22CGB018
Plant Engineering

Semester 2 2022/23 Online Short-window Exam paper

This is an online short-window examination, meaning you have a total of **2 hours plus an additional 30 minutes** to complete and submit this paper. The additional 30 minutes are for downloading the paper and uploading your answers when you have finished. If you have extra time or rest breaks as part of a Reasonable Adjustment, you will have further additional time as indicated on your exam timetable.

It is your responsibility to submit your work by the deadline for this examination. You must make sure you leave yourself enough time to do so.

It is also your responsibility to check that you have submitted the correct file.

Exam Help

If you are experiencing difficulties in accessing or uploading files during the exam period, you should contact the Exam Helpline. For urgent queries please call **01509 222900**.

For other queries email examhelp@lboro.ac.uk

You may handwrite and/or word process your answers, as you see fit.

You may use a calculator for this exam.

Attempt **THREE** questions in total. Each question carries 25 marks.

Candidates should show full working for all calculations and derivations.

1. Part of a walkway can be approximated by the pin jointed plane frame shown in Figure Q1.

(a) With the aid of an appropriate free body diagram, calculate the magnitude of the reaction forces at the supports. [6 marks]

(b) With the aid of appropriate free body diagrams, for bars DE, CH and CR, calculate the magnitude of the forces acting in the bars and indicate whether these forces are compressive or tensile. [13 marks]

(c) If the bars in the frame are made from hollow circular section tubes with an outside diameter of 60 mm and wall thickness of 5 mm, and Young's modulus is 220 GPa, determine the margin of safety for bar CR. [6 marks]

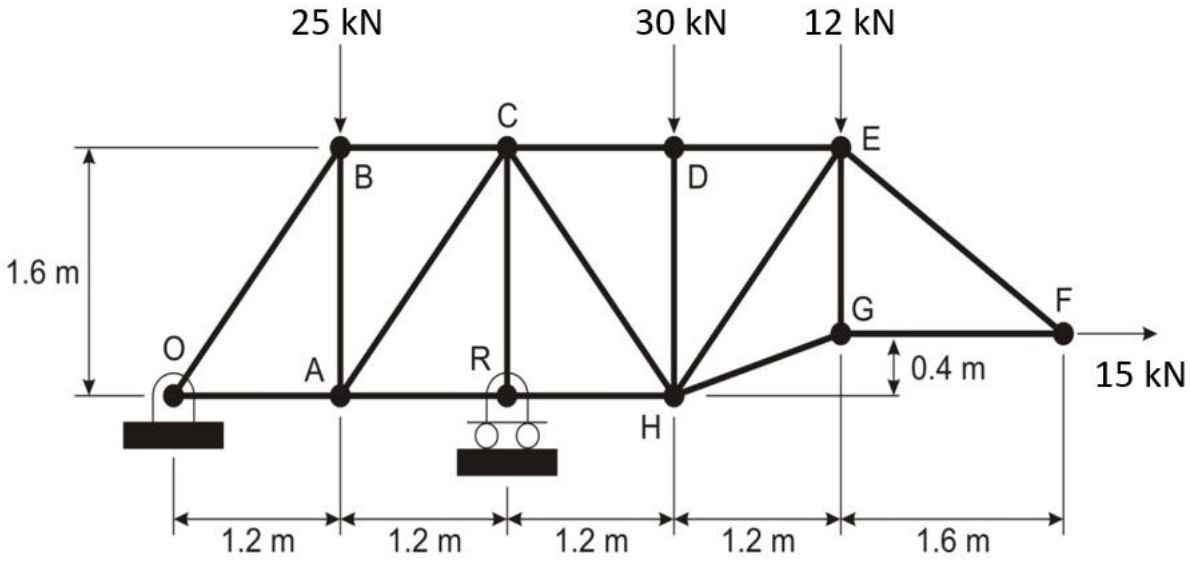

Figure Q1: Representation of pin jointed plane frame

2. The outline mechanical design of a pressurised (cylindrical) distillation column is to be performed based on the data provided below. The column can be considered to be securely anchored at its base. A primary concern is the magnitude of stresses that may arise in the cylindrical shell wall of the column.

   (a) Calculate the hoop stress and longitudinal stress arising in the cylindrical shell as a direct result of the internal pressure (only). State whether these stresses are tensile or compressive. [8 marks]

   (b) Calculate the stress arising in the cylindrical shell at the base of the column as a direct result of supporting the total weight of the column above. State whether this stress is tensile or compressive. [5 marks]

   (c) Evaluate the stresses that would be induced in the cylindrical shell at the base of the column as a direct result of a sideways and uniform wind loading of 2 kN per metre of column height (corresponding to a wind speed of 100 mph). State whether these stresses are tensile or compressive. [9 marks]

   (d) With your results, assess the suitability of the chosen thickness (8 mm) of the cylindrical shell. Give your reasoning. [3 marks]

   <u>Data</u>

   Column design pressure (absolute) = 12 bar

   Exterior diameter of column = 1.5 m

   Height of column = 40 m

   Thickness of column shell (initial estimate) = 8 mm

   Total mass of column (including internal plates, external pipework etc.) = 21 tonnes

   Uniaxial yield stress of stainless steel = 201 MPa

   Margin of safety = 1.5

3. Part of a support structure can be considered as an overhanging, simply supported beam which is loaded as shown in Figure Q3.

