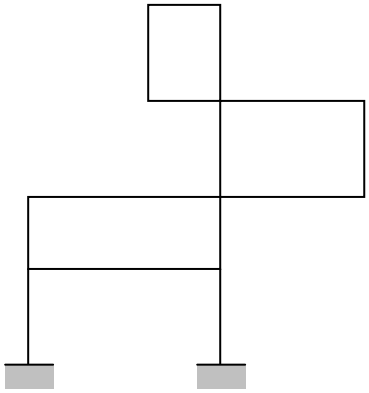
iii) daya ricih, Q dan daya paksi N di titik D (dengan beban kenaan)

[4 markah]



Rajah 7 (b)

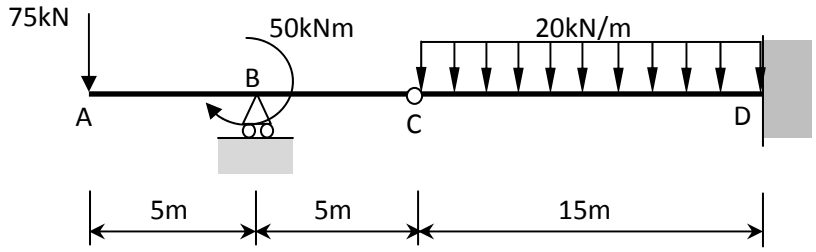
6. a) *Tanpa penggunaan sebarang persamaan, takrifkan konsep kebolehtentuan statik. Semak kebolehtentuan statik kerangka yang ditunjukkan dalam Rajah 8.*



Rajah 8

[2 markah]

b) *Rajah 9 menunjukkan analisis model satu rasuk dengan sambungan pin pada C. Rasuk berkenaan di sokong oleh penyokong rola di B dan penyokong tegar di D. Beban yang bertindak ke atas rasuk adalah seperti berikut: Satu beban tertumpu 75kN pada hujung bebas A, satu momen tertumpu 50kNm pada B dan satu beban teragih seragam 20kN/m sepanjang bahagian CD.*



Rajah 9

Lukiskan gambarajah daya ricih dan momen lentur untuk rasuk berkenaan. Lakarkan juga bentuk pesongan kualitatif.

[18 markah]

7. (a) *Senaraikan **DUA (2)** perbezaan antara gambarajah garis imbas dengan gambarajah sambutan struktur seperti gambarajah daya ricih dan gambarajah momen lentur.*

[2 markah]

(b) *Rajah 10 menunjukkan satu kerangka jambatan yang dibina untuk trak bergerak melaluinya. Lakarkan garis imbas untuk:*

(i) *daya tindakbalas menegak dan mengufuk di penyokong A,*

(ii) *daya tindakbalas menegak di penyokong B,*

(iii) *daya ricih di titik F yang berada di bahagian kiri sambungan rasuk ke tiang, dan*

(iv) *momen lentur di titik E.*

Kemudian, tentukan momen lentur maksimum di titik E.

[14 markah]

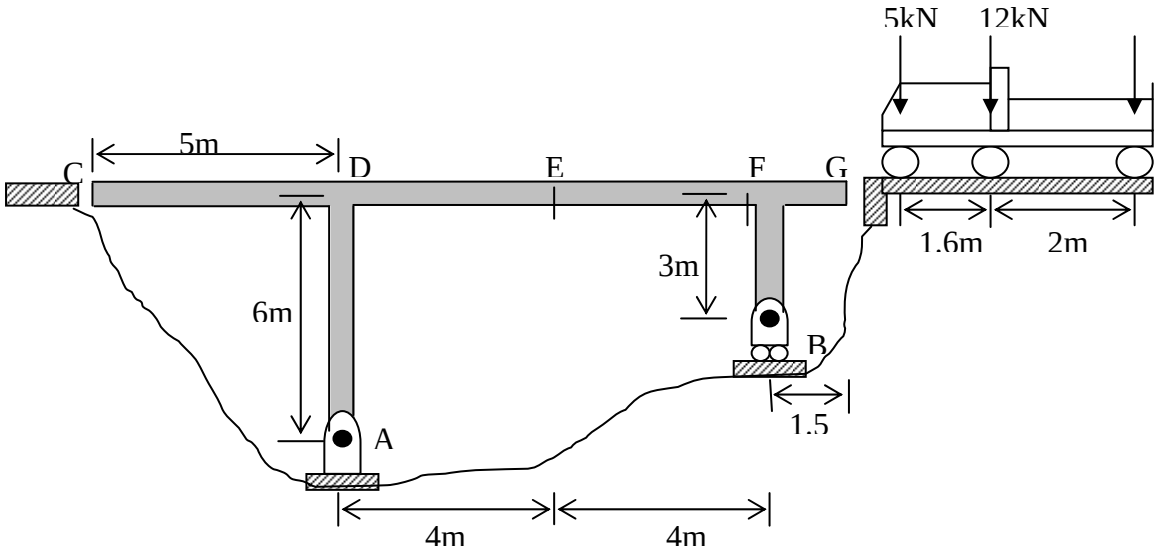
(c) *Jika titik E adalah engsel seperti yang ditunjukkan dalam Rajah 11, lakarkan garis imbas untuk:*

