2014-2018 Chapter 8: Moments

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3. A beam AB has length 15 m and mass 25 kg. The beam is smoothly supported at the point P, where $AP = 8$ m. A man of mass 100 kg stands on the beam at a distance of 2 m from A and another man stands on the beam at a distance of 1 m from B. The beam is modelled as a non-uniform rod and the men are modelled as particles. The beam is in equilibrium in a horizontal position with the reaction on the beam at P having magnitude 2009 N. Find the distance of the centre of mass of the beam from A.

(5)

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Question 3 continued

Q3

(Total 5 marks)

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6. A uniform rod AC, of weight W and length $3l$, rests horizontally on two supports, one at A and one at B, where $AB = 2l$. A particle of weight $2W$ is placed on the rod at a distance x from A. The rod remains horizontal and in equilibrium.

(a) Find the greatest possible value of x.

(5)

The magnitude of the reaction of the support at A is R. Due to a weakness in the support at A, the greatest possible value of R is $2W$,

(b) find the least possible value of x.

(5)

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Question 6 continued

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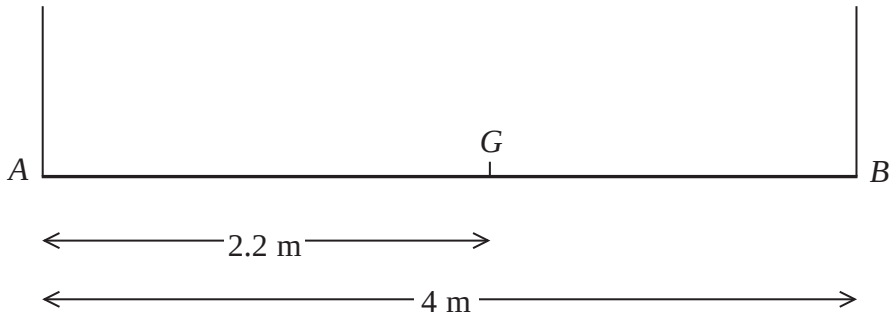

Figure 2

A non-uniform rod AB has length 4 m and weight 120 N. The centre of mass of the rod is at the point G where $AG = 2.2$ m. The rod is suspended in a horizontal position by two vertical light inextensible strings, one at each end, as shown in Figure 2. A particle of weight 40 N is placed on the rod at the point P, where $AP = x$ metres. The rod remains horizontal and in equilibrium.

(a) Find, in terms of x,

(i) the tension in the string at A,

(ii) the tension in the string at B.

(6)

Either string will break if the tension in it exceeds 84 N.

(b) Find the range of possible values of x.

(4)

Question 5 continued

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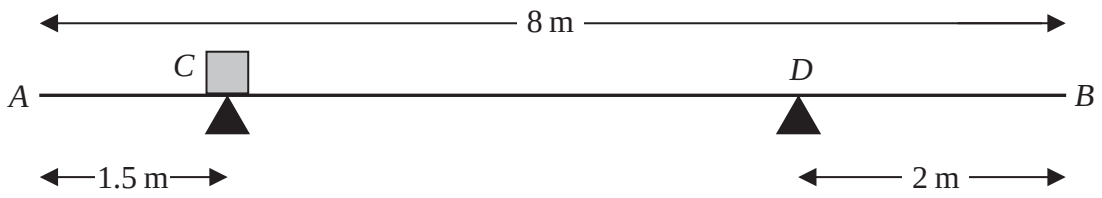

Figure 2

A plank AB of mass 20 kg and length 8 m is resting in a horizontal position on two supports at C and D, where $AC = 1.5$ m and $DB = 2$ m. A package of mass 8 kg is placed on the plank at C, as shown in Figure 2. The plank remains horizontal and in equilibrium. The plank is modelled as a uniform rod and the package is modelled as a particle.

(a) Find the magnitude of the normal reaction

(i) between the plank and the support at C,

(ii) between the plank and the support at D.

(6)

The package is now moved along the plank to the point E. When the package is at E, the magnitude of the normal reaction between the plank and the support at C is R newtons and the magnitude of the normal reaction between the plank and the support at D is $2R$ newtons.

(b) Find the distance AE.

(6)

(c) State how you have used the fact that the package is modelled as a particle.

