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5.

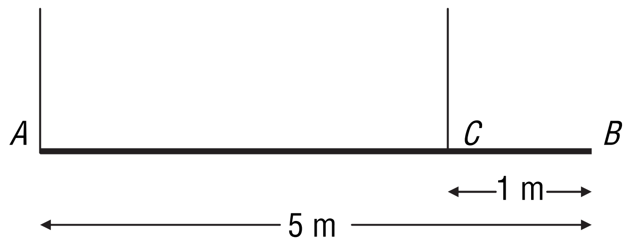

Figure 2

A beam *AB* has mass 12 kg and length 5 m. It is held in equilibrium in a horizontal position by two vertical ropes attached to the beam. One rope is attached to *A*, the other to the point *C* on the beam, where *BC* = 1 m, as shown in Figure 2. The beam is modelled as a uniform rod, and the ropes as light strings.

(a) Find

(i) the tension in the rope at *C*,

(ii) the tension in the rope at *A*.

(5)

A small load of mass 16 kg is attached to the beam at a point which is *y* metres from *A*. The load is modelled as a particle. Given that the beam remains in equilibrium in a horizontal position,

(b) find, in terms of *y*, an expression for the tension in the rope at *C*.

(3)

The rope at *C* will break if its tension exceeds 98 N. The rope at *A* cannot break.

(c) Find the range of possible positions on the beam where the load can be attached without the rope at *C* breaking.

(3)

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Question 5 continued

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6.

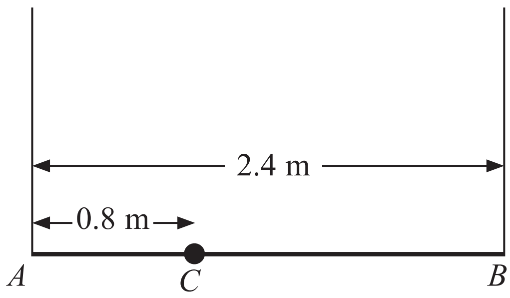

Figure 2

A plank AB has mass 12 kg and length 2.4 m. A load of mass 8 kg is attached to the plank at the point C, where AC = 0.8 m. The loaded plank is held in equilibrium, with AB horizontal, by two vertical ropes, one attached at A and the other attached at B, as shown in Figure 2. The plank is modelled as a uniform rod, the load as a particle and the ropes as light inextensible strings.

(a) Find the tension in the rope attached at B.

(4)

The plank is now modelled as a non-uniform rod. With the new model, the tension in the rope attached at A is 10 N greater than the tension in the rope attached at B.

(b) Find the distance of the centre of mass of the plank from A.

(6)

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Question 6 continued

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4.

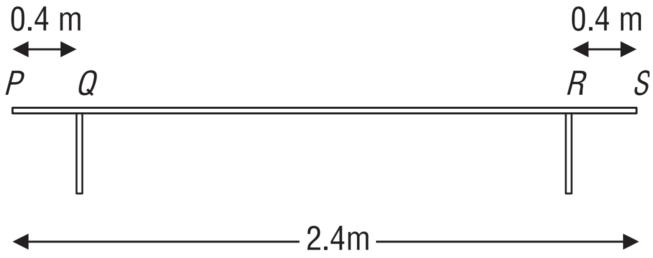

Figure 1

A bench consists of a plank which is resting in a horizontal position on two thin vertical legs. The plank is modelled as a uniform rod PS of length 2.4 m and mass 20 kg. The legs at Q and R are 0.4 m from each end of the plank, as shown in Figure 1.

Two pupils, Arthur and Beatrice, sit on the plank. Arthur has mass 60 kg and sits at the middle of the plank and Beatrice has mass 40 kg and sits at the end P. The plank remains horizontal and in equilibrium. By modelling the pupils as particles, find

(a) the magnitude of the normal reaction between the plank and the leg at Q and the magnitude of the normal reaction between the plank and the leg at R.

(7)

Beatrice stays sitting at P but Arthur now moves and sits on the plank at the point X. Given that the plank remains horizontal and in equilibrium, and that the magnitude of the normal reaction between the plank and the leg at Q is now twice the magnitude of the normal reaction between the plank and the leg at R,

(b) find the distance QX.

(6)

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Question 4 continued

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7.

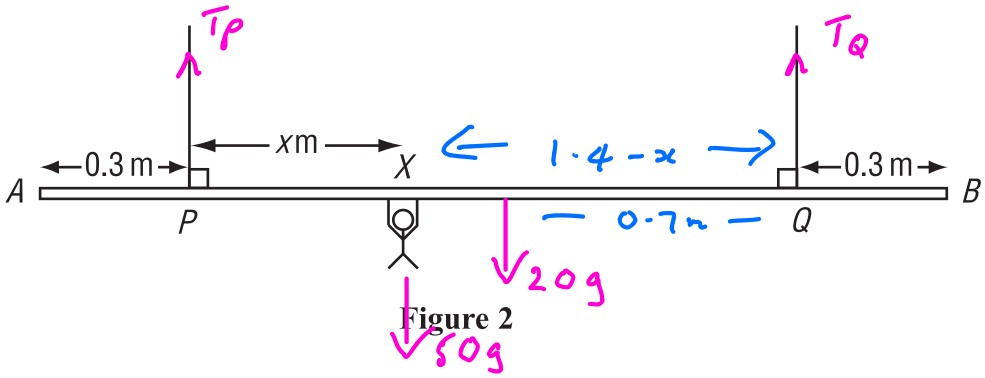

Figure 2

A beam AB is supported by two vertical ropes, which are attached to the beam at points P and Q, where $AP = 0.3$ m and $BQ = 0.3$ m. The beam is modelled as a uniform rod, of length 2 m and mass 20 kg. The ropes are modelled as light inextensible strings. A gymnast of mass 50 kg hangs on the beam between P and Q. The gymnast is modelled as a particle attached to the beam at the point X, where $PX = x$ m, $0 < x < 1.4$ as shown in Figure 2. The beam rests in equilibrium in a horizontal position.

