Date of Lab 10/18/17 Date of Submission 10/25/17

Laboratory Report

Title
表題 Forces in equilibrium

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Summary

To confirm the net forces made from several forces is 0 by using the graphic method and the math method. When the ring is balanced, we confirmed angle, and weights, and then we used parallelogram method, Head-to-tail method and component method

・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

Teacher Comments
It is good to show % errors in equilibrium

1 Due 提出期限	2 Summary 要旨	3 Intro. 序	4 Method. 方法	5 Results 結果	6 Table/Fig. 表/図	7 Discussion 考察	8 Clearness わかりやすさ	9 General 全般
+					++	++	++	++

* Write your report in Japanese or in English * Use this form as a cover sheet.
* Submit your reports by the seventh day after your lab.

2. Introduction

(1) Objective

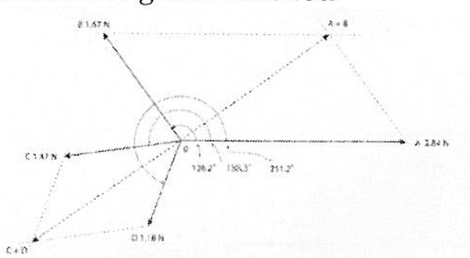
To confirm that the net force made from several forces in equilibrium is zero by using a force table and the net force indicate in graphically by using parallelogram method, head-to-tail method and component method.

(2) Theory and Past knowledge

1) Gravitational acceleration is 9.80 m/s^2
2) Newton's first law
   - An object at rest remains at rest as long as no net force acts on it.
3) Newton's second law.

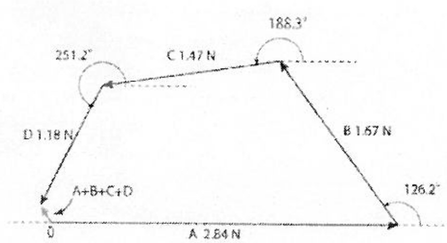
   $\Sigma\vec{F} = m\vec{a}$

   The sum of the forces (the net force) acting on an object is equal to its mass times its acceleration.
4) Parallelogram method



Parallelogram method

5) Head-to-tail method



Head-to-tail method

6) Component method

2. Component method

Example

	F [N]	θ [°]	Fx = Fcos θ [N]	Fy = Fsin θ [N]
A	2.84	0	2.84	0
B	1.67	126.2	-0.986	1.348
C	1.47	188.3	-1.455	-0.212
D	1.18	251.2	-0.380	-1.117
		ΣFx, ΣFy	0.019	0.019

The magnitude and direction of the net force $F = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$ $\theta = \tan^{-1}\frac{\Sigma F_y}{\Sigma F_x}$

(3) Hypothesis

The net force of all the tensional forces acting on three or four wires is zero like below formula. The net force is not zero when the forces are slightly off the balance.

$$\vec{F_1} + \vec{F_2} + \vec{F_3} + \vec{F_4} = 0$$

(4) Reasons

Newton's first law said that "an object at rest remains at rest as long as no net force acts on." No net force means that net force is equal to 0.

3. Experiment

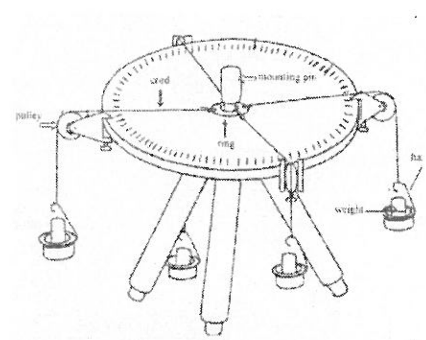


Fig. 1 Force Table.

