Date of Lab 10/1/2014 Date of Submission 10/15/2014

Physics Laboratory Report

Title 表題

Forces in Equilibrium

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Summary

To ascertain that the net force made from several forces in equilibrium is zero, we did this experiment using a force table. In this experiment, we put different weights in 3 or 4 hangers and balance them. Using the angles of the wires at the equilibrium and weight data, we drew figures by parallelogram method and Head-to-Tail method to calculate $\vec{A}+\vec{B}+\vec{C}+\vec{D}$. math analysis

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・作図ともに正確．ていねいに実施している．3方法をならべてレポートしたのはすばらしく良い．3方法と定量的に比較すればもっと良かった． すぐれたレポートです

* 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.

Introduction

1. Objectives

- To ascertain that the net force made from several forces in equilibrium is zero by using a force table.

2. Theory

The net force of all the forces acting on three or four wires is zero.

$$\vec{A} + \vec{B} + \vec{C} + \vec{D} = 0$$

Experiment

1. Apparatus

- Force Table
- Wires
- Pulleys
- Hangers
- Ring
- Graph Paper
- Ruler
- Circular Protractor
- Weights

2. Methods

① Set the force table with pulleys, wires (A-D), rings, and hangers.

② Put different weights in three or four hangers.

③ Set one of wire A at 0 on the force table.

④ Change the positions of the other wires to let the ring be at the center and balance all of the wires.

⑤ Read the angle of the wires on the force table.

⑥ Make a table of weight (kg), Newton (N), and angle (degree).

⑦ Make figures on the graph paper using parallelogram method and head-to-tail method.

⑧ Change the types of weights and do the same thing.

⑨ Find the net force at the unbalanced state.

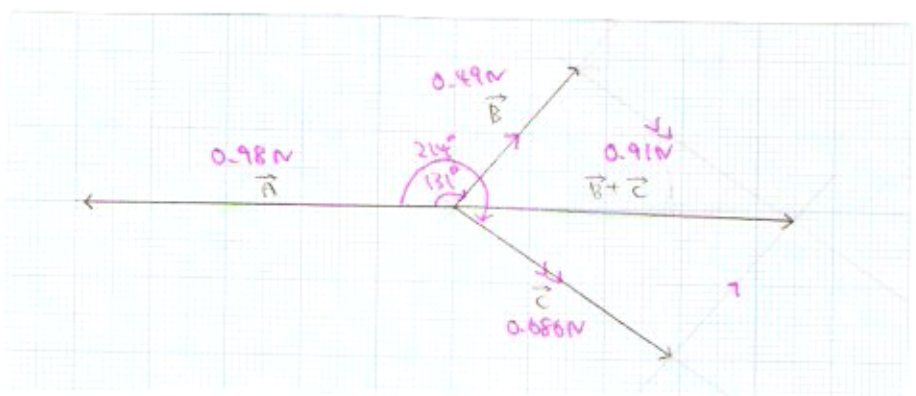
⑩ Do mathematical analysis and compare it to the figures.

Results

Test1

Table1-1	Kg	N	Angle
A	0.1	0.98	0°
B	0.05	0.49	131°
C	0.07	0.69	214°

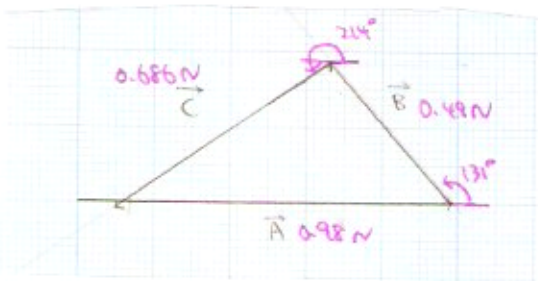
① Figuring Analysis



[Parallelogram Method] Fig.1-1

If they were balanced, the two lines of net force would have the same length and would be on the opposite sides.

3 方法を対比したのが 大変良い



[Head-to-Tail Method] Fig.1-2

If they were balanced, the tail of $\vec{C}$ line would reach the top of $\vec{A}$ line.

