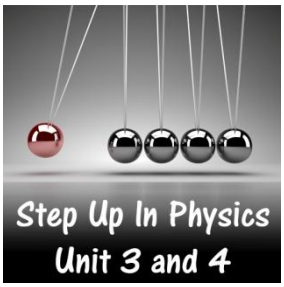
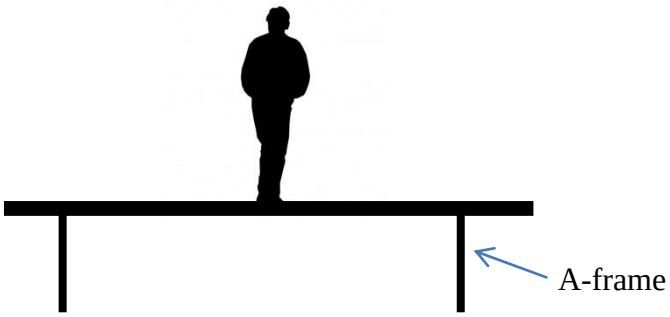
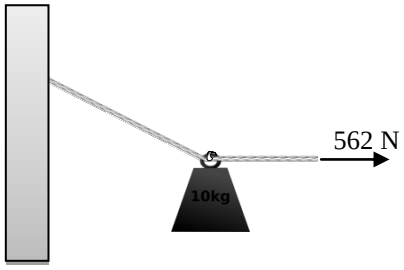
Equilibrium
Problems Worksheet



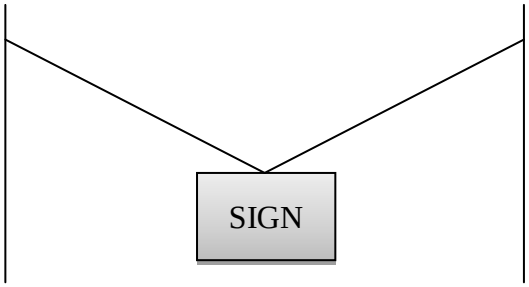
1. A painter is standing on a trestle as he paints a wall. The 6.50 kg plank he stands on is supported at either end by A-frames. The left A-frame exerts a force of 420 N while the right frame exerts a force of 453 N onto the plank. Calculate the mass of the painter.



2. Peter pulls horizontally on a rope attached to a 10.0 kg mass. Another rope is connected from the mass to a wall. Peter pulls horizontally with a force of 562 N which holds the mass in place, just above the floor. Calculate the tension in the rope connected to the wall.



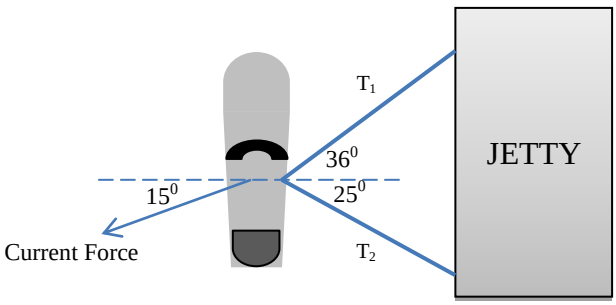
3. An 18.0 kg frame is displayed over a street by connecting two wires from the frame to a building on either side of the street.



a. The angle between the two wires is 140^{o} and the tension in each wire is equivalent in magnitude. Calculate the tension in each wire.

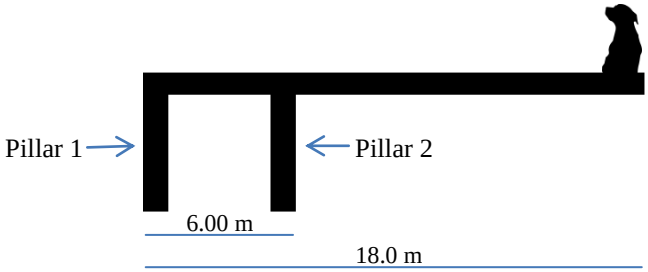
b. Over the Christmas holidays a council worker adjusts the sign to hang decorations from it. The total angle between the wires stays the same but one side now makes an angle of 80.0^{0} with the building it is attached to. 3.00 kg of decorations are attached to the sign. Calculate the tension in each wire.

