First Semester Examination
Academic Session 2018/2019

December 2018/January 2019

# EAS253 – Teori Struktur
## *(Theory of Structures)*

Duration : 3 hours
*(Masa : 3 jam)*

Please check that this examination paper consists of **SIXTEEN (16)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **ENAM BELAS (16)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini].*

**Instructions**: This paper contains ***SEVEN*** **(7)** questions. **PART A IS COMPULSORY** and answer **TWO (2)** questions in **PART B.**

***[Arahan**: Kertas ini mengandungi **TUJUH (7)** soalan. **BAHAGIAN A WAJIB DIJAWAB** dan jawab **DUA (2)** soalan di **BAHAGIAN B**.]*

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

*[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]*

**PART A:** Answer **ALL** questions.
***BAHAGIAN A:*** *Jawab* ***SEMUA*** *soalan.*

(1). **Figure 1** shows a frame structure with pinned supports at A and E. An internal hinge is located at C. Inclined member AB is subjected to a uniformly distributed load of 4 kN/m in vertical direction. A uniformly distributed load of 3 kN/m acts along member BD and a horizontal point load of 35 kN acts at point D. For the given frame,

***Rajah 1*** *menunjukkan satu struktur kerangka dengan penyokong pin pada A dan E. Satu sambungan pin dalaman terletak pada C. Anggota condong AB dikenakan satu beban teragih seragam 4 kN/m dalam arah pugak. Satu beban teragih seragam 3 kN/m bertindak di sepanjang BD dan satu beban tumpu ufuk 35 kN bertindak pada D. Untuk kerangka yang diberikan,*

(a). prove that the frame structure is statically determinate

buktikan bahawa struktur kerangka berkaitan adalah boleh tentu statik

(b). draw the corresponding shear force and bending moment diagrams

*lukiskan gambarajah daya ricih dan momen lentur*

(c). determine the axial force in member DE

*tentukan daya paksi dalam anggota DE*

(d). sketch the corresponding qualitative deflected shape.

*lakarkan bentuk pesongan kualitatif.*

[20 marks/*markah*]

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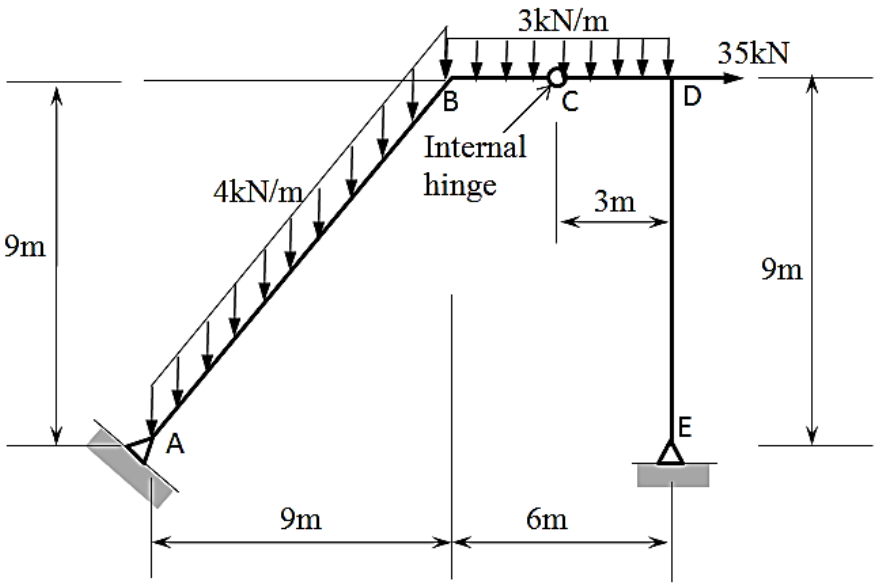


**Figure 1/*Rajah 1***

(2). (a). **Figure 2(a)** shows **FOUR (4)** different types of plane trusses. Check for the statical determinacy of the trusses. All supports and members are pinned connections.