1) Prepared weights, pulley, cord, nomination pin, force table, four hangers and assemble force table as shown in <u>the Fig.1</u>.
2) Put different amount of weights in three hangers.
3) One cord is set on 0° on the force table.
4) Relocate the other two cords (pulleys) so that the ring is centered and the three forces are balanced by trial and error.
5) When the system is balanced, record the angles and the mass of weights in the table below.
6) Calculate the magnitude of force. Obtain the length of an arrow expressing the magnitude of each force vector.
7) On graph paper, net force is obtained using the parallelogram method and using head to tail method. (Exp.1)
8) Repeat the above using four hangers with weights. (Exp.2)
9) Repeat the above but the four forces are slightly off the balance. (Exp.3)
10) Perform the component method and compare the results with thee graph method.

4. Results

(1) Table.1 Three forces are balanced

Length of arrow 1N = 3 cm

Exp.1	Weight (kg)	Force (N)	Arrow (cm)	Angle (°)
A	0.25	2.45	7.35	0
B	0.15	1.47	4.41	126.0
C	0.2	1.96	5.88	218.0

※ Force = mass × gravitational acceleration. (Newton's second law)
= mass × 9.80 m/s^2

(2) Table.2 Four forces are balanced

Length of arrow 1N = 3 cm

Exp.2	Weight (kg)	Force (N)	Arrow (cm)	Angle (°)
A	0.25	2.45	7.35	0
B	0.15	1.47	4.41	94.0
C	0.2	1.96	5.88	244.0
D	0.15	1.47	4.41	170.0

※ Force = mass × gravitational acceleration. (Newton's second law)
= mass × 9.80 m/s^2

(3) Table.3 Four forces are not balanceLength of arrow 1N = 3 cm

Exp.3	Weight (kg)	Force (N)	Arrow (cm)	Angle (°)
A	0.2	1.96	5.88	0
B	0.1	0.98	2.94	94.0
C	0.15	1.47	4.41	170.0
D	0.2	1.96	5.88	244.0

※ Force = mass × gravitational acceleration. (Newton's second law)
= mass × 9.80 m/s^2

