Friction Practice Problems

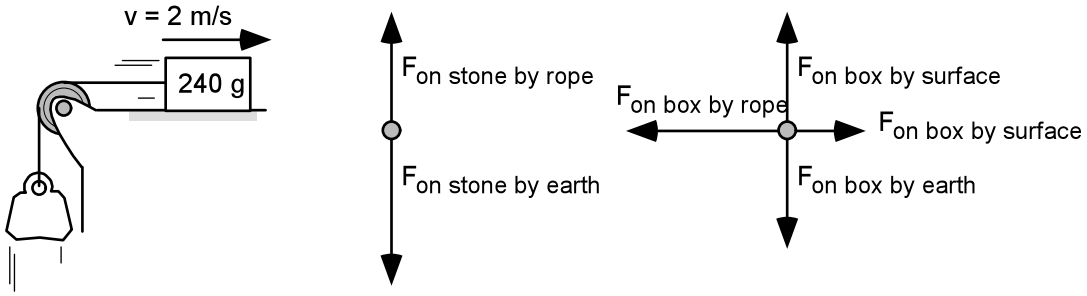
1. Compare the ease of pulling a lawn mower and pushing it. In particular, in which case is the friction force that the grass exerts on the mower greater and why?

2. Two of your neighbor's children (40 kg together) sit on a sled. You push on the back child, exerting a 50 N force on him directed 37^{o} below the horizontal. The sled slides forward with a constant velocity. Complete the table below to answer the question: What is the coefficient of kinetic friction between the snow and the sled?

Sketch the situation described in the problem; provide all known information.	
Draw a force diagram for the system object. Label the forces. Make sure the diagram is consistent with the motion of the system object. Include perpendicular *x* and *y* axes.	
Apply Newton's Second Law in component form (*x* and *y* axes) to the situation shown in the force diagram you drew.	
Solve the equations for the unknown quantities. Evaluate the results to see if they are reasonable (units, magnitudes, and values for limiting situations).	

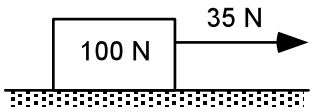
3. A boy pulls a 47.5 kg crate with a rope. The rope makes an angle of 28.0° to the horizontal. The coefficient of kinetic friction for the crate and the deck is 0.300. The boy exerts a force of 185 N. What is the acceleration of the crate? How far does the crate travel in 5 seconds?

4. Explain and show with equations why as the angle of incline is increased, the maximum friction force decreases.



5. What, if anything, is wrong with these free-body diagrams above? If something is wrong, identify it and explain how to correct it. If nothing is wrong, explain why the diagrams are appropriate.

6. A 100 N box is initially at rest on a rough horizontal surface. The coefficient of static friction between the box and the surface is 0.6 and the coefficient of kinetic friction is 0.4. A constant 35 N force is applied to the box horizontally as shown.



Identify from choices (1)-(5) how each change described below will affect the frictional force on the box by the surface *1 second after the horizontal force is first applied.*

Compared to the case above, this change will:

(1) *increase* the frictional force exerted on the box by the surface.
(2) *decrease* the frictional force exerted on the box by the surface but not to zero.
(3) *decrease* the frictional force exerted on the box by the surface to zero.
(4) *have no effect* on the frictional force exerted on the box by the surface.
(5) *have an indeterminate* effect on the frictional force exerted on the box by the surface.

All of these modifications are changes to the initial situation shown in the diagram.

a) The weight of the box is changed to 50 N. _____

b) The weight of the box is changed to 200 N. _____

c) The applied force is increased to 50 N. _____

d) The applied force is increased to 80 N. _____

e) The coefficient of static friction is increased to 0.7. _____

f) The coefficient of kinetic friction is increased to 0.5. _____

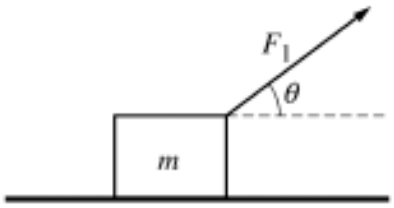
g) The coefficient of kinetic friction is increased to 0.5 and the coefficient of static friction is increased to 0.7. _____

h) The weight of the box is changed to 200 N and the coefficient of static friction is increased to 0.7._____

i) The weight of the box is changed to 200 N and the coefficient of kinetic friction is increased to 0.5._____

k) The weight of the box is changed to 200 N and the applied force is increased to 50 N. _____

Free response problem practice:



7. A block of mass m is pulled along a rough horizontal surface by a constant applied force of magnitude F_1 that acts at an angle Θ to the horizontal, as indicated above. The acceleration of the block is a_1. Express all algebraic answers in terms of m, F_1, Θ , a_1, and fundamental constants.

a. On the figure below, draw and label a free-body diagram showing all the forces on the block.

b. Determine normal force exerted by the surface on the block. Is the normal force greater than or less than mg and why?

c. Derive an expression for the coefficient of kinetic friction μ between the block and the surface.

d. On the axes below, sketch graphs of the speed v and displacement x of the block as functions of time t if the block started from rest at $x = 0$ and $t = 0$.