Date of Lab____________ Date of Submission______________

Laboratory Report

Title Moment of Inertia and Rotational Motion
Hooke's Law and Spring Pendlum

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Summary

We did two experiments.
First, we tried to determined a spring constant k by the Hooke's Law apparatus and by measuring the period. In this experiments, I knew that elastic force was in proportion to displacement and we could determined a spring constant k both ways.
Second, we investigated the equation of rotational motion by using rotational apparatus. Then, I knew that torque was in proportion to angular acceleration.

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

Teacher's Comments
Very clear and reasonable analysis and discussion

1	2	3	4	5	6	7	8	9
Due	Summary	Intro.	Method.	Results	Table/Fig.	Discussion	Clearness	General
+					+++	+	+	++

* Use this form as a cover sheet.
* Submit your reports by the seventh day after your lab.

Introduction.

Objective.

To determine a spring constant k (N/m) by using the Hooke's Law apparatus.

To determine a spring constant k (N/k) by measuring the period.

Theory and Past Knowledge.

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$$

F = kx

Hypothesis.

According to Hooke's Law apparatus, F (force) will be in proportion to x (displacement).

T^2 (the square of period) will be in proportion to m (mass of weighs).

Experimental.

Instruments.

- Spring
- Weights
- Stand
- Stop watch

Procedure.

1. Hang a string from the stand. Put weights of 20g on the end of the string.
2. Record the time of the string going up and down 20 times. Find the period.
3. Find the spring constant by using the Hooke's Law apparatus and from the period.
4. Repeat the experiment with other weight of weights, such as 50g, 70g and 100g.

Result.

Table 1. Result of spring A

m ($\times 10^{-3}$ kg)	F (N)	x ($\times 10^{-2}$ m)	t (s)	T (s)	T^2 (s^2)
20	0.196	0.8	4.81	0.2405	0.05784
30	0.294	1.3	5.28	0.2640	0.06970
50	0.490	1.8	6.06	0.3030	0.09181
70	0.686	2.8	6.65	0.3325	0.11056
100	0.980	3.9	7.87	03935	0.15484

Table 2. Result of spring B

m ($\times 10^{-3}$ kg)	F (N)	x ($\times 10^{-2}$ m)	t (s)	T (s)	T^2 (s^2)
20	0.196	0.6	4.40	0.2200	0.04840
30	0.294	0.8	5.21	0.2605	0.06786
50	0.490	1.4	5.90	0.2950	0.08703
70	0.686	2.2	6.62	0.3310	0.10956
100	0.980	3.0	7.56	0.3780	0.14288

The spring constant k calculated from the slopes of Graph 1. OK

$F = kx$

$k = \frac{\Delta F}{\Delta x}$

Spring A: $k = \frac{1.0-0.2}{0.04-0.01} = 26.66$ (N/m)

Spring B: $k = \frac{0.95-0.4}{0.03-0.013} = 32.35$ (N/m)

The spring constant k calculated from the slopes of Graph 2.

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T^2 = 4\pi^2\ \frac{m}{k}$$

$$k = \frac{4\pi 2\Delta m}{\Delta T2}$$

Spring A: $k = \frac{4\pi 2(0.1-0.045)}{0.15-0.085} = 33.40$ (N/m)

Spring B: $k = \frac{4\pi 2(0.080-0.025)}{0.12-0.055} = 33.40$ (N/m)

Table 3. The spring constant k (N/m)

	Graph 1	Graph 2
Spring A	26.66	33.40
Spring B	32.35	33.40

very clear

Discussion.

As shown in graph 1, the elongation became longer as the elastic force was larger. It meant that there was a direct relationship between them (x and F). This relationship is also shown by Hooke's Law. Some dots were away from the lines in graph 1 because the springs might not stop.

As sown in graph 2, the period became longer as the weights were heavier. It meant that there was a direct relationship between them (m and T^2). This relationship is also shown by $T = 2\pi\sqrt{\frac{m}{k}}$.

