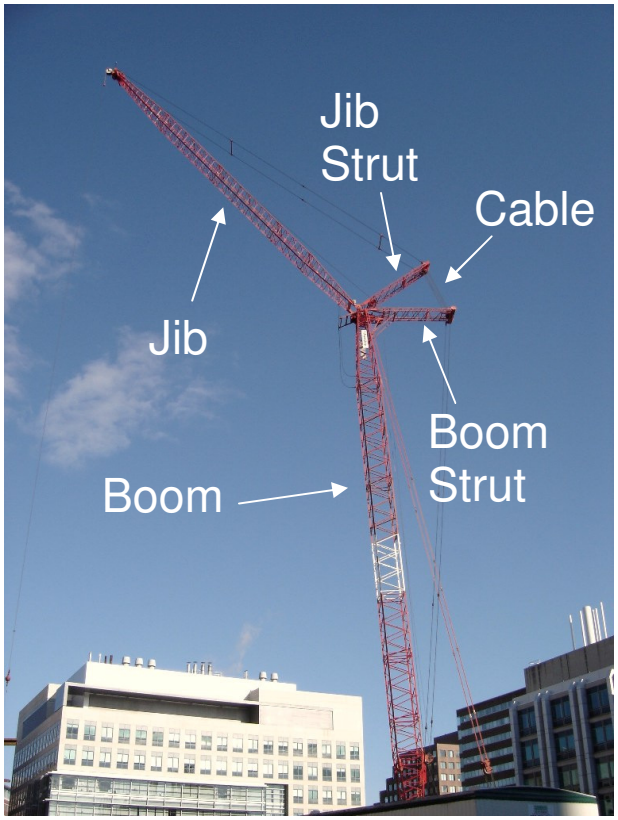

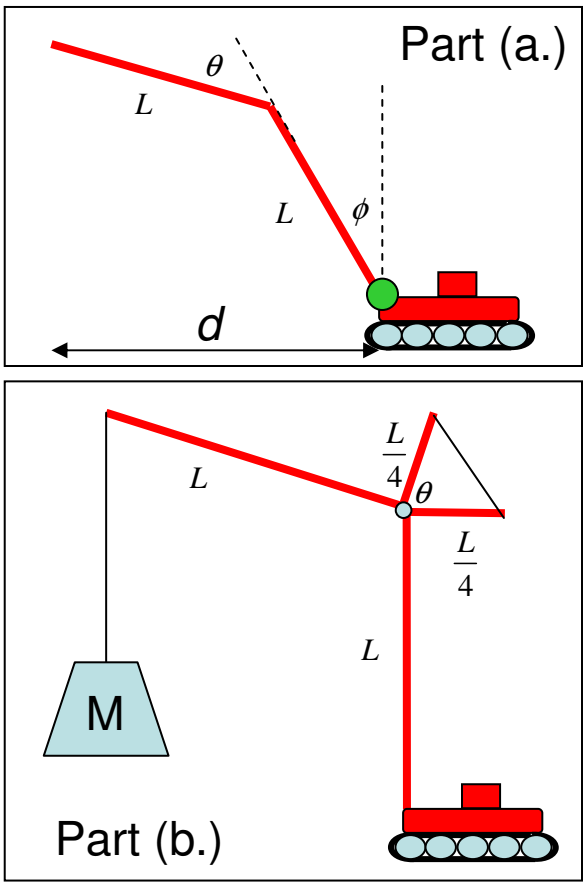

The booms of some cranes, like the one shown in the picture above, are composed of two elements. The lower part is called the boom, and the upper part is called the jib. In some configurations, the jib is nearly as long as the boom.

a.) Consider a very simple crane where the boom and jib have equal lengths L and equal masses m (see the top right picture above). Suppose the operator needs to pick up a load that sits a distance d in front of the crane. Show that the torque from the boom plus jib about the base of the boom (shown as a large dot) is minimized if the boom is angled straight up (the angle ϕ shown in the picture is zero). Hint: You can avoid using calculus if you use the fact that d is constant and you know the behavior of the sine function. Look for terms in the expression for the torque that sum up to give d.

b.) For the crane in the photo above, both the jib and the boom are actually "L" shaped structures. Each has a large strut protruding at a right angle next to the point where the boom and jib are joined. The ends of the struts are tied together by a cable which is wound around pulleys so that it passes back and forth several times, as shown in the picture at right. Consider the simple model shown in the bottom right picture above. In this model, the jib and boom are each of length L and the struts are each of length $L/4$. Suppose the boom stands straight up. If the crane is lifting a load of mass M, what is the maximum force that must be provided to the jib strut by the cable in terms of Mg? For this part, ignore the mass of the jib itself.

c.) Suppose the cable that is attached to the load and the cable that runs between the ends of the struts are of the same type (they are *not* the same cable, but they might be the same *kind* of cable). If the crane wants to lift a load that will nearly break the load cable, how many times, at minimum, must the strut cable run back and forth between the struts to ensure it won't break? Use your answer to part (b.).