Name _____

Section _____ **Date** _____

Physics 211 PreLab #3: Frictional Forces

Reading: **Tipler**

Chapter 5, Section 1 - Applications of Newton's Laws, Friction

Fact or Friction?

You know from personal experience that if you briefly shove an object so that it moves across a surface with some initial velocity, the object will slow down and eventually stop. Do your observations contradict Galileo's and Newton's concept of inertia, i.e., the idea that "an object in motion tends to remain in motion unless acted on by an external force"? No, these observations simply tell us that there must be an external "contact" force that acts between the object and the surface. We call this "contact" force *friction*. While you will see in this course that we commonly idealize physics problems by assuming the presence of a "frictionless" surface, friction is in fact an essential feature of our lives - just imagine trying to walk, drive, or do practically anything else without it!

There are two types of friction we deal with every day, *static friction* between surfaces at rest with respect to one another, and *kinetic friction* between surfaces in relative motion. Static friction between two surfaces is characterized by the *coefficient of static friction*, μ_s, which relates the static frictional force, F_s, on an object to the normal force, F_n, on that object according to

$$F_s = \mu_s F_n. \qquad \text{(Eq. 1)}$$

Consequently, the maximum static frictional force, $F_{s,max}$, is related to the normal force by the relationship,

$$F_{s,max} = \mu_s F_n \qquad \text{(Eq. 2)}$$

Similarly, the *coefficient of kinetic friction*, μ_k, relates the kinetic frictional force, F_k, to the normal force according to the relationship,

$$F_k = \mu_k F_n \qquad \text{(Eq. 3)}$$

In Investigation 1, you will study the relationship between static and kinetic friction by using a force probe to drag a wooden block as illustrated in Figure 1.

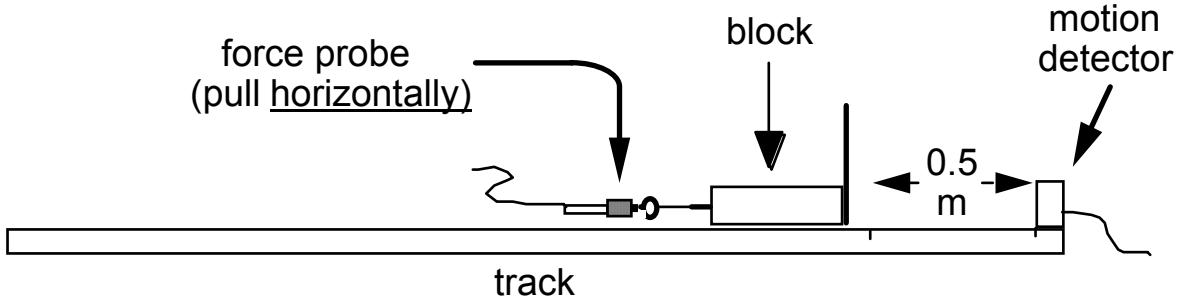


Figure 1. Experimental setup for Investigation 1

Answer the following questions concerning Investigation 1.

Q1 - Why is it more difficult to push a box on the floor from rest than to keep it moving once it starts to slide?

_____

_____

_____

Q2 - You can hold a book of mass *m* at rest on a perfectly vertical wall by applying a horizontal force *F* with your hand. Describe how this is possible, and derive a relationship for the force *F* needed to hold the book at rest in terms of *m* and other relevant parameters. Assume that the frictional force between your hand and the book is negligible.

In Investigation 2 you will study the influence of friction on the kinematics of a cart traveling up and down an incline (see Figure 2).

