3.7 Mechanics: Moments and Statics Depth: 1-hour Pack

EDEXCEL 9MA0 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Two point masses of 3 kg and 5 kg are placed on a light rod at x = 0 and x = 8 m respectively. Find the x-coordinate of the centre of mass of the system.

(Total for Question 1 is 1 mark)

---

2 A light rod AB rests horizontally on a pivot at C. A weight of 25 N hangs at a distance 0.8 m from C on one side. Find the distance from C at which a weight of 40 N must hang on the other side, for the rod to be in equilibrium.

(Total for Question 2 is 2 marks)

---

3 A light rod AB rests horizontally in equilibrium on a pivot at C. Weights of 15 N and 25 N hang from the rod at distances 0.3 m and 0.5 m from C, on the same side of the pivot. A weight W hangs at a distance 0.4 m from C on the other side. By taking moments about C, find W.

(Total for Question 3 is 2 marks)

---

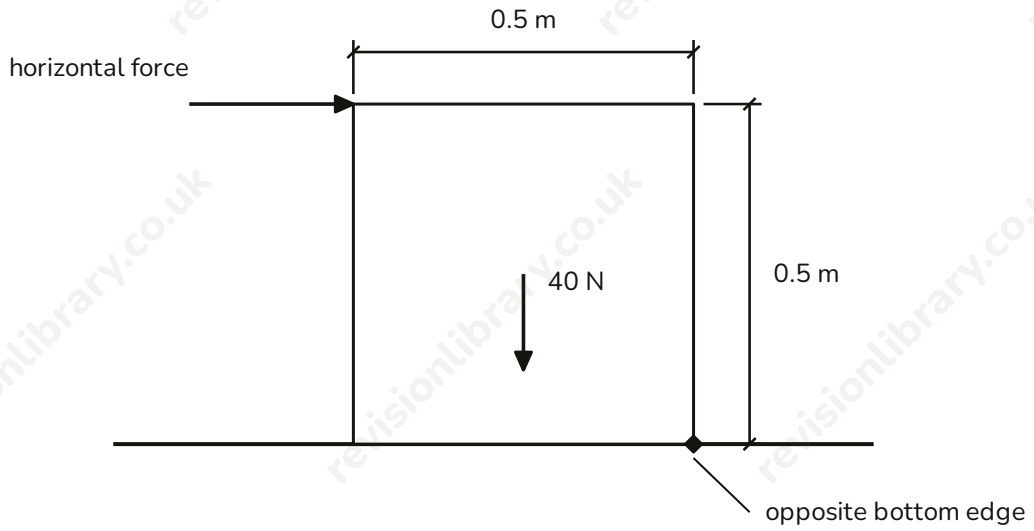
4 A bent rod OAB has two straight arms, OA and AB, rigidly joined at right angles at A. When the rod is laid flat with OA horizontal and AB vertical, its centre of mass is a horizontal distance 0.3 m and a vertical distance 0.4 m from O. The rod is suspended freely from O and hangs in equilibrium. Find the angle OA makes with the vertical, giving your answer to 3 significant figures.

(Total for Question 4 is 2 marks)

© Revision Library | revisionlibrary.co.uk

5 A uniform cube of side 0.5 m and weight 40 N rests on rough horizontal ground. A horizontal force is applied to the top edge, increasing until the cube is on the point of toppling about the opposite bottom edge. Find the moment of the weight about this edge at the point of toppling.

Diagram NOT accurately drawn



(Total for Question 5 is 2 marks)

---

6 A light rigid rod AB has length 1.2 m and rests horizontally in equilibrium on a smooth pivot at point C on the rod. Weights of 30 N and 50 N hang from the rod at distances 0.2 m and 0.5 m from C, on one side of the pivot. A weight of magnitude W hangs at a distance 0.8 m from C, on the other side. By taking moments about C, find W, and hence find the reaction at the pivot.