(1)

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Question 4 continued

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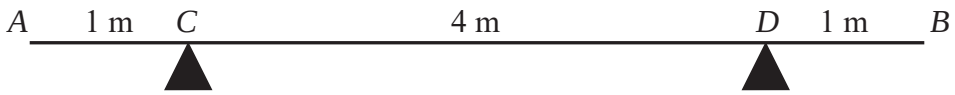

Figure 3

A non-uniform rod AB has length 6 m and mass 8 kg. The rod rests in equilibrium, in a horizontal position, on two smooth supports at C and at D, where $AC = 1$ m and $DB = 1$ m, as shown in Figure 3. The magnitude of the reaction between the rod and the support at D is twice the magnitude of the reaction between the rod and the support at C. The centre of mass of the rod is at G, where $AG = x$ m.

(a) Show that $x = \frac{11}{3}$.

(6)

The support at C is moved to the point F on the rod, where $AF = 2$ m. A particle of mass 3 kg is placed on the rod at A. The rod remains horizontal and in equilibrium. The magnitude of the reaction between the rod and the support at D is k times the magnitude of the reaction between the rod and the support at F.

(b) Find the value of k.

(6)

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Question 7 continued

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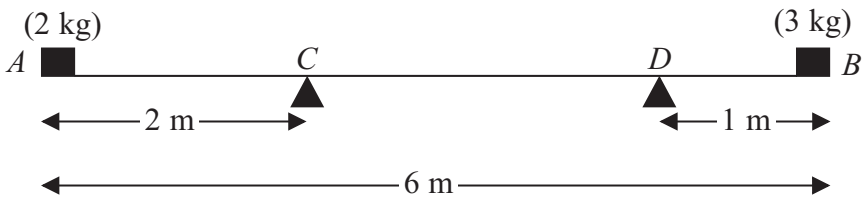

Figure 2

A plank AB, of length 6 m and mass 4 kg, rests in equilibrium horizontally on two supports at C and D, where $AC = 2$ m and $DB = 1$ m. A brick of mass 2 kg rests on the plank at A and a brick of mass 3 kg rests on the plank at B, as shown in Figure 2. The plank is modelled as a uniform rod and all bricks are modelled as particles.

(a) Find the magnitude of the reaction exerted on the plank

(i) by the support at C,

(ii) by the support at D.

(6)

The 3 kg brick is now removed and replaced with a brick of mass x kg at B. The plank remains horizontal and in equilibrium but the reactions on the plank at C and at D now have equal magnitude.

(b) Find the value of x.

(4)

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Question 4 continued

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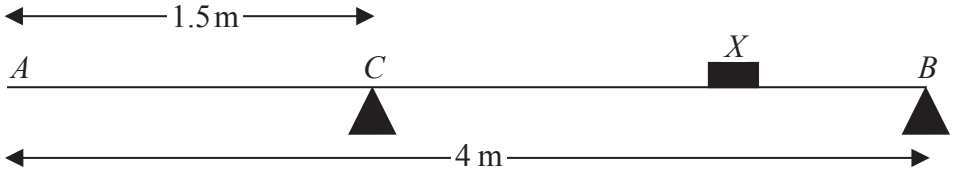

Figure 2

A plank AB has length 4 m and mass 6 kg. The plank rests in a horizontal position on two supports, one at B and one at C, where $AC = 1.5$ m. A load of mass 15 kg is placed on the plank at the point X, as shown in Figure 2, and the plank remains horizontal and in equilibrium. The plank is modelled as a uniform rod and the load is modelled as a particle. The magnitude of the reaction on the plank at C is twice the magnitude of the reaction on the plank at B.

(a) Find the magnitude of the reaction on the plank at C.

(3)

(b) Find the distance AX.

(5)

The load is now moved along the plank to a point Y, between A and C. Given that the plank is on the point of tipping about C,

(c) find the distance AY.