Fig. 2 Parallelogram method of Exp. 1

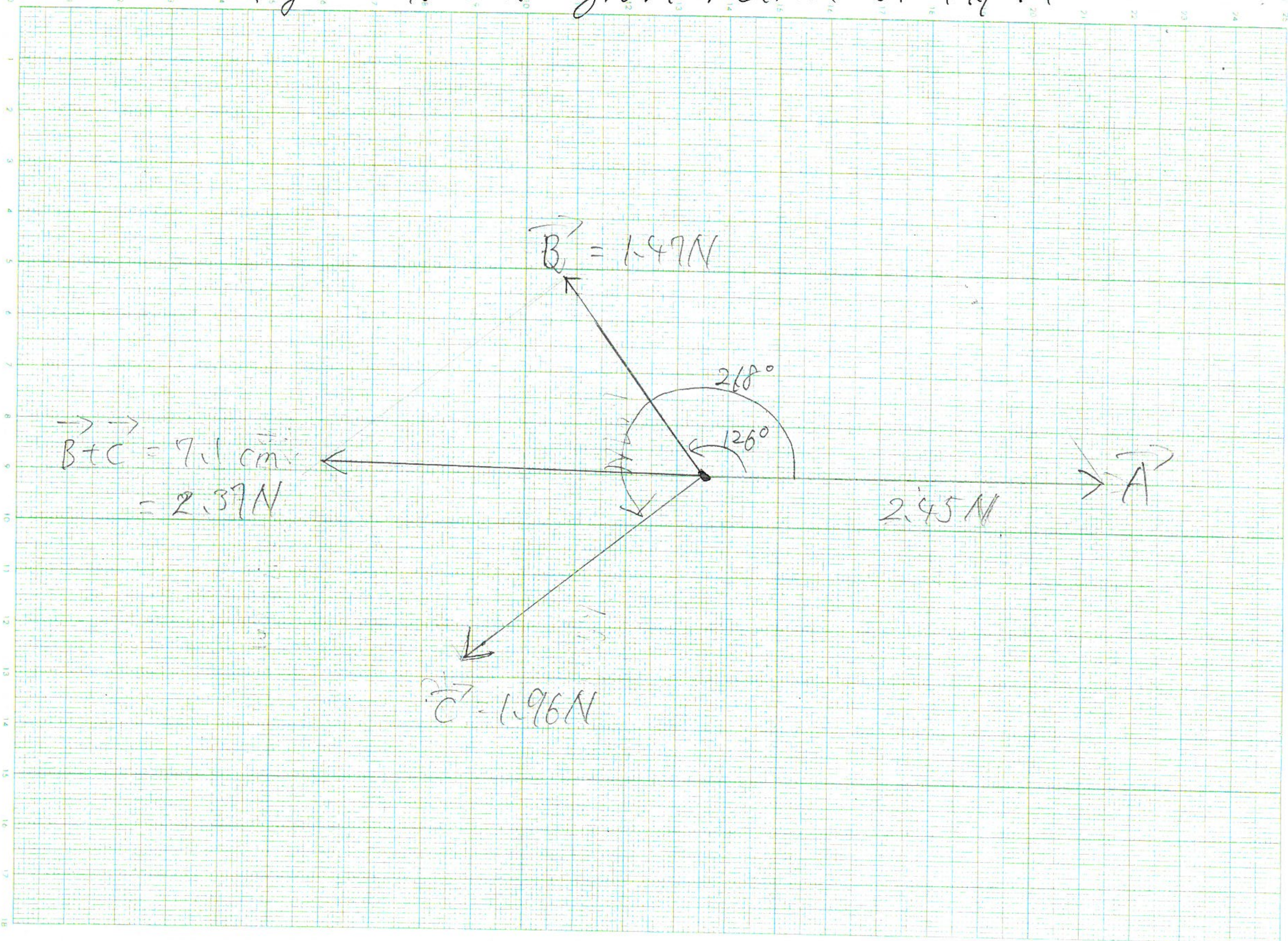


Fig. 3 Head-to-tail method of Exp. 1

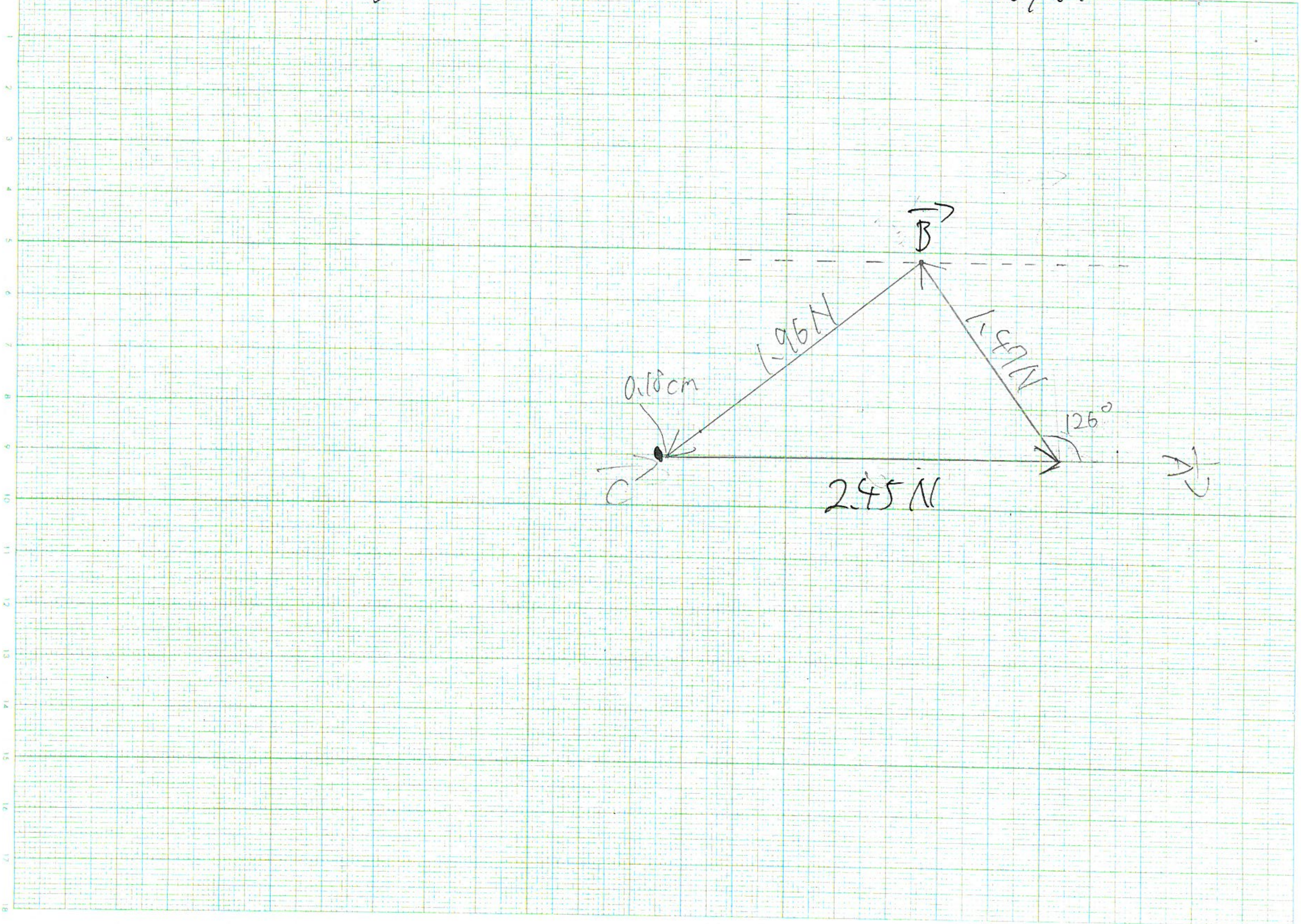


Fig.4 Parallelogram method of Exp-2

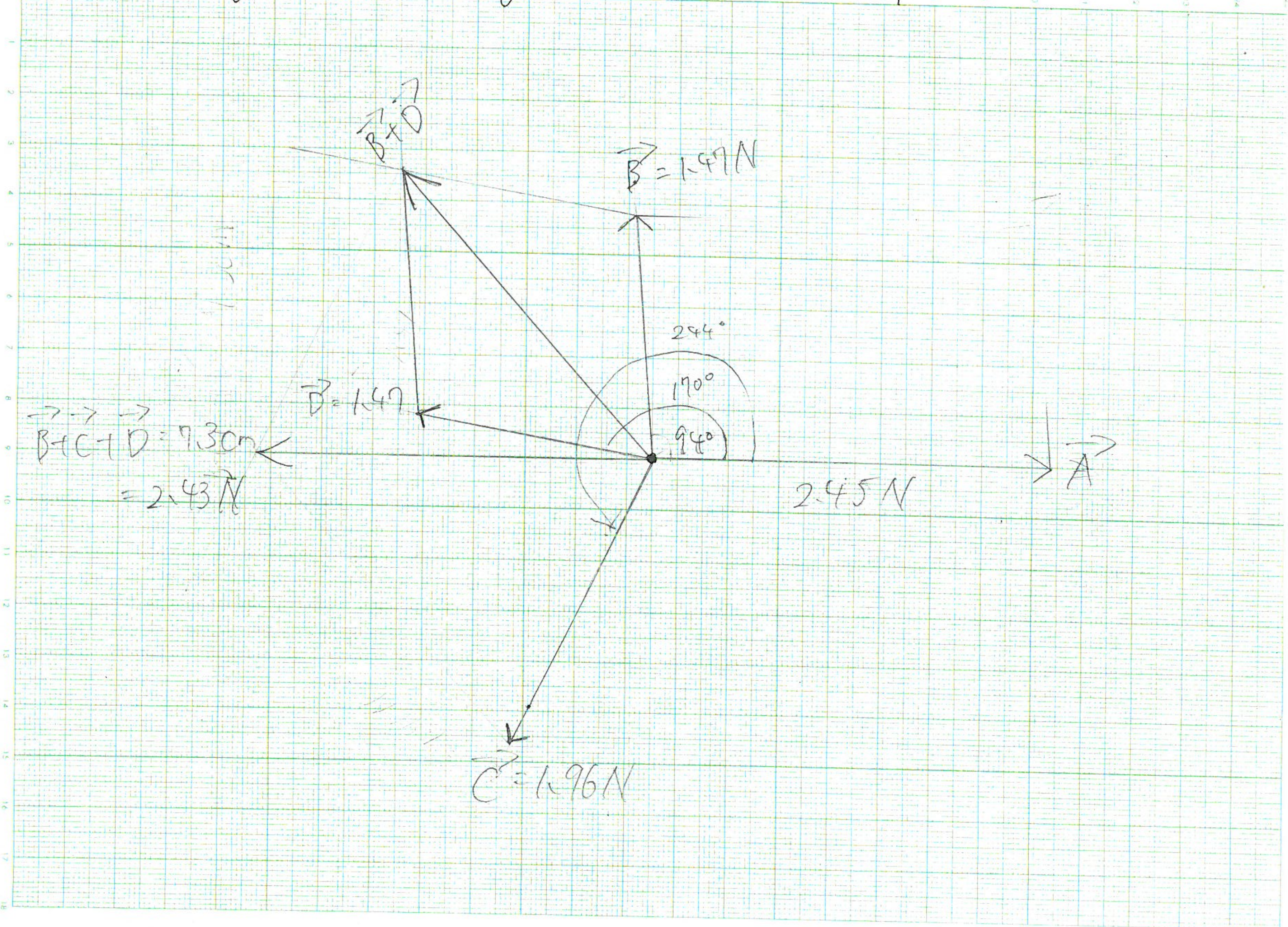