(Total for Question 6 is 3 marks)

---

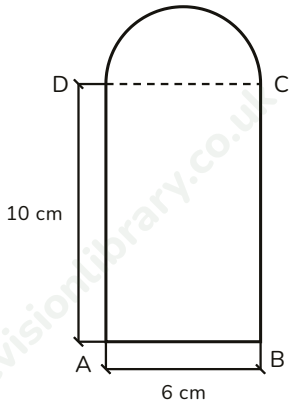
7 A uniform beam AB has length 6 m and weight 240 N. The beam rests horizontally in equilibrium on two smooth supports, one at C, 1 m from A, and one at D, 1 m from B. By taking moments about C, find the reaction at D, and hence find the reaction at C.

(Total for Question 7 is 3 marks)

© Revision Library | revisionlibrary.co.uk

8 A uniform lamina is formed from a rectangle ABCD, where AB = 6 cm and BC = 10 cm, together with a uniform semicircular lamina of the same material and thickness, of diameter 6 cm, attached along the edge CD, so that the semicircle bulges outward from the rectangle. The centre of mass of a uniform semicircular lamina of radius r lies a distance $4r/(3*\pi)$ from the centre of its diameter, along the axis of symmetry.

Diagram NOT accurately drawn



(a) Show that the area of the semicircular portion is $4.5*\pi$ cm^2. **(2)**

(b) Find the distance of the centre of mass of the whole lamina from the edge AB (the edge of the rectangle furthest from the semicircle). **(4)**

(Total for Question 8 is 6 marks)

---

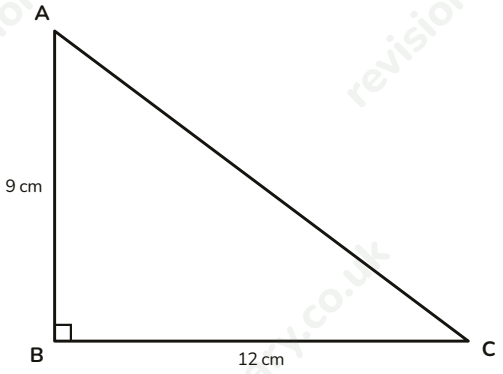
9 A non-uniform rod AB has length 5 m and weight 150 N. The rod is held in equilibrium in a horizontal position by two vertical strings, one at A and one at B. The tension in the string at A is twice the tension in the string at B. Find the tension in each string, and hence, by taking moments about A, find the distance of the centre of mass of the rod from A, giving your answer to 3 significant figures.

(Total for Question 9 is 4 marks)

© Revision Library | revisionlibrary.co.uk

10 A uniform triangular lamina ABC has a right angle at B, with AB = 9 cm and BC = 12 cm.

Diagram NOT accurately drawn



(a) Show that AC = 15 cm. **(1)**

(b) Taking B as the origin, with BC along the x-axis and BA along the y-axis, find the coordinates of the centre of mass of the lamina. **(3)**

(c) The lamina is freely suspended from the vertex A and hangs in equilibrium. Find the angle that AB makes with the vertical, giving your answer to 3 significant figures. **(5)**

(Total for Question 10 is 9 marks)

© Revision Library | revisionlibrary.co.uk

11 A uniform rod AB has length 2.4 m and weight 100 N. The rod rests with end A on rough horizontal ground and passes over a small smooth peg fixed at the point P on the rod, where AP = 1.6 m. The peg supports the rod from below, exerting a force on the rod perpendicular to the rod. The rod is inclined to the horizontal at an angle θ, where $\tan(\theta) = 3/4$, and rests in equilibrium.

