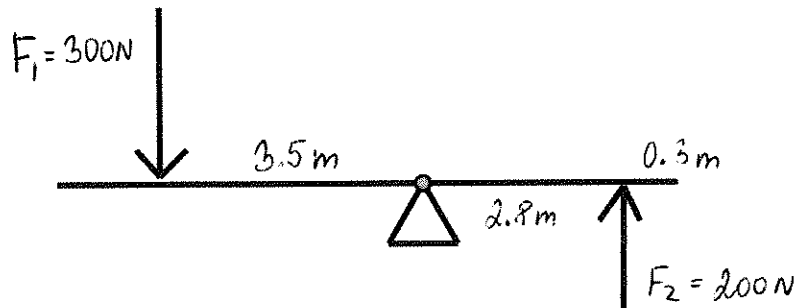
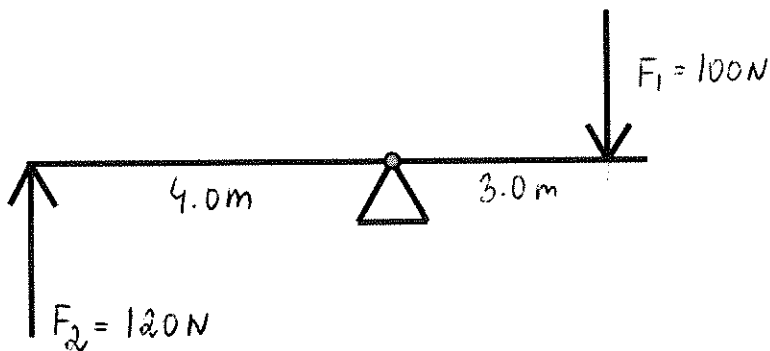


### Rotational and Static Equilibrium

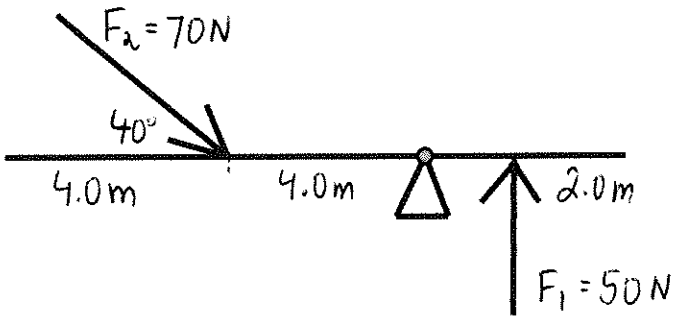
1. Find the force needed at the very left end of a lever in order to maintain rotational equilibrium of a 8.0 m long lever.



2. a) How far left from the fulcrum would you have to place an object with mass  $50.0\text{ kg}$  in order to ensure a rotational equilibrium?
- b) Predict how far right from the fulcrum would you have to place this  $50.0\text{ kg}$  mass in order to ensure a rotational equilibrium? Why? Confirm your reasoning by calculating the  $\sum \vec{\tau}$ .



3. Consider an 11.0-m long lever. Where and at what direction would you apply a smallest possible force that would ensure a rotational equilibrium of the system?

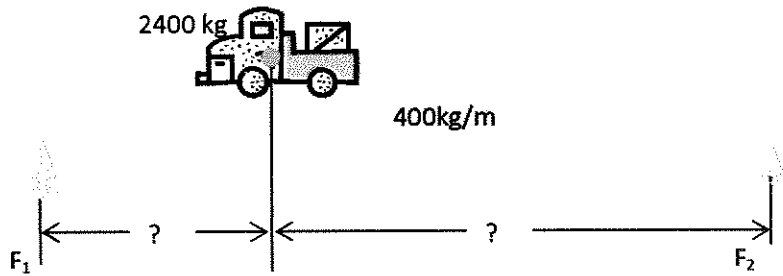


4. Provided that the bar below is 8.0 m long, its mass is 50.0 kg, and the pivot point is 1.2 m from the its right-most point, what is the torque of the bar?



