

**SULIT**

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First Semester Examination  
2021/2022 Academic Session

February/March 2022

**EAS253 – Theory of Structures**

Duration : 3 hours

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Please check that this examination paper consists of **NINE (9)** pages of printed material including appendix before you begin the examination.

**Instructions** : This paper contains **SEVEN (7)** questions. Answer all **THREE (3) COMPULSORY** questions in **PART A** and any **TWO (2)** questions in **PART B**.

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

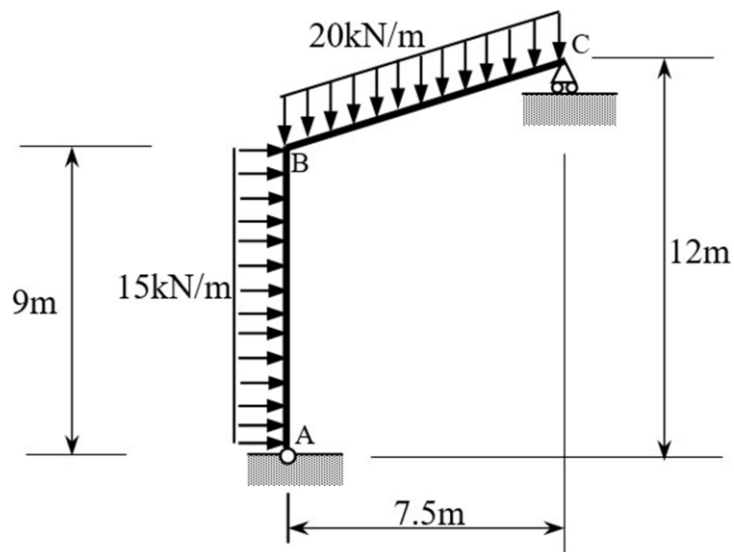
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**SULIT**

**PART A : ANSWER ALL QUESTIONS**

1. **Figure 1** shows a frame with pinned and roller supports at A and C, respectively. It is loaded by a uniformly distributed load  $15\text{kN/m}$  along vertical member AB and a uniformly distributed load  $20\text{kN/m}$  along inclined members BC. Draw shear force and bending moment diagrams for the frame. Calculate axial force in member AB. Sketch also the qualitative deflected shape.

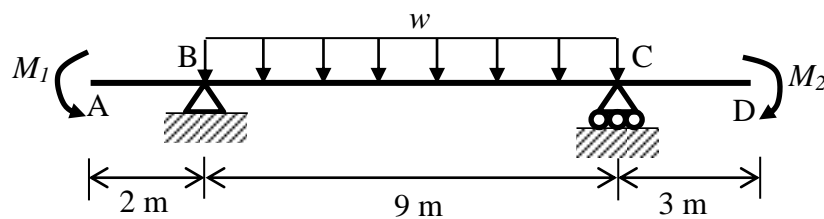
[20 marks]

**Figure 1**

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2. **Figure 2** shows a beam of 14 m subjected to a uniformly distributed load of  $w$  acting on span BC and two concentrated moments of  $M_1$  and  $M_2$  at points A and D, respectively. Flexural rigidity of the beam is  $EI$ . Given  $E = 210 \text{ GPa}$  and  $I = 175(10^6) \text{ mm}^4$ , calculate the slope of the beam at a points A and D and the deflection at midspan of BC. Use either moment-area method or conjugate-beam method. The values of  $w$ ,  $M_1$  and  $M_2$  are given in **Table 1** according to your matric number.

[20 marks]

**Figure 2****Table 1**

Last digit of matric number	$w$ (kN/m)	$M_1$ (kNm)	Second last digit of matric number	$M_2$ (kNm)
0	3	14.5	0	3
1	3.5	13.5	1	4
2	4	12.5	2	5
3	4.5	11.5	3	6
4	5	10.5	4	7
5	5.5	9.5	5	8
6	6	8.5	6	9
7	6.5	7.5	7	10
8	7	6.5	8	11
9	7.5	5.5	9	12

Note: If your matric number is 15628, use  $w = 7 \text{ kN/m}$ ,  $M_1 = 6.5 \text{ kNm}$ , and  $M_2 = 5 \text{ kNm}$ .

