

Richard Hendricks**Subject taught:** AP physics**Topic:** Finding the coefficient of friction used in a simulation**Objectives:**

Students will interpret a graph developed through an interactive physics animation to determine the effects of frictions presumed in the simulation.

Key Ideas and standards:

When we study Newton's second law, we find that net force may be applied to more than one object as when one mass provides the same force to two masses connected together with a string that is pulled over a pulley. In lab, we attempt to do the same experiment by allowing a 200 g mass to accelerate both itself and a 1.0 Kg mass. Ideally we can predict the acceleration of both provided the surfaces are "frictionless".

When Friction is actually present, it may be predictable if the coefficient of friction is uniform. In a simulation, it is. In reality, friction is rarely uniform so it's tough to pin down characteristics but not in a simulation.

Equipment:

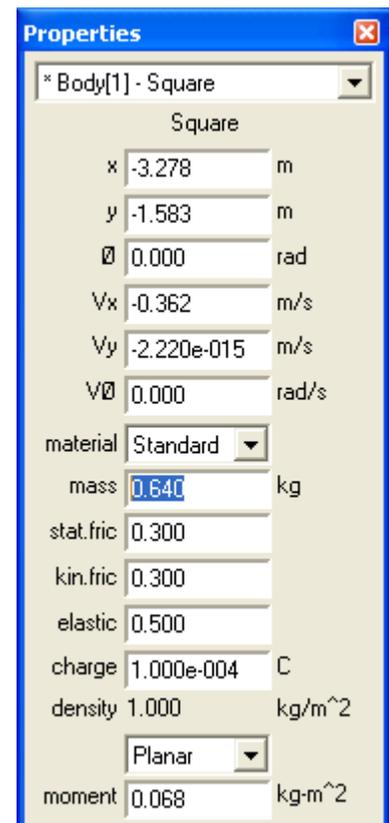
Interactive physics software.

Description

Use the interactive physics software to simulate the classic Newton's law experiments we attempt in class by simulating a 200 g mass to accelerate both itself and a 1.0 Kg mass. The larger mass should be placed on a level surface such that it drags along on the level surface. As it does, track the horizontal velocity vs time. Since velocity = acceleration * time, $V = a \cdot t$, This plot should reveal the acceleration of the block dragged along the surface.

If you multiply this acceleration by mass, you should find the net force using Newton's second law. By noting that this is a net force and that you are able to calculate the force on the system from the mass being accelerated, the force of friction may be found. Compare this value for the coefficient of kinetic friction (μ_k) between the surfaces assumed with that value used in the program. That is, if the simulation assumes concrete dragging across wood, find that μ_k . Slope.

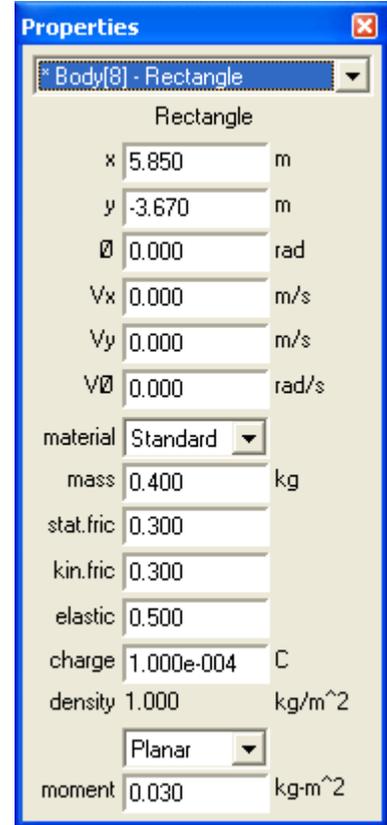
In the screen capture shown below, a mass being dragged produces a change in velocity of about 6 m/sec in about 3.2 sec. This is $6/3.2$ m/sec². for an acceleration. Since the mass being simulated here is