5. How would the torque from question 4 change if the pivot point was 1.2 m from the left-most point of the bar? Sketch a labelled diagram. And show calculation supporting your prediction.

6. Consider a truck is parked on a 75.0-m bridge. The truck's mass is 2400 kg. Assume that the center of gravity of the truck is 2m from its front bumper and the truck is parked 15 m from the left-most support beam (measured from the front bumper) .The bridge' mass is uniformly distributed at 400 kg per meter. Assume that the bridge is rigid.



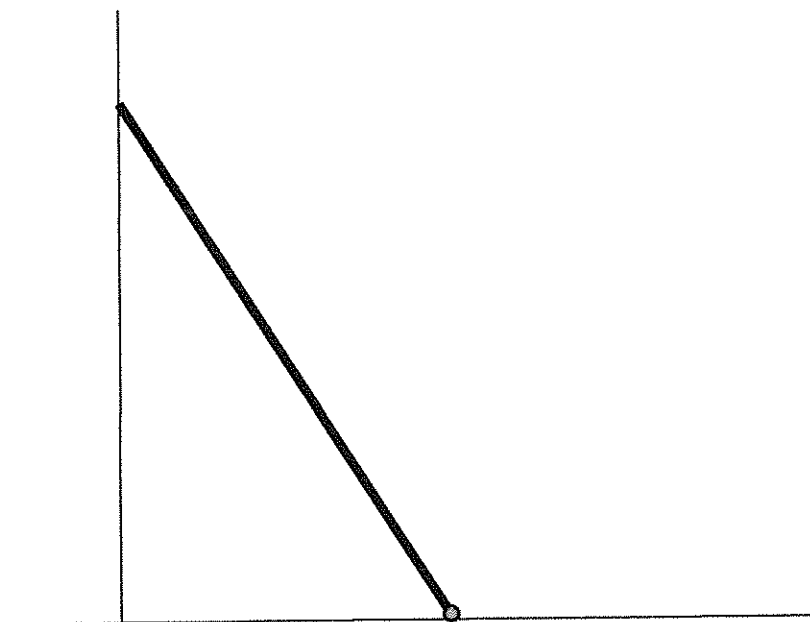
a) Draw a FBD.

b) What will be the reaction forces at the supports of bridge at the two ends? (Hint: chose the left support beam as a pivot point and solve for  $F_2$ , then choose the right support beam as a pivot point and solve for  $F_1$ ).

Refer to the textbook p250-251 example 4.

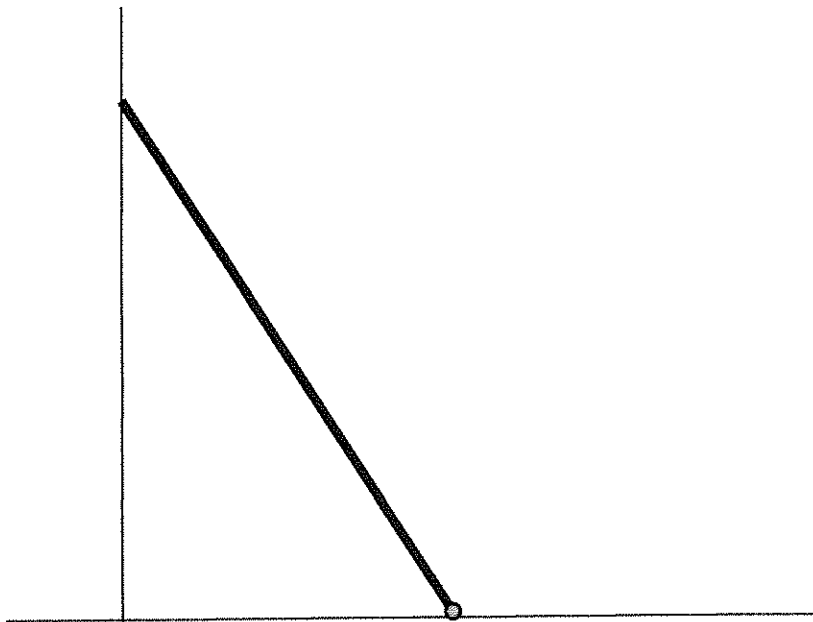
7. Consider an 80-kg painter holding a 2.0-kg can of paint and standing 0.4 from the top of a 3.0-m long and 20 kg ladder. The 20.0- kg ladder is leaning against a frictionless (=“smooth”) wall and is placed at an angle of  $55^\circ$  against the ground. The ladder is in static equilibrium. Find:

