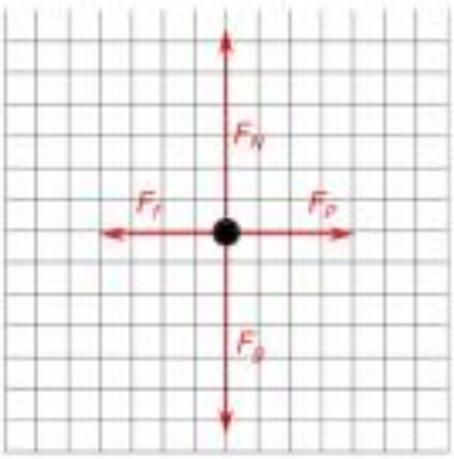
NAME _____ DATE _____

Scenario

Carlos pushes a block of mass, m, across a rough horizontal surface at a constant speed by applying a force, F, directly to the right.

Using Representations

PART A: The dot at right represents the block. Draw a free-body diagram showing and labeling all the forces (not components) exerted on the block. Draw the relative lengths of all vectors to reflect the relative magnitudes of all the forces. Each force must be represented by a distinct arrow starting on and pointing away from the dot.



Quantitative Analysis

PART B: Blake is asked to use Newton's second law to derive an equation that relates the force of gravity and the normal force from the surface exerted on the block. Annotate his derivation by filling in the right side of the table below. For each line of the derivation, explain in words what was done mathematically. The first line is done for you as an example.

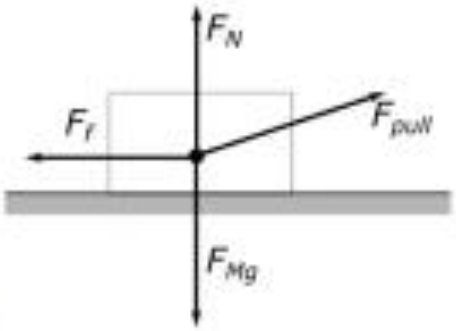
$\Sigma F_y = ma_y$	We start with Newton's second law, which says that the sum of all the forces exerted on an object is equal to the object's mass times the object's acceleration.
$F_N - F_g = ma_y$	In the vertical direction, there are two forces acting, the normal force upward and the gravitational force downward. In one dimension, direction is determined by a + or − sign. Taking up to be +, down is −.
$F_N - F_{mg} = ma^0$	Because the box is not accelerating in the vertical direction, the acceleration in this direction is zero.
$F_N - F_{mg} = 0$	Therefore, the normal force minus the gravitational force equals zero.
$F_N = F_{mg}$	Therefore, in this case, the magnitude of the normal force is equal to the magnitude of the gravitational force.

Make an Argument

PART C: Carlos gets tired of pushing and instead begins to pull with force F_{pull} at an angle to the horizontal. The block slides along the rough horizontal surface at a constant speed. A free-body diagram for the situation is shown below. Blake makes the following claim about the free-body diagram:

Blake: "The velocity of the block is constant, so the net force exerted on the block must be zero. Thus, the normal force F_N equals the weight F_{Mg}, and the force of friction F_f equals the applied force F_{pull}."

What, if anything, is wrong with this statement? If something is wrong, identify it and explain how to correct it. If this statement is correct, explain why.



Blake is correct that the net force exerted on the block must be zero. However, he forgot that since the force of the pull is at an angle, there will be a vertical component of the pull. Therefore, it is the vertical component of the pull plus the normal force that will equal the gravitational force. So, the normal force will be less in magnitude than the gravitational force. In the horizontal direction, it is the horizontal component of the force of the pull that is equal to the friction force. Therefore, the magnitude of the force of the pull is greater than the friction force on the block.

Checklist:

- ✓ I answered the question directly.
- ____ I stated a law of physics that is always true.
- ____ I connected the law or laws of physics to the specific circumstances of the situation.
- ____ I used physics vocabulary (force, mass, acceleration, velocity, coefficient, friction).