Name ______________________________________ Hour ____________

Work and Force

http://lectureonline.cl.msu.edu/~mmp/kap5/work/work.htm

Qualitative Observation:
Let's start out our exploration of the relationship between work, force, and displacement by moving the box around (via mouse-drag, button-click, or arrow keys on the keyboard) in the simulation. The work you have to do against the force of gravity and/or friction is calculated and displayed numerically and graphically in the upper part of the applet.

Do all movements of the box alter the amount of work done? ____________________________

When is work increased when you move the box vertically? ______________________________

When is work decreased when you move the box vertically? ______________________________

When is work done when you move the box horizontally? ________________________________

When is work NOT done when you move the box horizontally? _____________________________

Summary:

Describe how you move the box without doing WORK. ___________________________________

How is the box moved to accomplish WORK? ____

Does the distance the box moves affect the amount of work done? ___________________________

Change the mass of the box. Does this change the amount of work done when the box is lifted to equal

elevations (heights)? ____________ Why? ____

In general, what are the two factors that determine the amount of work done? ____________________

Quantitative Observations:
The weight of the box can be calculated using the physics formula: W = mg. (Where " W " is the weight of the box, "m" is the mass of the box, and "g" is the acceleration of gravity = 9.81 m/s^2). The minimum force needed to lift an object (and do work) is equal to the weight of the object. A force greater than its weight will lift and accelerate the object. Work is done to an object when an applied force opposes another force to move the object and/or the kinetic energy of an object is changed. Kinetic energy is energy of motion that depends on two factors: mass and velocity ($KE = \frac{1}{2} mv^2$).

Two variables can be altered in the simulation using slider controls. The first is the mass of the box. The other is the coefficient of friction (mu =μ). The higher the mu value the greater the frictional force will be between the bottom of the box and the floor surface. The formula to calculate the force of friction (f) is

$f = \mu N$. The normal force (N) is the force pressing the surface of the floor upward on the bottom of the box. In the simulation the normal force equals the weight of the box.

Data Collection:
1. Press the reset button. Set the box mass to 20 kg and mu to 0.0. Move the box to the right by clicking the ">" button ten times. Record the work done in the data table below. Press Reset and complete the other trials in the table.

Table #1

Trial	Mass (kg)	Mu	Work (J)	
1	20	0.0		
2	20	0.2		
3	20	0.4		
4	20	0.6		
5	20	0.8		

When was the greatest amount of work done in table #1? ____

Would moving the box back ten spaced to its starting location increase or decrease the work done? ______

Why is no work done when the mu value is zero? ____

Why are lubricants used when surfaces slide over each other? _____________________________________

2. Repeat above procedure but increase the mass of the box to 40 kg.

Table #2

Trial	Mass (kg)	Mu	Work (J)	
1	40	0.0		
2	40	0.2		
3	40	0.4		
4	40	0.6		
5	40	0.8		

Compare the results of table #1 and Table #2.

Summarize the results you observe regarding mass, friction, and work:

When is work done when a box slides horizontally on a surface?

3. Set the mass of the box to 10 kg. Press Reset. Lift the box 1.0 meter and record the amount of work done in the table. Repeat for each mass provided in table #3. Also, determine the work done when each box is lifted 2.0 meters.

Trial	Mass (kg)	Height (m)	Work (J) 1.0 m lift	Work (J) for 2.0 m lift
1	10	1.0		
2	30	1.0		
3	50	1.0		
4	70	1.0		
5	90	1.0		

When is the greatest work done in lifting the box 1.0 meter in table #3? __________________

How much did the amount of work increase when the lift distance was doubled to 2.0 meters? _________

How much work is done when the box is lifted 1.0 meters and lowered 1.0 meters? __________________

Lifting the box is positive work and lowering the box is _____________ work.

How much work is done when the box is lifted one meter and then moved horizontally?

Does horizontal movement of the lifted box result in work being done? __________

Why or Why not? (Hint: Inertia is not a force) ____

Calculating Work:

Work is equal to the applied force multiplied by the distance the object moves in the direction of the force.

$$W = F \Delta x$$

If the direction of the force is not parallel to the direction of the movement, then the component of force that is parallel to the direction of movement is used to calculate the work done. Thus,

$$W = F \Delta x \cos \theta$$

Calculate the work done lifting these boxes to these heights. $W = F \Delta x$. Then use the simulation to verify the calculations. NOTE: $F = mg$ to lift the box. Assume $g = 9.81\ m/s^2$.

Table #4

Trial	Mass (kg)	Height (m)	Calculated Work (J)	Simulated Work (J)
1	10	1.0		
2	40	1.0		
3	10	2.0		
4	40	2.0		
5	80	2.0		

How well does the equation $W = F\Delta x = mgh$ compare to the work given by the simulation? __________

How is work illustrated by this simulation?

How is movement related to work? Is all movement work?

No work is done when the force or distance equals zero. When can an object move without a force applied? Describe the characteristics of this motion.