- The center of gravity of the ladder and label it in the diagram
- $\vec{F}_g$  of the ladder, express it in vector notation and label it in the diagram.
- $\vec{F}_g$  of the painter holding the can, express it in vector notation and label it in the diagram.
- $\vec{F}_N$  the ground exerts on the ladder, express it in vector notation and label it in the diagram
- $\vec{F}_f$  between the ladder and the ground, express it in vector notation and label it in the diagram
- $\vec{F}_w$  the force of the wall pushing against the ladder and express it in vector notation.
- $\vec{F}_{net}$  and express in vector notation and as a vector sum of all forces above.
- $\vec{\tau}_p$  = torque created by the weight of the painter holding the can. What do you think would vector notation look like for  $\vec{\tau}_p$  ?
- $\vec{\tau}_l$  = torque created by the weight of the ladder. What do you think would vector notation look like for  $\vec{\tau}_l$  ?





8. Consider the ladder from the previous question. If there were no objects on the ladder, with what force would you have to pull down on the ladder at angle  $30^\circ$  in order to tip the ladder over?

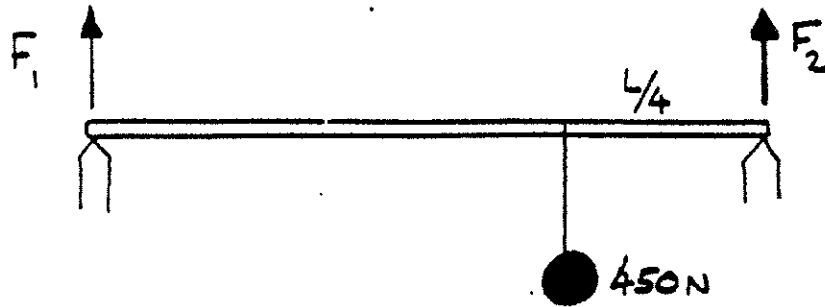


Answers #9  $F_1 = 213 \text{ N}$

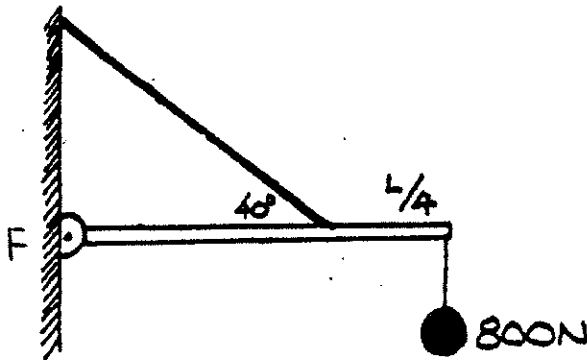
$F_2 = 438 \text{ N}$

#10  $F_{\text{rope}} = 2.28 \times 10^3 \text{ N}$  ;  $F_x = 1.7 \times 10^3$  ;  $F_y = -66 \text{ N}$

