الحقيبة التدريبية لمختبر الميكانيك

Republic of Iraq

Ministry of Higher Education and Scientific Research

AL-Furat AL-Awsat Technical University – Iraq

Kerbela Polytechnic College

Department of Mechanical Engineering Technology

Mechanical Engineering Laboratory

By

Assist. Lectures

Zahraa S. Alkhfajy

MS.C Physics Science

2025-2026

Names of technicians in the laboratory

Ali Musa Hamidi

Ali Karim Thamer

Mustafa Uday Abdullah

Sajjad Ammar Jawad

Afrah Maitham Abdul Kadhim

Banin Nazim Aziz

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Resolution of a Vector into Components

By

Assist. Lectures

Zahraa S. Alkhfajy

MS.C Physics Science

2025-2026

Aim of the Experiment

The aim of this experiment is to study the analysis of vectors by resolving forces into their rectangular components and determining the resultant of multiple forces acting at a point using analytical, graphical, and experimental methods.

Learning Outcomes

After completing this experiment, the student will be able to:

1- Understand the concept of vectors and scalar quantities.

2- Resolve a force into its horizontal and vertical components.

3- Determine the resultant of two or more concurrent forces.

4- Verify vector laws experimentally using a force table.

5- Compare theoretical and experimental results and analyze errors.

Apparatus and Equipment

Force table with circular degree scale

Pulleys

Weight hangers

Slotted weights

Strings

Protractor

Ruler

Calculator

Theory

Vector Quantity

A vector is a physical quantity that has both magnitude and direction, such as force, velocity, and acceleration.

Resolution of a Vector

Resolving a vector means breaking it into two perpendicular components, usually along the x-axis and y-axis.

For a force F acting at an angle θ with the positive x-axis:

Horizontal component: F_X

Vertical component: F_Y

$F_X = F \cos \theta$

$F_Y = F \sin \theta$

Resultant of Vectors

The resultant force R is a single force that has the same effect as all the forces acting together.

If multiple forces act at a point:

$$\Sigma F_x = F_{1x} + F_{2x} + \dots$$
$$\Sigma F_y = F_{1y} + F_{2y} + \dots$$

Magnitude of the resultant:

$$R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$$

Direction of the resultant:

$$\theta_R = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$$

Procedure

1- Fix the force table on a level, horizontal surface.

2- Suspend a mass on one of the strings and orient it at an angle.

3- Calculate the magnitude of the applied force:

4- Theoretically analyze the force into two components.

5- Balance each component with a suitable mass on the horizontal and vertical axes.

6- Record the experimental values and compare them with the theoretical values.

Table of Experimental Readings

Theoretically

Mass (g)	Mass(kg)	F	θ	F_X (N)	F_Y (N)

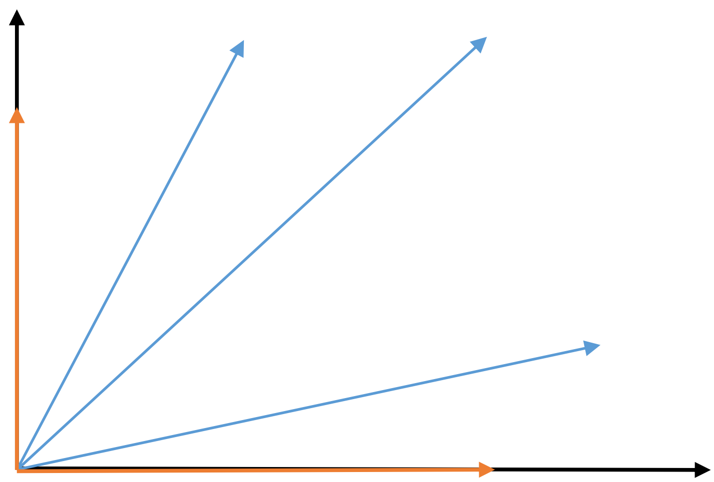
Practically

Mass (g)	θ	F_X	F_Y

Graphically

1- Draw the original vector.

2- Plot the two components on the coordinate axes.



Discussion

Do practical values match theoretical values?

What are the reasons for the error?

What are vector quantities and scalar quantities? Give examples of each.

What is meant by vector resolution, and why is it used in mechanics?

If a force of magnitude (F) acts at an angle θ to the horizontal axis, what are its components?

In the vector resolution experiment using a force table, what is the purpose of pulleys and weights?

A mass of 200 g is suspended at an angle of 30° to the horizontal. Find the force components?

What is the condition of equilibrium in the vector resolution experiment?

Why do we resolve forces into components instead of dealing with the force directly?

