**Question**: Does the acceleration of 2 equal masses change when the angles of the inclined planes change?
**Hypothesis**: Yes, the relationship between the angles and the acceleration will be linear.
**Strategy**: Two tracks were leveled and set next to each other at 0 degrees. Next, two identical carts, which were attached by a string and pulley, were placed on either side of the track. It was observed that the carts were not moving at this stage, confirming that the tracks were level. Then, textbooks were added to the tracks to examine how the changes in angles affected acceleration. The collected data was graphed in Excel and the expected results were calculated with an equation solving for $a$, which was derived from the formula $F_{Net} = ma$.

**Data**:

| difference in # of books | theta1 (deg) | theta2 (deg) | trial1 acceleration (m/s^2) | trial2 acceleration (m/s^2) | trial3 acceleration (m/s^2) | avg acceleration (m/s^2) | theoretical acceleration (m/s^2) | % error |
|---|---|---|---|---|---|---|---|---|
| 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 3 | 2 | 0.1552 | 0.1591 | 0.1599 | 0.1580667 | 0.0854387 | 85 |
| 2 | 5 | 2 | 0.3158 | 0.319 | 0.3187 | 0.3178333 | 0.2560556 | 24.1 |
| 3 | 7 | 2 | 0.4743 | 0.4734 | 0.4693 | 0.4723333 | 0.4261522 | 10.8 |
| 4 | 11 | 2 | 0.6361 | 0.6389 | 0.6327 | 0.6359 | 0.7639565 | -16.8 |
| | | | | | | | | |
| 1 | 9 | 7 | 0.1549 | 0.1579 | 0.1554 | 0.1560667 | 0.1693691 | -7.85 |
| 1 | 15 | 13 | 0.1638 | 0.1673 | 0.1649 | 0.1653333 | 0.1659532 | -0.37 |
| | | | | | | | | |
| 1 | 2 | 3 | 0.1531 | 0.1522 | 0.1546 | 0.1533 | 0.0854387 | 79.4 |
| 2 | 2 | 5 | 0.3115 | 0.3106 | 0.3106 | 0.3109 | 0.2560556 | 21.4 |
| 3 | 2 | 7 | 0.4723 | 0.488 | 0.4921 | 0.4841333 | 0.4261522 | 13.6 |
| 4 | 2 | 11 | 0.6376 | 0.6575 | 0.6534 | 0.6495 | 0.7639565 | -15 |

Figure 1: Data including the number of books used, angle measures, and measured and theoretical acceleration.

**Analysis**:
The following free-body diagrams depict the forces on the masses in the experimental setup, which was based on an Atwood's machine.

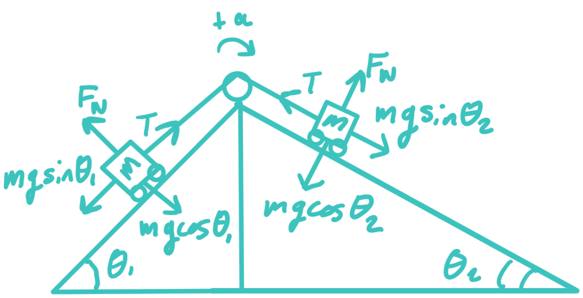



Figure 2: Free body diagram

The following equations represent the forces in the above diagrams, given that the masses are the same and that friction is negligible. Positive acceleration is described as up the incline for one mass and down the incline for the other.

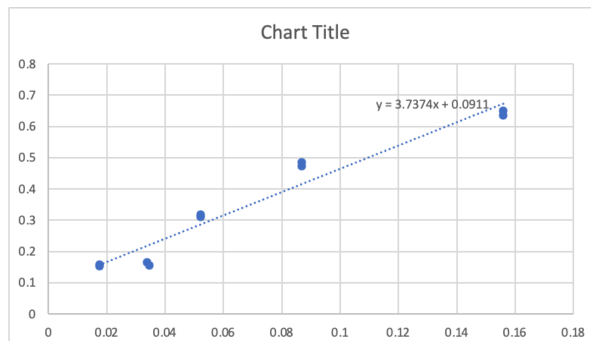
$$F_{net} = ma$$
$$T - mg\sin\theta_1 = ma$$
$$mg\sin\theta_2 - T = ma$$
$$mg\sin\theta_2 - mg\sin\theta_1 = 2ma$$

To solve for $a$, the system can be manipulated into the following equation.

$$a = \frac{g}{2}(\sin\theta_1 - \sin\theta_2)$$

To graph the data using this equation, the equation can be linearized to $y = \frac{g}{2}x$, where $x = \sin\theta_1 - \sin\theta_2$ and $y = a$. Then, the theoretical slope of this graph would be $\frac{g}{2}$, or 4.9.

Figure 3: $\sin\theta_1 - \sin\theta_2$ vs $a$ graph




The actual slope of the graph is 3.7274, which means that the acceleration found from the angles is 23.73% smaller than expected. The fact that it is too small indicates that the measured angle values likely had significant uncertainty. Similarly, the values had more error at lower angle values, which would support this hypothesis. Another likely source for this discrepancy is friction in the wheels of the cart, as any friction would reduce the acceleration.