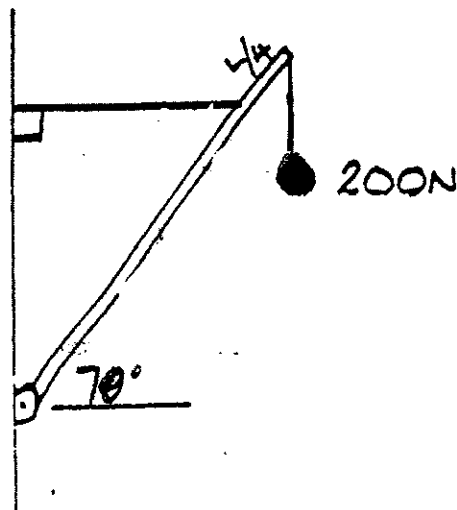
9. A UNIFORM BEAM WEIGHS 200N AND HOLDS A 450N WEIGHT AS SHOWN. FIND THE MAGNITUDE OF  $F_1$  AND  $F_2$



10. A UNIFORM 600N BEAM IS HINGED AT "P". FIND THE TENSION IN THE TIE ROPE AND THE VERTICAL AND HORIZONTAL FORCES EXERTED BY THE HINGE.

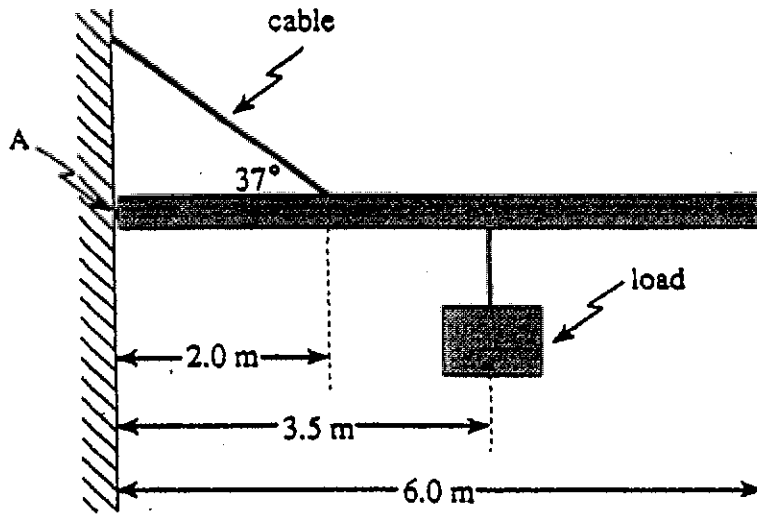


11. REPEAT QUESTION 10 FOR THE SITUATION BELOW: (Answers:  $T = 243 \text{ N}$  ;  $F_x = 243 \text{ N}$  ;  $F_y = 300 \text{ N}$ )



12.

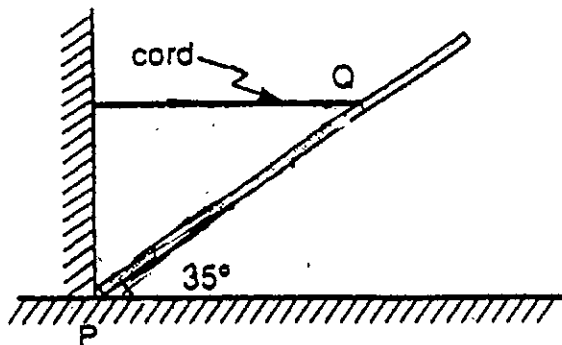
A uniform beam 6.0 m long, and with a mass of 75 kg, is hinged at A. The supporting cable keeps the beam horizontal.



If the maximum tension the cable can withstand is  $2.4 \times 10^3$  N, what is the maximum mass of the load?

ANS:  $m = 19.9 \text{ kg} = 20 \text{ kg}$

13 uniform beam 1.8 m in length is supported by a horizontal cord attached at Q, 1.39 m from pivot P, as shown in the diagram below. The tension in the cord is 13 N.



What is the mass of the beam?

ANSW:  $m = 1.43 \text{ kg}$



14.

Uniform beam of length 8.0 m and mass 25 kg is connected to a wall by a hinge as shown below. 5 kg mass is suspended from the beam. What is the tension in the rope?

ANSW: 340N

