Charles Darwin University

Final Examination

Family Name						
Given Name/s						
Student Number						
Teaching Period	Semester 1, 2019					

ENG469 – Structural Analysis	DURATION	
	Reading Time:	10 minutes
	Writing Time:	180 minutes

INSTRUCTIONS TO CANDIDATES

1. Read all questions carefully.
2. Answer all questions.
3. Show all working (calculations and sketches)
4. This exam constitutes 60% of the total marks for this unit.
5. Total marks available on this exam is 100.
6. Questions are not of equal value
7. Use dark blue or black ink.

EXAM CONDITIONS

You may begin writing from the commencement of the examination session. The reading time indicated above is provided as a guide only.

This is a CLOSED BOOK examination

Any non-programmable calculator is permitted

No handwritten notes are permitted

No dictionaries are permitted

ADDITIONAL AUTHORISED MATERIALS	EXAMINATION MATERIALS TO BE SUPPLIED
No additional printed material is permitted	1 x 20 Page Book

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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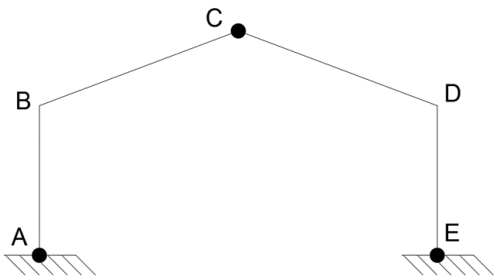
Question 1. (8 Marks)

Give brief comments on each of the frames below, including determinancy, redundancy, method of analysis and anything else you consider important.

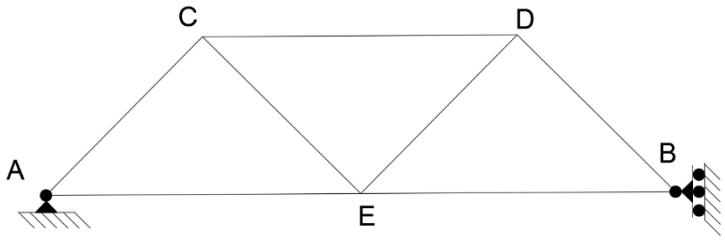
1.1 (2 Marks)

Gable frame with pin connections at A, C and E. Joints B and D are fixed.



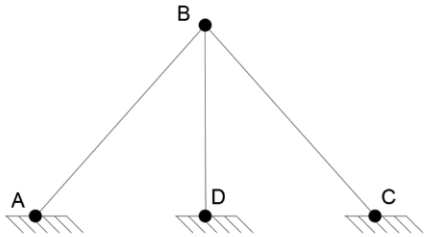
1.2 (2 Marks)

Pin-jointed frame, pinned support at A and roller support at B.



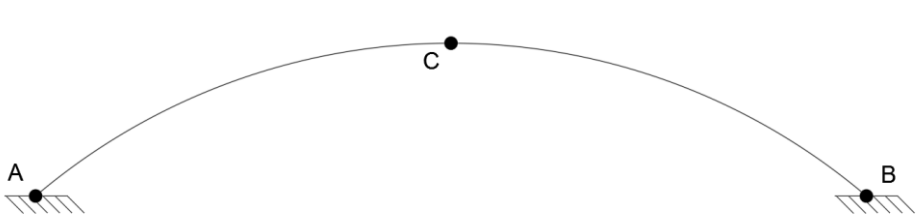
1.3 (2 Marks)

Pin-jointed frame, each member is pinned at one end to a rigid foundation.



1.4 (2 Marks)

Arch with pin connections at A, B and C.



Question 2. (6 Marks)

An arch structure, as shown in the picture below, carries a vertical point load of 45 kN acting at 6 m from the right-hand side support. The arch has a rise of 4 m and a span of 24 m. Determine the values and directions of the reactions at the supports.

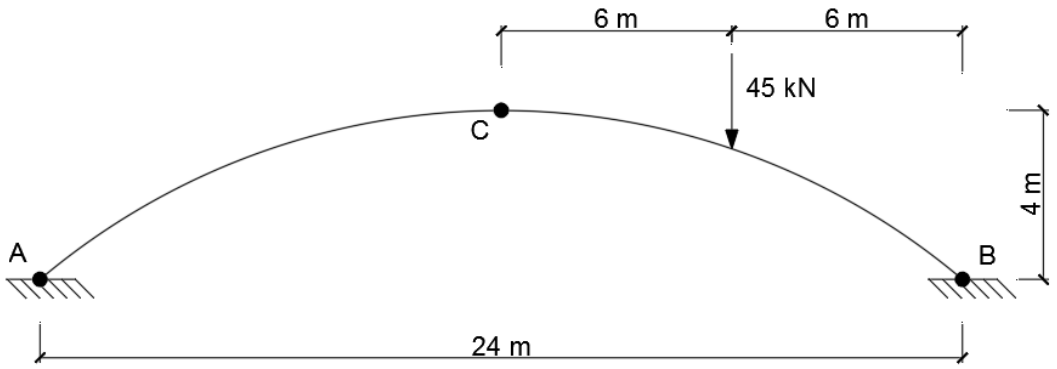


Figure Q2

Question 3. (6 Marks)

A 12 m column is made of 150-UC-30 steel with second moments of area I_{xx} = 1760 cm^4 and I_{yy} = 562 cm^4. The area of cross-section is 3860 mm^2 and the Young's modulus of steel is 200 kN/mm^2.

