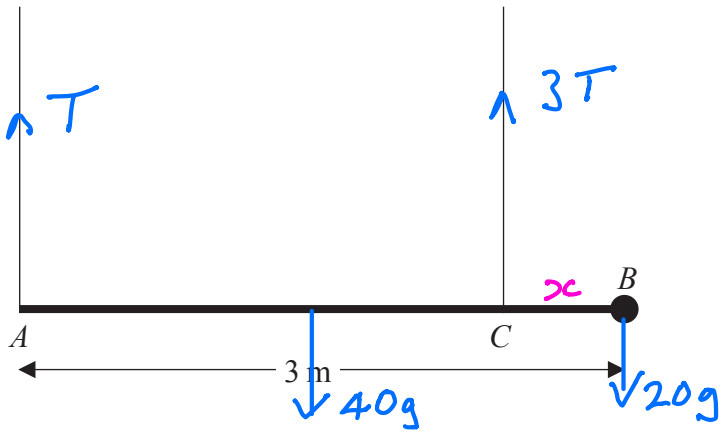
Leave blank

2. **Figure 1**



A plank AB has mass 40 kg and length 3 m. A load of mass 20 kg is attached to the plank at B. The loaded plank is held in equilibrium, with AB horizontal, by two vertical ropes attached at A and C, as shown in Figure 1. The plank is modelled as a uniform rod and the load as a particle. Given that the tension in the rope at C is three times the tension in the rope at A, calculate

(a) the tension in the rope at C,

(2)

(b) the distance CB.

(5)

a) ↕ equilibrium $4T = 60g$

$T = 15g$

$3T = 45g = 441\,N$

Tension at C = 441 N

b) Moments about B

$T \times 3 + 3T \times x = 40g \times 1.5$

$441 + 441x = 588$

$441x = 147$

$x = \frac{147}{441} = \frac{1}{3}\,m$

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6.

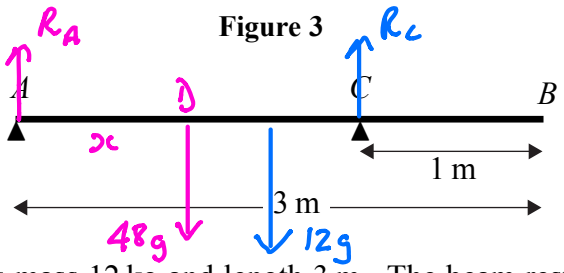

Figure 3

A uniform beam AB has mass 12 kg and length 3 m. The beam rests in equilibrium in a horizontal position, resting on two smooth supports. One support is at the end A, the other at a point C on the beam, where $BC = 1$ m, as shown in Figure 3. The beam is modelled as a uniform rod.

(a) Find the reaction on the beam at C.

(3)

A woman of mass 48 kg stands on the beam at the point D. The beam remains in equilibrium. The reactions on the beam at A and C are now equal.

(b) Find the distance AD.

(7)

a) Moments about A

$12g \times 1.5 = 2 \times R_C$

$176.4 = 2R_C$

$\frac{176.4}{2} = R_C$

$R_C = 88.2$ N

b) ↕ equilibrium $R_A + R_C = 60g$

$R_A = R_C = 30g = 294$ N

Moments about A

$48g \times x + 12g \times 1.5 = 30g \times 2$

$48x + 18 = 60$

$48x = 42$

$x = \frac{7}{8}$ m

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Question 6 continued

Q6

(Total 10 marks)

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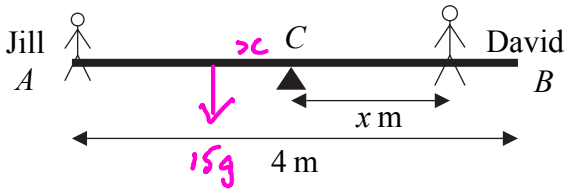
3. **Figure 1**



A seesaw in a playground consists of a beam AB of length 4 m which is supported by a smooth pivot at its centre C. Jill has mass 25 kg and sits on the end A. David has mass 40 kg and sits at a distance x metres from C, as shown in Figure 1. The beam is initially modelled as a uniform rod. Using this model,

(a) find the value of x for which the seesaw can rest in equilibrium in a horizontal position.

(3)

(b) State what is implied by the modelling assumption that the beam is uniform.

(1)

David realises that the beam is not uniform as he finds that he must sit at a distance 1.4 m from C for the seesaw to rest horizontally in equilibrium. The beam is now modelled as a non-uniform rod of mass 15 kg. Using this model,

(c) find the distance of the centre of mass of the beam from C.

(4)

a) Moments about C

$25g \times 2 = 40g \times x$

$\frac{50}{40} = x$

$x = 1.25\text{ m}$

b)

Centre of mass of beam is halfway along beam

c) Moments about C

$25g \times 2 + 15gx = 40g \times 1.4$

$15x = 56 - 50$

$15x = 6$

$x = 0.4\text{ m}$

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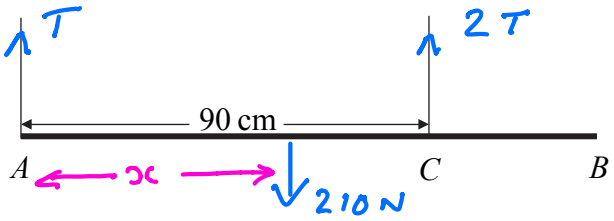
Question 3 continued

Q3

(Total 8 marks)

Leave blank

5. **Figure 3**



A steel girder AB has weight 210 N. It is held in equilibrium in a horizontal position by two vertical cables. One cable is attached to the end A. The other cable is attached to the point C on the girder, where $AC = 90$ cm, as shown in Figure 3. The girder is modelled as a uniform rod, and the cables as light inextensible strings.

