King Saud University
Science College
Physics and Astronomy Department

109 Phys

Physics Experiments for Medical fields

Written by:
Khulud Almutairi

Table of content

Friction's Coefficients Experiment

1) Aim of the experiment

Finding the coefficient of static friction and the coefficient of kinetic friction.

2) Theory

In the ideal setting of Newton's Laws, we usually ignore the Friction and air resistance. However, from everyday experience of motion we know we should take into account the Friction forces, which describe the resistance between two surfaces which oppose their relative motion. It arises because of the defects, irregularities and molecular forces (bonds) between the material.

There are two types of friction forces:

1) Static Friction
2) Kinetic Friction

The **Static Friction** is the frictional force between two objects that are at rest with each other. The maximum value of the static friction force is the minimum force needed to start the motion of an object (prior to sliding). The static friction between two surfaces can be described by the **coefficient of static friction** (μ_s). Experimentally, the Static Friction force ($\mathbf{F_s}$) is proportional to the normal force, and it doesn't depend on the area of touched surfaces. Therefore, the Static Friction force is:

$$\mathbf{F_s} = \mu_s N \qquad (1)$$

If we study the motion of an object on tilted plane (inclined plane) that make an angle ($\boldsymbol{\theta}$) with the horizontal surface. The object will move as seen in Fig. [1]. Mathematically, from analyzing the forces that are acted on the object we can find the static friction force as:

$$\mathbf{F_s} = mg \sin \boldsymbol{\theta} \qquad (2)$$

The normal force in this case is given by:

$$N = mg \cos \boldsymbol{\theta} \qquad (3)$$

By substituting the values of (2) and (3) into (1), we find:

$$mg \sin \boldsymbol{\theta} = \mu_s \ mg \cos \boldsymbol{\theta} \qquad (4)$$

$$\mu_s = \tan \boldsymbol{\theta} \qquad (5)$$

Therefore, the coefficient of static friction is proportional to the tangent of the sliding angle.

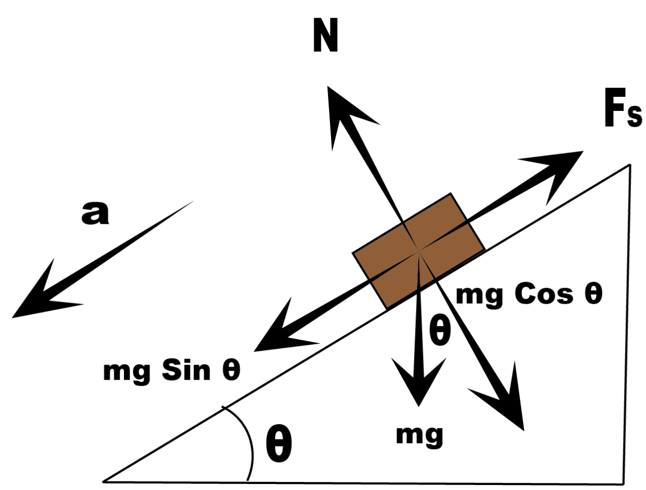


Fig. [1]: analysis of forces on a block on an inclined plane.

The second type is the Kinetic Friction force which is the friction of two surfaces in a relative motion. Mathematically, it is proportional to the normal force.

$$\mathbf{F_k} = \mu_k N \tag{6}$$

Where μ_k is the coefficient of kinetic friction, both the coefficient of static and kinetic friction doesn't have any units because they are the ratio of forces. For any touched surfaces we have always $\mu_s > \mu_k$.

If we study the motion of an object moving on a straight plane and connected by a thread passing through the pulley toward the handled weights, where the object is moving in the same direction of the weights as seen in Fig [2].

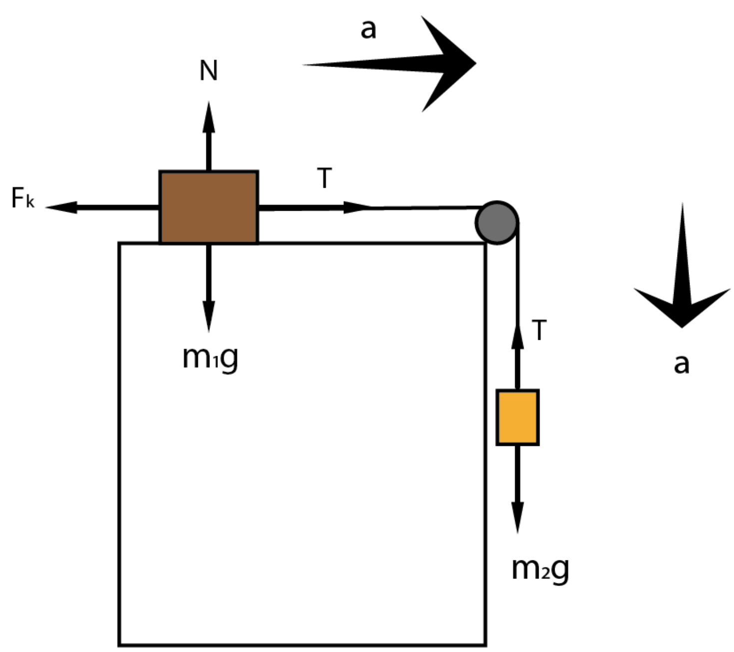


Fig. [2]: analysis of forces of a block on a straight plane connected with weights.

.

By using the free body diagram of Fig. [2], and applying Newton's second law, we can find the following:

$$T - F_k = m_1 a \qquad (7)$$

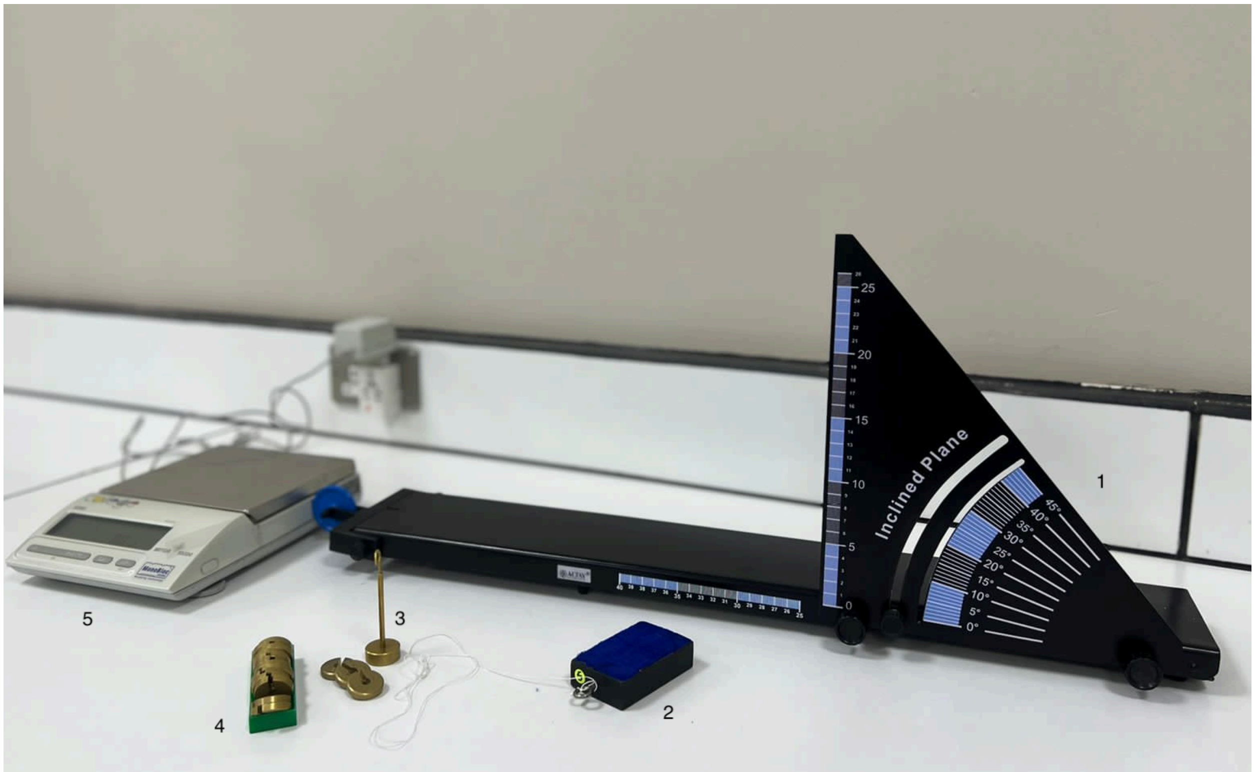
$$T - m_2 g = m_2 a \qquad (8)$$

$$N - m_1 g = 0 \qquad (9)$$

In this case, we ignore the frictional forces on the pulley, and we assume a constant speed therefore the acceleration will be zero, this will lead us to:

$$\mathbf{F_k} = m_2 g \qquad (10)$$

Where m_1, and m_2 are the masses of the block, and the handle respectively. In this experiment, we assume that m_N is m_1 plus any added weights above the block, and m_F is m_2 and all weights on the handle.



3) Apparatus

1) Inclined Plane with pulley.
2) Wooden block
3) Handle with thread
4) Slotted weights (5, 10, 20, 50 grams)
5) Scale

4) Method

A) Finding the value of the coefficient of static friction (μ_s)

1) Place the wooden block at the end of the inclined plane, then slowly increase the angle by raising the surface from the pulley side until the first angle that makes the block slide.
2) Fix the angle of the inclined plane and then report it at Table (1). Make sure that the speed of the sliding block is constant.
3) Repeat Steps (1) and (2) three times, and report the angles values in table (1).
4) Calculate the coefficient of static friction from equation (5):

$$\mu_s = \tan \boldsymbol{\theta}$$

5) Take the average of the coefficient of static friction.

