Newton's 2nd Law Experiment

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AIM: Validate Newton's second law. To find the relationship between acceleration and external force and draw a graph with acceleration against force.

EQUIPMENTS:

1. Air track,
2. air pump,
3. light gates,
4. digital timer,
5. glider,
6. weights,
7. little bucket, string,
8. digital balance.

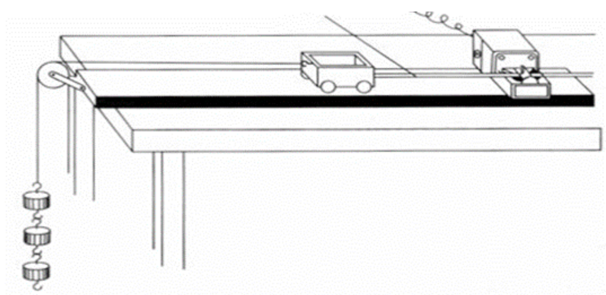

Figure 1: a graph of the main equipments (light gates, air track, digital balance, glider, etc.)

DATA COLLECTING:

1. Set up the equipments as the diagram.
2. Remain the mass of the glider as constant and change the number of the masses.

   The weight of small bucket is $(0.064 \pm 0.001)kg$ and the weight of nut is $(0.009 \pm 0.001)kg$
3. Collect the acceleration and the external force of the glider each time.
4. Organize the raw data in a data table with units and uncertainties.

   We did experiment with the bucket and 7 nuts.

We change the mass of the weight from the mass of the bucket, and add 1 nut each time and get the raw data below with uncertainty $\pm 0.001kg$ and $\pm 0.001m/s^2$ since the data are measured with digital equipment.

	Mass (kg)	Acceleration (m/s^2)
1	0.064 ± 0.001	0.266 ± 0.001
2	0.073 ± 0.001	0.304 ± 0.001
3	0.081 ± 0.001	0.341 ± 0.001
4	0.090 ± 0.001	0.378 ± 0.001
5	0.098 ± 0.001	0.416 ± 0.001
6	0.107 ± 0.001	0.450 ± 0.001
7	0.115 ± 0.001	0.483 ± 0.001
8	0.124 ± 0.001	0.521 ± 0.001

The external force of the glider is $T = mg$ where m is the mass of the weights and the little bucket. Because the glider is on the air track, the friction is very small and can be neglected.

So the external force $F_{net} = T = mg$.
The uncertainty of F_{net} can be calculated using

$$\frac{\Delta F_{net}}{F_{net}} = \frac{\Delta m}{m}$$

So

$$\Delta F_{net} = \frac{\Delta m}{m} \cdot F_{net} = \frac{\Delta m}{m} \cdot mg = \Delta m \cdot g$$

For example, when $m = (0.064 \pm 0.001)$kg, $\Delta F_{net} = 0.001 \cdot g$.
In Shanghai, the gravitational acceleration $g = 9.794$, so ΔF_{net} remained to be $0.009794 \approx 0.01$ N.
And $F_{net} = mg = 0.064 \cdot 9.794 = 0.626816 \approx 0.63$N
So the value containing uncertainty is $F_{net} = (0.63 \pm 0.01)$N.
Using the same method, we can derive the processed data table:

	Net Force (N)	Acceleration (m/s^2)
1	0.63 ± 0.01	0.266 ± 0.001
2	0.71 ± 0.01	0.304 ± 0.001
3	0.79 ± 0.01	0.341 ± 0.001
4	0.88 ± 0.01	0.378 ± 0.001
5	0.96 ± 0.01	0.416 ± 0.001
6	1.05 ± 0.01	0.450 ± 0.001
7	1.13 ± 0.01	0.483 ± 0.001
8	1.21 ± 0.01	0.521 ± 0.001

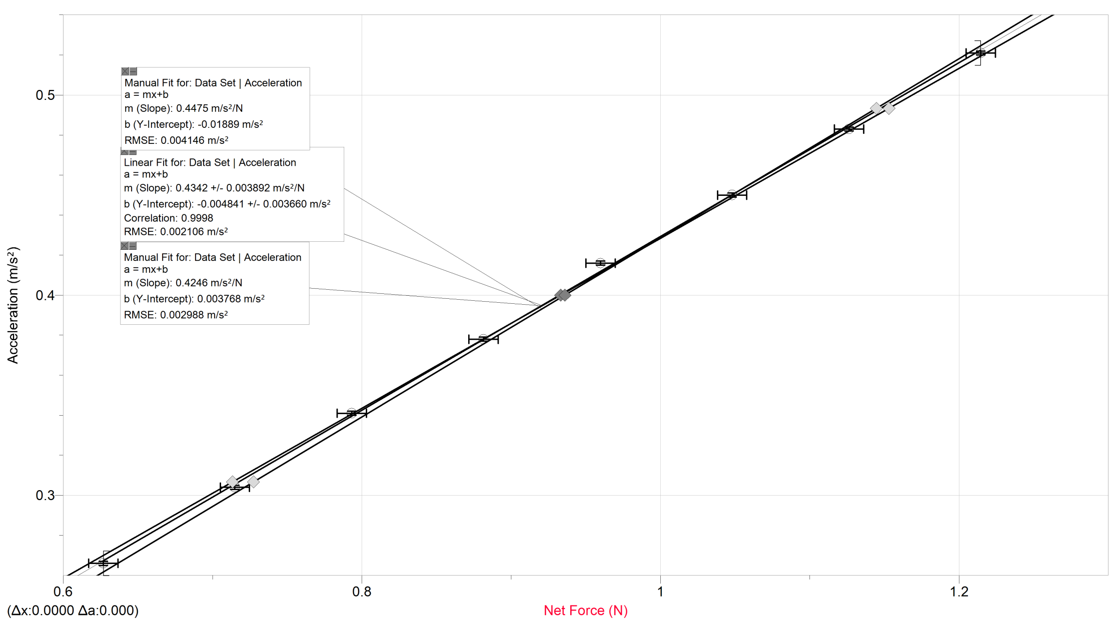

Figure 2: a-F_{net} graph with error bar

Because the line is nearly a straight line passing through the origin, we can draw the conclusion that actually a is proportional to F_{net}.

Thus, when m is constant, a is proportional to F_{net}.

EVALUATION:

The line has its Y-intercept not equal to 0 and the systematic error may be the result of the friction force between air track and glider is non equal.