Given that the tension in the cable at C is twice the tension in the cable at A, find

(a) the tension in the cable at A,

(2)

(b) show that $AB = 120$ cm.

(4)

A small load of weight W newtons is attached to the girder at B. The load is modelled as a particle. The girder remains in equilibrium in a horizontal position. The tension in the cable at C is now three times the tension in the cable at A.

(c) Find the value of W.

(7)

a) ↕ equilibrium $3T = 210\text{ N}$

$T = 70\text{ N}$

Tension at A = 70 N

b)

Moments about B

$140 \times 0.9 = 210 \times x$

$\frac{126}{210} = x$

$x = 0.6\text{ m} = 60\text{ cm}$

Weight acts at centre of uniform girder so girder AB = 2 x 60 = 120 cm long

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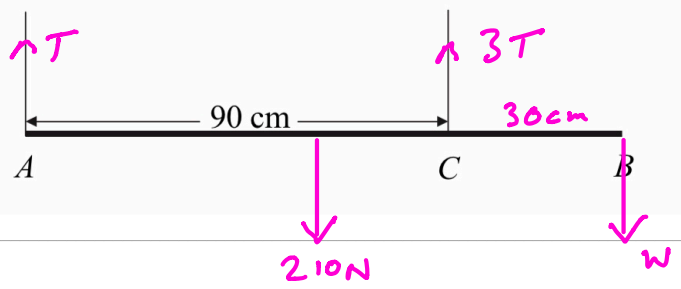
Question 5 continued

c)

Figure 3



Moments about A

$210 \times 0.6 + W \times 1.2 = 3T \times 0.9$

$126 = 2.7T - 1.2W$ (1)

↕ equilibrium

$4T = 210 + W$

$210 = 4T - W$ (2)

Solve (1) and (2) simultaneously

By calc $T = 60N$ $W = 30N$

$W = 30N$

Q5

(Total 13 marks)

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2.

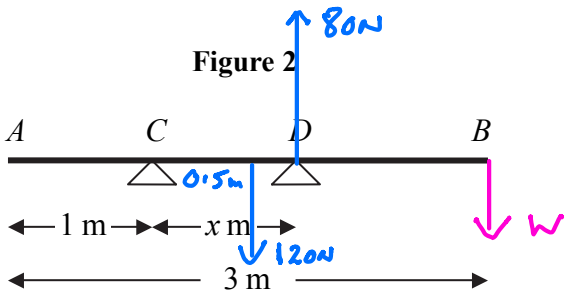

Figure 2

A uniform plank AB has weight 120 N and length 3 m. The plank rests horizontally in equilibrium on two smooth supports C and D, where $AC = 1$ m and $CD = x$ m, as shown in Figure 2. The reaction of the support on the plank at D has magnitude 80 N. Modelling the plank as a rod,

(a) show that $x = 0.75$

(3)

A rock is now placed at B and the plank is on the point of tilting about D. Modelling the rock as a particle, find

(b) the weight of the rock,

(4)

(c) the magnitude of the reaction of the support on the plank at D.

(2)

(d) State how you have used the model of the rock as a particle.

(1)

a) Moments about C

$120 \times 0.5 = 80x$

$60 = 80x$

$\frac{60}{80} = x$

$x = 0.75$ m

b)

Moments about D (on point of tilting, $R_C = 0$)

$120 \times (0.75 - 0.5) = W(3 - 1.75)$

$30 = 1.25W$

$W = 24$ N

Leave blank

Question 2 continued

c) ↕ equilibrium $R_D = 120 + 24$

$R_D = 144\ N$

d) Weight of rock acts at a point (B)

Q2

(Total 10 marks)

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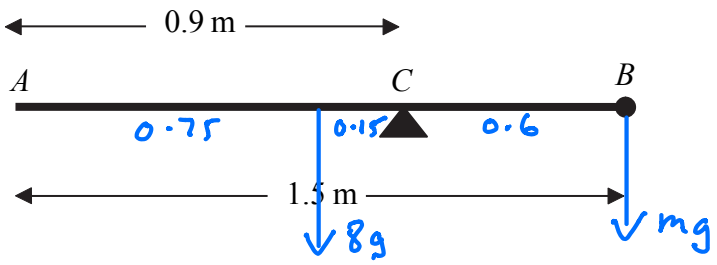
3. **Figure 2**



A uniform rod AB has length 1.5 m and mass 8 kg. A particle of mass m kg is attached to the rod at B. The rod is supported at the point C, where $AC = 0.9$ m, and the system is in equilibrium with AB horizontal, as shown in Figure 2.

(a) Show that $m = 2$.

(4)

A particle of mass 5 kg is now attached to the rod at A and the support is moved from C to a point D of the rod. The system, including both particles, is again in equilibrium with AB horizontal.

(b) Find the distance AD.

(5)

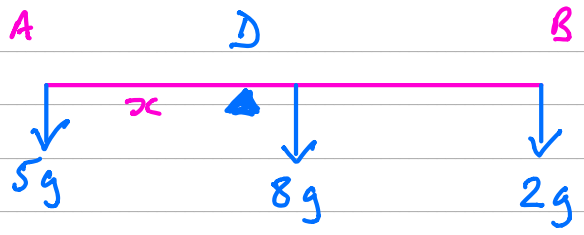
a) Moments about C

$8g \times 0.15 = mg \times 0.6$

$\frac{8 \times 0.15}{0.6} = m$

$m = 2$ kg

b)



Moments about D

$8g \times (0.75 - x) + 2g \times (1.5 - x) = 5gx$

$6 - 8x + 3 - 2x = 5x$

$9 = 15x$

$AD = x = 0.6$ m

Leave blank

Question 3 continued

Q3

(Total 9 marks)