B) Finding the value of the coefficient of kinetic friction (μ_k)

1) Weight the wooden block on the scale and report the value.
2) Place the block on the inclined plane, make sure the surface is at a stable and horizontal level, not inclined.
3) Connect the thread by the end of the block, then it goes through the pulley and the handle, where the handle is connected to the block on one side, and the other side is hanging in the air.
4) Make sure that the weight of the handle is less than the force that makes the block slide.
5) Add slotted weight on the handle until the block slides in a constant speed, report it at table (2), where $\mathbf{m_F}$ is the weight of the handle and the weight of the slotted weight added. From this data, you can find the driving force as:

$$\mathbf{F_k} = g\ \mathbf{m_F}$$

6) Add weight on the block then add another weight on the handle, report the weight of the block and the extra weight on it as $\mathbf{m_N}$ in table (2), from this data you can calculate the normal force N, as:

$$\mathbf{N} = g\ \mathbf{m_N}$$

7) Repeat step (6) five times and report your data in table (2).

8) Plot a graph between the normal force and the driving force, make sure you have a straight line.

9) Find the slope of the straight line, where the slope is given as:

   Slope = $\Delta \mathbf{F_k}$ / $\Delta \mathbf{N}$

10) Find the coefficient of the kinetic friction, which is given by:

   μ_k **= Slope**

11) Compare between the values of the coefficient of static and kinetic friction.

109 Phys

Friction’s Coefficients Experiment

Group	
Students names	
Date	
Day	

1) What is the aim of this experiment?

……………………………………………………………………………………………………….

A) Coefficient of Static Friction (μ_s):

	θ ( )	μ_s = Tan (θ)
1		
2		
3		

μ_S = ………………..

B) Coefficient of Kinetic Friction (μ_k):

Block's mass= ……………………

	Weight of the block with the extra weight on it m_N ( )	Normal Force N= g m_N ( )	Weight of the handle with the extra weight on it m_F ( )	Driving Force F_k= g m_F ( )
1				
2				
3				
4				
5				

μ_k = Slope = ………………………………….

2) Compare the coefficient of Static and Kinetic Friction, what do you observe?

…………………………………………………………………………………………….

Force Table Experiment

1) Aim of the experiment

Finding the resultant force, and the equilibrium force graphically via the parallelogram and the polygon method, and verifying it experimentally.

2) Theory

All measurable quantities are classified as either a vector or a scalar quantity. Vector quantity can have a magnitude and a direction, on contrast scalar quantity can have only a magnitude. Examples of vectors are forces, displacements, velocities, accelerations, and few examples of scalars are mass, speed of an object, temperature and energy.

In this experiment we are dealing with forces, therefore we are working with vectors. These forces are at equilibrium, and from Newton's second law we have:

$$\sum \mathbf{F}_{\mathbf{net}} = 0 \qquad (1)$$

Where $\mathbf{F}_{\mathbf{net}}$, or **R** is the Resultant force, the sum of two or more vectors, and it is equal in magnitude to the Equilibrium force **E** but opposite in direction. Suppose we have three vectors, **A**, **B**, and **C**, we can find the resultant force by two methods:

1) Parallelogram method
2) Polygon method/ or Tip-to-Tail method

The parallelogram method is based on adding vectors starting from the same original point and then forming a parallelogram, as shown in Fig. [1]. In contrast, the polygon method/ or tip-to-tail method, once the first vector is formed, the second vector is drawn from the tip of the first vector, as shown in Fig. [2].

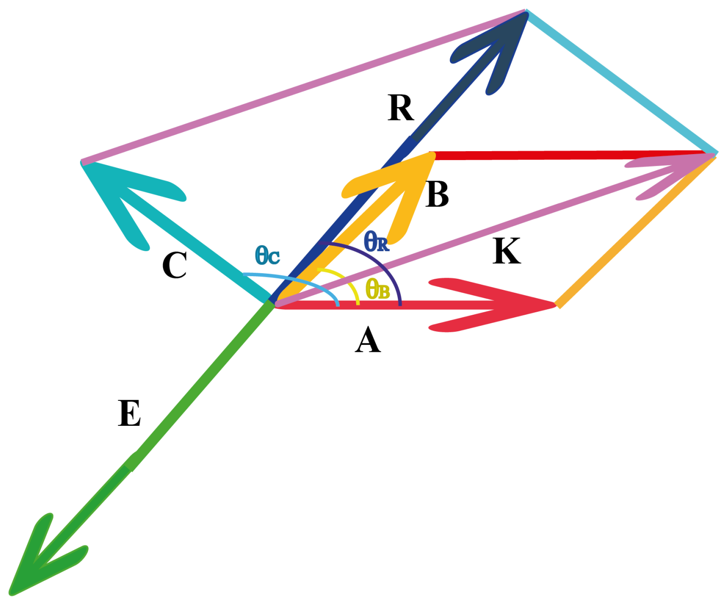


Fig.[1]. Parallelogram method for adding three vectors

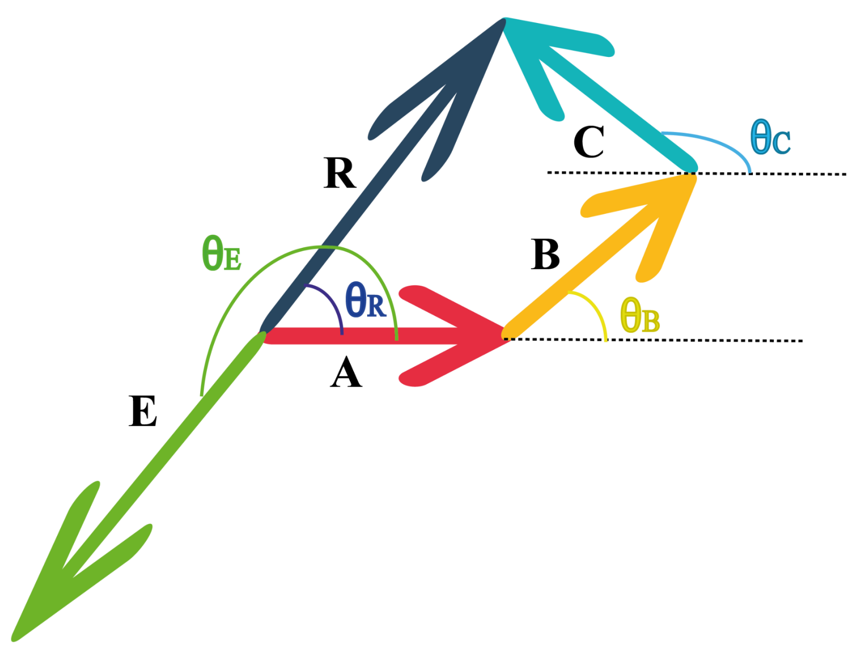
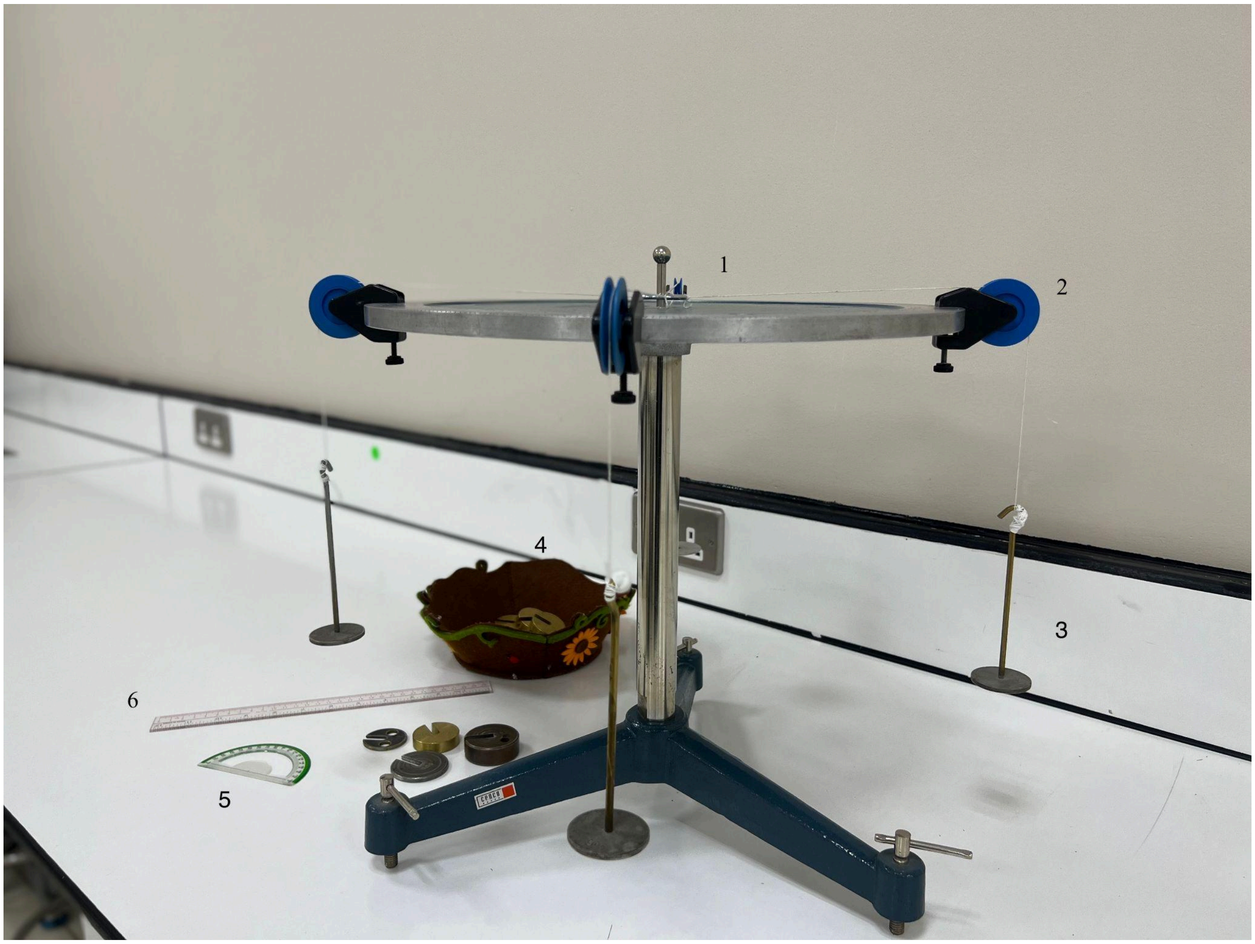


Fig. [2]. Polygon method for adding three vectors



3) Apparatus

1) Round Table with a central ring
2) Pulley
3) Handle with thread
4) Slotted weights (5, 10, 20, 50, 100 grams)
5) Protractor
6) Ruler

4) Method

A) Finding the Resultant and Equilibrium forces graphically by using Parallelogram

1) Pick one set of data from the 6 groups in table (1).

