Physics 1

(BAS021)

For

Preparatory Year Engineers

"First semester"

By

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CONTENTS

1. Introduction

Physics is the science of matter and its motion, the science that deals with concepts such as force, energy, mass, and charge. As an experimental science, its goal is to understand the natural world. ... Today, physics is a broad and highly developed subject.

What does experimental mean in physics?

A test under controlled conditions that is made to demonstrate a known truth, examine the validity of a hypothesis, or determine the efficacy of something previously untried.

Experimental uncertainity

All measurements are subject to some uncertainty as a wide range of errors and inaccuracies can and do happen. Measurements should be made with great care and with careful thought about what you are doing to reduce the possibility of error as much as possible.

There are three main sources of experimental uncertainties (experimental errors):

1. Limited accuracy of the measuring apparatus.
2. Limitations and simplifications of the experimental procedure - e.g., we commonly assume that there is no air friction if objects are not moving fast. Strictly speaking, that friction is small but not equal to zero.

3. Uncontrolled changes to the environment. For example; small changes of the temperature and the humidity in the lab.

$$\text{Relative error} = \frac{\text{Experimental value} - \text{Accepted value}}{\text{Accepted value}} \times 100$$

2. Hook's law

Aim of the experiment:

1- Determine the force constant (k).

2- Determine an unknown mass (m).

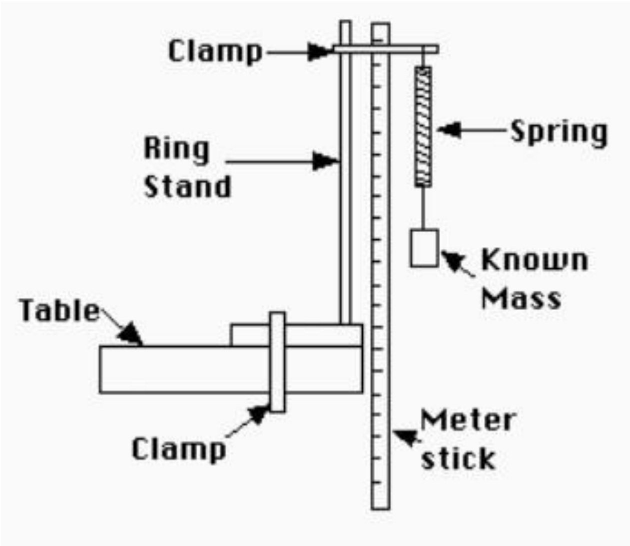


Fig.1: The Apparatus

The Apparatus (Fig.1):

1) Consists of a spring fixed vertically from one end in a stand, while the other end holds a pan.
2) Set of different known masses.
3) Pan. 4) Graduated ruler
5) Unknown mass.

Theory:

When stretching the spring by adding a mass (m) its length will increase by the amount (Δl). Hook's law is best where the deforming force (F) due to the attached mass is proportional to the stretching distance (Δl). In equation from, we have.

$$F = k\,\Delta l$$

Where (F) is the deforming force, (k) is the spring constant, and (Δl) is the elongation of the spring.

From $$F = m\,g$$

$$m\,g = k\,\Delta l$$

So, $$\Delta l = \frac{g}{k} m$$

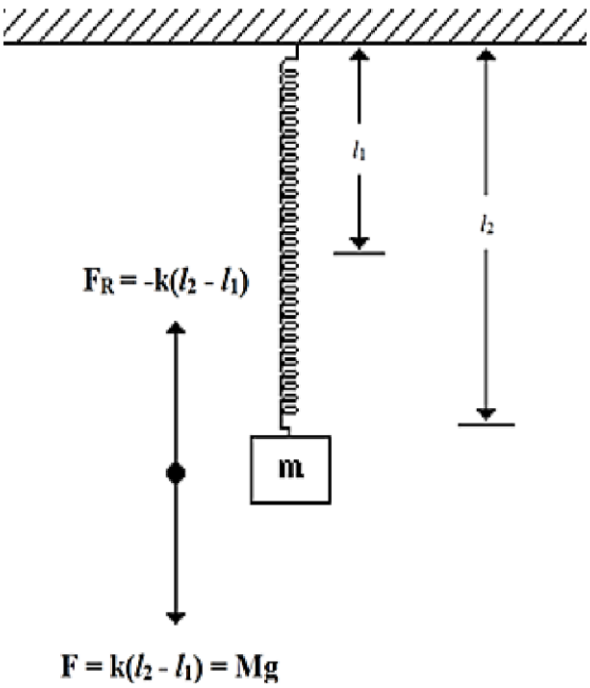
This is a linear relation between (Δl) and (m).

