Question: Does the angle affect the coefficient of friction between a block and a ramp?

Hypothesis: The angle of the ramp should not affect the coefficient of friction.

Strategy:

Fig 1: Modified Atwood's machine

- The cart used in a modified Atwood's machine was attached to a wooden block using fishline.
- The hanging mass was washers from a paper clip tied to fishline.
- The angle was varied using 4cm tall books which raised one end.
- Acceleration was measured using a Vernier motion detector and was used to calculate coefficient of friction. Coefficient of friction was then graphed against the angle. The slope of this graph determined whether the hypothesis was true.
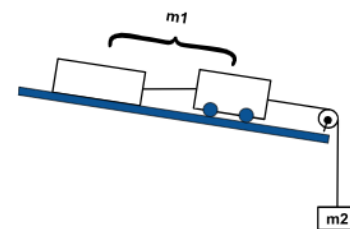
Data:

Total mass of the system: 0.466 kg

Angle (°)	Raise (cm)	Acceleration (m/s²)	μ
0	0	0.173	0.084
2.23	3.8	0.470	0.090
4.23	7.6	0.610	0.109
6.91	11.4	0.818	0.133
8.49	15.2	1.269	0.110
10.63	19	1.615	0.108

Each acceleration is an average of 3 trials.

Analysis:

The free body diagrams in Figure 2 show the forces on the masses in the modified Atwood's machine.
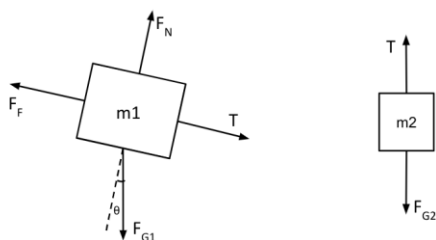

Fig 2: Free Body Diagrams

The following equations are based on the free body diagrams. Positive motion is defined as to the right for the cart and block, and down for the hanging mass.

$$T - F_F + m_1 g \sin\theta = m_1 a$$
$$T = m_2(g - a)$$
$$F_F = \mu m_1 g \cos\theta$$

These equations can be combined to form the equation:

$$\mu = (m_1 g \sin\theta - a(m_1 + m_2) + m_2 g)/(m_1 g \cos\theta)$$

A graph of the coefficient of friction vs. angle data for this experiment shows that there is a slight slope, indicating an increase of friction with increase of angle, contradicting the hypothesis.
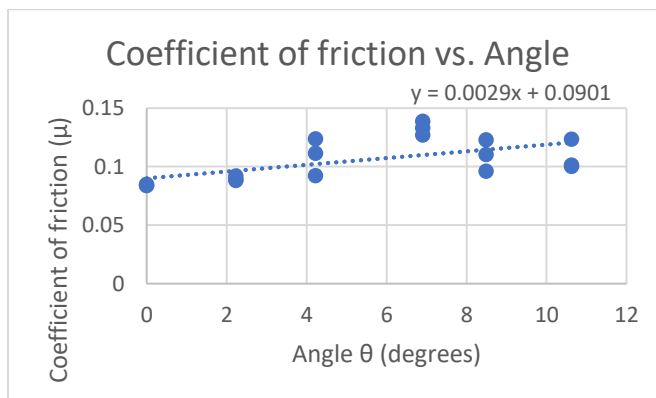

Figure 3: Coefficient of friction vs. Angle Graph

The increase in coefficient of friction was expected to be 0. However, as the slope is very slight, only 0.0029, it can be ignored and considered 0. Some possible sources of error could be considered that would create this difference. With the equipment available, it was difficult to measure the acceleration accurately. This is seen in the 6-degree angle test, where trials 2 and 3 differ by 38% of the average.