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Physics Laboratory Report

Title 表題

The Second Law of Motion

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Summary
In this experiment, we let a Dynamic Cart run on a desk by using rubber bands, and calculated its acceleration ~~of it~~. We made six different cases changing the mass of the cart or number of the rubber strings, and examined its effect on the acceleration. Then we realized that every object follow Newton's Second Law of motion : $\Sigma\vec{F} = m\vec{a}$.

Addition/Correction 追加／修正		

・Meet a deadline ・Write logically ・Write clearly ・Write with your own words

・締切り守って ・論理的に ・わかりやすく ・自分のことばで

実験．解析，レポート，表，グラフと共にすばらしいできである。

* Write your report in Japanese or in English * Use this form as a front cover.

* Submit your reports by the seventh day after your lab. You can add to or correct your report: note when you have done this.

I. Introduction

1. Objectives

Prove the second Low of Motion by Newton about force, mass, and acceleration.

2. Theory

Newton's second law: $\Sigma\vec{F} = m\vec{a}$

When the force is constant, acceleration is inversely proportional to the mass of the moving object.

When the mass is constant, acceleration is directly proportional to the force.

II. Experiment

1. Apparatus

- Spark Timer
- C Clamp
- Recording Tape
- Dynamic Cart
- Desk
- Rubber String
- Small Clamp
- Wooden Block
- Spring Scale
- Safety Goggles

2. Methods

① Make single and double 50cm rubber string, and form a ring at every edge of the string.

② Set the apparatus on the desk as shown in Fig.1.

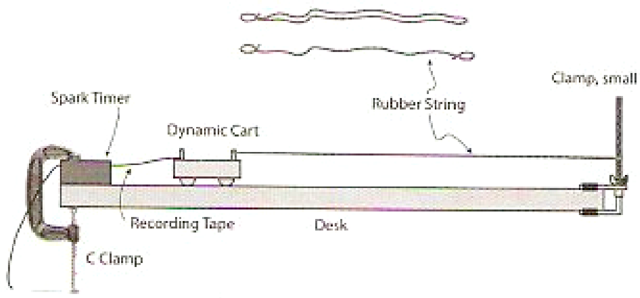


Fig.1 (Cited from tmoritani.com)

③ Measure the mass of the dynamic cart.

④ Put on the safety goggles.

⑤ Use single rubber string to let the dynamic cart run, and record the motion on the recording tape by spark timer.

⑥ Put 250g weights on the dynamic cart and do the same experiment (1 and 2 weights).

⑦ Adjust zero of the spring measure.

⑧ Measure the elastic force of the rubber string by spring measure as shown in Fig.2.

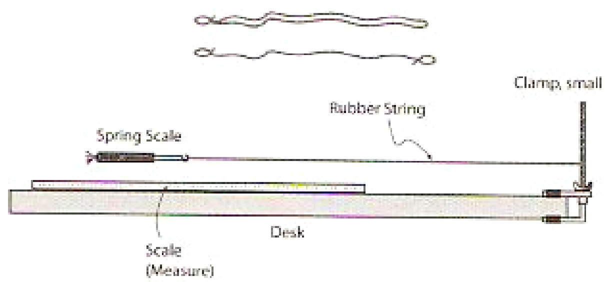


Fig.2 (Cited from tmoritani.com)