3.1 (2 Marks)

If the column is fixed at both ends, determine the effective length and the Euler buckling load of the column.

3.2 (2 Marks)

If the column is fixed at one end and pinned at the other end, determine the effective length and the Euler buckling load of the column.

3.3 (2 Marks)

If the column is a cantilever, determine the effective length and the Euler buckling load of the column.

Question 4. (25 Marks)

Using strain energy or complementary energy method of analysis, calculate the deflection of Joint C of the bridge truss shown in Figure Q4. All members of the truss are made of the same linear-elastic material with Young's modulus of 200 kN/mm^2. The cross-sectional area of all members is 4010 mm^2.

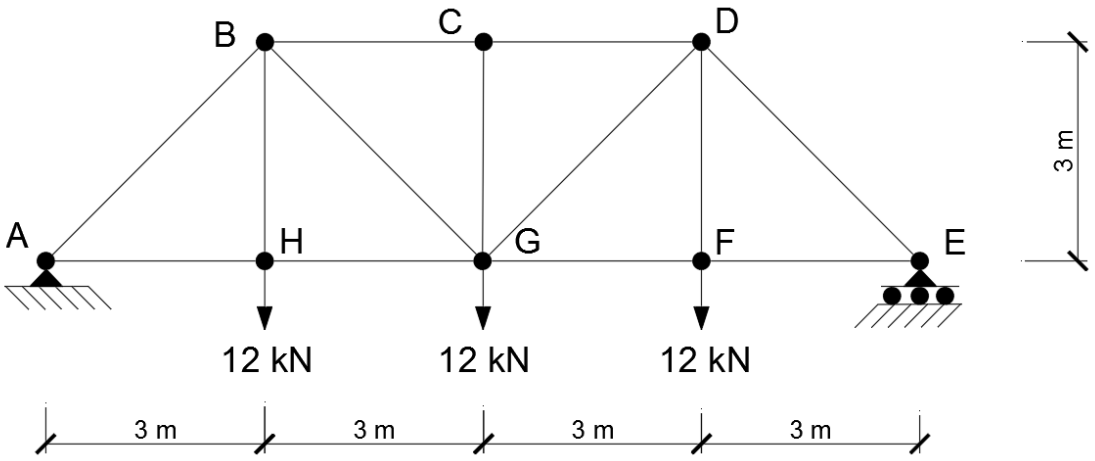


Figure Q4

Question 5. (25 Marks)

Figure Q5.a shows a simply-supported beam with uniformly distributed load of 2 kN/m over its entire length of 3 m. The beam has constant EI and is made of 150 x 100 x 10 unequal angle steel section as shown in Figure Q5.b.

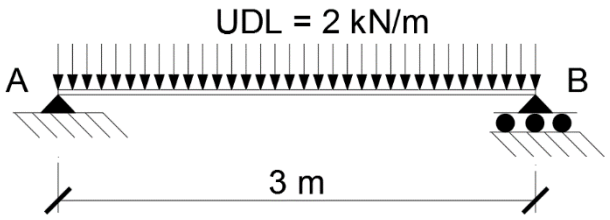


Figure Q5.a

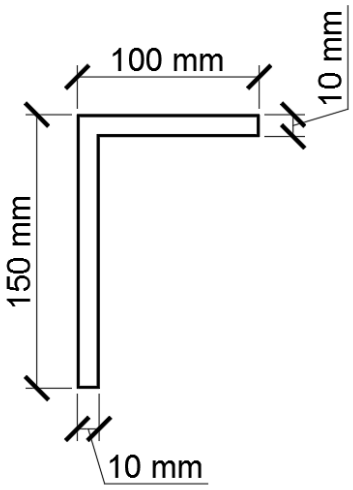


Figure Q5.b

5.1 (10 Marks)

Using an energy method of analysis, calculate the angular rotation of the beam at support A and the deflection at mid-span.

5.2 (5 Marks)

Find and sketch the position of the centroid of the cross-section and calculate the second moments of area about XX axis and YY axis.

5.3 (10 Marks)

Determine the equation of the neutral axis.

Question 6. (30 Marks)

Figure Q6 shows a portal frame which is pinned to rigid supports at A and D. A horizontal load of 100 kN is applied at position B and a uniformly distributed load of 45 kN/m is applied on the horizontal member over 4 m from position C. The flexural rigidity (EI) of the horizontal member is twice that of each of the vertical member.

