Rotational equilibrium questions

Question 1

A torque wrench is used to tighten nuts onto their bolts to a specific tightness or force. A torque wrench has a handle (black in the photo below) on one end and a socket that fits over a nut on the other end. In between is a scale that gives a reading in Newton metres.

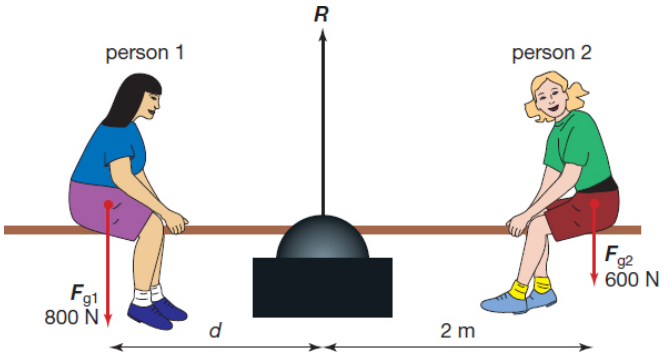
The scale on a torque wrench has a reading of 30 Newton metres. If the hand applying the force is 30 cm from the end, what is the size of the force by the hand on the wrench?

Question 2

The handle of a torque wrench is hollow so an extension rod can be inserted. If you can exert only 30 N of force, how far along the extension rod from the handle should you place your hand to achieve a torque of 30 N m?

Question 3

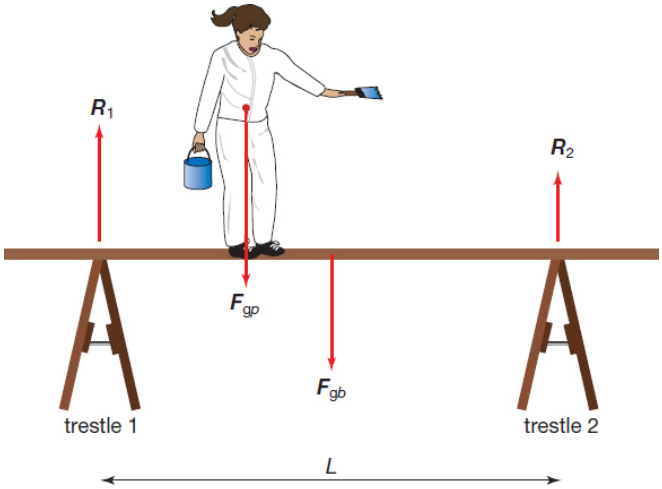
a. Calculate the normal reaction force (R) if the seesaw is balanced



b. Where should person 1 sit to balance the seesaw?

Question 4

Consider the painter's plank supported between two trestles shown below. The plank behaves as a simple bridge or beam, and the weight of the painter must be transferred through the plank to the two trestles. The mass of the beam is 40 kg, the mass of the painter is 60 kg and she is a quarter of the distance from trestle 1. What is the magnitude of the reaction forces R_1 and R_2?

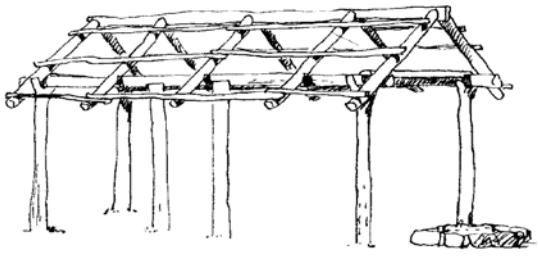


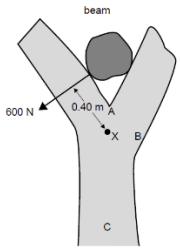
Question 5 2001 Question 1

The frame of a bush hut is shown.

The roof is held up by four corner posts, each a forked tree trunk. In a detailed examination of such a structure, an engineer finds the force exerted by one of the roof beams on one side of the fork is 600 N in a direction perpendicular to the beam.