Fig.5 Head-to-tail method of Exp 2

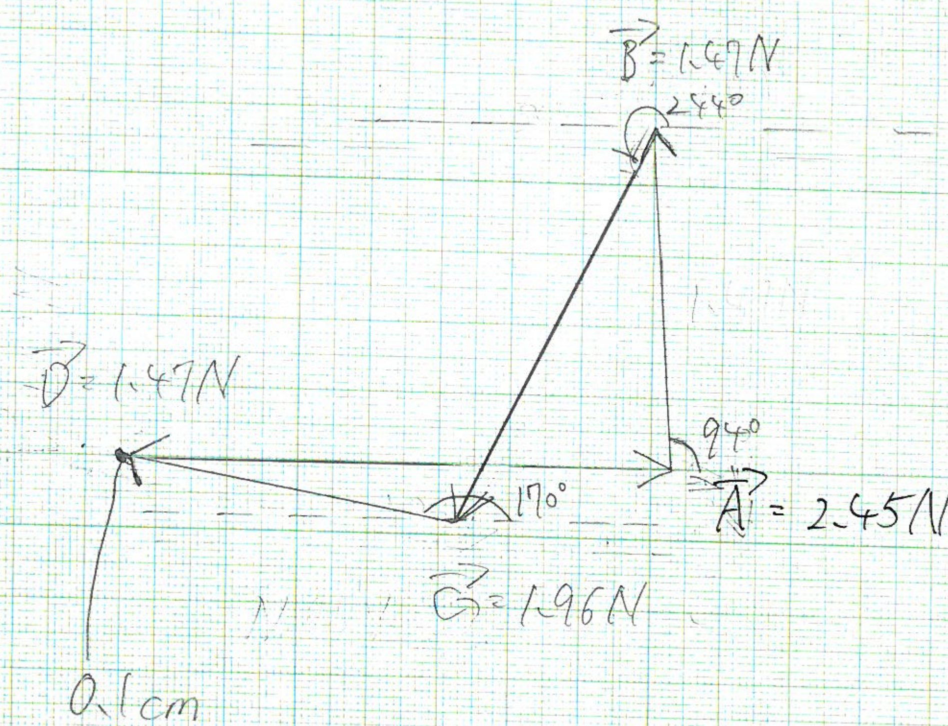


Fig.6 Parallelogram method of Exp.3

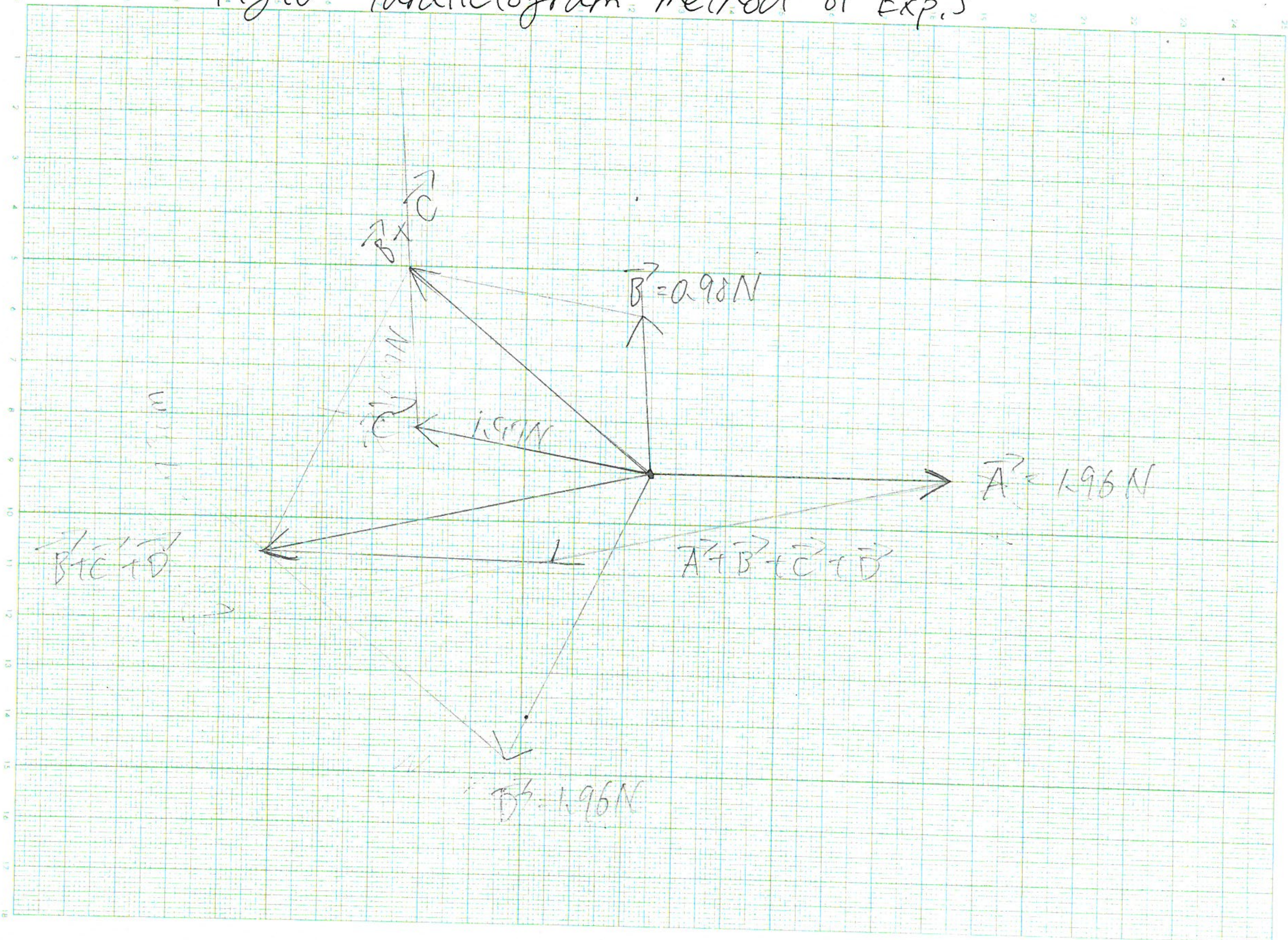


Fig.7 Head-to-tail method of Exp.3

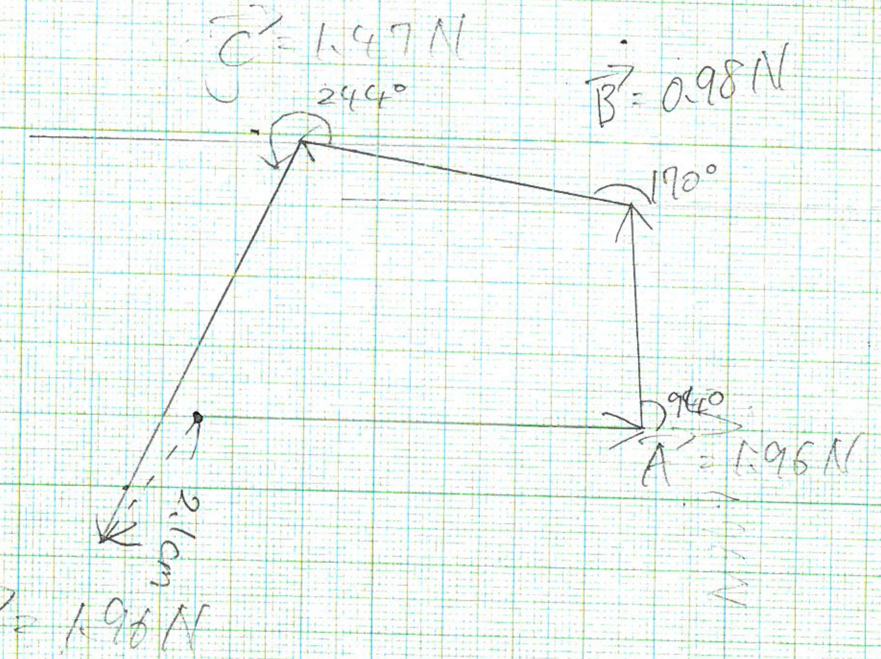


Table.4 Component method of Exp.1

