EAST WEST UNIVERSITY

Physics Lab

Department of MPS

Course Name :Engineering Physics -1

Course Code :PHY 109 LAB

Section No :04

Group No :01

Experiment No : 01

Name of the Experiment : spring constant and effective mass of a spring.

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Experiment No: 01

Name of the Experiment:

Determination of **spring constant** and **effective mass** of a given spiral spring.

Theory:

If a spring be clamped vertically at one end point, and loaded with a mass at the other end , then, the **time period of vibration** of the spring along a vertical line is given by

$$T = 2\pi\sqrt{\frac{m+m'}{k}} = 2\pi\sqrt{\frac{M}{k}} \quad .....(1)$$

Where,

$\boldsymbol{M}(=m+m')$ is the **effective mass** of the **oscillating system**(load and spring),

$\boldsymbol{m}$ = mass of**loads** suspended from the spring,

m' =**effective mass** of the spring

k = **spring constant** = ***F / x = mg / x***

How the mass of the spring contributes to the **effective mass** of the vibrating system(load and spring) can be shown as follows.

Consider the **kinetic energy** of a spring and its load undergoing simple harmonic oscillation. At the instant under consideration let the **load*m*** be moving upwards with **velocity$\boldsymbol{v_o}$** as shown in the figure.

At this same instant **an element** of ***dm***of the total mass $\boldsymbol{m_o}$ of the spring will also be moving up but with a **velocity*v*** which is less than $\boldsymbol{v_o}$**.**

It is evident thatthe ratio between ***v* and $\boldsymbol{v_o}$** is just the ratio between ***y*** **and $\boldsymbol{y_o}$**. (in figure -1)

Hence $$\frac{v}{v_o} = \frac{y}{y_o},$$

So, $$v = \frac{y \times v_o}{y_o} \quad \text{.} \quad ....(2)$$

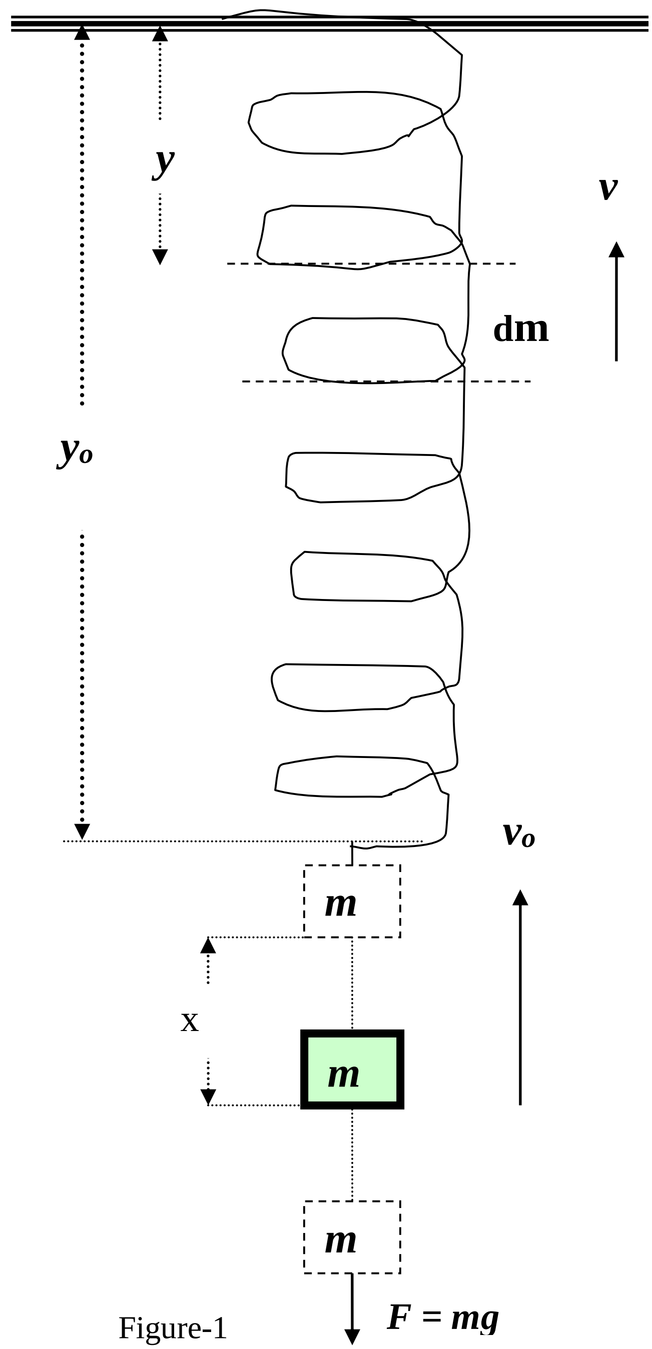


Figure-1

Kineticenergy of small **part of mass*dm*** of the **spring** will be $=\frac{1}{2}dm\,v^2$

Therefore**kinetic energy** of full part of the **springalone** will be $=\int_0^m \frac{1}{2}v^2 dm$

