Course and Section_______ Names ____________________________

Date__________ ________________________________

FRICTION SIMULATION

Introduction

Friction is the force that resists the sliding of one surface against another. The ratio of the frictional force to the normal force while an object is sliding refers as the coefficient of kinetic friction μ_K which, for most of the ordinary materials is given by

$$\mu_k = \frac{F_k}{F_n} \qquad (1)$$

In the case of static friction, the coefficient μ_S is defined as the ratio of the maximum frictional force to the normal force before motion

$$\mu_s = \frac{F_{s,max}}{F_n} \qquad (2)$$

In this simulation we are interested in the characteristics and effects of the force of friction. You will use different methods to measure the coefficients of friction.

Submit your answers using Blackboard.

1 - Preliminary questions

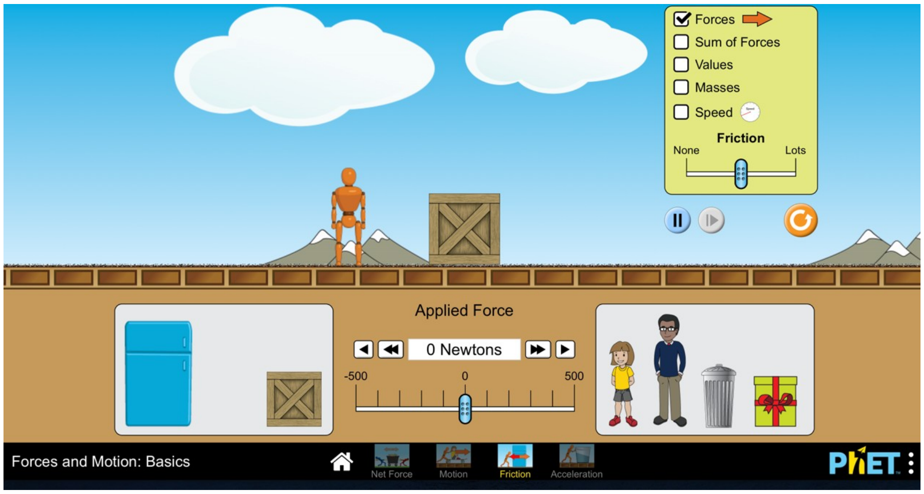
1. According to your textbook, how does μ_k compare to μ_s .

2. How do you expect μ_k to depend on the size of the contact area between the two sliding surfaces?

3. How do you expect the *coefficient of friction* to depend on the normal force? For example, do you expect μ_k to increase, decrease, or remain constant as the normal force is increased?

2 – Friction Proprieties

Click the following link and run the simulation. Select on *Friction*
https://phet.colorado.edu/en/simulation/forces-and-motion-basics

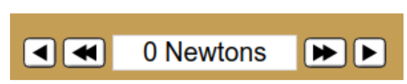


Choose the box with mass 50 kg. Set the friction to any non-zero value (halfway for example). Now drag the person toward the box to apply a force of 50N (a push) on it.
4. Is it true that the box begins to move as soon as you apply the force?

Static Friction (box not in motion)
5. Is it true that the force of static friction acts in the same direction as the applied force?
6. How does the magnitude of the static friction change as you decrease the applied force?
7. What is the magnitude of the force of static friction as you apply the force? (N)
8. What is the value of the net force (the Sum) as you applied the force to the box when the box is not moving?

Kinetic friction (box in motion)
9. How does the direction of kinetic friction compare to the the direction of the static friction?
10. How does the magnitude of kinetic friction change as you increase the push?
11. How does the value of the net force change as you increase the push?
12. Adjust the push to a value equal to kinetic friction. What is the net force?
13. Which term(s) best describes the velocity in question 12?
14. While the box is moving, stop applying the force, what happens to the velocity of the box?

Start over and set the value of friction to halfway (it might already have this value or you can start over the simulation to make sure) place a second box on the first. Carefully increase the values of the applied force, using the buttons displayed in the figure to the right.



15. What is the maximum value of the static friction?
16. Find the magnitude of Applied Force necessary to move the box at constant speed.
17. In order for the box to move at a constant speed less than in question 16, what would you need to do?