(i) *daya tindakbalas menegak dan mengufuk di penyokong A, dan*

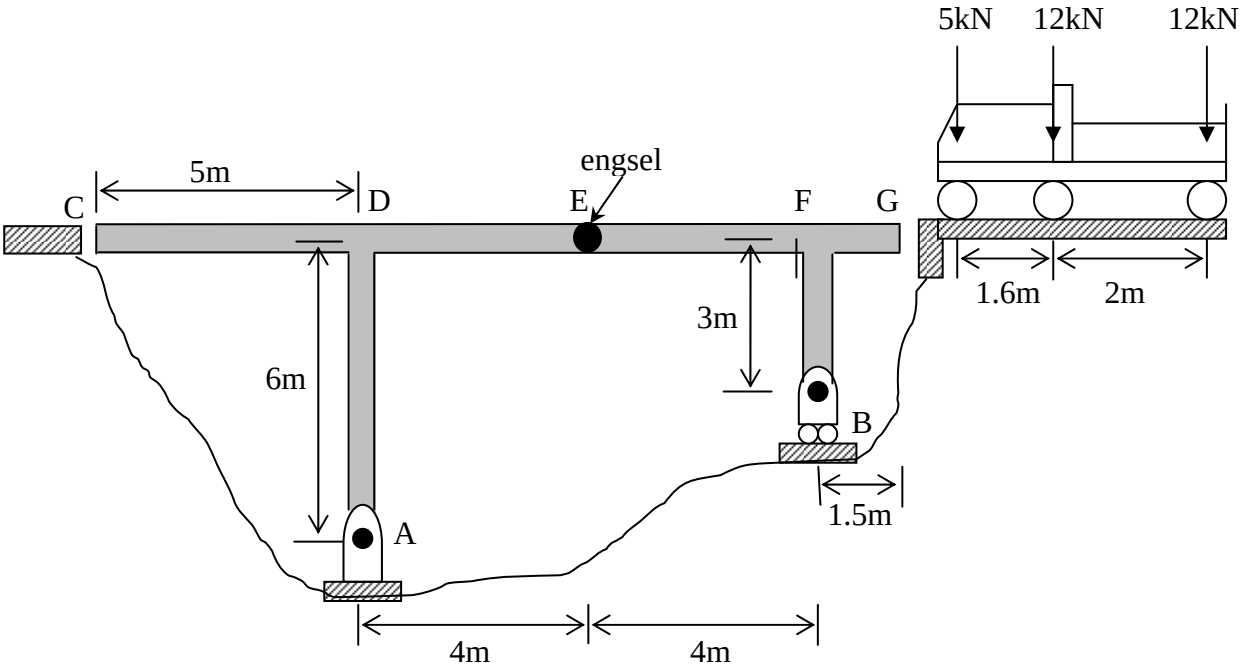
(ii) *daya tindakbalas menegak di penyokong B.*

Komen tentang keputusan untuk daya tindakbalas mengufuk seperti yang diperolehi daripada bahagian (b) dan (c).

[4 markah]

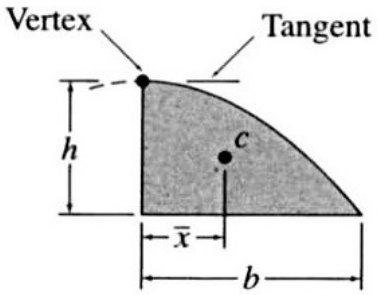
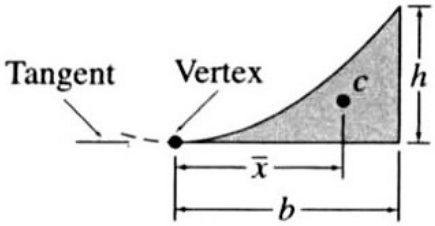
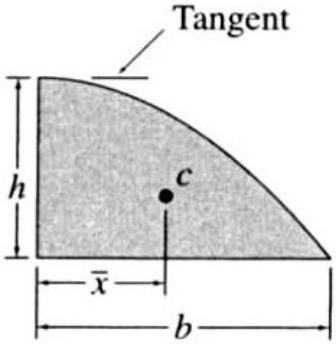
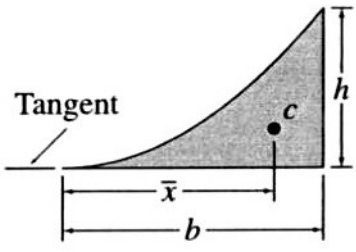


Rajah 10



Rajah 11

Appendix 1
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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