Method:

1) Record the initial position of the pan on the graduated ruler, l_i
2) Add a suitable mass (m ≈ 10 g) in the pan and record the reading (l_f).
3) Find the elongation of the spring from the relation ($\Delta l = l_f - l_i$).
4) Record the value of l_f for different masses ($m \approx 20, 30, 40$……..g), and calculate the spring elongation Δl.
5) Plot the (Δl versus m) graph and find its slope (s),
6) Calculate the spring constant from the slope:

   Slope $= \frac{g}{k}$ → k $= \frac{g}{slope}$ (where $g = 980\ cm/s^2$)

7) Add the unknown mass ($m_{unknown}$) in the pan and record the reading (l_f). Find the elongation (Δl) and then find the mass from the curve.



Results:

$g = 980\ cm/s^2$

l_i = …………….. *cm*

m (g)	l_f (cm)	Δl (cm)
500		
1000		
1500		
2000		
2500		
$m_{unknown}$		

Slope $\frac{\Delta y}{\Delta x} =$ ………………………………..…………cm/g

The force constant $k = \frac{g}{slope} =$ ……………..………dyne/cm

$m_{unknown}$ =…………………………………….……… g

3. Young's Modulus

Aim of the experiment:

We are going to determine the Young's modulus of the material of a spring (cantilever) by recording its period time of oscillation when loaded by a certain weight

Apparatus required (Fig.1):

1) A spring of the given material fixed from one end
2) pan
3) Weights
4) ruler

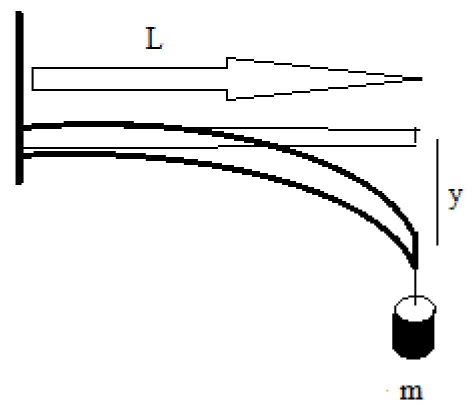


Fig.1: Schematic diagram for the rod

Theory:

Consider a light beam (rod or bar) fixed horizontally from one end and loaded with a mass (M) at the other, Fig.1. The value of the total depression (y) at the free end of the bar is given by:

$$Y = \frac{4gl^3}{Ybd^3} m$$

Where (g) is the acceleration of gravity, (*l*, b, d) are the length, the breadth سعة, and thickness of the bar, respectively, (Y) is Young's Modulus. It is a linear relation between the depression (y) and the mass (m).

Method:

1) Record the dimensions of the bar (*l*, b, and d).
2) Place the pan at the free end of the bar.
3) Record the initial depression on the ruler (y_i).
4) Place a certain mass (for example m = 10g) in the pan.
5) Record the final depression (y_f) then calculate the depression of this end due to the mass m from the relation ($y = y_f - y_i$).
6) Record the value of (y_f) for (m = 20, 30, 50, 70 g), and calculate the depression of the bar y.
7) Plot the (y versus m) curve and determine its slope.
8) Calculate (y) from the following relation

$$Y = \frac{4gl^3}{slope\ bd^3}$$

Results:

l = ……………………….cm

b = ……………………….cm

d = ……………………….cm

y_i =……………………….cm

g = 980 cm/s^2

m (g)	y_f (cm)	y (cm)

The slope $= \frac{\Delta y}{\Delta x} =$ …………………………..……………………cm/g.

$$Y = \frac{4gl^3}{slope\ bd^3} = \cdots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots .\ dyne/cm^2$$

4. Surface Tension

Aim of the experiment:

Determine the surface tension coefficient (γ) of a given liquid by Jaeger's method.

