Lecture 22
(Equilibrium of Rigid Bodies)

Physics 160-02 Spring 2017

Douglas Fields

Equilibrium

- Two conditions for equilibrium:

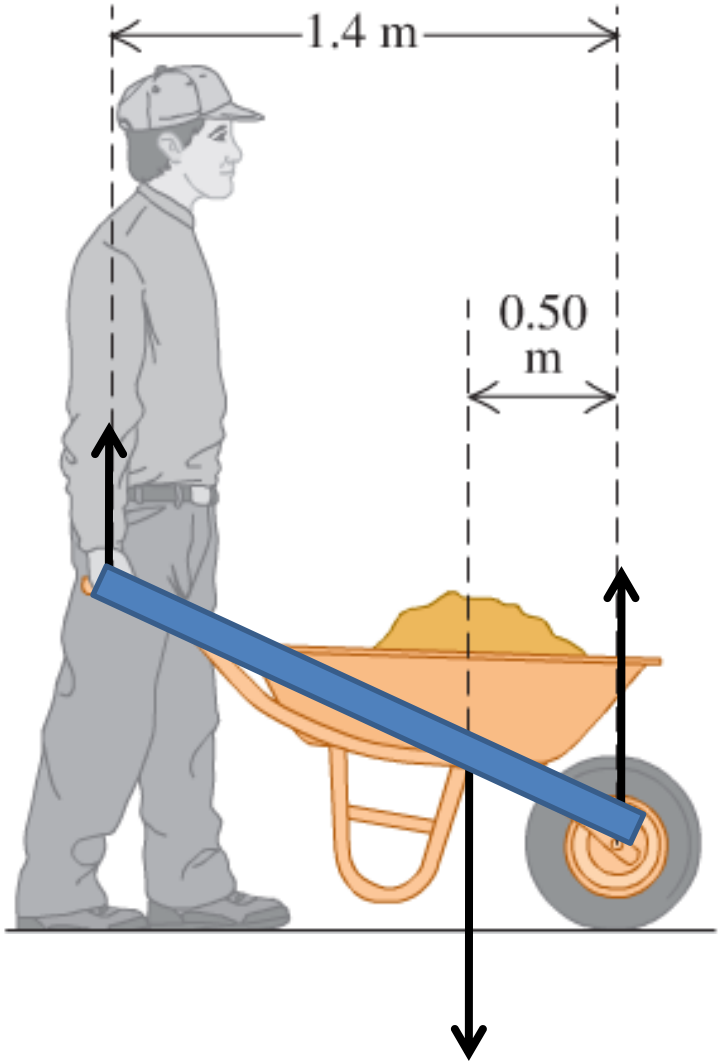
$$\sum \vec{F} = 0 \qquad\qquad \sum \vec{\tau} = 0$$

- That's it…

Problem 11.16

11.16. Suppose that you can lift no more than 650 N (around 150 lb) unaided. (a) How much can you lift using a 1.4-m-long wheelbarrow that weighs 80.0 N and whose center of gravity is 0.50 m from the center of the wheel (Fig. 11.28)? The center of gravity of the load carried in the wheelbarrow is also 0.50 m from the center of the wheel. (b) Where does the force come from to enable you to lift more than 650 N using the wheelbarrow?

Figure **11.28** Exercise 11.16.