As shown in table 3, the spring constant k calculated from graph 1 was almost same as one calculated from graph 2. The difference of k of spring A was larger than the difference of spring B. It was because the resonance occurred and the spring A didn't go up and down straight when using spring A and 100g weights. It made the period long. If there was no resonance, the period (when using 100g weigh) would be short, the slope of spring A in graph 2 would be gentle, and the difference would be less.

Conclusion.

F (elastic force) is in proportion to x (displacement).

T^2 (the square of period) is in proportion to m (mass of weights).

We can use both Hooke's Law and $T = 2\pi\sqrt{\frac{m}{k}}$ to determine a spring constant k.

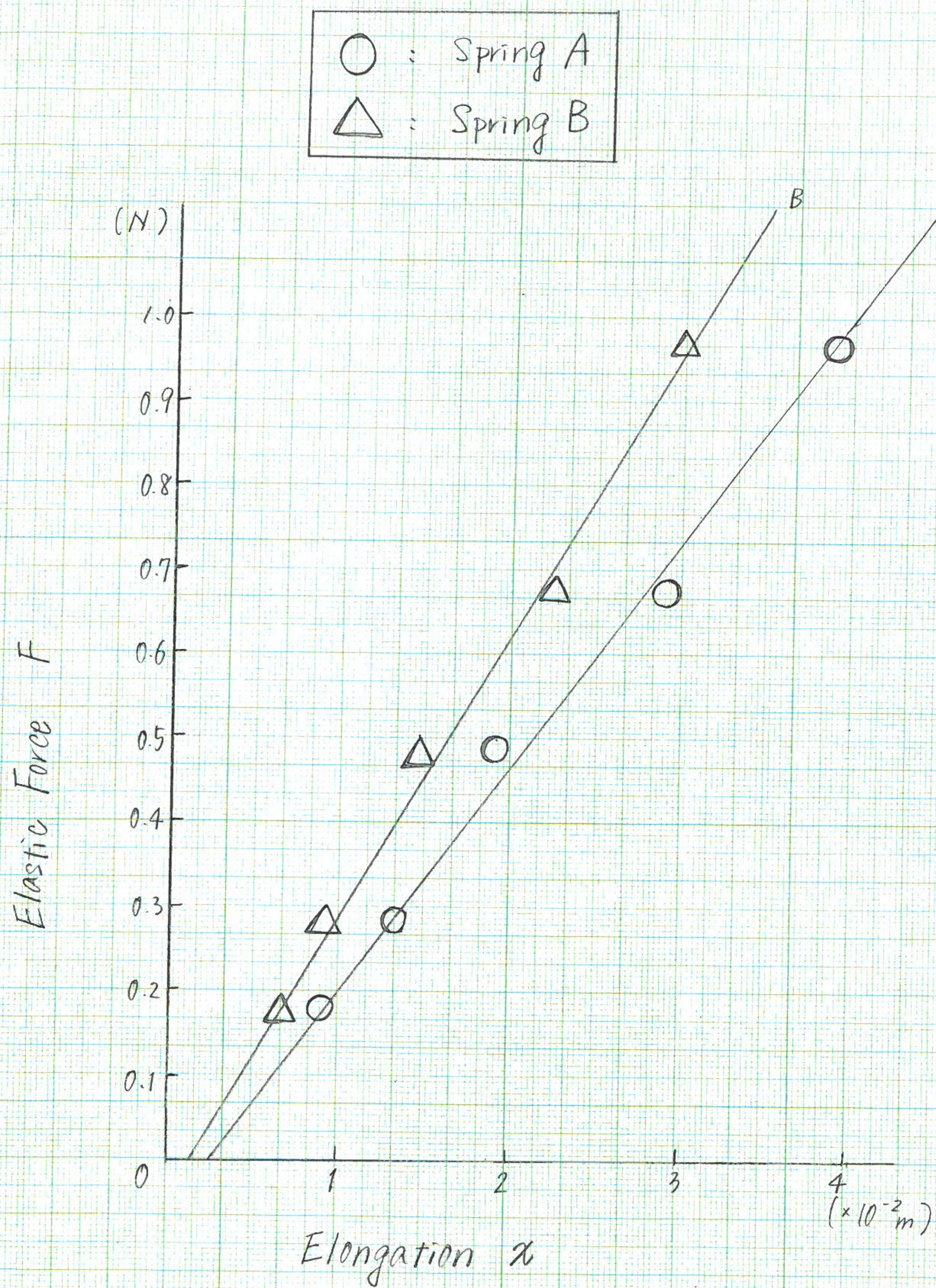
Opinion.