Exp.1	Force	θ	Fx = Fcosθ	Fy = Fsinθ
Unit	[N]	[°]	[N]	[N]
A	2.45	0	2.450	0.000
B	1.47	126.0	−0.864	1.189
C	1.96	218.0	-1.545	-1.207
		ΣFx, Σfy	0.041	-0.018

$$F = \sqrt{(\Sigma Fx)^2 + (\Sigma Fy)^2} = \sqrt{(0.041)^2 + (-0.018)^2} = 0.047 \quad \underline{A,\ 0.05\ N}$$

Table.5 Component method of Exp.2

Exp.2	Force	θ	Fx = Fcosθ	Fy = Fsinθ
Unit	[N]	[°]	[N]	[N]
A	2.45	0	2.450	0.000
B	1.47	94.0	-0.103	1.466
C	1.96	244.0	-0.859	-1.762
D	1.47	170.0	-1.448	0.255
		ΣFx, Σfy	0.040	-0.041

$$F = \sqrt{(\Sigma Fx)^2 + (\Sigma Fy)^2} = \sqrt{(0.040)^2 + (-0.041)^2} = 0.057 \quad \underline{A,\ 0.06\ N}$$

$$\theta = tan^{-1}(\frac{\Sigma Fy}{\Sigma Fx}) = tan^{-1}(\frac{-0.041}{0.040}) = -45.70^\circ \ =314.3^\circ \quad \underline{A,\ 314^\circ}$$

