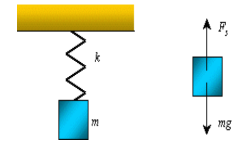
Mechanics Lab.
1st Year Physics- 2nd Semester **Name:……………………….**
Exp.6 : Hooke's Law and Simple Harmonic Motion **Group:…………**

The Aim: ---

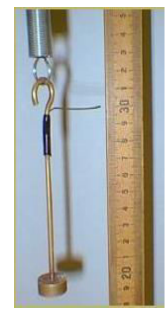
Introduction:



If the spring is stretched or compressed a small distance from its equilibrium position, the spring will exert a force on the body given by Hooke's Law, namely

$F_s = -kx$ -------------------(1) ; where F_S is known as the **spring force**.

Here the constant of proportionality, k, is the known as the **spring constant**, and x is the **displacement** of the body from its equilibrium position (at x= 0).



When a mass, m, is suspended from a spring and the system is allowed to reach equilibrium, as shown in Figure, Newton's Second Law tells us that the magnitude of the spring force equals the weight of the body, F_s=mg. Therefore, if we know the mass of a body at equilibrium, we can determine the spring force acting on the body.

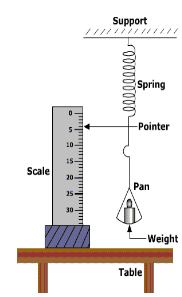
Procedure:

1: Static

a) Suspend the spring so that it hangs vertically from a rigid support; attach the first of the slotted weights (the hanger) to the lower end. Clamp the scale vertically alongside spring so that a small pointer or flag attached to the spring moves lightly against the scale.

b) Increase the load by successive increments of 20g, and record the pointer reading each time , when about six reading have been taken, and before the spring has stretched to more than double its original unloaded length, start unloading the weights. And again record the pointer readings.

c) Plot a graph with the values of the mean pointer read X/m as ordinates against the corresponding values of the load m/kg.



d) Find the spring constant k using the eq.

$$k = g.\frac{1}{Slope}$$

Static

Load $m \times 10^{-3}$ (kg)	Displacement: Increasing $X_1 \times 10^{-2}$ (m)	Decreasing $X_2 \times 10^{-2}$ (m)	$X_{ave} = (X_1+X_2)/2 \times 10^{-2}$ (m)
20			
40			
60			
80			
100			
120			

2:Dynamic

a) Suspend the spring from a firm support and load it, by means of slotted weights *m* attached to the free lower end, until it is possible to measure the time *t* taken by the suspended load to execute 20 complete vertical oscillations. Repeat the timing.

b) Increase the load *m* and again take the two timings of 20 oscillations. Continue until for six different loads. Calculate the period of one oscillation by using, $T=t/20$

c) Plot a graph with values of T^2/s^2 as ordinates against the corresponding values of m/kg.

d) find the earth gravity g from eq. below:

$$g = 4\pi^2 \frac{slope1}{slope2}$$

Load	Time for (20) oscillation				Time for (1) oscillation	
$m \times 10^{-3}$ (kg)	t_1 (s)	$t2$ (s)	$t3$ (s)	$t_{ave}=(t_1+t2+t3)/3$ (s)	$T_{ave}=t_{ave}/20$ (s)	T_{ave}^2 (s^2)
40						
60						
80						
100						
120						
140						

Post lab Questions

1- What physical indication does the springs constant give?

2- What do the negative sign indicate in equation (1)?

3- Regarding the equilibrium position, what is the effect of spring force?

4- What are the sources of error? How can you reduce them? Explain.

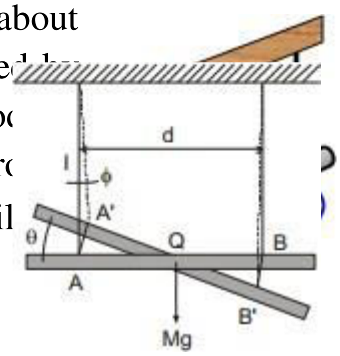
Mechanics Lab.
1st Year Physics- 2nd Semester **Name:……………………….**
Exp.5: Bifilar Suspension **Group:…………..…**

The Aim: --

Apparatus: Meter rule as a support, thread, metal rod (about 60 cm and with a diameter of between 0.5 and 1.5 cm, stop-watch.