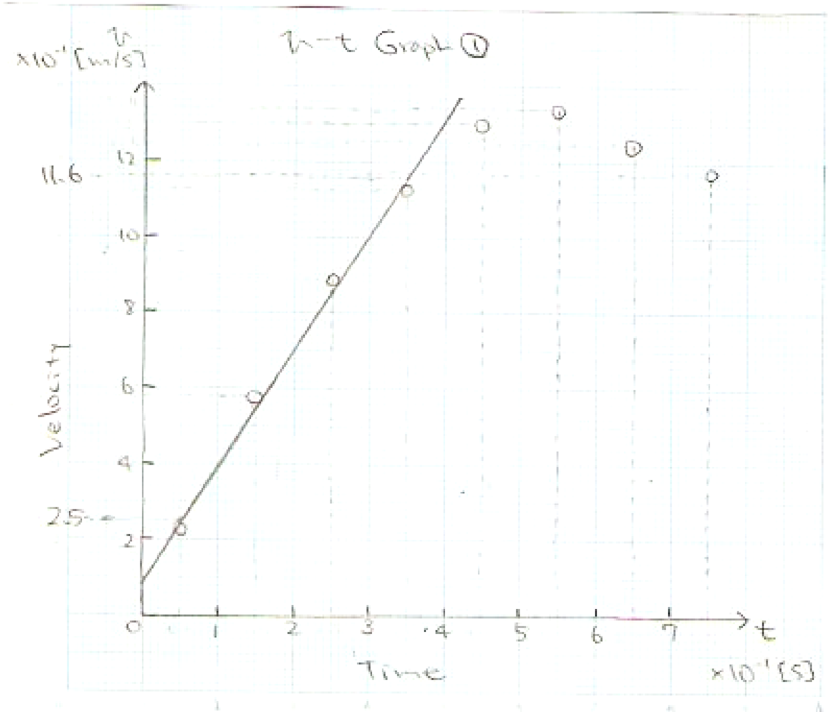
⑨ Change the number of rubber string and do the same experiment (2, 3, and 4 strings).

III.Results

① Single rubber string and no weights on the cart.

-Elastic Force 2.2N

-Mass of the Cart 494g



$$a = \frac{\Delta v}{\Delta t}$$

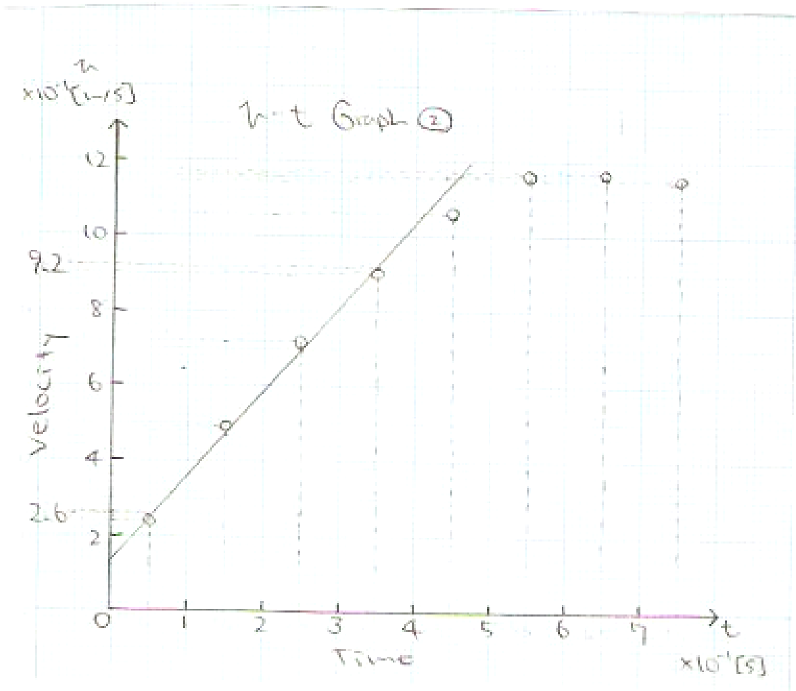
$$= \frac{(11.6-2.5)\times10^{-1}}{(3.5-0.5)\times10^{-1}}$$

$$= 3.03 \ [m/s^2]$$

② Single rubber string and 1 weight on the cart.

