PHYSICS DYNAMICS LAB

- Question: How does the angle at which a modified Atwood's machine is positioned affect the hanging mass necessary to move a 0.125kg block up the incline? What is the coefficient of static friction of the 0.125kg mass?
- Hypothesis: The steeper the angle, the more hanging mass is necessary to move the block. The relationship between the distance of the angle from 180 degrees and the threshold weight will have a positive exponential relationship.

STRATEGY:

- A modified Atwood's machine was created by placing an incline against a vertical support at various angles. The 0.125kg mass was attached to a string that went over a pulley where the incline met the vertical support. The hanging mass was a sum of weights and washers tied to the string.
- After adding weight to the hanging mass until the 0.125kg mass started to move, the hanging mass was measured (in kilograms) and graphed with the angle of the incline to display the correlation between the angle and the threshold mass.

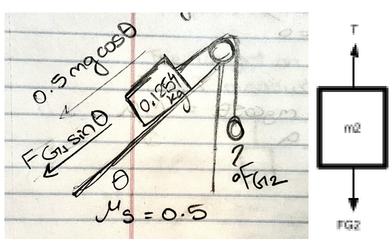
DATA:

Angle (degrees)	Experimental hanging mass threshold	Static friction coefficient
0	0.056	0.45
30	0.108	0.42
45	0.126	0.42
60	0.136	0.44

Figure 1: A table with the experimental data of the threshold hanging mass needed for each angle of incline and its calculated static friction coefficient

ANALYSIS:

The free body diagram in figure 2 show the masses on each side of the machine.



The theoretical threshold mass for each angle was calculated by using the equations:

$$T = \mu m_1 g \cos\theta + m_1 g \sin\theta$$

and

$$T = m_2 g$$

which could be rewritten as

$$m_2 g = \mu m_1 g \cos\theta + m_1 g \sin\theta$$

and

$$m_2 = m_1(\mu \cos\theta + \sin\theta)$$

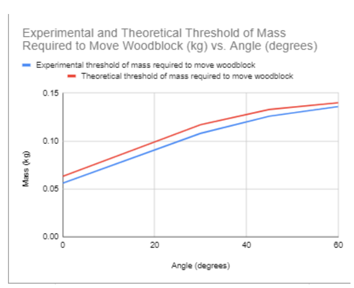
thus where *T* is the tension, m2 is the hanging mass, and m1 is equal to 0.125kg. This equation indicates that there is an exponential relationship between the threshold mass and the angle at which the machine is kept due to the nature of sine and cosine curves.

The coefficient of static friction (experimental) was also derived from the equation:

$$\tan\left(\sin^{-1}\left(\frac{a}{c}\right)\right)$$

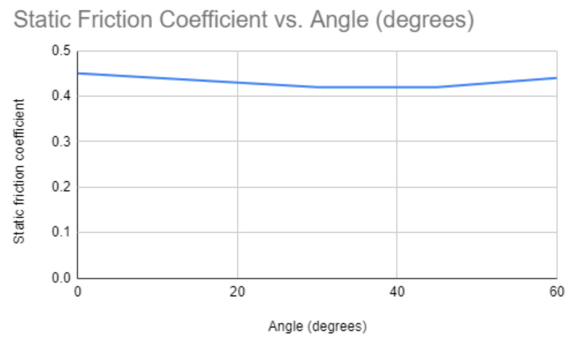
Where *a* is the height necessary for a 0.125kg mass to move down an incline and *c* is the length of the incline. The expression arcsin(a/c) results in the angle of the incline, or the angle at which the force of gravity is greater than the force of static friction. The experimental static friction was 0.5.

After finding the theoretical mass of the threshold mass using the equation above, it was graphed along with the theoretical mass and angle in figure 3:



This graph verifies the exponential nature of the curve.

The coefficient of static friction was also derived from the equation using experimental masses. This was graphed against the angle in Figure 4:



Which shows that the value remains constant no matter the incline level. The values measured are not too far from the measured value of 0.5, and thus the Atwood's machine depicts a working system.

ERROR ANALYSIS:

The percent error for the values of m2 were -11%, -8%, -5%, and -3%. The negative values indicate that the hanging mass weights were not specific or small enough.

The percent error for the coefficient of static friction was 16%, which could be caused because of errors in measurement of the incline on which the 0.5 value was measured.