UNIVERSITI SAINS MALAYSIA

First Semester Examination
2015/2016 Academic Session

December 2015 / January 2016

EAS253 – Theory of Structures
[Teori Struktur]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of **ELEVEN (11)** printed pages including **ONE (1)** appendix before you begin the examination.
*[Sila pastikan kertas peperiksaan ini mengandungi **SEBELAS (11)** muka surat bercetak termasuk **SATU (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 **SEVEN (7)** soalan. Jawab **THREE (3)** soalan wajib di Bahagian A dan pilih **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.]

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai]

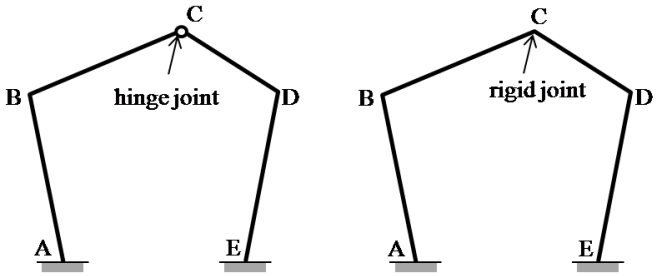
PART A : ANSWER ALL THREE (3) QUESTIONS.

BAHAGIAN A : JAWAB SEMUA TIGA (3) SOALAN.

1. [a] Show that the degree of statical indeterminacy changes from 2 to 3 for the frames in **Figure 1** (a) and (b).

Tunjukkan bahawa darjah ketidakbolehtentuan statik bertukar daripada 2 ke 3 untuk kerangka dalam ***Rajah 1****(a) dan (b).*

[3 marks*/markah*]



(a) (b)

Figure 1 / Rajah 1

[b] **Figure 2** shows a continuous beam with pinned support at A, roller supports at B, D and hinged joint at C. The beam is loaded with a uniformly distributed load of 15 kN/m and 25 kN/m along spans AB and BD, respectively; a linearly distributed load varying from 25 kN/m to 0 kN/m along overhang span DE; and a couple with a magnitude of 15 kNm at E.

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

Rajah 2 *menunjukkan satu rasuk selanjar dengan penyokong pin di A, penyokong rola di B, D dan sambungan sendi di C. Rasuk berkenaan membawa beban teragih seragam 15 kN/m dan 25 kN/m masing-masing di sepanjang rentang AB dan BD; satu beban teragih lelurus yang berubah daripada 25 kN/m kepada 0 kN/m di sepanjang rentang terjulur DE; dan satu gandingan dengan magnitud 15 kNm pada E.*

Lukis gambarajah daya ricih dan momen lentur untuk rasuk berkenaan. Lakarkan juga bentuk terpesong kualitatif.

[17 marks/*markah*]

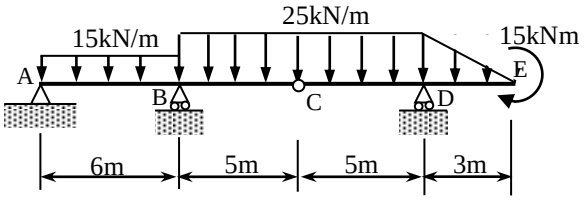


Figure 2 / Rajah 2

2. [a] The conjugate-beam method is based on the analogy between the relationships among load, shear and bending moment and the relationships among M/EI, slope and deflection. Using this analogy, explain why

[i] a simple end support in the real beam remains as a simple end support in the conjugate beam,
[ii] an internal hinge in the real beam becomes an interior simple support in the conjugate beam.

Kaedah rasuk konjugat adalah berasaskan analogi antara hubungan beban, daya ricih dan momen lentur dengan hubungan M/EI, kecerunan dan pesongan. Dengan menggunakan analogi ini, jelaskan mengapa

[i] penyokong hujung mudah untuk rasuk sebenar kekal sebagai penyokong hujung mudah untuk rasuk konjugat,
[ii] engsel dalaman di rasuk sebenar menjadi penyokong mudah dalaman untuk rasuk konjugat.

[4 marks/markah]

[b] A continuous beam as shown in **Figure 3** is subjected to a uniformly distributed load of 5 kN/m throughout the whole span of the beam and a concentrated moment of 15 kNm at point C. Using E = 200 GPa and I = 300(10^6) mm^4, calculate the slope at both ends and the deflection at point C.