Theory:

Consider a spherical air bubble of radius (R) is produced in a liquid of density (ρ) and surface tension (γ) at depth (h) from its surface. The bubble is at rest; thus the inside pressure is greater than the outside pressure by the amount 2γ/R .

$$P_{in} - P_{out} = \frac{2\gamma}{R} \qquad (1)$$

The outside pressure equals:

$$P_{out} = P_0 \rho g h \qquad (2)$$

Where P_0 is the atmospheric pressure, g is the acceleration of gravity, and R is the radius of the bubble as well as the radius of the capillary tube; see Fig.1. Jaeger performed an experiment to measure the inside pressure as shown in Fig.1. He used a manometer to measure the inside pressure. If the manometer records the value H, and the density of the liquid in the manometer is a, then the inside pressure is:

$$P_{in} = P_0 \, a \, g \, H \qquad (3)$$

From Eq.'s 1, 2 and 3:

$$P_0 + a\,g\,H - (P_0 + \rho g h) = \frac{2\gamma}{R}$$

So $$H = \left(\frac{\rho}{a}\right) h + \frac{2\gamma}{a\, g\, R} \qquad (4)$$

It is a linear relation between (H) and (h).

Apparatus:

1) Beaker containing the liquid under test (ρ = ? , γ = ?)
2) Capillary tube of known radius (R).
3) Water manometer (a =1 g/cm^3).
4) Empty jar.
5) Water source
6) Ruler

Fig.1: The Apparatus

Method:

1) Adjust the depth of the free end of the capillary tube (h) under the surface of the liquid in the baker.
2) Adjust the surface of water in the manometer to be in the same horizontal plane.
3) Let a steady rate of air to pass so that a bubble is formed (when the bubble is of the same radius of the orifice فتحة of the tube it becomes unstable and breaks of), at this point stop the flow of air.
4) Record the difference between the surfaces of water in the manometer (H).
5) Repeat the experiment for other values of (h).
6) Plot the (H) versus (h) graph, Fig.2, and find y-intercept "c" and the slope "s".
7) Calculate ρ from the relation (ρ = slope X a).
8) Calculate the surface tension (γ) from the relation ($\gamma = \frac{1}{2} agRc$)

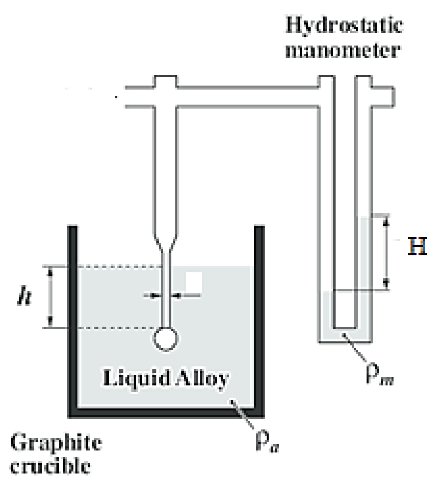


Fig.2

Results:

a = 1 g/cm^3 (for water)

g = 980 cm/s^2

R = ………………………. cm

h (cm)	H (cm)

y-intercept = c = ……………………………………….cm

slope = $\frac{\Delta y}{\Delta x}$ = ……………………..…………………………

ρ = slope = ……………………………………………….. g/cm^3

ɣ = a g R c = ………………………………………………dyne/cm

5. Stoke's law

Aim of the experiment:

Determine the viscosity for a liquid (η) by Stoke's method.

Apparatus (Fig.1)

1) Long glass tube.
2) Steel balls.
3) Micrometer.
4) Stopwatch.

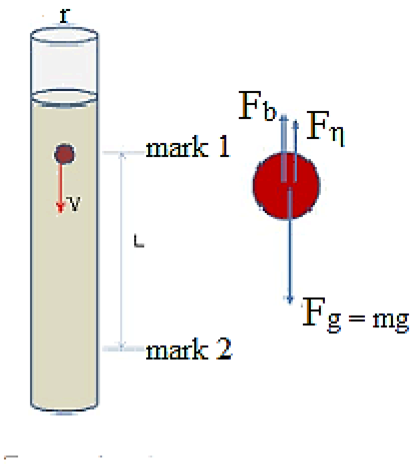


Fig.1: the apparatus

Theory:

When a sphere of radius (r) falls through a viscous fluid, it will suffer a retarding viscous force (F_η). According to Stoke's law, this force is given as

$$F_\eta = 6\,\pi\,\eta\,v\,r$$

Where (F_η) is the viscous force, it directs upward, (η) is the coefficient of viscosity of a liquid, (ν) is the terminal velocity of sphere, and (r) is the radius of a sphere.

The sphere suffers also the effects of its weight (F_g) and the buoyant force (F_b) which are given as

$$F_g = \rho_s\, g\, (\frac{4}{3}\pi\, r^3)$$

$$F_b = \rho_L\, g\, (\frac{4}{3}\pi\, r^3)$$

Where (F_g) is the weight of the sphere; it directs downward, (F_b) is the buoyant force; it directs upward, (ρ_s) is the density of a sphere, and (ρ_L) is the density of a liquid.