$$\sum \vec{F} = 0 \Rightarrow$$

$$\sum F_x = 0$$

$$\sum F_y = F_L + F_N - F_g = 0 \Rightarrow$$

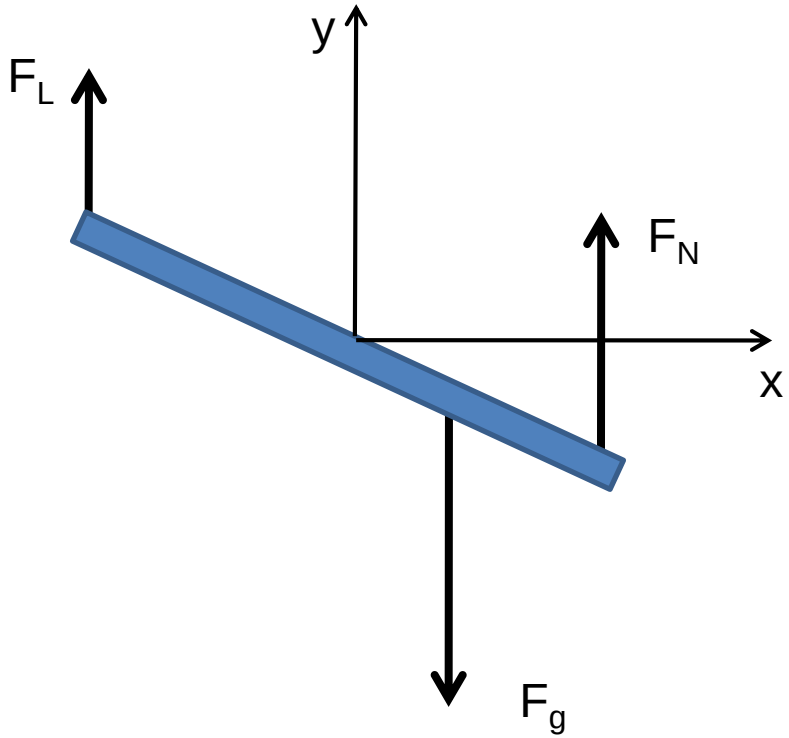
$$F_g = F_L + F_N = 650N + F_N$$

$$\sum \vec{\tau} = 0 \Rightarrow$$

$$F_L\left(0.9m\right) - F_N\left(0.5m\right) = 0 \Rightarrow$$

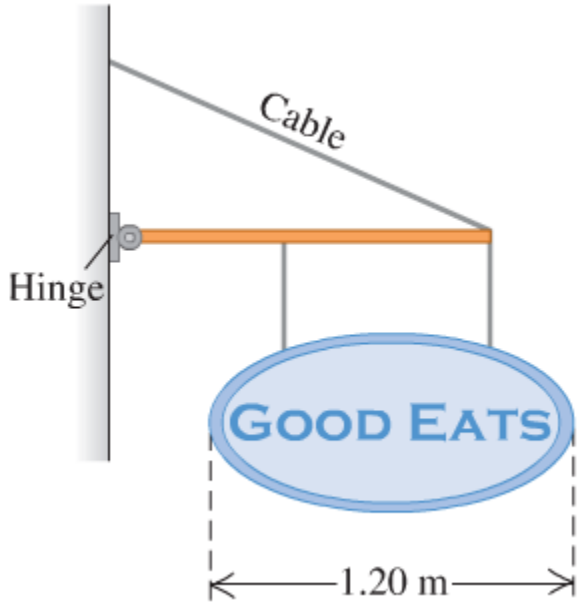
$$F_N = \frac{F_L\left(0.9m\right)}{\left(0.5m\right)}$$