***Rajah 2(a)*** *menunjukkan* ***EMPAT (4)*** *kekuda satah yang berbeza. Semak kebolehtentuan statik kekuda berkenaan. Semua sambungan adalah pin.*

[4 marks/*markah*]

(b). **Figure 2(b)** shows a plane truss with roller support at A and pinned support at F. Find the reactions at supports A and F. Identify zero force members, if any. Determine forces in member AB, BE and ED for the truss shown in **Figure 2(b)** by using section method. Next find the forces in member CB, CD and DB using joint method. Classify whether they are in tension or compression.

***Rajah 2(b)*** *menunjukkan satu kekuda satah dengan penyokong rola di A dan penyokong pin di F. Kenalpasti anggota kekuda yang mungkin mempunyai daya sifar, sekiranya ada. Kira daya dalam anggota AB, BE, dan ED bagi kekuda dalam* ***Rajah 2(b)*** *menggunakan kaedah keratan. Kemudian kira nilai daya dalam anggota CB, CD dan DB menggunakan kaedah sambungan. Nyatakan sama ada anggota tersebut mengalami tegangan atau mampatan.*

[12 marks/*markah*]

(c). If point load at D of 10 kN in **Figure 2(b)** is acting upward, without any calculation, determine the new forces in members DE and DB. Specify if there are any changes in the values of the forces.

*Sekiranya daya tumpu di D sebanyak 10 kN seperti dalam* ***Rajah 2(b)*** *bertindak ke atas, kira nilai baru daya dalam anggota DE dan DB. Terangkan sama ada anggota tersebut mengalami sebarang perubahan dalam nilai daya.*

[4 marks/*markah*]

