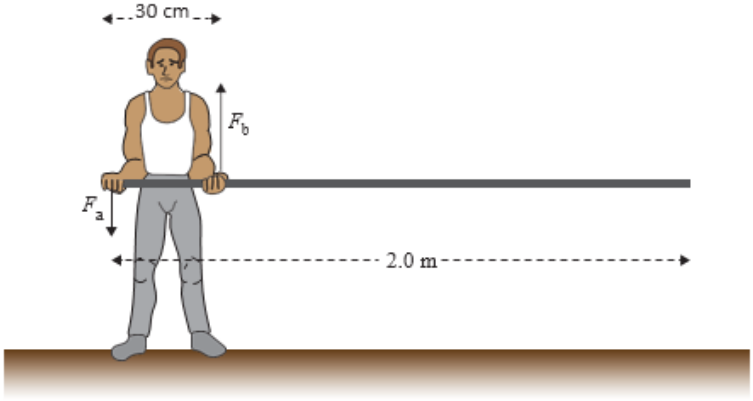
MECHANICS: EQUILIBRIUM QUESTIONS

FORCES (2022;3)

(c) An athlete in training holds a uniform rod, 2.0 m long, stationary in a horizontal position. The mass of the rod is 3.0 kg.

Calculate the forces F_a and F_b that are required by the athlete's hands to hold the rod in equilibrium, in the horizontal position.

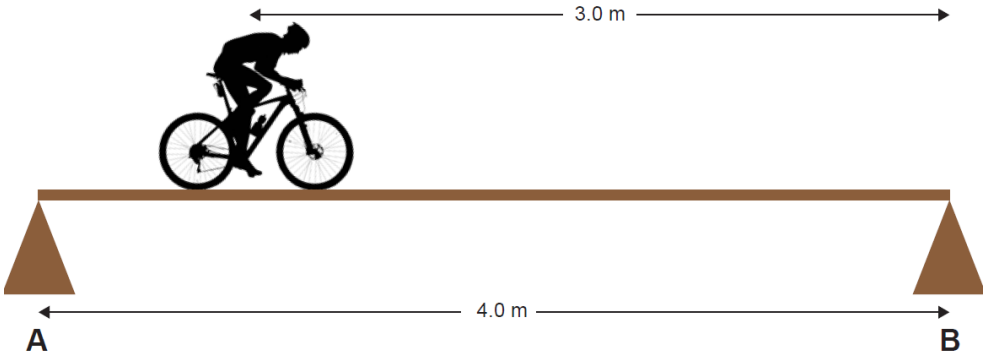


ENERGY (2021;3)

The rider bikes over a 4.0 m-long bridge and stops 3.0 m from the end. The bridge has a uniform mass of 700 kg. The combined mass of the rider and bike is 85 kg.

(b) State the conditions required for the bridge to be in equilibrium.

(c) Draw labelled arrows to represent all the forces acting on the bridge.

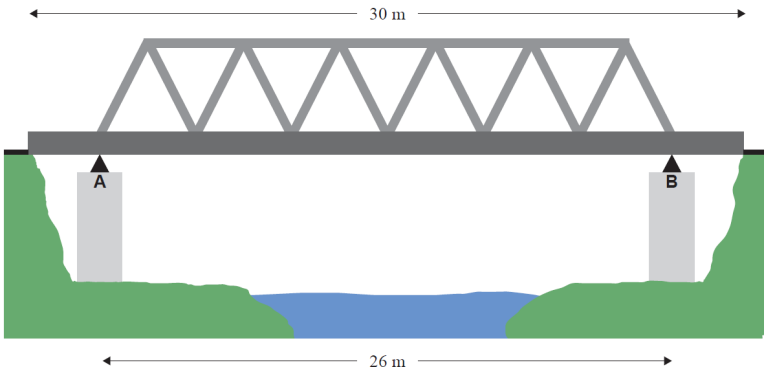


(d) Calculate the values of ALL the forces acting on the bridge.

THE BRIDGE (2020;3)

Jo and Alex need to cross a bridge to reach their destination.

The bridge is 30 m long and has a mass of 30 000 kg.
The supports are 26 m apart, and equal distance from the centre of the bridge.