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Addition of victors

By

Assist. Lectures

Zahraa S. Alkhfajy

MS.C Physics Science

2025-2026

Aim of the Experiment

1. To understand the concept of vectors and distinguish them from scalar quantities.

2. To learn how to add vectors practically and graphically.

3. To determine the resultant of two or more vectors using:

- Graphical method
- Analytical (component) method

4. To compare experimental results with theoretical calculations.

Learning Outcomes

1. Understand the concept of vectors and distinguish them from scalar quantities.

2. Graphically represent and add vectors.

3. Determine the magnitude and direction of the resultant vector.

4. Resolve vectors into their components along the axes.

5. Compare experimental results with theoretical values and estimate error.

6. Accurately use laboratory equipment.

Apparatus and Equipment

1.Force table

2. Pulleys

3. Strings

4. Slotted weights (50 g, 100 g, 200 g, etc.)

5. Protractor

6. Graph paper

Theory

Concept of Vector Addition

Vector addition means combining two or more vectors to obtain a single equivalent vector called the resultant.

The resultant vector is represented as:

$$\vec{R} = \vec{A} + \vec{B}$$

Analytical Method (Component Method)

Each vector is resolved into horizontal (x) and vertical (y) components:

$$A_x = A \cos\theta$$

$$A_y = A \sin\theta$$

$$B_x = B \cos\theta$$

$$B_y = B \sin\theta$$

$$R_x = \Sigma \, (A_x + B_x + \ldots\ldots\ldots\ldots)$$

$$R_y = \Sigma \, (A_y + B_y + \ldots\ldots\ldots)$$

$$\sqrt{(R^2_x + R^2_y)}$$

$$\theta = \tan^{-1} (R_y \backslash R_x)$$

Or by

$$R = \sqrt{(F^2_1 + F^2_2 - 2 F_1 F_2 \cos \phi)}$$

$$\theta = \sin^{-1}(F_2 \sin \phi \backslash R)$$

ϕ the angle between two vector.

Procedure

1- Fix the force table on a horizontal surface.

2- Tie two or more strings to the central ring.

3- Hang a mass at a certain angle, such as (θ_1).

4- Hang another mass at a different angle (such as (θ_2).

5- Add a third mass until equilibrium is achieved (the ring remains in the center).

6- Record the values of the masses and angles.

Table of Experimental Readings

Theoretically

Mass1 (g)	Mass1 (kg)	F_1	θ_1	F_{X1} (N)	F_{Y1} (N)	Mass2 (g)	Mass2 (kg)	F_2	θ_2	F_{X2} (N)	F_{Y2} (N)

Practically

Mass1 (g)	θ_1	Mass2 (g)	θ_2	R	θ R

Graphically

1. Draw the first vector according to its given magnitude and angle.

2. Draw the second vector starting from the endpoint of the first vector, also according to its given magnitude and angle.

3. The vector resulting from the beginning of the first vector to the endpoint of the second vector is the final resultant vector, R.

4. θR, The angle that the resultant vector makes with the axis.

