2.

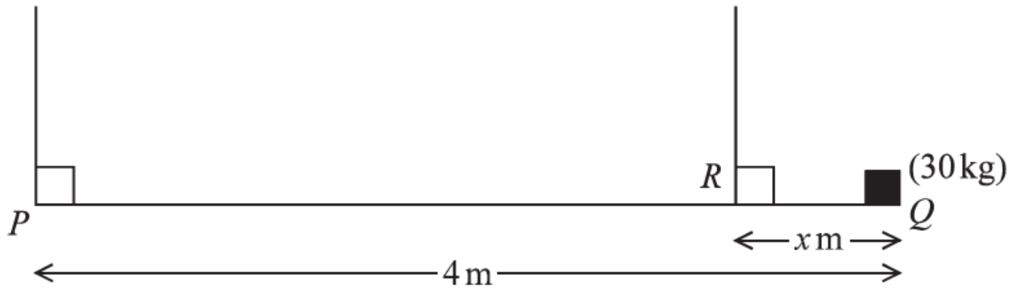


Figure 1

A girder PQ has length 4 m and mass 60 kg. A load of mass 30 kg is placed on the girder at Q. The loaded girder is held in equilibrium in a horizontal position by two vertical ropes. The ropes are attached to the girder at the points P and R, where $RQ = x$ metres, as shown in Figure 1. The tension in the rope at R is four times the tension in the rope at P. The girder is modelled as a uniform rod, the ropes as light inextensible strings and the load as a particle.

Find

(i) the tension in the rope at P,

(ii) the value of x.

(7)

6. A non-uniform plank AB has length 6 m and mass 30 kg. The plank rests in equilibrium in a horizontal position on supports at the points S and T of the plank where $AS = 0.5$ m and $TB = 2$ m.

When a block of mass M kg is placed on the plank at A, the plank remains horizontal and in equilibrium and the plank is on the point of tilting about S.

When the block is moved to B, the plank remains horizontal and in equilibrium and the plank is on the point of tilting about T.

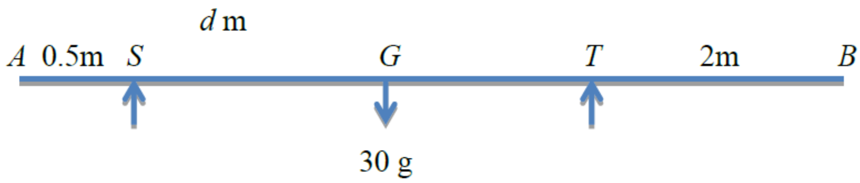
The distance of the centre of mass of the plank from A is d metres. The block is modelled as a particle and the plank is modelled as a non-uniform rod. Find

(i) the value of d,

(ii) the value of M.

(7)

2.		$T + 4T = 60g + 30g$ OR $M(P)$, $60g \times 2 + 30g \times 4 = 4T(4 - x)$ OR $M(Q)$, $4Tx + T \times 4 = 60g \times 2$ OR $M(R)$, $T(4-x) + 30gx = 60g(2-x)$ OR $M(G)$, $T \times 2 + 30g \times 2 = 4T(2-x)$ $T = \dfrac{90g}{5}$ oe, 176 N or 180 N (Tension at P) $x = \dfrac{2}{3}$ (0.67 or better)	M1 A1 M1 A1 A1 A1 A1
			(7)

6.		 $M(S)$: $Mg \leftrightarrow 0.5 = 30g(d - 0.5)$ $M(T)$: $Mg \leftrightarrow 2 = 30g(4 - d)$ dividing: $4 = \dfrac{(4-d)}{(d-0.5)}$ => (i) $d = 1.2$ => (ii) $M = 42$	M1 A1 M1 A1 **DM1** A1 A1

3.