(a) By taking moments about A, show that the normal reaction at the peg, N, has magnitude 60 N. **(5)**

(b) Find the normal reaction at A, N_A. **(3)**

(c) Find the friction force at A. **(2)**

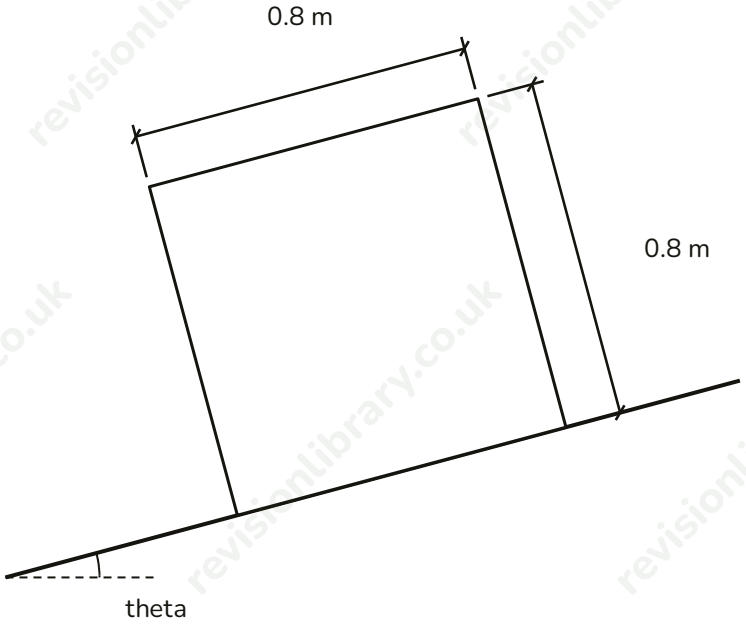
(d) Given that the rod is on the point of slipping at A, find the coefficient of friction between the rod and the ground. **(2)**

(Total for Question 11 is 12 marks)

---

12 A uniform cube of side 0.8 m rests on a rough plane inclined at angle θ to the horizontal, which is slowly increased from 0. The coefficient of friction between the cube and the plane is 0.5. Find the angle θ at which the cube would be on the point of toppling about its lower edge (assuming it does not slide first), and find the angle at which it would be on the point of sliding (assuming it does not topple first). Hence determine, with justification, whether the cube slides or topples first as θ increases from 0.

Diagram NOT accurately drawn



(Total for Question 12 is 4 marks)

© Revision Library | revisionlibrary.co.uk

Mark scheme · 3.7 Mechanics: Moments and Statics Depth: 1-hour Pack

Question 1

5 cao **B1**

Answer: x = 5 m

Question 2

take moments about C: 25 x 0.8 = 40 x d **M1**

0.5 m cao **A1**

Answer: 0.5 m

Question 3

take moments about C: 15(0.3) + 25(0.5) = 0.4W **M1**

42.5 N cao **A1**

Answer: 42.5 N

Question 4

the rod hangs with its centre of mass directly below O, so the angle OA makes with the vertical satisfies tan(angle) = horizontal distance / vertical distance = 0.3/0.4 **M1**

awrt 36.9 degrees **A1**

Answer: 36.9 degrees (3 s.f.)

Question 5

at the point of toppling, the weight still acts through the centre of the cube, a horizontal distance of half the side (0.25 m) from the toppling edge **M1**

10 N m cao **A1**

Answer: 10 N m

Question 6

take moments about C: 30(0.2) + 50(0.5) = 0.8W **M1**

W = 38.75 N cao **A1**

reaction = 30 + 50 + 38.75 = 118.75 N cao (ft) **A1**

Answer: W = 38.75 N; reaction at pivot = 118.75 N

Question 7

the weight acts at the midpoint (3 m from A, so 2 m from C); D is 5 m from A, so 4 m from C; take moments about C: $R_D(4) = 240(2)$ **M1**

R_D = 120 N cao **A1**

resolve vertically: R_C = 240 - 120 = 120 N cao (ft) **A1**

Answer: R_D = 120 N, R_C = 120 N

Question 8

(a) radius = 3 cm (half of the 6 cm diameter); uses area = $0.5*\pi*r^2$ **M1**

(a) = $0.5*\pi*9 = 4.5*\pi$ cm^2 cso **A1**

(a) Answer: $4.5*\pi$ cm^2 (shown)