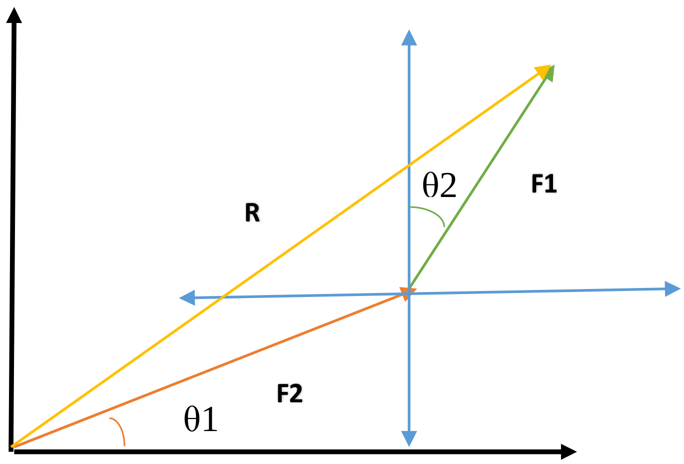

Figure 1

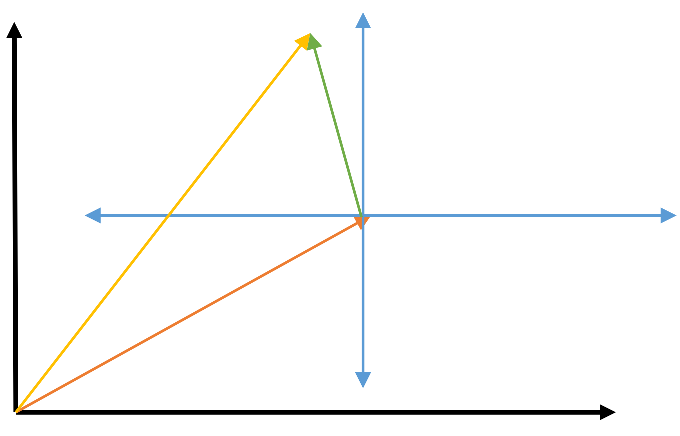

Figure 2

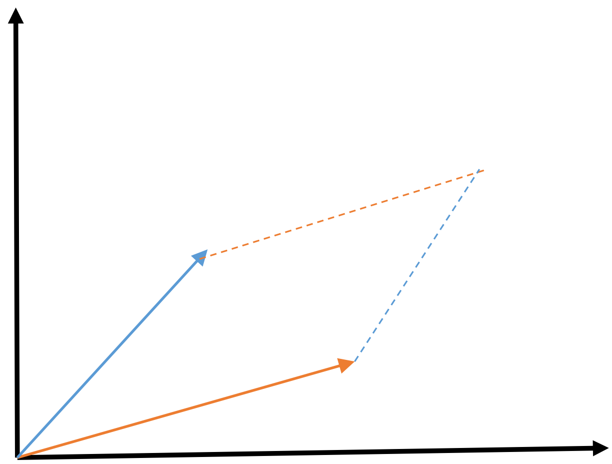

Figure 3

Discussion

1. What is a vector? What is the difference between vector quantities and scalar quantities?

2. What is meant by the vector addition experiment? What is its main objective?

3. Why can vectors not be added algebraically in most cases?

4. What is meant by the resultant vector?

5. Mention the different methods used for vector addition?

6. When do we use the component method instead of the graphical method?

7. What is the difference between the triangle method and the parallelogram method?

8. Why is the angle between vectors important when calculating the resultant?

9. Why is the direction of a vector important during addition?

10. What is the role of the force table in the vector addition experiment?

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Equilibrium

By

Assist. Lectures

Zahraa S. Alkhfajy

MS.C Physics Science

2025-2026

Aim of the Experiment

The objective of this experiment is to study vectors and compare experimental results with graphical and analytical calculations by finding a resultant force that balances out the given force so that the system will be in equilibrium.

Learning Outcomes

1. Define the concept of mechanical equilibrium.

2. Distinguish between balanced and unbalanced forces.

3. Apply the equilibrium conditions: $\Sigma R_x = 0$ **and** $\Sigma R_y = 0$ **.**

4. Resolve concurrent forces into horizontal and vertical components.

5. Calculate the resultant force and the unknown force required for equilibrium.

6. Use graphical methods (force polygon) to verify equilibrium.

7. Interpret experimental results and compare them with theoretical values.

8. Identify possible sources of error and suggest ways to reduce them.

Apparatus and Equipment

Force table

Weight holders

Sets of masses

Rulers

Protractors

Spirit levels

Theory

Vectors A and B can be added graphically by drawing them to scale and aligning them head to tail. The vector that connects the tail of A to the head of B is the resultant vector R. Vector addition is both associative and commutative. The components (A_x and A_y) of a vector A can be calculated by projecting the length of A onto the coordinate axes as shown in figure 1. The components can be obtained by using the following equations:

$$A_x = |A| \cos \theta_A \qquad A_y = |A| \sin \theta_A$$

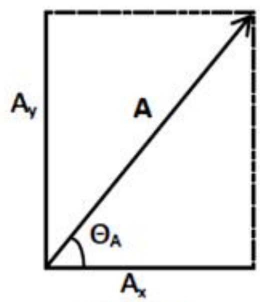

Figure 1.

The sign of a component gives its direction along the x or y axis. Conversely, from the components, the magnitude |A| and direction θ of the vector can be calculated using the following:

$$|A| = \sqrt{A_x^2 + A_y^2} \qquad \theta = \tan^{-1}(A_y/A_x)$$

In order to add vectors analytically, they must be in component form. The components of a vector sum of two vectors A and B yields the components of a new vector, called a resultant vector and will be denoted by R. The components of R can be calculated by:

$$R_x = A_x + B_x \qquad R_y = A_y + B_y$$

In this experiment, each group will find the direction and magnitude of a force C that balances out the forces of A and B so that the system will be in equilibrium. In order to for the system to be in equilibrium, the following must hold:

$$\mathbf{A + B = -C} \qquad \mathbf{A + B + C = 0}$$

Procedure

1. Place the force table on a flat surface. Using the spirit level, make sure the force table is level. Cut three pieces of string ~21 inches long. Tie a loop at the end of each piece of string, and attach the other end of the string to the ring. Place the ring in the center of the force table so that it encircles the pin. Put the strings over the pulleys attached to the force table. Make sure that the pulleys are fixed at the same height around the table.

2. Get three mass holders. For vector A, add mass to one mass holder until the entire setup (mass holder and added mass) is ~50 g. Place this mass on the end of one of the strings looped over a pulley and set the pulley at an angle of 0°. For vector B, to the second mass holder, add mass until the entire setup is ~100 g. Place this mass on the end of one of the available strings looped over a pulley and set the pulley at an angle of 120°.

3. For vector C (the resultant), attach the last mass holder to the last string looped over a pulley. Add mass to the system and adjust the angle until the system is in equilibrium.

4. When the system is in equilibrium, the ring with the attached strings will be parallel to and suspended above the ring painted on the force table, and the pin can be removed.

5. Once equilibrium is reached, determine the entire mass for the setup of vector C.

6. Record the values for mass and angle for vectors A, B, and C in Table 1. Record the values for mass and angle of vectors A and B in Table 2. Use the formulas given to calculate the mass and x and y- components of vectors A and B, and calculate the mass, force, components, and angle for vector C.

