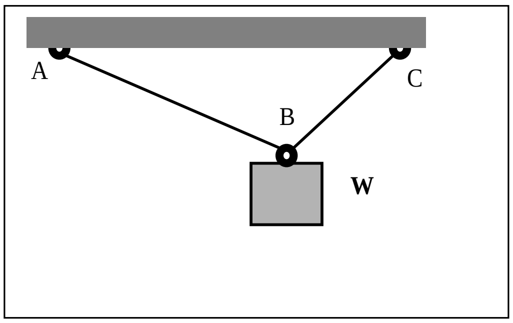
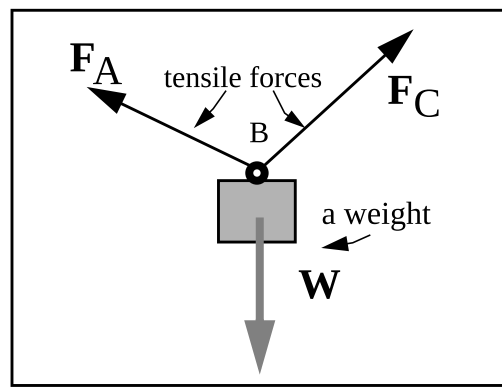
CHAPTER 2 Equilibrium Requires...

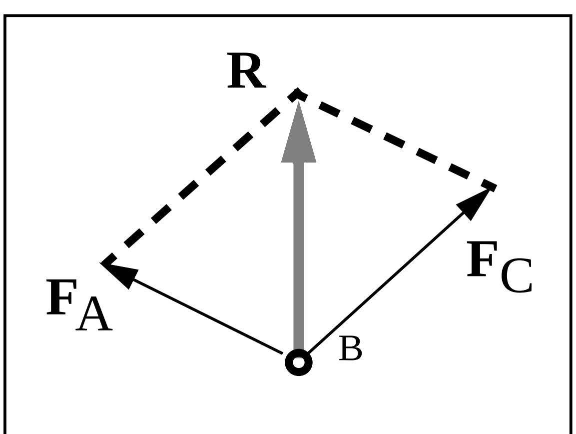
2.1 Force is a *vector*.



It requires specifying a direction as well as a magnitude to define a force. web

Each string experiences a *tensile* force. The weight is due to, is, a *gravitational* force.For equilibrium, the resultant of all forces acting upon the weight, as a particle, must be zero.





The **resultant of two forces** is the diagonal of the *parallelogram* formed by the two force vectors as sides. E.g.,

The resultant should be vertical since, for equilibrium, the resultant of all three forces must vanish.

$$\mathbf{F}_A + \mathbf{F}_C + \mathbf{W} = 0$$

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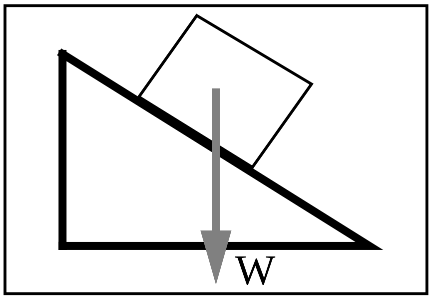
Friction is another kind of force. It acts at a surface of a body, in contact with another, parallel to the surface, and always in a sense to oppose motion.



When will the **block slide down the plane**?

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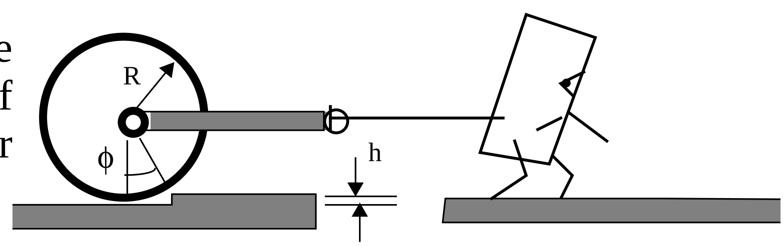
2.2 Concept of Moment

Force is not enough. You know from your studies in physics of the dynamics of bodies other than particles, that you must speak about their rotation as well as translation through space; about how they twist and turn.

Exercise *Show that* the force required to *just start* the lawn roller, of radius *R* and weight *W*, moving up over the ledge of height *h* is given by



$$F/W = \tan\phi \qquad \text{where} \qquad \cos\phi = 1 - (h/R)$$

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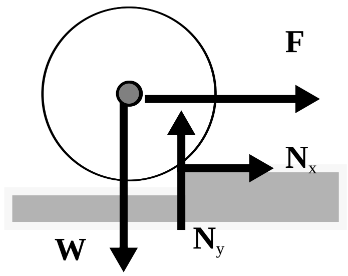

Isolate the system – the roller – showing all the forces acting upon it. These include the weight acting downward through the center of the roller; the horizontal force applied along the handle by the child laborer (note the frictionless pin fastening the handle to the roller); and the components of the reaction force at the bump, shown as N_x and N_y.

Note the phrase *just start*... This implies there is no contact with the ground at any other point than at the bump. Hence the reaction of the ground upon the roller acts at the bump alone. Furthermore it must pass through the center of the roller. This is a consequence of another rule, namely

For an isolated system subject to but three forces, a *three force system*, the three forces must be concurrent. That is, their lines of action must all run together and intersect at a common point.

If we take moments about the point of contact at the bump we have;

$$F\, R \cos\phi = W\, R \sin\phi$$

So $$F/W = \tan \phi$$

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