Lab 6: Friction II (Vertical Plane)

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Class: **PHYS 2125 (15921)**
Date: **2025-02-21**

Objective

Determine the kinetic coefficient of friction between the wooden block and the track.

Equipment

- (1) small A-base
- (1) long metal rod
- (1) clamp
- (1) short rod
- (1) set of weights with known masses
- (1) 50cm "PASTrack" track with four legs
- (1) 114g friction block
- (1) 5g hook
- (1) ~70cm length of string
- (1) pulley

Theory

Applying $F_{net} = ma$ for both masses in the direction of motion.

Given:

$M_H g - T = M_H a$,

$T - (f_k + M_b g \cdot sin(\theta)) = M_b a$, and

$f_k = \mu_k n = \mu_k M_b g \cdot cos(\theta)$.

Then:

$T = (\mu_k(M_b g \cdot cos(\theta)) + M_b g \cdot sin(\theta)) + M_b a$,

$M_H g - ((\mu_k(M_b g \cdot cos(\theta)) + M_b g \cdot sin(\theta)) + M_b a) = M_H a$, and

$M_H g - \mu_k(M_b \cdot gcos(\theta)) - M_b g \cdot sin(\theta) = M_H a + M_b a$.

Setting $a = 0$ and cancelling out g

$M_H \cancel{g} - \mu_k M_b \cancel{g} \cdot cos(\theta) - M_b \cancel{g} \cdot sin(\theta) = M_H(0) + M_b(0)$

results in

$M_H - \mu_k M_b \cdot cos(\theta) - M_b \cdot sin(\theta) = 0$, and

$\mu_k = \frac{M_H - M_b \cdot sin(\theta)}{M_b \cdot cos(\theta)}$

where:

g is the gravitational constant (of Earth) $(9.8\frac{m}{s^2})$,

T is the force of Tension,

a is acceleration (which we attempt to minimize),

θ is the angle of inclination,

f_k is the force of friction,

μ_k is the coefficient of friction,

M_b is the mass of the block $(114g)$,

M_h is the mass of the hook $(5g)$,

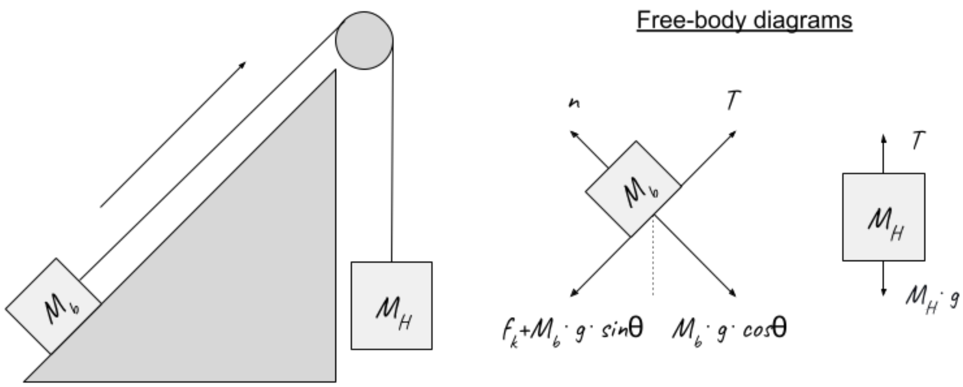
M_a is the mass added with each trial, and

$M_H = M_a + M_h.$

We then leverage this relationship to determine μ_k using the slope of least squares regression divided by M_b:

$$M_H = (\mu_k M_b) \cdot cos(\theta) + M_b sin(\theta)$$

We will graph the above relationship using $cos(\theta)$ as our *x-axis*, M_H as our *y-axis*, $\mu_k M_b$ as the *slope*, and $M_b sin(\theta)$ as the would-be *y-intercept*.



Procedure

Initial Setup

A track and pulley system were constructed.

1. A small cast iron A-base was placed on the table.
2. A 45cm steel rod was secured into the A-frame.
3. The vertical mounting side of a steel clamp was secured at the very top of the rod.
4. A 15cm rod was attached to the horizontal side of the same steel clamp, to the far end of the smaller rod.
5. A $50cm$ piece of PASTrack was placed on the table, with one set of legs resting on the 15cm rod.
6. A pully was connected to the track, on the elevated end.
7. A friction block was tied to a 5g hook using a length of string.
8. The friction block was placed on the track, furthest from the edge near the pulley.
9. The string was laid over the pulley and the hook was left hanging.
10. An angle indicator was connected to the track to determine θ.