*Satu rasuk selanjar seperti yang ditunjukkan dalam **Rajah 3** dikenakan beban teragih seragam 5 kN/m di sepanjang rasuk dan momen tertumpu 15 kNm di titik C. Dengan menggunakan E = 200 GPa dan I = 300(10^6) mm^4, kirakan kecerunan di kedua-dua hujung dan pesongan di titik C.*

[16 marks/markah]

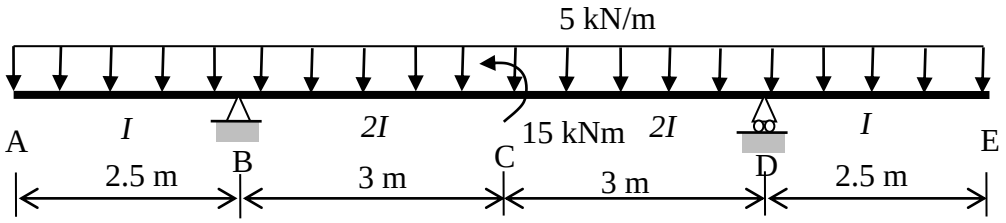


Figure 3 / Rajah 3

3. [a] **Figure 4** shows a plane truss of a cantilever roof in residential area. Check the statical determinacy of the truss. Support A is roller and support B is pinned. All member connections are pinned. Find the reactions at both supports and identify zero force members, if any. Determine forces in member DF, CF and EF by using section method and members FG, EG, AD and AC by using joint method. Classify whether they are in tension or compression.

***Rajah 4** menunjukkan satu kekuda satah bumbung julur di kawasan perumahan. Semak kebolehtentuan statik kekuda berkenaan. Penyokong A adalah rola penyokong B adalah pin. Semua sambungan anggota adalah pin. Kira nilai daya tindakbalas di kedua penyokong dan kenalpasti anggota kekuda yang mungkin mempunyai daya sifar, sekiranya ada. Kira daya dalam anggota DF, CF and CE menggunakan kaedah keratan dan anggota FG, EG, AD dan AC menggunakan kaedah sambungan. Nyatakan sama ada anggota tersebut mengalami daya mampatan atau tegangan.*

[17 marks/*markah*]

[b] If one member DE is added to the truss shown in **Figure 4**, what will happen to the overall stability of the truss? Without any calculation, state if there is any changes to the forces in members DF, CF and EF.

*Sekiranya satu anggota kekuda DE ditambah kepada kekuda dalam **Rajah 4**, apakah yang akan berlaku kepada kestabilan kekuda tersebut? Tanpa sebarang pengiraan, nyatakan samada terdapat sebarang perubahan daya dalam anggota DF, CF dan EF.*

[3 marks/*markah*]

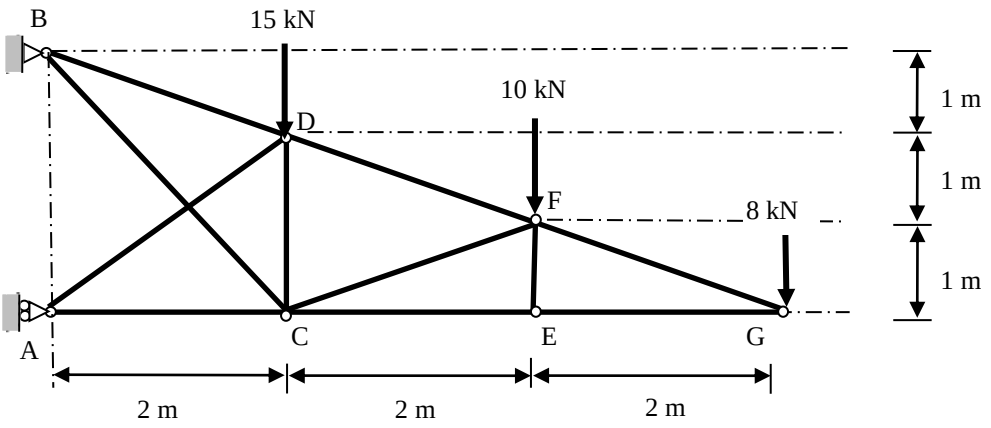


Figure 4 / Rajah 4

PART B : ANSWER ANY TWO (2) QUESTIONS.

BAHAGIAN B: JAWAB MANA-MANA DUA (2) SOALAN.

4. [a] State **TWO (2)** characteristics of cables.

