Lab Physics

105 & 125



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@q8dynamics

* How to Calculate the:

* Average: ($\bar{x}$)

$$\bar{x} = \sum_{i=1}^{i=n} \frac{x_i}{n} = \frac{x_1 + x_2 + ... + x_n}{n} \tag{1}$$

where x represents the physical parameter measured, n equals the number of measurements, and x_i is the i^{th} measured value.

* Standard deviation: (σ_x)

$$\sigma_x = \sqrt{\frac{1}{n-1} \sum_{i=1}^{i=n} (x_i - \bar{x})^2}$$

$$= \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + ... + (x_n - \bar{x})^2}{n-1}}$$

* Standard Error: ($\sigma_{\bar{x}}$)

$$\sigma_{\bar{x}} = \frac{\sigma_x}{\sqrt{n}}$$

* Example:

quantity	T_1	T_2	T_3	T_4	T_5	T_6
T_i (s)	1.430	1.368	1.402	1.324	1.389	1.422

Find $\bar{T}$, σ_T, $\sigma_{\bar{T}}$:

$n = 6$

$$\bar{T} = \frac{1.43 + 1.368 + 1.402 + 1.324 + 1.389 + 1.422}{6}$$

$$= 1.39 \text{ s}$$

$$\sigma_T = \sqrt{\frac{(1.43 - 1.39)^2 + (1.368 - 1.39)^2 + (1.402 - 1.39)^2 + \cdots}{6 - 1}}$$

$$= 0.039$$

$$\sigma_{\bar{T}} = \frac{\sigma_T}{\sqrt{n}} = \frac{0.039}{\sqrt{6}} = 0.016$$

* Linear Graph:

* Slope:

$$m = \frac{y_B - y_A}{x_B - x_A}$$

* General equation of straight line:

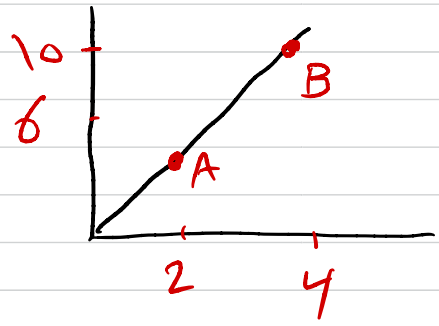
$$y = mx + C$$

Example:

Slope:

$$m = \frac{10-6}{4-2}$$

$$= \frac{4}{2} = 2$$



Measurements of Density

Objectives

In this experiment the students will be introduced to the most frequently used measuring devices. Those devices are used for determining the length, diameter, and mass of a set of cylindrical objects. The main objective of this experiment is to show the students how to use those measuring devices properly to determine the density of the cylindrical objects and compare it to the accepted values of the density of the metals.

* measuring devices:

① the *Micrometer Screw Gauge* (for small body)

↳ in mm

The **micrometer screw gauge**, (Figure 2), is most convenient for the accurate measurement of short lengths. The object is placed between the end of the screw and the anvil. The distance through which the screw travels is measured by two scales:

- **Main Scale** which is divided into millimeters on the lower part and half millimeters on the upper part.
- **Rotating Scale** which is divided to (50) divisions each of which represents (0.01 mm).

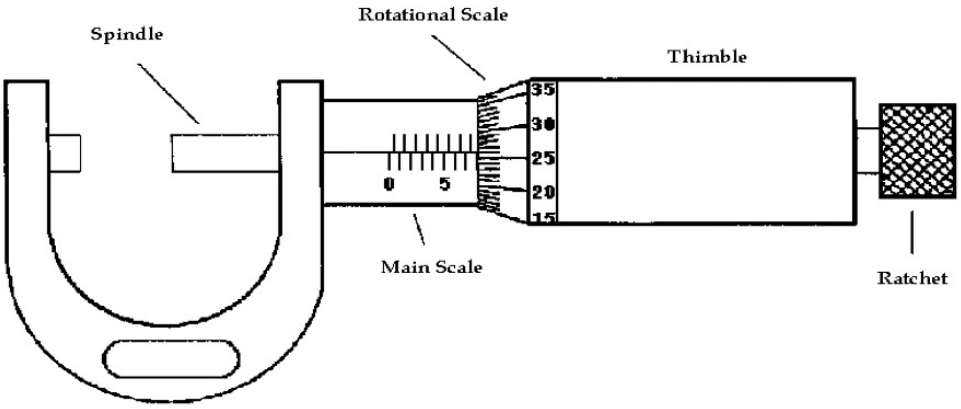


Figure 2. Micrometer Screw Gauge

How to take readings from Micro-meters

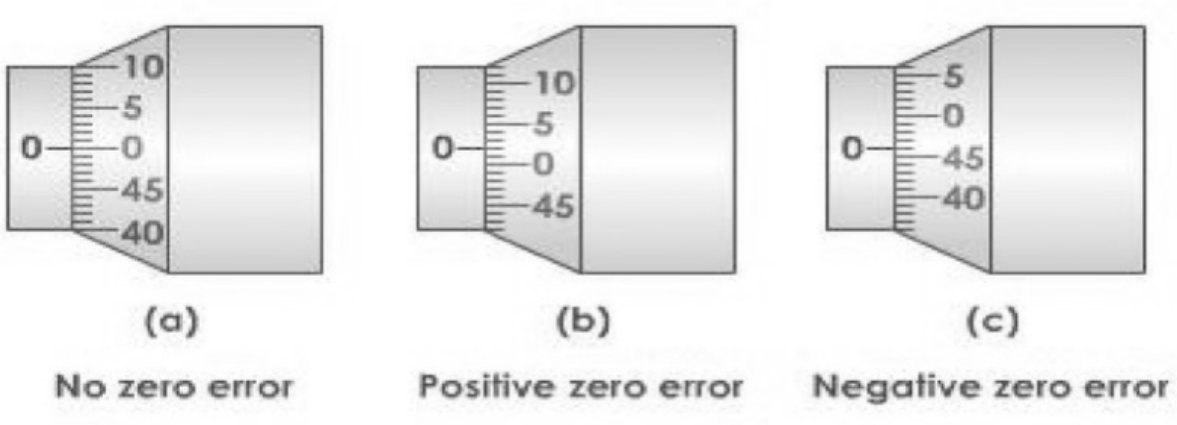


Figure 5:(a). has no zero error and hence zero correction (Z.C)=0, (b). has a zero error of +2 and hence zero correction (Z.C)=-2, (c). has a zero error of -4 therefore its zero correction (Z.C)= +4

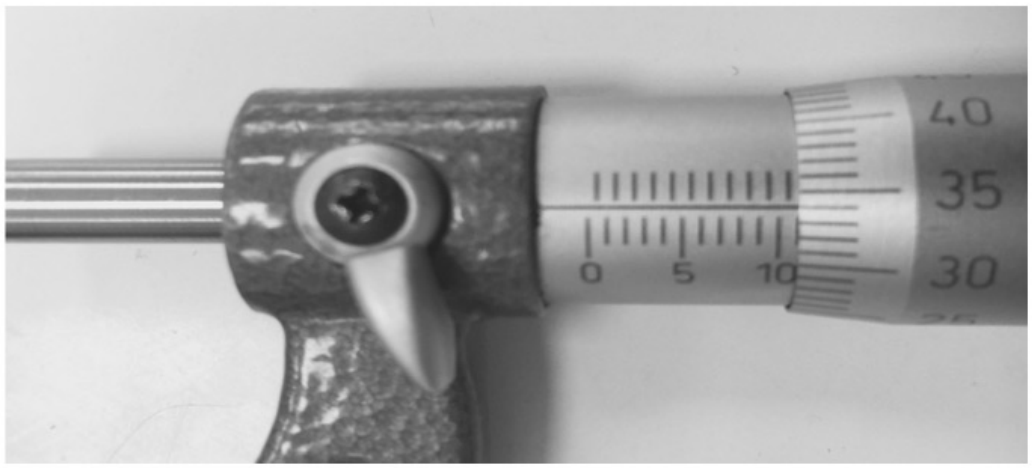


Figure 6. Assuming that zero correction (Z.C)=+5. In this figure Main scale reading **(M.S.R)**=10.5mm, and the rotation scale reading **(R.S.R)**=34, thus the total reading is:

$$T.R = M.S.R + \frac{R.S.R}{100}$$

$$T.R = 10.5 + \frac{34+5}{100} = 10.89mm$$

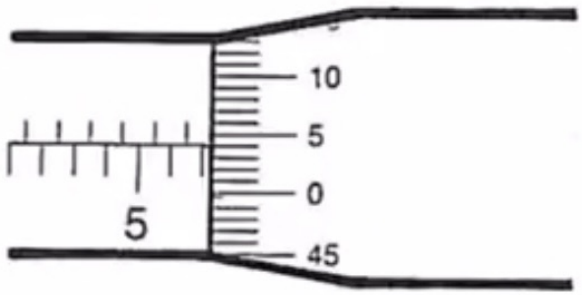
What is the total reading for the micrometer? (assume that ZC=0)
(5 Points)



- 12.99 mm
- 12.49 mm
- 10.69 mm
- 10.99 mm

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QUESTION-10) The diameter of a solid cylinder is measured using a micrometer screw gauge. The diagram shows an enlargement of the shaft of the micrometer screw gauge when taking the measurement.
What is the diameter of the solid cylinder (Zero correction = Z.C= -4)?
(2 Points)



- 6.05 mm
- 6.54 mm
- 7.18 mm
- 7.00 mm

② the *Vernier Caliper* (for Small body)

↳ in cm

The **Vernier Caliper**, (Figure 3), is considered also as a convenient device for accurate measurement of short lengths of objects. The object placed between the jaws. The distance through which the jaws travel is measured by two scales:

- **Main Scale** which is divided into inches on the upper part and centimeters on the lower part.
- **Vernier Scale** which is divided to (20) divisions each of which represents (0.005 cm).