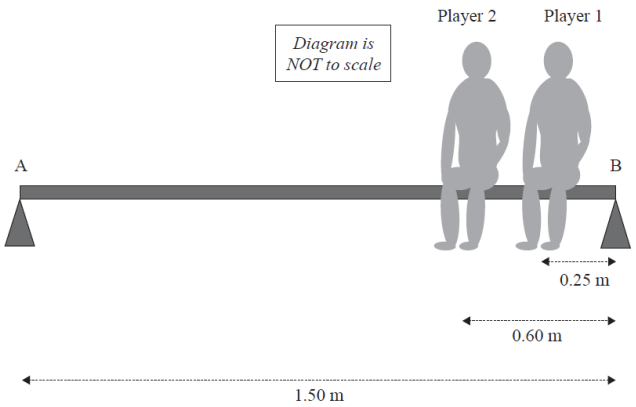
(a) State the two requirements for an object to be in equilibrium.

(b) The road is closed as the bridge is under repair. The support column at end B can supply a maximum support force of 160 000 N. By finding torques about support A, calculate the furthest distance from support A that a 1600 kg mass could be placed before the support at B became overloaded.

HALF TIME AT THE HOCKEY MATCH (2019;2)

(d) The team is waiting on the side-line. Two players sit on the bench, as shown.

The bench is 1.50 m long and has a mass of 10 kg. Each player has a mass of 60 kg. Player 1 is 0.25 m from the support B, Player 2 is 0.60 m away from support B.



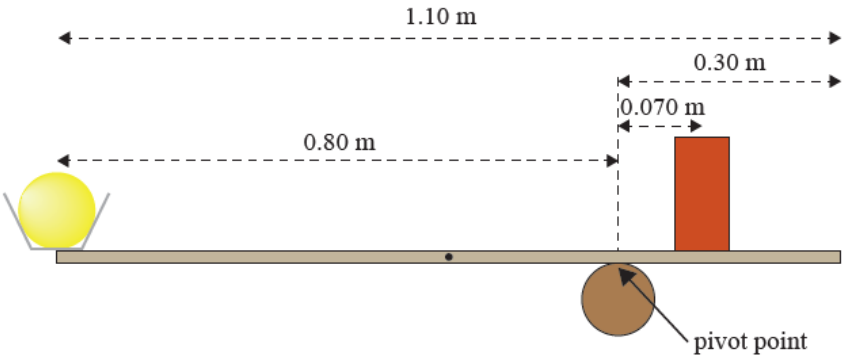
(i) Draw labelled arrows showing all the forces acting on the bench.

(ii) By first determining the torques about point B, calculate the support forces at each end of the bench. What assumptions have you made?

ALTERNATIVE LAUNCHERS (2018;2)

Jimmy made a launcher using a uniform 1.10 m long wooden beam that has a mass of 0.30 kg. He placed his water balloon in a holder that had a combined mass of 0.19 kg on the far left-hand end of the beam, 0.80 m from the pivot point. To get the launcher level (state of equilibrium), he added a brick to the right-hand side of the pivot point.

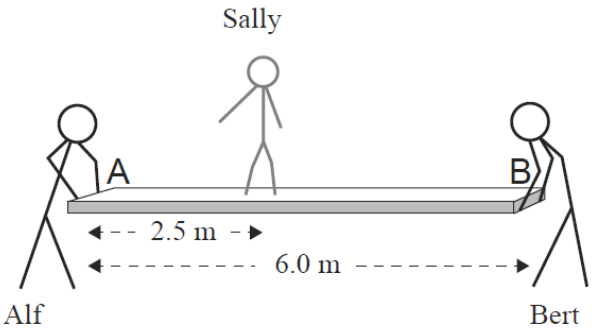
(a) In the diagram below, draw and label ALL forces acting on the wooden beam.



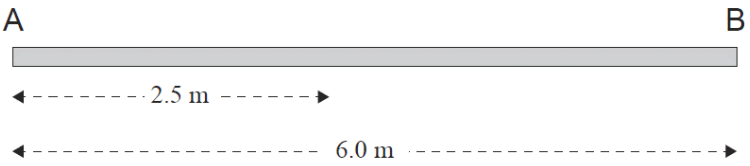
(b) Calculate the mass of the brick on the right side required for the beam to be level.

Torques and energy (2017;3)

A uniform wooden plank of mass 5.0 kg and length 6.0 m is resting in the hands of two circus employees, Alf and Bert. Sally, a circus dancer of mass 40.0 kg, stands 2.5 m away from end A of the wooden plank, as shown.