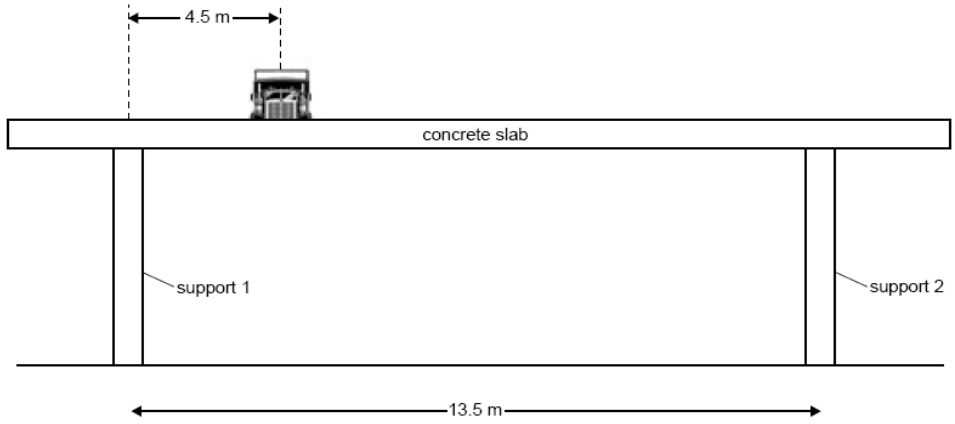
A detailed section is also shown.





Calculate the magnitude of the torque on the left side of the fork about the point **X**, due to the force from the roof beam.

Question 6 2003 Question 6



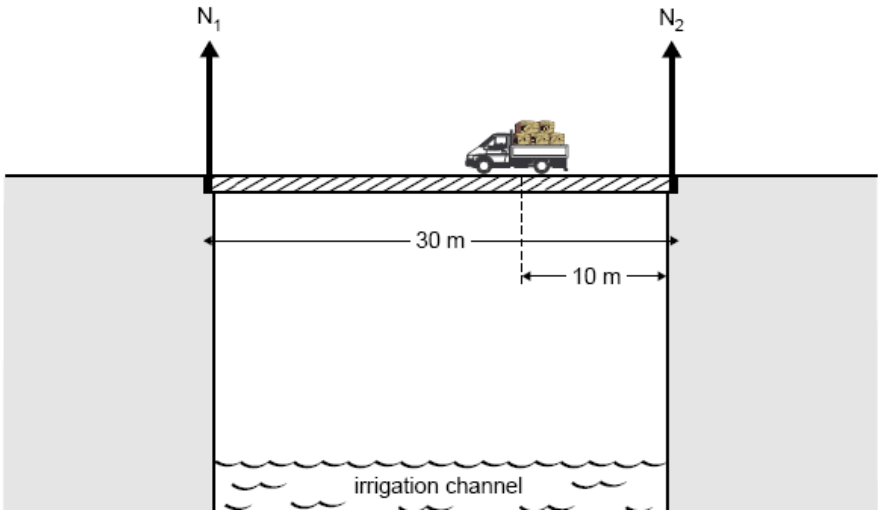
The figure above shows the front-on view of a loaded truck crossing a uniform concrete slab inside a building. The mass of the slab is 300 tonne, and the mass of the loaded truck is 50.0 tonne.

The centre of mass of the truck is 4.5 m from support 1.

Calculate the magnitude of the contact forces supporting the slab when the centre of mass of the truck is 4.5 m from support 1.

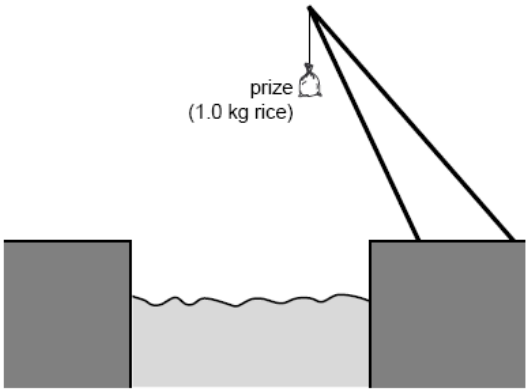
Question 7 2002 Question 3

The bridge over an irrigation channel is shown. The bridge can be considered as a uniform concrete beam of length 30 m and mass 20 tonnes. A heavily loaded small truck of mass 6 tonnes is pictured crossing the bridge.