(b) identifies the rectangle's area (60 cm^2) at distance 5 cm from AB, and the semicircle's area ($4.5*\pi$) at distance $10 + 4*3/(3*\pi)$ from AB **M1**

(b) correct areas and positions listed **A1**

(b) combines: $xbar = (60*5 + 4.5*\pi*(10 + 4/\pi)) / (60 + 4.5*\pi)$ **M1**

(b) xbar = awrt 6.20 (cm) cao **A1**

(b) Answer: awrt 6.20 cm from AB

Question 9

$T_A + T_B = 150$ with $T_A = 2T_B$, so $3T_B = 150$ **M1**

T_B = 50 N, T_A = 100 N **A1**

take moments about A: $T_B(5) = 150(d)$, where d is the distance of the centre of mass from A **M1**

awrt 1.67 m **A1**

Answer: T_A = 100 N, T_B = 50 N; centre of mass is 1.67 m from A (3 s.f.)

Question 10

(a) AC = $\sqrt{9^2+12^2} = \sqrt{225}$ = 15, using Pythagoras' theorem, cso **B1**

(a) Answer: AC = 15 cm (shown)

(b) uses the standard result that the centre of mass of a uniform triangular lamina is the average of the coordinates of its vertices **M1**

(b) xbar = (0+0+12)/3 = 4 **A1**

(b) ybar = (9+0+0)/3 = 3 **A1**

(b) Answer: (4, 3) cm

(c) recognises that AG becomes vertical, and that AB is initially vertical in the lamina's own frame, so the required angle is between AG and AB **B1**

(c) finds the horizontal and vertical displacement of G from A **M1**

(c) 4 cm horizontally and 6 cm vertically (or magnitude $2*\sqrt{13}$ cm) **A1**

(c) tan(angle) = 4/6 (oe) **M1**

(c) angle = awrt 33.7 (degrees) cao **A1**

(c) Answer: awrt 33.7 degrees

Question 11

(a) recognises that the moment of N about A is N * AP, since N acts perpendicular to the rod at the point P on the rod **M1**

(a) recognises that the moment of the weight about A is W * (AB/2) * cos(θ), since the weight acts vertically at the midpoint of the rod **A1**

(a) uses the 3-4-5 triangle from tan(θ) = 3/4 to state cos(θ) = 4/5 **M1**

(a) forms N * 1.6 = 100 * 1.2 * 4/5 (= 96) **A1**

(a) N = 96/1.6 = 60 cso **A1**

(a) Answer: N = 60 N (shown)

(b) resolves vertically: $N_A + N*\cos(\theta) = 100$ **M1**

(b) $N_A = 100 - 60*(4/5) = 100 - 48$ **A1**

(b) N_A = 52 (N) cao **A1**

(b) Answer: 52 N

(c) resolves horizontally: $F_A = N*\sin(\theta)$ **M1**

(c) $F_A = 60*(3/5) = 36$ (N) cao **A1**

(c) Answer: 36 N

(d) $\mu = F_A / N_A$ **M1**

(d) $\mu = 36/52 = 9/13$ (awrt 0.692) cao **A1**

(d) Answer: μ = 9/13 (awrt 0.692)

© Revision Library | revisionlibrary.co.uk

Question 12

for a cube, toppling occurs when the line of action of the weight passes through the lower edge, i.e. when tan(θ) = (half the side)/(half the side) = 1	**M1**
toppling angle = 45 degrees	**A1**
sliding occurs when tan(θ) = μ = 0.5	**M1**
sliding angle = awrt 26.6 degrees; since 26.6 < 45, the cube slides first	**A1**

Answer: Toppling angle = 45 degrees; sliding angle = 26.6 degrees (3 s.f.); the cube slides before it would topple

© Revision Library | revisionlibrary.co.uk