(a) In the diagram below, draw and name all forces acting on the plank.



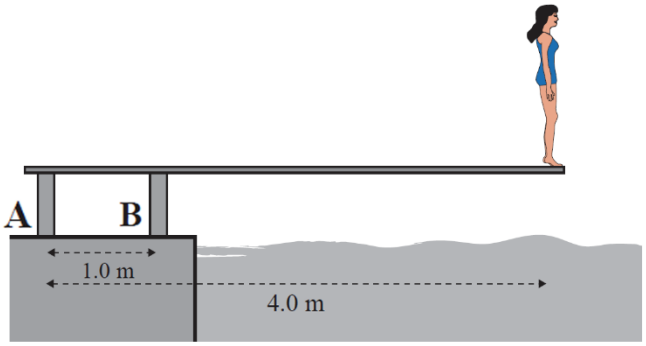
The plank is in a state of equilibrium when Sally is standing still, 2.5 m away from end A of the plank.

(b) (i) Describe the conditions needed for the plank to be in an equilibrium state.
(ii) Calculate the total clockwise torque around end A of the plank

(c) (i) Calculate the size of the force experienced by Alf, who is holding end A of the plank.
(ii) Explain whether Alf experiences any change in force when Sally moves from her existing position towards end B during her dance routine.

Torques and energy (2016;3)

Sarah stands at the end of a diving board of total length 4.0 m. The diving board is fixed to two supports, A and B, which are 1.0 m apart. The mass of the board is 10 kg and Sarah's mass is 50 kg. Assume the mass of the board is evenly distributed.



(a) Calculate the torque exerted by Sarah about support B. Give units with the answer.

(b) What is the direction of the force supplied by support A? Explain your answer. No calculations are required.

Circular motion and Torques (2015;4)

(d) Janet's study table has two panels, one at each end. Janet has a pile of books on her table. Use the details given below to calculate the support force provided by panel A of the study table.

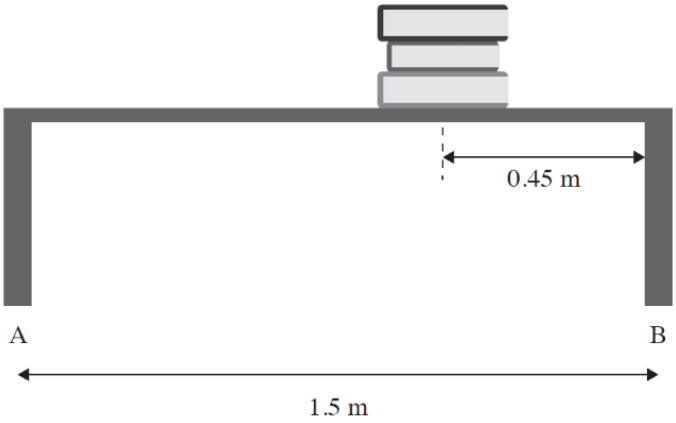
Mass of table =37 kg

Length of table =1.5 m

Mass of books =7.4 kg

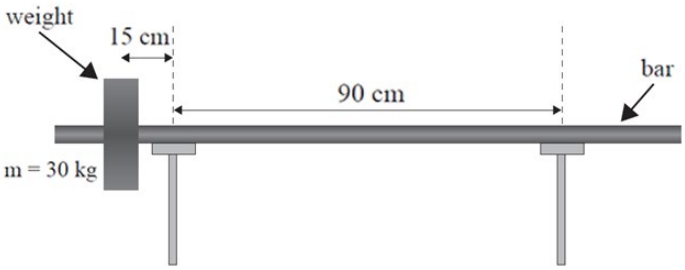
Weight of the books acts at a distance of 0.45 m from end B of the table.

Assume Janet's study table is uniform.



At the Gym (2014;2)

(b) Jamie puts the barbell on two supports and changes the weights on the bar. With no weights on one end and a 30 kg weight on the other end, the support force provided by the right-hand support is zero.

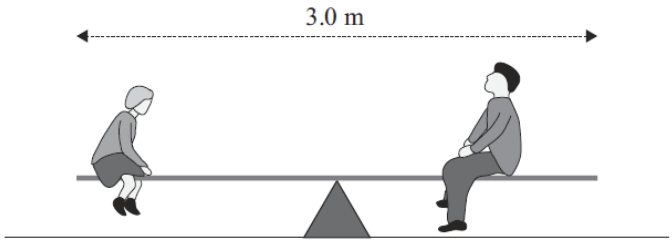


Draw labelled arrows on the diagram showing the forces on the bar.