Introduction

The bifilar suspension is used to determine the moment of inertia of a body about an axis passing through its center of gravity (mass). The body is suspende two parallel threads of length l and a distance d apart. If the mass of the bo M, then the tension in either cord is $Mg/2$. If the system is now displaced thr a small angle θ at its central axis, then an angular displacement ϕ wil produced at the supports (see figure below



If both angles are small, then

If both angles are small, then $l\phi = \left(\frac{d}{2}\right)\theta$

The restoring force F at the point of attachment of the threads B and B' is:

$$F = \frac{Mg}{2}\sin\phi$$

$$= \frac{Mg}{2}\phi \qquad \text{(for small } \phi)$$

Since $\phi = \theta\, d/2l$, the restoring force = $Mg\,\theta\, d/4l$,
and the restoring couple is thus $-Mgd\,\theta\, d/4l$
The equation of motion is:

$$I\theta = \frac{-Mgd^2}{4l}\theta\ ,$$

that is, $\theta + \frac{Mgd^2}{4Il}\theta = 0$ ……….……………………………………………….(1)

which implies that the motion is S.H.M. of period:

$$T = 2\pi\sqrt{\frac{4Il}{Mgd^2}} \qquad \text{……….………………………………………….(2)}$$

Therefore, the moment of inertia I of the body about its center of gravity is:

$$I = \frac{Mgd^2T^2}{16\pi^2 l}$$

Also, T may be expressed as

$$T = 2\pi\frac{2K}{d}\sqrt{\frac{l}{g}}, \qquad \text{……….(3)}$$

where $K^2 = \frac{1}{M}$ and K is the radius of gyration of the body about its center of gravity.

Procedure:

1. Measure the horizontal distance d between the vertical threads and let it be 56 cm.
2. Set the bar to oscillate through a small angle about the vertical axis passing through its center of mass and, with a stop-watch, take two determinations of the time for 20 complete oscillations. Then, calculate the period T.
3. Change d by moving each thread 2 cm away from the end of the rod. The threads must always be vertical. Then, repeat the timings. Continue to move the threads 2 cm at a time. Tabulate the readings. Assuming that the relation between T and d is of the form $T \propto d^a$, then:
   $T = C\, d^a$ .... (4)
   where C is the proportionality constant.
   Taking logs: $\mathrm{Log}_{10}(T/\mathrm{s}) = a\, \mathrm{Log}_{10}(d/\mathrm{m}) + \mathrm{Log}_{10} C$ .... (5)
   Plot a graph between values of $\mathrm{Log}_{10}(T/\mathrm{s})$ as ordinates against the corresponding values of $\mathrm{Log}_{10}(d/\mathrm{m})$. To determine the dependence of T on d, find a using:
   $$a = \frac{\Delta(Log_{10}T)}{\Delta(Log_{10}d)}$$
   From the intercept $\mathrm{Log}_{10}C$, calculate the moment of inertia I_{exp} of the rod.

Table

Distance between vertical threads d(m)	***Time for (20) oscillation***			***Time for (1) osc.***	**$\mathrm{Log}_{10}(T_{ave}/s)$**	**Log_{10} (d/m)**
	t1 (s)	***t_2 (s)***	***$t_{ave}=(t_1+t_2)/2(s)$***	***$T_{ave}= t_{ave}/20(s)$***		
0.56						
0.52						
0.48						
0.44						
0.40						
0.36						
0.32						

Post lab Questions

1. Why the angle θ must be small?

2. Calculate the I_{theor} of the rod, and then calculate the percentage error in determining I_{exp}?

3. In a bifilar suspension, if the length of the connecting rod is decreased, which quantities will increase?

4. What is the theoretical value of a? Calculate percentage error in determining a experimentally

****** **NOTE** ***********************************

To know a_{theor} and calculate I_{exp}:

Write Eq.(2) in the form $T = C\, d^a$:

$$T = 2\pi\sqrt{\frac{4Il}{Mg}}\, d^{-1}$$

which, when compared with Eq.(4), we get:

$a_{\text{theor}} = -1$

and

$$C = 2\pi\sqrt{\frac{4Il}{Mg}} \quad \text{..(6)}$$

Now, knowing the intercept $\mathrm{Log}_{10}C$, calculate C and then calculate $I \equiv I_{\text{exp}}$ using Eq.(6).

