Question: Does μ remain constant for a given object on a given surface? And if so, does the angle of incline affect the frictional force acting upon an object sliding down a ramp?

Hypothesis: μ will remain constant and the frictional force will decrease as the angle of incline increases.

Strategy:
A wooden board was set up and propped on a stack of textbooks as a ramp. The length of the board (hypotenuse of the triangle) was measured and the height of the textbook stack (vertical leg of the triangle). After three trials at each height, another textbook was added.

A wooden block with felt at the bottom was held at the top of the ramp and released. A Vernier motion detector was used to measure the acceleration of the block for each height.

The mass of the block and the length of the board were constants. The height of the board was the dependent variable and the acceleration was the dependent variable.

From this data, calculations were made to find the angle of incline, μ, and the frictional force.

Measured Data:
The length of the board was measured to be 71.9 cm and the mass of the block was massed to be 131.7 g. For each iteration, the height of the board and acceleration was measured as well.

Height of board (cm)	Average acceleration (m/s^2)
26.4	0.4806
29.3	1.0240
33.4	1.6480
37.3	2.1940
41.5	2.9563
44.9	3.3907

Table 1: The average acceleration of 3 trials for each ramp height

Calculations:

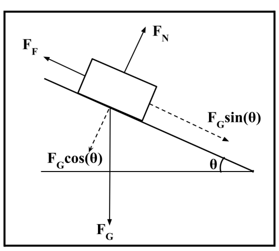

Figure 1: free body diagram of the system

By using the length of the board and the height of the ramp, the angle of incline (θ) can be calculated using *arcsin(length/height)*.

By using the acceleration of gravity (g) and the mass of the block, the force of gravity (F_G) can be calculated: $F_G = mg$

The normal force (F_N) is equal to $F_G cos(\theta)$: $F_N = F_G cos(\theta)$. Since Frictional force (F_F) is equal to μF_N, we can substitute:

$$F_F = \mu F_G cos(\theta).$$

To solve for μ, the equation for F_{Total} can be rearranged to be $(F_G sin(\theta - ma))/F_G cos(\theta) = \mu$. Thus, by using the acceleration and angle for each ramp iteration, μ can be calculated.

Then, $F_F \mu = * F_G cos(\theta)$

Analysis:

Angle of incline (deg)	μ	F_F
21.54	0.3420	0.4106
24.05	0.3318	0.3911
27.68	0.3347	0.3825
31.25	0.3449	0.3806
35.25	0.3374	0.3556
38.64	0.3566	0.3594

Table 2: The angle of incline and the calculated μ for each iteration

The precision of the calculated μ values shows that μ does remain constant though the angle of incline changes. The standard deviation, 0.0089, can be attributed to lab error.

Possible sources of error include inconsistencies on the ramp surface, slight air resistance, or inconsistencies on how the block was released down the ramp.

In addition, it is evident that the frictional force does slightly decrease as the angle increases. The blue line is a linear trend line.

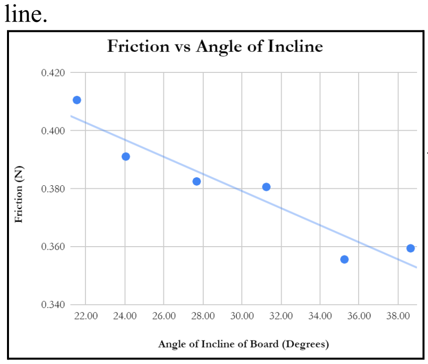

Figure 2: graph of friction vs angle of board

This makes sense since as θ increases, cos(θ) will decrease. Thus, since μ and F_G remain constant, as cos (θ) decreases (θ increases), F_F will decrease.

$$\mu F_G cos(\theta) = F_F$$

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Thus, the hypothesis was correct