From similarity we can write, $\frac{dm}{m_o}=\frac{dy}{y_o}$, (in figure -1) hence, $dm = \frac{m_o}{y_o}dy$ ………**(3)**

Where m_o= mass of the spring , dm = mass of an element of the spring
y_o= length of the spring, dy= length of an element of the spring

Thus the integral becomes (using equation 2 and 3)

$$\int_0^m \frac{1}{2}v^2 dm = \int_0^{y_o}\frac{1}{2}\left(\frac{y\times v_o}{y_o}\right)^2 \frac{m_o}{y_o}dy = \frac{m_o v_o^{\,2}}{2y_o^{\,3}}\int_0^{y_o} y^2 dy = \frac{m_o v_o^{\,2}}{2y_o^{\,3}}\times\frac{y_o^{\,3}}{3} = \frac{1}{2}\left(\frac{m_o}{3}\right)v_o^{\,2}$$

Therefore,
Total **kinetic energy** (**K.E.**)of the system will be
= K.E. of the **load** (suspended mass) +K.E. of the **spring**

$$= \frac{1}{2}mv_o^{\,2} + \frac{1}{2}\left(\frac{m_o}{3}\right)v_o^{\,2} = \frac{1}{2}\left(m+\frac{m_o}{3}\right)v_o^{\,2}$$

Hence the **effective mass** of the **vibrating system** (**load and spring**)= $M = m+\frac{m_o}{3}$.

Comparing with **equation (1)** ,$M(=m+m')$; hence $m'=\frac{m_o}{3}$ **;** where,
m' = **effective mass** of the spring, m_o = mass of the spring.

So, the **effective mass (** m' **)** of the spring is **one third mass(*m_o/ 3***) of the spring.

Spring Constant:

The **applied force** (weight of the load), ***F(=mg)***on the spring is **proportional** to the **extension*x***of the spring within the elastic limit. Therefore
$F \propto x$ Or, $F = k\,x$ or, $mg = k\,x$ … ………..(4),
where ***k*** is **spring constant**.

Apparatus:

(1)A spiral spring, (2) convenient masses with hanging arrangement, (3) top pan balance, (4) a rigid framework of heavymetal rods, (5) stop watch, (6) meterscale.

Data Sheet:

Table: Data for extensions and time periods for different loads

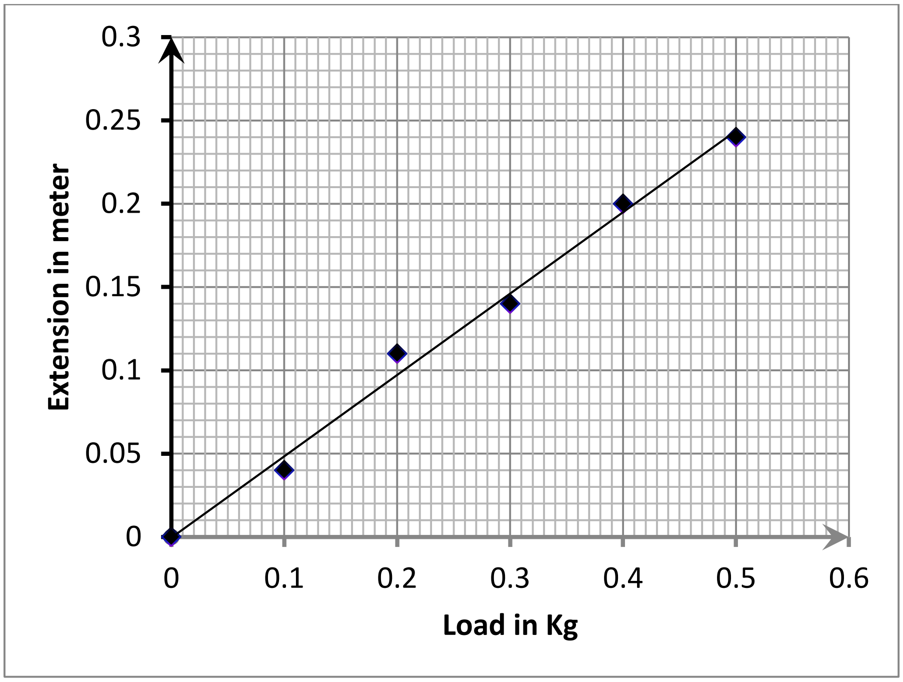
No. of obs.	Load m *Kg*	Reading of bottom end of the spring on the vertical scale l *meter*	Extension x *meter*	Total time for 20 oscillations *t / sec*	Time period T = (t / 20) *sec*	T^2 *sec²*
1	**0 (No load)**	$l_o = .48$	$(l_o - l_o) = 0$			
2	**0.05**	$l_1 = .60$	$(l_1 - l_o) = .12$	13.98	0.699	0.488
3	**0.1**	$l_2 = .72$	$(l_2 - l_o) = .24$	20.58	1.029	1.05
4	**0.15**	$l_3 = .84$	$(l_3 - l_o) = .36$	24.30	1.21	1.46
5	**0.2**	$l_4 = .97$	$(l_4 - l_o) = .49$	28.70	1.435	2.059
6	**0.25**	$l_5 = 1.09$	$(l_5 - l_o) = .61$	32.32	1.616	2.611
7	**0.3**	$l_6 = 1.21$	$(l_6 - l_o) = .73$	35.32	1.766	3.11