-Elastic Force 2.2N

-Mass of the Cart 744g



$$a = \frac{\Delta v}{\Delta t}$$

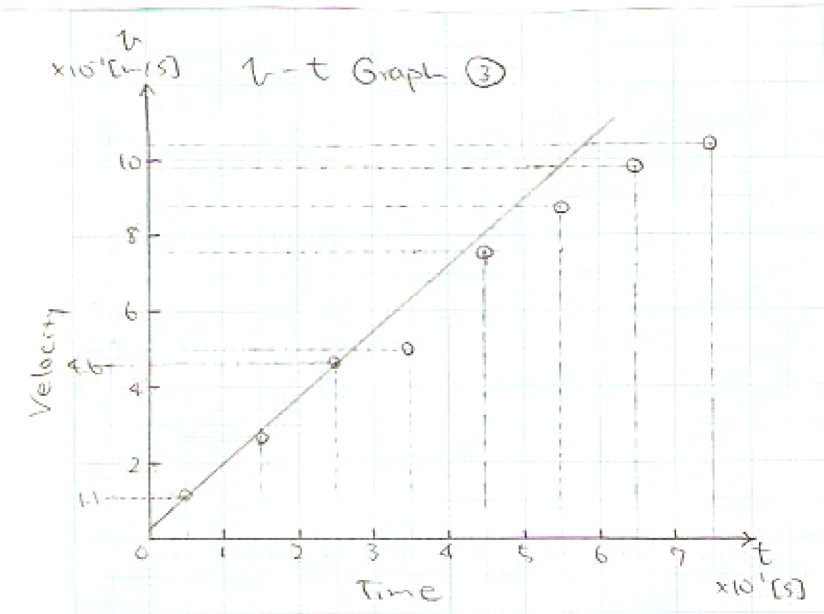
$$= \frac{(9.2-2.6)\times10^{-1}}{(3.5-0.5)\times10^{-1}}$$

$$= 2.20\ [m/s^2]$$

③ Single rubber string and 2 weights on the cart.

-Elastic Force 2.2N

-Mass of the Cart 994g



$$a = \frac{\Delta v}{\Delta t}$$

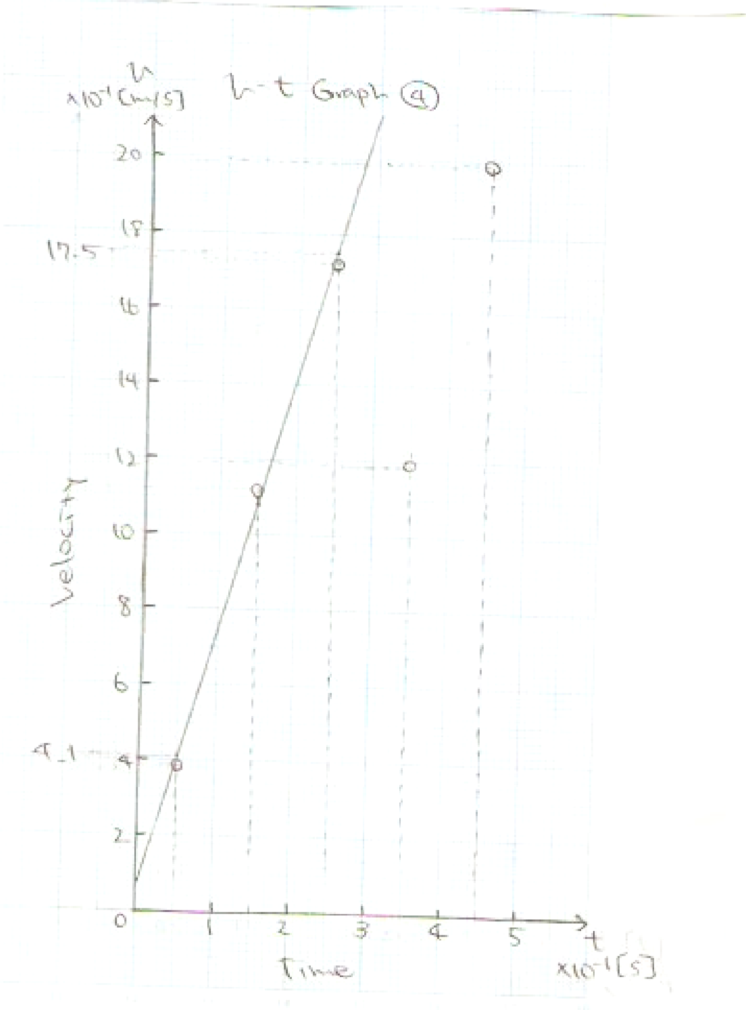
$$= \frac{(4.6-1.1)\times10^{-1}}{(2.5-0.5)\times10^{-1}}$$

$$= 1.75\ [m/s^2]$$

④ Double rubber strings and no weights on the cart.