Table (1)

No.	A		B		C	
	m (g)	**θ** (deg)	m (g)	**θ** (deg)	m (g)	**θ** (deg)
1	150	0	110	70	250	135
2	200	0	100	55	200	135
3	200	0	100	41	150	132
4	200	0	200	97	150	138
5	150	0	200	79	150	154
6	100	0	200	71	160	144

2) Set a draw scale, where you can replace the mass for each vector above from grams to cm. For example if you have a mass with 300 g, you can set your scale a 50 g for 1 cm, therefore, you will have 6 cm for this vector. Put your scale in the report.

3) Convert vectors **A**, **B**, and **C** in your specific group to cm and write them down in table (2), remember angles are the same.

4) For the Parallelogram method, we start drawing the first vector **A** with the length and angle in table (2) from the original point (0,0). Same for vectors **B**, and **C**, we draw them from the original point (0,0) and make sure that we always read the angles from the protractor from right to left.

5) Draw a similar vector of **B**, parallel to B (in a yellow line) as seen in Fig[1], from the tip of vector **A**, with the same angle of **B**. And then we draw a similar vector of **A** (in a red line) to close the first parallelogram.

6) The resultant vector of the first parallelogram will be formed from the original point to the diagonal, and let's call this **K**, which is the resultant vector of **A** and **B**.

7) We form another parallelogram between vector **C** and **K**, by the tip of vector **K**, we draw a vector (in blue line) parallel to **C** vector with same length and angle, and then we close the second parallelogram, the resultant of this parallelogram is **R**, which can be drawn from the original point to the diagonal line between vectors **C** and **K**.

8) We measure the resultant length in cm and the resultant angle $\boldsymbol{\theta_R}$ and write them down in Table (3). Then we take the length of **R** in cm, and convert it to *g* by using the draw scale, after that we convert it from *g* to *Kg*, and then by using the weight formula: F= mg, we can list it in the last column in Table (3).

9) We draw the same length of **R** but in the opposite direction for the Equilibrium force **E**, where the equilibrium angle $\boldsymbol{\theta_E}$ is given by:

$$\boldsymbol{\theta_E} = 180 + \boldsymbol{\theta_R} \qquad (2)$$

and find it is value in g, then kg to find the force, and list the data in table (4). We will form two Parallelograms similar to Fig. [1].

B) Finding the Resultant and Equilibrium forces graphically by using the Tip-to-Tail method or Polygon method:

1) Repeat the steps from (1-3) in the previous method.

2) For the polygon method, we draw the first vector **A** from the origin point (0,0), and then vector **B**, where the tail of **B** is starting at the tip of vector **A**, with the right angle of **B**, and make sure that we always read the angles from the protractor from right to left.

3) We draw the vector **C**, starting from the tail of **C** at the tip of vector **B**, with the right angle of **C**.

4) The resultant vector **R**, is the one that will close the polygon, from the origin point till the tip of vector **C**, and the angle ($\boldsymbol{\theta_R}$) is the measured from vector **A** to the vector **R** as seen in Fig. [2].

5) Repeat steps 8, and 9 in the previous method, and list the data in table (5) and (6).

6) Compare the resultant and equilibrium forces between the first and second method.

C) Finding the Resultant and Equilibrium forces Experimentally:

1) Set the angle of A in the force table by changing the pulley to the right angle, and then add the right amount of grams as your chosen group from Table (1).
2) then set the angle of B, and C, and add the grams in the handles.
3) The fourth pulley is for the equilibrium vector, choose the angle from part A or B, then add grams till you see the central ring in the middle.
4) List the data of the equilibrium force that makes the forces at equilibrium.
5) Compare the equilibrium force experimentally vs graphically.

109 Phys

Force Table Experiment

Group	
Students names	
Date	
Day	

1) What is the aim of this experiment?

………

2) Graphical part

A) Which group of data did you choose?

Table (1)

No	A		B		C	
	m ( )	θ ( )	m ( )	θ ( )	m ( )	θ ( )

a) What is the draw scale for 1 cm (how many grams are needed to draw 1 cm)?

……………………………………………………………………………………………………..

b) Please find the values for the vectors A, B, and C in terms of length (L) in cm?

Table (2)

No	A		B		C	
	L ( )	θ ( )	L ( )	θ ( )	L ( )	θ ( )

B) For the method of Parallelogram:

a) Draw the Resultant (R) vector of A, B and C, and find the Equilibrium (E) vector, stating all angles, by using the data from Table (2).

b) Find the Resultant vector in cm, in grams, angle, and then the net resultant force?

Table (3)

R			
L ( )	m ( )	θ_R ( )	F ( )

c) **Find the Equilibrium vector in cm, grams, angle and then equilibrium force?**

Table (4)

E			
L ( )	**m ( )**	**θ_E ( )**	**F ( )**

C) For the method of Polygon:

a) **Draw the Resultant (R) vector of A, B and C, and find the Equilibrium (E) vector, stating all angles, by using the data from Table (2).**

b) **Find the Resultant vector in cm, in grams, angle, and then the net resultant force?**

Table (5)

R			
L ( )	**m ( )**	**θ_R ( )**	**F ( )**

c) **Find the Equilibrium vector in cm, grams, angle and then equilibrium force?**

Table (6)

E			
L ( )	**m ( )**	**θ_E ( )**	**F ( )**

d) **Compare the Resultant and Equilibrium Forces between the Parallelogram and the Polygon method?**

……………………………………………………………………………………….

3) Experimental part

a) Experimentally, find the equilibrium force that makes the ring in equilibrium.

………………………………………………………………………………………………………

b) Compare the equilibrium force result that you got graphically with experimentally?

………………………………………………………………………………………………………

Free Fall Experiment

1) Aim of the experiment

Studying the free fall motion of a falling object by finding the acceleration of gravity experimentally.

2) Theory

When an object falls to the ground it has an acceleration due to the gravity of Earth (g). It follows the equation of motion:

$$D = v_0\, t + \frac{1}{2}\, g\, t^2 \qquad (1)$$

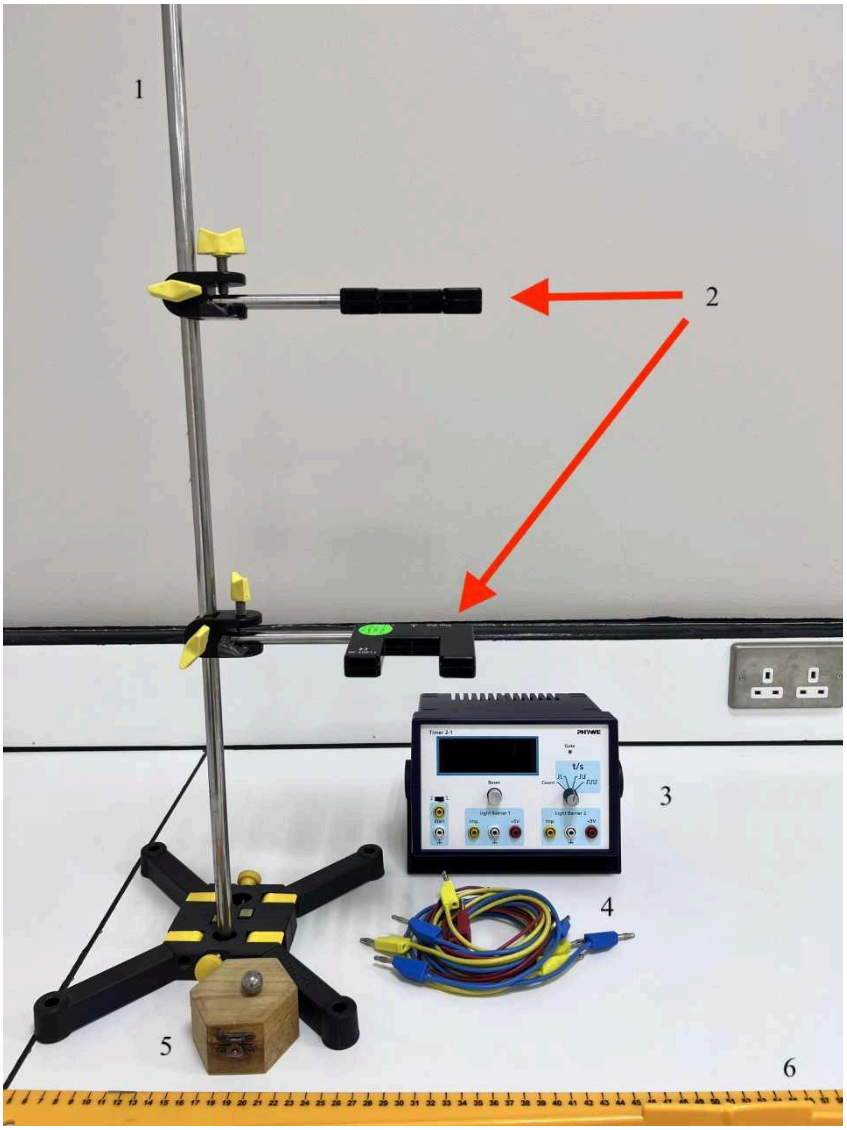
Where D is the displacement between the starting position of the object till the falling position, v_0 is the initial velocity, and g is the acceleration of gravity, and t is the time of falling of the object.

If the falling object start from rest, then the initial velocity is zero, therefore the equation of motion is given by:

$$D = \frac{1}{2}\, g\, t^2 \qquad (2)$$

In this experiment, we aim to find the acceleration of gravity experimentally, therefore finding g from equation (2), will lead to:

$$g = 2D/\, t^2 \qquad (3)$$



3) Apparatus

1) Big holder.
2) Two photoelectric gates.
3) Electric timer.
4) Wires for connection.
5) Iron ball.
6) Ruler.