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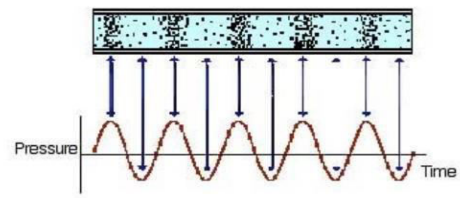
Mechanics Lab.
1st Year Physics- 2nd Semester **Name:…………………………**
Exp.4: Speed of Sound and Resonance **Group:………**

The Aim: --

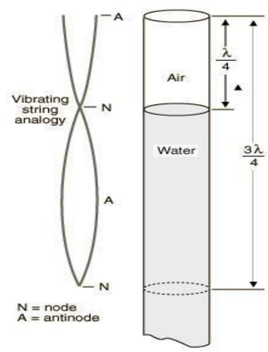
Introduction:

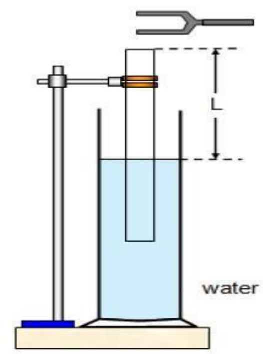
Sound waves are longitudinal waves. They can propagate in gases, liquids and solids. Sound waves in air travel by the motions of the air molecules as periodic variations in the air pressure with respect to time.



For a tube open at one end, the length of the resonance column l for the first position at that resonance is given by:

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





Procedure:

1. Fill the tube nearly full of water. Strike one of the tuning forks with the rubber mallet supplied and hold it above the water column. Caution: do not touch the tube with the tuning fork - the rapidly moving fork can break the plastic.

2. Using the moveable water reservoir, lower the water surface slowly, listening for amplification of the tone. When a resonance is found, a pronounced reinforcement of the sound will be heard. Move the water surface up and down several times to locate the point of maximum sound intensity (l) and mark that point with a rubber band on the outside of the tube. Do measuring twice for each fork and compute l_{ave}. Tabulate data.

3- Repeat the procedure for the other tuning forks supplied.

4- Plot a graph with values of lave (m) on y- axis against the corresponding values of $1/f$ (s) on x-axis. Find the sound velocity.

5- Find the speed of sound by substituting the slope in eq. $l = \frac{c}{4f}$

6- Find the speed of sound theoretically by using eq. below

$$c = c_o\sqrt{\frac{273+T}{273}}$$

where co =331 m/s at T=0 C, and T is the room temperature) .

7- find the percentage error using the formula below:

$$\% \text{ Error} = \left|\frac{\text{Theoretical Value} - \text{Experimental Value}}{\text{Theoretical Value}}\right| \text{X } 100$$

Note: the tube of length l open at one end will have an end correction for the open end so that the corrected length of the tube is l = l + ε. The end correction for a tube of radius r, is given by ε = 0.61r.

Table:

$f(Hz)$	$l_1 \times 10^{-2}$ (m)	$l_2 \times 10^{-2}$ (m)	$l_{ave} = (l_1+l_2)/2 \times 10^{-2}$ (m)	$1/f \times 10^{-3}$ (sec)
426				
384				
355.5				
320				
300				
288				
256				

Post lab Questions

1- How does the speed of sound change with humidity?

2- What happens to the speed of sound when you go higher in altitude?

3- Why does sound travel faster in solids than liquids or gases?

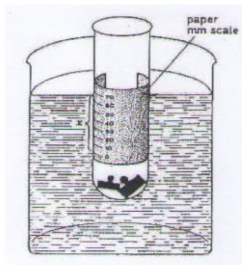
Mechanics Lab.
1^{st} Year Physics- 2^{nd} Semester Name:…………………………
Exp.3: Density of Water Group:……….

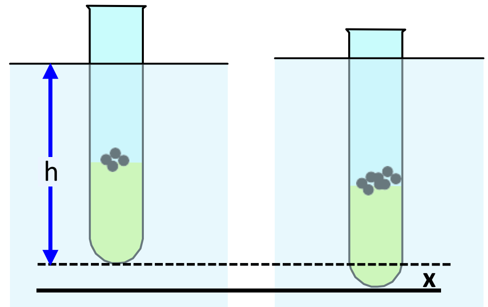
The Aim: ---

Introduction:

Density is a very useful property. It helps us identify unknown solids, liquids, or gases. It lets us know what will sink or float. Also, by knowing the density of something, we can figure out its weight if given the volume, or we can figure the volume if given how much it weighs.
Usually, density is found by massing the object, measuring its volume, and then dividing mass by volume.

