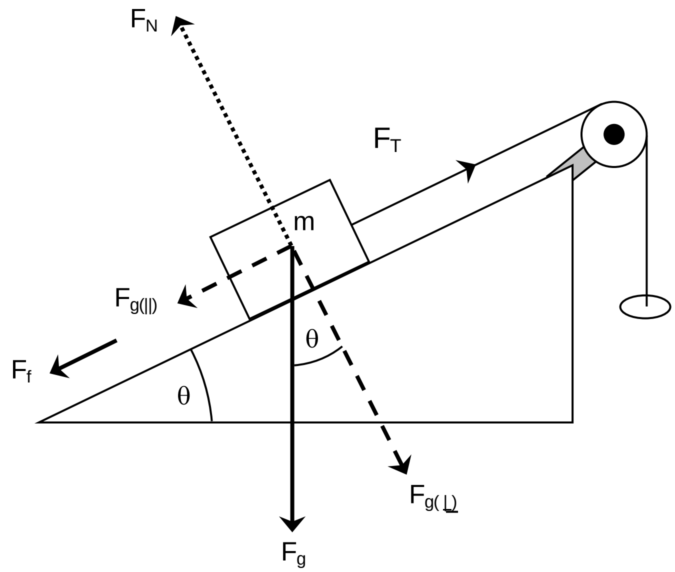
Determining the Coefficient of Friction Lab

Theory:

A block of wood resting on an incline at some angle θ is being pulled up by a string at **constant velocity**. Since the acceleration of the system is zero, there is no unbalanced force on the block. The tension (F_T) on the block must therefore provide enough force to equal the sum of the friction and parallel component of the weight ($F_{g(||)}$).



$F_f = \mu F_N$ (1)

From the diagram above, we can develop a relationship for the forces acting along the plane as follows:

$F_{net} = F_T - F_{g(||)} - F_f$

Since $F_{net} = 0$ if the block is moving at a constant speed, the formula can be solved for F_T.

$F_T = F_{g(||)} + F_f$ (2)

Since $F_N = F_{g(\perp)}$, we can use a little trig and substitute (1) into (2) to arrive at:

$F_T = F_g \sin\theta + \mu F_g \cos\theta$ (3)

where μ is the coefficient of friction.

Objective:

To determine the coefficient of kinetic friction between two pieces of wood.
To investigate the affect of the normal force and the angle of the incline on the coefficient of friction.

Materials:

- Inclined plane (wooden board)
- Slotted weights
- Block of wood with eye screw
- Books
- Balance
- Weight hanger
- Pulley
- String

Procedure:

1. Place the inclined wooden plane flat on the lab table and attach a pulley to the end such that if protrudes over the lab table edge.
2. Tie the string to the eye screw. Measure the mass of the wooden block with the eye screw and the string to the nearest tenth of a gram.
3. Run the string over the pulley and attach a weight hanger to the other end.

Produce a formal lab report; Show calculation in the results section; put the analysis in the discussion section.

4. Adjust the orientation of the string so that it is parallel to the wooden incline plane.
5. The wooden planes will differ in their smoothness. Be certain that your surface is clean and dry.
6. Add masses to the hanger until the wooden block moves at constant velocity **after tapping it lightly**. Be sure it does not accelerate Measure the total hanging weight in your table for data. (Do not trust the printed masses – measure everything to the nearest 0.1 g!)
7. Add different amounts of mass to your wooden block for different values of F_g and repeat step 6. Be sure to use masses that differ greatly from any previous masses. Collect at least 6 good trials. Be consistent with your significant digits of your measurements.
8. Incline the plane at some angle between 5 and 20 degrees using textbooks. Instead of measuring with a protractor, measure the adjacent side and the opposite side and calculate the angle using the arctangent and record this value in the table to the nearest 0.1º.
9. Repeat step 6 for one trial only – add mass that is different from the data table. Record the total weight. This is the tension (F_T) at angle θ.

Data Table:

θ	$Mass_{block}$ (kg)	$F_{g(block)} = F_N$	$Mass_{masses}$ (kg)	$F_T = F_{g(masses)}$	μ
0 degrees					
$5 \leq \theta \leq 20$ degree	$F_{g(block)}$		Actual	Theoretical	Average

Analysis:

1. Using equation (3), show that for θ = 0 degrees, the coefficient of kinetic friction is given by

   μ = total weight of hanger (F_T) /total weight of block (F_g)

   -Work out the problem on paper (**Do not use your data.)**

2. Determine the value of μ for each set of data taken on the level surface.
3. Produce a graph. Plot the value of μ versus total block weight. Scale the y-axis from 0 – 1. Describe the relationship between μ and total block weight, i.e. is there a trend, and what does it tell you?
4. Determine the average μ.
5. Theoretically predict a value for F_T using the average value of μ obtained during the first set of trials and the final value for total block weight (F_g) at the angle θ in the procedure above. **Work this problem out on paper.**
6. Compare the computed theoretical value of F_T with the actual value obtained when the incline was set on an incline by calculating the % error. Explain what your error tells you about the coefficient of friction and the angle θ.
7. Why was it important to have the block move at a constant speed?

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