4) Method

1) Set the displacement (D) between the two photoelectric gates, and let it be 30 cm. Make sure that you calculate it from the middle point of the first gate to the middle of the last gate near the floor. List this displacement in meters in table (1).
2) Turn on the electric timer, and make sure it is at rest mode.
3) Hold the iron ball and release it from rest (the initial velocity here is zero) near the middle of the first sensor, and place your second hand after the second sensor to avoid losing the ball.
4) Write down the time of falling in the table (1) in your report, and repeat this step three times, and then take the average, and then square your result.
5) Change this distance by 10 cm, and repeat steps 1-4. Fill the table (1) for all data.
6) Draw the relationship between the distance D, and the square of average time, and find the slope, which is given by:

$$\text{Slope} = \Delta t^2 / \Delta D \qquad (4)$$

7) Find the acceleration of gravity by using:

$$\mathbf{g = 2/ Slope} \qquad (5)$$

8) Calculate the percentage of error of g, if you know the real value of acceleration of gravity is: $g = 9.8\ m/s^2$.

109 Phys

Free Fall Experiment

Group	
Students names	
Date	
Day	

1) What is the aim of this experiment?

……

2) Fill out the table below:

No.	Displacement	Time			Average Time	Square of Average Time
	D ( )	t_1 ( )	t_2 ( )	t_3 ( )	t_{avg} ( )	t^2_{avg} ( )

3) Draw a graph representing the relation between the Displacement (D) and the square of the average time (t^2_{avg}).

4) What is the slope?

………………………………………………………………………………

5) Find the acceleration of gravity (g)?

……………………………………………………………………………….

6) What is the percentage of error for the acceleration of gravity?

……………………………………………………………………………….

Simple Pendulum Experiment

1) Aim of the experiment

Studying the simple harmonic motion of the simple pendulum by verifying the acceleration of gravity experimentally.

2) Theory

The definition of a simple pendulum is a small ball connected by a massless inelastic thread. When we move it for a short displacement (x), and angle (θ), we can analyze it as Fig. [1].

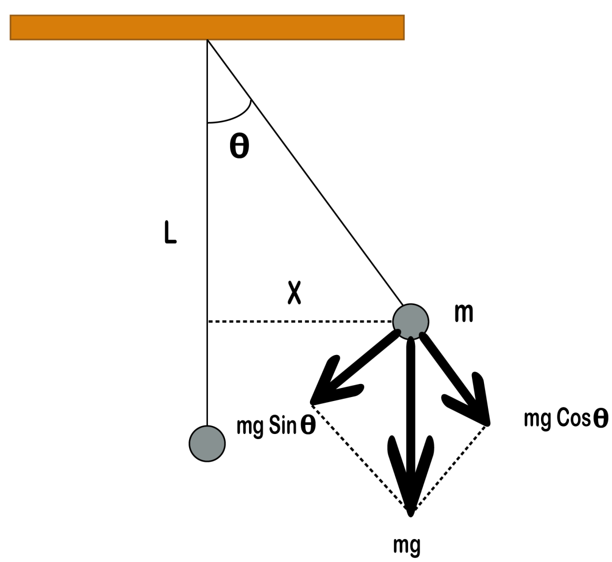


Fig. [1]: Simple harmonic motion of Pendulum

The motion of the pendulum can be analyzed for small movement from the equilibrium position, where x is the displacement, L is the pendulum length, and θ is the angle. The relation between x and L is given by: $x= L\ \theta$.

The force required to return the ball towards its original position is given by:

$$F = - mg \sin \theta \qquad (1)$$

Where m is the ball's mass. The motion of pendulum can't be a simple harmonic motion unless we have a small angle (θ), where we can replace Sin θ by: Sin θ = θ, this leads to:

$$F = - mg \theta = - mg x / L \qquad (2)$$

In simple harmonic motion, the force can be written as:

$$F = - \omega^2 x m \qquad (3)$$

Where ω is angular frequency and is given by:

$$\omega = 2 \pi f \qquad (4)$$

Where f is simple harmonic frequency, the periodic time is the inverse of frequency, therefore equation (3) can be written as:

$$F = -4 \pi^2 x m / T^2 \qquad (5)$$

From equation (2) and (5), the square of periodic time of simple pendulum is:

$$T^2 = 4\pi^2 L / g \qquad (6)$$

Solving for g in equation (6), this leads to:

$$g = 4\pi^2 L/T^2 \qquad (7)$$

3) Apparatus

1) Simple Pendulum.
2) Big holder.
3) Ruler.
4) Micrometer.
5) Stopwatch.

4) Method

1) Measure the diameter (d) of the simple pendulum ball by using the Micrometer, then find the radius (r) and record it in the report.
2) Set the length of the thread (l) to 30 cm or approximate to this number.
3) Calculate the total length of pendulum (L), which is given by: $L = l + r$.
4) Move the pendulum with a small angle (~ 15^{o}), with no force, just by releasing it from rest then simultaneously turn on the stopwatch.
5) Let it take 25 vibrations, where one vibration is counted as from the position of release till it comes back to the same position and record the total time (t).
6) Find out the periodic time (T) by using: $T = t/n$, where T is the periodic time of making one vibration, t is the total time of 25 vibrations and n is the number of vibrations, in our case it is 25, and then find the square of periodic time T^2.
7) Increase the length of the thread (l) by a few centimeters, and then repeat the steps from 3 to 6.
8) Plot the graph that represents the relationship between the total length of the pendulum L and the square of periodic time T^2, and then find the slope of the straight line.
9) Find the acceleration of gravity (g) by using:

   $g = 4\pi^2 / \text{Slope}$

10) Calculate the percentage of error of g, if you know the real value of acceleration of gravity is: $g = 9.8\ m/s^2$.

109 Phys

Simple Pendulum Experiment

Group	
Students names	
Date	
Day	

1) What is the aim of this experiment?

………………………………………………………………………………………………………

2) Find the diameter of the Pendulum's ball (d)?

………………………………………………………………………………………………………

3) Find the radius of the Pendulum's ball (r)?

………………………………………………………………………………………………………

4) Fill out the table below:

No.	Thread length l ( )	Total Pendulum's length $L = l + r$ ( )	Time of 25 vibrations t ( )	Periodic time T ( )	Square of Periodic time T^2 ( )
1					
2					
3					
4					
5					

3) Draw a graph representing the relation between the total length of the pendulum (L) and the square of the periodic time (T^2).

4) What is the slope?

……………………………………………………………………………..

5) Find the gravity (g)?

………………………………………………………………………………

6) Find the percentage of error for gravity

………………………………………………………………………………

Newton's law Experiment

1) Aim of the experiment

Finding the mass of a car by using Newton's second law.

2) Theory

Suppose we have an object like a car with a mass m moving on a smooth horizontal surface and is connected by inelastic thread moving via the pulley to another object with a mass m_g as seen in Fig. [1].

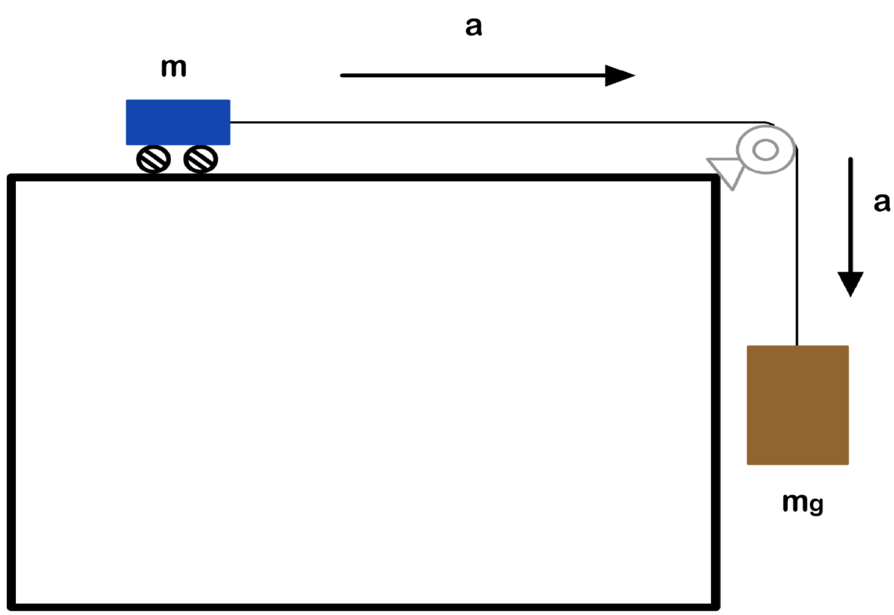


Fig. [1]: Diagram of Newton's second law experiment.

By using Newton's second law for m in the horizontal axis, we have:

$$T = m\,a \qquad (1)$$

By using Newton's second law for m_g in the vertical axis, we have:

$$T - F_g = -m_g\,a \qquad (2)$$

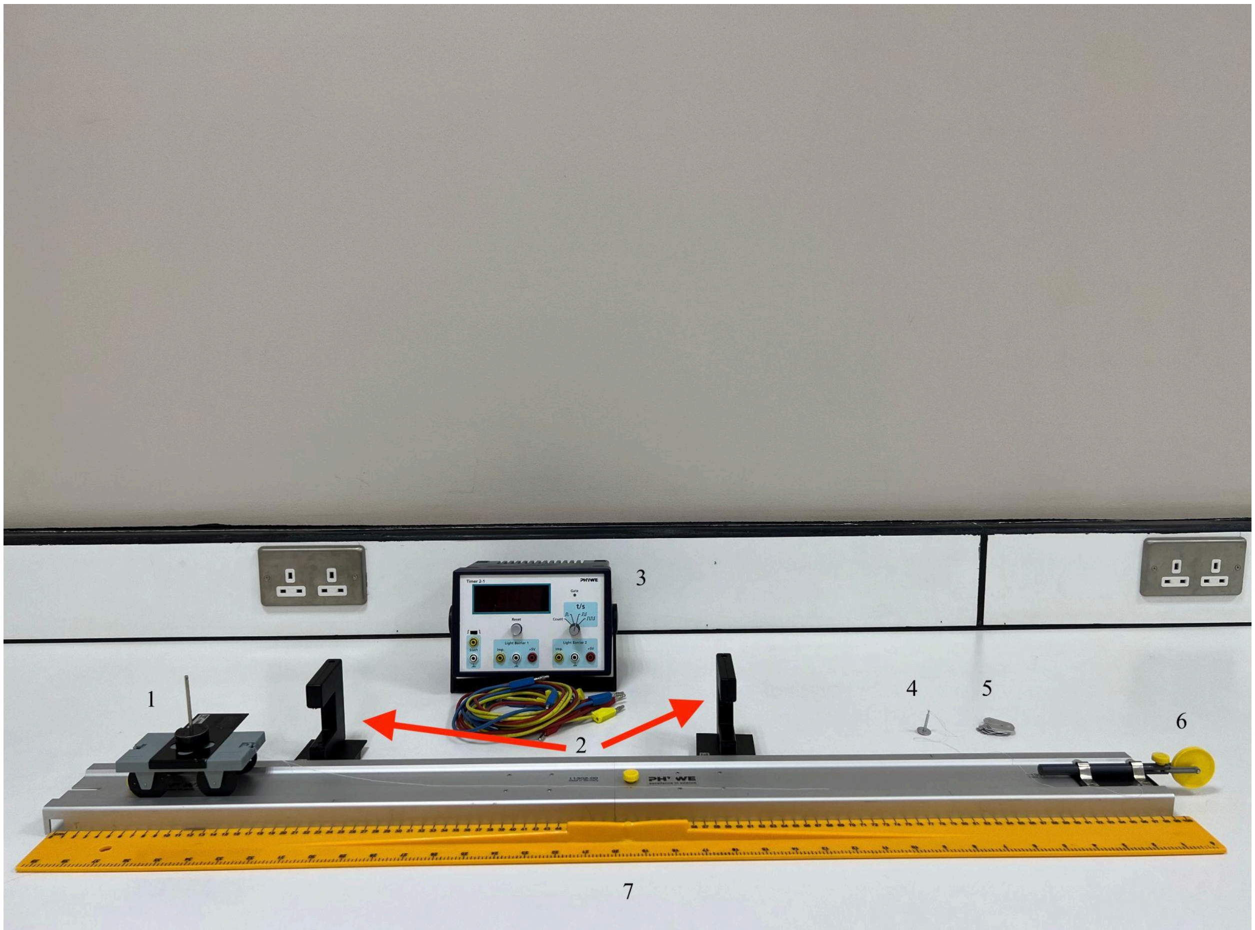
By substituting equation (1) into (2), we have:

$$a = F_g / (m + m_g) \tag{3}$$

By using the actual numbers in making this experiment, and very small m_g, we can rewrite equation (3) as:

$$a = F_g / m \tag{4}$$

We notice from equation (4), that the acceleration of the car (a) is directly proportional to the weight force for the object (F_g).



3) Apparatus

1) Car on track/ or carriageway.
2) Light barriers.
3) Electric timer.
4) Handle.
5) Slotted weight.
6) Pulley.
7) Ruler.

4) Method

1) Set the distance between the two light barriers to 50 cm, which represents the distance for the car in the track (S).
2) Take the thread that connects the car and pass it by the pulley, and then to the handle, where the handle weight is 1 g, write it down in the mass of m_g in the table (1).
3) Place the car at the end of the track before the first light barrier, press Reset on the electric timer, and let the car move from rest and with constant speed, read the time t from the electric timer and report it in table (1).
4) Calculate the acceleration of the car, from the equation of motion: $a= 2\ S/t^2$.
5) Find F_g by using: $F_g= m_g\ g$, where g is the acceleration of gravity: $g= 9.8\ m/s^2$.
6) Add more slotted weight by 1 g for each reading, and repeat steps 2-5, and record it in table (1).
7) Plot the relationship between the weight force F_g and the acceleration of the car a, where the slope is given by: Slope= $\Delta a/\ \Delta F_g$.
8) Calculate the mass of the car m from the slope, where it is given by:

   m = 1/ Slope

109 Phys

Newton’s Law Experiment

Group	
Students names	
Date	
Day	

1) What is the aim of this experiment?

………

2) Fill out the table below:

Table (1)

No.	Total mass of the slotted weight and the handle m_g ( )	Weight of the total mass on the handle F_g ( )	Time interval of the car t ( )	Acceleration a ( )
1				
2				
3				
4				
5				

3) Draw a graph representing the relation between Force and Acceleration.

4) What is the slope?

………………………………………………………………………………………………..

5) Find the mass of the car?

………………………………………………………………………………………………..

Hooke's law Experiment

1) Aim of the experiment

Finding the spring's constant by using the displacement method and the vibration method, and verifying Hooke's law.

2) Theory

Hooke's law is the law of elasticity discovered by Robert Hooke, which states that for relatively small deformations of an object, the displacement of the deformation is directly proportional to the deforming force, where the object returns to its original size upon removal of the force. This is due to the restoring force within the the elastic object, mathematically, the restoring force F on an elastic object is given by:

$$F = -k\,x \qquad (1)$$

Where k is the proportionality constant, or spring constant (if we use spring as the elastic object), which is depending on the elastic material type, radius of the spring's wire, and radius of spring's coil, and the number of coils. The negative sign is representing that the displacement x and the restoring force are in opposite directions.

Suppose we hanged a mass m on an elastic object like spring, then the spring will have a displacement from its original length with magnitude of ΔL, and the increase in mass will increase the displacement, therefore Hooke's law can be written in terms of displacement:

$$k = m\,g / \Delta L \qquad (2)$$

Where g is the acceleration of gravity, and we can measure the spring's constant in the units of **N/m**, or **Kg/ s^2**.

Alternatively, we can find the spring's constant in terms of the periodic time. Suppose we have a mass hanging in a spring, if we move this mass then it will have a simple harmonic motion from the original state, it will require periodic time (T) to complete one cycle/vibration. Hence, the periodic time is the time required for the mass to get back to its original rest position, and time to do so is: $T = t/n$, where t is the total time required to have number of vibration (n), then we can write Hooke's law in terms of vibration as:

$$k = 4 \pi^2 m / T^2 \qquad (3)$$

3) Apparatus

1) Spring.
2) Holder.
3) Stopwatch.
4) Handle.
5) Slotted weight (5, 10, 20, 50 grams).
6) Ruler.

4) Method

A) Finding Spring constant by using the displacement method:

1) Use a ruler to measure the original length of the spring, make sure no weight is added, and record it as L_0.
2) Add slotted weight, you can start with 50 g, and then measure the length L+, and record it in the (addition) column in the table.
3) Add another weight to increase the length, and measure the length L+, repeat this step until you finish five readings.
4) In the last reading, keep the weight and measure it again and type the measurement as L- in the (deduction) column in the table.
5) You will reduce the weight from the reading four, and make sure that the mass is the same as the addition, and measure it, you will fill the deduction column from last reading coming upward by reducing the weight similar to the addition's column weight. Where the last removal will be the first reading and record it in the table.
6) Then take the average of the two readings, the addition and deduction.
7) In the displacement ΔL, it is given by: $\Delta L = L_{avg} - L_0$. You deduct the average length with the original length of the spring.
8) Plot a graph between the mass m and the displacement ΔL, and find the slope of the straight line, which is given by: Slope= Δ(ΔL)/Δm.
9) Calculate the spring's constant from this relationship:

k= g/ Slope

B) Finding Spring constant by using the vibration method:

1) Add slotted weight, let it 150 g, and then move it downwards for small displacement, and let it move in simple harmonic motion.
2) Keep your eye in the position of displacement, and when the spring reaches the same position, you can count one cycle/ one vibration.
3) Simultaneously count the time with a stopwatch for 20 vibrations, and record it in t, then calculate the time required for one cycle T, which is given by: $T = t/20$.
4) Repeat steps 1-3, by increasing the weight with 50 g for each reading.
5) Plot the graph between the mass and the square of periodic time and find the slope, which is given by: Slope= $\Delta T^2/\Delta m$.
6) Calculate the spring constant from this relationship:

$k = 4\pi^2$ / Slope

109 Phys

Hooke's Law Experiment

Group	
Students names	
Date	
Day	

1) What is the aim of this experiment?

……………………………………………………………………………………………………..

2) Spring constant

A) The displacement method:

L_0 = ……………………… (   )

no.	Mass m ( )	Addition L+ ( )	Deduction L- ( )	Average L ( )	Displacement **Δ**L ( )
1					
2					
3					
4					
5					

Slope= ……………………………

K= …………………………………

B) The vibration method:

no.	Mass m ( )	Time of 20 vibrations ( )			Average t ( )	Periodic time T=t/20 ( )	Square of periodic time T^2 ( )
		t_1	t_2	t_3			
1							
2							
3							
4							
5							

Slope= ……………………….

K= ……………………………

3) Compare the result of K in part (A) with part (B)?

……………………………………………………………………………………………

Focal Length Experiment

1) Aim of the experiment

Finding the Focal length by using the Reflection method, and the Refraction method, as well as finding the magnification, and verifying the law of lenses.

2) Theory

We have two types of thin-lenses: converging lens and diverging lens. For converging lenses, which are thicker in the center than at the edge, the optical rays from the object are refracted parallel rays toward the optical axis, to form a real image but inverted, as seen in Fig. [1]. In contrast to diverging lenses, which are thinner in the center than at the edges, the optical rays are refracted parallel rays away from the optical axis and scatter to form a virtual image. In this experiment, we use only converging lenses.