7. Draw the vectors A, B, and C and their corresponding components to scale in the space provided. Also, draw the complete system of vectors A, B, and C together in the space provided. Be sure to label the vectors, forces and angles.

8. Compare the experimental results for mass and angle measure of vector C with the analytical calculations. Determine the percentage error.

Figure 2

Table of Experimental Readings

Theoretically

	A	B	C
Mass (g)			
Force (N)			
x-component (N)			
y-component (N)			
Θ (°)			

Practically

	A	B	C
Mass (g)			
Θ (°)			

Graphically

1- Draw the first vector according to its given value and angle, which represents f1.

2- Draw the second vector according to its given value and angle, which represents f2.

3- Draw the new vector, which represents f3, and determine its angle and direction through the resulting calculations.

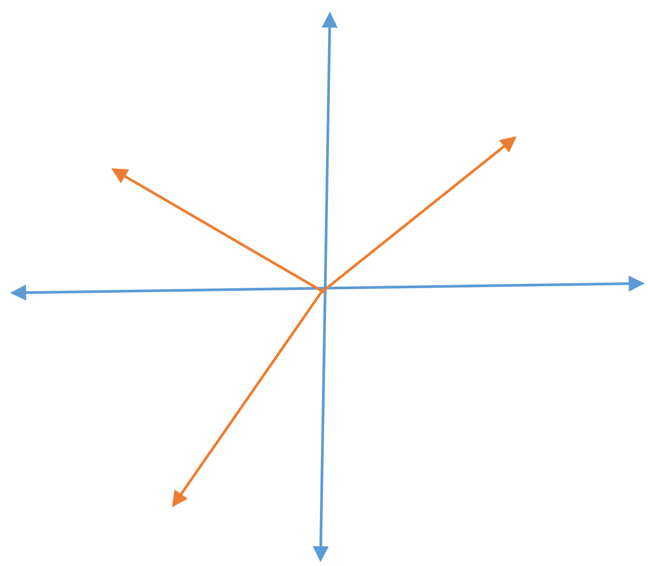

Figure 1

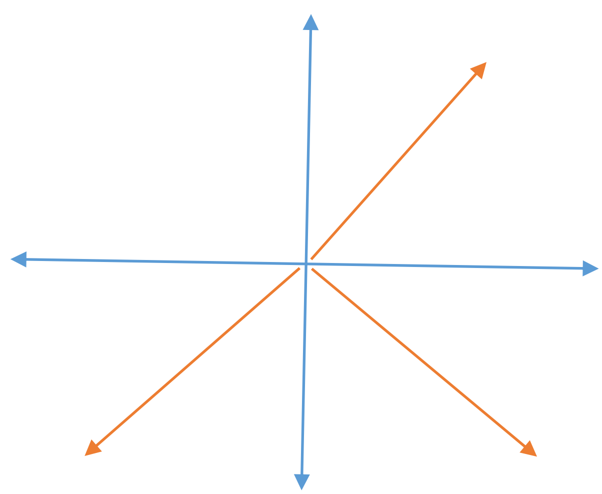

Figure 2

Discussion

1. **What is meant by equilibrium?**
2. **What is the condition for equilibrium of a body subjected to several forces?**
3. **Why do we resolve forces into components?**
4. **What is the purpose of using a force table?**
5. **When is the ring in the force table considered in equilibrium?**
6. **What is meant by the equilibrant force?**
7. **How do we verify equilibrium using a graphical method?**
8. **Why do experimental results sometimes differ from theoretical results?**
9. **What happens if the equilibrium conditions are not satisfied?**
10. **Can equilibrium occur with unequal forces?**

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Verification of the Principle of Moments

By

Assist. Lectures

Zahraa S. Alkhfajy

MS.C Physics Science

2025-2026

Aim of the Experiment

The aim of this experiment is to verify the principle of moments, which states that for a body in rotational equilibrium, the sum of clockwise moments about a pivot is equal to the sum of anticlockwise moments.

Learning Outcomes

1. **Understand the concept of the principle of moments and rotational equilibrium.**
2. **Experimentally verify the principle of moments.**
3. **Calculate the moment of a force using : M = F * d .**
4. **Distinguish between clockwise and anticlockwise moments.**
5. **Analyze the effect of the moment arm on torque.**
6. **Properly use laboratory equipment.**
7. **Identify possible sources of experimental error.**
8. **Relate theoretical principles to practical results.**

Apparatus and Equipment

1. **Meter Rule / Beam**
2. **Pivot (Knife Edge)**
3. **Base Blocks / Support Stand**
4. **Weight Hangers**
5. **Slotted Weights**
6. **Measuring Scale / Ruler**
7. **Spirit Level (if available)**
8. **Thin, non-stretchable string**
9. **Clamps**
10. **Data recording sheet and pen**

Theory

When a force acts on a rigid body at a distance from a fixed point (pivot), it tends to cause rotation about that point. This turning effect of a force is known as the moment of a force or torque.