Calculate the magnitude of each of the normal contact forces N_1 and N_2 at each end of the bridge when the centre of mass of the truck is 10 m from one end.

A survival course requires the participants to get a prize (1.0 kg of rice) suspended above a river. The figure shows the problem.



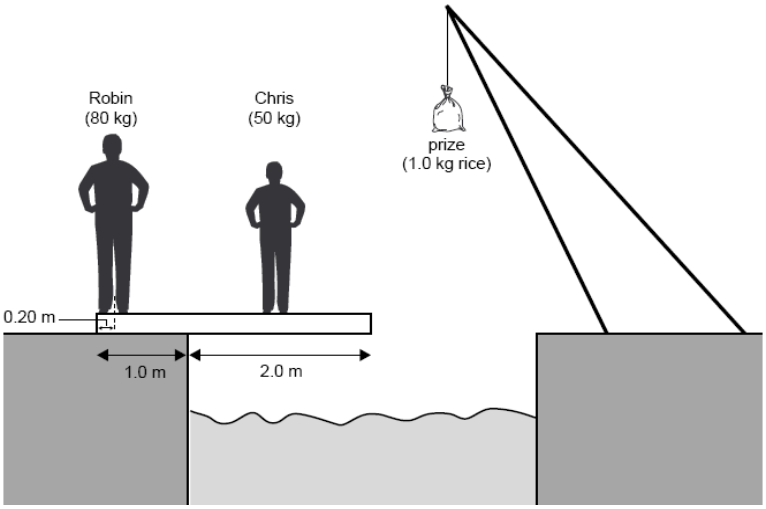
Question 8 2001 Question 7

Calculate the net force on the prize as it hangs.

Question 9 2001 Question 8

Calculate the tension in the string supporting the prize.

Two participants in the course, Chris and Robin, arrive on the scene. They are allowed to use a 40 kg, 3.0 m long plank to reach the prize. They set up the plank with 1.0 m on the bank, and Robin is standing so that his centre of mass is 0.20 m from the end. The figure below shows Chris walking out on the plank.

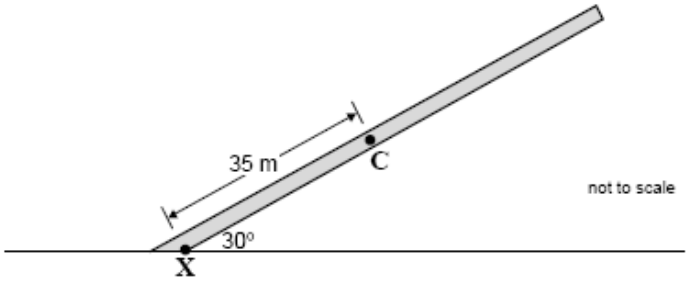


Question 10 2001 Question 9

Calculate how far from the bank Chris can safely walk.

Question 11 2000 Question 5

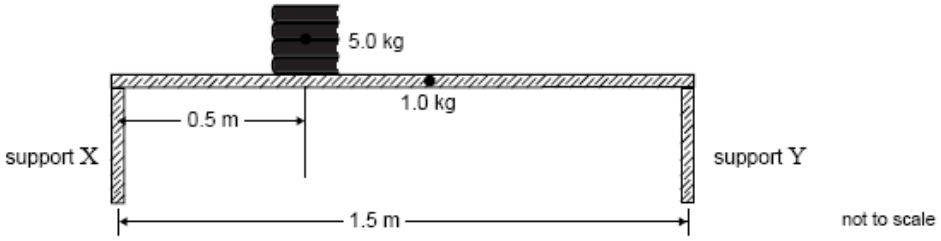
The huge yellow beam which forms part of the Gateway to Melbourne can be modelled as a simple cantilever. It is a 70 m long steel box beam with a mass of 107 tonne, at an angle of 30º to the horizontal. This is shown below



The centre of mass of the beam, C, can be considered to be 35 m from point X as shown.