-Elastic Force 4.4N

-Mass of the Cart 494g



$$a = \frac{\Delta v}{\Delta t}$$

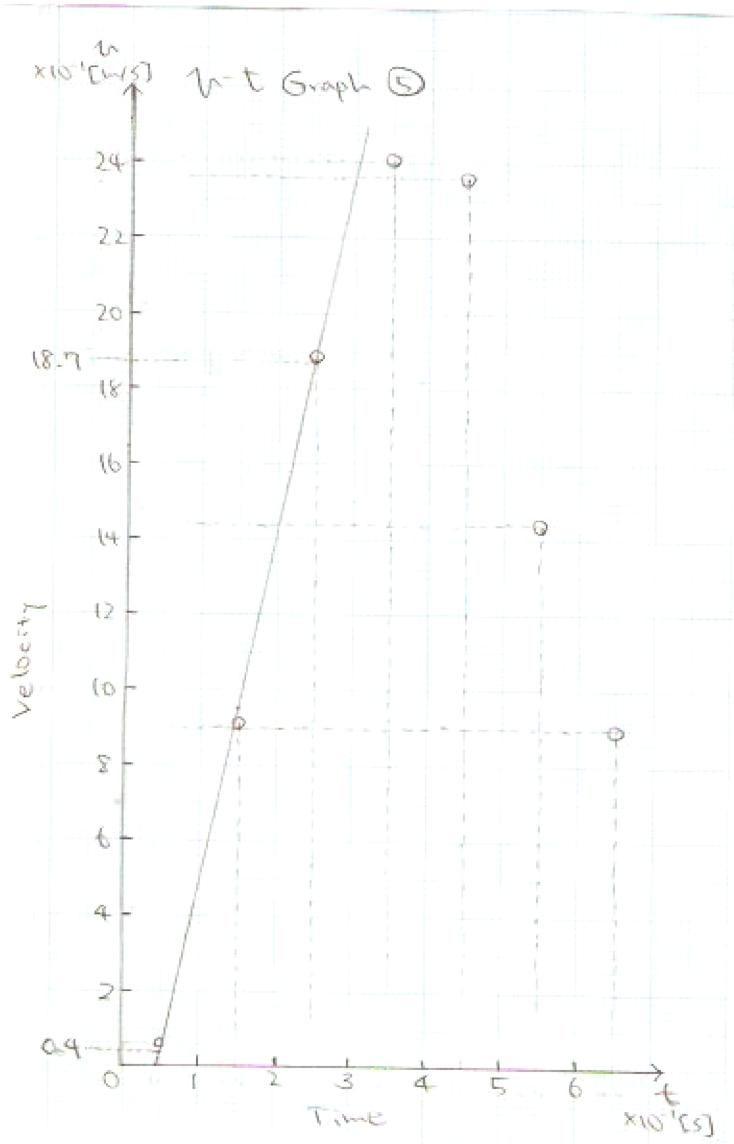
$$= \frac{(17.5-4.1)\times 10^{-1}}{(2.5-0.5)\times 10^{-1}}$$

$$= 6.70\ [m/s^2]$$

⑤ Triple rubber strings and no weights on the cart.

