PHYS 2211L - Principles of Physics I Laboratory

Laboratory Advanced Sheets
Forces of Friction

Objective. The objective of this laboratory is to experimentally determine the coefficients of static and kinetic friction by using an object on an incline technique.

Theory.

Friction is a force that resists the relative motion of surfaces sliding against each other. In order to make an analysis of friction easier, it is subdivided into *static friction* between non-moving surfaces, and *kinetic friction* between moving surfaces. Friction can be thought of as a vertical component of a single contact force which develops between such surfaces (normal force is another component). Experiments show that if an increasing horizontal push is applied to an object resting on a horizontal surface, the *static* friction will increase accordingly, until a maximum value is reached at which point the motion becomes imminent. Once the object starts to slide along the surface, the friction force (now called *kinetic*) decreases in magnitude, fluctuating around a certain average value (as pictured in Figure 1). Experiments further show that both kinetic friction and the maximum static friction force are approximately proportional to the magnitude of the normal force exerted on the object by the surface:

$$f_k = \mu_k n$$

$$f_s \leq \mu_s n,$$

where μ_k and μ_s are called coefficients of kinetic and static friction.

An easy way to measure the coefficients of static and kinetic friction is to place two objects together and then tilt them until the top one slides. The angle at which one object starts to slip on the other is called critical angle (θ_c) and is directly related to the coefficient of static friction:

$$\mu_s = \tan(\theta_c).$$

For a given angle θ above the critical, measuring the relative acceleration will produce the coefficient of kinetic friction:

$$\mu_k = \frac{gsin(\theta) - a}{gcos(\theta)},$$

where *g* is the magnitude of acceleration due to gravity, and *a* is the magnitude of the relative acceleration.

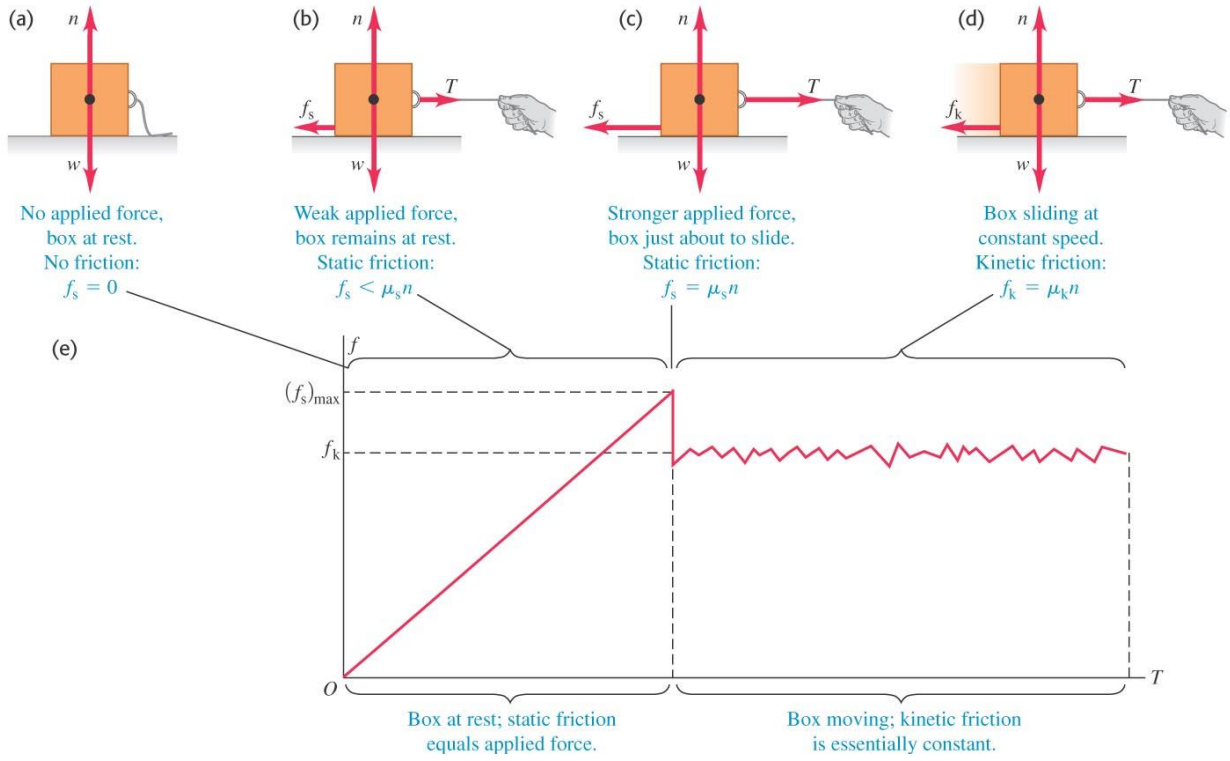

Figure 1. Static and kinetic friction.

Apparatus and experimental procedures.

- Equipment.
    1. Incline.
    2. Block.
    3. Meter stick/ruler.
    4. Camera.
    5. Computer with the Tracker software.

- Experimental setup. The experimental setup is shown in Figure 2 (provided by the student).
- Capabilities. To be provided by the student.

. **Requirements**.

- In the laboratory.
    1. Take a video of a block sliding along the incline for an angle above the critical.
    2. Take a video of a gradual increase in the inclination angle until the block starts to slide down the incline.
- After the laboratory. Complete the following portions of the laboratory report.

Para. 3. Apparatus and experimental procedures.

1. Provide a figure showing the experimental setup.
2. Provide a description of the capabilities of the equipment used in the experiment.

Para. 4. Data.

1. Provide a video of your experiment.
2. Provide a copy of your spreadsheet with calculations. Include the following:
    A. The Tracker data for the sliding block.
    B. Graphs of the *x*- and *y*- coordinates of a sliding block as a function of time with the quadratic regression equation included on the graph.
    C. Calculation of the magnitude of the acceleration of a block and the angle of the incline.
    D. Calculation of the coefficient of kinetic friction.
    E. Critical angle from the Tracker data.
    F. Calculation of the coefficient of static friction.

***Para. 5. Results and Conclusions.**

1. Provide a statement of the coefficient of kinetic friction.
2. Provide a statement of the coefficient of static friction.
3. Provide a statement on the accuracy and precision of your experiment.
4. Describe sources of systematic error in the experiment.
5. Describe sources of random error in the experiment.