Calculate the torque that the weight of the beam produces about the anchor point X.

A uniform shelf of mass 1.0 kg rests on two supports X and Y. A pile of books, of mass 5.0 kg, is placed on the shelf as shown below.



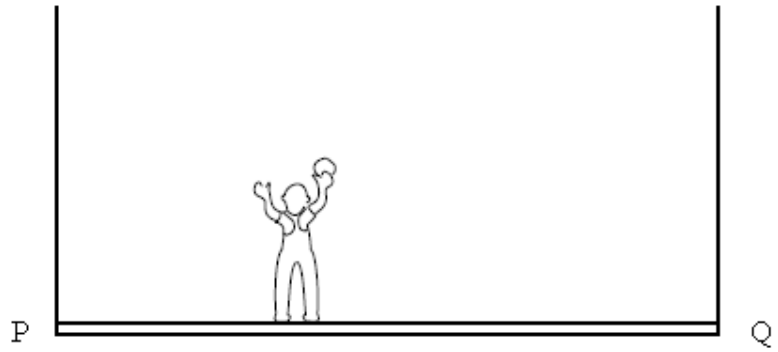
Question 12 1999 Question 3

Calculate the **total** upward force exerted on the shelf by the two supports.

Question 13 1999 Question 4

Calculate the magnitude of the upward force exerted by support X on the shelf.

A window cleaner of mass 60 kg walks along a plank of wood of mass 10 kg and of length 4.0 m from end P to end Q as shown below. The plank is suspended at each end by a light cable.



Question 14 1997 Question 11

As the cleaner moves from P to Q the tension in the cable connected to end Q can best be described as

A. varying from 0 N to 600 N.

B. varying from 50 N to 650 N.

C. being constant as he moves.

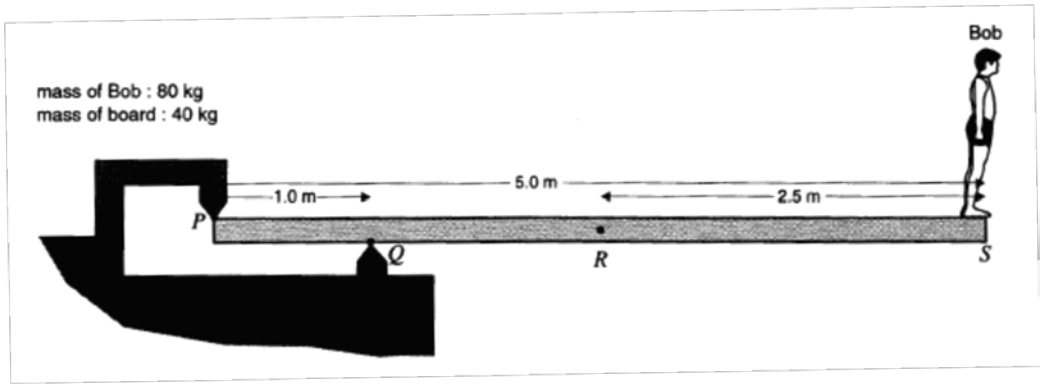
D. varying from 100 N to 700 N.

Question 15 1997 Question 12

Find the tension in the cable connected to end P when the cleaner is 1.0 m from P.

Rotational equilibrium questions

Bob walked out and stood at the end (point, S) of a diving board as shown below.



Question 16 1996 Question 1

Indicate the direction of the contact forces acting on the board at points P and Q.

Question 17 1996 Question 2

Calculate the magnitude of the contact force acting on the board at the point P. Show your working.

Bob decides not to dive and walks back along the board.

Question 18 1996 Question 3

Which one of the following statements (**A** - **E**) best describes what would happen to the relative size of the contact forces acting on the board at points P and Q if Bob walked back down the board from S to R?

A. Both of the forces at P and Q would increase in magnitude.

B. Both of the forces at P and Q would decrease in magnitude.

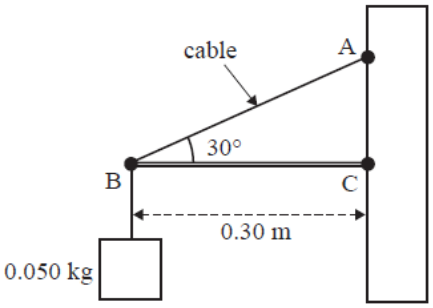
C. The force at P would increase and that at Q would decrease in magnitude.