4. A boat tied to a jetty in a bay experiences a 78.0 N force due to the current. The direction of this current is shown in the diagram. Two ties are used to secure the boat in place. Calculate the tension in both ties.



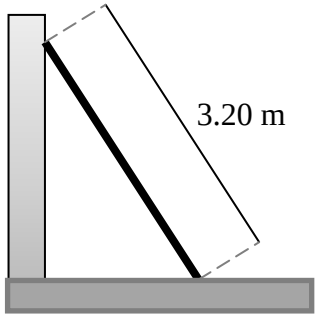
5. Jane and Isabelle sat at the two opposing ends of a see-saw. The see-saw's plank has a mass of 22.0 kg and was able to pivot about an axle located at its centre. Jane weighs 450 N while Isabelle weighs 436 N. Under these conditions the see-saw was in equilibrium. Do not assume the plank was uniform in density. Determine where the centre of mass of the plank is as a fraction of the plank's length.

6. Spot sits at the end of the Jetty shown in the diagram below. The horizontal jetty section is secured by two support pillars. Spot's mass is 45.0 kg and the horizontal jetty has a uniformly distributed mass of 240 kg.



Calculate the force applied by each support pillar onto the horizontal jetty section to keep the system in equilibrium.

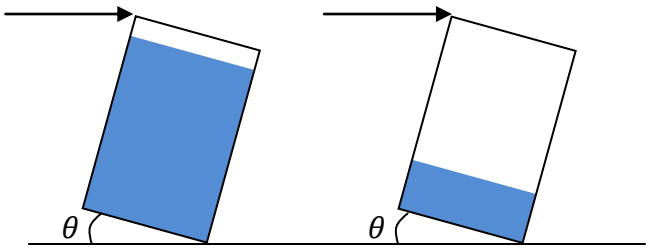
7. A 3.20 m ladder leans against a frictionless wall. James stands on the ladder, 0.60 m along its length from the bottom. The ladder makes an angle of 25.0 ^{0} with the wall. James has a mass of 50.0 kg and the ladder has a uniformly distributed mass of 12.0 kg.



a. Calculate the reaction force the wall applies to the ladder.

b. Calculate the reaction force the floor applies to the ladder.

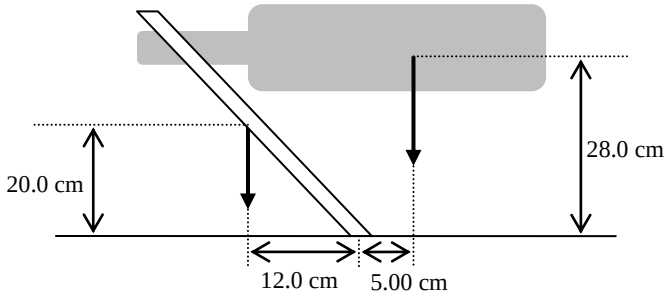
8. Two identical barrels, one mostly empty and one mostly full, are each standing upright. Each barrel then has a horizontal force applied to it at the top of the barrel, causing it to start rotating.



a. Which barrel requires more force to start it rotating? Explain how you made your choice.

b. After both barrels rotate by the same angle θ (diagram not to scale) the force applied to both barrels is removed. One barrel continues tipping over while the other returns to an upright position. Which barrel tips over? Explain how you made your choice.

9. A 1.20 kg full bottle of wine is stable while sitting in the wine stand shown below. The weight force of both the bottle and stand are also shown in the diagram.