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3. (a). **Figure 3** shows a plane truss. Check the statical determinacy of the truss. Support A is pinned and support E is roller. All member connections are pinned. Calculate the reactions at both supports and identify zero force members, if any. Determine forces in members AD, BD and BC by using section method and forces in members EF, FG and GC by using joint method. State whether they are in tension or compression.

[14 marks]

- (b). If the dimension of all the members in the truss shown in **Figure 3** are doubled, determine the changes of the forces in members AD and BD.

[3 marks]

- (c). If all the loads in the truss shown in **Figure 3** are reduced by 50%, determine the changes of the forces in horizontal members EF and FG.

[3 marks]

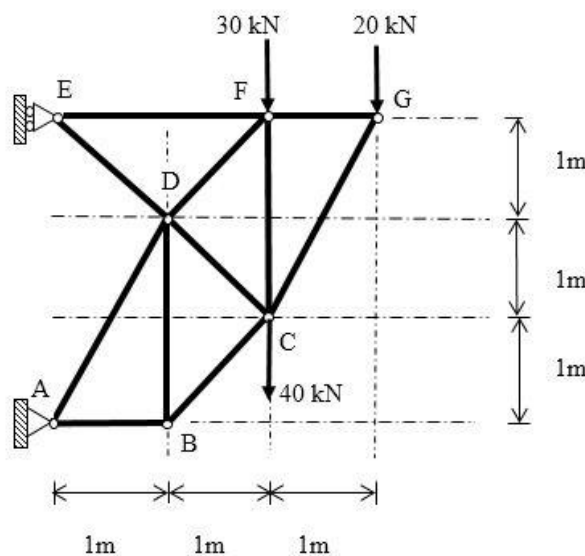


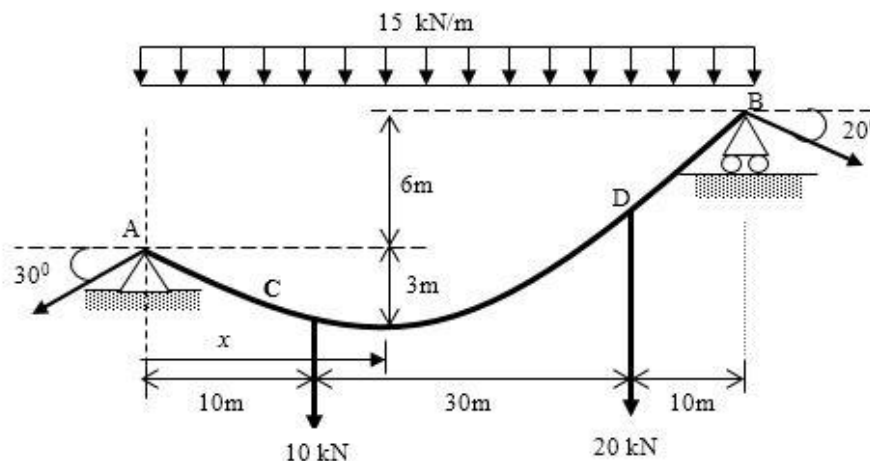
Figure 3

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**PART B : ANSWER TWO (2) QUESTIONS**

4. The cable system shown in **Figure 4** carries a uniformly distributed load of 15 kN/m between the supports and two point loads of 10 kN and 20 kN at 10 m away from both 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. Determine:
- the lowest point of the cable ( $x$ ).
  - the maximum and minimum tension in cable between A and B ( $T_{\max}$  and  $T_{\min}$ ).
  - the tension in anchor cables ( $T_A'$  and  $T_B'$ ).
  - vertical and horizontal reactions at supports ( $R_{VA}$ ,  $R_{HA}$  and  $R_{VB}$ ,  $R_{HB}$ ).
  - minimum size of the cable, if the allowable stress is 15500 kN/m<sup>2</sup>.

[20 marks]

**Figure 4**

...6/-

5. Unsymmetrical three pinned arch shown in **Figure 5** is in the form of  $y=4hx(L-x)/L^2$ , where  $L = 40$  m and  $h = 8$  m. Support A is 2.88 m lower than support E. It is designed to carry a uniformly distributed load of 5 kN/m spanning 26 m on span BCDE and a point load of 10 kN at D. A horizontal point load of 20 kN is applied at point B. Joints A, C and E are hinged. Determine:

- support reactions at A and E.
- bending moment at points B and D.
- shear force (Q) and thrust (N) at points B and D (with loading).
- sketch the bending moment diagram of the arch.

