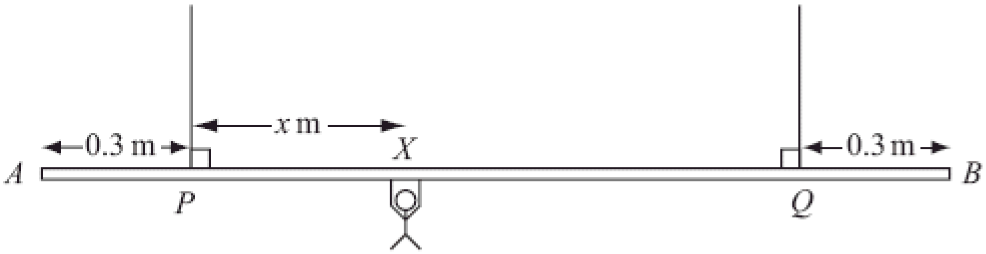
1.



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 the diagram above. 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.

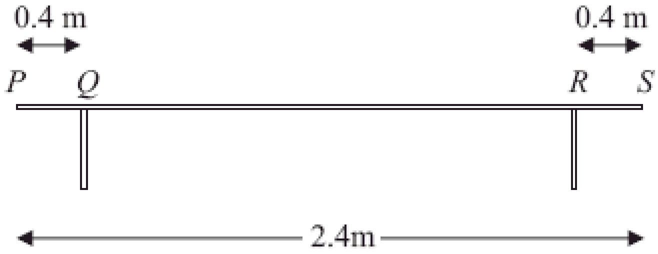
(3)

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)
(Total 12 marks)

2.



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 the diagram above.

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.

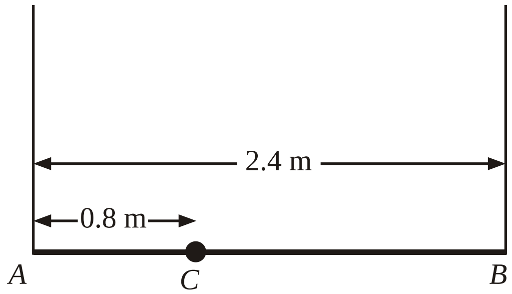
(7)

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)
(Total 13 marks)

3.



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 the diagram above. 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)
(Total 10 marks)

1. (a) $M(Q)$, $50g(1.4 - x) + 20g \times 0.7 = T_P \times 1.4$ A1

$T_P = 588 - 350x$ Printed answer A1 3

(b) $M(P)$, $50gx + 20g \times 0.7 = T_Q \times 1.4$ or $R(\uparrow)$, $T_P + T_Q = 70g$ A1

$T_Q = 98 + 350x$ A1 3

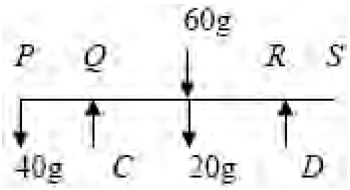
(c) Since $0 < x < 1.4$, $98 < T_P < 588$ and $98 < T_Q < 588$ A1 A1 3

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

$x = 1.19$ DM1 A1 3

[12]

2. (a)



$C + D = 120g$

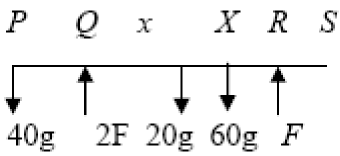
$M(Q)$, $80g.0.8 - 40g.0.4 = D.1.6$ A1

solving A1

$C = 90g$; $D = 30g$

A1 A1 7

(b)



$2F + F = 40g + 20g + 60g$ A1

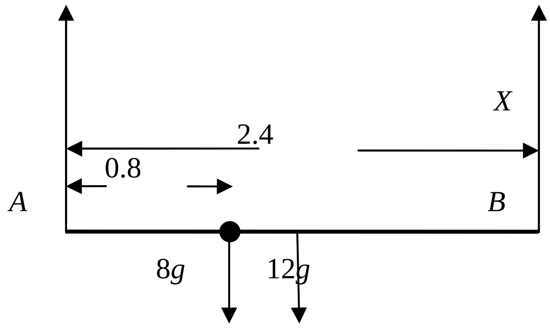
$M(Q)$, $60gx + 20g.0.8 = 40g.0.4 + F.1.6$

solving A1

$QX = x = \dfrac{16}{15}$ m = 1.07m A1 6

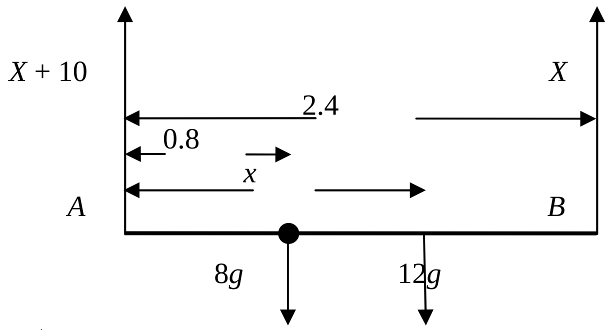
[13]

3. (a)



$M(A)$ $8g \times 0.8 + 12g \times 1.2 = X \times 2.4$		M1A1	
$X \approx 85$ (N)	accept 84.9, $\dfrac{26g}{3}$	DM1A1	4

(b)



$R(\uparrow)$ $\underline{(X + 10)} + \underline{X} = 8g + 12g$ $(X = 93)$		M1B1A1	
$M(A)$ $8g \times 0.8 + 12g \times x = X \times 2.4$		M1A1	
$x = 1.4$(m)	accept 1.36	A1	6

[10]

1. Most candidates chose to take moments about Q in part (a). Common errors were incorrect distances, missing g's or lack of a distance in the moment of T_P. Some used the answer for part (a) and resolved vertically to obtain the answer for part (b).

The third part proved to be difficult for many candidates and answers with inequalities in x were offered. Some candidates used $x = 0.1$ or 1.39 to calculate the boundaries. A few managed to get the correct boundaries but did not express their answers correctly.

In the final part a significant minority lost marks by using $T_P = 3\ T_q$ to obtain their answer.

2. Part (a) was well answered with the majority of candidates realising that they had to take moments. A common and costly error was to omit the distance when taking the moment of one or both of the reaction forces. Some candidates took moments twice, usually about Q then about R but these tended to be less successful than those who took moments and resolved vertically. A few students missed off g’s from their weight terms. In the second part, again the most productive method was to resolve vertically and use one moments equation. Those who opted to take moments twice had more algebraic manipulation to contend with, which at times was a problem. Poor diagrams often resulted in finding and using wrong distances.

3. Part (a) was well done by many who produced and solved an appropriate moments equation, although a minority thought that the two tensions were equal and ‘solved’ the problem by a vertical resolution. The second part proved to be more demanding, with those candidates who tried to use the value of the tension from part (a) scoring very little. Most resolved vertically and took moments about a point. There were occasional errors in the relevant lengths or omission of g and some candidates interpreted the tensions as T and $10T$ rather than T and $T + 10$. Errors were more prevalent in the working of those who took moments about two points giving them simultaneous equations to solve.