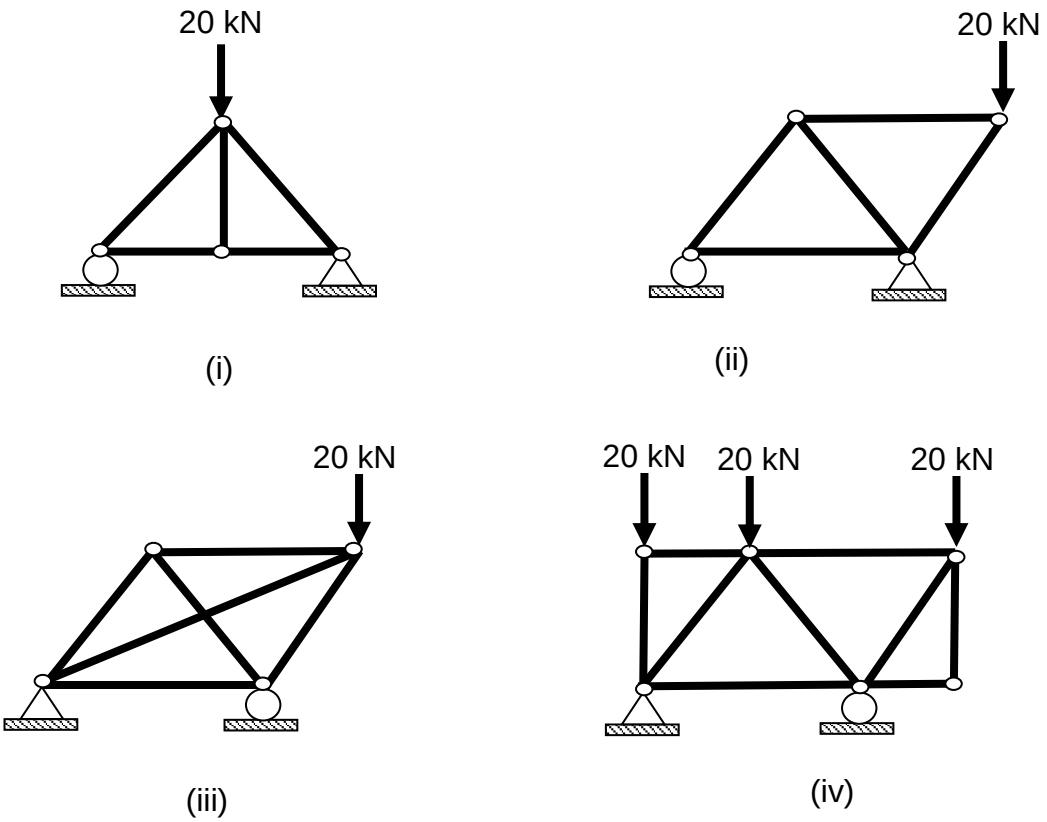


**Figure 2(a)/*Rajah 2(a)***

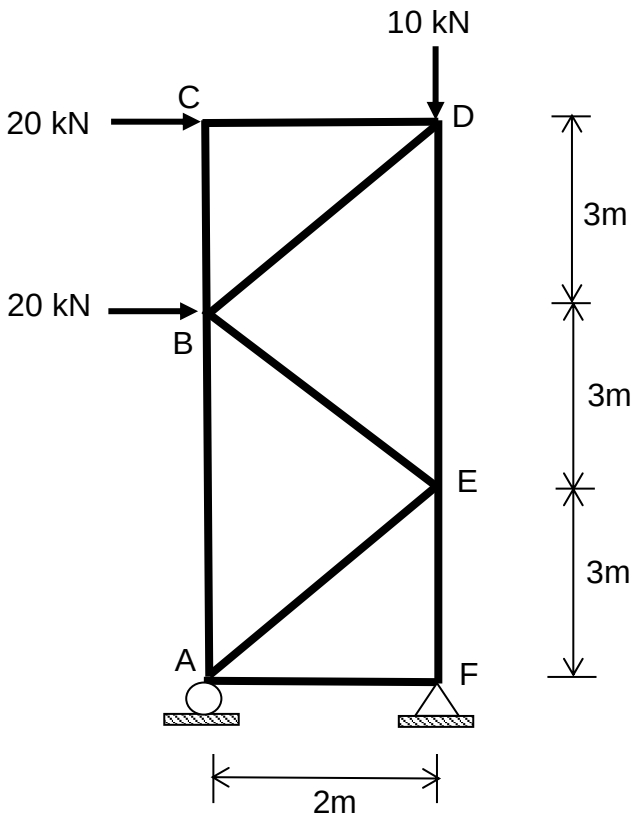


**Figure 2(b)/*Rajah 2(b)***

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(3). (a). The conjugate-beam method is developed 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. Explain why when constructing a conjugate beam, a fixed support and a simple interior support in the real beam become a free end and an internal hinge in the conjugate beam, respectively.

*Kaedah rasuk konjugat dibangunkan berasaskan kesamaan antara hubungan-hubungan di antara beban luar, daya ricih dan momen lentur dan M/EI, kecerunan dan pesongan. Terangkan kenapa apabila membina rasuk konjugat, penyokong terikat dan penyokong dalaman mudah dalam rasuk sebenar masing-masing menjadi hujung bebas dan engsel dalaman dalam rasuk konjugat.*

[4 marks/*markah*]

(b). A beam as shown in **Figure 3** is subjected to a point load of 35 kN at point B and a concentrated moment of 12 kNm at point E. Flexural rigidity for spans AC and CE are 2*EI* and *EI*, respectively. Point C is an internal hinge. Given $E$ = 200 GPa and $I = 150(10^6)$ mm$^4$, calculate the maximum deflection of the beam. Use either moment-area method or conjugate-beam method.

*Satu rasuk seperti yang ditunjukkan dalam **Rajah 3** dikenakan beban tumpu 35 kN di titik B dan momen tertumpu 12 kNm di titik E. Ketegaran lenturan untuk rentang AC dan CE ialah masing-masing 2EI dan EI. Titik C ialah engsel dalaman. Diberikan E = 200 GPa dan I = 150(10$^6$) mm$^4$, kirakan pesongan maksimum rasuk tersebut. Guna kaedah momen-luas atau kaedah rasuk konjugat.*

[16 marks/*markah*]

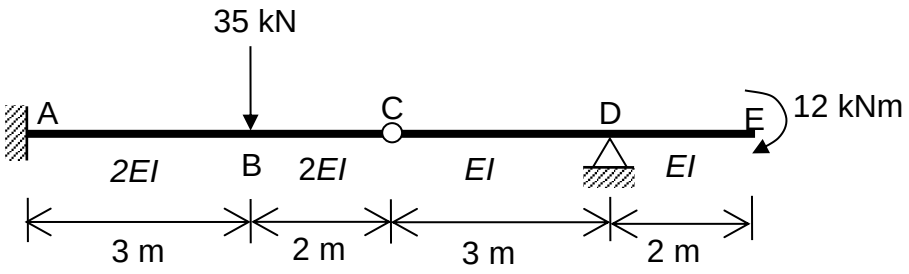



**Figure 3/*Rajah 3***

**PART B:** Answer **TWO (2)** questions.
***BAHAGIAN B:*** *Jawab* ***DUA (2)*** *soalan.*

(4). (a). **Figure 4(a)** shows a portal frame with fixed supports at A and F. Show that the degree of statical indeterminacy reduces from 3 to 1 when two internal hinged joints C and D are introduced into the frame as shown in **Figure 4(b).**