The moment of a force about a pivot is given by:

where: M = F * d

M = moment (torque)

F = applied force

d = perpendicular distance from the pivot to the line of action of the force

A rigid body is said to be in rotational equilibrium if the algebraic sum of all moments acting on it about any point is zero. This means that:

$$\sum M_{\text{clockwise}} = \sum M_{\text{anticlockwise}}$$

That means :

$$\tau_1 = \tau_2$$

$$F_1 * d_1 = F_2 * d_2$$

Procedure

1. **Fix the pivot on the stand and place the meter rule on it.**
2. **Locate the center of the meter rule and adjust the pivot so that the rule is balanced horizontally without any loads.**
3. **Suspend a weight hanger at a known distance from the pivot on one side of the meter rule.**
4. **Add standard weights to the first hanger and record the values of the weights and the distance.**
5. **Suspend another weight hanger on the opposite side of the meter rule at a suitable distance.**
6. **Add weights to the second hanger until the meter rule returns to a horizontal balanced position.**
7. **Record the distances and weights on both sides after achieving equilibrium.**
8. **Repeat the experiment for different values of weights and distances to improve accuracy.**
9. **Calculate the moments for each side and compare the clockwise and anticlockwise moments.**

Table of Experimental Readings

Theoretically

If τ_1 constant, τ_2 is :

$Mass_2$ (kg)	F_2 (N)	d_2 (m)	τ_2 (N.m)
		0.02	
		0.04	
		0.06	
		0.08	
		0.010	

Practically

Mass (g)	d (cm)
	2
	4
	6
	8
	10

Graphically

1. Plot each pair of values as a point: (τ , d)
2. Draw the Best-Fit Line
3. Draw the best-fit straight line through the plotted points.
4. The line should pass close to the origin.
5. Determine the Force from the Slope from the equation: **slope = Δy \ Δx**

So:

The slope of the straight line represents the applied force (N).

Slope = F

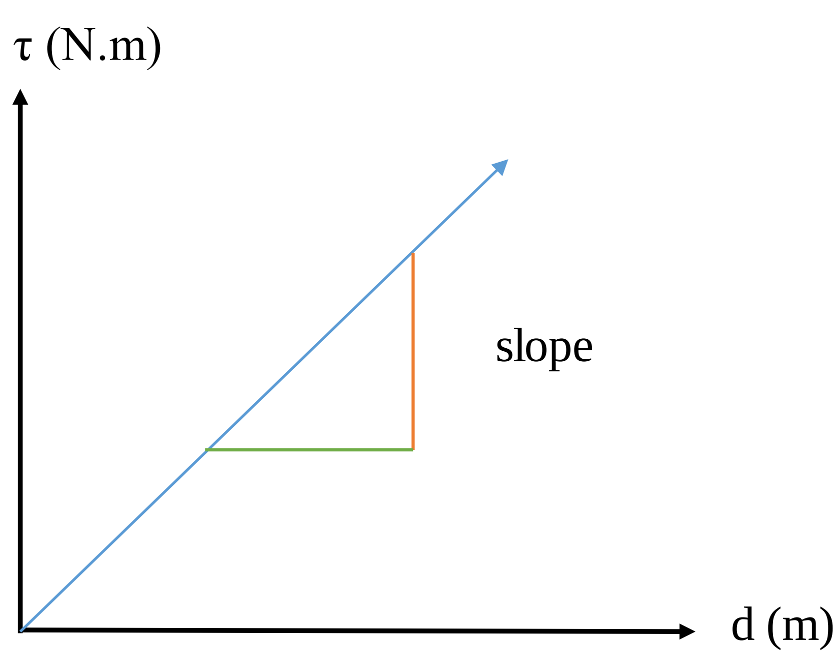

Figure 1

Discussion

1. What is meant by the moment of a force?
2. What is the mathematical formula for the moment of a force?
3. What is the condition for rotational equilibrium?
4. What is the aim of the moment of force experiment?
5. How does changing the distance affect the moment of force?
6. Why must the distance be perpendicular when calculating the moment?
7. What are the possible sources of error in the moment of force experiment?
8. Can equilibrium be achieved using unequal forces? Why?
9. What is the graphical relationship between moment and distance?
10. How can the value of force be obtained from the graph?

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Verification of the Principle of Moments

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Aim of the Experiment

1. **To study the frictional force between two surfaces in contact.**
2. **To understand the relationship between frictional force and the normal force acting on a body.**
3. **To distinguish between static friction and kinetic friction.**
4. **To determine the conditions required for the start of motion and sliding.**
5. **To calculate the coefficient of static friction and the coefficient of kinetic friction.**
6. **To investigate the effect of surface type and roughness on the value of friction.**
7. **To relate theoretical concepts to practical application and develop measurement and analysis skills.**

Learning Outcomes

1. **To define friction and identify its types.**
2. **To distinguish between static friction and kinetic friction.**
3. **To explain the relationship between frictional force and the normal force.**
4. **To apply the laws of friction in practical experiments and problem solving.**
5. **To determine the conditions for the onset of motion and sliding.**
6. **To calculate the coefficient of static friction and the coefficient of kinetic friction from experimental data.**
7. **To interpret the effect of surface type and roughness on the coefficient of friction.**
8. **To accurately record experimental data and discuss sources of error.**
9. **To relate theoretical concepts of friction to real-life applications.**

