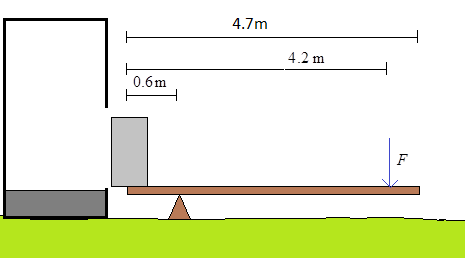
**Homework 7 Due 3/6**

\* Note, the space provided doesn’t really correlate to the expected amount of work necessary to solve the problem – I’m just trying to keep things tidy.

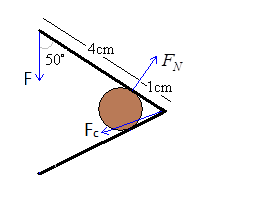
**Problem 1.** Let’s consider how a lever can reduce the force required to lift an object. Suppose you’re trying to load a large crate into a shipping container. The crate has a mass of 325 kg. The length of the lever you’re using is ℓ = 4.7m, and its mass is m = 13kg.



(a) What is the weight of the crate?

(b) What force F must you apply? Don’t forget to take into account the mass of the board ☺.

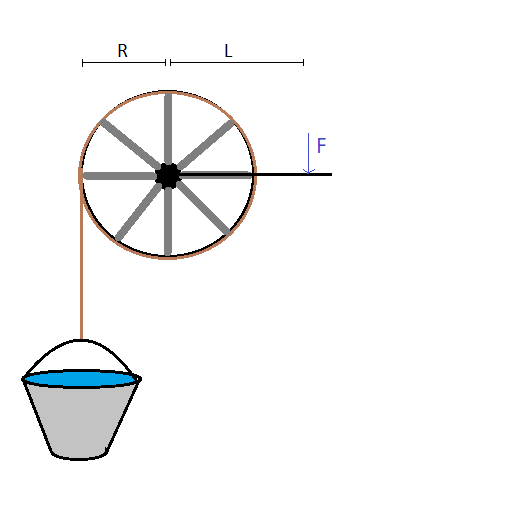
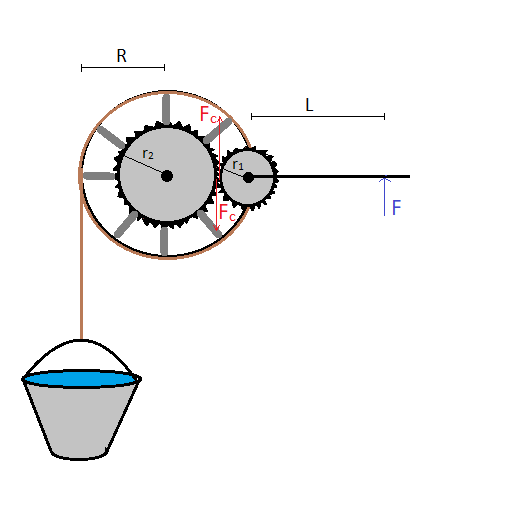
**Problem 2.** As another example of how levers can multiply applied force, consider the nut-cracker shown below. You can ignore gravity acting on the upper lever. Let F be 50N.



(a) If you exert a force of F on the ends as shown, what force, FN, is exerted on the nut?

(b) What is the magnitude and direction of the contact force the hinge exerts?

**Problem 3.** Now let’s consider a different application – to how gears can magnify (or diminish)an applied torque. Let the mass of the bucket of water be m = 20kg. Let the radius of the wheel be R = 30cm, and the length of the lever be L = 45cm. Also let the radii of the gears be r2 = 20cm, and r1 = 10cm. And suppose everything is rotating at a constant rate (or not at all).

(a) In the left diagram, symbollically in terms of L and F, what torque does the force F exert on the wheel?

(b) In the left diagram, what force must F be to raise the bucket?

(c) In the right diagram, symbollically in terms of L and F, what torque does the force F exert on the first gear?

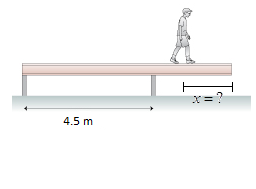
(d) The first gear exerts a contact force on the second gear, Fc. The second gear will exert the same contact force Fc on the first gear (by N3L). Symbollically, in terms of L, F, and r1, what is Fc?

(e) Symbolically, in terms of L, F, r1, and r2, what torque does Fc exert on the second gear then?

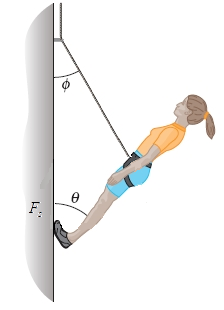
(f) Symbolically, in terms of L, F, r1 and r2, what torque is exerted on the wheel then? And how does this compare to your answer in part (a)?

(g) What force F is required to raise the bucket now?

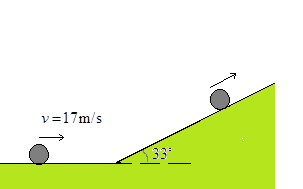
**Problem 4**. A 50kg, 7m long beam is supported, but not attached to, the two posts in the figure. A 25kg boy starts walking along the beam. How close can he get to the end before the the beam tips over? Think of what the force the left post will exert on the beam, when it starts to tip….



**Problem 5.** In the figure, a climber with a weight of 480 N is held by a belay rope connected to her climbing harness and belay device; the rope is attached at her center of mass. Say φ = 30°, what is the smallest θ can be before her feet start to slip. Let μs = 0.75.



**Problem 6.** Suppose you roll a disk up a slope with initial velocity v = 17m/s. When will it come to rest? Gotta be careful about which way static friction will point. But you can ignore rolling friction.



**Problem 7**. A girl exerts an 85 N force tangent to a solid sphere resting on relatively frictionless water. If the sphere has a mass m = 800kg and radius R = 45cm, how long until it has completed two revolutions?



**Problem 8.** A common example of connected gears is your bike (or a car which has the same kind of set up – minus the chain). Instead of the gears being in physical contact though, they are are connected by a chain – but the result is the same. Suppose the bike pedal has a length L = 12cm. And you step on it with a force of F = 300N perpendicular to the pedal. Suppose the pedal is connected to gear 1 (r1 = 2.5cm), which is connected via the chain to gear 2 (r2 = 5cm). And finally suppose the gear 2 is attached to the wheel, which can be treated as a hoop (mwheel = 10kg, R = 60cm). If the mass of you and the bike is a total of M = 90kg, how fast will you accelerate down the road? Note this problem is very similar to what was done in class. Only difference is the presence of the gears.