·Elastic Force 6.6N

·Mass of the Cart 494g



$$a = \frac{\Delta v}{\Delta t}$$

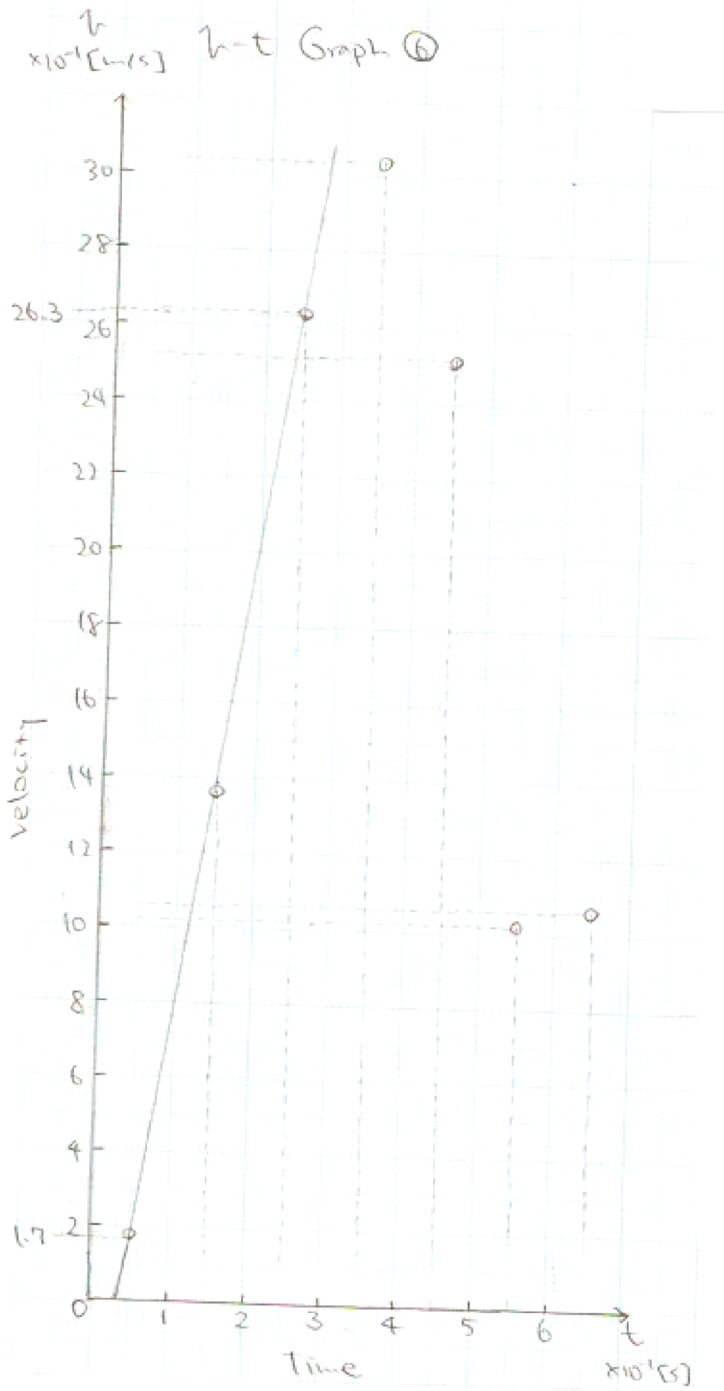
$$= \frac{(18.7 - 0.4) \times 10^{-1}}{(2.5 - 0.5) \times 10^{-1}}$$

$$= 9.15\ [m/s^2]$$

⑥ Four rubber strings and no weights on the cart.