In both cases, the focal length (f) is the distance from the optical center of the lens to the point at which rays parallel to the optical axis converge or from which they appear to diverge. The focal length has the unit of m. The distance between the object and the lens is called S, and the distance between the lens and the image is called S', both have the unit of m. From the law of lenses we have:

$$1/f = 1/S + 1/S' \qquad (1)$$

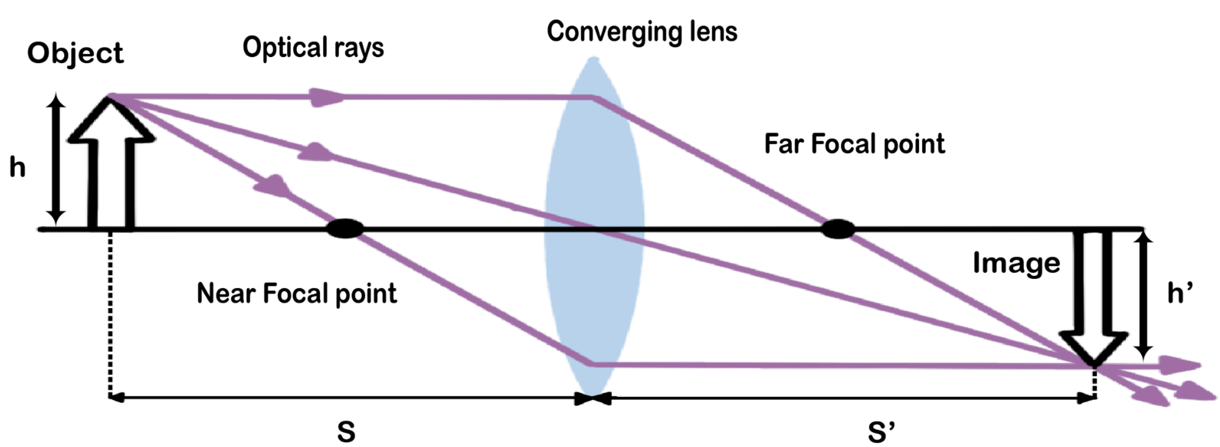


Fig. [1]: Diagram of the refraction rays of converging lenses.

In the reflection case, we have a converging lens, and then a mirror, as seen in Fig. [2]. The optical rays will move from the object to the converging lens and then reflected by the mirror to the object. In this special case, we have the focal length is equal to the distance from the object and lens (S), and equal to the distance from the lens to the image (S'), mathematically speaking it can be written as:

$$f = S = S' \qquad (2)$$

The inverse of the focal length is called power lens (P) and is given by:

$$P = 1/f \qquad (3)$$

Where the unit of the power lens (P) is **Dioptre** or **m^{-1}**.

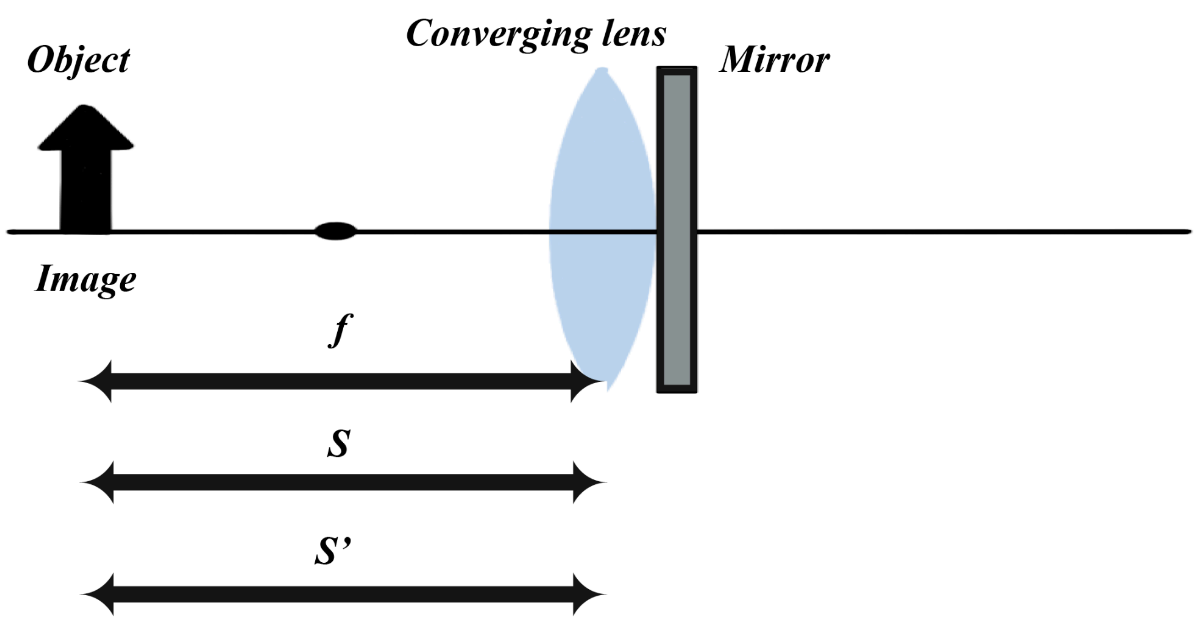
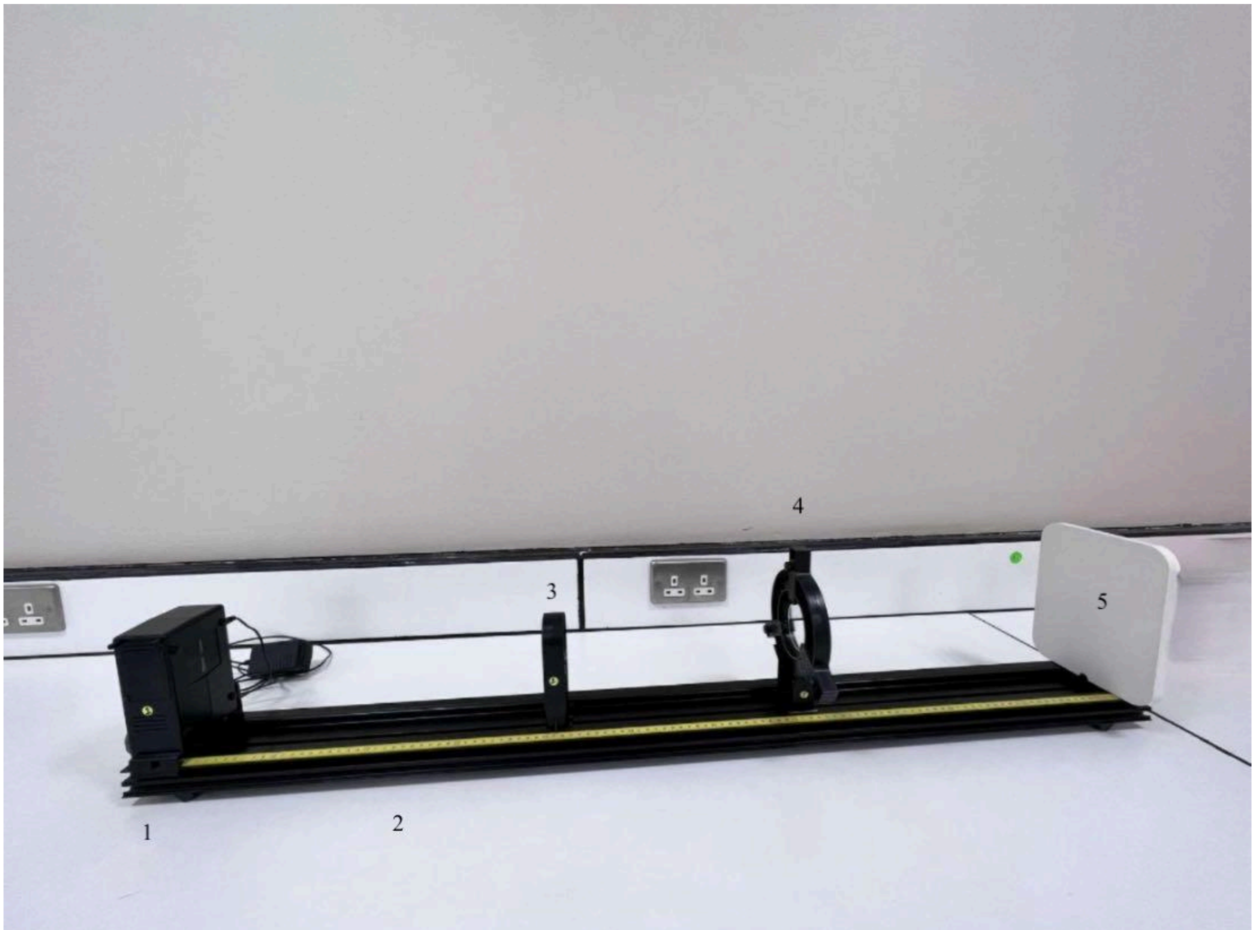


Fig. [2]: Diagram of the reflection rays of converging lenses.

In the case of magnification for converging lens:

$$M = -S'/S = h'/h \qquad (4)$$

Where h is the height of the object, and h' is the height of the image.



3) Apparatus

1) Light source that holds the object.
2) Optical track with a measuring scale.
3) Converging lens, and its holder.
4) Mirror, and mirror holder.
5) White Screen and its holder.

4) Method

A) Finding Focal length by using the reflection method:

1) Put the converging lens between the mirror and the object, similar setup as Fig. [2]. Make sure that the optical track is at the same level, and you work in a dark room.
2) Move the mirror and the lens together until you find the best image possible that is reflected back to the object.
3) Measure the distance between the lens and the object to find the focal length, remember in the reflection method we use equation (2).
4) Repeat steps 2 and 3, for two times and record your data in table (1).
5) Calculate the focal length average and then the power of the lens (P), by using equation (3).
6) Find the percentage of error for the focal length of the lenses. Figure out from where we can find the real value of the focal length.

B) Finding Focal length by using the refraction method:

1) Remove the mirror, and insert the white screen at the end of the optical track, similar setup of Fig. [1].
2) Place the lens between the object and the white screen, and then move it until you find the best small image possible.
3) Record your reading for S (distance between the object and the lens), and S' (distance between the lens and the image). Notice that the object is on the light source, and the image is seen on the white screen.
4) Move the lens again by increasing the distance S for each reading, until you find the best small image possible. Repeat these steps (2-4) until the end of table (2).
5) Find the inverse of S and S' and record it in the table (2).

6) Plot the relationship between 1/S on the x-axis, and 1/S' on the y-axis, and make sure that you start from zero in each axis.
7) Find the first focal length from the x-intercept of 1/S, mathematically is given by: $1/f_1 = 1/S$, and the second focal length is taken from the y-intercept of 1/S', which is given by: $1/f_2 = 1/S'$.
8) Calculate the average of the focal length, and record it in table (3).
9) Compare between the focal length from the reflection part, and the focal length from the refraction part.