$$F_g = 650N + F_N = 650N + \frac{650N\left(0.9m\right)}{\left(0.5m\right)}$$



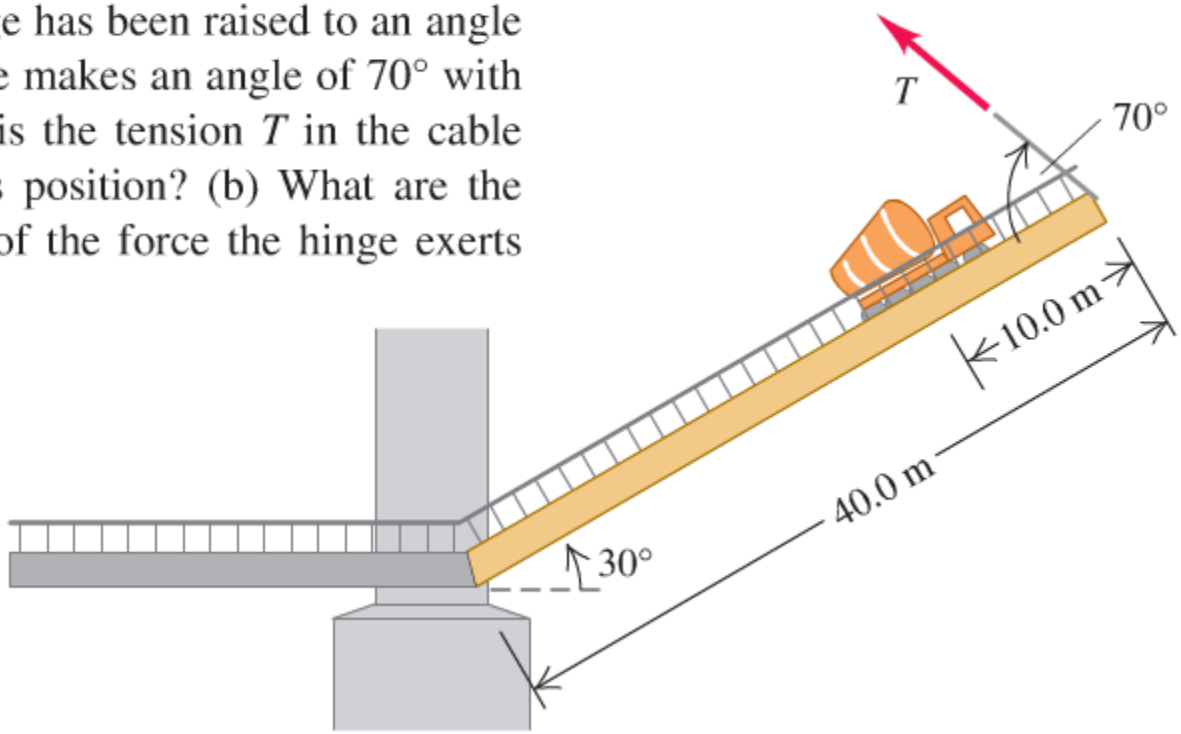
Problem 11.47

11.47. You open a restaurant and hope to entice customers by hanging out a sign (Fig. 11.37). The uniform horizontal beam supporting the sign is 1.50 m long, has a mass of 18.0 kg, and is hinged to the wall. The sign itself is uniform with a mass of 28.0 kg and overall length of 1.20 m. The two wires supporting the sign are each 32.0 cm long, are 90.0 cm apart, and are equally spaced from the middle of the sign. The cable supporting the beam is 2.00 m long. (a) What minimum tension must your cable be able to support without having your sign come crashing down? (b) What minimum vertical force must the hinge be able to support without pulling out of the wall?



Problem 11.52

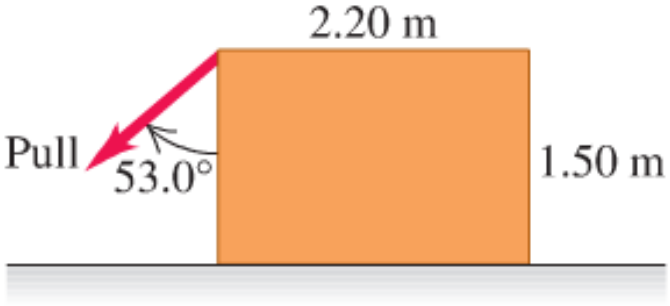
11.52. A Truck on a Drawbridge. A loaded cement mixer drives onto an old drawbridge, where it stalls with its center of gravity three-quarters of the way across the span. The truck driver radios for help, sets the handbrake, and waits. Meanwhile, a boat approaches, so the drawbridge is raised by means of a cable attached to the end opposite the hinge (Fig. 11.42). The drawbridge is 40.0 m long and has a mass of 12,000 kg; its center of gravity is at its midpoint. The cement mixer, with driver, has mass 30,000 kg. When the drawbridge has been raised to an angle of 30° above the horizontal, the cable makes an angle of 70° with the surface of the bridge. (a) What is the tension T in the cable when the drawbridge is held in this position? (b) What are the horizontal and vertical components of the force the hinge exerts on the span?



Problem 11.65

11.65. A worker wants to turn over a uniform 1250-N rectangular crate by pulling at 53.0° on one of its vertical sides (Fig. 11.49). The floor is rough enough to prevent the crate from slipping. (a) What pull is needed to just start the crate to tip? (b) How hard does the floor push on the crate? (c) Find the friction force on the crate. (d) What is the minimum coefficient of static friction needed to prevent the crate from slipping on the floor?

Figure **11.49** Problem 11.65.



Problem 11.76

11.76 •• You are trying to raise a bicycle wheel of mass m and radius R up over a curb of height h. To do this, you apply a horizontal force $\vec{F}$ (Fig. P11.76). What is the smallest magnitude of the force $\vec{F}$ that will succeed in raising the wheel onto the curb when the force is applied (a) at the center of the wheel and (b) at the top of the wheel? (c) In which case is less force required?

Figure **P11.76**