Work-Energy Theorem & Friction

OBJECTIVE

To calculate the effective spring constant of a rubber band by using the Work-Energy Theorem and compare to the expected value by using Hooke's Law.

EQUIPMENT

1. 2 metal rods
2. meter stick
3. long rubber band
4. wood block
5. friction paper
6. brown spring scale
7. pan balance

THEORY

Using the Work-Energy Theorem to Find the Effective Spring Constant K_{eff}

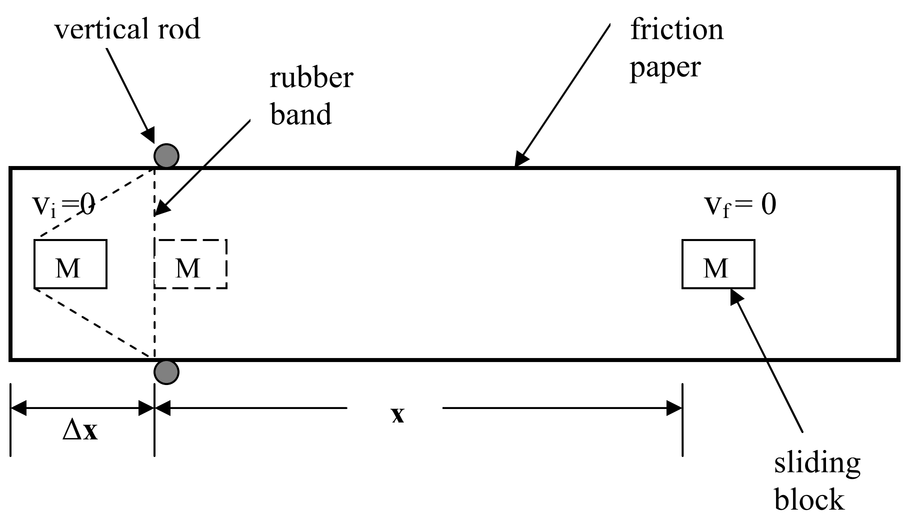

Figure 1

1. A block of mass M will be pushed against a rubber band and released from rest. The block will then slide on a long strip of "friction" paper until it comes to rest.

2. Apply the Work-Energy Theorem between the release point ($v_i = 0$) and the final point where the block comes to rest ($v_f = 0$).

3. Solve the resulting equation for the effective spring constant K_{eff} of the rubber band. K_{eff} should in terms of μ_k, M, g, Δx, and x.

   μ_k = coefficient of kinetic friction between paper and block
   M = mass of the sliding block
   g = acceleration of gravity 9.80 m/s^2
   Δx = amount rubber band was stretched from equilibrium position
   x = distance sliding block traveled before coming to rest

4. M, Δx, and x will be measure directly.

5. The coefficient of kinetic friction will be calculated graphically by making a graph of f_k vs. N.

Using Hooke's Law to Find the Expected Value of the Effective Spring Constant K_{eff}.

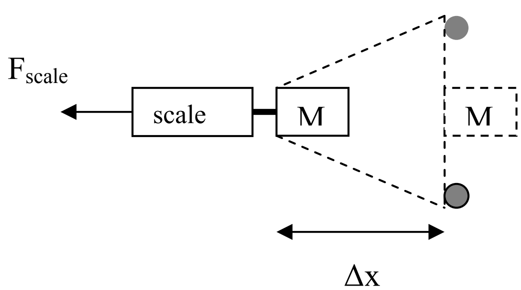

Figure 2

1. Set the block against the rubber band and attach the brown spring scale to the block.
2. Begin to pull on scale until you have displaced the block a distance Δx.
3. Since the block is in equilibrium, then $F_s = F_{scale} = k_{equil}\,\Delta x$. Thus,

$$k_{equil} = \frac{F_{scale}}{\Delta x}$$

PROCEDURE

(Using Hooke's Law to Find the Expected Value of the Effective Spring Constant K_{eff} – see Figure 1)

1. Setup apparatus as shown in Figure 1.
2. Measure the mass M of block.
3. Place block against rubber band, pull a distance Δx from equilibrium and release block.
4. Measure Δx and the distance x the block slid before coming to rest. (If $x < 50$cm, Δx should be adjusted so that $x > 50$cm.)
5. Repeat for a total of 5 runs for five values of x.

Finding the Coefficient of Kinetic Friction μ_k Graphically

1. Place 500g on top of block and measure the horizontal force required to slide it on "friction" paper at constant velocity.
2. Measure the normal force N acting on block.
3. Repeat step (1) and (2) for 1000g, 1500g, and 2000g.
4. Fill in the following table:

$F_{scale}(f_k)$	N

5. Using EXCEL make a graph of f_k vs. N and determine μ_k.

Calculating the Effective Spring Constant K_{eff}

1. Calculate K_{eff} (using the derived equation) for each of the 5 values of x. Calculate the average of K_{eff}.

Calculating the Expected Spring Constant K_{equil} - see Figure 2

1. Set the block against the rubber band and attach the brown spring scale to the block as shown in Figure 2.
2. Begin to pull on scale until you have displaced the block a distance Δx (the same Δx that was used to launch block).
3. Since the block is in equilibrium, then $F_s = F_{scale} = k_{equil}\,\Delta x$. Thus,

$$k_{equil} = \frac{F_{scale}}{\Delta x}$$

4. We will take k_{equil} to be the expected value of the effective spring constant.
5. Compare the average of k_{eff} to k_{equil}.