$$Density = \frac{Mass}{Volume}$$





Procedure:

a) Put the test tube in to the beaker so that it floats vertically in the water with the zero mark just immersed, note the depth of immersion (ho) of the zero mark.
b) Add a 1g mass to the test tube and record the new depth of immersion (h) of the zero mark, Continue to increase the load by successive increments of 1g and measure the new depth of immersion each time.
c) Plot a graph with values of X/mm on y-axis as against the corresponding values of m/g on x-axis.
d) Find the density of water by substituting the slop in eq. below

$$\rho = \frac{4}{\pi d^2} \cdot \frac{1}{slope}$$

where d is the diameter of tube .

ho= ; **d =**

Mass $m \times 10^{-3}$ (kg)	*$h \times 10^{-2}$ (m)*	*$X = (h - h_o) \times 10^{-2}$ (m)*
1		
2		
3		
4		
5		
6		

Post lab Questions

1- You are given a bottle that contains 4.59 cm^3 of a metallic solid. The total mass of the bottle is 35.66 g. The empty bottle weighs 14.23 g. What is the density of the solid?

2- Mercury is traded by the “flask”, a unit that has a mass of 34.5 kg. What is the volume of a flask of mercury if the density of mercury is 13.6 g/ml?

3- How does density of a liquid vary with the temperature?

4- The density of a substance is 1.63 grams per milliliter. What is the mass of 0.25 liters of the substance in grams?

5- Two liquids,A and B, have densities 0.75grams per milliliter and 1.14 grams per milliliter, respectively. When both liquids are poured into a container, one liquid floats on top of the other. Which liquid is on top?

6- Explain why the density of any size sample of water is always the same.

Mechanics Lab.

1^{st} Year Physics- 2^{nd} Semester **Name:…………………………**

Exp.2: Bending Beam Experiment – Young's Modulus **Group:………**

Aim:---

Apparatus

Metal beam, two parallel knife edges on which the beam is placed and fixed, hook to suspend weights, weights, spherometer, battery, LED, wires, vernier calipers, micrometer, meter scale. The spherometer is mounted and fixed on a plate that has a hole under the middle leg of the spherometer. The electric circuit is connected as shown in the figure such that the LED glows when the middle leg of the spherometer touches the beam.

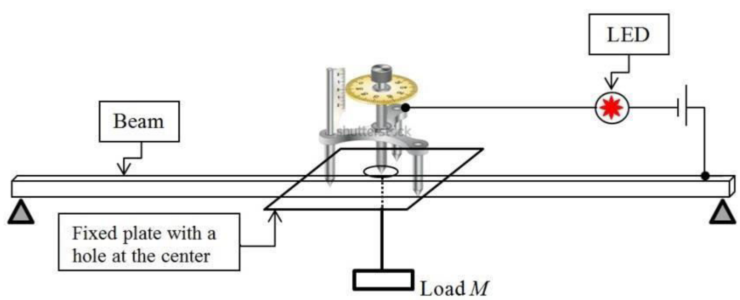
Formula

When a load *M* is suspended at the mid-point of a beam, the mid-point is depressed by λ:

$$\lambda = \frac{Mg\,l^3}{4bd^3E} \qquad (1)$$

From Eq.(1), one has:

$$E = \frac{gl^3}{4bd^3}\,\frac{M}{\lambda} \qquad (2)$$



where g = acceleration due to gravity,
l = length of the beam between the two knife edges,
b = breadth of the beam,
d = thickness of the beam,
E = Young's modulus for the beam material.

Procedure

(1) Measure the length of the beam l between knife edges using meter scale.
(2) Using micrometer, measure the thickness of the beam d.
(3) Using vernier calipers, measure the breadth of the beam b.
(4) With the beam unloaded, rotate the spherometer down: As soon as it touches the beam, the LED glows, stop rotating the spherometer and note its reading. This gives **zero mass reading** (y_o).
(5) Note the readings of depression while increasing load from zero to 2500 gm as follows:
(5.1) Load 500 gm. Notice that the bulb will stop glowing. Rotate the spherometer further down till the bulb just glows. Stop the rotation of spherometer and note its reading. This reading minus the zero mass reading gives depression λ for 500 gm.

(5.2) Increase the loaded mass till 2500 gm in interval of 500 gm and note the spherometer readings as the LED glows. Get the values of λ = spherometer reading – zero mass reading (y_o).

(6) Note the readings of depression while decreasing load from 2500 gm as follows:

(6.1) Remove the 500gm mass from hanger and rotate the spherometer in opposite direction till the bulb just becomes off. Note the spherometer readings. This value minus the zero mass reading is depression λ for 2000 gm mass at load decreasing case.