I learned two ways to determine a spring constant k. I want to use both ways to check calculation. Also, I saw the resonance of a spring in this experiment. I want to know the condition that the resonance occurs. I understood the relationship between period and mass through this experiment.

Reference.

Nozomi Takaki's lab report

Hibiki Shigetomi's lab report

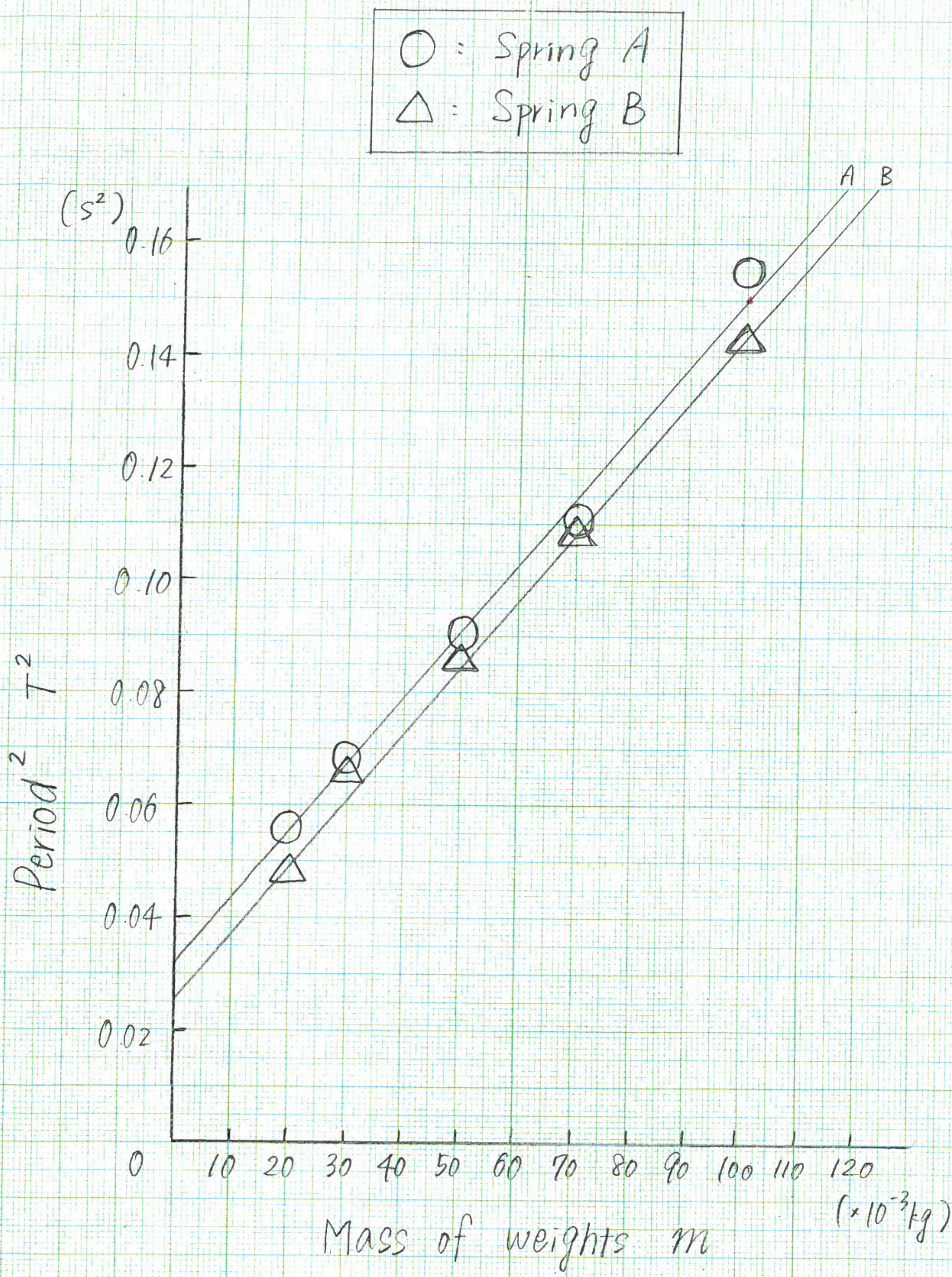


Graph 1. Elongation x vs. Elastic Force F

$$\text{Slope} = \frac{(.15 - .032)}{100 \times 10^{-3}\ \text{kg}} = 1.18 = \frac{T^2}{m}$$

$$T^2 = 4\pi^2 \cdot \frac{m}{k}$$

$$k = 4\pi^2 \frac{m}{T^2} = 4\pi^2 \times \frac{1}{1.18} = \underline{33.5}$$



Graph 2. Mass of weighs m vs. Period² T^2

Introduction.

Objective.

Investigation of the equation of rotational motion.

Theory and Past Knowledge.

$I = 1/2\ MR^2$

$a = -\ 2d/t^2$

$T - mg = ma\ (T = m(a+g))$

$\alpha = a/r$

$\tau = -Tr$

$\tau = I\alpha$

Experimental.

Instruments.

- Rotational motion apparatus
- Pulley
- String
- Weight
- Stop watch

Procedure.

1. Set the instruments like a figure below.
2. Put 50g weights on the end of a spring.
3. Record the time of the weights falling 1m.
4. Repeat the experiment with other weights such as 100g, 150g…