[20 marks]

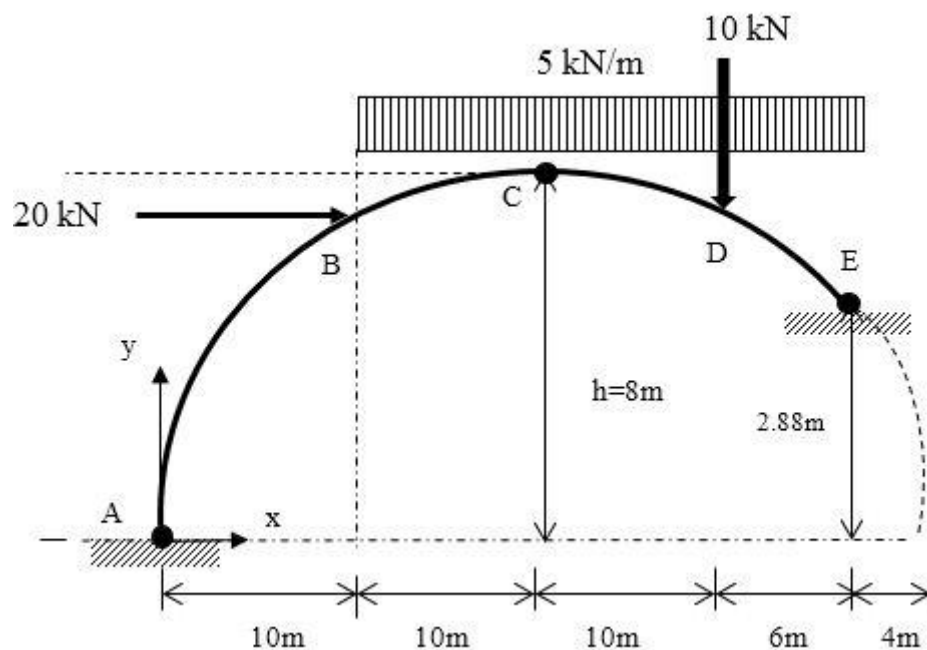


Figure 5

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6. (a). Influence line for shear force and shear force diagram are diagrams showing the response of a structure. Using a simply supported beam as an example, explain the ways to construct an influence line for shear force at mid span of the beam. Describe the meaning of the values shown on the influence line at both supports of the beam.

[5 marks]

- (b). **Figure 6** shows a truck traveling on a 12 m long bridge girder which is constructed across a river. Vehicles travel on it in both directions. Determine the maximum values of the shear force at point B and bending moment at point C of the beam when a truck travels from:

- i) point A to point D, and
- ii) point D to point A.

[15 marks]

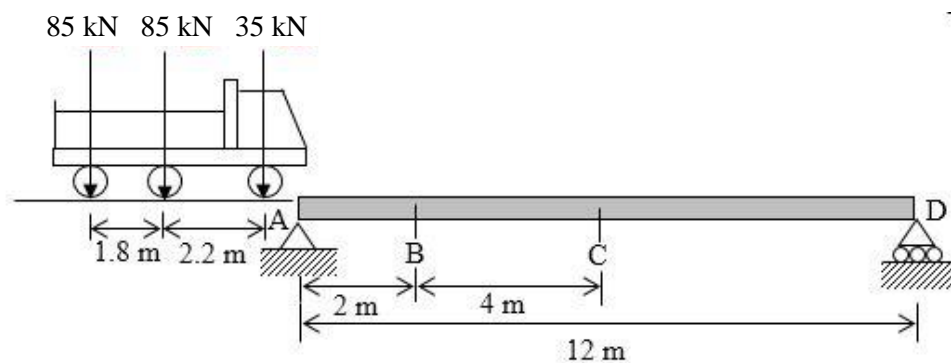
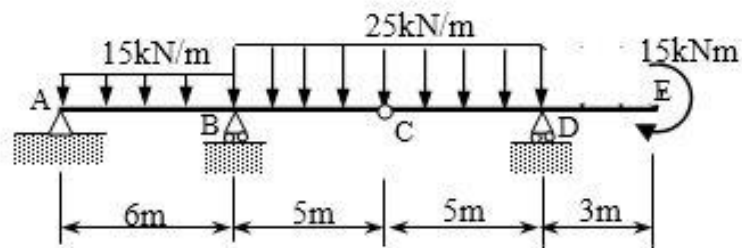