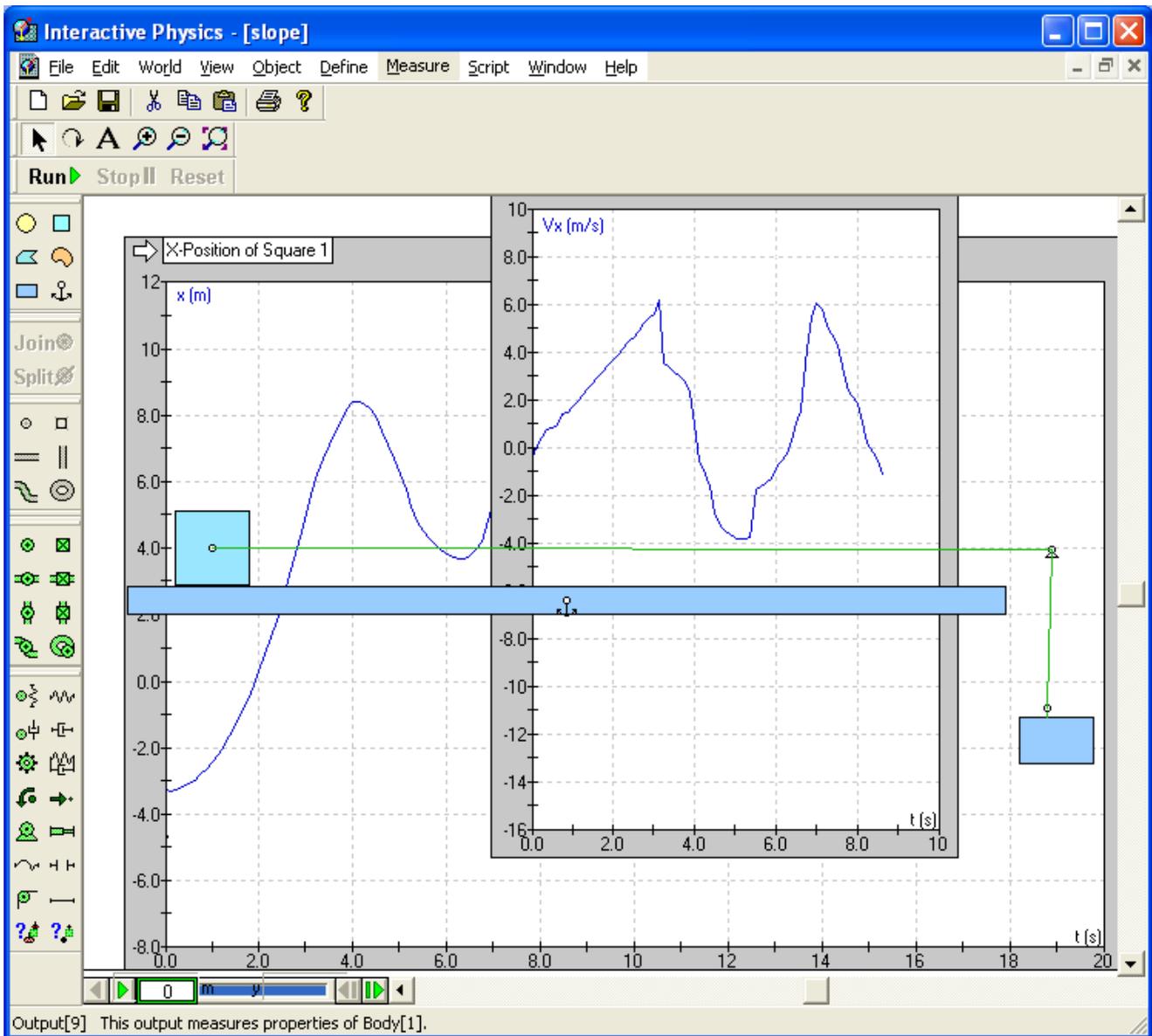


shown in the properties tab as 0.64 kg, the net force on the object is $0.64 \text{ Kg} * 6/3.2 = 1.2 \text{ Newtons}$. You will also note that the properties tab lists the coefficient of kinetic friction used. We are trying to test that value with these results. Don't use it.

If you note in my simulation that the mass being used to accelerate both masses is 0.40 Kg, which (along with gravity) creates a force of 3.92 N on both masses. (1.040 Kg) or an acceleration of 3.76 m/sec^2 . At $3.76 \text{ m/sec}^2 * .64 \text{ Kg}$ the tension force on the horizontal sliding object is 3.91 N. Since the graph showed a net force of 1.2 Newtons, there must be substantial drag caused by friction. We get a drag force of $3.91 - 1.2 \text{ Newtons} = 2.71 \text{ Newtons}$.

If the parameter of the simulation are correct, this force should be $F_f = m g \mu_k = 0.64 * 9.8 * \mu_k = 2.71 \text{ N}$ From this I calculate that $\mu_k = 0.43$ This is substantially different from the value given in the table but it is reliable and reasonably close for a simulation.





Lab analysis:

Show details of the calculation and parameters needed to find the coefficient of kinetic friction. Use screen captures to show both the simulation used and the parameters of both masses moved. Include in your screen capture, the velocity vs. time graph which you will use to determine acceleration. Your complete labeling of each step required to use the parameters to calculate the simulated quantities will be used to determine how successful you have been. In sequence you should find:

- The mass parameters of each object in your simulation
- The graph of velocity vs time as your simulation runs
- The resulting true acceleration of your simulation
- The net force from this acceleration
- The force produced by gravity
- The acceleration and resulting force from the falling mass
- Subtract to find the frictional force

Divide to find your coefficient of kinetic friction and compare to the value shown. I got about 0.43 when the simulation shows about 0.30. Perhaps the mass was bouncing a bit but it was close to being smooth. See if you get results that are as far off as mine.

Assessment and evaluation

5 points	3 to 4 points	1 to 2 points
<p>Student simulates the motion and details the simulation parameters in sufficient details. He/she then takes those parameters through a labeled calculation that shows the resulting coefficient of friction.. You should compare results of your analysis to those suggested by the software.</p>	<p>Student simulates the motion and details the simulation parameters in sufficient details. He/she then takes those parameters through a labeled calculation that shows the resulting coefficient of friction..</p>	<p>Student simulates the motion and details the simulation parameters in sufficient details.</p>