(6.2) Similarly, decrease the load up to zero mass in steps of 500 gm and note the spherometer readings at the just off situation of bulb. This will give you the depressions at different masses in case of load decreasing: λ = spherometer reading – zero mass reading (y_o).

(7) Take the mean of depressions for load increasing and load decreasing for each mass.
(8) Plot a graph of depression versus mass.
(9) From the slop of the graph and using Eq.(2), calculate the value of *E*.
(10) Calculate the percentage error if you have the exact value of *E*.
(11) Discuss.

Observations

(1) Length of beam between knife edges (l) = ... cm
(2) Breadth of the beam (b) = ... cm
(3) Thickness of the beam (d) = ... cm
(4) Zero mass reading (y_o) = ... cm

Table: (Depression = spherometer reading – y_o)

Mass M (gm)	*Depression (cm)*		*Depression (cm)*
	Load increasing λ_1	*Load decreasing* λ_2	$\lambda = (\lambda_1 + \lambda_2)/2$

Precautions

1. The weights must be placed and removed gently.
2. The spherometer must be moved in one direction: downwards for load increasing case and upwards for load decreasing case.

Questions:

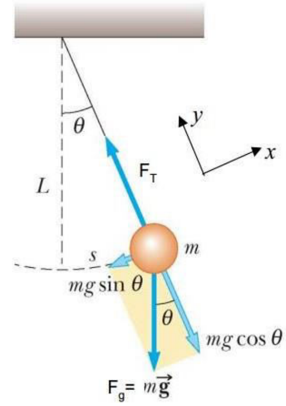
1. Is there any limit for the value of the load that you can use? Explain.

2. On what does the Young's modulus of the beam depend?

Mechanics Lab.
1st Year Physics- 2nd Semester **Name:..............................**
Exp.1:Simple Pendulum **Group:……..…**

Aim:..

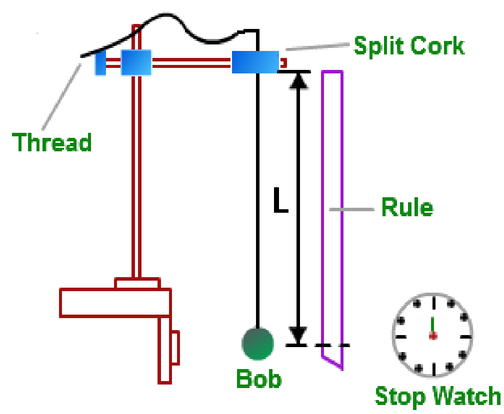
Introduction:

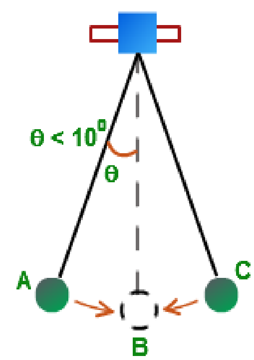


The simple pendulum is a system consisting of a string of length L, which is assumed to be massless and unstretchable, and a particle of mass m attached to the string called pendulum bob.When the mass is displaced a small angle from equilibrium and then released, the motion.

Procedure:

a) Set up the apparatus as shown in Fig. below. A small metal bob was attached to the thread, the thread was held by a clamp of the stand.





b) Measure the length of the thread L by a meter rule from the point of suspension to the middle of the bob, starting with 90 cm. This treatment is valid for angles less than 10° and all experiments should be conducted with this small angle.

c) The time for 20 complete oscillations t was taken using the stop watch, repeat the timing three times then calculate the period of one oscillation by using, $T=t/20$

d) Repeat step c for different lengths as tabulated below.

e) Plot a graph with values of $T^2(s^2)$ on y-axis against the corresponding values of L/m on x- axis.

f) Find the earth gravity g from eq. below:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Length $L\times10^{-2}$ ***(m)***	***Time for (20) oscillation***				***Time for (1) oscillation***	
	t_1 *(s)*	t_2 *(s)*	t_3 *(s)*	$t_{ave}= (t_1+t_2+t_3) / 3$ *(s)*	$T_{ave=tave/20}$ *(s)*	$Tave^2(s^2)$
90						
85						
80						
75						
70						
65						
60						
55						

Post lab Questions

1. What kinds of forces do act on the bob of the simple pendulum?

2. How does the restoring force will exist in the system of the simple pendulum?

3. What condition or conditions are required for simple harmonic motion to occur?

4. What are the sources of error? How can you reduce them? Explain.