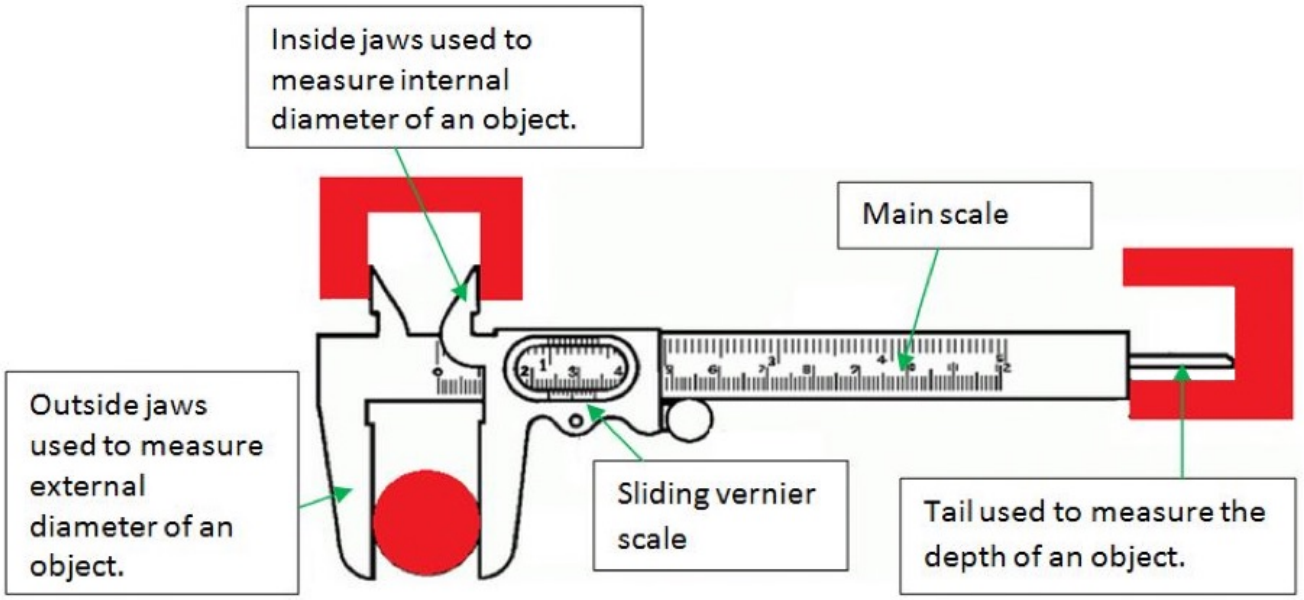


Figure 3. Vernier Caliper

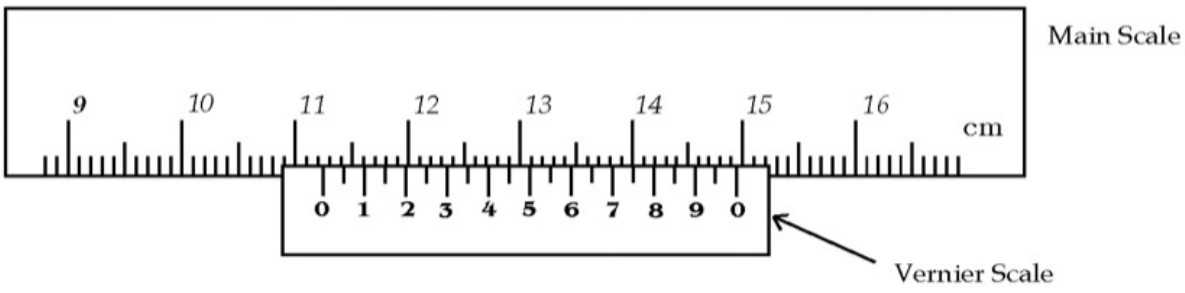
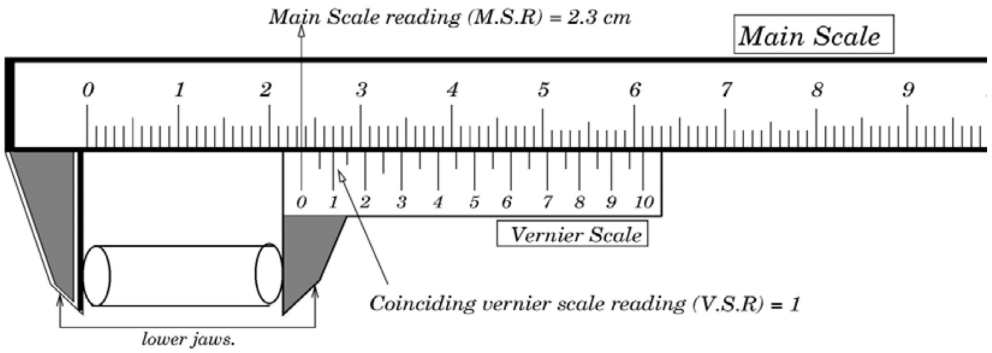


Figure 4. Magnified view of the Vernier Caliper

Example: Find the total reading (T.R)



① $M.S.R = 2.3\ cm$ → إذا كان بين رقمين آخذ الرقم الأقل

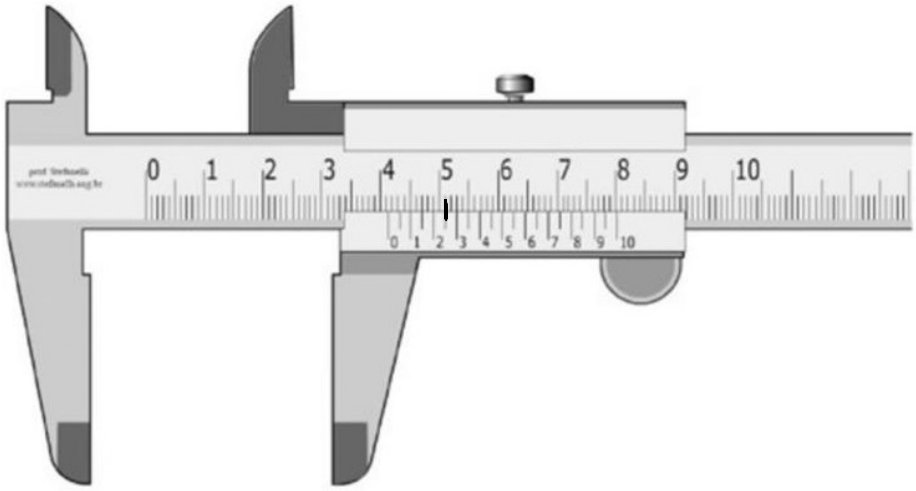
② $V.S.R = 1$ → الرقم المتطابق مع الخط

③ $$T.R = M.S.R + \frac{V.S.R}{100}$$

$$= 2.3 + \frac{1}{100} = 2.31\ cm$$

1

What is the reading on the Vernier Caliper * ?in the picture shown below
(1/1 نقطة)



cm 9.150

cm 4.354

cm 4.125

cm 3.395

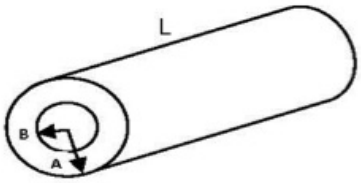
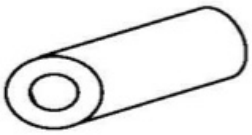
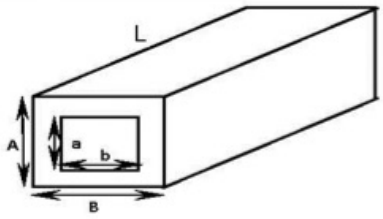
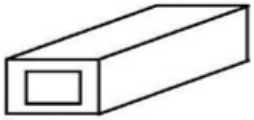
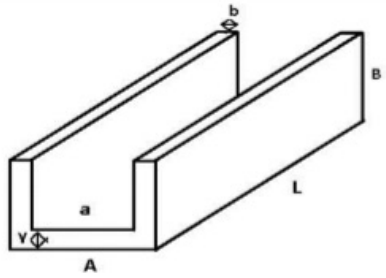
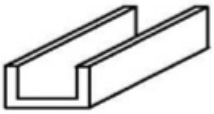
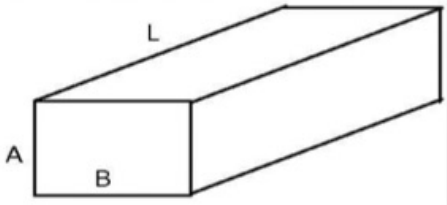
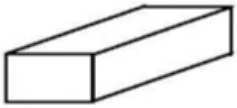
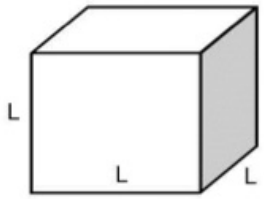
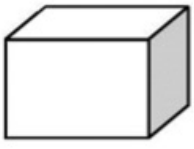
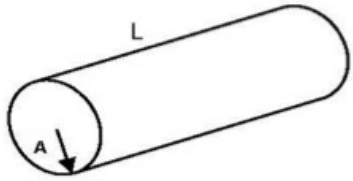
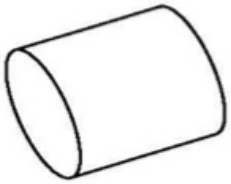
* Density: (ρ)

$$\rho = \frac{m}{V}$$

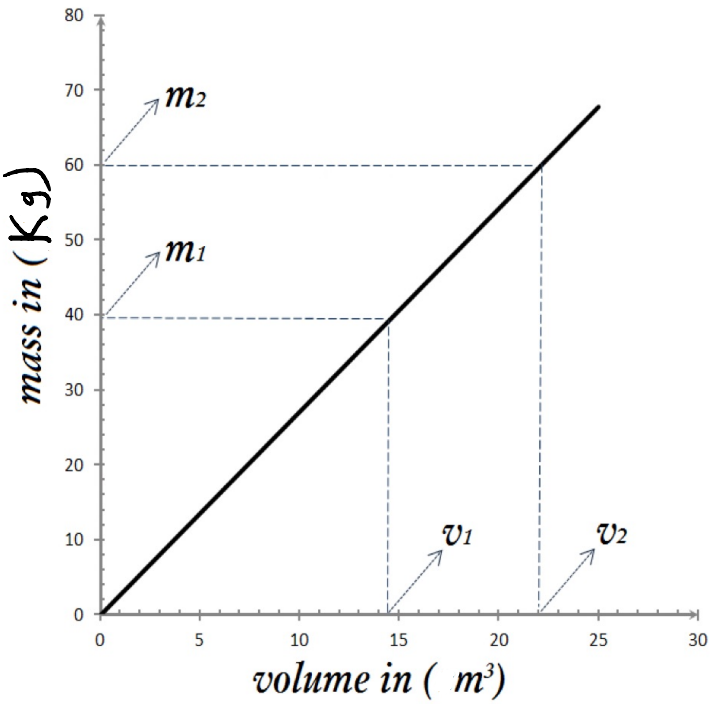
m → الكتلة

V → الحجم

Table 1. Geometrical Shapes and their corresponding volumes

Shape and dimensions		Volume
		$V = \pi(a^2 - b^2)L$
		$V = L(AB - ab)$
		$V = 2(B - y)bL + (ALy)$
		$V = A \times B \times L$
		$V = L^3$
		$V = \pi A^2 \times L$

Example:



$$Slope = \frac{m_2 - m_1}{v_2 - v_1} = \frac{(60) - (46)}{(22) - (14)}$$

$$Density = Slope = \frac{2.5\ Kg}{m^3}$$

لـ الكثافة ثابته لكل نوع مادة.

EX:

What can you comment on two copper right circular cylinders of different masses and dimensions
(5 Points)

- ○ The one with bigger mass has a larger density
- ○ The one with bigger radius has a larger density
- ○ Not enough information to decide which one has the larger density
- ○ They both have the same density

1. Two cylindrical objects made from the same material, if the mass of the first object is doubled then the densities of the two objects are:
(0/5 Points)

- P1 = 2P2
- P1 = 0.5P2
- P1 = 0.25P2
- P1 = P2
- None of above

2

A right circular cylinder with a radius of 2.3 cm and a height of 1.4 m has a volume of
(5 Points)

- ○ $0.20\ m^3$
- ○ $0.14\ m^3$
- ○ $0.0093\ m^3$
- ○ $0.0023\ m^3$

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QUESTION-11) An experiment is carried out in the physics laboratory to determine the density of the cylindrical object.
You are required to find the mass (M) of the metal used to make the cylinder using the data set provided below.
(2 Points)

Density (ρ)	Length of the cylinder (L)	Diameter of the cylinder (D)
$7.83\ g/cm^3$	$12.59\ cm$	$5.45\ mm$

- 27.00 g
- 25.00 g
- ✓ 23.00 g
- 19.00 g
- None of the above.

5

The measurements of the dimensions of a cylinder of copper are given in the table below. Complete the table and find the density "ρ" of copper *
(2 Points)

Height = 3 cm	Volume = --------	m = 47 g	ρ = ------
Diameter = 1.5 cm			

- ◯ $3.54\ cm^3, 1.18 g/cm^3$
- ◯ $5.30\ cm^3, 8.87 g/cm^3$
- ◯ $3.53\ cm^3, 2.35 g/cm^3$
- ◯ $10.59\ cm^3, 7.07 g/cm^3$

2. If the mass of the cylindrical object is 0.045 kg , its density is 8.9 g/cm3 and its length is 2 cm, then the radius of the base is: (0/5 Points)

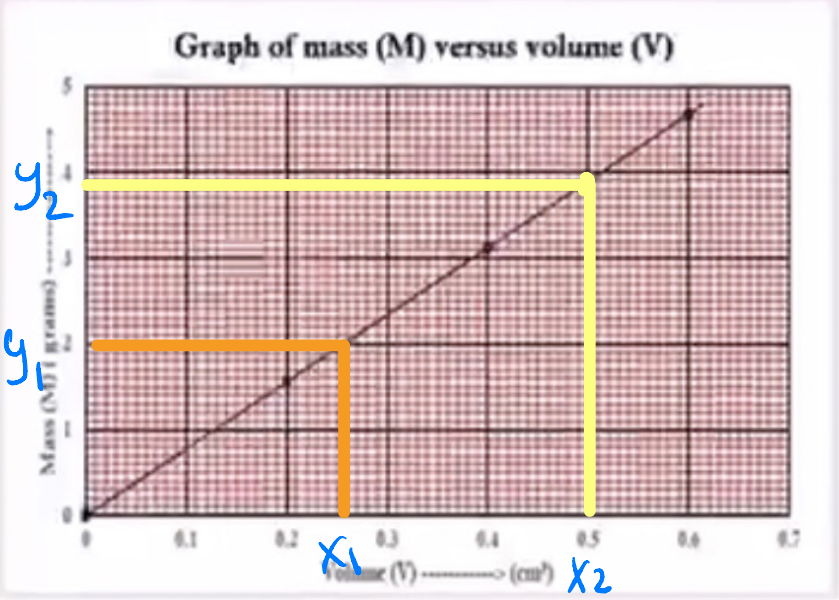
- 0.028 cm
- 0.28 cm
- 2.8 cm
- 0.9 cm ✓

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QUESTION-12) Measurement of density experiment is carried out and a graph of Mass (M) versus Volume (V) is plotted using the data set recorded. The object was cylindrical in shape. You are required to find the density of the material used to make the cylindrical object.