② Mathematical Analysis

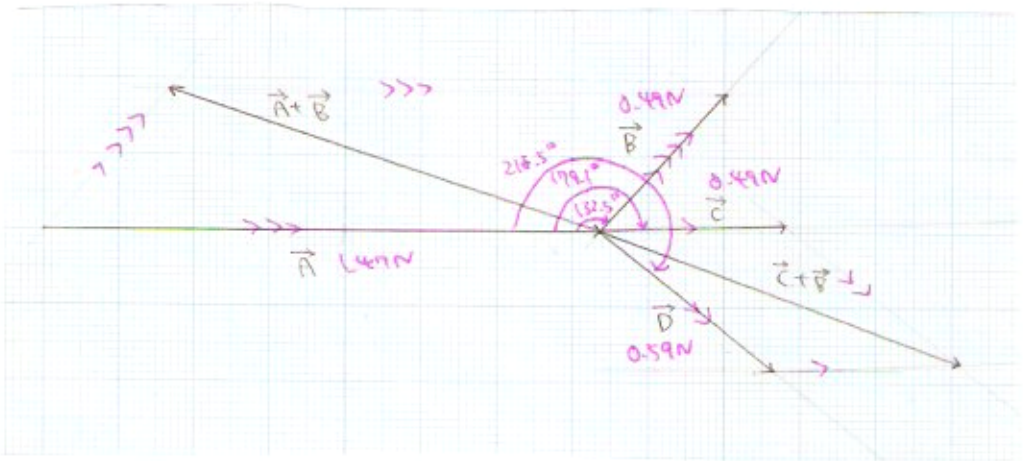
Table1-2	F [N]	θ [°]	$F_x = F\cos\theta$ [N]	$F_y = F\sin\theta$ [N]
A	0.98	0°	0.98	0
B	0.49	131°	-0.321	0.370
C	0.69	214°	-0.572	-0.386
		$\Sigma F_x, \Sigma F_y$	0.087	-0.016

If they were completely balanced, $\Sigma F_x = 0$, $\Sigma F_y = 0$.

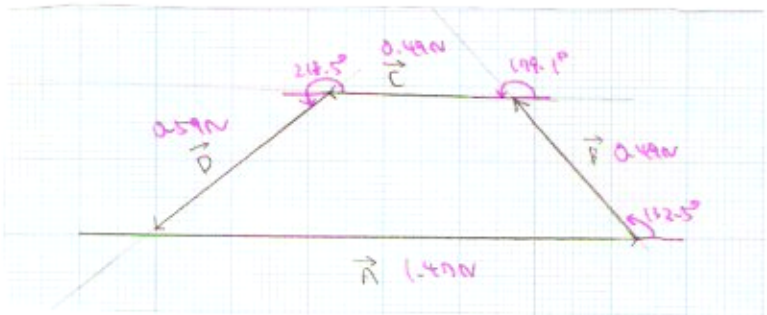
Test2

Table2-1	Kg	N	Angle
A	0.15	1.47	0°
B	0.05	0.49	132.5°
C	0.05	0.49	179.1°
D	0.06	0.59	218.5°

