Activity: Investigating Friction   Name: _____

PROBLEM PRESENTATION / EXPLORATION

A.   Frictional force is a *force acting in the opposite direction of an object's motion.* If the object is at rest, the frictional force (static friction) is equal to the force it takes to just get the object moving. If the object is in motion, the frictional force (sliding friction) is the force it takes to keep the block moving at constant velocity (this means that the acceleration is zero.)

FRICTIONAL FORCE ◄━━━━ [■•] APPLIED FORCE ━━━►

1.   You will investigate which factors affect friction using a multifaced block. Two of the block's sides will be of the same kind, only differing in surface type. The other two sides will be the same type with different areas.
2.   Weigh each of the wooden blocks by suspending them from a spring balance or mass them with a balance.
3.   Attach a spring balance to the wooden block and pull it horizontally over the table top. Determine the amount of force to overcome a block's inertia and start it moving. This is the <u>static</u> frictional force.
4.   Using the same face of the block and the same area of the table, attach a spring balance to the wooden block and determine the amount of force needed to keep each block moving at a constant velocity. This is the <u>sliding (kinetic)</u> frictional force.
5.   Vary the weight of the block by adding weights to it. Determine the static and kinetic frictional force. Do the same test while varying surface area (different faces of the block) and any other variable you wish to test.
5.   **Is there any relationship between the variables you tested and the frictional force for the same type of wood?**

| VARIABLE TO TEST	FORCE TO GET GOING	FORCE AT CONSTANT VELOCITY	WEIGHT OF BLOCK	μ_{static}	$\mu_{sliding}$
Narrow face, original weight	100 N	30 N	200 N	0.5	0.15
Narrow face, added weight	150N	55N	300N	0.5	0.183

CLASS RESPONSE / CONCEPT INVENTION

A.   A ratio between the frictional force and a force equal to the weight produces a relationship known as the ***coefficient of friction***. In its simplest form:

$$\mu = \frac{force\ of\ friction}{normal\ force}$$ $$\mu = \frac{force\ of\ friction}{weight}$$

The *normal force* is the perpendicular force with which the supporting surface pushes on the sliding object. The magnitude of this normal force, F_N and the weight, F_W, is the same but the direction is 180° different (*when on a level surface only!*). Note also that these two equal but opposite forces are on different objects. F_W pushes down on the table; F_N pushes up on the block. These are an example of the two opposite but equal forces (*action-reaction forces*) discussed in Newton's Third Law.

NORMAL FORCE

FRICTIONAL FORCE   APPLIED FORCE
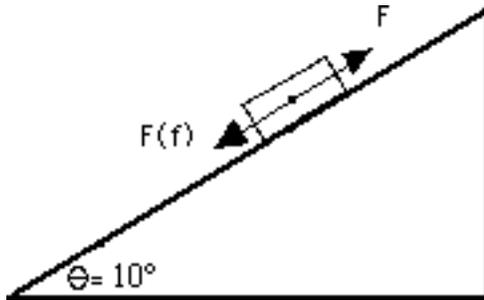
WEIGHT
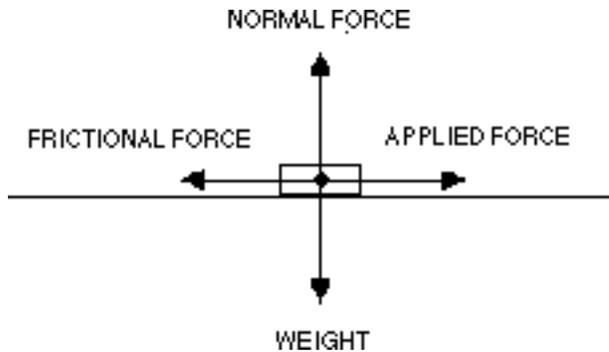
CALCULATIONS:

B.   QUESTIONS

1.   Why is it important to pull the block at a constant speed?

2.   What is the difference between *frictional force* and *coefficient of friction*? What symbols do we use to describe each?

3.   How does the force of kinetic friction vary with the **weight** of the block?

4.   How does the force of kinetic friction vary with the **area of contact** between the block and the horizontal surface?

5.   How does the force of kinetic friction vary with the **type of material** between the block and the horizontal surface?

6.   How does the force of kinetic friction vary as the **speed** (force to get going vs. force to keep going) varied due to the different hanging masses?

7.   What is the *mathematical* relationship between the coefficient of kinetic friction and the mass, surface area, or speed of the object?

8.   Why do you think the force of friction increases when the mass of the block is increased? How does this fit with your understanding of what friction is?

CONCEPT EXTENSION

A.   Place the blocks on an inclined plane (>10°).

1.   Attach the spring balance to each block. Predict whether the **frictional force** will be larger than, smaller than, or equal to the frictional force when the same block was being pulled on the horizontal table top.

2.   Pull the block up the plane maintaining constant velocity and read the amount of force required.

3.   Remember friction always acts in a direction opposite to the motion. Therefore, the frictional force is the equal and opposite force directed down the plane to the force pulling the block up the plane.

4.   The force of the surface pushing upon the object is equal to the entire weight of the object only when the supporting surface is horizontal. When the object is on an incline, this force is less than the object's weight. Because of our definition of m we see that the force of friction, F_f, depends on m and this normal force. (If we broke F_w into its two components, we would see that F_N = the Y component of the object's weight. From basic geometry we can see that this component must be less than F_w.
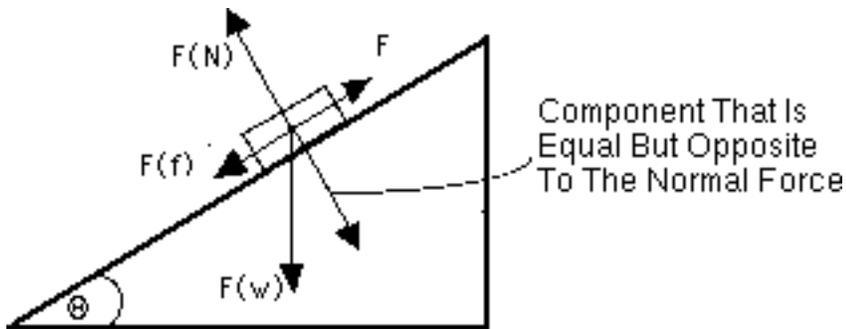
$$\frac{\text{Frictional Force}}{\text{Weight}} = \mu \quad \text{or} \quad \text{Frictional Force} = \mu \text{ (Normal Force)}.$$

5.   Is more or less FORCE needed to pull the block up the ramp (compare to one of your trials on the level surface)? Is ALL of this force due to friction? Explain.

6.   Is the normal force more or less on an inclined plane? If the normal force decreases, what will the *frictional* force do? Will the coefficient of friction on the inclined plane be the same as on the horizontal table (assume the surface types are the same). Why?

B.   What do you think would happen to the frictional force and the coefficient of friction if the angle of the inclined plane increased?

1.   What would happen if the angle became 90°?

2.   What will happen if the mass of the block is increased:
          a.   to the frictional force?
          b.   to the m ?
          c.   to the normal force ?