(4)

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Question 6 continued

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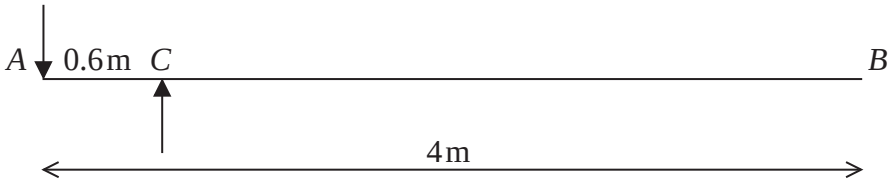

Figure 1

A diving board *AB* consists of a wooden plank of length 4 m and mass 30 kg. The plank is held at rest in a horizontal position by two supports at the points *A* and *C*, where *AC* = 0.6 m, as shown in Figure 1. The force on the plank at *A* acts vertically downwards and the force on the plank at *C* acts vertically upwards.

A diver of mass 50 kg is standing on the board at the end *B*. The diver is modelled as a particle and the plank is modelled as a uniform rod. The plank is in equilibrium.

(a) Find

(i) the magnitude of the force acting on the plank at *A*,

(ii) the magnitude of the force acting on the plank at *C*.

(6)

The support at *A* will break if subjected to a force whose magnitude is greater than 5000 N.

(b) Find, in kg, the greatest integer mass of a diver who can stand on the board at *B* without breaking the support at *A*.

(3)

(c) Explain how you have used the fact that the diver is modelled as a particle.

(1)

Question 4 continued

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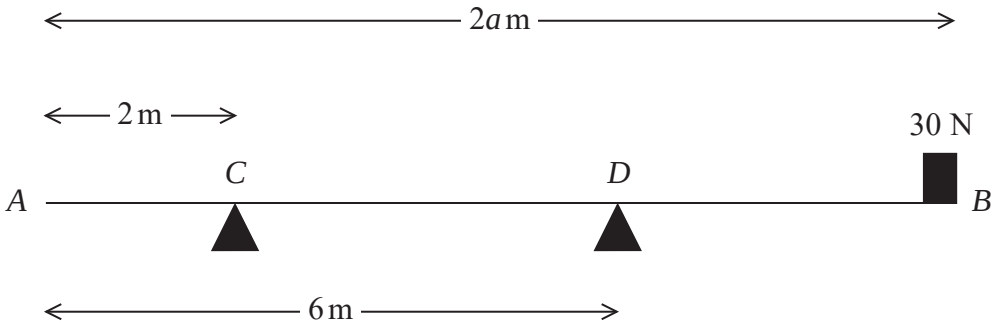

Figure 2

A wooden beam AB has weight 140 N and length $2a$ metres. The beam rests horizontally in equilibrium on two supports at C and D, where $AC = 2$ m and $AD = 6$ m. A block of weight 30 N is placed on the beam at B and the beam remains horizontal and in equilibrium, as shown in Figure 2. The reaction on the beam at D has magnitude 120 N. The block is modelled as a particle and the beam is modelled as a uniform rod.

(a) Find the value of a.

(4)

The support at D is now moved to a point E on the beam and the beam remains horizontal and in equilibrium with the block at B. The magnitude of the reaction on the beam at C is now equal to the magnitude of the reaction on the beam at E.

(b) Find the distance AE.

(5)

Question 2 continued

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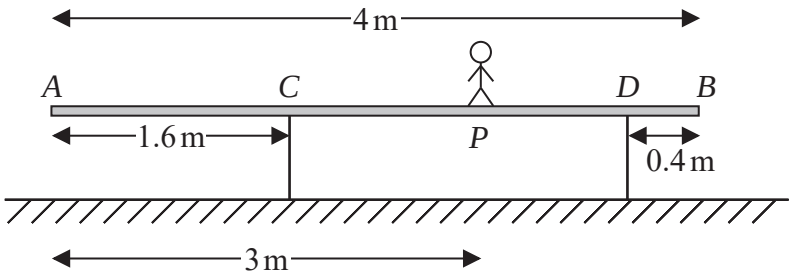

Figure 1

A uniform wooden beam AB, of mass 20 kg and length 4 m, rests in equilibrium in a horizontal position on two supports. One support is at C, where $AC = 1.6$ m, and the other support is at D, where $DB = 0.4$ m. A boy of mass 60 kg stands on the beam at the point P, where $AP = 3$ m, as shown in Figure 1. The beam remains in equilibrium in a horizontal position.

By modelling the boy as a particle and the beam as a uniform rod,

(a) (i) find, in terms of g, the magnitude of the force exerted on the beam by the support at C,

(ii) find, in terms of g, the magnitude of the force exerted on the beam by the support at D.

