Exercise 6: Force of friction

Purpose: To investigate the kinetic and static friction forces acting on an object.

Introduction

Friction is a force that opposes the relative motion between two surfaces. The frictional force depends on the nature of the surfaces and the reaction force acting between the surfaces. The frictional force depends on whether the surfaces are initially at rest relative to the other or not. In the case where the objects are at rest, then the minimum force required to just start them moving relative to the other is a measure of the maximum frictional force prior to the motion, and this is called the maximum static frictional force, or critical force. It is known that the magnitude of the static frictional force of an object on a flat surface is given by

$$F_s \leq \mu_s N,$$

where N is the normal force on the object and μ_s is the coefficient of static friction.

The laboratory assignment will determine the coefficient of static friction of two types of materials on an aluminum track by finding the critical force, $F_{\text{critical}} = \mu_s N$

Laboratory assignment

1. Attach each meter stick to the two vertical posts. Make sure that the two meter sticks start at the same height relative to the table.
2. Place on of the vertical meter sticks at the 70 cm mark ruled out on the track. Place the other vertical meter stick at the 10 cm mark ruled out on the track keeping the track flat on the table.
3. Place the cork bottomed boat on the aluminum track and leave it stationary for 10 seconds before moving on to step 3.
4. Gradually increase the angle of the track by picking up the track on the end with the highest ruled values. Keep watching the height changes of both meter sticks and the change in hypotenuse between the two vertical meter sticks.
5. When the cork bottom boat begins to move, keep the track stable. Then record the two height values from the meter sticks and the two locations of the meter sticks on the ruled section of the track.
6. Repeat these steps two more times and tabulate your data by placing it in a table similar to Table I. The notation in the table is such that h_1 and h_2 are the heights of the track measured by the meter stick, d_1 and d_2 are the positions of the vertical meter sticks recorded from the ruled track, and θ_{avg} is the average angle that you calculate.

Table I: data from static friction measurements.

	h_1 (cm)	h_2 (cm)	d_1 (cm)	d_2 (cm)	θ (°)	θ_{avg} (°)
Trial 1						
Trial 2						
Trial 3						

7. Calculate the angles of each trial using the relationship $\sin\theta = \frac{h_2 - h_1}{d_2 - d_1}$.
8. Calculate the average angle, θ_{avg}.
9. Repeat steps 1-7 by replacing the cork boat with the felt boat.
10. Draw a free body diagram for the friction boat.
11. Derive an expression for the static coefficient of friction μ_s in terms of the critical angle θ using your free body diagram.
12. Calculate the coefficient of static friction μ_s for both the felt and cork materials on the aluminum track. Which material has the larger coefficient of friction on the aluminum surface?

Equipment list: aluminum track, friction boats, mass hanger set, strings, large mass set, vertical stand (2), meter stick (2), motion sensor, laptop.