-Elastic Force 8.8N

-Mass of the Cart 494g



$$a = \frac{\Delta v}{\Delta t}$$

$$= \frac{(26.3 - 1.7)\times 10^{-1}}{(2.5 - 0.5)\times 10^{-1}}$$

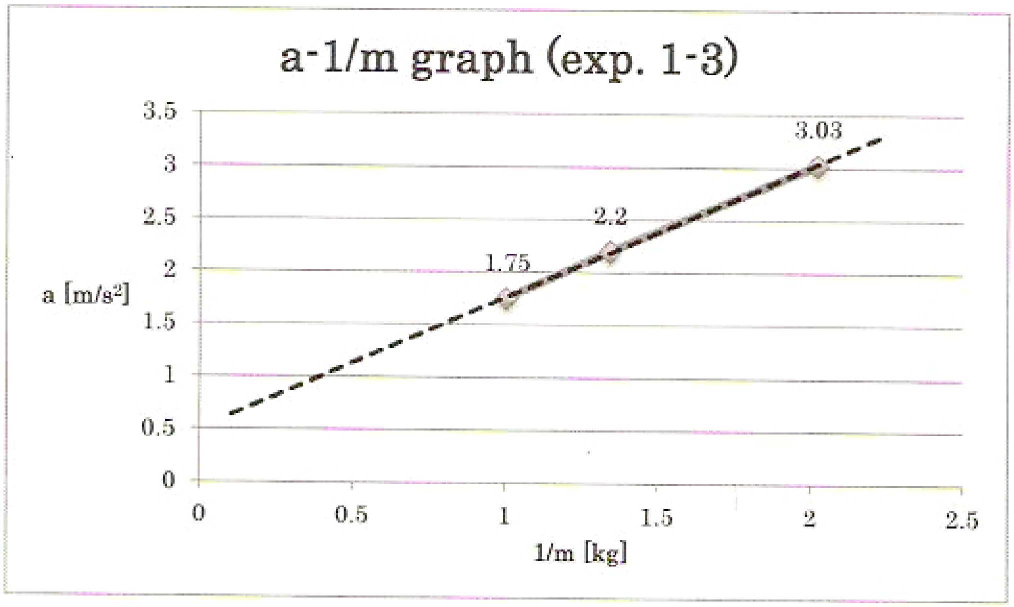
$$= 12.3\ [m/s^2]$$

この表はわかりやすい

Exp . #	Numbe r of Rubber String	Origina l Length of Rubber String	Expande d Length of Rubber String	Elasti c Force (F)	Mass of Cart Includin g Weights (m)	(1/m)	Acceleratio n (a)
		m	m	N	kg	kg	m/s²
1	1	0.513	1.05	2.20	0.494	2.02	3.03
2	1	0.513	1.05	2.20	0.744	1.34	2.20
3	1	0.513	1.05	2.20	0.994	1.01	1.75
4	2	0.522	1.05	4.40	0.494	2.02	6.70
5	3	0.516	1.05	6.60	0.494	2.02	9.15
6	4	0.521	1.05	8.80	0.494	2.02	12.3