Apparatus and Equipment

1. Adjustable inclined plane
2. Solid block (with hook)
3. Additional weights
4. Spring balance
5. Protractor or angle scale
6. Measuring ruler
7. Digital balance or mass balance
8. Strong string
9. Different surface materials (wood, metal, sandpaper, plastic)
10. Stand and clamp

Theory

Friction is a resistive force that arises when two surfaces are in contact and acts opposite to the direction of motion or the tendency of motion. It occurs due to microscopic irregularities interlocking between the contacting surfaces. The frictional force depends on the nature of the surfaces and the normal force between them, and it does not directly depend on the apparent area of contact.

Friction is classified into two main types: static friction and kinetic friction. Static friction is the force that prevents a body from starting to move while at rest, and it increases with the applied force until it reaches a maximum value, beyond which motion begins. Kinetic friction acts when the body is already in motion and is usually less than the maximum static friction.

The frictional force is given by:

Frictional force = Coefficient of friction × Normal force

The coefficient of friction represents the roughness of the contacting surfaces and has different values for static and kinetic friction.

In the friction experiment, the relationship between frictional force and normal force is studied experimentally, and the coefficients of static and kinetic friction are determined using different methods such as an inclined plane or a spring balance. The experiment also demonstrates the effect of surface type and

roughness on friction and helps relate theoretical laws to practical and real-life engineering applications.

The coefficient of friction is a dimensionless physical quantity that represents the amount of resistance to motion between two surfaces in contact. It is usually denoted by the symbol (μ) and indicates how easily or difficultly one surface slides over another. The value of the coefficient of friction depends on the nature and roughness of the contacting surfaces and does not depend on the apparent area of contact.

The coefficient of friction is defined as the ratio of the frictional force to the normal force acting on the body and is given by:

μ = Frictional force ÷ Normal force

There are two main types of the coefficient of friction: the coefficient of static friction (μ_s) and the coefficient of kinetic friction (μ_k).

The coefficient of static friction represents the maximum frictional force that prevents a body from starting to move while at rest. The static friction force increases with the applied force until it reaches a maximum value, beyond which motion begins.

The coefficient of kinetic friction represents the resistance experienced by a body while it is sliding over a surface. Its value is usually smaller than that of the static friction coefficient because resistance decreases once motion has started.

Experimentally, the coefficient of friction can be determined using several methods, such as the inclined plane method, where the angle at which the body just begins to slide is measured, and the coefficient of friction is calculated using:

$\mu = \tan \theta$

It can also be determined using a spring balance by measuring the pulling force required to move the body at constant velocity.

The coefficient of friction plays an important role in engineering and everyday applications, including vehicle motion, braking systems, object stability, and mechanical system design.

First: Calculation of the Coefficient of Static Friction (μ_s)

1- Using the Inclined Plane Method

When the angle of the inclined plane is gradually increased, the body starts to slide at a certain angle called the angle of repose (θ).

Formula:

$$\mu_s = \tan\theta$$

2- Using a Spring Balance

The body is pulled horizontally, and the maximum force just before motion starts is recorded.

Given:

Maximum static friction force = F_s

Normal force = N = mg

Formula:

$$\mu_s = \frac{F_s}{N}$$

Second: Calculation of the Coefficient of Kinetic Friction (μ_k)

1- Using the Inclined Plane (Uniform Motion)

When the body slides down the inclined plane with constant velocity:

Formula:

$$\mu_k = \tan\theta$$

2- Using a Spring Balance

When the body is pulled at constant speed, the pulling force equals the kinetic friction force.

Given:

Kinetic friction force = F_k

Normal force = N = mg

Formula:

$$\mu_k = \frac{F_k}{N}$$

Important Notes:

Always it depends on the nature of the surfaces, not on the area of contact.

Procedure

1. **Place the inclined plane on a table and secure it firmly.**
2. **Choose the block to be tested and note its mass.**
3. **Place the block on the inclined plane.**
4. **Gradually increase the angle of the plane until the block starts to slide, and record the angle of repose (θ).**
5. **Calculate the coefficient of static friction using $\mu_s = \tan\theta$.**
6. **Use a spring balance to pull the block horizontally and record the force required to start motion.**
7. **Calculate the coefficient of static friction using $\mu_s = F_s / N$.**
8. **Pull the block at constant velocity and record the force during sliding.**
9. **Calculate the coefficient of kinetic friction using $\mu_k = F_k / N$ or from the angle of the plane for uniform motion.**
10. **Repeat the experiment with different surfaces to determine the effect of surface type on friction.**
11. **Record all data accurately and calculate the average readings.**
12. **Discuss the results and their relation to the theoretical laws of friction.**