(2 Points)

What is the density (ρ) of the material?



- [x] $7.80\ g/cm^3$
- [ ] $8.91\ g/cm^3$
- [ ] $13.6\ g/cm^3$
- [ ] $2.70\ g/cm^3$
- [ ] *None of the above*

Exp. 2:

Kinematics of one dimensional motion with constant acceleration

Objectives

This experiment is divided to two main parts. The objective of the first part of this experiment is to study the displacement as a function of time for a one-dimensional uniformly accelerated motion; and to determine the instantaneous velocity of the moving object at a given position. In the second part; however, the velocity of a moving object as a function of time is analyzed and the acceleration is determined.

Part A:

If an object is set to move from rest under the action of gravity on an inclined frictionless track, its displacement Δx as a function of time t is given by

$$\Delta x = v_0\, t + \frac{1}{2}\, a\, t^2 \implies \Delta x = \frac{1}{2}\, a\, t^2. \qquad (1)$$

where, $a = g \sin\theta$ is the acceleration with which the object is moving and θ is the angle of inclination of the air-track. A plot of Δx versus t represents a parabolic curve as seen in Figure 1.

The instantaneous velocity v at a given time is defined as

$$v = \lim_{\Delta t \to 0} \left(\frac{\Delta x}{\Delta t}\right) = \frac{dx}{dt}. \qquad (2)$$

Equation 2 indicates that the instantaneous velocity equals the slope of the tangent to the curve of Δx versus t at a given point. See Figure 1.

Also, the velocity at the end of a displacement Δx is given as

$$v^2 = v_o^2 + 2\,a\,\Delta x. \tag{3}$$

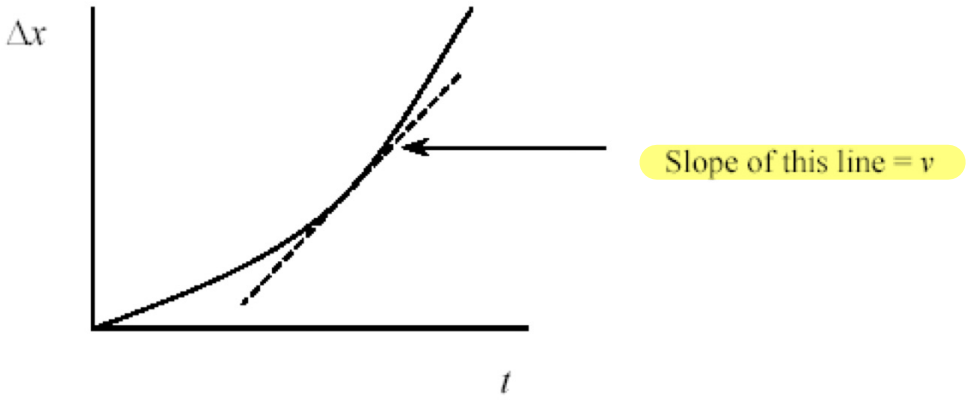


Figure 1. Displacement versus time

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part B:

For an object that is set to move from rest under the action of gravity on an inclined frictionless track, the velocity v as a function of time is given by

$$v = v_o + at, \tag{4}$$

where, v_o is the initial velocity, $a = g\,sin\,\theta$ is the acceleration of motion as mentioned earlier. If the motion starts from rest, then Equation 4 is reduced to

$$v = at, \tag{5}$$

The graph of velocity (v) versus (t), therefore, represents a straight line whose slope equals the acceleration (a). See Figure 2 below.

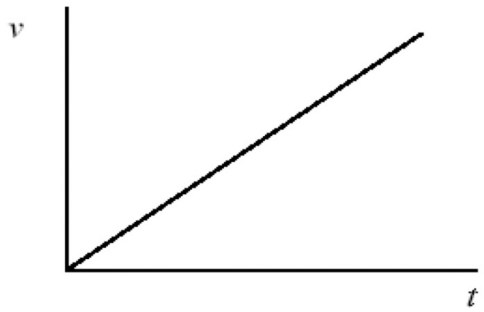


Figure 2. Velocity versus time

Notes:

* The Slop in ΔX and t curve is instantaneous velocity.

* The Slop in V and t curve is acceleration.

* The acceleration is constant.

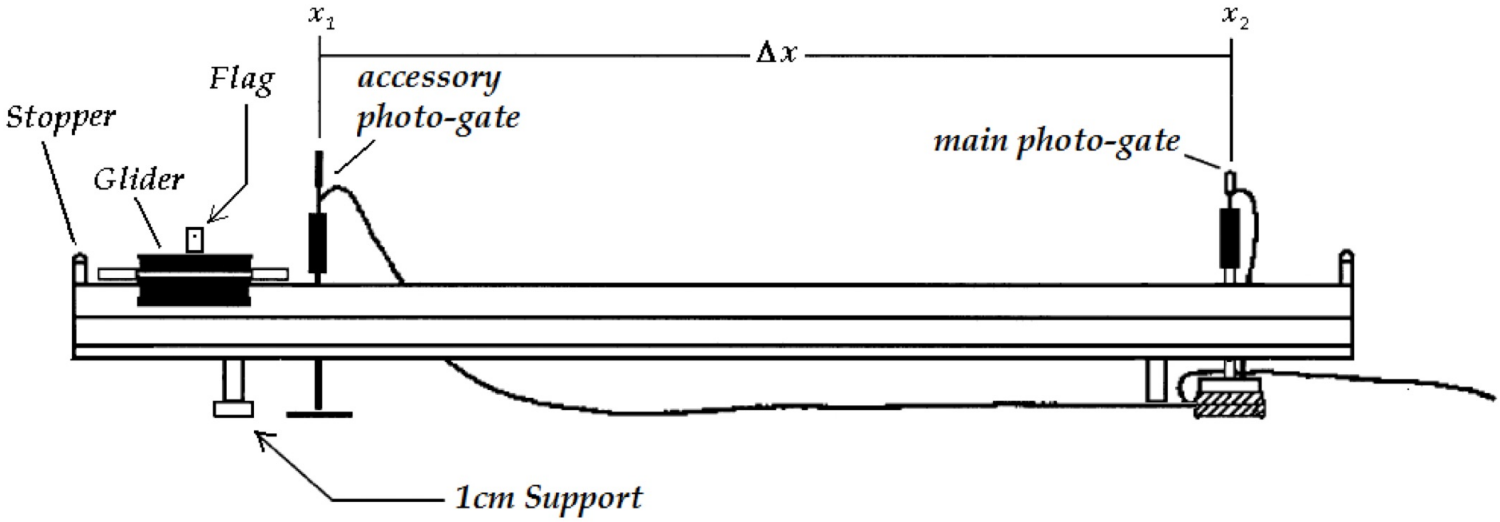


Figure 3. Air Track setup

1. By studying the graph of displacement as a function of time for one-dimensional uniformly accelerated motion, the slope of the tangent line to the curve at a given point enables you to determine:
(5/5 Points)

- The average velocity at that point
- The time to reach that point
- ✓ Instantaneous velocity of moving object at that point
- None of above

.2 The purpose of compressed air emitted from a matrix of holes along the body of the 2m long air track is * (1/1 نقطة)

- other.
- to accelerate the glider along the track.
- to eliminate the friction between glider and air track. ✓
- to slow down the glider along the track.
- to balance the glider on the air track.

Using an air track with an inclination angle Θ=1.2o, a glider is set to move from rest under gravity force only .Find the acceleration of glider.

---

2. If an object is moving from rest under the action of gravity on an inclined air track with $\theta = 5^0$ the acceleration of the object in m/s^2 is:
(5 Points)

- 9.8
- 0.85
- 0.085
- 0.14

1. The graph of velocity versus time for one dimentional uniformly accelerated motion represents a straight line whose slope equals:
(5 Points)

- The time of trip
- The acceleration of the glider
- Speed of the glider
- Angle of inclination

4. The plot of ΔX versus time in our experiment gives
(5 Points)

- Parabola
- straight line
- vertical line
- Non of the above

3. In our experiment, the Plot of velocity versus time is a (5 Points)

- Inversely proportional
- straight line parallel to x-axis
- Parabolic curve
- directly proportional

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3. If X_1=10 cm, X_2=50 cm, V_0=0 , a= 0.14 m/s², the instantanous velocity at X_2 is (5 Points)

- 0.55 m/s
- 0.47 m/s
- 0.60 m/s
- 0.33 m/s

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QUESTION-13) Two experiments for Kinematics (Uniformly accelerated motion) are conducted in the laboratory for two different values of acceleration.

The value of the displacement Δx_2 for the second experiment is twice the value of the displacement Δx_1 in the first experiment.

Also, the value of time t_2 in the second experiment is half the value of the time t_1 in the first experiment.

You are required to find the ratio of the acceleration a_1/a_2.

(Assume that the glider (flag) starts from rest in both the experiments).
(2 Points)

Find the ratio of the acceleration $\frac{a_1}{a_2}$?

- $\frac{a_1}{a_2} = \frac{1}{4}$
- $\frac{a_1}{a_2} = \frac{1}{6}$
- ✓ $\frac{a_1}{a_2} = \frac{1}{8}$
- $\frac{a_1}{a_2} = \frac{1}{10}$

18

QUESTION-14) Experiment Kinematics (one dimensional uniformly accelerated motion) is performed in the laboratory. You are required to find the width (w) of the flag used in the experiment by using the data set given in the table below: (Assume that the glider (flag) starts from rest).
(2 Points)

acceleration of the glider (flag)	=	0.15 m/s^2
time (t) taken by the glider to cover a distance (Δx)	=	2.40 s
time (Δt) taken by the glider (flag) to cross the position x_2	=	0.05 s

- 1.40 cm
- 1.80 cm
- 1.95 cm
- 1.10 cm

EXP. 3:

Determination of Acceleration due to Gravity

Objectives

The aim of this experiment is to understand the concept of acceleration in general and the acceleration due to gravity in specific. To achieve this goal, the acceleration due to gravity ($\boldsymbol{g}$) is determined using two different methods. In free falling method, the kinematics of motion with constant acceleration is utilized to determine the value of ($\boldsymbol{g}$). In the second method; however, simple harmonic motion phenomenon of a simple pendulum is used and the period of this motion is analyzed. At the end of the experiment, you should be able to verify that the value of ($\boldsymbol{g}$) computed is constant

Part A: Free Fall

A freely falling body is an object that is moving under the influence of gravity only. This object has a downward acceleration, denoted by ($\boldsymbol{g}$), toward the center of earth. In order to calculate the value of the gravitational acceleration, you will use the free fall experimental setup illustrated in Figure 1. The plastic yellow ball is fixed to the releasing mechanism of the free fall drop box. Allowing the ball to fall a fixed distance h toward the time of flight receptor plate, the smart timer will compute the time elapsed for the ball to fall that distance.

