GLASGOW CALEDONIAN UNIVERSITY

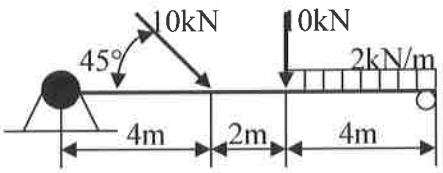
School of Engineering & Built Environment

ENGINEERING DESIGN & ANALYSIS 2 (M2H721926)

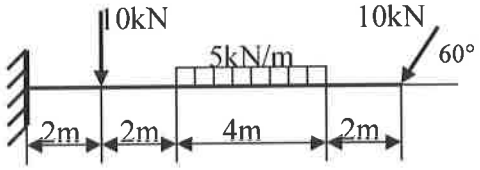
Tutorial: Shear Force (SF) and Bending Moment (BM) Diagrams

1. For both beams shown below, calculate the unknown reactions and draw the SF, BM and thrust force diagrams, highlighting the significant values and their positions in each case.

i)



ii)



2. A beam ABCD is simply-supported at A and D by a knife edge and a roller respectively and is point loaded at B, C and D, with a udl between B and C as shown in Figure Q2.

(a) Draw a free body diagram for the beam, showing the direction of the reaction forces provided by the supports.
(b) Determine the magnitude of the force reactions at the supports.
(c) Sketch the shear force diagram, highlighting all significant values.
(d) Sketch the bending moment diagram, highlighting all significant values.

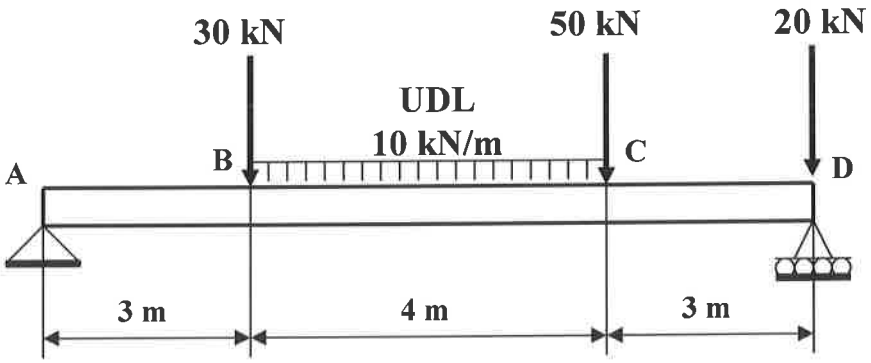


Figure Q2

3. A horizontal cantilever ABC of length 4 m and built-in at A, carries a uniform distributed load of 4 kN/m between A and B. AB = 3 m and BC = 1 m. There is also a concentrated load of 10 kN at the free end C. Determine the reactions at A and draw the SF and BM diagrams, stating the magnitude and position of the maximum bending moment.

4. A uniform shaft ABCD of length 4 m and mass 306 kg, is simply supported by bearings at A and C which are 3 m apart. It carries two gear wheels - one of mass 408 kg at B and one of mass 102 kg at D. AB is 2 m long and the overhang CD is 1 m. Draw the SF and BM diagrams, showing the significant values and points.

5. A beam ABCDE is simply supported at A and D. It carries the following loading: a distributed load of 30 kN/m between A and B; a concentrated load of 20 kN at B; a concentrated load of 20 kN at C; a concentrated load of 10 kN at E; a distributed load of 60 kN/m between D and E. Span AB = 1.5 m, BC = CD = DE = 1 m.

i) Calculate the value of the reactions at A and D.
ii) Draw the shear force diagram.
iii) Draw the bending moment diagram.
iv) State the magnitude and position of the maximum bending moment.

6. Figure Q6 below shows a loaded uniform beam ABCDE which is supported at A by a pin and at D by a roller. Lengths: AB = BC = 2 m; CD = DE = 1 m.

(a) Determine the reaction forces.
(b) Sketch the following diagrams:
  (i) thrust force;
  (ii) shear force;
  (iii) bending moment.
(c) Indicate all significant values.

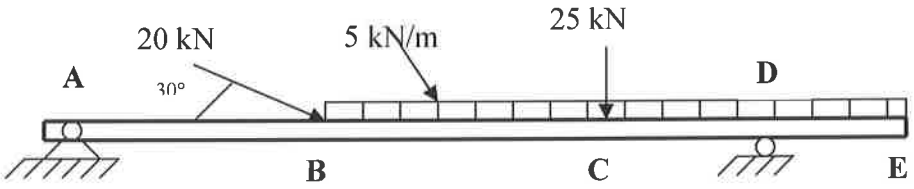


Figure Q6

7. A 2.5 m long beam ABC is built-in at A with the length AB = 1 m and BC = 1.5 m. The beam supports 3 loads: a point load of 3 kN inclined at 30° to the beam at B in the +X direction; a uniformly distributed load of 1 kN/m acting between B and C, and a point load of 2 kN inclined at 60° to the beam at C in the –X direction.
Calculate the reactions at the built-in support and, by drawing appropriate diagrams, determine the significant values of thrust force, shear force and bending moment acting on the beam, and state their positions.