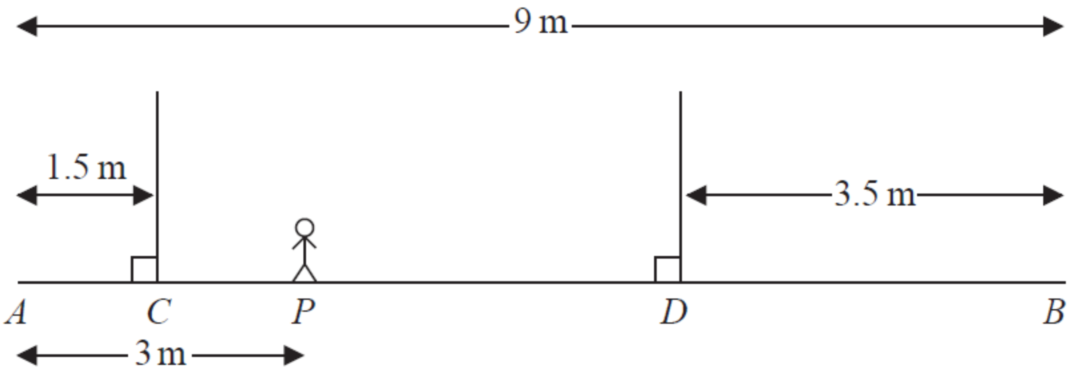


Figure 2

A wooden beam AB, of mass 150 kg and length 9 m, rests in a horizontal position supported by two vertical ropes. The ropes are attached to the beam at C and D, where $AC = 1.5$ m and $BD = 3.5$ m. A gymnast of mass 60 kg stands on the beam at the point P, where $AP = 3$ m, as shown in Figure 2. The beam remains horizontal and in equilibrium.

By modelling the gymnast as a particle, the beam as a uniform rod and the ropes as light inextensible strings,

(a) find the tension in the rope attached to the beam at C.

(3)

The gymnast at P remains on the beam at P and another gymnast, who is also modelled as a particle, stands on the beam at B. The beam remains horizontal and in equilibrium. The mass of the gymnast at B is the largest possible for which the beam remains horizontal and in equilibrium.

(b) Find the tension in the rope attached to the beam at D.

(4)

3.(a)	$M(D),\ (150g \times 1) + (60g \times 2.5) = Tc \times 4$	M1 A1
	$Tc = 75g$ or 735 N or 740 N Allow omission of N	A1 (3)
(b)	$M(B),\ (150g \times 4.5) + (60g \times 6) = T_D \times 3.5$	M1 A2
	$T_D = 2900$ N or $\frac{2070g}{7}$ Allow omission of N	A1 (4)
		(7)

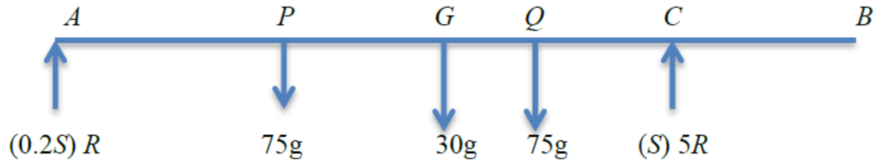
3. A plank AB has length 6 m and mass 30 kg. The point C is on the plank with $CB = 2$ m. The plank rests in equilibrium in a horizontal position on supports at A and C. Two people, each of mass 75 kg, stand on the plank. One person stands at the point P of the plank, where $AP = x$ metres, and the other person stands at the point Q of the plank, where $AQ = 2x$ metres. The plank remains horizontal and in equilibrium with the magnitude of the reaction at C five times the magnitude of the reaction at A. The plank is modelled as a uniform rod and each person is modelled as a particle.

(a) Find the value of x.

(7)

(b) State two ways in which you have used the assumptions made in modelling the plank as a uniform rod.

