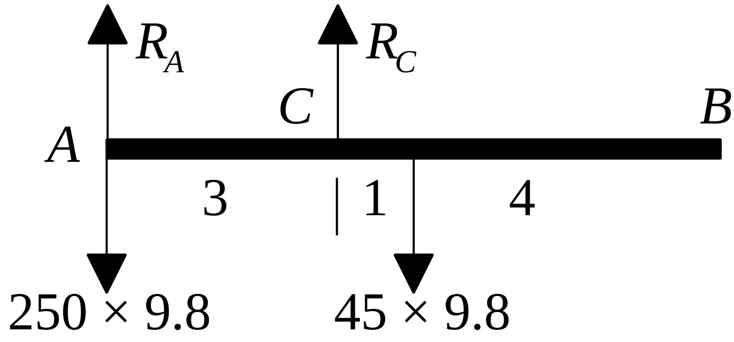
3.3 Answers

3.3.1 Solution to the Introductory Example

As the rod is *uniform*, the 45 kg mass of the plank can be assumed to act at the midpoint of the *rod*, at it's *centre of mass*.
Thus, the working diagram becomes;



(a) Taking moments about A (as forces at A then have moments of zero)

$$45 \times 9.8 \times 4 = 3 \times R_C$$
$$R_C = 588\,N$$

(b) Balancing forces vertically;

$$R_A + R_C = 250 \times 9.8 + 45 \times 9.8$$
$$= 2891$$
$$\therefore\ R_A = 2303\,N$$

(c) At tipping point, reaction at A will be zero
Taking moments about C

$$250 \times 9.8 \times 3 = 45 \times 9.8 \times 1 + M \times 9.8 \times 5$$
$$M = 141\,kg$$

(d) An adult typically has a mass of 70 kg
A skinny man typically has a mass of about 48 kg
An obese man typically has a mass of 141 kg

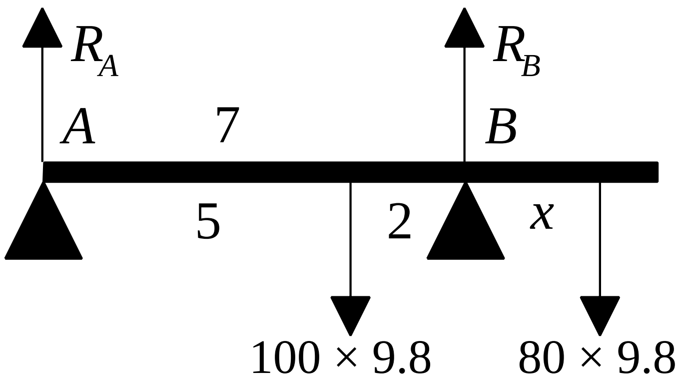
$\therefore$ Don't let move than one person at a time use the diving board !

Also : Jumping at the end, as divers do, considerably adds to the maximum force, the impulse, being exerted on the board.

3.3.2 Solutions to 3.2 Exercise

Answer 1

(i) In the diagram R_A could be omitted as it will be 0 N on the point of tipping.



(ii) When the beam is on the point of tipping, $R_A = 0$ N

(iii) Balancing forces vertically,

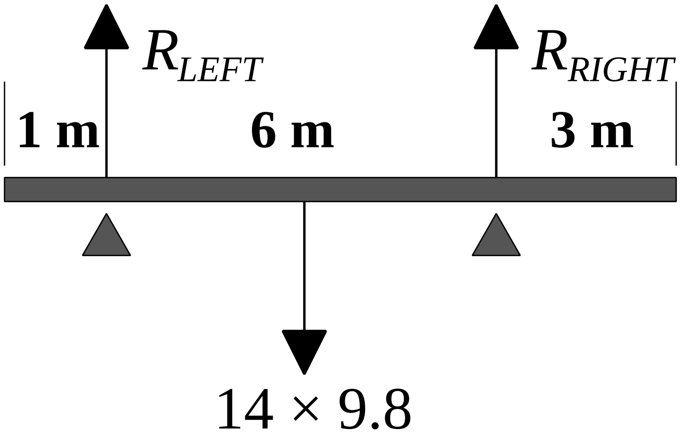
$$\begin{aligned} R_A + R_B &= 100 \times 9.8 + 80 \times 9.8 \\ 0 + R_B &= 980 + 784 \\ R_B &= 1764 \text{ N} \end{aligned}$$