Result.

M = 0.944 (kg)

R = ~~25~~ 12.5 ($\times 10^{-2}$ m)

I = 1/2MR^2 = ~~0.0295~~ 7.38×10^{-3}

Table 1.

Experiment #	1	2	3	4
Radius of hub r ($\times 10^{-2}$ m)	2.58	2.58	2.58	2.58
d (m)	1.0	1.0	1.0	1.0
Weight m ($\times 10^{-3}$ kg)	50	100	150	200
Time t (s)	5.96	4.03	3.56	2.97
Acceleration a (m/s^2)	-0.0563	-0.1231	-0.1578	-0.2267
Tensional force T (N)	0.4872	0.9677	1.4463	1.9147
Torque τ(Nm)	-0.0126	-0.0250	-0.0373	-0.0494
Angular acceleration α (rad/s^2)	-2.1822	-4.7713	-6.1163	-8.7868

Determine torque by using the equation of rotational motion:

Experiment 1: $\tau = I\alpha = 0.0295 \times (-2.1822) = -0.0644$

Experiment 2: $\tau = I\alpha = 0.0295 \times (-4.7713) = -0.1408$

Experiment 3: $\tau = I\alpha = 0.0295 \times (-6.1163) = -0.1804$

Experiment 4: $\tau = I\alpha = 0.0295 \times (-8.7868) = -0.2592$

Table 2. Comparison of torque

Experiment #	1	2	3	4
$\tau = -Tr$ (Nm)	-0.0126	-0.0250	-0.0373	-0.0494
$\tau = I\alpha$ (Nm)	~~-0.0644~~ 0.0161	~~-0.1408~~ 0.0352	~~-0.1804~~ 0.0451	~~-0.2592~~ 0.0648

Discussion.

As shown in graph1, torque became smaller as angular acceleration was slower. It meant that there was a direct relationship between them (τ and α).

