

Friction*

Object

To determine the coefficient of friction between two given materials.

Theory

When a dry solid object slides over another, it experiences a retarding force (opposite to the direction of motion). This is the force of friction. Its magnitude is proportional to the normal reaction acting on the sliding object. So

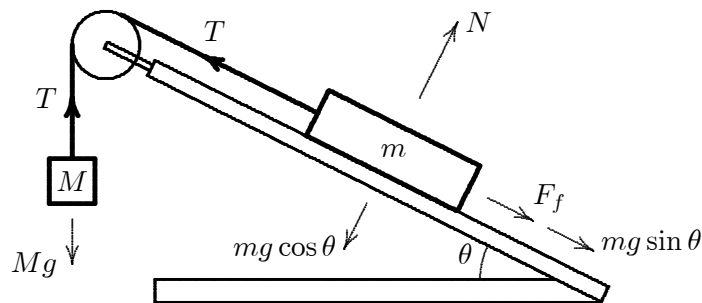
$$F_f = \mu_k N, \quad (1)$$

where F_f is the magnitude of the force of friction, N is the normal reaction and μ_k is the coefficient of kinetic friction which depends on the properties of the two surfaces in contact. A similar formula holds when the object is not sliding but is about to do so due to an external force.

$$F_f = \mu_s N, \quad (2)$$

where μ_s is the coefficient of static friction. Usually, $\mu_s > \mu_k$.

The measurement method



The setup is shown above. The mass M is increased gradually to the point that the sliding block (of mass m) just about starts to move upwards along the inclined plane. You may

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have to gently tap the surface of the plane to get the block to start sliding. It is important not to increase M to the point that the block begins to accelerate. This is because in our analysis we shall assume the block to be moving at constant velocity and hence, there would be no net force acting on it. Hence, the string tension

$$T = F_f + mg \sin \theta. \quad (3)$$

As the mass M is not accelerating, it is also seen that

$$T = Mg. \quad (4)$$

There is no motion in the direction perpendicular to the plane. Hence,

$$N = mg \cos \theta. \quad (5)$$

From equations 1, 3, 4 and 5, we get

$$Mg = \mu_k mg \cos \theta + mg \sin \theta. \quad (6)$$

This gives

$$\mu_k = \frac{M - m \sin \theta}{m \cos \theta}. \quad (7)$$

Some trials

Do the experiment for several values of θ (including zero) and find μ_k for each case. Find the average μ_k and the statistical error in your experiment.

Can you find the coefficient of static friction, μ_s , using a similar method?