***Rajah 4(a)*** *menunjukkan satu kerangka portal dengan penyokong tegar pada A dan F. Tunjukkan bahawa darjah ketidak-bolehtentuan statik berkurang dari 3 ke 1 apabila dua sambungan pin dalaman C dan D ditambah kepada kerangka seperti yang ditunjukkan dalam* ***Rajah 4(b).***

[2 marks/*markah*]

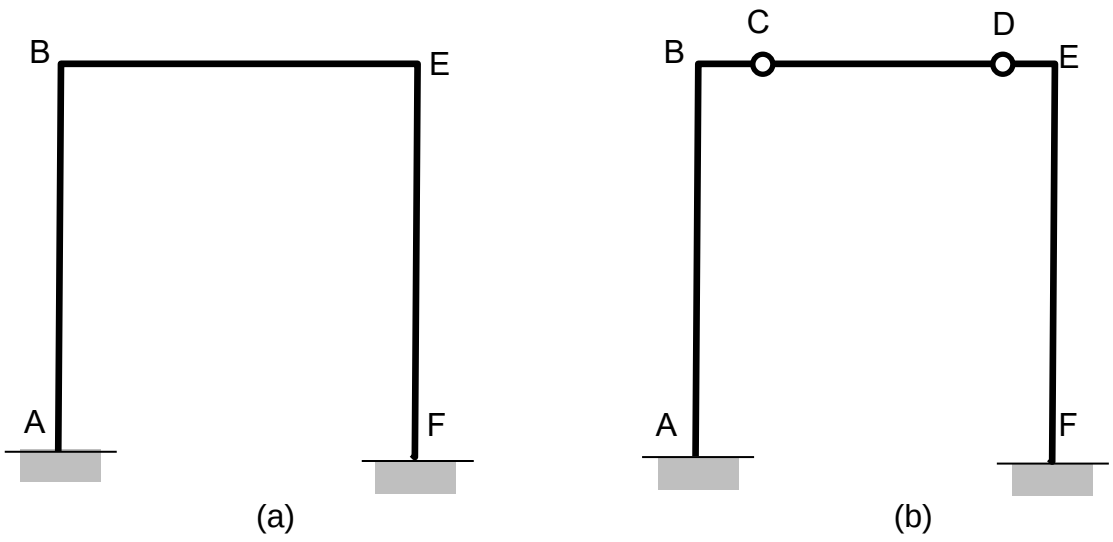



**Figure 4/*Rajah 4***

(b). **Figure 5** shows a beam supported by a fixed support at A and a roller support D. An internal hinge is located at B. Uniformly distributed loads of 7.5 kN/m and 2.5 kN/m act along AD and DE, respectively. Point loads of 25 kN and 15 kN act at point C and E, respectively. For the given beam problem,

***Rajah 5*** *menunjukkan satu rasuk yang disokong oleh penyokong tegar pada A dan penyokong rola pada D. Satu sambungan pin dalaman terletak pada B. Beban teragih seragam 7.5 kN/m dan 2.5 kN/m masing-masing bertindak di sepanjang AD dan DE. Beban tumpu 25 kN dan 15 kN masing-masing bertindak pada C dan E. Untuk masalah rasuk yang diberi,*

(i). draw the corresponding shear force and bending moment diagrams

*lukiskan gambarajah daya ricih dan momen lentur*

(ii). sketch the corresponding qualitative deflected shape.