As the sphere falls down, its velocity as well as the viscous force increases until we reach the steady state condition where the acceleration becomes zero and the terminal velocity becomes constant this called the steady state condition, At steady state, the forces affecting the sphere become equilibrium, i.e. the total force of the system is zero; that is

$$F_\eta + F_b = F_g$$

$$6\,\pi\,\eta\,\nu\, r + \rho_L\, g\, (\frac{4}{3}\pi\, r^3) = \rho_s\, g\, (\frac{4}{3}\pi\, r^3)$$

$$\therefore v = \frac{2}{9}\frac{g\,(\rho_s - \rho_L)}{\eta} r^2$$

It is a linear equation between (ν) and (r^2).

Method:

1) Label two marks on a glass tube, mark 1 and mark 2, provided that mark 1 is 20cm at least under the surface of a liquid in the tube.
2) Record the distance between the two markers (l) and the inner radius of a glass tube (R).

3) Measure the radius of a metallic sphere (r) by a micrometer.
4) Let the sphere to fall freely in a tube and measure the time taken by a sphere to pass the two marks (t).
5) Calculate the velocity of a sphere ($\nu_0 = l/t$), then calculate the terminal velocity in unlimited medium ($\nu = \nu_0\,(1+2.4\, r/R)$).
6) Repeat steps 3, 4 and 5 for other spheres of different radius.
7) Plot the relation between ν and r^2, and then find its slope.
8) Determine the coefficient of viscosity from a relation

$$\eta = \frac{2}{9}\frac{g\ (\rho_s - \rho_L)}{\text{slope}}$$

Results:

R = …………………….………..cm

l = ……………..……………..cm

$\rho_L = 1.26$ g/cm^3

$\rho_s = 7.8$ g/cm^3

g = 980 cm/s^2

r	2r(cm)	r^2(cm^2)	t(s)	ν_0(cm/s)	ν(cm/s)

$slope = s = \frac{\Delta y}{\Delta x}$ = ………………………..………...cm^{-1}s^{-1}

$\eta = \frac{2}{9}\frac{g\ (\rho_s - \rho_L)}{\text{slope}}$=…………………..…………………pois

6. Simple Pendulum

Aim of the experiment:

Determine the acceleration of gravity (g).

Apparatus, Fig.1:

1) Simple pendulum.
2) Stand and clamp.
3) Meter rule.
4) Electronic stopwatch.

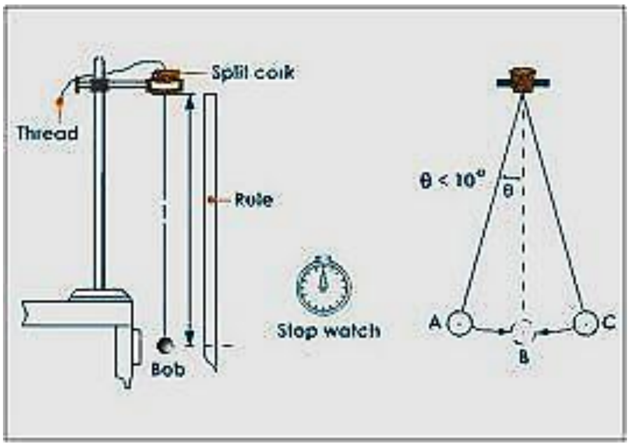


Fig.1: Simple pendulum

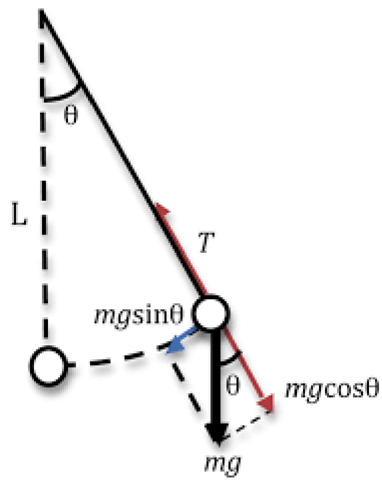


Fig.2

Theory:

When we give the mass (M) of the pendulum a small angular displacement (θ), Fig.2, it will vibrate by the effect of the restoring force (F):

$$F = -m\, g \sin(\theta) \qquad (1)$$

According to Newton's second law, the force (F) is given as the mass (m) multiples the acceleration ($\ddot{x}$); that is

$$F = m\, \ddot{x} \qquad (2)$$

From 1 and 2:

$$\ddot{x} = g \sin(\theta)$$

The angle (θ) is very small so that we can replace ($\sin\theta$) by ($\tan\theta$) and use ($\tan\theta = x/l$), where (x) is linear displacement of the mass from the equilibrium position and (l) is the length of the pendulum, thus

$$\ddot{x} = -g\frac{x}{l} \qquad \rightarrow \qquad \ddot{x} + \frac{g}{l}x = 0$$