(iv) Taking moments about B,

$$\begin{aligned} 80 \times 9.8 \times x &= 100 \times 9.8 \times 2 \\ 784x &= 1960 \\ x &= 2.5 \text{ metres} \end{aligned}$$

Answer 2

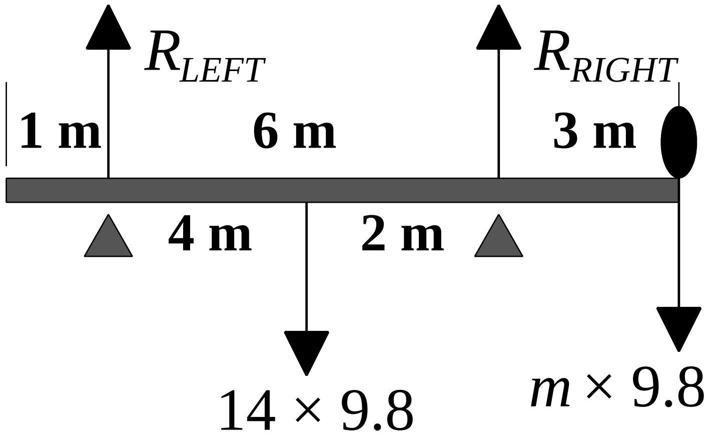
(a)



Balancing forces vertically,

$$R_{LEFT} + R_{RIGHT} = 14 \times 9.8$$
$$R_{RIGHT} = 137 - 75$$
$$= 62 \text{ N}$$

(b)



(i) 0 N

(ii) Taking moments about the right hand support,

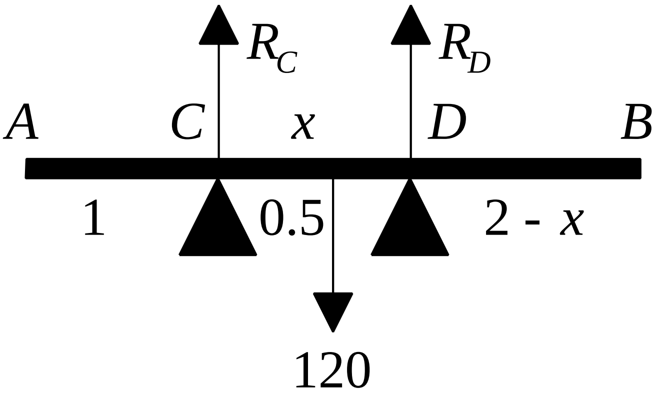
$$R_{LEFT} \times 6 + m \times 9.8 \times 3 = 14 \times 9.8 \times 2$$
$$0 + 29.4m = 274$$
$$m = 9.33 \text{ kg}$$

(iii) Balancing forces vertically,

$$R_{LEFT} + R_{RIGHT} = 14 \times 9.8 + m \times 9.8$$
$$0 + R_{RIGHT} = 137 + 9.33 \times 9.8$$
$$R_{RIGHT} = 229 \text{ N}$$

Answer 3

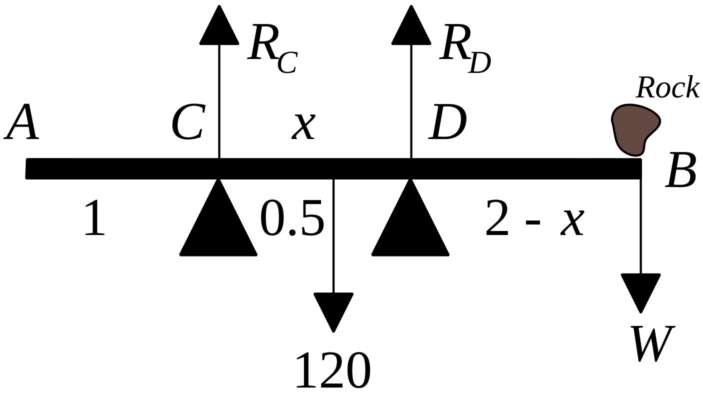
(a)