8. A beam ABC is 9 m long and is supported at B and C, 6 m apart as shown in Figure Q8. The beam carries a non-uniform distribution load over the portion BC of 48 kN/m, together with an applied counterclockwise couple of moment 80 kNm at B, and a uniformly distributed load of 10 kN/m over AB. Draw the shear force and bending moment diagrams for the beam, indicating all significant points.

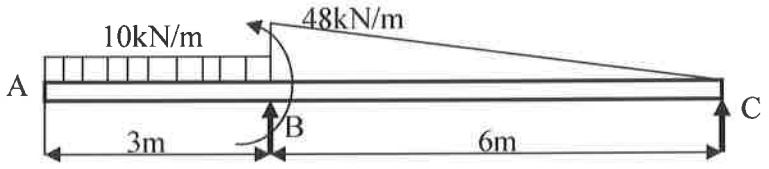


Figure Q8

9. A uniform rod ABC is 1.2 m long, weighs 150 N and is inclined at 45° as shown in Figure Q9. The rod is supported by means of a hinge fastened to the wall at A, and is held by a horizontal cord at B, which is 0.2 m from C. If a load of 50 N is suspended from C, determine the force in the cord and hence draw the shear force and bending moment diagrams for the rod, indicating all significant points.

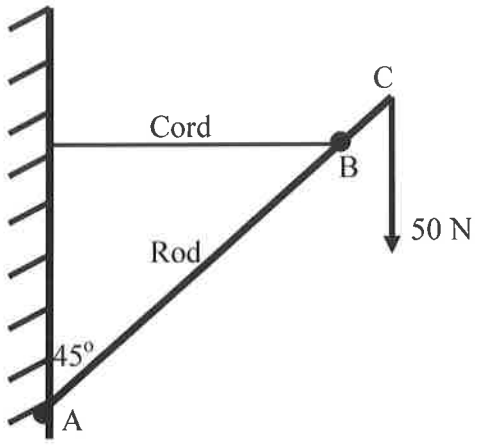


Figure Q9

Answers:

1 **i)** $R_{Ax} = -7.07kN$; $R_{Ay} = 9.84kN$; $M_{max} = 44.9kNm$
ii) $R_{Ax} = 5kN$; $R_{Ay} = 38.7kN$; $M_{max} = -226.6kNm$

2 **(b)** $R_A = 56kN$; $R_D = 84kN$; **(c)** $SF_{max} = -64kN$; **(d)** $M_{max} = 201.8kNm$

3 $R_A = 22kN$; $M_A = 58kNm$

4 $R_A = 2kN$; $R_C = 6kN$; $M_{max} = 4kNm$; Contraflexure at 0.8m RHS of 408kg wheel.

5 **i)** $R_A = 41kN$; $R_D = 114kN$; $M_{max} = 44.9kNm$
ii) $R_{Ax} = 5kN$; $R_{Ay} = 38.7kN$; $M_{max} = 28kNm$ at 1.37m RHS of A (CW)
$M_{max} = -40.25kNm$ at D (ACW); Contraflexure at 2.6m RHS of A

6 **(a)** $R_{Ax} = -17.32kN$; $R_{Ay} = 15kN$; $R_D = 40kN$; **(b)** Thrust/SF/BM Diagrams
(c) $SF_{max} = -35kN$; $M_{max} = 32.5kNm$ at 3m RHS of A
Contraflexure at 1.07m LHS of E

7 $R_{Ax} = -1.598kN$; $R_{Ay} = 4.732kN$; $SF_{max} = 4.732kN$ at A; $M_{max} = -8.455kNm$ at A

8 $R_B = 146.8kN$; $R_C = 27.2kN$; $M_{max} = 47.3kNm$ at 2.61m LHS of C (CW);
$M_{max} = -125kNm$ at B; Contraflexure at 4.5m LHS of C.

9 $R_{Ax} = 247kN$; $R_{Ay} = 35.33kN$; $R_{Bx} = 35kN$; $R_{By} = -35.33kN$ $SF_{max} = 53kN$ at C;
$M_{max} = 7.067kNm$ at 0.4m RHS of A (CW); $M_{max} = -8.85kNm$ at B;
Contraflexure at 0.5m LHS of C.