When comparing the last equation with the general equation of the simple harmonic motion (S.H.M.) we get the angular frequency as

$$\omega^2 = \frac{g}{l} \qquad \rightarrow \qquad \left(\frac{2\pi}{T}\right)^2 = \frac{g}{l}$$

Thus, the periodic time of this motion is given as:

$$T^2 = \frac{4\pi^2}{g}l$$

It is a linear relation between (T^2) and (l).

Method:

1) Adjust the length (l) of the pendulum.
2) Give the pendulum a small angular displacement (θ) then let it to vibrate.
3) Record the time of 10 vibrations then measure the periodic time (T) from the relation ($T = t_{10}/10$).
4) Repeat the experiment for different values of (l).
5) Plot the curve (T^2) vs.(l) and find its slope, fig. (2).
6) Calculate (g) from the relation,

$$\left(g = \frac{4\pi^2}{slope}\right)$$

Results:

l (cm)	T_{10}(s)	T (s)	T^2(s^2)

Slope = $\frac{dy}{dx}$ = ………………………………..……….s^2/cm

$g = \frac{4\pi^2}{slope} =$ ……………………………………….cm/s^2

7. Speed of Sound wave in air

Aim of the experiment:

Determine the speed of sound by using the resonance tubes.

The apparatus (Fig.1):

1) Set of forks of different frequencies.
2) Scaled tube.
3) Glass jar filled with water.

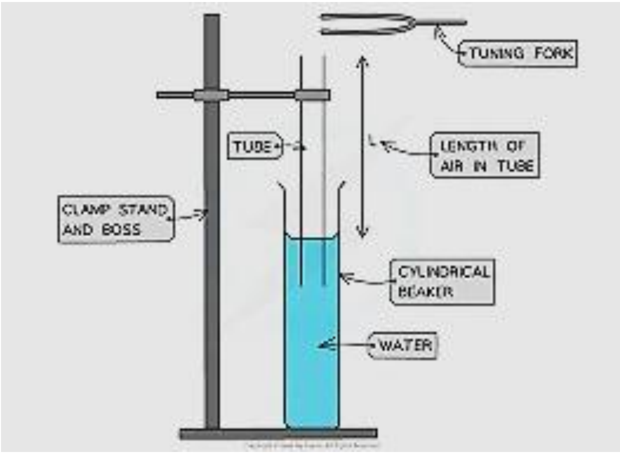


Fig.1: the apparatus

Theory:

If a vibrating tuning fork forces the air column to vibrate, and if the frequency of the tuning fork equal to the natural frequency of vibration of the column, the tube resonates and a loud sound is heard. To insure that, the water surface "that reflects back the sound wave so that a standing wave is established" is lowered, by raising the scaled tube up, until the note is at its loudest. Water surface acts like the closed end of pipe and is therefore the site of a displacement node.

There is a displacement antinode a short distance **c** above the top of the tube, where c is the end-correction. The manner in which the resonance has been located ensures that the tube is vibrating in its fundamental mode, and therefore:

$$\frac{1}{4}\lambda = l + c$$

Where *l* is the length of the air column at resonance, and λ is the wavelength of the sound wave produced by the tuning fork.

If the (known) frequency of the tuning fork is f, and v is the speed of sound, λ can be replaced by (v/f), and therefore:

$$L = \frac{1}{4}v.\frac{1}{f}c$$

Method:

1) Let the water level be near the top of the resonance tube.
2) As this is done vibrating forks is held over the mouth of the tube and then raise the resonance tube until the note is at its loudest.
3) Record the length of resonance tube above water level.
4) Repeat pervious steps for each vibrating forks.

Results:

F (Hz)	1/f (Hz^{-1})	*l*(cm)

Slope = $\frac{\Delta y}{\Delta x} =$ ……………………………………………

∵ slope = 1/4 v

∴ v = ………………..……………………..cm/s

c = ………………..……..………………cm

Monitoring and Evaluation Schedule

Student Information

Name	
Section	

Student Assessment

Date	Experiment Name	Degree	Supervisor

Average of student degree through 1st semester	
The extent of the student's commitment in the laboratory.	

Signature of doctor

……………………..