① Figuring Analysis



[Parallelogram Method] Fig.2-1



[Head-to-Tail Method] Fig.2-2

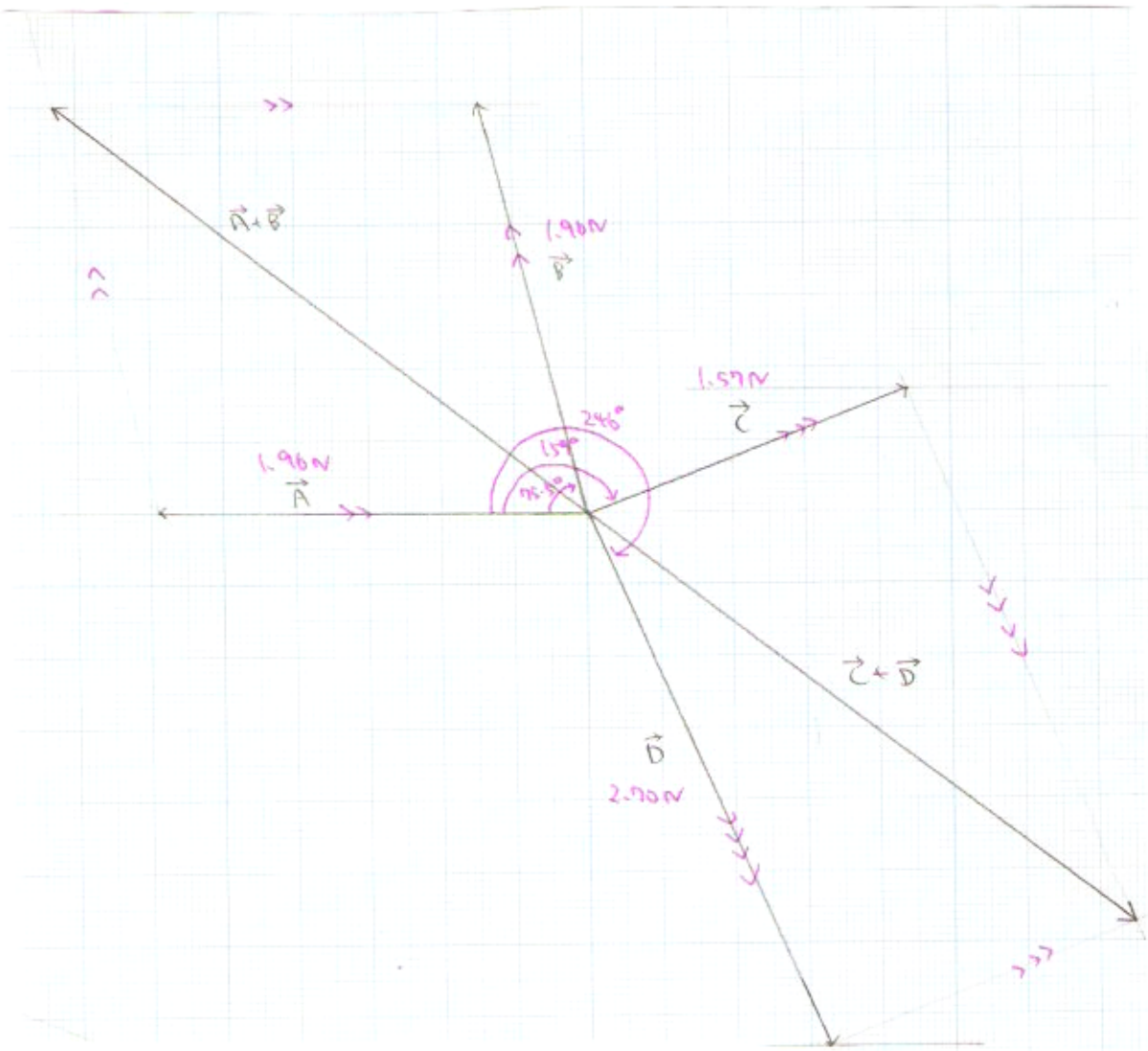
② Mathematical Analysis

Table2-2	F [N]	θ [°]	$F_x = F\cos\theta$ [N]	$F_y = F\sin\theta$ [N]
A	1.47	0°	1.47	0
B	0.49	132.5°	-0.331	0.361
C	0.49	179.1°	-0.490	0.008
D	0.59	218.5°	-0.462	-0.367
		$\Sigma F_x, \Sigma F_y$	0.187	0.002