Table.6 Component method of Exp.3

Exp.3	Force	θ	Fx = Fcosθ	Fy = Fsinθ
Unit	[N]	[°]	[N]	[N]
A	1.96	0	1.960	0.000
B	0.98	94.0	-0.068	0.978
C	1.47	170.0	-1.448	0.255
D	1.96	244.0	-0.859	-1.762
		ΣFx, Fy	-0.415	-0.529

$$F = \sqrt{(\Sigma Fx)^2 + (\Sigma Fy)^2} = \sqrt{(0.415)^2 + (-0.529)^2} = 0.672 \quad \underline{A,\ 0.67\ N}$$

$$\theta = tan^{-1}(\frac{\Sigma Fy}{\Sigma Fx}) = tan^{-1}(\frac{-0.415}{-0.529}) =38.11^\circ \quad \underline{A,\ 38^\circ}$$

5. Discussion

(1) Exp.1

- In the Fig.2, the length of $\vec{A}$ is almost same as length of $\vec{B}+\vec{C}$ and their arrow represent almost opposite direction.
- In the Fig.3, the tail point of $\vec{C}$ almost reaches the origin point of A.
- In the table.4 and calculation, the force is almost zero.

→From above three sentences, three forces are balanced, and the equation is made.

$$\vec{A} = -(\vec{B} + \vec{C})$$
$$\vec{A} + \vec{B} + \vec{C} = 0$$

- From the calculation result of Table.4, the ring is pulled by 0.05 N to 337°

(2) Exp.2

- In the Fig.4, the length of $\vec{A}$ is almost same as length of $\vec{B} + \vec{C} + \vec{D}$ and their arrow represent almost opposite direction
- In the Fig.5, the tail point of $\vec{D}$ almost reaches the origin point of $\vec{A}$.
- In the table.5 and calculation, the force is almost zero.

→From above three sentences, these four forces are balanced, and the equation is made.

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

- From the calculation result of Table.5, the ring is pulled by 0.06N to 314°

(3) Exp. 3

- When the four forces are slightly off the balance, the length of $\vec{A}$ is not same as length of $\vec{B} + \vec{C} + \vec{D}$, according to Fig.6.
- When the four forces are slightly off the balance, the tail point of $\vec{D}$ does not reach the origin point of $\vec{A}$, according to Fig.7.
- When the four forces are slightly off the balance, the force is not zero according to Table.6.

→From above three sentences, the net forces are not balanced.

- From the calculation result of Table,6, the ring is pulled by 0.67 N to 38°

(4) Percent error

All of three experimentations, results are including error because the mass of weight is not exactly correct because of oxidation of weight, and the hangers weight are not including. ed

1) Exp.1

Exp.1	Force	θ	Fx = Fcosθ	Fy = Fsinθ
Unit	[N]	[°]	[N]	[N]
B	1.47	126	−0.864	1.189
C	1.96	218	-1.545	-1.207
		ΣFx, Σfy	-2.409	0.985

$$F = \sqrt{(-2.409)^2 + 0.985^2} = 2.602$$

$$percent\ error\ [\%] = \frac{|(2.602) - (2.45)|}{(2.45)} \times 100$$

=6.204

A, 6.20 %

2) Exp.2

Exp.2	Force	θ	Fx = Fcosθ	Fy = Fsinθ
Unit	[N]	[°]	[N]	[N]
B	1.47	94	-0.103	1.466
C	1.96	244	-0.859	-1.762
D	1.47	170	-1.448	0.255
		ΣFx, Σfy	-2.410	-0.041

$$F = \sqrt{(-2.409)^2 + (-0.041)^2} = 2.408$$

$$percent\ error\ [\%] = \frac{|(2.408) - (2.45)|}{(2.45)} \times 100$$

= -1.714

A. 1.71 %

7. Conclusion

The net force made from several forces is 0 at equilibrium. This thing shows the below equation.

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

8. Opinion

I learned how to draw the head-to-tail method and parallelogram method in this laboratory. Also, I learned how to use component method. This is a big help of preparation of Exam.

9. Reference

1. James S. Walker. Physics. Person. Page 152- 156
2. Anne Marie Helmenstine, Ph.D.,(Sep,21,2017), How to calculate percent error, Oct,23,2017, https://www.thoughtco.com/how-to-calculate-percent-error-609584

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