*lakarkan bentuk pesongan kualitatif.*

[18 marks/*markah*]

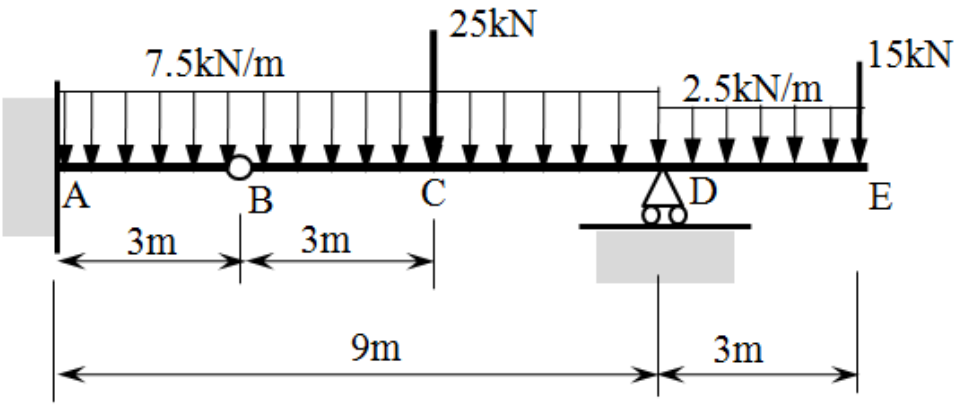



**Figure 5/*Rajah 5***

(5). (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.

*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 terbawah ke penyokong, h. Nyatakan sebarang anggapan yang digunakan berbantukan lakaran.*

[4 marks/*markah*]

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

*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 10 m dari kedua-dua penyokong A dan B. Jarak ufuk antara penyokong ialah 50 m dan jarak menegak dari titik terendah dan penyokong di sebelah kiri ialah 3 m. Penyokong di sebelah kanan berada 6 m lebih tinggi daripada penyokong kiri.*

Determine/Kira:

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

*Kedudukan titik terendah kabel (x).*

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

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

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

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

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

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

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

*saiz minima kabel yang diperlukan sekiranya tegasan kabel dibenarkan ialah 15500 kN/$m^2$.*

[16 marks/*markah*]

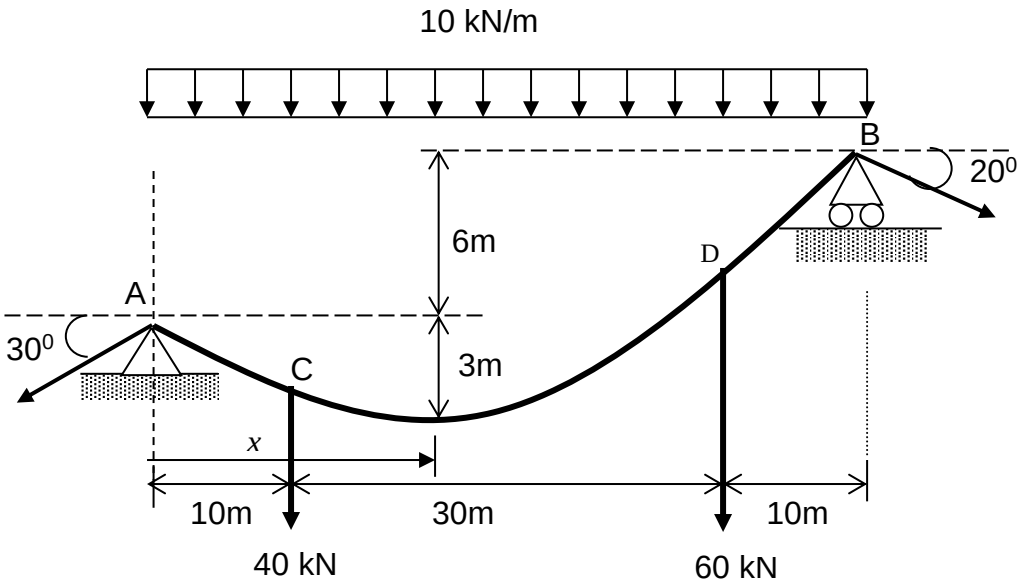



**Figure 6/*Rajah 6***

(6). (a). Check the statical determinacy of both determinate and indeterminate arches as shown in **Figure 7(a).**

*Semak kebolehtentuan statik kedua-dua gerbang boleh tentu statik dan tidak boleh tentu statik dalam **Rajah 7(a).***

[4 marks/*markah*]