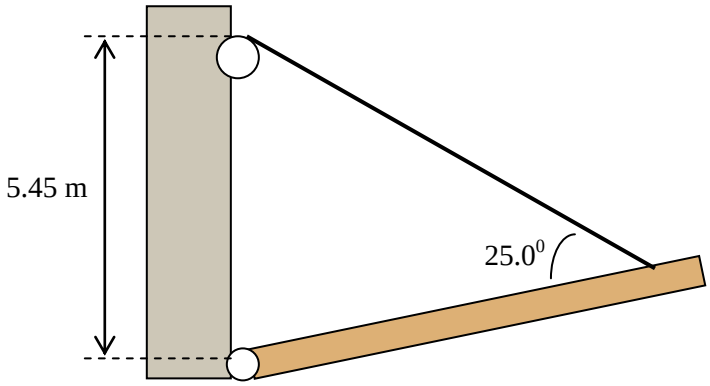


a. Calculate the mass of the wine stand.

b. Calculate the reaction force of the ground acting on the stand.

c. After half of the wine is removed from the bottle it is placed back in the stand but it can no longer remain stable. Which direction does the wine bottle and stand fall? Justify your response.

10. A medieval drawbridge is being lowered by two identical chains attached either side of the drawbridge and 12.1 m along it. The drawbridge stops not quite fully lowered. The mass of the drawbridge is 2300 kg which is distributed uniformly along its 13.0 m length.



a. Calculate the tension in **each** chain.

b. If the drawbridge did not stop at this position but instead continued to be lowered at a steady rate, how would the tension in the chains at this point compare to your answer to part (a)? Explain.

11. A 60.0 cm diameter barrel is being pulled over a 12.0 cm high step. Justify whether it is easier to pull the barrel over the step from the centre in the direction shown in figure 1 or from the top in the direction shown in figure 2.

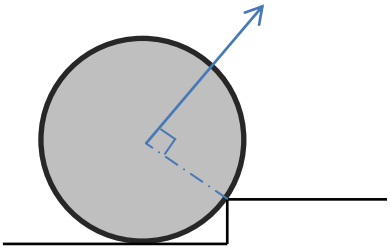


Figure 1

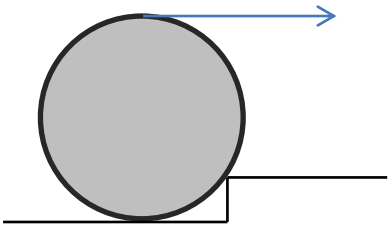
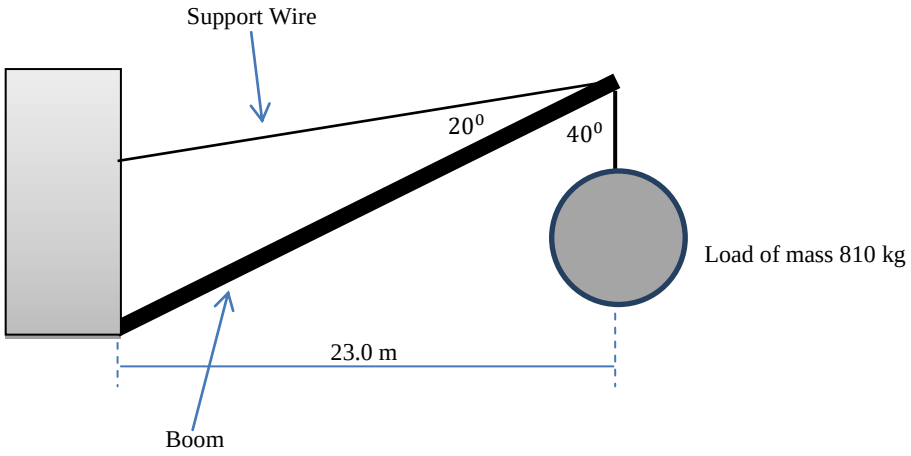


Figure 2

12. A crane uses a support wire to help stabilise the uniform 230 kg boom while lifting heavy loads. Using the information provided in the diagram, calculate the tension in the support wire.



13. The lift generated by the wings of a plane are used to adjust the altitude and to make turns. Lift always acts perpendicular to the wingspan, as indicated in the diagram by vectors L_1 and L_2. The 1650 kg plane has a 12.0 m wingspan. A horizontal crosswind causes the pilot to maintain a constant bank angle in order to maintain a constant heading and speed. Assuming the crosswind can be modelled as a single force acting on the centre of mass of the plane and that L_1 and L_2 are equal in magnitude, calculate the magnitude of the force applied by the crosswind.