D. The force at P would decrease and that at Q would increase in magnitude.

E. There would be no change in the magnitude of the forces at P and Q.

Question 19 2016 Question 11

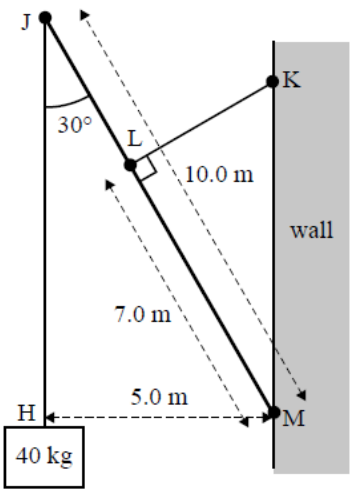
A horizontal beam, BC, is attached to a wall, as shown. The mass of the beam is 0.20 kg and there is a hanging mass of 0.050 kg at point B. The point C is a hinge. Ignore the mass of the cable AB.



Find the tension in the cable AB.

Question 20 2015 Question 11

A uniform beam, JM, of mass 20 kg and length 10 m is joined to a wall at point M by a frictionless hinge. A cable, KL, connects the beam to the wall, as shown. Ignore the mass of the cable. A mass of 40 kg hangs from point J with a cable JH.



Find the tension in KL.

Use the following information to answer Questions 21–23.

In an experiment, students set up the cantilever structure shown in Figure 3a below and attach it to the wall PQ. The pivot at X is a freely rotating hinge. The mass of the beam XY is 50 g and the string ZW can be considered to have no mass.

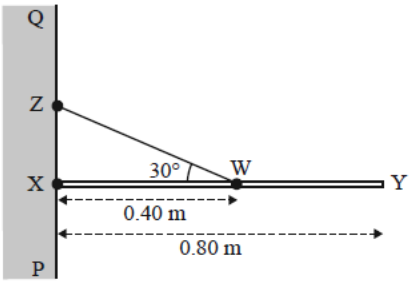


Figure 3a

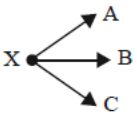


Figure 3b

Question 21 2014 Question 7

Find the tension in the string ZW.

Question 22 2014 Question 8

Using Figure 3b as a direction reference, which one of the following best describes the direction of the force of the wall PQ on the beam XY at point X?

Question 23 2014 Question 9

A 150 g hanging mass is now attached at point Y, as shown in Figure 4.

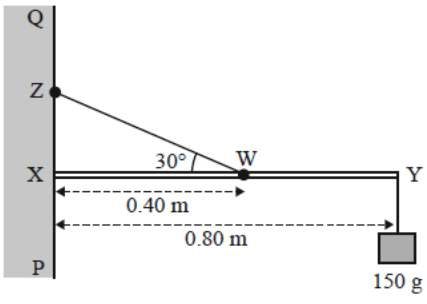


Figure 4

Find the torque on the beam about point X due to the 150 g hanging mass.

Use the following information to answer Questions 24 and 25.

A rod PQ of mass 10 kg and length 6.0 m is joined to a wall at point P by a frictionless hinge. A mass of 20 kg hangs from point Q. A cable SR holds the rod at an angle of 60° to the horizontal. SR makes an angle of 90° with the rod PQ. The situation is shown in Figure 2.

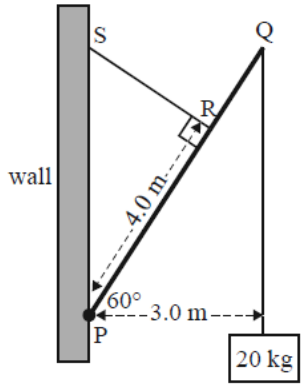


Figure 2

Question 24 2013 Question 6

Find the torque about point P due to the 20 kg mass.

