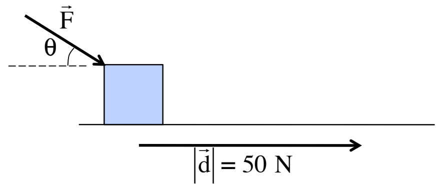
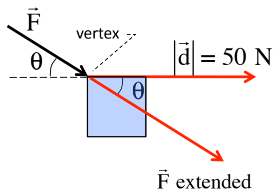
Problem 7.5

A 35.0 N force is applied by a shopper at 25.0° below the horizontal. If the cart moves with constant velocity:



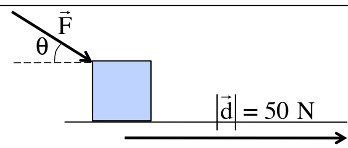
a.) How much work does the shopper do during the motion?

For no particularly good reason, let's use the *definition approach*. Extending the line of the two vectors to generate a vertex and, from that, get the angle (see to right), we can write:



$$\begin{aligned} W_F &= |\vec{F}||\vec{d}|\cos\phi \\ &= (35.0 \text{ N})(50.0 \text{ m})\cos 25^{\circ} \\ &= 1.59\text{x}10^{3} \text{ J} \end{aligned}$$

b.) What is the net work done by all the forces acting on the cart?

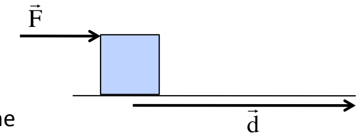


There are two easy ways to approach this:

i.) The whole idea behind "work" is that if there is a net force on a body and the net force does work, the body's velocity will change by some amount. We know in this situation that the change of velocity is zero, so we can conclude that the net work must also be zero. OR

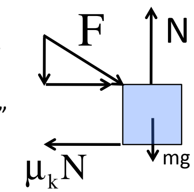
ii.) We know that both the normal force and gravity are perpendicular to the motion and do no work. That means that there are only two forces doing work in this situation. The component of the shopper's force F that is directed along the line of motion and that does *positive work* as that force component and the displacement are in the same direction, and the frictional force that is directed opposite the line of motion, is of the same magnitude as the shopper's force component (this has to be true as no change in velocity means the acceleration is zero which means the forces are balanced) and does *negative work*. The net work is the sum of those two, which will be zero.

c.) If we'd had the same situation but the force had been horizontal, how would "F" have differed?

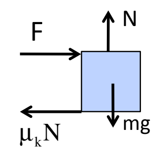


It might not be a bad idea to do a f.b.d. on the cart, just to see what all the forces are doing.

In the original situation, the normal force N had to counteract both gravity and the downward component of "F." That made the normal force fairly large, which made the frictional force large. The horizontal *component* of "F" had to counteract friction (so the velocity would stay constant), so "F" had to be even larger.

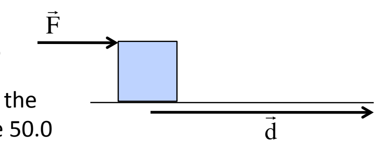


In the new situation, the normal force N is small because it only has to counteract gravity (there *is* no downward component of "F"). That makes the normal force small, which makes the frictional force small. The horizontal force "F" still has to counteract friction (so the velocity would stay constant), but "F" doesn't have to be very large to do that.



Bottom Line: "F" is smaller.

d.) How would the net work done by the shopper change, given the situation in *Part c*?



As the shopper's force decreased in *Part c*, the amount of work the shopper does over the 50.0 meter distance decreases.