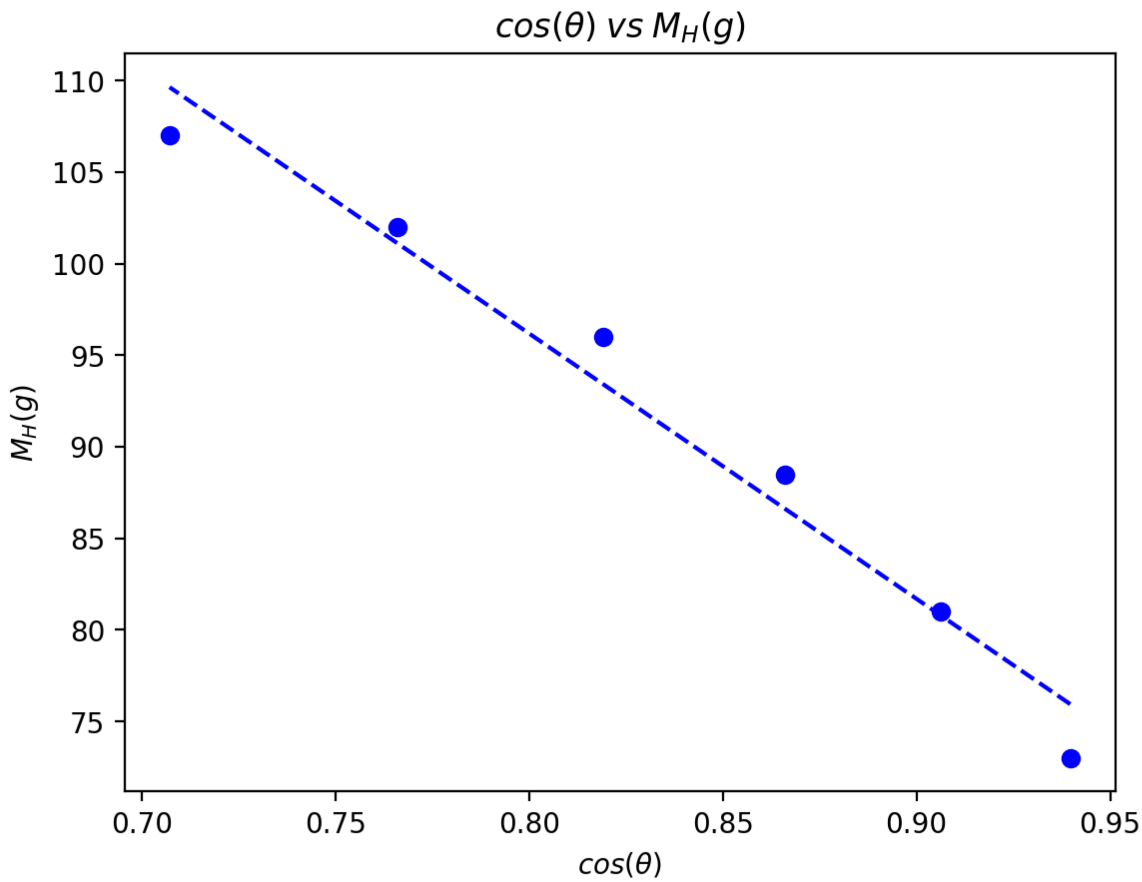
Trial (completed for each M_b)

1. For each trial the inclination of the track was adjusted.
2. The block was moved to the end of the track opposite the pulley.
3. Weight was slowly added to the hook M_a until the following occurred:
    A. The block was lightly tapped in the direction of the pulley to overcome the static friction.
    B. The block steadily advanced down the track until reaching the pulley.

Data

θ\textdegree	M_a (g)	M_h (g)	M_H (g)	$cos(\theta)$	$sin(\theta)$
20.0	68.0	5.0	73.0	0.939693	0.34202
25.0	76.0	5.0	81.0	0.906308	0.422618
30.0	83.5	5.0	88.5	0.866025	0.5
35.0	91.0	5.0	96.0	0.819152	0.573576
40.0	97.0	5.0	102.0	0.766044	0.642788
45.0	102.0	5.0	107.0	0.707107	0.707107
Average					
StdDev					

Calculations



Using the least squares method a trend line is fit to the data with *slope* -144.864 and y*-intercept* 212.074, resulting in the equation $y = -144.864x + 212.074$.

Results

The value of μ was determined using the mean, μ_t, and the least squares fit, μ_g.

$\mu_t = 0.323$ with σ of 0.005

$\mu_g = -1.271$

This equates to a -3.364% difference.

Discussion

Discussion

Questions

Why do you try to maintain the constant speed motion of the block?

Question 1 Answer

What is the most important part of the experiment?

Question 2 Answer