Use the concept of torque to calculate the weight of the bar. Assume it is a uniform bar.

Forces and motion (2013;2)

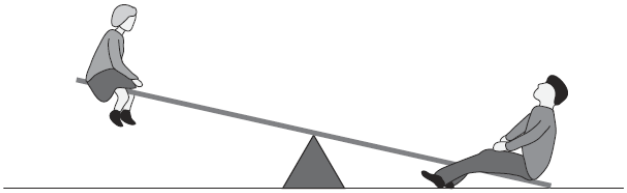
The diagram below represents a see-saw on a pivot at its centre with Jane and her dad sitting on opposite sides such that the see-saw is in equilibrium. The mass of the see-saw itself is 60 kg.



(a) On the diagram, draw labelled vectors to show all the forces acting on the see-saw.

(b) Jane and her dad move to opposite ends of the see-saw. The diagram shows what happens when Jane sits at one end of the see-saw while her dad sits at the other end.

Jane's mass	= 30 kg
Jane's dad's mass	= 72 kg
Mass of see-saw	= 60 kg
Length of see-saw	= 3.0 m



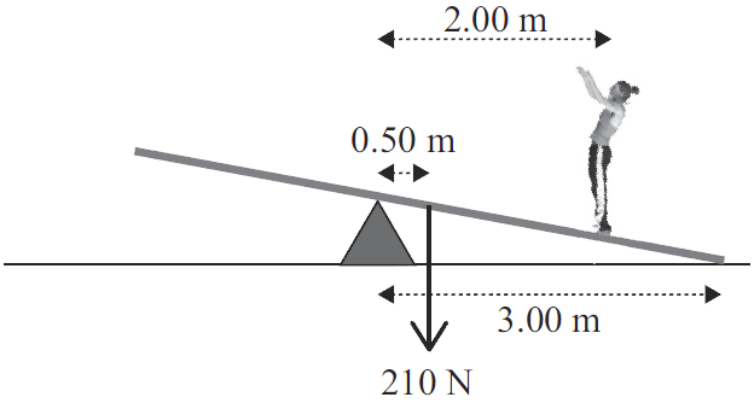
Calculate the size of the support force from the ground at the end where Jane's dad sits. Round your answer to the correct number of significant figures.

THE SEE-SAW (2012;2)

In their next act, Hannah (55 kg) stands on a see-saw. The see-saw has a weight of 210 N.

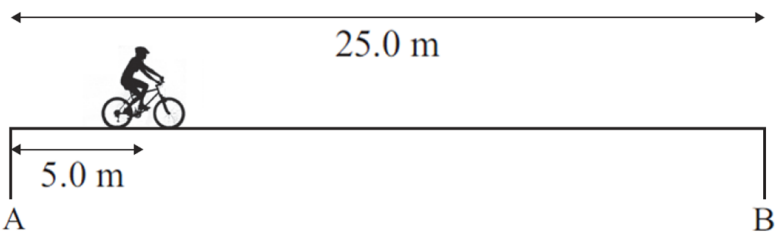
(a) Calculate the **size** and **direction** of the force that the floor exerts on the **right hand** end of the see- saw.

(b) Round your answer to part (a) to the correct number of significant figures. State the reason for your choice of significant figures in part (a).



THE BRIDGE (2011;2)

(a) Jacquie the bike rider cycles along a uniform bridge that is supported at both ends, as shown in the diagram.

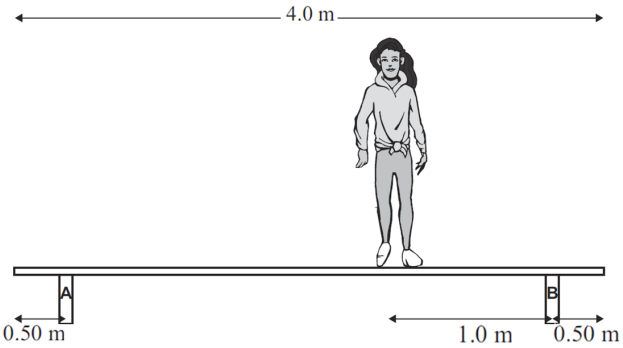


The length of the bridge is 25.0 m. The mass of Jacquie and her bike is 72 kg. The mass of the bridge is 760 kg. Calculate the **support force (F_A)** provided by **end A,** and the **support force (F_B)** provided by **end B** of the bridge when Jacquie is 5.0 m from end A.

