D: Dragging Problems 1 Name_____

This packet contains problems about dragging or pushing a block.
Physicists love problems about blocks!
They do a great job of explaining and providing practice for how objects move and how forces work in basic situations.

Part A: Brief review of Newton's Laws (as they apply to blocks)

Newton's First Law
An object in motion remains in motion at a constant velocity unless acted upon by a net outside force. An object at rest remains at rest unless acted upon by a net outside force.

Implication 1:
If an object is NOT moving, the net force is zero.
Implication 2:
If an object is MOVING AT A CONSTANT VELOCITY, the net force is zero.

Newton's Second Law

$$\Sigma F = ma$$

Symbol	**Quantity**	**SI Unit**
ΣF	Net Force	Newton's
m	Mass	Kilograms
a	Acceleration	m/s^2

Questions:

1. A 10 kg block is not moving, What is the net force acting on the block?

2. A 10 kg block is moving at a constant velocity. What is the net force acting on the block?

3. A 10 kg block is moving with an acceleration of 2 m/s^2. What is the net force acting on the block?

4. A 10 kg block is moving at a constant velocity of 8 m/s. What is the net force acting on the block?

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Part B: A Block Resting on a Flat Surface:

The simplest block problem is just a block resting on the floor, doing absolutely nothing. But it still experiences two forces on it!

Force 1: Gravity

Weight (The force of gravity)

Acts on any object that is on the surface of a planet.

The direction of gravity is always straight down.

The magnitude is always *mg*, mass times the free-fall acceleration

$$F_g = mg$$

Symbol	Quantity	SI Unit	Notes
F_g	Magnitude of force of gravity (weight)	Newtons (N)	
m	Mass	Kilograms (kg)	
g	Free-fall acceleration (on earth, 9.8 m/s^2)	Meters per second squared (m/s^2)	Property of the planet.

Force 2: The Normal Force

Normal Force

A constraint force that prevents items from falling through the floor.

The direction of the normal force is always *perpendicular* to a surface. In physics, the word "normal" means perpendicular.

In most simple situations, the magnitude is equal to the force of gravity.
In more complex situations, the magnitude will change such that the net force in the y-axis is zero.

Physically, the normal force represents the strength of the connection between an object and a surface.

For simper problems, the normal force is upward and the magnitude of the normal force is equal to that of gravity, thus canceling gravity out.
In more complex situations, the normal force can change to match the situation.

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Situation 1. An block is resting on a table. It has a mass of 2.00 kg. (2 forces)

What is the *net force* acting on the block? How do you know?

Free-Body Diagram		
Force	Magnitude	How do you determine the magnitude?

Situation 2: A block is resting on a table. It has a mass of 5.00 kg.

Free-Body Diagram		
Force	Magnitude	How do you determine the magnitude?

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Part C: A Block Being Pulled on a Frictionless Surface

A block pulled on a frictionless surface experiences three forces:
gravity, the normal force, and an **applied force**, which is a fancy name for the pull.

If there is no opposing force, like friction, acting on the block, then the pulling force on the block will definitely cause the block to *accelerate*.

Force 3. Applied Forces

Forces such as pushes or pulls acting on an object.
The magnitude and direction are not determined by any specific formula. Often, they are given in the problem or need to be determined as part of the problem.

Situation 3: A 2.00 kg object is on a frictionless table. It is being pushed to the right with a force of 16.0 Newtons.

Is the object accelerating or moving at a constant velocity?

Free-Body Diagram		
Force	Magnitude	How do you determine the magnitude?

What is the net force acting on the block?

What is the acceleration of the block?

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Situation 4: A 3.56 kg object is on a frictionless table. It is being pushed to the right with a force of 12.6 Newtons.

Free-Body Diagram		
Force	Magnitude	How do you determine the magnitude?

What is the acceleration of the block?

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Part D: Dragging a Block with *kinetic friction*

Realistically, all real surfaces experience some amount of *friction*.
If a block is being dragged on such a surface, the friction it experiences is **kinetic** friction, or the friction that affects moving objects.

If the applied force is stronger than kinetic friction, they object will accelerate.
Typically, however, people will pull blocks at a *constant velocity.* Moving something at a constant speed is more efficient than having it constant speed up or slow down, and the human mind seems to adapt naturally and make this happen.

Friction can also cause a block to *slow down* if there is *no applied force* or an *applied force weaker than friction*.

Force 4: Kinetic Friction

Kinetic Friction

Acts on any object that is sliding on a surface.
It *only* prevents motion, it never creates motion. Once an object is stopped, the force of kinetic friction disappears.

The direction of kinetic friction is always opposite the motion of object.

The magnitude of kinetic friction is given by the formula:

$$F_{fr} = \mu_k F_N$$

Symbol	Quantity	SI Unit	Notes
F_{fr}	Magnitude of force of friction	Newtons (N)	
μ_k	Coefficient of kinetic friction	Unitless	A property of the two materials sliding against each other.
F_N	Magnitude of normal force	Newtons (N)	Represents the strength of the connection between two objects.

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Situation 5: A 2.00 kg object is being dragged on a surface *with friction* at a **constant velocity** by a force of 16.0 Newtons.

What is the *acceleration* and the *net force* acting on this object? How do you know?

Free-Body Diagram		
Force	Magnitude	How do you determine the magnitude?

What is the *coefficient of kinetic friction*?

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Situation 6: A 12.0 kg object is being dragged on a surface *with friction* at a constant velocity by a force of 44.0 Newtons.

What is the *acceleration* and the *net force* acting on this object? How do you know?

Free-Body Diagram		
Force	Magnitude	How do you determine the magnitude?

What is the coefficient of kinetic friction?

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Situation 7: A 6.00 kg object is being dragged on a surface *with friction* by a force of 44.0 Newtons. The object is NOT moving at a constant velocity. It is accelerating! The coefficient of kinetic friction between the object and the surface is 0.400.

Free-Body Diagram		
Force	Magnitude	How do you determine the magnitude?

What is the net force? [The two vertical forces cancel out, and we need to deal only with two horizontal forces to find net force.]

What is the acceleration? [Use Newton's Second Law, from page 5!]

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Situation 8: A 8.00 kg object is being dragged on a surface *with friction* by a force of 48.0 Newtons. The object is NOT moving at a constant velocity. It is accelerating! The coefficient of kinetic friction between the object and the surface is 0.380.

Free-Body Diagram		
Force	Magnitude	How do you determine the magnitude?

What is the net force? [The two vertical forces cancel out, and we need to deal only with two horizontal forces to find net force.]

What is the acceleration? [Use Newton's Second Law, from page 5!]