*Nyatakan **DUA (2)** ciri kabel.*

[2 marks/*markah*]

[b] The 60 m cable shown in **Figure 5** is loaded with point loads at C, D and E. Supports A and B are pinned. Assuming that self weight of the cable is negligible, determine:

*Kabel sepanjang 60 m seperti yang ditunjukkan dalam **Rajah 5** menanggung beban tumpu di C, D dan E. Kedua-dua penyokong A dan B adalah pin. Andaikan bahawa beban kendiri kabel diabaikan, kira:*

[i] Support reactions at A and B
Tindakbalas penyokong A dan B

[ii] Tension forces in segments AC, CD, DE and EB
Daya tegangan dalam segmen AC, CD, DE dan EB

[iii] Total length of cable, (S)
Jumlah panjang kabel, (S)

[iv] Tension forces at supports A and B (T_A and T_B)
Daya tegangan pada penyokong A dan B (T_A dan T_B)

[v] Minimum size of the cable, if the allowable stress is 16000 kN/m^2.
Saiz minima kabel yang diperlukan sekiranya tegasan kabel dibenarkan ialah 16000 kN/m^2.

[18 marks/*markah*]

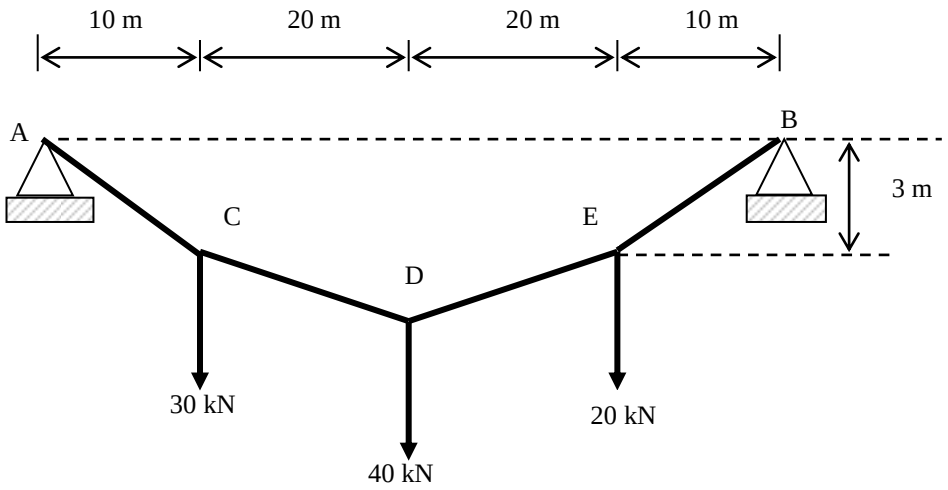


Figure 5 / Rajah 5

5. [a] What is the main difference between arch structures and cable structures?

Apakah perbezaan utama antara struktur gerbang dan struktur kabel?

[2 marks/*markah*]

[b] An unsymmetrical three pinned arch in the form of $y = \frac{4hx(L-x)}{L^2}$ is shown in **Figure 6**. It is designed to carry a uniformly distributed load of 20 kN/m spanning 36 m and point loads of 100 kN and 80 kN at B and D, respectively. A horizontal point load of 20 kN is applied at point B. Joint A, C and E are hinged. Determine the support reactions, bending moment at B and D, shear force (Q) and thrust (N) at point B and D (with loading). Sketch the bending moment diagram of the arch.

Satu gerbang tiga engsel tidak simetri dibentuk daripada persamaan $y = \frac{4hx(L-x)}{L^2}$ *seperti ditunjukkan dalam* ***Rajah 6****. Ia direkabentuk untuk membawa beban teragih seragam sebanyak 20 kN/m di sepanjang rentang 36 m dan beban tertumpu 100 kN dan 80 kN masing-masing pada B dan D. Beban tumpu mengufuk sebanyak 20 kN dikenakan di titik B. Sambungan A, C dan E adalah engsel. Tentukan daya tindakbalas di penyokong, momen lentur di titik B dan D, daya ricih (Q) dan daya tujah (N) di titik B dan D (dengan beban kenaan). Lakarkan rajah moment lentur untuk gerbang tersebut.*

[18 marks/*markah*]