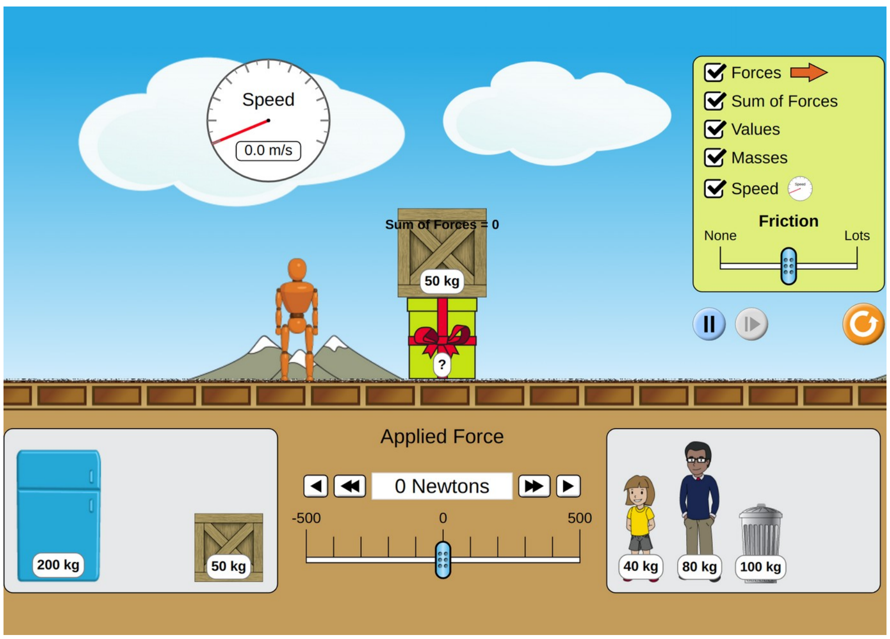
3 – Coefficients of Friction.

Run the same simulation above. Use 50 kg mass and set the friction a*gain to half way*. Apply the push, observe and record the maximum value of static friction (as you did for question 15).
18. Find the coefficient of static friction μ_s by using the equation (2)

Now apply the push so that the object moves with constant speed.
19. Find the coefficient of kinetic friction μ_k by using the equation (1)
20. Are you answers to questions 18 and 19 consistent with the preliminary question 1. (If not repeat the experiment)

Now add another 40 kg mass and repeat the experiment to find $\mu_{k.}$
21. What is μ_K now?
22. Are your results in questions 19 and 21 different?
23. Are they consistent with your answer to question 3? If not repeat again.

4 – Find the unknown Mass



Run the same simulation above. Use the unknown mass (the yellow present with the red ribbon) and place on top of it a box. Set the friction again at half. Apply the push such that the net force is zero and the object moves at constant speed.
24. Normal force and weight have the same magnitude and act in opposite directions in this experiment. Is this statement true?
25. Using the value of μ_k found previously, find the mass of the total system of the present plus the box. (kg)

5 – Find the coefficient of kinetic friction

A physicist applies a force on an block with mass 50 kg which speeds up to the velocity v_0. Then the physicist stops applying the force, the block keeps moving until it comes to a stop in a time interval Δt. The physicist repeats the experiment and records the initial velocities and times intervals as shown in the table, ($g=9.81 m/s^2$)

v_0 (m/s)	14.6	14.7	14.9	15.5	15.2	15.3
Δt (sec)	6.76	6.81	6.90	7.18	7.04	7.08

Your goal is to find the coefficient of friction μ_k between the block and the surface.
Applying Newton Law

$$-F_k = ma$$
$$-\mu_k N = -\mu_k mg = ma$$

and therefore

$$\mu_k = -\frac{a}{g}$$

You need to find the acceleration in order to calculate μ_k. We assume the acceleration to be constant and since the final velocity is zero we have $v_0 = -a\Delta t$. To estimate the acceleration make a plot of v_0 vs Δt.

26. The slope is the positive quantity $-a$. What is the value of the slope?
27. Finally, what is the coefficient of kinetic friction?