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Newton's 2nd Law

The purpose of this lab was to find the relationship between acceleration and force and between acceleration and mass to prove Newton's second law.

F=ma

Procedure:

Acceleration vs. mass

1. Figure out the mass of the trolley by using a scaler.
2. Put the track on a flat surface
3. Connect Motion detector to GLX machine.
4. Connect the apparatus to a power source.
5. Eliminate eventual incline by putting something under the track.
6. Put trolley on track, if it moves slow whit constant speed the track is fine.
7. Tie strain as long as the track to the trolley.
8. Attach a 50 g weight to the strain.
9. Put weights on trolley (50 g- 1000 g)
10. Put trolley on the track, hold on to it.
11. Put strain over the pulley.
12. Start the GLX machine
13. Let go of trolley
14. Stop trolley before it fly of the track.
15. Check acceleration on the GLX machine.
16. Repeat with 8 different weights on the trolley (50 g- 1000 g), three trials per weight.

Acceleration vs. force

1-8 are the same as in the last experiment.

9. Attach a (20 g- 200 g) weight to the strain. (Adjust the weights on the trolley so the mass of the system remain constant when the hanging weight change)

1. Put trolley on the track, hold on to it.
2. Put strain over the pulley.
3. Start the GLX machine
4. Let go of trolley
5. Stop trolley before it fly of the track.
6. Check acceleration on the GLX machine.
7. Repeat with 8 different weights attached to the strain (20 g- 200 g), three trials per weight.

Apparatus:

- Track
- Motion detector
- GLX Machine
- Trolley
- Strain
- Pulley
- Weights (20 g- 1000 g)

Variables:

Acceleration vs. Mass

Independent: mass

Dependent: acceleration

Control: force

Acceleration vs. Force

Independent: force

Dependent: acceleration

Control: mass

Data:

Acceleration vs. mass

Mass of Trolley: 0.475 kg.

Trial	**Mass of system (kg)**	**Mass on trolley (kg)**	**Acceleration (m/s^2)**	**Acceleration (m/s^2)**	**acceleration (m/s^2)**	**Average acceleration (m/s^2)**	**Force (N)**
1	0.525	0	0.940	0.948	0.957	0.948	0.49
2	0.625	0.10	0.812	0.812	0.812	0.812	0.49
3	0.725	0.20	0.675	0.667	0.667	0.670	0.49
4	0.825	0.30	0.581	0.581	0.599	0.587	0.49
5	0.925	0.40	0.530	0.522	0.522	0.525	0.49
6	1.225	0.70	0.394	0.394	0.403	0.397	0.49
7	1.425	0.90	0.351	0.351	0.342	0.348	0.49
8	1.525	1.0	0.334	0.334	0.334	0.334	0.49

Acceleration vs. Force

Mass of Trolley: 0.475 kg.

Trial	**Mass of system (kg)**	**Hanging weight (kg)**	**Acceleration (m/s^2)**	**Acceleration (m/s^2)**	**acceleration (m/s^2)**	**Average acceleration (m/s^2)**	**Force (N)**
1	0.875	0.02	0.231	0.230	0.231	0.231	0.196
2	0.875	0.05	0.555	0.560	0.557	0.577	0.49
3	0.875	0.07	0.769	0.770	0.764	0.768	0.69
4	0.875	0.10	1.10	1.08	1.11	1.10	0.98
5	0.875	0.12	1.36	1.39	1.36	1.37	1.18
6	0.875	0.15	1.68	1.65	1.72	1.68	1.47

7	0.875	0.17	1.88	1.88	1.89	1.88	1.67
8	0.875	0.20	2.23	2.23	2.29	2.25	1.96

Analysis and Conclusion:

The relationship between acceleration and force is direct proportional. The relationship between acceleration and mass is inverse proportional.

To minimize frictional force we made sure the track was flat so that the trolley was moving at a constant speed by putting some papers under the track so the incline was eliminated.

The hanging weight was the net force because the friction was zero and the normal force and gravity force will erase each other so the only unbalanced force is the hanging weight acting in the horizontal direction.

The mass of the system is the mass of the trolley, the hanging weight and the weights on the trolley added together.

To linearize the graph we changed mass to 1/mass to get the inverse values and a linear graph.

Acceleration vs. Force:

$$Force(N) = 0.876\ (kg) \times Acceleration\left(m/s^2\right) + 0.0018(N)$$

Y: Force (N)
m (slope): mass (kg)
x: acceleration $\left(m/s^2\right)$
b (Y-intercept): Force (N) That we have a b-value shows on a little bit of error it´s very low but it gotta be like that some times. This is explained in the part with sources of error.

$$Force(N) = mass(kg) \times Acceleration\left(m/s^2\right) + Force(N)$$

Acceleration vs. $\frac{1}{mass}$

$$acceleration\left(m/s^2\right) = 0.498\ (N) \times \frac{1}{mass(kg)} - 0.005\left(m/s^2\right)$$

Y: acceleration $\left(m/s^2\right)$
m (slope): Force (N)
x: $\frac{1}{mass}$
b (Y-intercept) : acceleration $\left(m/s^2\right)$ this value should not exist if the experiment was perfect.

$$acceleration\left(m/s^2\right) = Force\ (N) \times \frac{1}{mass(kg)} - acceleration\left(m/s^2\right)$$

Newton's law states: $force = mass \times acceleration.$ A body accelerates when acted upon by a net external force, which means that the forces are not balanced, the net force is not zero. Acceleration is direct proportional to force. It is acting in the direction that the net force is acting. Acceleration is inverse proportional to mass.

The experiment proof Newton's second law. The correlation is almost one, which means that the % of error is very low. This lab is proof that the theory in Newton´s second law is true.

Calculation of error:

% of Error

Acceleration vs. 1/mass

$$\frac{0.498 - 0.49}{0.498} \times 100 \approx 1.6\%$$

Acceleration vs. Force

$$\frac{0.8755 - 0.875}{0.8755} \times 100 \approx 0.057\%$$

Sources of error:

Our results are not perfect. The b values should not exist and the m value is a little bit wrong compared to the expected. Therefore, something went wrong and here are some reasonable sources of error:

- The track could have had an incline that affected the acceleration.
- We never weighed the weights so it is possible that we have the wrong mass for the weights and the mass of the system.
- There can be something wrong with the technology, the GLX machine, the motion detector or the scaler we used to figure out the mass of the trolley.
- The human factor have big impact on this experiment. We probably released the trolley from different distances every time and the readings from the GLX machine was shifting.
- We started the experiment one day and finished it the day after. Things can have changed between the experiments. Maybe the trolleys was mixed up or the the incline of the track increased.