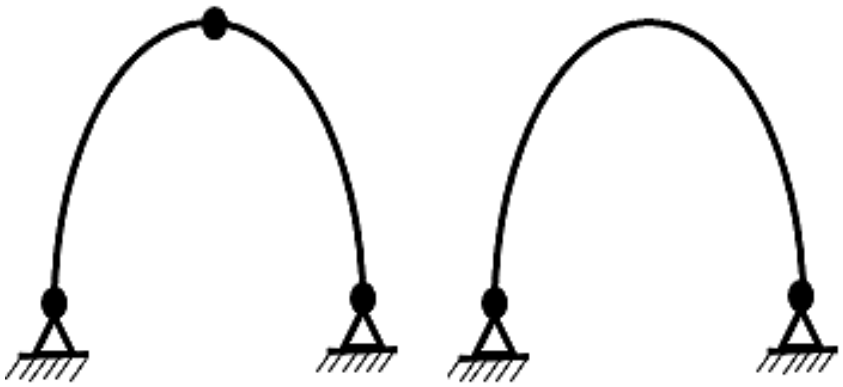


**Figure 7(a)/*Rajah 7(a)***

(b). An unsymmetrical three pinned arch in the form of parabolic given by $y = \frac{4hx\,(L-x)}{L^2}$ 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 100 kN and 80 kN at points D and E. Joints A, B and C are hinged.

*Gerbang tiga engsel tidak simetri berbentuk parabolik diberi sebagai* $y = \frac{4hx\,(L-x)}{L^2}$ *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*.

Determine/Tentukan:

(i). support reactions at A and C.

*daya tindakbalas di penyokong A dan C.*

[8 marks/*markah*]

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

*momen lentur di titik D dan E. Lakarkan rajah moment lentur untuk gerbang tersebut untuk rentang ADBEC.*

[4 marks/*markah*]

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

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

[4 marks/*markah*]

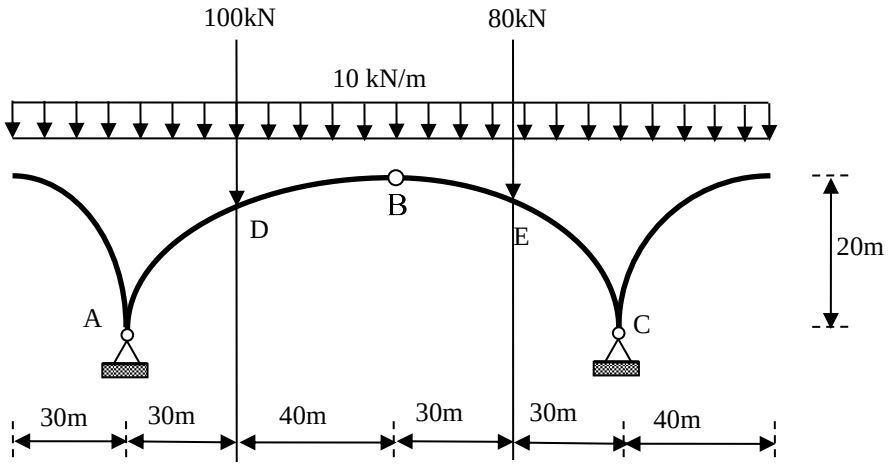



**Figure 7(b)/*Rajah 7(b)***

(7). (a). Explain the differences between influence lines and the diagrams of structural response such as shear force diagram and bending moment diagram.

*Jelaskan perbezaan antara garis imbas dan gambarajah untuk tindakbalas struktur seperti gambarajah daya ricih dan gambarajah momen lentur.*

[4 marks/*markah*]

(b). **Figure 8** shows a bridge girder which is constructed to allow vehicle to travel on it. Draw the influence lines for

***Rajah 8*** *menunjukkan satu galang jambatan yang dibina untuk kenderaan melaluinya. Lukis garis imbas untuk*

(i). the reactions at supports B and E,

*tindakbalas di penyokong B dan E,*

(ii). the shear at point C which is just to the right of support, and

*daya ricih di titik C yang berada hanya sedikit kanan dari penyokong, dan*

(iii). the bending moment at point D.

*momen lentur di titik D.*

[10 marks/*markah*]

(c). Determine the maximum values of the shear at point C and bending moment at point D due to a truck travels from point A to point G and from point G to Point A.