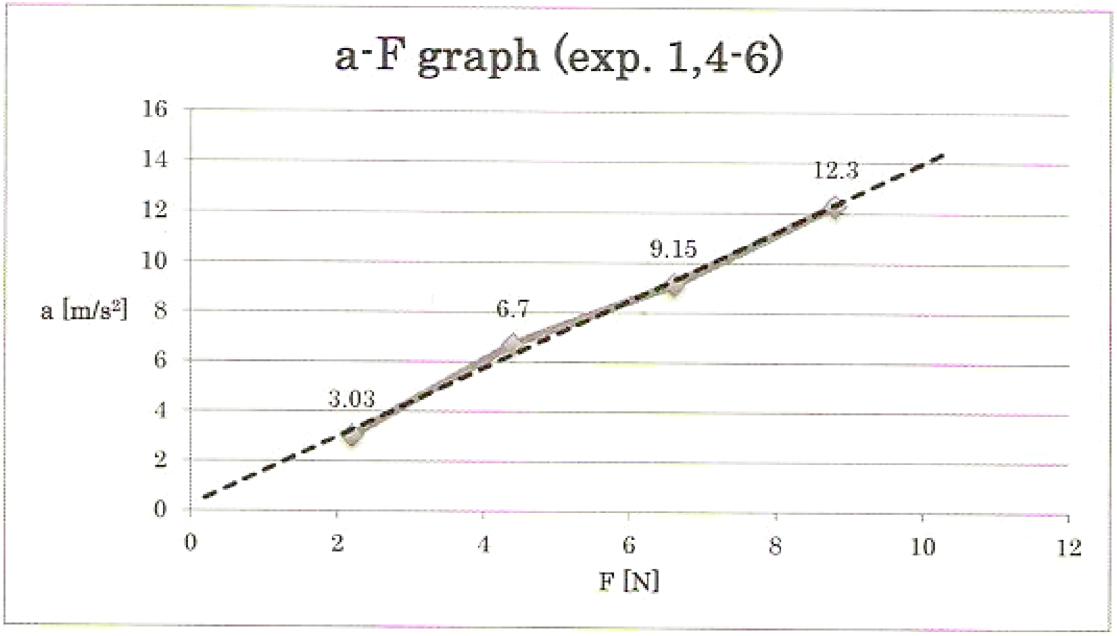
← 単語の途中で行替えが起っているのは良くない。

工夫しなさい。



→The acceleration and the value of 1 over the mass are directly proportional.

→The acceleration and mass of the object are inversely proportional.



→The acceleration and force are directly proportional.

IV. Discussion

- The acceleration and the mass of the object are inversely proportional if the force is constant.
  Furthermore, the acceleration and force are directly proportional if the mass is constant.
  These results follow Newton's second law: $\Sigma\vec{F} = m\vec{a}$.

- Percent Error
  From a-1/m graph, we can calculate the elastic force of experiment 1-3. Comparing it to the actual value of elastic force we measured, we can find the percent error.
  - [Exp.1]
    F=am
    $= 3.03 \times 0.494$
    $= 1.50$

$$\% Error = \frac{|2.20-1.50|}{2.20} \times 100\%$$

$=31.8\%$

- [Exp.2]

F=am

$= 2.20 \times 0.744$

$=1.64$

$$\% Error = \frac{|2.20-1.64|}{2.20} \times 100\%$$

$=25.5\%$

- [Exp.3]

F=am

$= 1.75 \times 0.994$

$=1.74$

$$\% Error = \frac{|2.20-1.74|}{2.20} \times 100\%$$

$=20.9\%$

From a-F graph, we also find the percent error by comparing measured mass and actual mass.

- [Exp.1]

$$m = \frac{F}{a}$$

$$= \frac{2.20}{3.03}$$

$= 0.726$

$$\% Error = \frac{|0.494-0.726|}{0.494} \times 100\%$$

$=47.0\%$

- [Exp.4]

$$m = \frac{F}{a}$$

$$= \frac{4.40}{6.70}$$

$$= 0.657$$

$$\% \, Error = \frac{|0.494 - 0.657|}{0.494} \times 100\%$$

$$= 33.0\%$$

- [Exp.5]

$$m = \frac{F}{a}$$

$$= \frac{6.60}{9.15}$$

$$= 0.721$$

$$\% \, Error = \frac{|0.494 - 0.721|}{0.494} \times 100\%$$

$$= 46.0\%$$

- [Exp.6]

- $m = \frac{F}{a}$

$$= \frac{8.80}{12.3}$$

$$= 0.715$$

$$\% \, Error = \frac{|0.494 - 0.715|}{0.494} \times 100\%$$

$$= 44.7\%$$

➢ Possible causes of the error

- The start point of the cart was wrong.
- The lengths of the rubber strings were different.
- The spark timer did not record the motion correctly because of

its ink.

- We may did not read the recording tape correctly.

- In v-t graphs of experiment 4 and 6, the velocity once decreases but then increases again as the time increase.
  The velocity decreases because the force of rubber string decreases as the cart runs. There is also frictional resistance.
  The velocity then increases again because the cart drops from the desk as it runs very fast.

V. Conclusions

Every object follows Newton's second law: $\Sigma\vec{F} = m\vec{a}$.
If the force is constant, mass of the object and its acceleration are inversely proportional.
If the mass is constant, force and acceleration are directly proportional.

VI. Opinions

During the experiment, the ink of the spark timer ran out and we could not conduct the procedure smoothly. But we got the correct data after changing the ink.
I could understand Newton's second law when I was introduced it, but I hardly could imagine it. However, doing this experiment, the law now totally makes sense to me.

VII. Reference

Lab Report by Takahide Miyairi (2013)