C) Finding the Magnification:

1) Same setup as the refraction method. Move the lens until you find the best bigger image possible.
2) Record the distances S, and S', and the heights h, and h'.
3) Use equation (4) to find the magnification, one from the distances S, and S', and the second from the heights, h and h'.
4) Compare between the first and second methods of magnification.

109 Phys

Focal Length Experiment

Group	
Students names	
Date	
Day	

1) What is the aim of this experiment?

………

2) The focal Length

A) The Reflection part

1) Fill out the table below:

Table (1)

Focal Length			Average Focal Length	Power of the lens
f_1 ( )	f_2 ( )	f_3 ( )	f_{avg} ( )	P ( )

2) What is the value of the experimental average focal length?

……………………………………………………………………………………….

3) Find what is the real value of the focal length? And from where?

……………………………………………………………………………………….

4) What is the percentage of error for the Focal length?

……………………………………………………………………………………….

B) The Refraction part

1) Fill out the table below:

Table (2)

No.	S ( )	S' ( )	1/ S ( )	1/S' ( )
1				
2				
3				
4				
5				

2) **Draw a graph representing 1/S vs 1/S'.**

3) **Fill out the following table, if you know the deductive value of x and y axes are 1/S vs 1/S' respectively.**

Table (3)

1/S ( )	1/S' ( )	f_1 ( )	f_2 ( )	f_{avg} ( )

4) **Compare the focal length of the first part of reflection and the second part of refraction?**

……………………………………………………………………………………………..

C) Magnification

1) **Find out the magnification by using the values of S, and S'?**

…………………………………………………………………………………………….

2) **Find out the magnification by using the values of h, and h'?**

……………………………………………………………………………………………..

3) **Compare the values of magnification from 1) and 2) ?**

……………………………………………………………………………………………

Ohm's Law Experiment

1) Aim of the experiment

Finding unknown resistances by using Ohm's law, as well as finding the equivalent resistance in series and in parallel.

2) Theory

Ohm's law states that the current (I), that flows in an electric circuit is directly proportional to the voltage (V), and inversely proportional to the resistance (R), and mathematically is given by:

$$V = I\,R \qquad (1)$$

Where V is the voltage and is measured by voltmeter, and has the unit of Volt (V), and I is the current and measured by Ammeter, and has the unit of Ampere (A), and R is the resistance and is measured by a resistor and has the unit of Ohm (Ω).

Resistor in general is a wire from a conducting material, and has two types: ohmic resistors, and non-ohmic resistors. Ohmic resistors are resistors that obey Ohm's law, in contrast, non-ohmic resistors are not obeying Ohm's law. Overall, resistors are used in electric circuits to reduce the current in the circuit. As seen in Fig. [1].

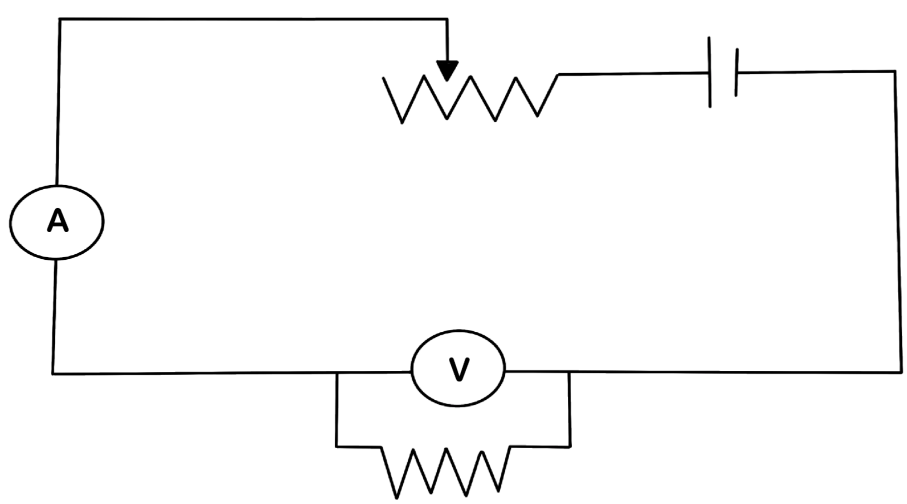


Fig.[1]: Ohm's law circuit

We have two ways to connect resistors in a circuit:

1) Connecting resistors in series.
2) Connecting resistors in parallel.

In the case of series, resistors are connected next to each other in series, and then connected by the voltmeter in parallel, as seen in Fig.[2]. The equivalent resistance R_S for this case is more than the individual resistance, and is given by:

$$R_S = R_1 + R_2 + R_3 + \dots \qquad (2)$$

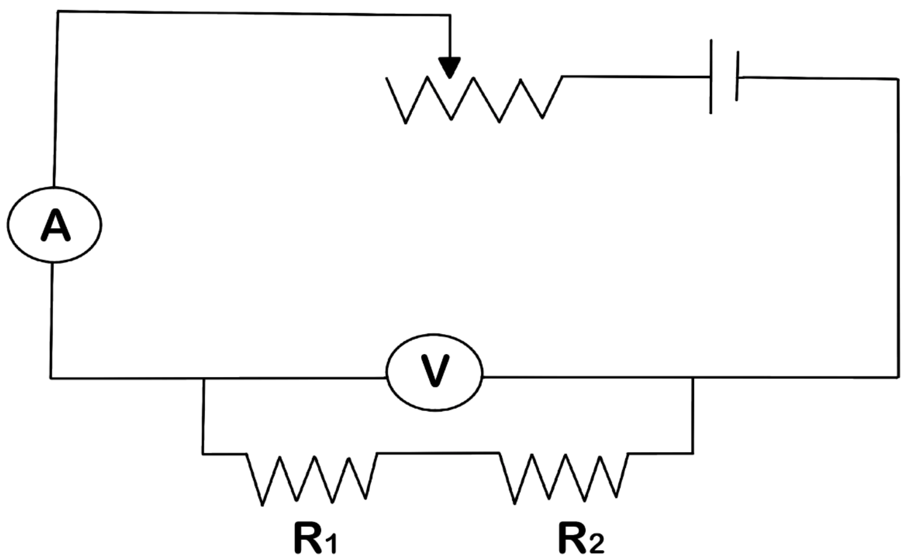


Fig.[2]: The electric circuit for connecting resistors in series

For series connected in parallel, we will have each resistor in the top of each other parallelly, and connected also with voltmeter in parallel as seen in Fig.[3]. The equivalent resistance R_P for this case is less than any individual resistance, and is given by:

$$1/R_P = 1/R_1 + 1/R_2 + 1/R_3 + \dots \qquad (3)$$

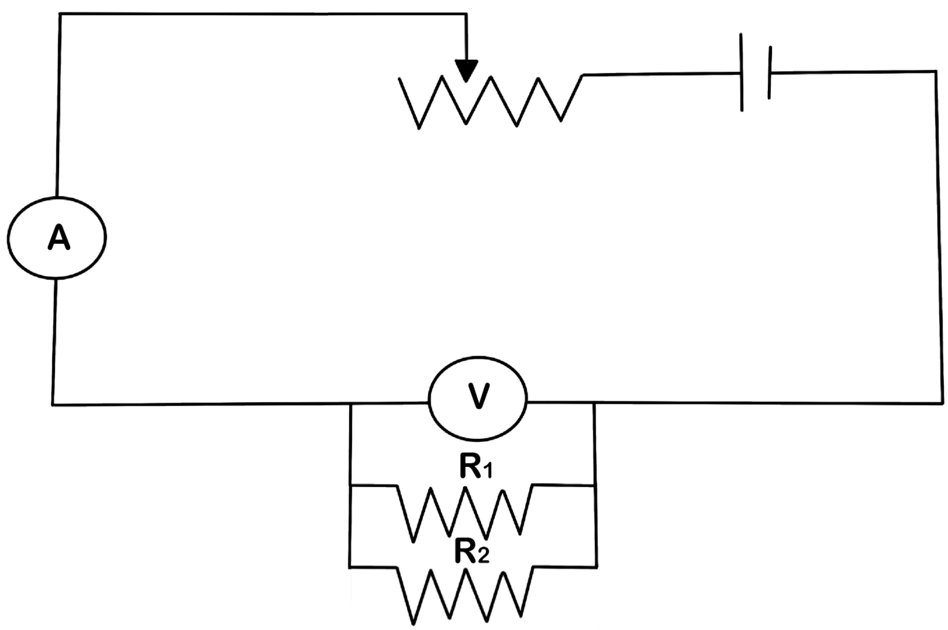


Fig.[3]: The electric circuit for connecting resistors in parallel.

3) Apparatus

1) DC Voltage source, battery.
2) Rheostat (variable resistor).
3) Circuit board.
4) Two ohmic fixed resistors (R_1, R_2).
5) Connecting wires.
6) Ammeter.
7) Voltmeter.

4) Method

A) Finding unknown resistance R_1:

1) Connect the electric circuit as Fig. [1].
2) Move the Rheostat to the maximum end.
3) Record the values of I from the Ammeter, and V from the voltmeter and list it in table (1).
4) Change the value on Rheostat and take the readings for I and V, until you record 5 readings.
5) Plot the graph between I and V, and find the slope of the straight line as the following: Slope= $\Delta V/\Delta I$.
6) Find the unknown resistance R_1 from the use of the slope, where R_1= Slope.

B) Finding unknown resistance R_2:

1) Connect the electric circuit as Fig. [1], but replace R_1 by R_2.
2) Same as part (A), change the rheostat and record the values of I and V, and record it in table (2).
3) Find the resistance for each reading by using Ohm's law in equation (1), and then take the average, the value of this average is representing R_2.

C) Finding the equivalent resistance in series (R_S):

1) Connect R_1 and R_2 as Fig.[2].
2) Change the rheostat and record the values of I and V in table (3).
3) Find the resistance for each reading by using Ohm's law in equation (1), and then take the average, the value of this average is representing the experimental value of the equivalent resistance in series ($\overline{R}_S$).
4) Calculate the theoretical value of the equivalent resistance R_S, as the following: $\mathbf{R_S= R_1 +R_2}$.
5) Compare between the theoretical and experimental value of R_S.