Practically for F_S

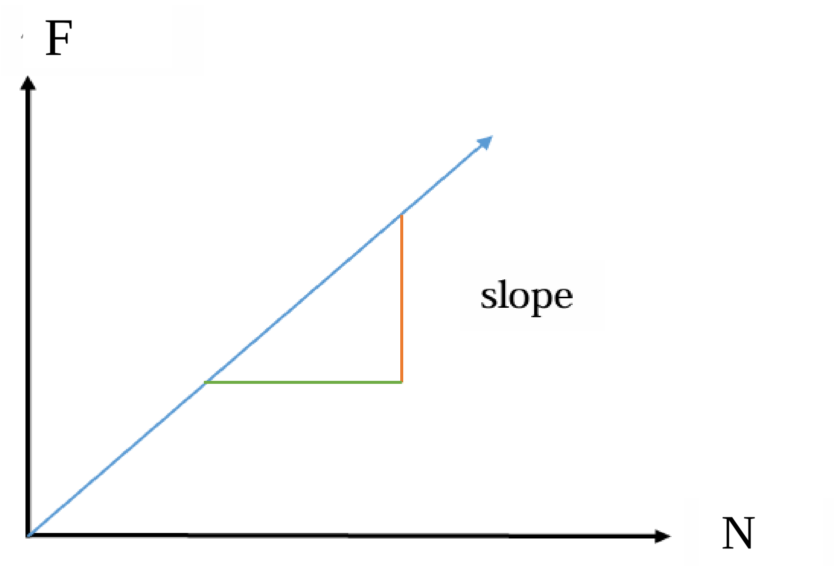
$Mass_1$ (kg)	N (N)	$Mass_2$ (kg)	F_S (N)

Practically for F_k

$Mass_1$ (Kg)	N (N)	$Mass_2$ (Kg)	F_k (N)

Graphically

1. Horizontal axis: Normal force (N) or weight (W) of the block.
2. Vertical axis: Frictional force (F).
3. You can also plot $\mu = F / N$ to compare the coefficient of friction on different surfaces.
4. Choose a suitable scale for each axis to cover all values.
5. Plot the data points according to the pairs (N,F).
6. If the relationship is linear (as in most practical experiments):
7. Draw a straight line that best fits the points.
8. The slope of the line $\mu = \Delta y/\Delta x = \Delta F/\Delta N$
9. The slope represents the coefficient of friction.
10. If the relationship is nonlinear, draw an appropriate curve using graphing software or tools.



- **What is friction, and what is the difference between static friction and kinetic friction?**
- **What is the coefficient of friction, and how can it be determined experimentally?**
- **How does the type of surface affect the frictional force? Give examples.**
- **What is the relationship between frictional force and the normal force acting on a body?**
- **Why is static friction usually greater than kinetic friction?**
- **How can an inclined plane be used to determine the coefficient of static friction?**
- **What is the difference between the angle of repose and the angle of inclination of the plane?**
- **How can the coefficient of friction be calculated using a spring balance?**
- **What is the importance of friction in daily life and engineering applications?**
- **What are the possible sources of error in a friction experiment, and how can they be minimized?**
- **If a body slides at constant velocity on a surface, what can we conclude about the forces acting on it?**
- **How can the coefficient of friction be compared between different surfaces using a graph?**
- **How does mass affect the frictional force? Does it affect the coefficient of friction?**
- **What is the difference between practical friction and theoretical friction?**
- **Explain how the friction experiment can be used to understand the design of brakes or vehicle wheels.**

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Determination of the Center of Gravity

By

Assist. Lectures

Zahraa S. Alkhfajy

MS.C Physics Science

2025-2026

Aim of the Experiment

1. To determine the position of the center of gravity of regular and irregular bodies experimentally.
2. To understand the concept of the center of gravity and its relation to mass distribution in a body.
3. To verify the physical laws and theories related to the center of gravity.
4. To study the effect of the shape and dimensions of a body on the position of its center of gravity.
5. To develop skills in accurate measurement and the use of laboratory instruments.
6. To relate the experimental results to engineering and physical applications in daily life, such as stability and equilibrium.

Learning Outcomes

1. Learning Outcomes in English:
2. Understand the concept of the center of gravity and its importance in the balance of objects.
3. Be able to determine the center of gravity of an irregular solid body using the suspension and vertical line method.
4. Be able to interpret experimental results and relate them to the geometric shape and mass distribution.
5. Develop skills in drawing and practical analysis of lines and intersections to identify the center of gravity.
6. Recognize cases where the center of gravity lies outside the body itself.

Apparatus and Equipment

1. Wooden board or metal plate (regular or irregular body).
2. Retort stand.
3. Thin string.
4. Small weight (plumb bob).
5. Pin or nail.
6. Graduated ruler or measuring tape.
7. Pencil or marker.
8. Drawing paper or plain paper.

Theory

The center of gravity is the point at which the entire weight of a body may be considered to act. In other words, the resultant of the weights of all parts of the body passes through this point. The position of the center of gravity depends on the shape of the body and the distribution of its mass, and it does not necessarily lie within the body; in some irregular shapes, it may lie outside the body.

