Physics Laboratory   Name_____

<div align="center">

Work-Energy Theorem Demonstrations
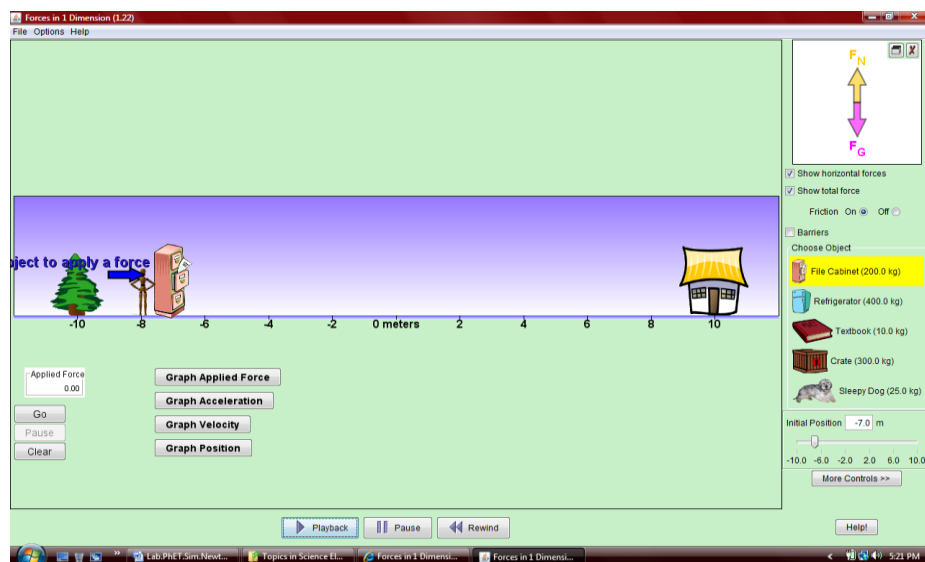Using the PhET Computer Simulations

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Introduction: We have learned the definitions for work, energy, kinetic energy and have solved problems to calculate these various values. It is another thing entirely to see that demonstrated and make calculations from the observed motion whether it is real life motion or computer generated motion. We are going to put our "Book" knowledge to the test and **see** work being done and the resulting changes in motion that that work causes.

Objective: In this lab we will use the Physics Education Technology (PhET) computer simulations to:
1. Use virtual forces to see how they change the motion of simulated objects when there is no friction.
2. Calculate the work done by a particular amount of force acting through a given distance.
3. Compare the work done by a force to the kinetic energy of an object.
4. Illustrate the Kinetic Energy/Velocity relation for a moving object.
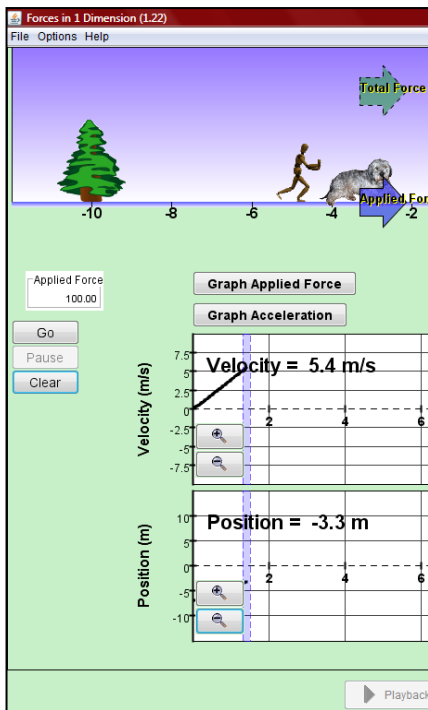
Procedures and Observations:
1. Go to the school's *Projects (P:)* folder, then open the following folders: SciSims, PhysSim, and PhET. Double Click the *PhET simulations* shortcut and let the program load.   Once it has loaded, click on the *Play with Sims* button on the opening page. From the menu on the left hand side of the page click on *Physics*, and then *Motion*.   From the selection of simulations on the right hand side of the page, scroll down and select *Forces in 1 Dimension*.   Click on the *Run Now* Button and the simulation will open up a new Java Script enabled window that should look like the picture to the right.   You can also find this simulation at the University of Colorado web page: http://phet.colorado.edu .