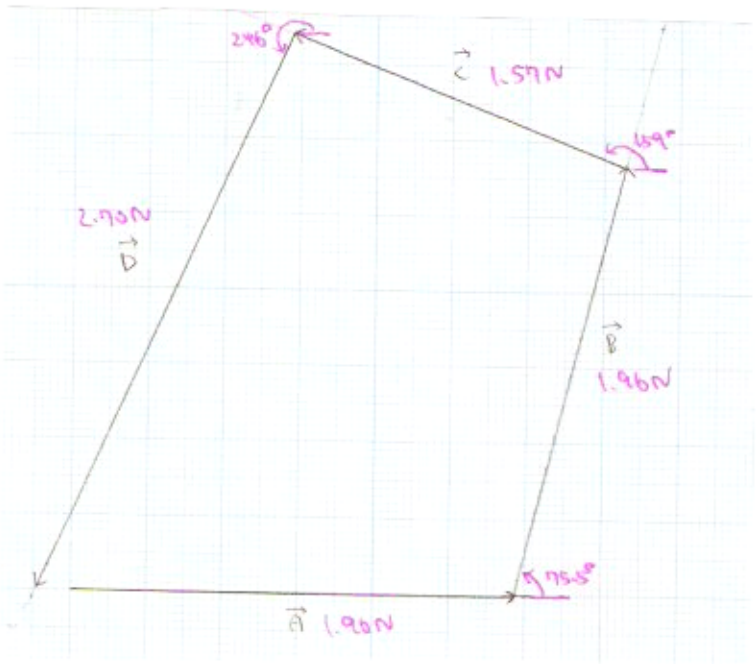
Tset3

Table3-1	Kg	N	Angle
A	0.2	1.96	0°
B	0.2	1.96	75.5°
C	0.16	1.568	159°
D	0.275	2.695	246°

① Figuring Analysis



[Parallelogram Method] Fig.3-1



[Head-to-Tail Method] Fig.3-2

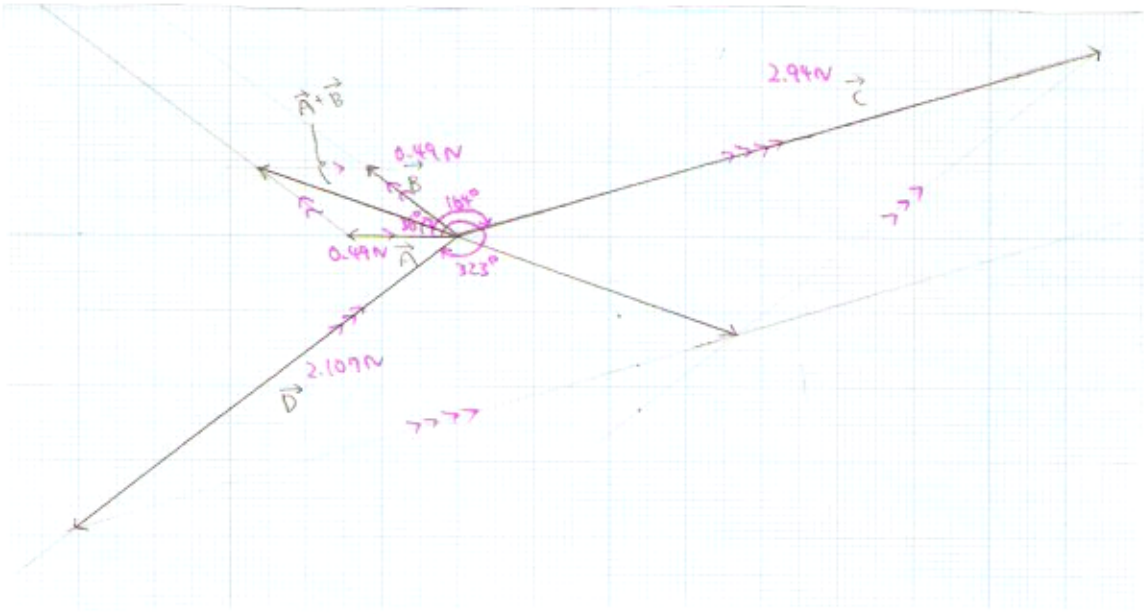
② Mathematical Analysis

Table3-2	F [N]	θ [°]	$F_x = F\cos\theta$ [N]	$F_y = F\sin\theta$ [N]
A	1.96	0°	1.96	0
B	1.96	75.5°	0.491	1.898
C	1.568	159°	-1.464	0.562
D	2.695	246°	-1.096	-2.462
		$\Sigma F_x, \Sigma F_y$	-0.109	-0.002