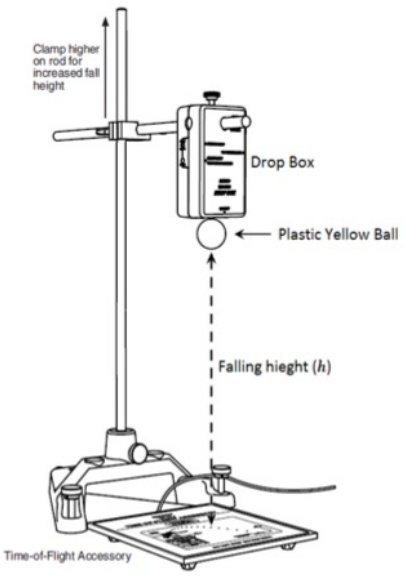


Figure 1 Free Falling Apparatus

The position of the ball, starting from rest at time $t = 0$ and undergoing constant downward acceleration along the y-direction, can be calculated using the following equation

$$y(t) - y_o = -\frac{1}{2}gt^2, \quad \Rightarrow \quad h = \frac{1}{2}gt^2.$$

Part B: Simple Pendulum

The simple pendulum setup consists of a small bob (in theory a particle) of mass m suspended by a light inextensible thread of length l from some point about which it is allowed to swing back and forth as shown in Figure 2. The forces on the bob are the tension in the thread T and the weight mg of the bob acting vertically downwards (as shown in Figure 2). Resolving mg radially and tangentially at point **A** we see that the tangential component is the unbalanced restoring force acting towards the equilibrium position **C**

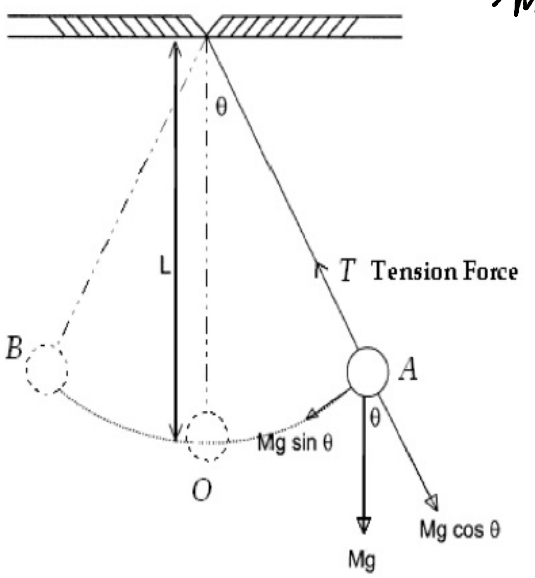


Figure 2. Simple Pendulum

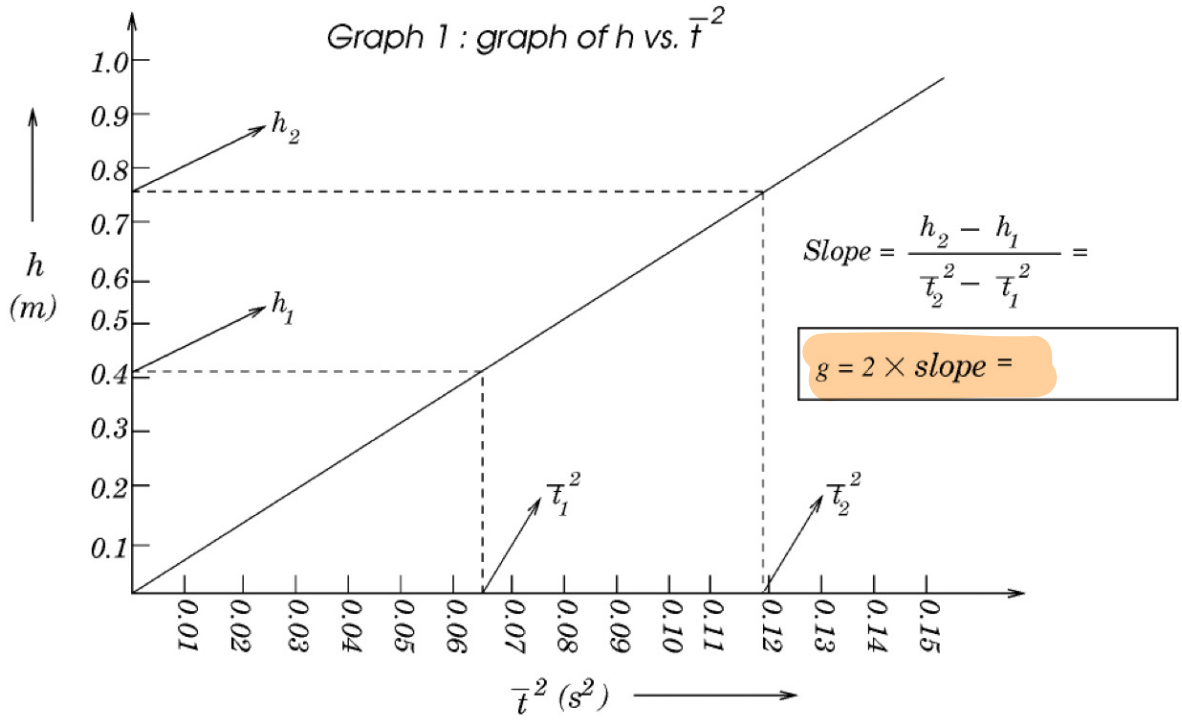
When θ, the angle of the simple pendulum with the vertical, is small then the restoring force is proportional to θ and the period of oscillation T is constant and given by

$$T = 2\pi\sqrt{\frac{l}{g}}\,. \tag{3}$$

where, l is the length of the simple pendulum, and $\boldsymbol{g}$ is the acceleration due to gravity. T is therefore independent of the amplitude of the oscillation and at a given place on the earths surface where $\boldsymbol{g}$ is constant; it depends only on the length l of the pendulum.

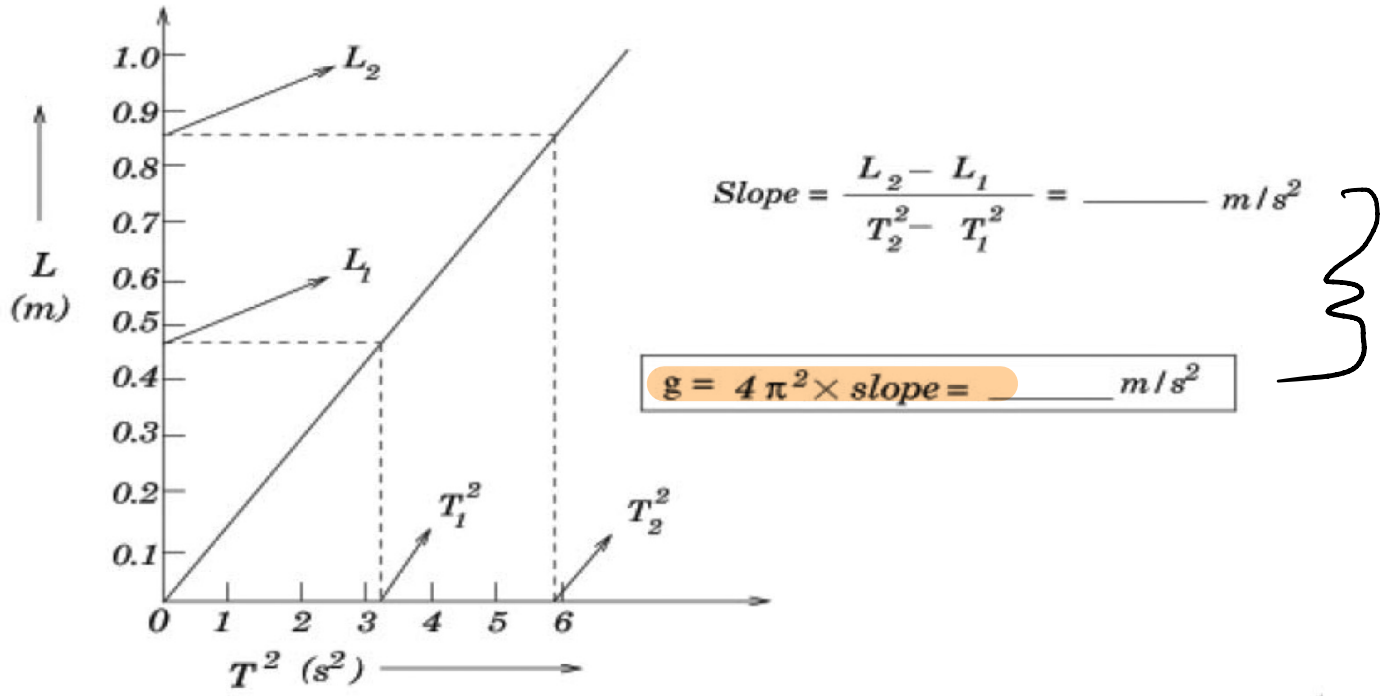
* For Free Fall:

Plot the graph of h versus $\bar{t}^2$ and determine the value of g



* For Simple pendulum:

Plot the graph of l versus $\bar{t}^2$ and determine the value of g



2. A ball is dropped from a tall building falls to the ground. Ball reaches the ground in3.0 seconds if g=10m/s then, the height of the building is
(2/2 Points)

- 70 m
- 30 m
- 60 m
- 45 m ✓
- 15 m

1. The period of the simple pendulum depends on
(2/2 Points)

- Length of the pendulum ✓
- Height from which it was released
- D) Density of the bob
- Mass of the bob

2. Ignoring the air resistance in free fall experiment. an object falling toward the earth has an acceleration that is
(5 Points)

- Constant
- Increasing
- Decreasing
- None of the above

4. In simple pendulum experiment, if you plot a relation between L and T^2, then the acceleration due to gravity is equal to
(5 Points)

- $2slope$
- $slope/2$
- $slope$
- $4\pi^2 Slope$ ✓

3. If the length of pendulum is 2.5 m, then what is the periodic time for simple pendulum
(5 Points)

- 1 s
- 2 s
- 2.5 s
- 3.2 s ✓

5. A marble and a piece of paper are dropped from same height in the laboratory in the presence of air. Let t1 and t2 represent the falling times for each successively. which of the following is true (2/2 Points)

- can not be decided
- t1 < t2
- t1 > t2
- t1=t2 ✓

4. an object falling toward the surface of the earth has a velocity that is (2/2 Points)

- increasing then decreasing
- decreasing then increasing
- constant
- decreasing
- increasing ✓

4. A piece of paper and iron piece are dropped simultaneously from same point. They will reach the ground simultaneously if they
(5/5 Points)

- e) have the same mass
- d)fall very far
- b) are in vacuum ✓
- have the same weight
- c)have the same density

A stone is dropped from a certain height 'h' on the surface of the moon. The same stone was dropped from the same height on the surface of the Earth. If the stone takes 4.1 seconds to reach the surface of the Earth, how long does it take for the same stone to reach the surface of the moon.

$g_{moon} = \frac{1}{6} g_{earth}$

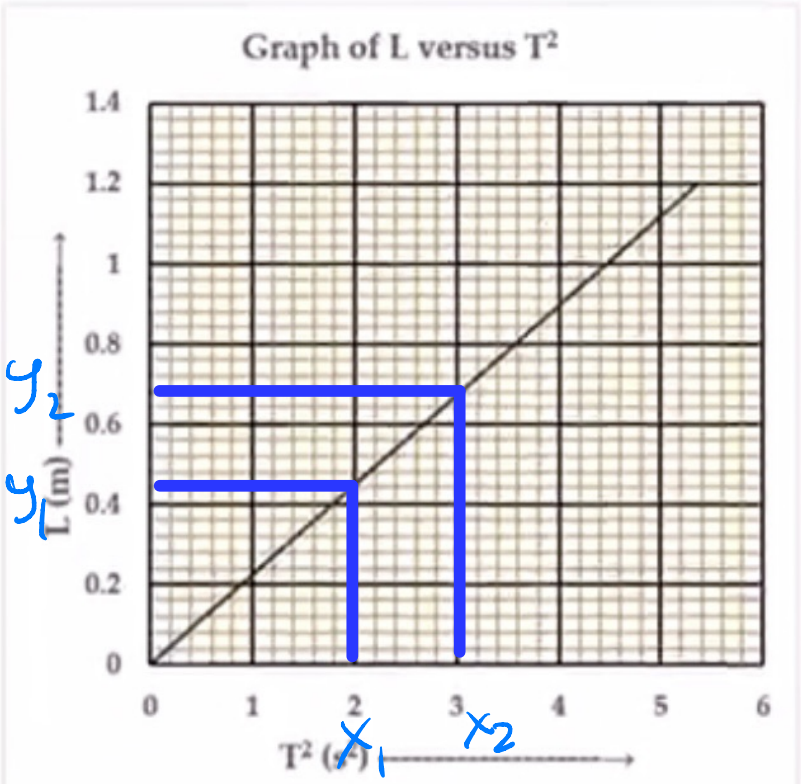
- 61.2 s
- 150.0 s
- 10.0 s
- 8.0 s

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QUESTION-17) The time period of a simple pendulum is 2 seconds. What will be its time period if its length is increased by 4 times?
(2 Points)

- 16 seconds
- 12 seconds
- 8 seconds
- 4 seconds

QUESTION-18) Simple pendulum experiment is carried out on the surface of planet X. Graph of length of the pendulum (L) versus square of time period (T^2) is plotted for you.
Use the graph shown below to determine the acceleration due to gravity (g) on the planet X.
(2 Points)



- ✓ $\approx 9.8\ m/s^2$
- $\approx 8.8\ m/s^2$
- $\approx 3.7\ m/s^2$
- $\approx 1.6\ m/s^2$

Exp.4:

Projectile Motion

Objectives

In this experiment we study the case in which the projectile is launched at an angle above the horizontal and allow it to land on a table top (floor) of a different level. The goal of this experiment is to determine how the horizontal distance traveled by this projectile depends on the launch angle, and determine the angle which gives the greatest horizontal distance for this projectile.