Taking moments about *C*,

$$R_D \times x = 0.5 \times 120$$
$$80x = 60$$
$$x = 0.75 \text{ metres}$$

(b)



Taking moments about *D*, and ignoring R_C as it is equal to zero,

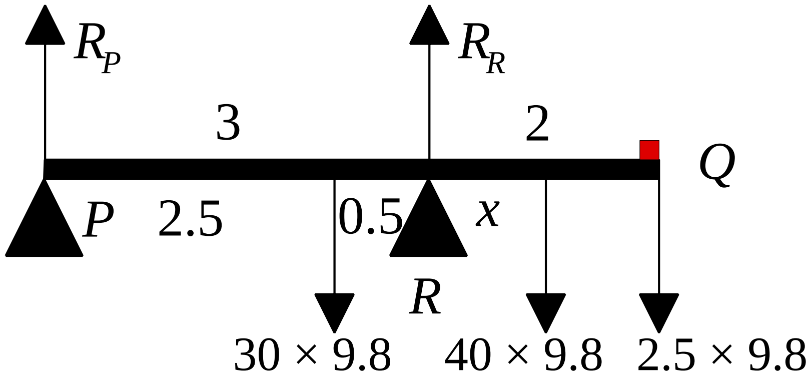
$$W \times 1.25 = 120 \times 0.25$$
$$W = 24 \text{ N}$$

(c) Balancing forces vertically,

$$R_D = 120 + 24$$
$$= 144 \text{ N}$$

(d) The weight of the rock is assumed to act precisely at *B*.
In practice a slight vibration might cause the rock to fall off the plank.

Answer 4



(a) Let x be the distance between the boy and support R when the plank is on the point of tipping. This choice of what to call x is based on the experience gained in Question 1.

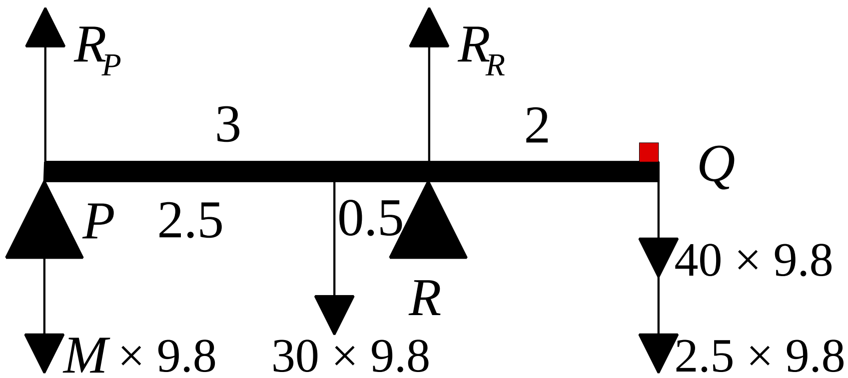
When on the point of tipping, R_P will be 0 N
Taking moments about R,

$$\begin{aligned} 40 \times 9.8 \times x + 2.5 \times 9.8 \times 2 &= 30 \times 9.8 \times 0.5 \\ 392x + 49 &= 147 \\ x &= 0.25\,\text{m} \end{aligned}$$

From P this will be a distance of 3.25 metres along the plank.

(b) I've assumed that the weight of the box is all at the very end of the plank whereas in the diagram the box is depicted in a manner that suggests the centre of mass of the box is a little in from the end of the plank.

(c)



Again, on the point of tipping, R_P will be 0 N
Taking moments about R,

$$\begin{aligned} M \times 9.8 \times 3 + 30 \times 9.8 \times 0.5 &= 40 \times 9.8 \times 2 + 2.5 \times 9.8 \times 2 \\ 29.4M + 147 &= 784 + 49 \\ M &= 23.3\,\text{kg} \end{aligned}$$