D) Finding the equivalent resistance in parallel (R_P):

1) Connect R_1 and R_2 as Fig.[3].
2) Change the rheostat and record the values of I and V in table (4).
3) Find the resistance for each reading by using Ohm's law in equation (1), and then take the average, the value of this average is representing the experimental value of the equivalent resistance in parallel ($\overline{R}_p$).
4) Calculate the theoretical value of the equivalent resistance R_P, as the following: **$R_P = (R_1 R_2)/(R_1 + R_2)$.**
5) Compare between the theoretical and experimental value of R_P.

109 Phys

Ohm's Law Experiment

Group	
Students names	
Date	
Day	

1) What is the aim of this experiment?

………

2) Finding the unknown resistance R_1

Table 1

No.	I ( )	V ( )
1		
2		
3		
4		
5		

Slope =

R_1 =

3) Finding the unknown resistance R_2

Table 2

No.	I ( )	V ( )	R_2 ( )
1			
2			

$\bar{R}_2$=

4) Finding the equivalent series resistance R_s

A) Experimentally

Table 3

No.	I ( )	V ( )	R_S ( )
1			
2			

$\bar{R}_s$=

B) Theoretically

R_S =

C) Compare the experimental value of the series resistance R_S with the theoretical value?

....

5) Finding the equivalent parallel resistance R_p

A) Experimentally

Table 4

No.	I ( )	V ( )	R_p ( )
1			
2			

$\bar{R}_p$=

B) Theoretically

R_p =

C) Compare the experimental value of the parallel resistance R_p with the theoretical value?

……

Coefficient of Viscosity of Glycerine Experiment

1) Aim of the experiment

To determine the coefficient of viscosity of Glycerine by using Stokes' law.

2) Theory

Viscosity is the resistance of a fluid to change in shape or movement of neighboring portions relative to one another. In this experiment, we determine the coefficient of viscosity of Glycerine by using Stokes' law. Stokes' law states that retards a sphere moving through a viscous fluid is directly proportional to the velocity, and the radius of the sphere, and the viscosity of the fluid.

For a sphere of radius $\boldsymbol{r}$ moving at velocity $\boldsymbol{v}$ in an extended fluid dynamic viscosity η, the frictional force F_1 according to Stokes' law is given as:

$$F_1 = 6 \pi r v \eta \qquad (1)$$

All the forces which are acting on the sphere will be in equilibrium: the frictional force F_1 which acts upwards, the buoyancy force F_2 which also acts upwards and the downward acting gravitational force F_3, shown in free body diagram. The latter two forces are given by:

$$F_2 = \frac{4}{3} \pi r^3 \rho_L g \qquad (2)$$

$$F_3 = \frac{4}{3} \pi r^3 \rho_S g \qquad (3)$$

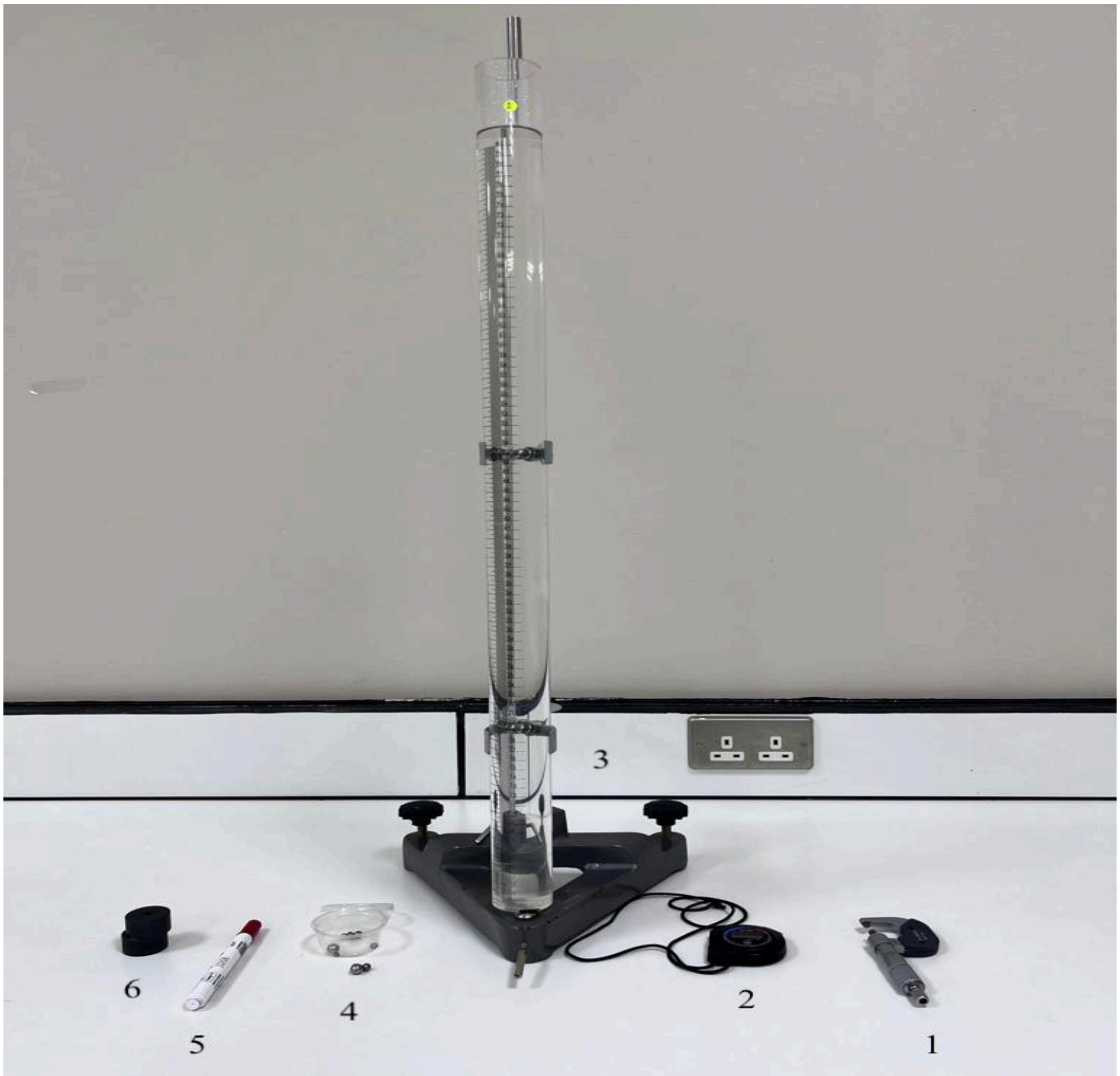
The net force in dynamic equilibrium will leads to:

$$F_1 + F_2 - F_3 = 0 \qquad (4)$$

Substituting equations (1), (2), and (3) into (4), and solving it for the viscosity η :

$$\eta = \frac{2}{9\,v}\, r^2\, (\boldsymbol{\rho}_S - \boldsymbol{\rho}_L)\, g \qquad (5)$$

Where η is the viscosity of the liquid, and $\boldsymbol{v}$ is the velocity and can be determined by measuring the fall time $\boldsymbol{T}$, over the distance $\boldsymbol{D}$. In addition, $\boldsymbol{\rho}_S$ is the destiny of the iron ball, $\boldsymbol{\rho}_L$ is the destiny of the liquid (Glycerine), $\boldsymbol{r}$ is the radius of the ball and g is the gravitational force. The viscosity unit is given by (Pascal**.**Second).



3) Apparatus

1) Micrometer.
2) Stopwatch.
3) Glass cylindrical jar with millimeter graduations, transparent viscous liquid (Glycerine), and 2 clamps with stand.
4) Different diameter iron balls.
5) Board’s pen.
6) Magnets.

4) Method

1) By using the Micrometer, calculate the diameter of the iron ball, you can start with the biggest ball, and type your result in the table.
2) On the glass cylindrical jar, use the board pen to mark (A) on the top of the cylindrical jar, and mark (B) at the end of it, let it be 50 cm, this will be the distance **D** required for the iron ball to fall in the Glycerine. This will be a fixed distance, and list it in the report.
3) From rest, take the iron ball and let it fall inside the glass cylindrical jar, exactly in the middle, and when it reach the mark A start the stopwatch and let it fall and count the time until it reach mark B then stop the stopwatch, repeat this step two times, and then take the average time T_{avg}.
4) To take out the iron ball from the glass cylindrical jar, use the magnet.
5) Repeat steps 1 to 4, for different diameters of iron balls.
6) Find the velocity v, by using this relationship: $\boldsymbol{v} = \mathbf{D} / T_{avg}$.
7) Plot the relationship between $\mathbf{r^2}$ and $\boldsymbol{v}$, where it is given by: Slope= $\Delta \boldsymbol{v} / \Delta r^2$.
8) Calculate the coefficient of viscosity of Glycerine by using:

$$\eta = \frac{2}{9\,Slope} (\boldsymbol{\rho}_S - \boldsymbol{\rho}_L)\, g$$

Where the constants here are:

$\mathbf{g} = 9.8 \text{ m/s}^2$

$\boldsymbol{\rho}_S = 7800 \text{ kg/m}^3$

$\boldsymbol{\rho}_L = 1260 \text{ kg/m}^3$

9) Find the percentage of error if you know that the real value of the coefficient of viscosity of Glycerine at 25 C is **0.95 Pa.S**.

109 Phys

Coefficient of Viscosity of Glycerine Experiment

Group	
Students names	
Date	
Day	

1) What is the aim of this experiment?

………

2) Calculation of the coefficient of viscosity of Glycerine

A) Finding the distance of the falling iron ball

D= ………….. (   )

B) Fill out the table

Diameter of the ball ( )	Radius of the ball ( )	Square of the radius ( )	Time of falling		Average of time T_{avg} ( )	Velocity v ( )
			T_1 ( )	T_2 ( )		

C) Find the Slope

Slope= ………………………………………..

D) Find the coefficient of viscosity of Glycerine

η = **…………………………………………….**

D) Find the percentage of error for η ?

…………………………………………………..