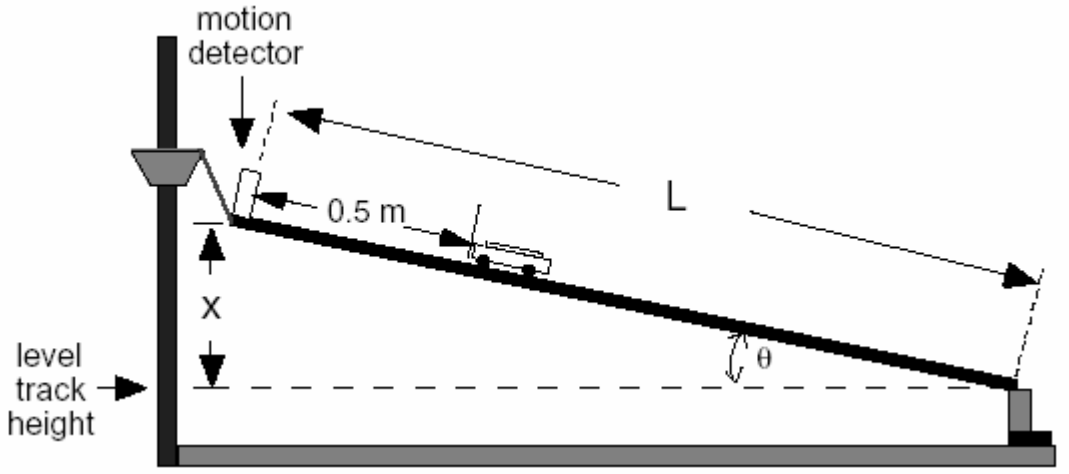
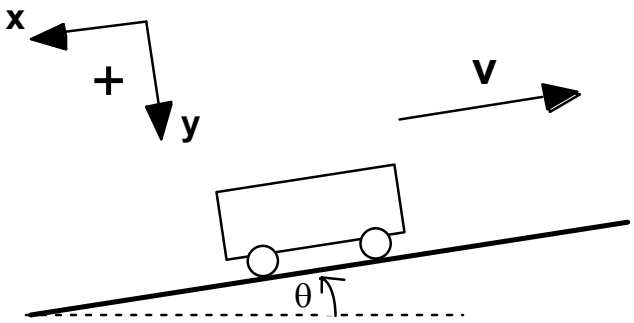


Figure 2. Experimental setup for Investigation 2

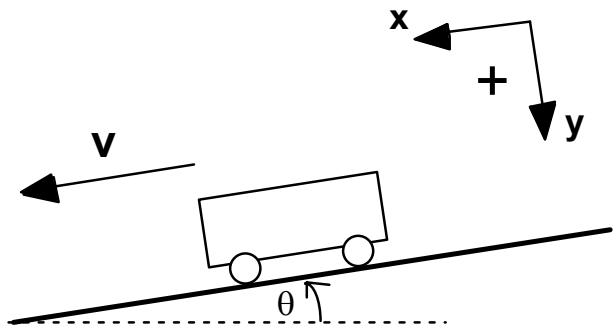
Please answer the following questions regarding Investigation 2.

Q3 - Consider a cart of mass m that travels up and down a rough incline of angle θ (see below). The coefficient of kinetic friction between the cart's friction pad and the incline is μ_k. Sketch below all the forces acting on the cart for the following cases: (a) the cart moves up the incline; (b) the cart moves down the incline.

(a). Motion *up* the incline



(b). Motion *down* the incline

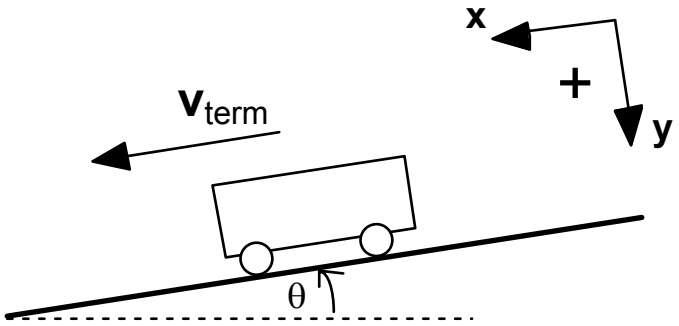


Also, for both cases (a) and (b) desribed and illustrated above, write below the net force acting on the cart in the x-direction. Assume the positive x- and y-directions are in the directions shown above.

(a) $\mathbf{F}_x$ = _____ (b) $\mathbf{F}_x$ = _____

In Investigation 3 of Lab 3 you will study the conditions under which a cart sliding down an incline in the presence of friction and gravity will attain a constant velocity.

Q4 - Consider a cart on an incline having an angle θ (see below). The coefficients of static and kinetic friction between the cart and the incline are μ_s and μ_k, respectively. Derive a relationship for the inclination angle θ at which the cart slides down the incline with a constant (nonzero) velocity.



θ = _____

Q5 - A car of mass m = 1000 kg is sliding down a hill. The coefficients of friction between the car's tires and the ground are μ_s=0.89 and μ_k=0.61. For what inclination angle will the car slide down the hill with a constant velocity?

Q6 - A skier finds that she must give herself a push to get started down ski slopes with angles less than 8°. What is the coefficient of static friction between the skis and the snow?