Question 25 2013 Question 7

Find the tension in the cable SR.

Question 26 2013 Question 8

A platform is constructed with a concrete beam KL of length 6.0 m and mass 4000 kg. The concrete beam is reinforced with steel rods. It is attached to stable rock at point K with a frictionless pivot and supported by a column MN. M is located 2.0 m from point K. The situation is shown in Figure 3. The designers test the platform with a test load of 1000 kg, located at the end of the platform at point L.

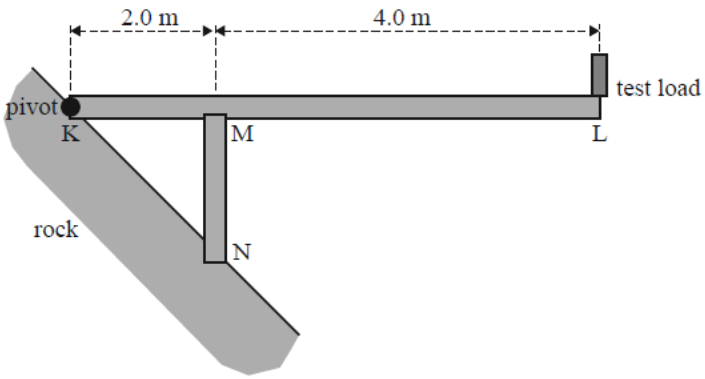


Figure 3

Find the force exerted by the beam KL downwards on the support MN.

Use the following information to answer Questions 27 and 28.

A new theatre has an entrance with a cantilever roof protruding from the main structure. The cantilever roof has a mass of 12 000 kg and is attached by a securing bolt to an anchor structure that is embedded firmly in the ground. The cantilever roof has uniform thickness and density, and is also supported (as shown) 40 m from its free end. Figure 4 shows the situation from the side.

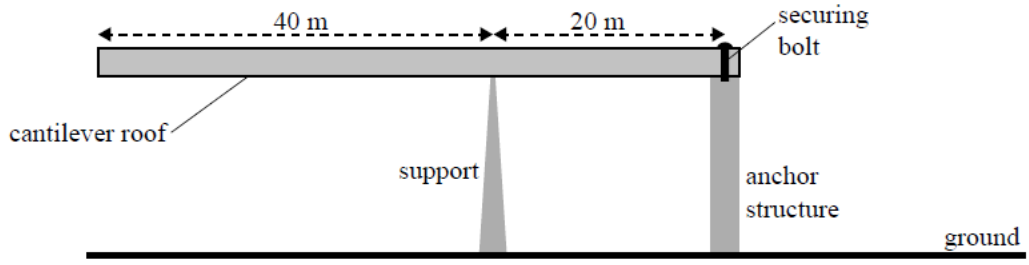


Figure 4

Question 27 2012 Question 8

Find the magnitude of the force that the support exerts on the cantilever roof.

Question 28 2012 Question 9

Find the force with which the anchor structure is pulling downward on the cantilever roof

A school crossing sign is supported by a rigid rod, AC, smoothly hinged to an upright pole at point A, and a cable, BC, as shown in Figure 3.

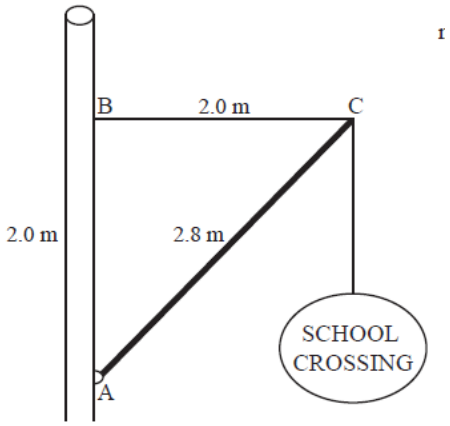


Figure 3

Length of rod AC = 2.8 m

Length of cable BC = 2.0 m

Length AB = 2.0 m

Mass of sign = 40 kg

Ignore mass of rod and all cables.

Question 29 2011 Question 8

Find the magnitude of the force in the cable BC.