2. We are going to perform these trials in an ideal or "Frictionless" Environment. On the right-hand side of the window you have a group of control settings (Pictured to the right). Make the following changes:

    A) Cancel the free body diagram box by clicking the **✗** in the upper right hand corner of the box.
    B) Turn Friction **Off** by clicking the "off button"
    C) Choose the "Sleepy Dog" Object instead of the File Cabinet.
    D) Highlight the Initial position box and type in the position -9.0.
    E) Under the picture of the mannequin and the dog, click "Graph Velocity" and "Graph Position".
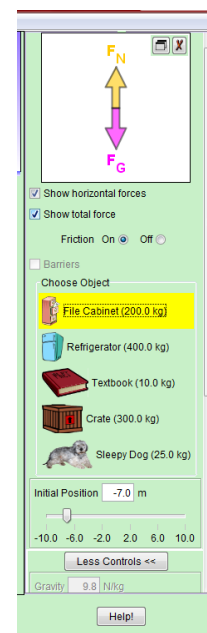
3. **READ ALL of the following Directions before actually doing them in this step.** In the main part of the window, highlight the Applied Force box and type in a force of 100.0 Newtons. Click the "Go" button and get ready right away to click pause. You will see the little mannequin push on the dog. Click pause as close as you can to when the dog passes the -4 meter position. [When Mr. Welkley prepared this lab, you will notice he stopped his demo at -3.3 meters…that was after four tries at stopping it as close to -4 as he could get it.] You will notice a grey vertical bar at the end of your graphs. Click and drag that bar back to where your position graph equals -4.0 meters. Record and calculate the following values:

A) What is the displacement of the "Sleepy Dog" as the mannequin pushes it?

B) What is the work done by the mannequin on the "Sleepy Dog"? __

C) What is the speed of the "Sleepy Dog" when it was as the position of -4.0 meters?

D) What is the kinetic energy of the "Sleepy Dog" at this position?

E) Compare the work done to the kinetic energy of the "Sleepy Dog". Why are they the same?

4. **Again, READ ALL** the directions for this step before doing them. Highlight the Applied Force box and change it to 0.0 Newtons (no force). Click Go and let the "Sleepy Dog" move until its position is zero (0.0) meters and pause the motion again. Change the Applied force to -50.0 Newtons [Please note the negative (-) sign for the force!]; Click Go; and pause the action once the "Sleepy Dog's" velocity reaches zero (0.0) m/s [or as close to zero as you can.] Using the grey bar again, click and drag it as directed below to make you observations and calculations:
A) Slide the bar back to the point on the velocity/time graph where it is level. Move it slowly back and forth at the point where the level part of the graph begins to curve down until you find the instant where the force of the mannequin is beginning to be applied. Record this velocity. This is the **initial velocity**

for this trial. Also record the position that this velocity is happening. This is the **initial position** for this trial.

Initial Velocity	m/s
Initial Position	m
Final Velocity	m/s
Initial Kinetic Energy	J
Final Kinetic Energy	J
Change in Kinetic Energy	J
Work done on Dog by Mannequin	J

B) Slide the bar until the position is 5 meters farther than the initial position. Record the velocity at this instant of time. This is the **final velocity** for this trial.

C) Calculate the initial and final kinetic energies of the "Sleepy Dog" with your recorded velocities.

D) Calculate the change in the kinetic energies.

E) Calculate the work done by the mannequin in that five meters of it applying its force to the dog. Compare this work to the change in kinetic energy of the dog.