(b) Express your answers to part (a) to the correct number of significant figures. Give a reason for your choice of significant figures in your answers to part (a).

THE SPECTATORS (2010;5)

Aroha has a mass of 55 kg. She steps onto a bench to get a better view. The bench is 4.0 m long.
Aroha walks towards one end so that she is 1.0 m away from support B.

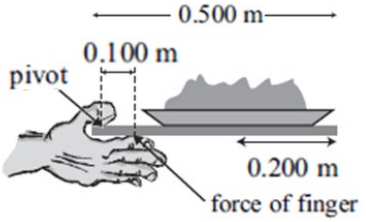


(c) The bench is in equilibrium. Explain what this means.

(d) Support B exerts a force of 420 N on the bench. Assuming the bench is uniform, calculate the mass of the bench.

EQUILIBRIUM, MOMENTUM AND SPRINGS (2009;3)

Harry carries his tray of food to his cafeteria table for lunch. The uniform tray is 0.500 m long and has a mass of 0.20 kg. It holds a 0.40 kg plate of food where the centre of the plate is 0.200 m from the right hand edge. Harry holds the tray on the left-hand side with one hand, using his thumb as the pivot (fulcrum), and pushes up 0.100 m from the pivot (fulcrum) with his fingertips.



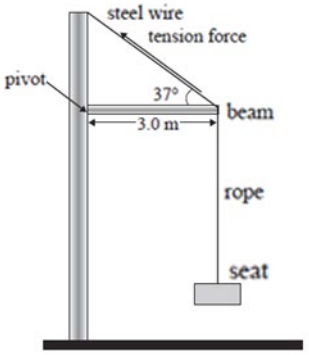
(a) State the conditions necessary for the tray to be in equilibrium.

(b) Calculate the weight (force of gravity) on:
(i) the plate of food
(ii) the tray.

(c) Calculate the size of the upward force that Harry's fingertips must exert to keep the tray level.

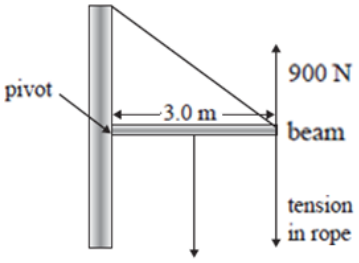
GOING TO THE PLAYGROUND (2008;2)

Rua goes across to the pole swing. The swing hangs on a rope attached to a uniform beam, as shown in the diagram.



The beam is 3.0 m long and has a mass of 35 kg.
The angle between the steel wire and the beam is 37°.
The tension force in the steel wire is 1500 N.

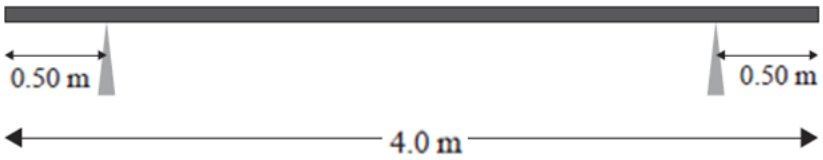
(i) The force exerted on the beam by the steel wire can be split into two components. Show that the vertical component of the force exerted on the beam by the steel wire is 900 N.



(j) By calculating the torques on the beam about the pivot, calculate the tension force in the rope.

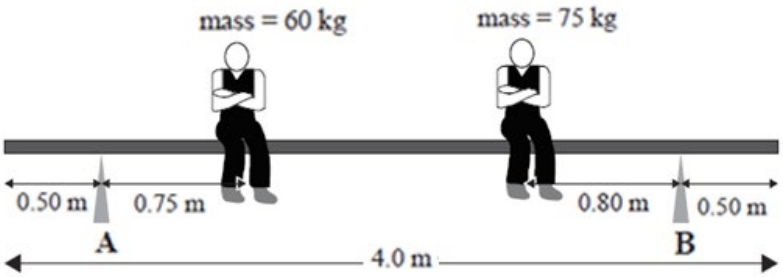
AT THE AIRPORT (2007;2)

Some painters are working at the airport. They have a uniform plank resting on two supports. The plank is 4.0 m long. It has a mass of 22 kg. The two legs that support the plank are 0.50 m from either end, as shown in the diagram.