Calculation:

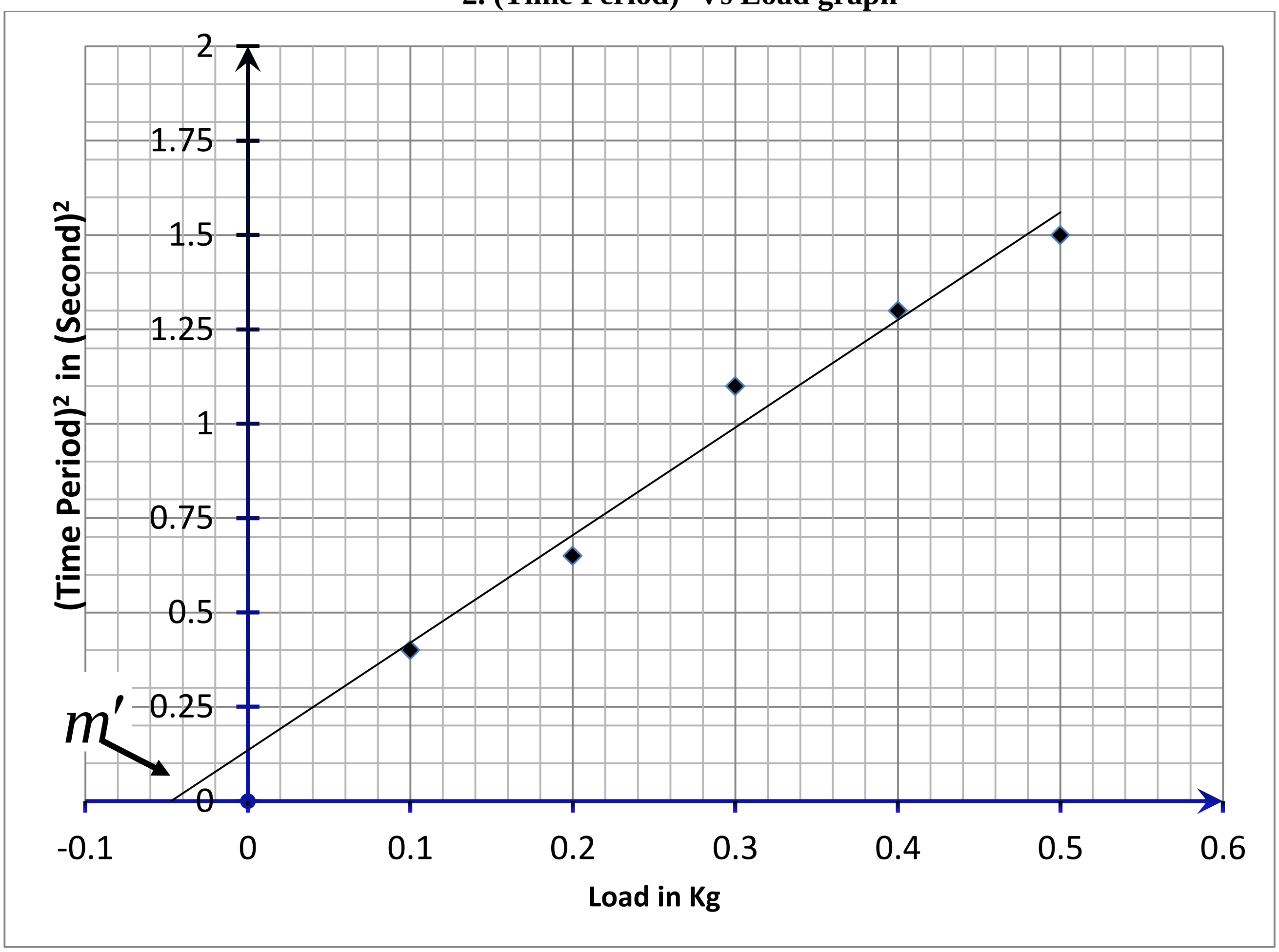
$$Spring\ Constant, K = \frac{mg}{x} = \frac{g}{\frac{x}{m}} = \frac{9.8\ \frac{m}{s^2}}{SLOPE\ of\ Extension\ vs\ Load\ graph} = \frac{9.8}{2.44} = 4.016 N/m$$

Graphs:

1. Extension (x) vs Load (m) Graph:



2. (Time Period)^2 Vs Load graph



Results:

Spring constant,   K = $\mathbf{4.016}\boldsymbol{N/m}$

Discussions:

1. A large number of oscillations should be counted for determining the period of oscillation.
2. The support from which the spring is suspended should be fixed.

Conclusion :

I think if we could do this same experiment in the lab, the measure value would change a little bit and most importantly we could learn how to use these elements.