

In this investigation you will use a ramp to (a) determine the coefficients of static and kinetic friction of objects made of a variety of materials and (b) experiment with other variables to see the effect, if any, on the coefficients of friction.

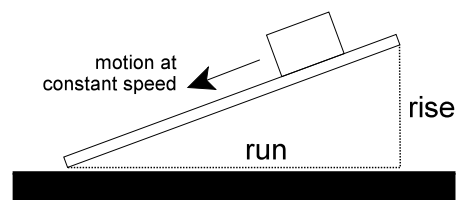
**Question**

How are the coefficients of friction affected by (i) the state of the object (at rest or in motion), (ii) the materials in contact, (iii) the mass of the object, and (iv) the type of friction (rolling or sliding)?

**Materials**

- wooden board
- metre stick
- 5 wooden objects with different materials attached
- cart with wheels
- masses

$$\mu = \text{rise}/\text{run}$$



**Procedure**

1. The board is used as a ramp in this investigation. Place the first object to be tested near the top of the ramp, as shown. Gradually raise the end of the ramp until the object just begins to slide. Try this several times to be sure of the best position. Hold the ramp steady, and use the metre stick to measure the rise and run. Record your data to one decimal place.
2. Use the rise and run to calculate the slope of the ramp. This value is the coefficient of static friction. Record your calculations to two decimal places.
3. Repeat step 1 with the same object, but this time, gently tap the object while the ramp is being raised until the object continues to move on its own with a constant speed down the ramp. In this case, the slope of the ramp yields the coefficient of kinetic friction. Record your data and calculations to the same precision as earlier.
4. Repeat steps 1 to 3 with the other objects and the cart.
5. Repeat steps 1 to 3 with two blocks of your choice with a mass attached to the block. Be sure to state which objects were used.

**Observations**

Object	STATIC			KINETIC		
	rise (cm)	run (cm)	$\mu_s$ (no units)	rise (cm)	run (cm)	$\mu_k$ (no units)
#1 countertop						
#2 steel						
#3 cork						
#4 sandpaper						
#5 rubber						
#6 wood (flip one of the objects 1-5)						
#7 cart						
#8 object 1-6 (your choice) with added mass						
#9 object 1-6 (your choice) with added mass						

\* Forgot to measure the run?  $\text{run} = \sqrt{L^2 - \text{rise}^2}$  where L is the length of the ramp

**Analysis**

- (a) Which material had the greatest friction with the board? The least?
- (b) Describe the most likely sources of error (2) in your investigation. How might these sources of error be reduced?
- (c) Q.2/P.178 (be sure to include a FBD and to show your work/thoughts)