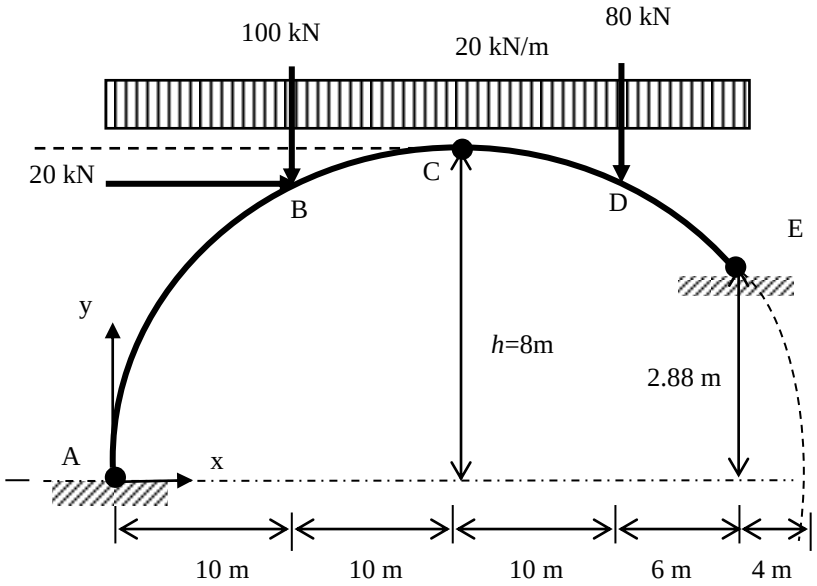


Figure 6 / Rajah 6

6. [a] Check the statical determinacy of the beam shown in **Figure 7**. Suggest a way to reduce the statical indeterminacy by 1 without changing the support condition.

*Semak kebolehtentuan statik untuk rasuk dalam **Rajah 7**. Cadangkan satu cara untuk mengurangkan 1 darjah ketidakbolehtentuan statik tanpa mengubah keadaan penyokong.*

[3 marks/markah]

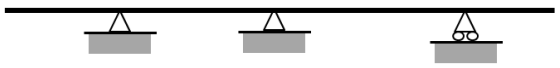


Figure 7 / Rajah 7

[b] **Figure 8** shows a frame with pinned and roller supports at A and C, respectively. It is loaded by a horizontal uniformly distributed load of 15 kN/m along vertical member AB, a vertical uniformly distributed load of 20 kN/m along inclined members BC, and a horizontal concentrated load of 25 kN at joint B. Draw the axial force, shear force and bending moment diagrams for the frame. Sketch also the qualitative deflected shape.

Rajah 8 *menunjukkan satu kerangka dengan penyokong pin pada A dan penyokong rola pada C. Kerangka berkaitan dibebankan dengan beban teragih seragam ufuk 15 kN/m di sepanjang anggota pugak AB, beban teragih seragam pugak 20 kN/m di sepanjang anggota condong BC dan beban tertumpu ufuk 25 kN pada sambungan B. Lukis gambarajah daya paksi, daya ricih dan momen lentur untuk kerangka berkenaan. Lakarkan juga bentuk terpesong kualitatif.*

[17 marks/*markah*]

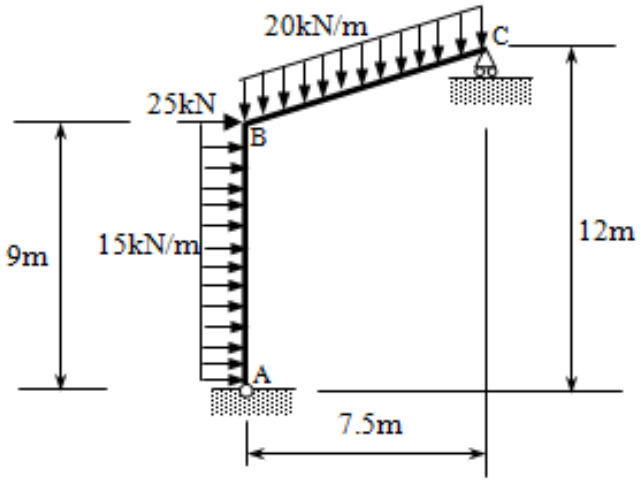


Figure 8 / Rajah 8

7. [a] **Figure 9** shows a bridge frame which is constructed to allow vehicle to travel on it. Draw the influence lines for

Rajah 9 *menunjukkan satu kerangka jambatan yang dibina untuk kenderaan melaluinya. Lukis garis imbas untuk*

[i] the vertical reactions at supports A and B,
tindakbalas menegak di penyokong A dan B,

[ii] the shear at point D which is just to the right of beam-to-column connection, and;
daya ricih di titik D yang berada hanya sedikit kanan dari sambungan rasuk ke tiang, dan;

[iii] the bending moment at points C and E.

momen lentur di titik C dan E.

