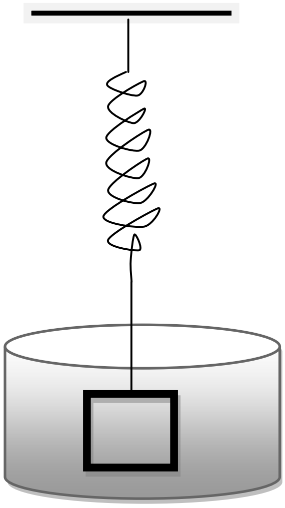
Experiment: 18

Damping coefficient for Simple Harmonic Oscillator

Aim: To determine Damping Coefficient of Simple Harmonic Oscillator.

Apparatus: Spring, Simple Harmonic Oscillator, stop clock, Damping apparatus

Introduction: In a damped harmonic oscillator, the amplitude decreases gradually due to losses such as friction, impedance etc. The oscillations of a mass kept in water, charge oscillations in a LCR circuit are examples of damped oscillations. Let us assume that in addition to the elastic force F = -kx, there is a force that is opposed to the velocity, F = b v where b is a constant known as resistive coefficient and it depends on the medium, shape of the body.



Mass (a magnet) is placed in a cylindrical Solenoid of 500 turns (22 gauge).The emf induced in the coil opposes the oscillations and provides velocity dependent damping.

For the oscillating mass in a medium with resistive coefficient b, the equation of motion is given by

$$m\frac{d^2x}{dt^2} + kx + b\frac{dx}{dt} = 0$$

This is a homogeneous, linear differential equation of second order.

The auxiliary equation is $D^2 + \frac{b}{m}D + \frac{k}{m} = 0$

The roots are $D_1 = -\frac{b}{2m} + \frac{1}{2m}\sqrt{b^2 - 4mk}$ and $D_2 = -\frac{b}{2m} - \frac{1}{2m}\sqrt{b^2 - 4mk}$

The solution can be derived as $x(t) = Ce^{-\left(\frac{b}{2m} - \frac{1}{2m}\sqrt{b^2-4mk}\right)t} + De^{-\left(\frac{b}{2m} + \frac{1}{2m}\sqrt{b^2-4mk}\right)t}$

Note: This can be expressed as x(t) = $Ae^{-\frac{b}{2m}t}\cos(\omega t-\phi)$ where $\omega=\sqrt{\frac{k}{m}-\left(\frac{b}{2m}\right)^2}$

$A=\sqrt{C^2+D^2}$ $\phi=\tan^{-1}(D/C)$

Here, the term $Ae^{-\frac{b}{2m}t}$ represents the decreasing amplitude and ($\omega t-\phi$) represents phase

Procedure:

1. Set the mass in to SHM and find its amplitude A.
2. Connect the two ends of the cylindrical solenoid to set up the damping by the process of Lenz's law.
3. Measure the time taken for amplitude A to decrease to $A_{1/2}$ and calculate damping coefficient by the formula

$$b=\frac{2m.\ln 2}{t_{\frac{1}{2}}}$$

OBSERVATIONS:

Mass of the oscillator = ………….kg

Trial no	Amplitude A (cm)	A/2	Time taken for amplitude A to decrease to A/2
1			
2			
3			

Formula:

$$x=Ae^{-\frac{b}{2m}t}$$

$$at\ \ t=t_{\frac{1}{2}}$$

$$\frac{A}{2}=Ae^{-\frac{b}{2m}t_{\frac{1}{2}}}$$

$$b=\frac{2m.\ln 2}{t_{\frac{1}{2}}}$$

Result: The damping coefficient is found to be …….kg/s