(a) Show that the tension in the rope attached to the beam at P is $(588 - 350x)$ N. **(3)**

(b) Find, in terms of x, the tension in the rope attached to the beam at Q. **(3)**

(c) Hence find, justifying your answer carefully, the range of values of the tension which could occur in each rope. **(3)**

Given that the tension in the rope attached at Q is three times the tension in the rope attached at P,

(d) find the value of x. **(3)**

a) Mom about Q

$$T_P \times 1.4 = 20g \times 0.7 + 50g \times (1.4 - x)$$

$$T_P = \frac{20 \times 9.8 \times 0.7 + 50 \times 9.8(1.4 - x)}{1.4}$$

$$T_P = \frac{137.2 + 686 - 490x}{1.4}$$

$$T_P = 588 - 350x \quad \text{N}$$

b) $\updownarrow$ $T_P + T_Q = 50g + 20g$

N 3 4 2 7 5 A 0 1 6 2 4

Leave blank

Question 7 continued

$T_Q = 70g - T_P$

$T_Q = 70g - (588 - 350x)$

$T_Q = 98 + 350x$ N

c)

$0 < x < 1.4$

$98N < T_P < 588N$

$98N < T_Q < 588N$

d) $98 + 350x = 3(588 - 350x)$

$98 + 350x = 1764 - 1050x$

$1400x = 1666$

$x = \frac{1666}{1400} = 1.19$ m

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4.

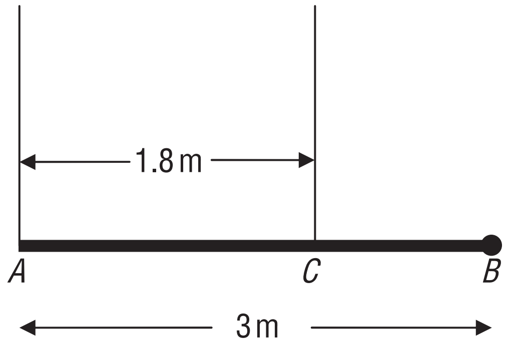

Figure 2

A pole AB has length 3 m and weight W newtons. The pole is held in a horizontal position in equilibrium by two vertical ropes attached to the pole at the points A and C where $AC = 1.8$ m, as shown in Figure 2. A load of weight 20 N is attached to the rod at B. The pole is modelled as a uniform rod, the ropes as light inextensible strings and the load as a particle.

(a) Show that the tension in the rope attached to the pole at C is $\left(\frac{5}{6}W + \frac{100}{3}\right)$N.

(4)

(b) Find, in terms of W, the tension in the rope attached to the pole at A.

(3)

Given that the tension in the rope attached to the pole at C is eight times the tension in the rope attached to the pole at A,

(c) find the value of W.

(3)

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Question 4 continued

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Turn over

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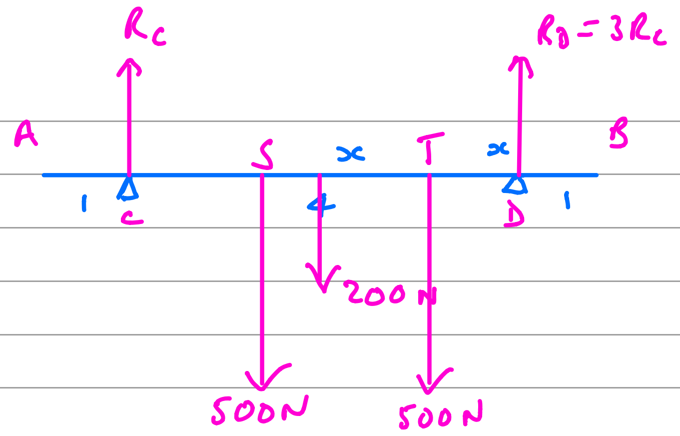
4. A beam AB has length 6 m and weight 200 N. The beam rests in a horizontal position on two supports at the points C and D, where $AC = 1$ m and $DB = 1$ m. Two children, Sophie and Tom, each of weight 500 N, stand on the beam with Sophie standing twice as far from the end B as Tom. The beam remains horizontal and in equilibrium and the magnitude of the reaction at D is three times the magnitude of the reaction at C. By modelling the beam as a uniform rod and the two children as particles, find how far Tom is standing from the end B.

(7)



↕ $R_c + 3R_c = 1200$ N

$R_c = 300$ N

Moments about B

$R_c \times 5 + R_D \times 1 = 500 \times 2x + 200 \times 3 + 500 \times x$

$1500 + 900 = 1000x + 600 + 500x$

$1800 = 1500x$

$x = \frac{1800}{1500}$

$x = 1.2$ m

N 3 5 3 9 0 A 0 8 2 8