[12 marks/markah]

[b] Determine the maximum values of the reaction forces at supports A and B, shear at point D and bending moment at point E due to a truck travelling from point F to point C.

Tentukan nilai maksimum untuk daya tindakbalas di penyokong A dan B, daya ricih di titik D dan momen lentur di titik E disebabkan sebuah lori yang bergerak dari titik F ke titik C.

[8 marks/markah]

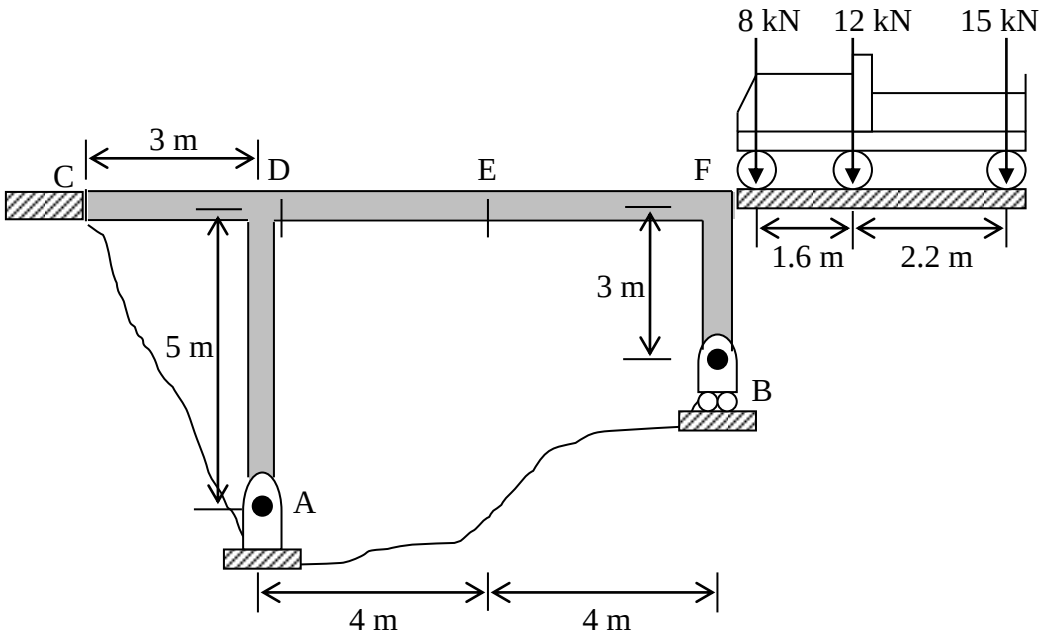
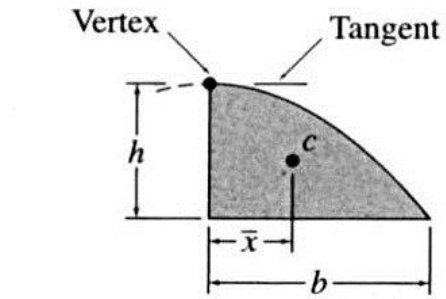
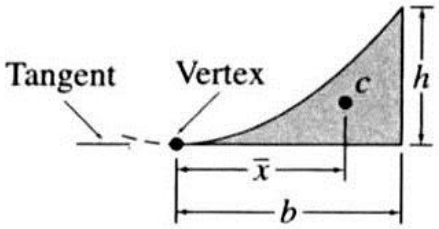
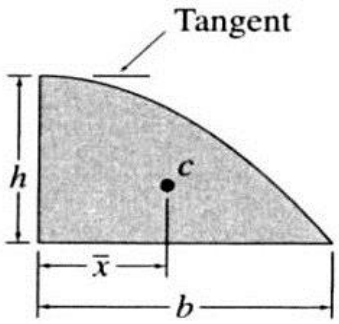
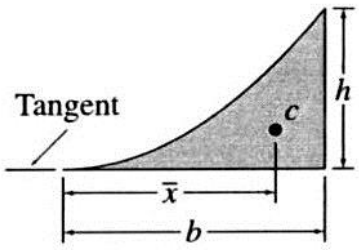


Figure 9 /Rajah 9

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 	$A=\frac{bh}{4}$	$\bar{x}=\frac{4b}{5}$

- oooOOOooo -