*Tentukan nilai maksimum untuk daya ricih di titik C dan momen lentur di titik D disebabkan sebuah lori yang bergerak dari titik A ke titik G dan dari titik G ke titik A.*

[6 marks/*markah*]

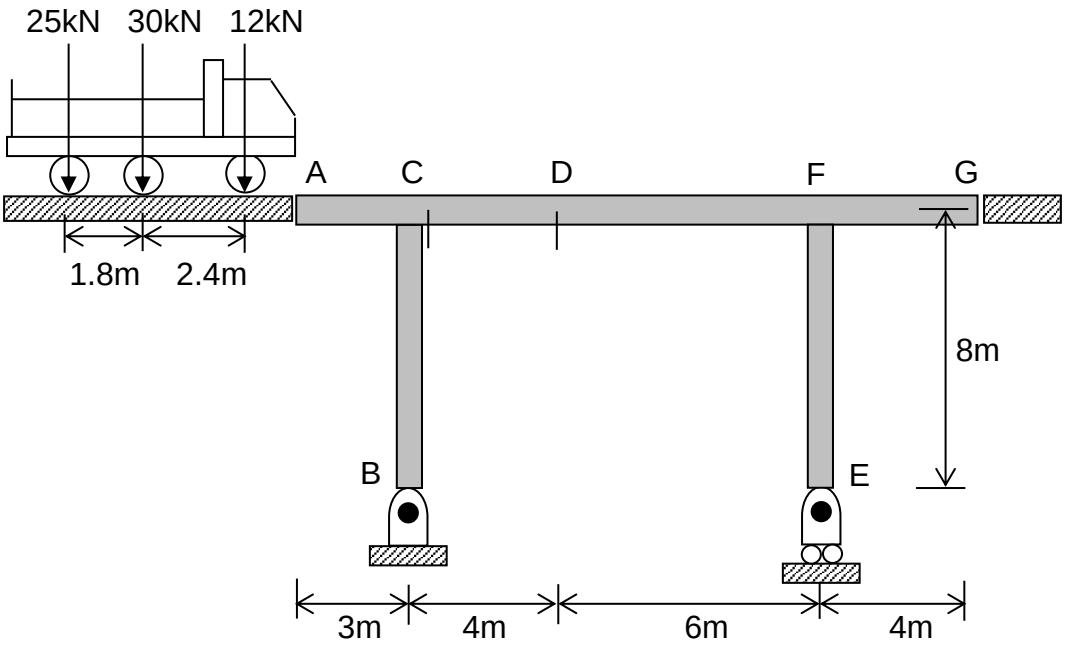
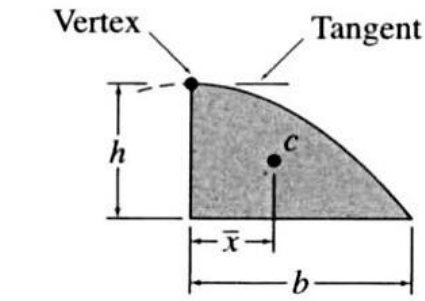
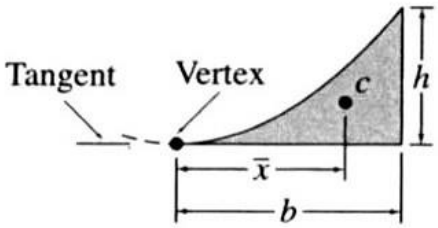
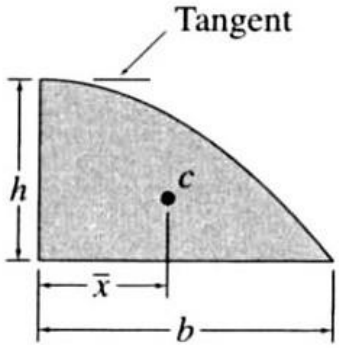
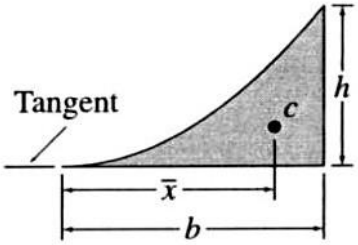



**Figure 8/*Rajah 8***

**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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