The projectile motion is a two-dimensional motion with constant acceleration. It can be analyzed as a combination of two independent motions with accelerations $a_x = 0$ in the x-direction and $a_y = -g$ in the y-direction. To fulfill the goal of this experiment,

v_x = const.

we study only the projectile motion with constant velocity along the horizontal x-direction. The horizontal distance, x, between the muzzle of the Launcher and the place where the projectile lands on a surface, is given by

$$x = v_x t = (v_o \cos\theta)t \qquad (1)$$

where v_o is the initial speed of the projectile as it leaves the muzzle, θ is the launch angle above horizontal, and t is the time of flight.

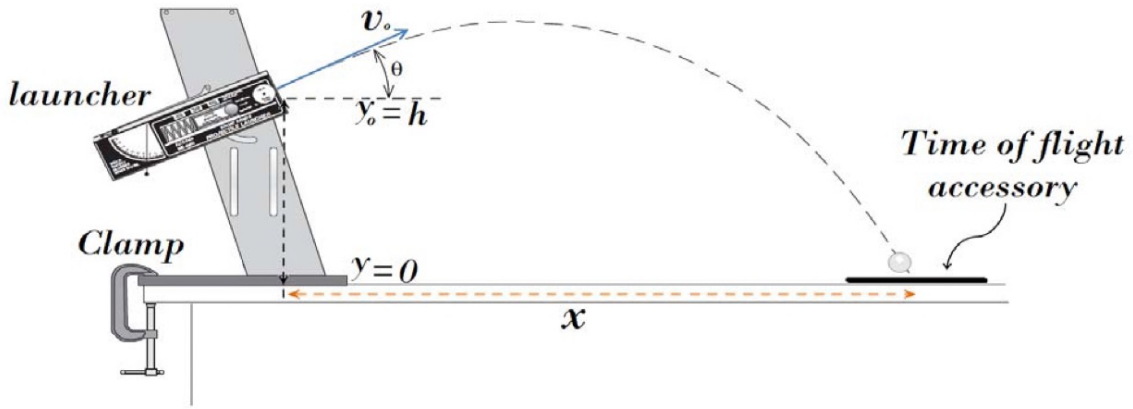


Figure 1. Experimental setup for Projectile motion.

Notes:-

* $\theta = 45^\circ$, is the angle for maximum horizontal displacement. (Range)

* The angles that completes each other to 90° will have same horizontal range.
Ex: (25°, 65°), (30°, 60°), (40°, 50°) ....

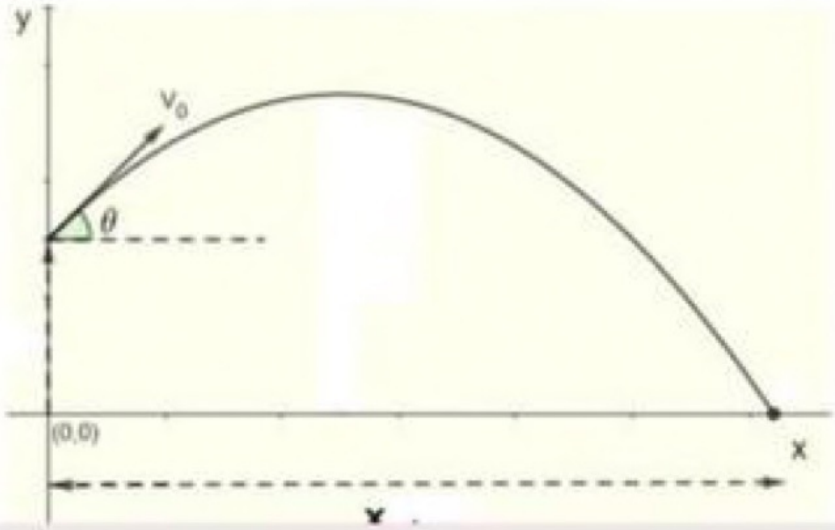
On a level surface, the maximum range is at 45°. For a non-level surface, the angle of maximum range is

_____

(5 Points)

- ○ *Always less than 45°*
- ○ *Always greater than 45°*
- ✓ *Always equal to 45°*
- ○ *None of the above.*

A football is thrown off a cliff with an initial velocity of 14 m/s at an angle 'θ' to the horizontal. The time the football remains in the air is 12.0 s. Determine angle 'θ' if the horizontal distance travelled (x_{calc}) by the football is 12 m.



- ○ 83.7^o
- ○ 85.9^o
- ○ 70.8^o
- ○ 67.3^o

A bullet is fired at an angle θ with the horizontal (projectile motion). When the bullet is at the highest point of its flight which one of the following is true:
(5 Points)

- The velocity and acceleration are both zero.
- The x-component of velocity is zero and y-component of the velocity is also zero.
- The x-component of velocity is not zero, but the y-component of the velocity is zero.
- Velocity components are not zero, but acceleration is zero.

In projectile motion, the acceleration in x- direction is
(5 Points)

- zero ✓
- g
- -g
- None of the above

The x and y components of the acceleration are .2 *

(0/1 نقطة)

- ax decrease, ay constant
- ax constant, ay decrease
- ax zero, ay constant ✓
- ax zero, ay increase

3. The experiment shows the relation between: * (5 Points)

- [x] Horizontal distance (x) and launch angle.
- [ ] Vertical distance (y) and launch angle.
- [x] Horizontal distance (x) and vertical distance (y).
- [ ] Launch angle and vertical acceleration (ay).
- [ ] Launch angle and horizontal acceleration (ax).

---

2. The projectile motion is a 2 dimensional motion with ay= * (5 Points)

- [ ] 0
- [ ] 5
- [x] -g
- [ ] not constant

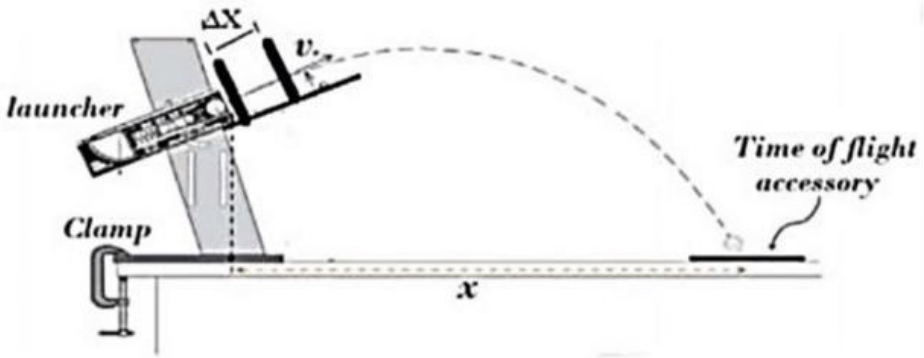
1. The x and y components of the velocity of a * projectile are (1/1 نقطة)

- Vx constant, Vy decrease up and increase down ✓
- Vx decrease, Vy increase
- Vx constant, Vy increase up and decrease down
- Vx increase, Vy decrease

QUESTION-20) The horizontal component of velocity of a projectile is half of its velocity of projection v_0. Find the initial angle of projection?
(2 Points)

- θ=30°
- θ=45°
- θ=60° ✓
- θ=75°

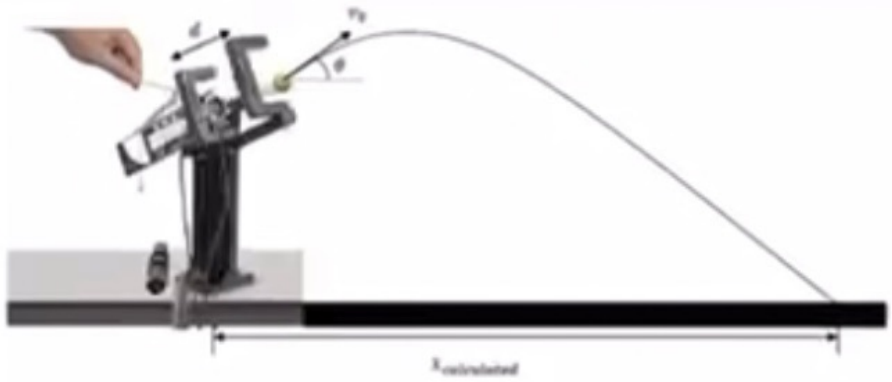
The data collected in a projectile motion experiment is given in the table. Δt is the time required by the projectile to cover Δx and t is the time of flight. What could be the horizontal distance covered by the projectile during this time of flight?



θ (deg)	ΔX (cm)	Δt (s)	t (s)
40	5	0.01	2.1

- 16.06 m
- 2.5 m
- 8.04 m
- 12.12 m

QUESTION-19) Projectile motion experiment is carried out, in the physics laboratory. The set of data obtained is recorded in the table given below. Observe the picture carefully and using the data set given, determine the time (t) of flight of the projectile.
(2 Points)



Δt = time taken by the projectile to pass between two photo gates as shown in the figure.
t = time of flight

θ	Δt	$x_{calculated}$	d	t
60°	0.024 s	2.750 m	0.150 m	?

- t=0.880 s
- t=1.100 s
- t=0.999 s
- t=1.520 s

EXP.5 :

Static Equilibrium of forces and Hook's Law

Objectives

The aim of this experiment is to study the "**Static equilibrium of forces**" and develop the conditions required to maintain equilibrium for a system of objects. (Newton's 2^{nd} and 3^{rd} Laws). We also study Hook's law and employ the theory of Static equilibrium of forces to calibrate a spring as a dynamometer and use it for the measurement of forces. We finally, use the theory of Static equilibrium once again to decompose forces into perpendicular components.

In this experiment the method of decomposing a force into components and expressing a force as a Cartesian vector will be used to solve problems involving equilibrium of particles. A particle of mass m under the influence of n forces is said to be in equilibrium if it is at rest, or is moving with a has a constant velocity ($\vec{a} = 0$). In

① or ②

both cases, the acceleration of the particle equals zero. Therefore, to maintain the state of equilibrium:

$$\sum_{i=1}^{n} F = m\,a = 0 \tag{1}$$

Since forces are vectors, and since we will mainly be dealing with forces that act in the xy plane, then Equation 1 states that each component of the net force must be zero. Thus, the condition for equilibrium is written as:

$$\sum_{i=1}^{n} F_x = 0, \quad \sum_{i=1}^{n} F_y = 0. \tag{2}$$

Hook's Law

Suppose you are holding a simple coil spring of natural (or unstretched) length x. When you apply a force F_x to stretch the spring and cause a Δx amount of extention beyond its natural length, the force F_x is found to be directly proportional to the extension Δx. See Figure 1.

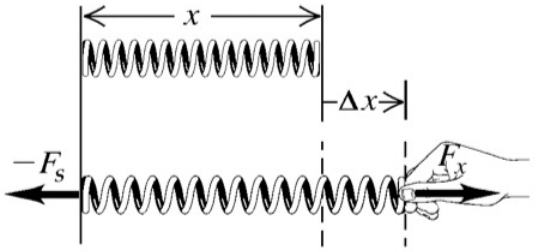


Figure 1. A spring of natural length x with applied force F_x.

Therefore, the force F_x can be written as

$$F_x = k\,(\Delta x).$$

Where k is a constant, known as the *Spring constant* or *Force constant*. It represents a measure of how elastic or how stiff this particular spring is. The extention in length (Δx), on the other hand, should be small because the elasticity feature of the spring may be damaged if you extend the spring beyond its elastic limit. The spring itself is found to exert a force F_s to the opposite direction of the applied force F_x. This force is known as restoring force because it tends to restore the spring to its natural length, and is given by **Hook's Law**:

$$F_s = -k\,(\Delta x). \tag{3}$$

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In order to calculate the spring constant k of the Dynamometer in the lab, we apply a force of a known magnitude F_w, (that is equal to the weight of a known mass m. See Figure 2), and measure the resulting extension to the spring.