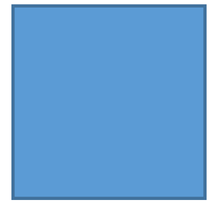
In a uniform gravitational field, such as near the Earth's surface, the center of gravity coincides with the center of mass. When a body is freely suspended from a point, the line of action of its weight always passes through its center of gravity. Therefore, by suspending the body from two different points and drawing a vertical line each time using a plumb bob, the intersection of these lines represents the position of the center of gravity.

For regular bodies with uniform density, the center of gravity can be determined theoretically using mathematical formulas. For example, the center of gravity of a uniform rod lies at its midpoint, that of a uniform rectangle lies at the intersection of its diagonals, while other shapes such as triangles and semicircles have different center-of-gravity locations.

The study of the center of gravity plays an important role in understanding equilibrium and stability. A body becomes more stable when its center of gravity is lower and its base of support is wider. This concept has wide applications in engineering, mechanics, building design, transportation, and machinery.

Regular geometric bodies

1- Square



$\bar{x} = a\backslash 2$

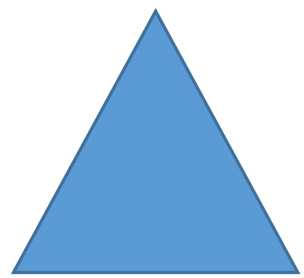
$\bar{y} = a\backslash 2$

2- Rectangle

$\bar{x} = a\backslash 2$

$\bar{y} = b\backslash 2$

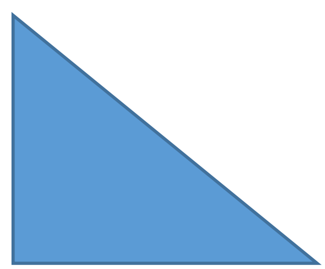
3- Isosceles triangle



$\bar{x} = 0$

$\bar{y} = h\backslash 3$

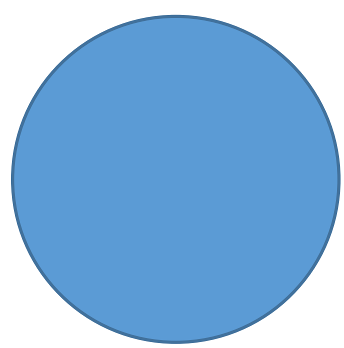
4- Right-Angled Triangle



$\bar{x} = b\backslash 3$

$\bar{y} = h\backslash 3$

5- Full Circle



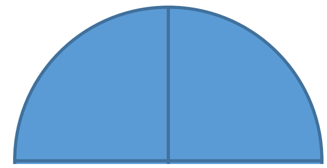
$\bar{x} = 0$

$\bar{y} = 0$

6- Semicircle (Horizontal Diameter)

$\bar{x} = 0$

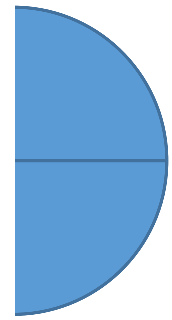
$\bar{y} = 4r\backslash 3\pi$



7-Semicircle (Vertical Diameter)

$\bar{x} = 2r\backslash \pi$

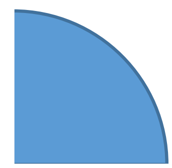
$\bar{y} = 0$



8- Quarter Circle

$\bar{x} = 4r\backslash 3\pi$

$\bar{y} = 4r\backslash 3\pi$



Procedure

1. Select a flat body (regular or irregular) and mark more than one suspension point near its edge.
2. Fix the body at one of the suspension points on the laboratory stand using a pin or nail.
3. Hang a thin string with a small weight (plumb bob) from the same suspension point.
4. Allow the body to stabilize completely, then draw a straight line on the body along the vertical string.
5. Remove the body and re-hang it from a different suspension point.
6. Repeat the process of hanging the string and drawing a vertical line.
7. Determine the intersection point of the drawn lines; this point represents the center of gravity of the body.

8. **For regular bodies, compare the experimental center of gravity with the theoretically calculated value.**
9. **Record the results and calculate the percentage error if necessary.**

Discussion

1. **What is the center of gravity?**
2. **How does the center of gravity differ from the center of mass?**
3. **Why can the center of gravity lie outside the body in some objects?**
4. **How does the shape of a body affect the position of its center of gravity?**
5. **What is the relationship between the center of gravity and the stability of a body?**
6. **How can the center of gravity be calculated theoretically for regular geometric shapes such as squares, triangles, and circles?**
7. **How can the center of gravity of an irregular body be determined experimentally?**
8. **Why is it necessary to suspend the body from more than one point during the experiment?**
9. **What is the importance of using a string with a small weight (plumb bob) when drawing vertical lines?**
10. **How can the experimental values of the center of gravity be compared with the theoretical values?**
11. **What are the possible errors when performing the center of gravity experiment and how can they be avoided?**
12. **Give an example from daily life where the concept of the center of gravity is applied.**