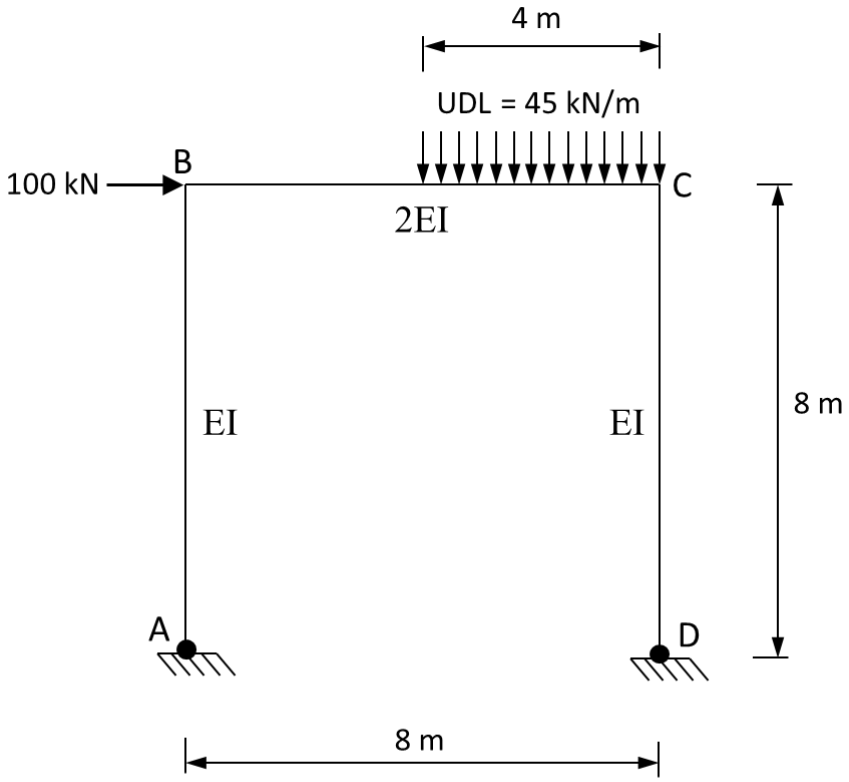


Figure Q6

6.1 (15 Marks)

Using an energy method of analysis, determine the magnitude (in kN) and direction of the horizontal reactions at the supports.

6.2 (3 Marks)

Determine the values and nature of bending moment at positions B, C and mid-span of the horizontal member.

6.3 (6 Marks)

Sketch the bending moment diagram for the portal frame, indicating the values and positions of maximum sagging and hogging moment and (if any) the point of contraflexure.

Question 6 (continued)

6.4 (2 Marks)

Sketch the shear force diagram for the portal frame, indicating all significant values and their positions.

6.5 (4 Marks)

Sketch the bending moment diagram for the portal frame if both supports are fixed and the values of the reactions at the supports are as follow:

- Vertical reaction at A is 2 kN (downwards)
- Vertical reaction at B is 182 kN (upwards)
- Horizontal reaction at A is 38.76 kN (to the left)
- Horizontal reaction at B is 61.24 kN (to the left)
- Moment at A is 182 kNm (anti-clockwise)
- Moment at B is 242 kNm (anti-clockwise)

Formula Sheet

$L_E = 2.0L$	$L_E = 0.5L$
$L_E = L$	$L_E = 0.7L$
$P_E = \frac{\pi^2 EI}{{L_E}^2}$	$extension = \frac{PL}{AE}$
$\Delta = \frac{\delta U}{\delta W}$	$U = C = \sum \frac{P^2 L}{2AE}$
$\Delta = \frac{\delta U}{\delta W} = \sum \left(\frac{PL}{AE} \times \frac{\delta P}{\delta W}\right)$	$\Delta = \int_0^L \frac{MM^*}{EI} \delta x$
$\theta = \frac{wL^3}{24EI}$	$\theta = \int_0^L \frac{MM^*}{EI} \delta x$
$\Delta = \frac{5wL^4}{384EI}$	$\frac{\delta C}{\delta H} = \int_0^L M \frac{\delta M}{\delta H} \frac{}{EI} \delta s$
$\Delta = \sum \left((extensions\ due\ to\ applied\ loads) \times (forces\ due\ to\ unit\ loading)\right)$	
$y_c = \frac{\sum A\bar{y}}{\sum A}$	$x_c = \frac{\sum A\bar{x}}{\sum A}$
$I_{xx} = \sum \left(\frac{1}{12} bd^3 + Ay^2\right)$	$I_{yy} = \sum \left(\frac{1}{12} b^3 d + Ax^2\right)$
$I_{xy} = \sum (A \times h \times k)$	$\tan 2\theta = \frac{2I_{xy}}{I_{yy} - I_{xx}}$
$I_{UU} = \frac{1}{2}(I_{xx} + I_{yy}) + \frac{1}{2}(I_{xx} - I_{yy}) \times \sec 2\theta$	$I_{VV} = \frac{1}{2}(I_{xx} + I_{yy}) - \frac{1}{2}(I_{xx} - I_{yy}) \times \sec 2\theta$
$M_{UU} = M_{xx} \cos 2\theta$	$M_{VV} = M_{xx} \sin 2\theta$
$\sigma = \frac{M_{VV} u}{I_{VV}} + \frac{M_{uu} v}{I_{uu}}$	$u = x \cos\theta + y \sin\theta$ $v = y \cos\theta - x \sin\theta$