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Physics

Dynamics Lab Report

Question: How do the incline angles affect the cart's acceleration in a modified Atwood's machine in which the cart's mass is on an incline but the hanging mass is not?

Hypothesis

When m_1 is on an inclined plane, as the angle increases, the acceleration would be greater towards the not-inclined mass than if both masses were hung straight down.

Lab setup

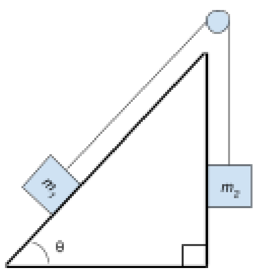

Figure 1: A model of the modified Atwood's machine with two masses leveled on an incline of θ

The experiment involves a cart on one side and a counterweight hanging down, with masses represented as *m1* and *m2,* respectively. The masses are not varied in the experiment, though they will be measured for redundancy. The independent variable in the experiment is the incline of one of the two masses while the dependent variable is the acceleration between the two masses used in the experiment.

Data

	Acceleration (m/s^2)			
Angle	Trial 1	Trial 2	Trial 3	Trial 4
0	3.951	3.578	3.983	3.837333
15	2.579	2.637	2.595	2.603667
30	1.135	1.185	1.177	1.165667
45	0.06859	0.07254	0.0759	0.072343

The table displays the accelerations of a cart measured over three trials at different angles, along with the average acceleration for each angle.

Analysis

The free-body diagrams below show the forces that acted on the masses that were placed on Atwood's machine.

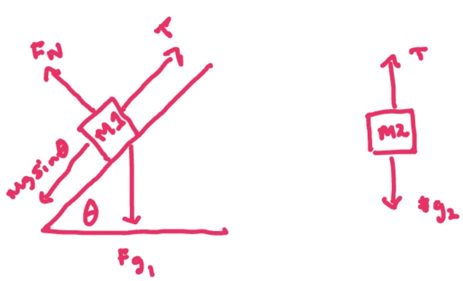

Figure 2: Free body diagrams of the masses

In this experiment, friction between the cart and the track is not taken into consideration. This is because the wheels are spinning freely, so the force of friction is extremely low. In the free-body diagrams, positive motion is defined as the cart going up the ramp for the cart (*m1*) and downward for the hanging mass (*m2*).

The equations used for this experiment are:
T - m1g sin(θ) = m1a
m2g - T = m2a

The equations can then be combined into one equation which is:
m2g - (m1g sin(θ) + m1a) = m2a

Simplifying further, we isolate the acceleration (a) in terms of known quantities:
a = (-m1g sin(θ) +m2g)/(m1+m2)

From this equation, it is seen that the acceleration depends linearly on sin (θ).

In the setup, the slope of the line represents -(m1g)/(m1+m2), while the y-intercept represents m2g/(m1+m2). The graph (seen in Figure 3) of the relationship between the sin of the incline angle (sin θ) and the mean acceleration of the cart in the modified Atwood's machine, shows a negative linear relationship. The linear trendline equation, y= −5.3846x + 3.8931 indicates that the acceleration decreases as the angle of incline increases. This trend is consistent with our hypothesis, as a steeper incline angle results in less acceleration toward the hanging mass. The slope of the line, −5.3846, represents the rate at which the acceleration decreases as the angle of incline increases, and is close to the expected value of -5.5674879. The y-intercept is approximately 3.8931 m/s^2 while the predicted value was 4.142517 which is near the actual slope. This difference in the slope can be because of the small amount of friction that reduces the acceleration of the system. The percent error in the slope is approximately 4.823% greater than expected. But this shows that the experimental and predicted values follow the same trend and are very close to one another showing that the relationship is correct.

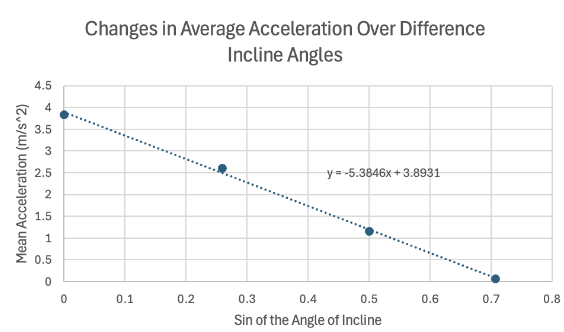

Figure 3: Graph showing the relationship between the angle of incline and the average acceleration

Overall, the negative slope suggests that the angle of the incline significantly affects the system's acceleration. When sin(θ) is higher (indicating a steep angle), the component of gravity acting on the incline for the cart *(m1)* becomes more significant, resulting in a decrease in net acceleration toward *m2.* Thus, this graph confirms that the incline angle is inversely related to the average acceleration, supporting the equations derived before.