Figure 6

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7. **Figure 7** shows a continuous beam with pinned support at A, roller supports at B, D and hinge joint at C. The beam is loaded with uniformly distributed loads 15 kN/m and 25 kN/m along spans AB and BD, respectively; and a couple 15 kNm at E. Draw the shear force and bending moment diagrams for the beam. Sketch the qualitative deflected shape.

[20 marks]

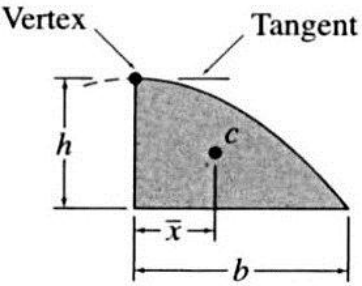
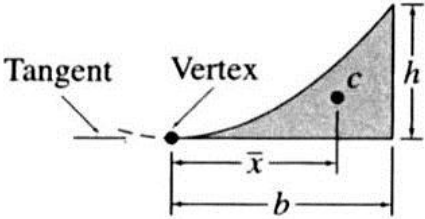
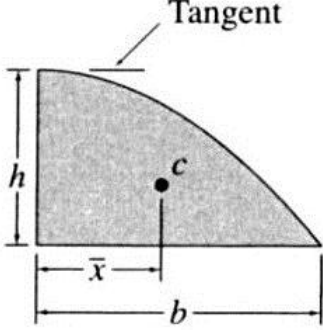
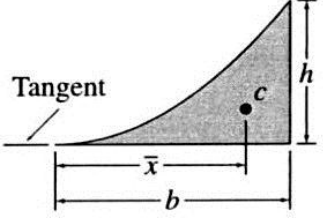


**Figure 7**

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**APPENDIX**

**Areas and Centroids of Geometric Shapes**

Shape	Area	Centroid
<p>Semi-parabola</p>  <p>The diagram shows a shaded semi-parabolic shape. The vertical height is labeled <math>h</math>. The horizontal base is labeled <math>b</math>. A dashed line represents the tangent at the top vertex. The centroid is marked with a dot and labeled <math>c</math>. A horizontal dimension line from the y-axis to the centroid is labeled <math>\bar{x}</math>.</p>	$A = \frac{2bh}{3}$	$\bar{x} = \frac{3b}{8}$
<p>Parabolic spandrel</p>  <p>The diagram shows a shaded parabolic spandrel shape. The vertical height is labeled <math>h</math>. The horizontal base is labeled <math>b</math>. A dashed line represents the tangent at the bottom vertex. The centroid is marked with a dot and labeled <math>c</math>. A horizontal dimension line from the y-axis to the centroid is labeled <math>\bar{x}</math>.</p>	$A = \frac{bh}{3}$	$\bar{x} = \frac{3b}{4}$
<p>Cubic</p>  <p>The diagram shows a shaded cubic shape. The vertical height is labeled <math>h</math>. The horizontal base is labeled <math>b</math>. A dashed line represents the tangent at the top vertex. The centroid is marked with a dot and labeled <math>c</math>. A horizontal dimension line from the y-axis to the centroid is labeled <math>\bar{x}</math>.</p>	$A = \frac{3bh}{4}$	$\bar{x} = \frac{2b}{5}$
<p>Cubic spandrel</p>  <p>The diagram shows a shaded cubic spandrel shape. The vertical height is labeled <math>h</math>. The horizontal base is labeled <math>b</math>. A dashed line represents the tangent at the bottom vertex. The centroid is marked with a dot and labeled <math>c</math>. A horizontal dimension line from the y-axis to the centroid is labeled <math>\bar{x}</math>.</p>	$A = \frac{bh}{4}$	$\bar{x} = \frac{4b}{5}$