F) Show all your work for your calculations in the space below.

5. Now that we have established the relationship between work and **change** in kinetic energy, we are going to explore the relation between kinetic energy and velocity. In a series of trials, if you always start the trial from rest and the determine the velocity at some point later, that means that the work done changing the motion will be equal to the final kinetic energy of the moving object ($KE_f - 0 = \Delta KE$ to that end point, thus the KE_f = the Work done). Set up the trials in the following manner:

A) Set the initial position at -5 meters.

B) Change the Object to the Crate (m = 300 kg).

C) You will note in the table below the series of applied forces that you will use to move the crate. You will set the applied force to that value for the trial, click GO, and pause the action once the crate passes the +5.0 meter position.

D) Drag the grey bar until it is highlighting the +5.0 meter position and record the velocity of the crate at the instant.

E) Graph the Velocity versus the Kinetic Energy (Work) for these trials.

Trial	Applied Force (N)	Kinetic Energy [Work] (J)	Velocity m/s
1	100	1000	
2	200	2000	
3	300	3000	
4	400	4000	
5	500	5000	
6	600	6000	
7	700	7000	
8	800	8000	
9	900	9000	
10	1000	10000	
11	1100	11000	
12	1200	12000	
13	1300	13000	
14	1400	14000	
15	1500	15000	
16	1600	16000	

6. This time we are going to look at the Kinetic Energy [Work] versus velocity. We are going to set the object in motion with a specific amount of applied force and record distance measurements at particular amounts of velocity and use those position measurements to calculate the work done (and thus what the kinetic energy is at that point. Reset the sim so that the initial position is -5.0 meters. Use the Textbook for the object and use an applied force of 25 Newtons. Click "Go" and pause the action once the speed has reached 15 meters per second. You will notice that the mannequin and book go really far off screen (to the right). That's OK…the book and mannequin are still moving even though you can't see them!

Trial	Velocity m/s	Position (m)	Displacement (m)	Kinetic Energy [Work] (J)
1	1.00			
2	2.00			
3	3.00			
4	4.00			
5	5.00			
6	6.00			
7	7.00			
8	8.00			
9	9.00			
10	10.00			

A) Drag the grey bar to the speed of 1.0 meters per second and record the position.
B) Calculate the displacement of the Textbook (final position – initial position).
C) Calculate the work done [25 N * displacement] (which is the kinetic energy).
D) Repeat steps A – C for each trial.
E) Graph the Kinetic Energy versus the Velocity of the Textbook.

Conclusions:
1. How are work and kinetic energy related?
2. Make the following comparisons from the trials in step 6.
   A) What is happening to the velocity when the kinetic energy is doubled? To see this compare the kinetic energies and velocity for the following trials: 2 & 4, 3 & 6, 4 & 8, 5 & 10, 6 & 12, 7 & 14, and 8 & 16.
   B) What is happening to the velocity when the kinetic energy is quadrupled? To see this compare the kinetic energies and velocities for the following trials: 1 & 4, 2 & 8, 3 & 12, and 4 & 16.
   C) What happened to the velocity between trials 3 & 9?
   D) What is the relation between the change in kinetic energy and the change in velocity for that change in energy?
   E) Is your graph consistent with this relation?
3. Make the following comparisons for the trials in step 7.
   A) What happens to the kinetic energy when the velocities double? To see this, compare the velocities and kinetic energies in the following trials: 1 & 2, 2 & 4, 3 & 6, 4 & 8, and 5 & 10.
   B) What happens to the kinetic energy when the velocity is tripled?
   C) What happens to the kinetic energy when the velocity is quadrupled?
   D) What kind of relation is this and is your graph consistent with that relation?
4. How much more energy is needed to have car travel at a highway speed (100 kph) compared to a speed around town (50 kph)?
5. Considering your answer in #4, why do vehicles get better gas mileage when traveling on a highway for a certain distance than the same car traveling the same distance around town?