Experimental No. (9)
Pendulum

Objective:

1. **To measure the dependence of period on length of the pendulum**
2. **To measure the acceleration of gravity.**
3. **To determine the spring's constant.**

Apparatus:

Pendulum bob, spring, slotted weights, meter and stop watch.

Theory:

All vibrating systems have frequency (f) at which they vibrate. The frequency is how many vibrations the system makes per unit time. Sometimes it is more useful to work with the period (τ) of the vibration or oscillation, and is the reciprocal of frequency. The size of the maximum displacement from the rest position is called the amplitude A. These quantities are related in such a way that they can describe the motion of an oscillating system mathematically. If we have a particle which is oscillating in the y-axes, the location in the y-axis at any given time (t) from the start of oscillation, can be found from the equation:

$$y = A\sin(2\pi ft) = A\sin(\omega t) \tag{44}$$

The velocity of the oscillating particle can be found from the displacement by taking the derivative of it with respect to time, the acceleration also can be found by taking the second derivative of displacement with respect to time as shown:

$$v = \frac{dy}{dt} = 2\pi fA\cos(2\pi ft) = \omega A\cos(\omega t) \tag{45}$$

$$a = \frac{d^2y}{dt^2} = -(2\pi f)^2 A \sin(2\pi f t) = -(2\pi f)^2 y \tag{46}$$

From equation (3)we can get the frequency:

$$f = \frac{1}{2\pi}\sqrt{(-\frac{a}{y})} \tag{47}$$

We will examine the two type of simple harmonic motions in this experiment:

1. **the first is a mass attached to a spring displaced a distance (-y) from the equilibrium point, since the displacement is not big the restoring force will be Hook's force (F=-ky), where, k is the spring constant. Using Newton's second law F= ma. We can write:**

$$ma = -ky; \frac{-a}{y} = \frac{k}{m} \tag{48}$$

Substituting into equation (4) will give us the frequency:

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \tag{49}$$

And the periodic time is:

$$\tau = \frac{1}{f} = 2\pi\sqrt{\frac{m}{k}} \qquad (masslessspring) \tag{50}$$

So far, we have assumed that the spring is massless, but the spring has a mass m', so its inertia affects the period of oscillation. This effect is very small and can be neglected. So from Eq.(7) you can predict the spring's constant.

2. **The other example of simple harmonic motion that we will examine is the simple pendulum, which is consist of a mass (m), called the bob, on the end of the string of length L. If we move the.bob a way from the rest position through some angle of displacement**

θ **As shown in Fig.(l), the bob will be acted upon by a restoring force due to gravity trying to move the bob back to its rest position. The magnitude of this force depends on the mass of the bob, acceleration due to gravity (g) and sine of the angle through which the bob has been moved. That is** $F = -mg\sin\theta$ **. So if we apply Newton's second law we get:**

$$F = -mg\sin\theta = ma; \qquad where,\ \sin\theta = \frac{y}{L} \tag{51}$$

As θ **is small we can express** $\sin\theta = \theta$**.**

Procedure:

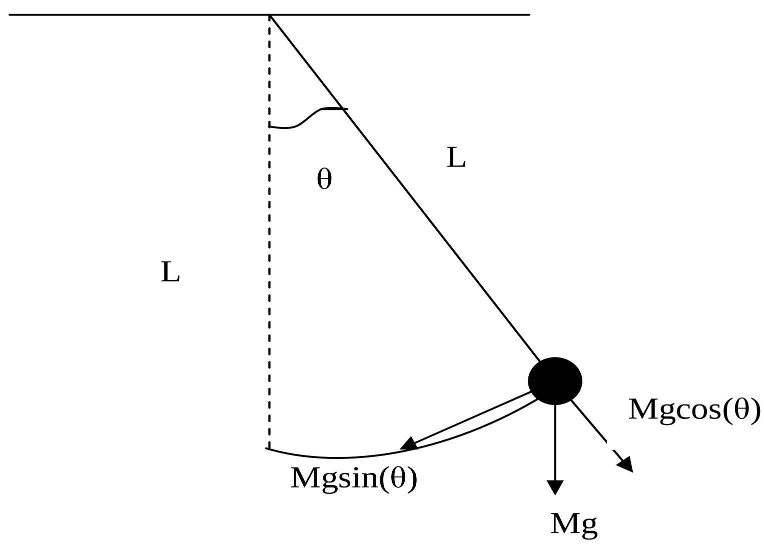

Figure 19:

- **For a mass on a spring: Part 1:**
  1. **Suspend the spring vertically from a rigid support.**
  2. **Use the slotted weights to elongate the spring, and record the displacements from the equilibrium position.**

3. **Tabulate your data as in table(l).**
4. **Plot x (meter) versus F= m *g (Newton) and from the slope find K of the spring.**

Part 2:

1. **Attach a mass to the spring and pull it downward a distance (A) from the equilibrium position.**
2. **Find the period of a vertical oscillation, use the stop watch to determine the time needed for 10 oscillations, do this twice and then find the average.**
3. **Tabulate your data as in table(2).**
4. **Plot T^2 versus m, using table (2) and find k from the graph.**

- **pendulum:**

1. **With the pendulum provided, displace the bob to one side and release (use small θ), use the stop watch to determine the time needed for 10 oscillation, do this step two times and then find the average.**
2. **Tabulate your data as in table(3)**

Name: **Grade:**

Students No.: **Date:**

Data and Conclusion:

Total Added mass	**Force**	**elongation**	**Spring constant**
m(kg)	**F=m*g(N)**	**x(m)**	**k(N/m)**

Draw F Vs x and fine k from the slope.................

Added mass	**Time for**	**10 oscillation**	**Period**	**Square period**
m(kg)	t_1	t_2	$\tau = \frac{t_1+t_2}{20}(sec)$	$\tau^2(sec^2)$

Draw τ^2 Vs m, find Slope = ... k = ...N/m intercept=..........

Pendulum Length	**Time for**	**10 oscillation**	**Period**	**Square period**
L(m)	t_1	t_2	$\tau = \frac{t_1+t_2}{20}(sec)$	$\tau(sec^2)$

Draw τ^2 Vs L

Find Slope=.............., g = ...m/sec^2 **,**$\frac{\Delta g}{g}$**%=.............**

Questions:

1. **Compare the two values of the spring's constant that you obtained from table(1) and table(2).**

2. **Is the period of the simple pendulum, in general depends on the amplitude?**

3. **what is the relation between k's and k'eq for parallel and series combination?**

4. **If the length of pendulum clock depends on temperature, in summer will the clock gain or lose time? Explain your answer.**

Experimental No. (10)
THE VISCOSITY

Objective:

- **To show that a small sphere falls with constant terminal velocity (v).**
- **To determine the viscosity coefficient η of glycerin.**

Apparatus: Viscosity is determined using the falling sphere viscometer which is composed of:

- **Glass cylinder : one meter Length, 0.1m inner diameter,**
- **Glycerin, shamboo and honey.**
- **Ball bearings of 3-8 mm diameter (density 7.8 gm/cm^3)**
- **Small magnet; Acetone ; Two rubber bands;**
- **Meter stick; Micrometer; Caliper; Stop watch.**

INTRODUCTION:

The resistance to the fluid flow due to the internal friction between adjacent fluid layers is called viscosity. If a sphere of diameter d and density ρ is allowed to fall from rest (Fig.20) through a liquid of density ρ_o , it will accelerate by the gravitational force F_G opposed by viscous force F_D, and the buoyant force of the fluid, F_B, until it reaches a constant terminal velocity, v_t. At this point, F_G is balanced by the F_D and F_B :

$$F_D + F_B = F_G \tag{52}$$

$$Gravitational force \qquad F_G = mg \tag{53}$$