(6)

The boy now starts to walk slowly along the beam towards the end A.

(b) Find the greatest distance he can walk from P without the beam tilting.

(4)

Question 2 continued

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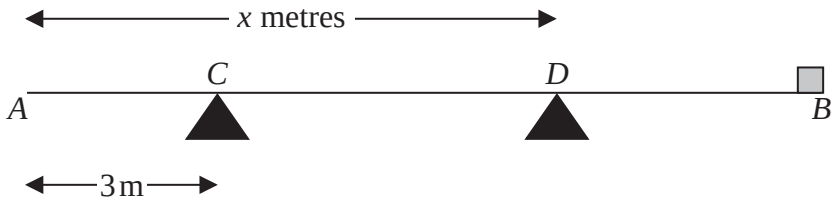

Figure 1

A plank AB has length 8 m and mass 12 kg. The plank rests on two supports. One support is at C, where $AC = 3$ m and the other support is at D, where $AD = x$ metres. A block of mass 3 kg is placed on the plank at B, as shown in Figure 1. The plank rests in equilibrium in a horizontal position. The magnitude of the force exerted on the plank by the support at D is twice the magnitude of the force exerted on the plank by the support at C. The plank is modelled as a uniform rod and the block is modelled as a particle.

Find the value of x.

(7)

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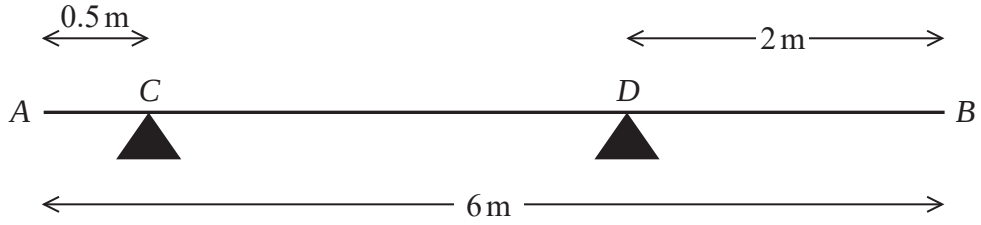

Figure 1

A metal girder AB, of weight 1080 N and length 6 m, rests in equilibrium in a horizontal position on two supports, one at C and one at D, where $AC = 0.5$ m and $BD = 2$ m, as shown in Figure 1. A boy of weight 400 N stands on the girder at B and the girder remains horizontal and in equilibrium. The boy is modelled as a particle and the girder is modelled as a uniform rod.

(a) Find

(i) the magnitude of the reaction on the girder at C,

(ii) the magnitude of the reaction on the girder at D.

(6)

The boy now stands at a point E on the girder, where $AE = x$ metres, and the girder remains horizontal and in equilibrium. Given that the magnitude of the reaction on the girder at D is now 520 N greater than the magnitude of the reaction on the girder at C,

(b) find the value of x.

(5)

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Question 2 continued

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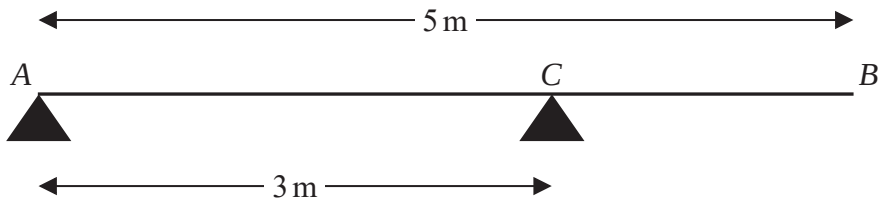

Figure 1

A non-uniform plank AB has weight 60 N and length 5 m. The plank rests horizontally in equilibrium on two smooth supports at A and C, where $AC = 3$ m, as shown in Figure 1. A parcel of weight 12 N is placed on the plank at B and the plank remains horizontal and in equilibrium. The magnitude of the reaction of the support at A on the plank is half the magnitude of the reaction of the support at C on the plank.

By modelling the plank as a non-uniform rod and the parcel as a particle,

(a) find the distance of the centre of mass of the plank from A.

(6)

(b) State briefly how you have used the modelling assumption

(i) that the parcel is a particle,

(ii) that the plank is a rod.

(2)

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Question 2 continued

(Total 8 marks)

Q2