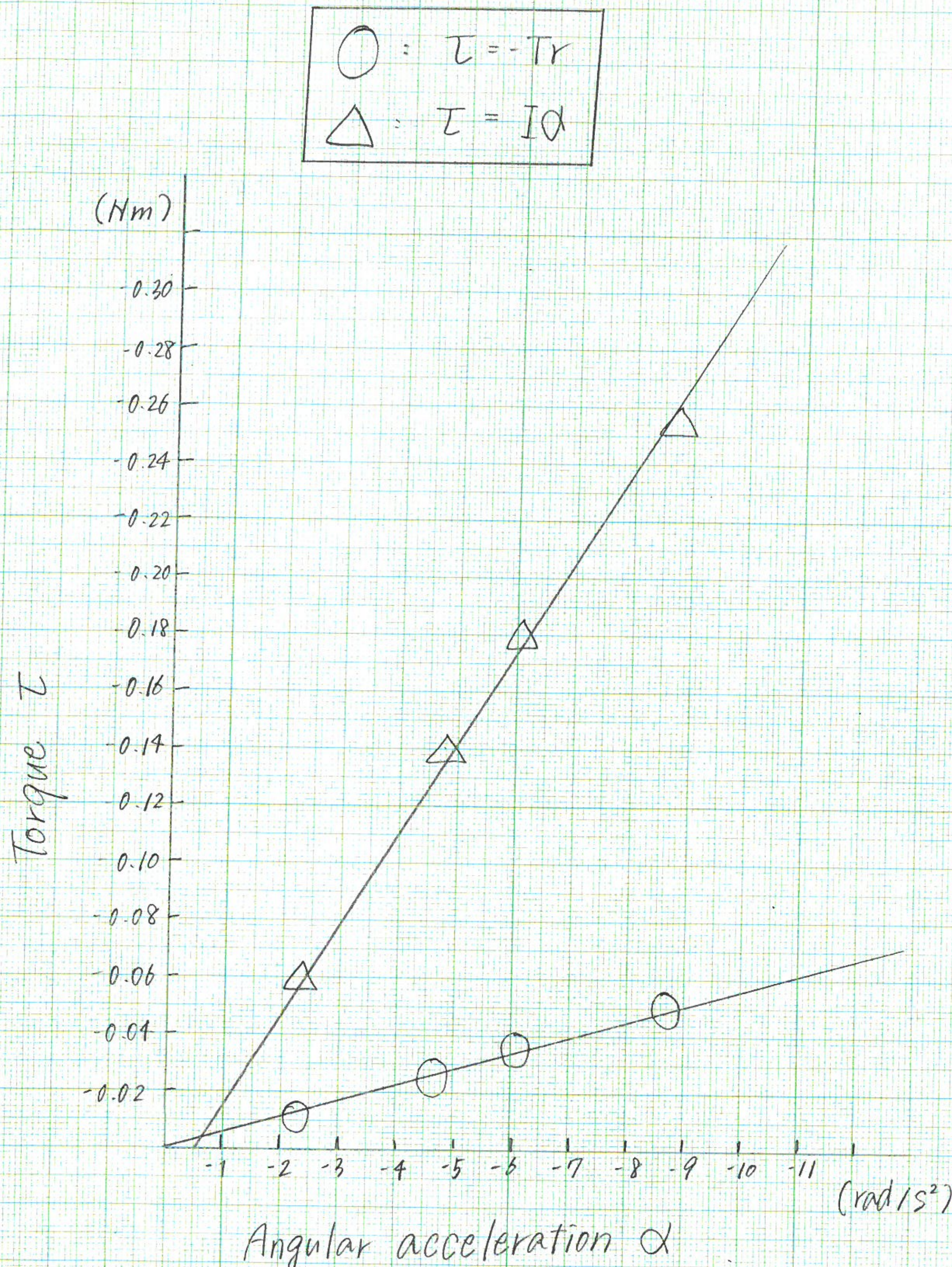
As shown in table2, torque was quite different from the torque that was calculated by equation of rotational motion. Some sources of error were considered. One of them was friction between string and pulley. It caused time to be slow. Then acceleration would become slow and tensional force would become small, then torque would be small. Also. As weights was heavier, the difference became larger. It was because time was too fast to measure when heavy weights were putted. If we could time accurately and decrease friction, we would get good result.

Conclusion.

τ (torque) is in proportion to α (angular acceleration).

Opinion.

In this experiment, there were a lot of equation. So, it was difficult for me to calculate a, T and so on. When I looked at Rotational motion apparatus, I remembered a top. A top is involved in previous unit. This connection is interesting. I want know other connections that are unimaginable.



Graph 1. Angular acceleration α vs. Torque τ