(a) With the aid of an appropriate free body diagram, calculate the magnitude of the reaction forces at the supports. [7 marks]

(b) Determine the equation of the loading line between A and B in terms of the distance from the left hand end of the beam (x). [2 marks]

(c) If the loading between B and C can be represented as a triangular shape load plus a rectangular shape load, determine the equation of the loading line due to the triangular load between B and C in terms of the distance x. [3 marks]

(d) Derive expressions, in terms of the distance x, for the shear force (V) and bending moment (M) acting over the beam. [13 marks]

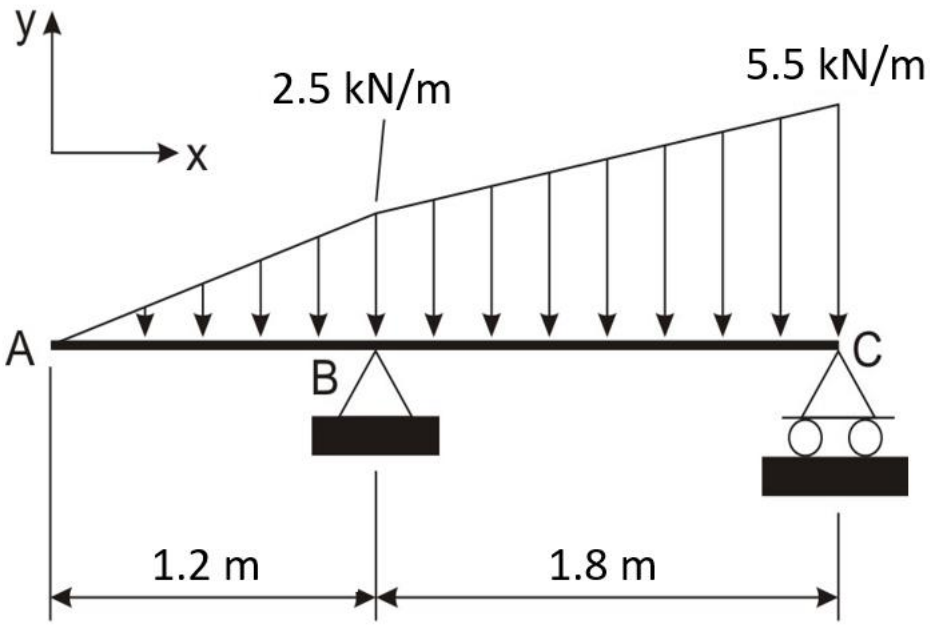

Figure Q3: Beam loading

4. A beam (ABC) is to be used to lift a point load (*P*) as shown in Figure Q4. The beam itself weighs *w* N m^{-1}, has a 2nd moment of area, *I* m^4, and Young's modulus, *E* Pa. It is attached to a fixed support by a pin-joint at A and is simply supported at B.

   (a) Derive an expression for the reaction forces at the two supporting points, A and B. State which direction each force is acting in. [3 marks]

   (b) Derive expressions for the bending moment (*M*) in each section of the beam, in terms of the distance *x* from A. [4 marks]

   (c) Derive an expression for the deflection (*v*) in section AB of the beam, in terms of the distance *x* from A. [6 marks]

   (d) Derive an expression for the deflection (*v*) in section BC of the beam, in terms of the distance *x* from A. [10 marks]

   (e) Obtain an expression for the deflection at C. [2 marks]

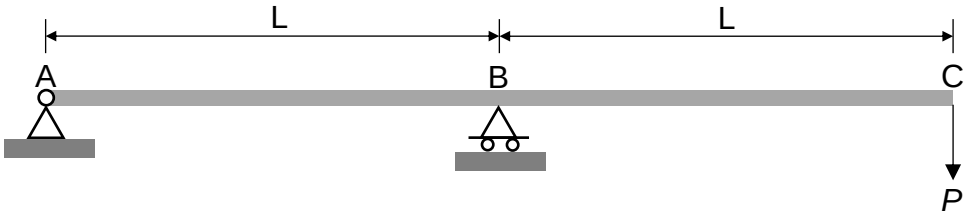

Figure Q4: Beam loading.

END OF PAPER

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