(2)

3(a)	 $(\uparrow)\ R + 5R = 75g + 30g + 75g$ $M(A)\quad 75gx + 75g2x + 30g \times 3 = 5R \times 4$ $x = \frac{34}{15} = 2.3$ or better (N.B. Or another Moments Equation)	M1 A2 M1 A2 A1 (M1 A2) (7)
(b)	uniform – mass is or acts at midpoint of plank; centre of mass is at middle of plank; weight acts at the middle of the plank, centre of gravity is at midpoint rod - plank does not bend, remains straight, is inflexible, is rigid	B1 B1 (2) **9**

5.

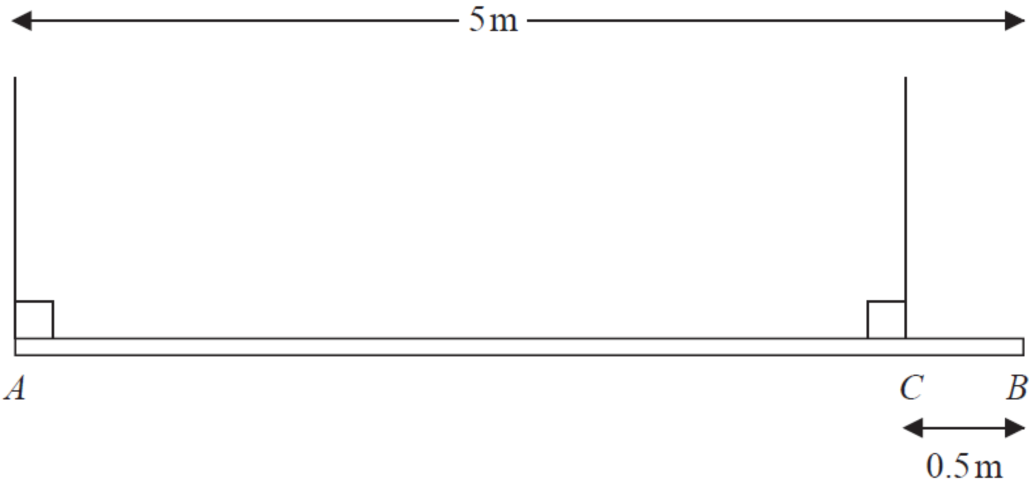


Figure 3

A beam AB has length 5 m and mass 25 kg. The beam is suspended in equilibrium in a horizontal position by two vertical ropes. One rope is attached to the beam at A and the other rope is attached to the point C on the beam where CB = 0.5 m, as shown in Figure 3. A particle P of mass 60 kg is attached to the beam at B and the beam remains in equilibrium in a horizontal position. The beam is modelled as a uniform rod and the ropes are modelled as light strings.

(a) Find

(i) the tension in the rope attached to the beam at A,

(ii) the tension in the rope attached to the beam at C.

(6)

Particle P is removed and replaced by a particle Q of mass M kg at B. Given that the beam remains in equilibrium in a horizontal position,

(b) find

(i) the greatest possible value of M,

(ii) the greatest possible tension in the rope attached to the beam at C.

(6)

5(a)	$T_A + T_C = 85g$ OR $M(A)$, $25g \times 2.5 + 60g \times 5 = 4.5 \times T_C$ OR $M(C)$, $T_A \times 4.5 + 60g \times 0.5 = 25g \times 2$ OR $M(B)$, $T_A \times 5 + T_C \times 0.5 = 25g \times 2.5$ OR $M(G)$, $T_A \times 2.5 + 60g \times 2.5 = 2 \times T_C$ $T_A = \frac{40g}{9} = 44$N or 43.6N; $T_C = \frac{725g}{9} = 790$N or 789 N	M1 A1 M1 A1 A1; A1 (6)
(b)	$\text{M}(C)$, $25g \times 2 = Mg \times 0.5$	M1 A1
(i)	$M = 100$	A1
(ii)	$T_c = 25g + 100g$ $T_c = 125g$ (1200 or 1230)N	M1 A1 B1 (6) **12**