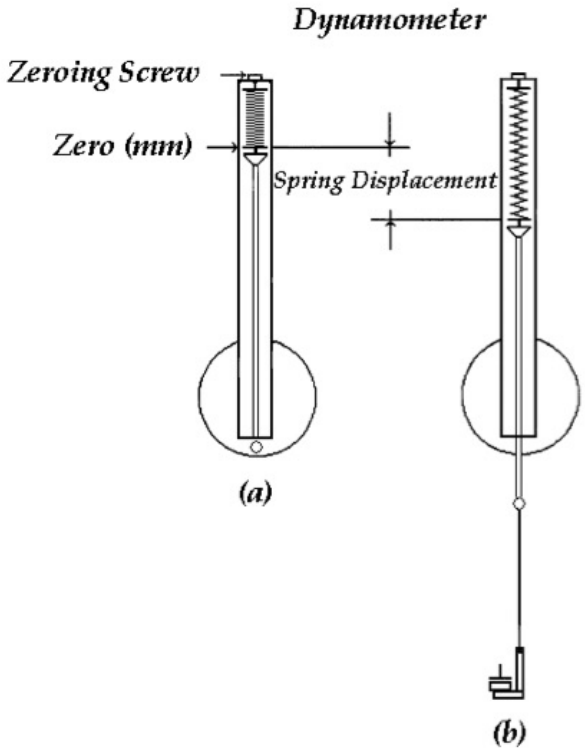


Figure 2. (a) The Dynamometer with its natural length
(b) The Dynamometer with applied force F_w.

Since the acceleration of the hanging mass equals zero (it is in equilibrium), then we can write

$$F_w + F_s = 0 \Longrightarrow mg - k(\Delta y) = 0 \Longrightarrow k = \left(\frac{mg}{\Delta y}\right) \tag{4}$$

Notes that the extention of spring length is denoted by Δy.

Decomposition of Forces

In this part of the experiment we test the validity of the conditions necessary for static equilibrium of forces, which are stated previously in Equation 2. Suppose we have three forces acting on a circular object and those forces are in fact in static equilibrium with each other. Thus, the circular object is either at rest or moving with constant velocity. See Figure 3.

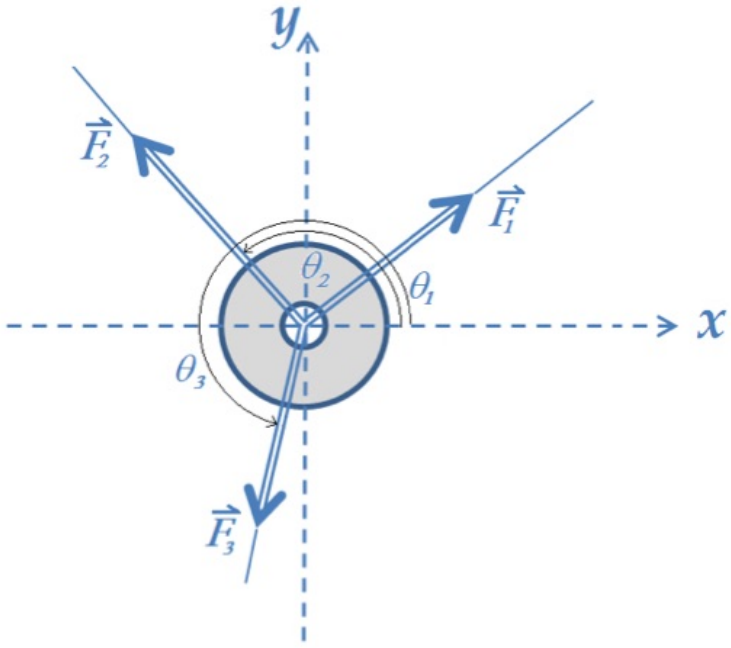


Figure 3. Free-Body Diagram

Now, applying the conditions stated earlier in Equation 2 we conclude:

- along the x-direction, we should have:

$$F_{1_x} + F_{2_x} + F_{3_x} = 0 \Longrightarrow F_1 \cos\theta_1 + F_2 \cos\theta_2 + F_3 \cos\theta_3 = 0$$

- along the y-direction we should have:

$$F_{1_y} + F_{2_y} + F_{3_y} = 0 \Longrightarrow F_1 \sin\theta_1 + F_2 \sin\theta_2 + F_3 \sin\theta_3 = 0$$

Refer to Figure 4. This analysis is carried out to show that the x component of the force F_3 applied to the force ring, is in fact equal in magnitude to the sum of the x components of the forces F_1 and F_2 applied to the same force ring by the hanging masses m_1 and m_2. Similarly, we should show that the magnitude of the y component of the force F_3 applied to the force ring is equal to the sum of the magnitude of the y components of the remaining forces F_1 and F_2.

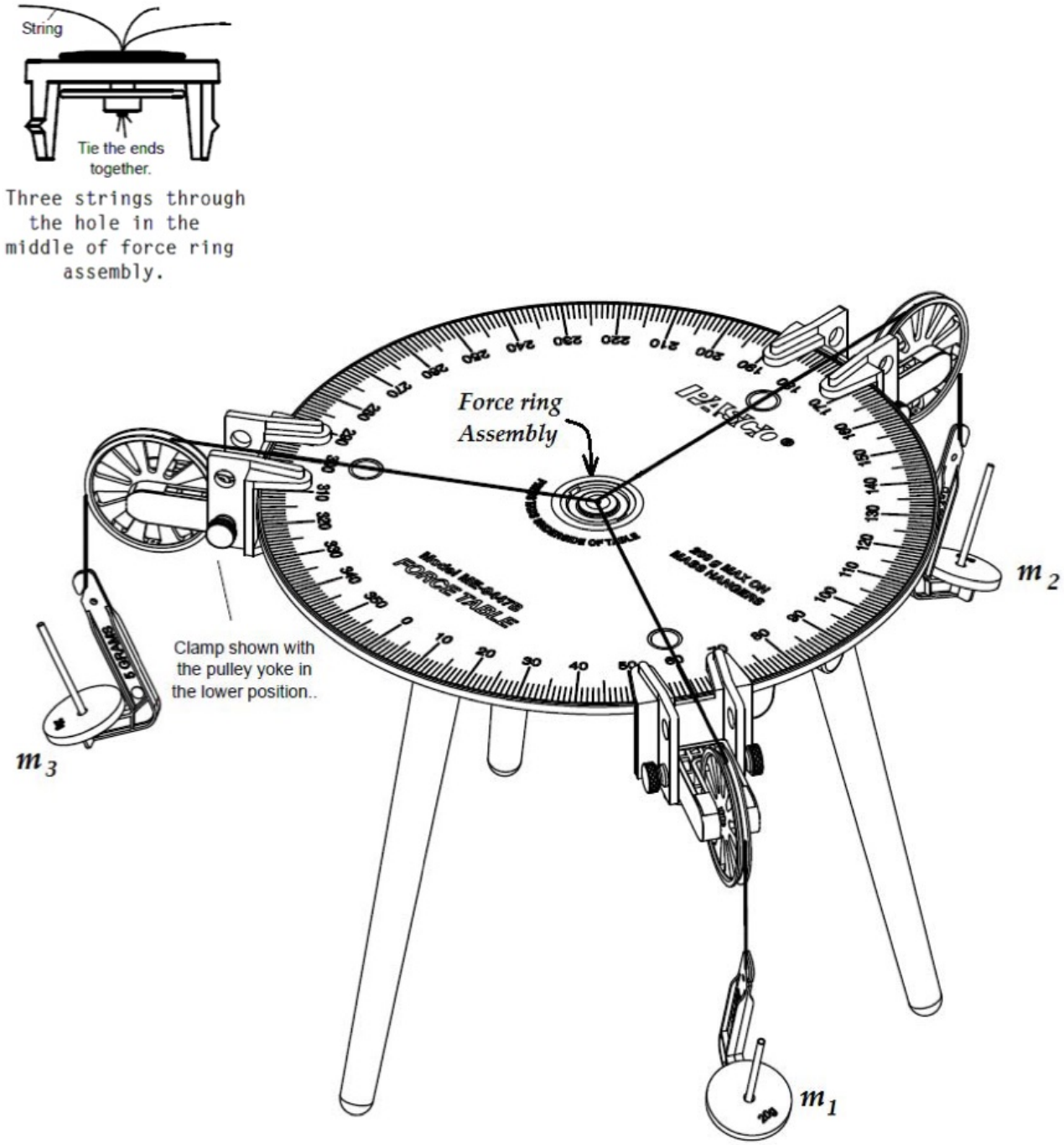
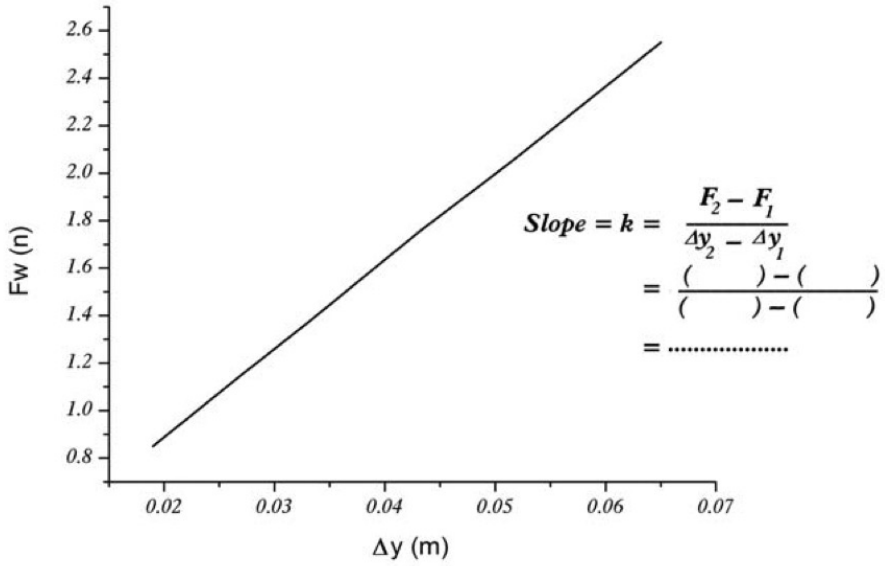


Figure 4. Force table, super pulley clamps, and the strings arranged from the force ring over the pulleys.

Static Equilibrium of forces and Hook's Law

Plot a graph of F_w versus Δy and determine the spring force constant (k) = slope



---

1. A spring is used to support 105 grams object, stretches by 18 mm. The force constant of the spring is:
(5 Points)

- 41 N/m
- 49 N/m
- ✓ 57 N/m
- 61 N/m
- 31 N/m

2. In Hook's Law , as the mass suspended increases the spring constant K :
(5 Points)

- [x] Increases
- [ ] Decreases
- [ ] Remains the same
- [ ] Non of the above

3. The slope of force versus spring extension graph represents
(5 Points)

- [x] Spring constant
- [ ] Force
- [ ] Mass
- [ ] acceleration

4. The force that tends to restore the spring to its natural length is
(5 Points)

- [ ] The magnetic force
- [ ] Gravitational force
- [x] Restoring force
- [ ] None of the above

1. The value of the spring constant gives us an understanding of: *
(5 Points)

- rigidity and stiffness of the spring.
- elongation of the spring
- maximum reading of the dynamometer
- maximum force can be applied to the spring

---

2. If there are 2 springs, their constants are k1= 100 N/m and k2= 150 N/m
(5 Points)

- Spring 1 is more rigid than spring 2.
- Spring 1 is less rigid than spring 2.
- Spring 1 is same rigidity of spring 2.
- Spring 2 is more elastic than spring 1

---

5. From Hook's law, we can conclude that there is a directly proportional relation between the applied force to a spring and ..... *
(0/1 Point)

- acceleration due to gravity
- number of turns in the spring
- the spring extension
- Hook's constant (k)

6. In order for a body to be in static equilibrium, the net external force acting on it has to be constant. *
(0/1 Point)