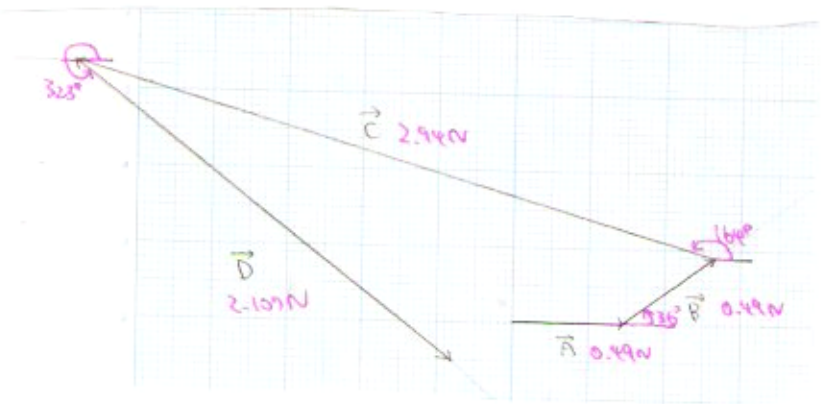
Test4

Table4-1	Kg	N	Angle
A	0.05	0.49	0°
B	0.05	0.49	36°
C	0.3	2.94	164°
D	0.215	2.107	323°

① Figuring Analysis



[Parallelogram Method] Fig.4-1



[Head-to-Tail Method] Fig.4-2

② Mathematical Analysis

Table4-2	F [N]	θ [°]	$F_x = F\cos\theta$ [N]	$F_y = F\sin\theta$ [N]
A	0.49	0°	0.49	0
B	0.49	36°	0.396	0.288
C	2.94	164°	-2.826	0.810
D	2.107	323°	1.683	-1.268
		$\Sigma F_x, \Sigma F_y$	-0.257	-0.170

Discussion

- In the parallelogram method figure, the two lines of net force have almost the same length and are on the opposite sides.

[Test1] $\vec{A} = -(\vec{B} + \vec{C})$

$\vec{A} + \vec{B} + \vec{C} = 0$

[Test2-4] $\vec{A} + \vec{B} = -(\vec{C} + \vec{D})$

$\vec{A} + \vec{B} + \vec{C} + \vec{D} = 0$

Percent Error Example

[Test1]

Length: $\frac{|0.98N-0.91N|}{0.98N} \times 100\% = \frac{0.07N}{0.98N} \times 100\%$

$=7.14\%$

Angle: $\frac{|180°-181°|}{180°} \times 100\% = \frac{1°}{180°} \times 100\%$

$=0.556\%$

- In the Head-to-Tale method figure, the tail point of $\vec{C}$ line almost reaches the top point of $\vec{A}$ line.
  → The difference between the tail point of $\vec{C}$ line and the top point of $\vec{A}$ line is $\vec{A}+\vec{B}+\vec{C}+\vec{D}$, meaning $\vec{A}+\vec{B}+\vec{C}+\vec{D}$ is not zero.

- In the mathematical analysis, $\sum F_x$ and $\sum F_y$ are almost zero.

⇒ Net force made from some forces in equilibrium is zero.

- The net forces are not exactly zero.
  There are slight differences because:
  - ✓ We thought the ring was at the center, but actually it was not the center.
  - ✓ Read the angle on the force table roughly.
  - ✓ Differences occur when I round off the values.

Conclusions

The net force made from several forces at equilibrium is zero.
$\vec{A}+\vec{B}+\vec{C}+\vec{D}=0$ at equilibrium

Opinions

In this experiment, it was difficult to find the angles where the ring becomes the center. Before doing this experiment, I could not imagine the

state of $\vec{A}+\vec{B}+\vec{C}+\vec{D}=0$. However, conducting this experiment, I understood very well what kind of state it is when $\vec{A}+\vec{B}+\vec{C}+\vec{D}=0$.

Reference

Lab Reports by Tamano Yano (2013)