3-week

Experiment 3

An Experimental Investigation into Force Equilibrium: Composition, Decomposition, and Conditions

Professor: Scopel Stefano

Assistant: Seo Gyeong-Seok

Student: Madina Sadullaeva

Student ID: 20232024

Major: Computer science and engineering

Experiment 3. Force Equilibrium

Experiment Objective

The primary objective of this laboratory report is to investigate and understand the principles of force composition, decomposition, and their conditions for equilibrium. This will be achieved through an experiment focusing on the equilibrium of a point mass in a planar context. The study will specifically explore the first equilibrium condition, which requires the net external force to be zero for a state of linear equilibrium and second equilibrium condition, which requires the sum of the moments of all external forces, the total torque to be zero for a state of rotational equilibrium state. Ultimately, this report aims to provide a comprehensive analysis of these concepts and their practical applications.

$$\sum F = 0$$

$$\sum \tau = 0$$

Data Compilation

Table 1

-Fixed mass

N	Mass (fixed) (g)			Angle (measured)(º)			Angle(theory) (º)			Angle(작도)(º)			Error (θ_C)
	m_A	m_B	m_C	θ_A	θ_B	θ_C	θ_A	θ_B	θ_C	θ_A	θ_B	θ_C	%
1	60	60	60	120	120	120	120	120	120	120	120	120	0
2	20	40	50	151	124	85	157.7	130.5	71.8	157.7	130.5	71.8	15.5
3	40	50	60	138	125	97	138.6	124.2	97.2	138.6	124.2	97.2	0.2

Table 2

-Fixed angle

N	Angle (fixed) (º)			Mass(measured)(g)			Mass(theory) (g)			Mass(작도)(g)			Error (m_C)
	θ_A	θ_B	θ_C	m_A	m_B	m_C	m_A	m_B	m_C	m_A	m_B	m_C	%
1	130	120	110	8.3	10.2	11.9	8.3	9.4	10.3	8.3	9.4	10.3	15.5
2	150	70	140	9.9	23.7	14.9	9.9	12.6	18.5	9.9	12.6	18.5	19.5
3	130	140	90	16.4	12.5	22.1	16.4	13.6	21.3	16.4	13.6	21.3	3.8

Results Analysis

The experiment focuses on the first condition of equilibrium, which involves linear forces and requires the vector sum of all forces acting on an object to be zero and involved measuring mass at fixed angles and fixed masses. The results indicate that the error percentages for the measured mass (mc) were consistently **percentage error** across different trials. This suggests an experimental errors existence in the experimental procedure and measurement accuracy.

The data presented in Table 1 shows the results of three trials, each with different error percentages. The first and third trials had minimal error percentages of 0% and 0.2% respectively, indicating a close match between the experimental and theoretical values. This suggests a high level of accuracy in the measurement process and the experimental setup for these trials. However, the second trial showed a significant deviation with an error percentage of 15.5%. This indicates the existence of an error in this particular trial. The cause of this error could be attributed to various factors such as inaccuracies in the measurement tools, human error, or external environmental factors that might have affected the state of equilibrium.

The data presented in Table 2 (fixed angles) shows the results of three trials, each with different error percentages. The first, second, and third trials had error percentages of 15.5%, 19.5%, and 3.8% respectively. These consistent error percentages across all trials indicate the existence of systematic errors in the experiment.

The results from Table 1 suggest high accuracy in the first and third trials, with minimal error percentages. However, the second trial showed a significant deviation, indicating an error possibly due to inaccuracies in measurement tools, human error, or external factors. The data from Table 2, with measurements of mass at fixed angles, showed consistent error percentages across all trials, indicating the existence of systematic errors. These could be due to consistent inaccuracies in the experimental procedure or measurement tools. This highlights the importance of precision and control in experimental setups to ensure accurate results. Further investigation is needed to identify and rectify these errors.

Discussion Formats:

The experiment aimed to observe the first condition of equilibrium, which involves linear forces and requires the vector sum of all forces acting on an object to be zero. The experiment involved measuring mass at fixed angles and fixed masses. The aspects that were clearly observed were the measurements of mass at fixed angles and fixed masses. However, the consistent percentage error across different trials suggests that there were some aspects that were difficult to observe due to potential experimental errors in the procedure and measurement accuracy.

The data presented in Table 1 and Table 2 shows the results of three trials, each with different error percentages. The first and third trials had minimal error percentages, indicating a close match between the experimental and theoretical values. However, the second trial showed a significant deviation, indicating the existence of an error. This error could be attributed to various factors such as inaccuracies in the measurement tools, human error, or external environmental factors that might have affected the state of equilibrium. To improve the experiment, it would be beneficial to ensure the accuracy of the measurement tools and control the experimental environment to minimize external influences.

To further confirm the physics phenomenon we aimed to observe, another experiment that could be conducted is the study of rotational equilibrium. This experiment would involve observing the sum of the moments of all external forces, i.e., the total torque, which must be zero for an object to be in equilibrium. This experiment would be related to the current experiment as it also deals with the conditions of equilibrium.

The physics laws confirmed by our experiment could be applied in various real-life and engineering applications. For instance, understanding the conditions of equilibrium is crucial in the field of civil engineering for the design of stable structures. Additionally, these principles could be used in other physics experiments or theories related to motion and forces. Understanding the conditions of equilibrium can also help in the study of other related phenomena such as the conservation of momentum and energy.

Question

(1) Explain the reason why we put the table in the horizontal position.

The table is placed in a horizontal position to ensure that the only forces acting on the object are the applied force and the force of gravity. This setup simplifies the analysis by reducing the system to a two-dimensional plane. It also minimizes the influence of other potential forces, such as friction or air resistance, that could complicate the equilibrium conditions.

(2) Explain the reason why the experimental results do not coincide exactly to the values expected from a geometrical construction.

The discrepancy between the experimental results and the values expected from a geometrical construction could be due to several factors. These include measurement errors, inaccuracies in the setup, or assumptions made in the theoretical model that do not perfectly match real-world conditions. For instance, the geometrical construction might assume ideal conditions that overlook factors such as air resistance, surface friction, or slight variations in the angle or mass measurements. These factors can introduce small deviations from the expected results. Additionally, the precision of the instruments used to measure angles and masses can also impact the accuracy of the results. Even small inaccuracies in these measurements can lead to significant differences in the expected and observed results. Therefore, it's important to consider these potential sources of error when interpreting the results of the experiment.

References:

- Haliday, General Physics, 2007, Edition 10, 2014, 94,149, 220, 327
- General Physics lab manual, Department of physics, Sogang
- The Physics classroom, Equilibrium and Statics,
https://www.physicsclassroom.com/class/vectors/Lesson-3/Equilibrium-and-Statics

- LibreText Physics, Equilibrium,
https://phys.libretexts.org/Bookshelves/University_Physics/Book%3A_Introductory_Physics_-_Building_Models_to_Describe_Our_World_(Martin_Neary_Rinaldo_and_Woodman)/11%3A_Rotational_dynamics/11.07%3A_Equilibrium