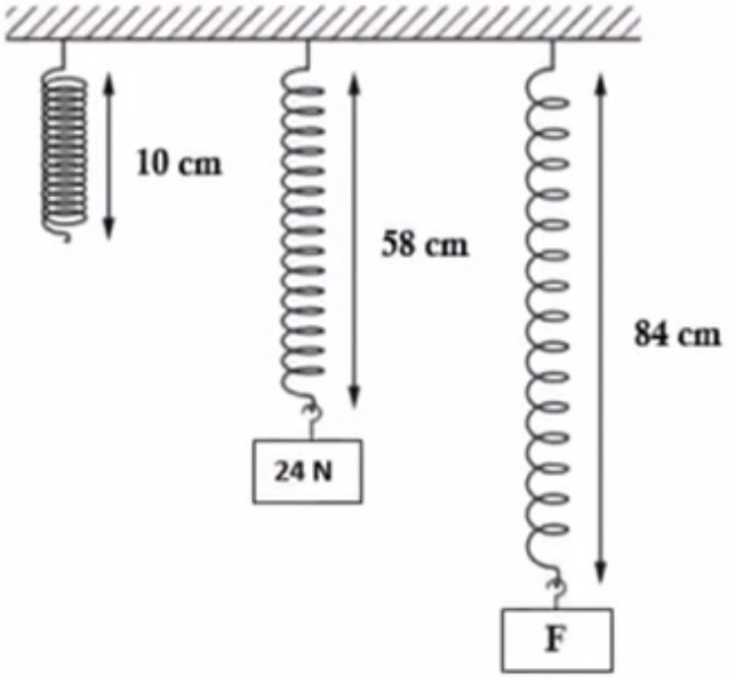
- False
- True

---

4. A spring has a spring constant of 5N/cm. What is its extension when loaded with 15N?
(5/5 Points)

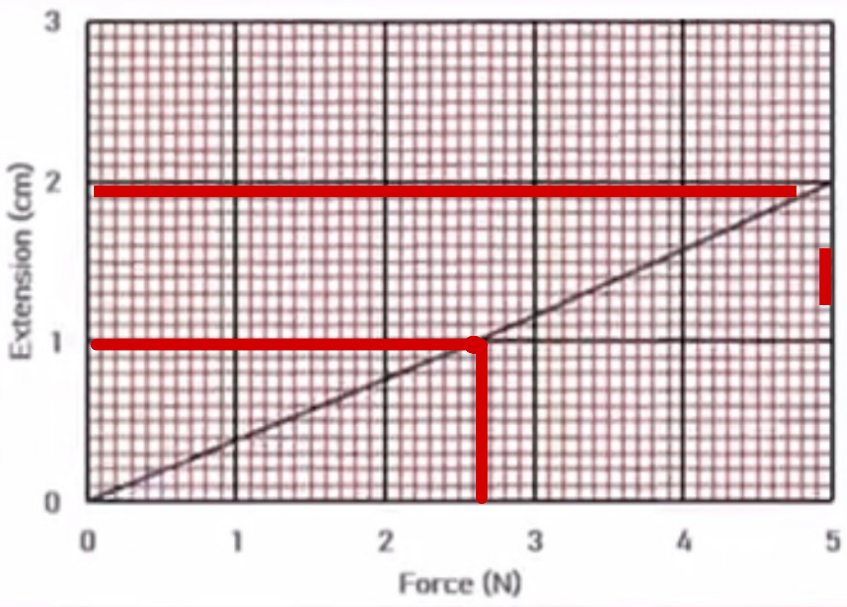
- 4cm
- 5cm
- 3m
- 3cm

QUESTION-1) Different weights are hung from a spring. The diagram shows the original length of the spring, and the lengths when different weights are added. The extension of the spring is directly proportional to the weight hung from it. What is the force (F) applied when the length of the spring is 84 cm? (2 Points)



- 47 N
- 37 N
- 57 N
- 13 N

QUESTION-3) The extension (along y-axis) and load (along x-axis) graph for a spring is shown. The unstretched length of the spring is 15.0 cm. When an object of unknown weight is suspended from the spring, the length of the spring is 16.5 cm. What is the weight of the object?
(2 Points)



- 0.55 *N*
- 0.67 *N*
- 3.8 *N*
- 4.1 *N*

3. Two different springs whose force constants are related in such a way that k2= (2)k1. Each spring was acted upon by an applied (stretching) force such that F2= (0.5)* F1, then the extensions in both springs are such that: *
(1/1 Point)

- $x_1 = \left(\frac{1}{2}\right) x_2$
- $x_1 = x_2$
- $x_1 = \left(\frac{1}{4}\right) x_2$
- $x_1 = (2)\, x_2$
- $x_1 = (4)\, x_2$ ✓

EXP. 6 :

Explosion and Elastic Collision

Objectives

The objective of this experiment is to study the conservation of linear momentum, conservation of kinetic energy, and to demonstrate both conservation laws for a one-dimensional elastic head-on collision as well as explosion.

The linear momentum $\vec{p}$ and the kinetic energy K of an object of mass m moving with velocity $\vec{v}$ is defined as

$$\vec{p} = m\vec{v} \quad , \quad K = \frac{1}{2}mv^2 \tag{1}$$

Collisions usually are categorized into two major types, mainly "Elastic collision" and "Inelastic collision". The Inelastic collision is divided further into two main subcategories known as the "Partial inelastic collision", where the lose of kinetic energy can be greater that zero and less than 100%. The second type; however, is known as the "Total or Completely inelastic collision" where the two objects stick together when they collide. In this case the lose of kinetic energy will be exactly equal to 100% and all of this energy is used specifically to bond the colliding objects together. One has to keep in mind that for all types of collisions mentioned above, that linear momentum is conserved.

When two bodies with masses m_1 and m_2 moving along the x-axis with initial velocities $\vec{v}_{1_i}$ and $\vec{v}_{2_i}$ encounter an elastic head-on collision, the total linear momentum will be conserved, i.e.:

$$\vec{p}_{1_i} + \vec{p}_{2_i} = \vec{p}_{1_f} + \vec{p}_{2_f}, \tag{2}$$

or

$$m_1\vec{v}_{1_i} + m_2\vec{v}_{2_i} = m_1\vec{v}_{1_f} + m_2\vec{v}_{2_f}. \tag{3}$$

And the total kinetic energy of the system is conserved as well. i.e.:

$$K_{1_i} + K_{2_i} = K_{1_f} + K_{2_f}. \tag{4}$$

or

$$\frac{1}{2}m_1v_{1_i}^2 + \frac{1}{2}m_2v_{2_i}^2 = \frac{1}{2}m_1v_{1_f}^2 + \frac{1}{2}m_2v_{2_f}^2. \tag{5}$$

And this type of collision is referred to as Elastic collision.

$\vec{P}$, K → conserved

As an example of completely inelastic collision we should analyze the case of explosion. In this experiment, we will consider the case when the physical system is divided, due to the explosion, to two product bodies pushed away from each other. If the system is initially at rest, then both the total initial linear momentum and the total initial kinetic energy of the physical system are equal to zero. Consequently,

the linear momentum of both bodies after the explosion will be equal in magnitude and opposite in direction. i.e.:

$$\vec{p}_{1_f} = -\vec{p}_{2_f} \Longrightarrow |\vec{p}_{1_f}| = |\vec{p}_{2_f}| \tag{6}$$

The kinetic energy, however is not conserved. Although the initial kinetic energy of both bodied is zero, their final kinetic energies are related as follows:

$$K_{1_f} = K_{2_f}\left(\frac{m_2}{m_1}\right) \tag{7}$$

Notes:

1- In inelastic Collision "explosions"
- → linear momentum is conserved.
- → Kinetic energy is not conserved.

2. In Compeletly elastic collision:
- → both linear momentum and Kinetic energy are conserved.

---

1. In Explosion:
(5 Points)

- ✓ Only the linear momentum of the system is conserved
- Only the kinetic energy of the system is conserved
- Both the linear momentum and the kinetic energy of the system is conserved
- Both the kinetic energy and the linear momentum of the system are not conserved

---

2. $\vec{P}$ K
The linear momentum and the kinetic energy are
(5 Points)

- Scalar and vector respectively
- ✓ Vector and scalar respectively
- Both vectors
- Both scalar

3. Which object has the greatest momentum
(5 Points)

- [x] A 5 kg mass moving at 5 m/s
- [ ] A 7 kg mass moving at 2 m/s
- [ ] A 6 kg mass moving at 3 m/s
- [ ] A 10 kg mass moving at 2 m/s

---

4. The linear momentum of an object at given instant depends on
(5 Points)

- [ ] Mass only
- [ ] Velocity only
- [ ] Acceleration only
- [x] Mass and velocity

* Required

1. In elastic collision between the two bodies _____.
A. D.
E. None of the above *
(5 Points)

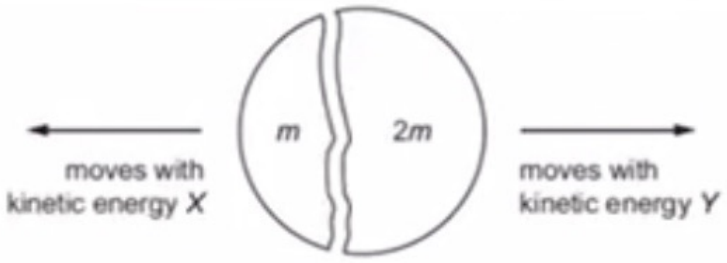
- [x] Both the kinetic Energy and Momentum of the system is conserved.
- [ ] Only momentum of the system is conserved.
- [ ] Momentum of the system is conserved but kinetic energy is not.
- [ ] Only the kinetic Energy of the system is conserved,

2. A particle of mass m moving with velocity V strikes a stationary mass 2m and sticks to it. The speed of the system will be *
(5 Points)

- V/3
- 3V
- V/2
- 2V

QUESTION-4) A stationary body explodes into two components of masses m and 2m. The components gain kinetic energies X and Y respectively.
(2 Points)

What is the value of the ratio $\frac{X}{Y}$?



What is the value of the ratio X/Y?

- $\frac{1}{4}$
- $\frac{1}{2}$
- $\frac{2}{1}$
- $\frac{4}{1}$

3. When the momentum of an object doubles and its mass remains constant, its kinetic energy:
(0/5 Points)

- Is halved
- Doubles ✗
- Quadruples(increase by 4 times) ✓
- None of above

1. Let m1=200 g and m2=400 g encounter an elastic one dimensional head-on collision. If v1i=6.0 m/s in +x-axis and v2i=0 then the final total kinetic energy equals to:
(5/5 Points)

- 4.0 J
- 1.5 J
- 3.0 J
- 2.5 J
- 3.6 J ✓

6

A body of mass M moving with velocity +10 m/s explodes into two equal parts. If one comes to rest and the other body moves with velocity V, what would be the value of V? *
(2 Points)

- ○ -20 m/s
- ✓ +20 m/s
- ○ -10 m/s
- ○ +10 m/s

Exp. 8 :

Torque of Parallel and Non-parallel Forces

Objectives

The objective of this experiment is to study the equilibrium conditions of rigid body and to analyze the torque produced by both parallel and non-parallel forces on a beam balance (lever).

We have seen earlier in experiment (6) th condition that needs to be satisfied in order to get static equilibrium of forces for a point mass. This condition is:

$$\Sigma F_{x_i} = 0 \quad , \quad \Sigma F_{y_i} = 0 \tag{1}$$

for an *extended rigid body* this condition remains valid if we apply it to the center of gravity. If the rigid body is free to rotate however, there is an additional condition that needs to be satisfied for equilibrium that is:

$$\Sigma \vec{\tau}_i = 0 \tag{2}$$

Where $\vec{\tau}_i$ is the torque produced by force F_i about the rotating point of the rigid body and hence it can be identified as a "turning agent". Figure 1 shows a force **F**

acting on a beam that is free to rotate about an axis. The force is applied at point **P**, whose position is defined by the vector $\vec{d}$.

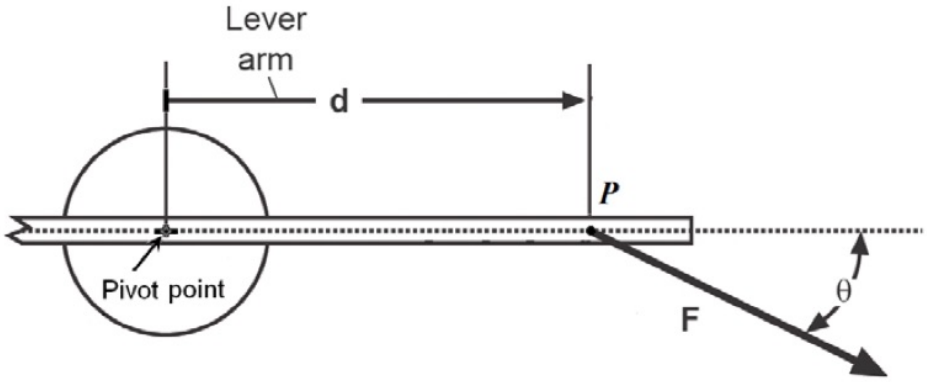


Figure 1. Torque of force **F** about a rotating point.