(a) The plank is in equilibrium. Draw labelled arrows of appropriate sizes in the correct position showing the forces acting on the plank on the diagram above.

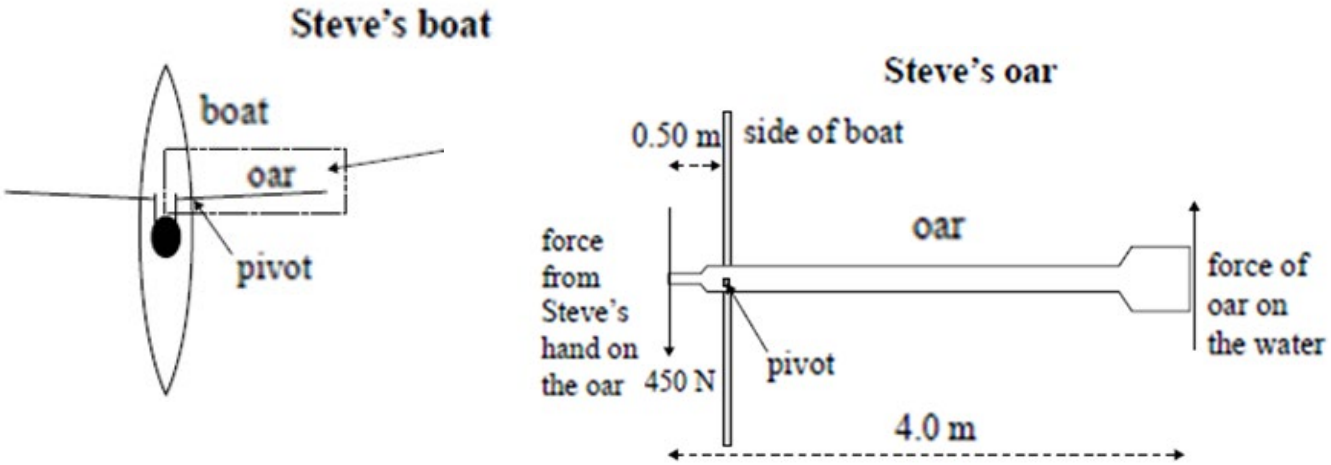
(b) Calculate the support force on the plank at A if a painter of mass 60 kg sits 0.75 m from A, and another painter of mass 75 kg sits at a distance of 0.80 m from B. Use g= 10 m s^{-2}.



ROWING (2006;1)

Steve is in a rowing race. The diagram below shows part of the side of the boat and one of Steve's oars as seen from above. The oar pivots on the side of the boat.

The oar is 4.0 m long. Steve's hand is 0.50 m from the pivot.
During a warm-up, Steve exerts a force of 450 N on the oar as shown in the diagram below.

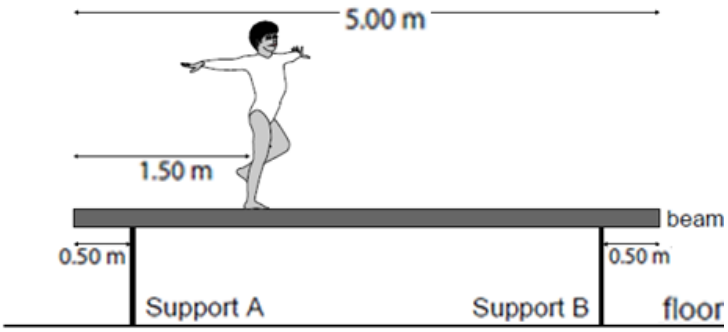


(f) Calculate the size of the force that the oar exerts on the water.

SCHOOL GYM (2004;3)

Where needed, use g = 10.0 ms^{-2}.

Nadia is performing an exercise on the balance beam. The beam is 5.00 m long and has two supports, A and B, each 0.50 m from either end. The beam is uniform and rigid and has a mass of 90 kg. Nadia's mass is 55 kg and she is standing 1.50 m from the left-hand end as shown.



(i) On the diagram, draw four labelled arrows in the correct positions and pointing in the correct directions to show each of the following forces: Nadia's weight, the weight of the beam, the support force provided by support A, the support force provided by support B

(ii) State the value of Nadia's weight and the weight of the beam

(iii) Calculate the value of the support force at A when Nadia is in the position shown.

(iv) Explain the physics involved in finding the answer to (iii).