The angle θ is the angle the force **F** makes with the direction of the arm vector $\vec{d}$. The torque τ is defined as:

$$\vec{\tau} = \vec{d} \times \vec{F} \quad \text{with magnitude} \quad \tau = d\ f\ sin(\theta) \tag{3}$$

In this experiment the rotating point is the pivot. If the sum of all torques is equal to zero then the lever remains in equilibrium. If the net torque is not equal to zero then the beam starts to rotate.

Notes:

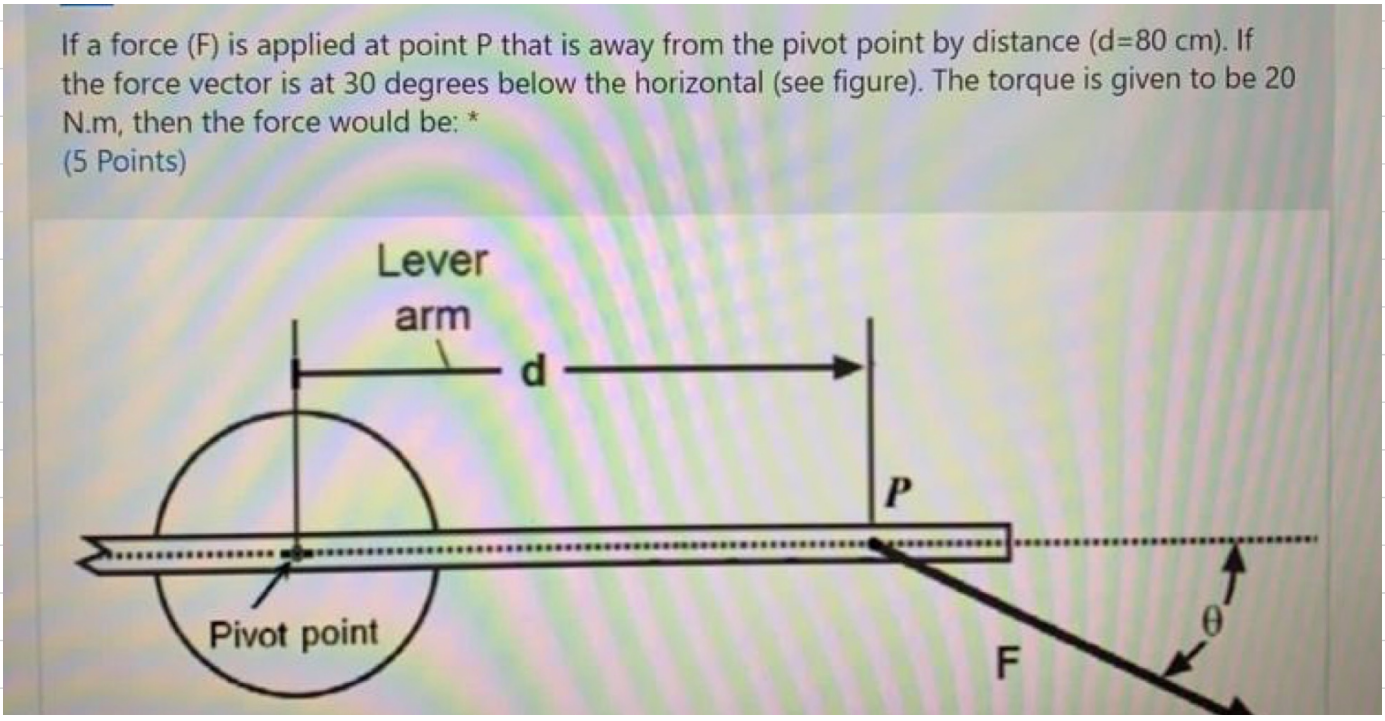
* Torque is vector quantity.
* τ ⟶ unit ⟶ N.m

1

A 800N man is playing on a seesaw with son who has a weight of 200N. If the child is setting 3 meters away, how far will the man have to sit to balance the seesaw *
(5 Points)

- 1 m
- 1.5 m
- ✓ 0.75 m
- 3 m

If a force (F) is applied at point P that is away from the pivot point by distance (d=80 cm). If the force vector is at 30 degrees below the horizontal (see figure). The torque is given to be 20 N.m, then the force would be: *
(5 Points)



- 1 N
- 10 N
- ✓ 50 N
- 100 N
- 200 N

3

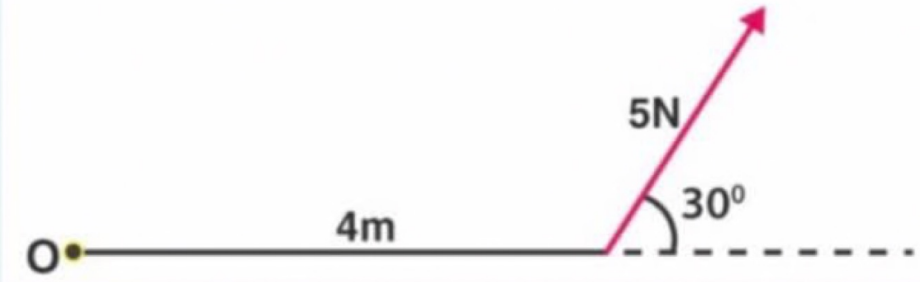
What is the unit of torque *
(5 Points)

- [x] Nm
- [ ] N/m
- [ ] N
- [ ] Joule

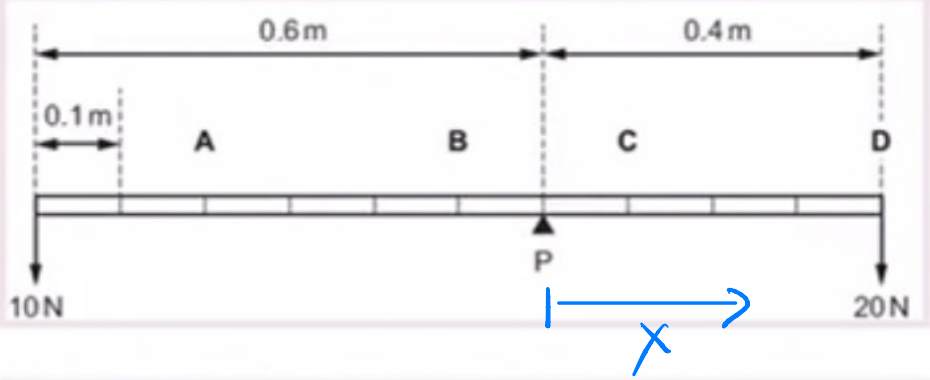
The torque is defined as the *
(5 Points)

- [ ] Addition of d and F
- [ ] Dot product of d and F
- [x] Cross product of d and F
- [ ] Non of the above

Find the torque about the point O , the only force acting is F=5N as shown in the figure *
(5 Points)



QUESTION-7) A beam is pivoted at P as shown. Weights of 10 N and 20 N are attached to its ends. The length of the beam is marked at intervals of 0.1 m . At which point should a further weight of 20 N be attached to achieve rotational equilibrium?
(Assume that beam has no mass for the purpose of calculation).
(2 Points)



- 0.2 m to the right of P
- 0.1 m to the left of P
- 0.1 m to the right of P
- 0.3 m to the left of P

Exp9:

Objectives

The objective of this experiment is to study the Phenomenon of Resonance in a column of air, and use its result to determine the velocity of sound in air at room temperature.

Theory

The velocity with which sound travels in a medium may be determined if the frequency and the wavelength are known. This relation is shown in the equation:

$$V = f\lambda \tag{1}$$

where, V is the velocity of sound propagation, f is the frequency, and λ is the wavelength. In this experiment the velocity of sound in air is to be found by using a the resonance tube setup that includes an open speaker driven by a sine wave generator (Figure 1) to produce a sound wave whose length will be measured by means of a resonating column of air.

the incident and reflected wave trains. The air column will then vibrate strongly in segments with a frequency. Only If the frequency of vibration of the air column is equal to the frequency of the speaker a **Resonance** occurs. This is indicated by the sudden increase in the intensity of the sound when the column is adjusted to the proper length. At the closed end of the tube the incident and the reflected waves interfere in such a way that their amplitudes cancel each other out then the air molecules remains at rest and this defines a **Node** (Figure 3). **Antinode**, however; occurs at a short distance e (known as the end correction) above the open end of the tube where the incident and the reflected waves reinforce each other.

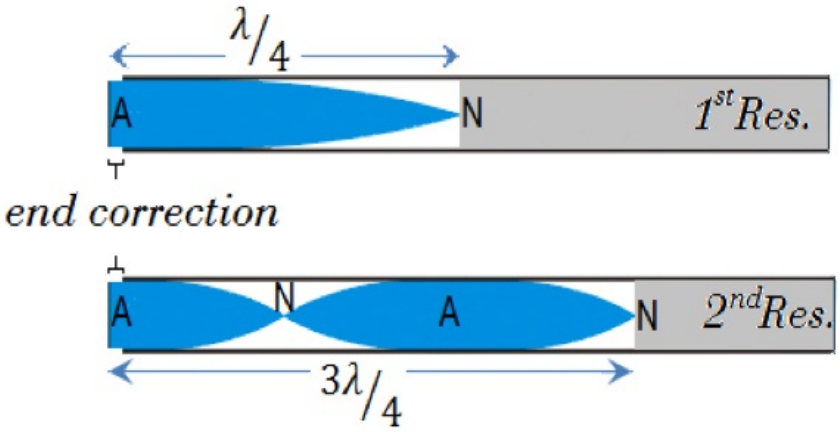


Figure 3. Standing wave in the air column of a closed end tube.

Figure 3 indicates the conditions of vibration for the first two positions of resonance, from which we have :

$$L_1 + e = \frac{\lambda}{4} \tag{2}$$

$$L_2 + e = \frac{3\lambda}{4} \tag{3}$$

by subtraction we can find λ in terms of L_1 and L_2. Substituting this result back in equation (1) we get the experimental value of speed of sound:

$$V_{experimental} = 2f(L_2 - L_1) \tag{4}$$

This experimental value of V can be compared to the result calculated from the

formula:

$$V_t = V_0 \sqrt{1 + \frac{t}{273}} \tag{5}$$

where V_o= 331 m/s, which is the velocity of sound in air at 0^oC temperature and t is the current room temperature. The value of the end correction e for the tube can be calculated :

$$e = \frac{1}{2}(L_2 - 3L_1) \tag{6}$$

3. How does the temperature of certain media change the speed of sound in that media? *
(0.5 Points)

- Speed of sound increase if temperature increased.
- Speed of sound decrease if temperature increased.
- Speed of sound increase if temperature decreased.
- Non of the given answers is correct
- Speed of sound remains the same even if temperature changes.

---

6. We witness the first resonance phenomenon when the length of the air column is equal to half of the wave length of the sound wave *
(0.5 Points)

- False
- True

4. Only If the frequency of vibration of the air column inside the tube is equal to the frequency of the speaker a Resonance occurs.? *
(0.5 Points)

- ◯ False
- ◯ True

5. For a sound wave of frequency 620nHz, the first resonance phenomenon occurs when the air column is 32cm. Find the length of the air column when the second resonance takes place. The speed of sound is 344m/s. *
(0.5 Points)

- ◯ .32m
- ◯ 0.277m
- ◯ 0.599m
- ◯ 0.043m
- ◯ non of the given answers is correct

1. A load speaker connected to a signal generator emits a sound of frequency 450 Hz. In the set up similar to the one in the lab, when the closed end of the long cardboard tube is slowly moved in by 20 cm from the load speaker side, a standing wave is formed and air column resonated. Assuming end correction (e) to be zero, the experimental value of speed of sound is [hint: second resonance occur at 3 times the distance of first resonance]: (5/5 Points)

- 300 m/s
- 360 m/s
- None of the above
- 325 m/s
- 340 m/s

2. For the (speed of sound) experiment, which one of these sentences is (TRUE) : * (5/5 Points)

- We will know that a resonance is happening when the sound we hear get loader
- We will know that a resonance is happening when the sound we hear get lower
- The 2nd resonance distance (L2) is lower than the 1st resonance distance (L1)
- None of the given answers is TRUE.

3. BONUS QUESTION: If the theoretical speed of sound at room temperature 20 degrees Celsius is 330 m/s and the theoretical speed of sound at current room temperature is 344 m/s then the current room temperature is:
(2/2 Points)

- 21 degrees Celsius
- 24 degrees Celsius
- 20 degrees Celsius
- 11 degrees Celsius
- 22 degrees Celsius