Practical-1

Acceleration due to gravity and Hooke's spring constant

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Reports

Aim

Part A

- Using a simple pendulum, determine the acceleration due to gravity (g).

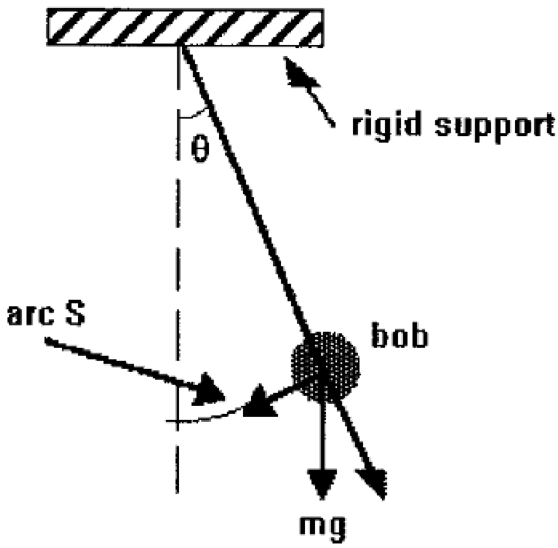
Part B

- Using helical spring, determine the Hooke's spring constant (k).

Introduction

Part A

- The simple pendulum consists of a metallic bob of mass 'm' attached to a string if length 'l'. The pendulum is suspended to one side so that the string makes angle **θ.**



The pendulum will oscillate back and forth showing simple harmonic motion (SHM). The time take by pendulum to complete one oscillation is called its time period and is denoted by 'T'.

According to Newton's second law, force is directly proportional to the product of mass and acceleration

$F=ma$ ...(i)

Moreover, acceleration can also be defined as the double derivative of distance with respect to time i.e.

$a=d^2s/dt^2$ ...(ii)

from (i) and (ii)

$F=m(d^2s/dt^2)$ ...(iii)

However, from the motion of the pendulum we get to know that force along the x component is

$F=-mgSin\theta$ ...(iv)

Where negative sign shows that the angle θ is decreasing or it is in opposite direction of increasing the arc 's'.

The angle is defined by arc divided by radius. This means

$s=l\theta$ ...(v)

Using (iii) and (iv)

$-mgSin\theta=m(d^2s/dt^2)$

Mass will cancel from both sides and the angle used here is very small($\theta<=10^o$), we can say that $Sin\theta\cong\theta$.

$-g\theta=d^2s/dt^2$

Substituting s from equation(v)

$d^2\theta/dt^2=(-g/l)$ ...(vi)

the bob is moving in a simple harmonic motion with a time period 'T'

$T=2\pi\sqrt{(l/g)}$

Squaring both sides

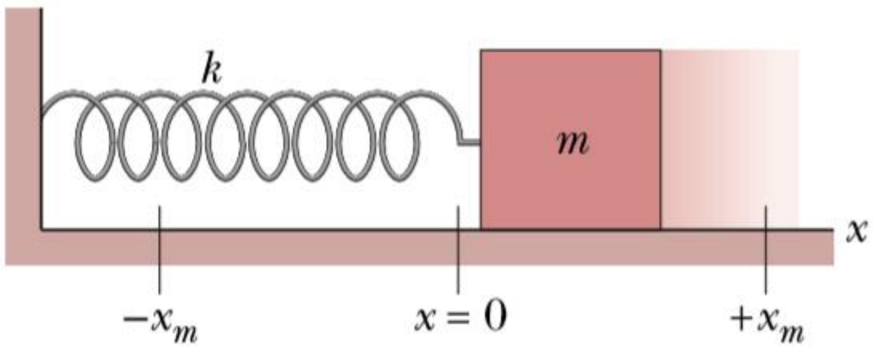
$T^2=4\pi^2(l/g)$ ...(vii)

If we compare this equation to a general y=mx equation, the slope for T^2 vs l will be

Slope=$4\pi^2/g$

Part B

- In this experiment a helical spring is attached to a rigid support and an object of mass 'M' is used. the object is attached to the spring.



Stretch the spring but not so much that the elasticity of spring is destroyed by going beyond young's modulus.

According to Hooke's law, force is directly proportional to the distance by which spring is extended

$F=-K\Delta x$ ...(i)

Where K is the spring constant and the negative sign show that the spring is pulled in the opposite direction. The equation (i) can be compared be y=mx, which will give us the slope -K.

When the spring undergoes simple harmonic motion (SHM), the time take to complete one oscillation is given by

$T=2\pi\sqrt{(M_t/K)}$ ...(ii)

Where M_t=M+m/3, and M is the mass of weight attached and m is mass of spring.

Squaring equation (ii)

$T^2=4\pi^2(M_t/K)$ ...(iii)

With the help of this equation, graph for T^2 vs M_t can be plotted, with the slope $4\pi^2/K$.

Experiment method

Part A

- Take a metallic bob of suitable mass and attach it to the string of length at least 1metre.
- Measure the length from the centre of the bob to the string. Firstly take 10 cm.
- Suspend the pendulum so that it makes an angle of 10^o with the vertical.
- Release the pendulum and let it make 50 oscillations. Use the stop watch to count the time taken for 50 oscillations.
- Repeat the experiment for 10 more readings by increasing 10 cm each time.
- Plot the graph for T^2 vs length of string so as to find the slope.
- Find the uncertainties in the readings.

Part B

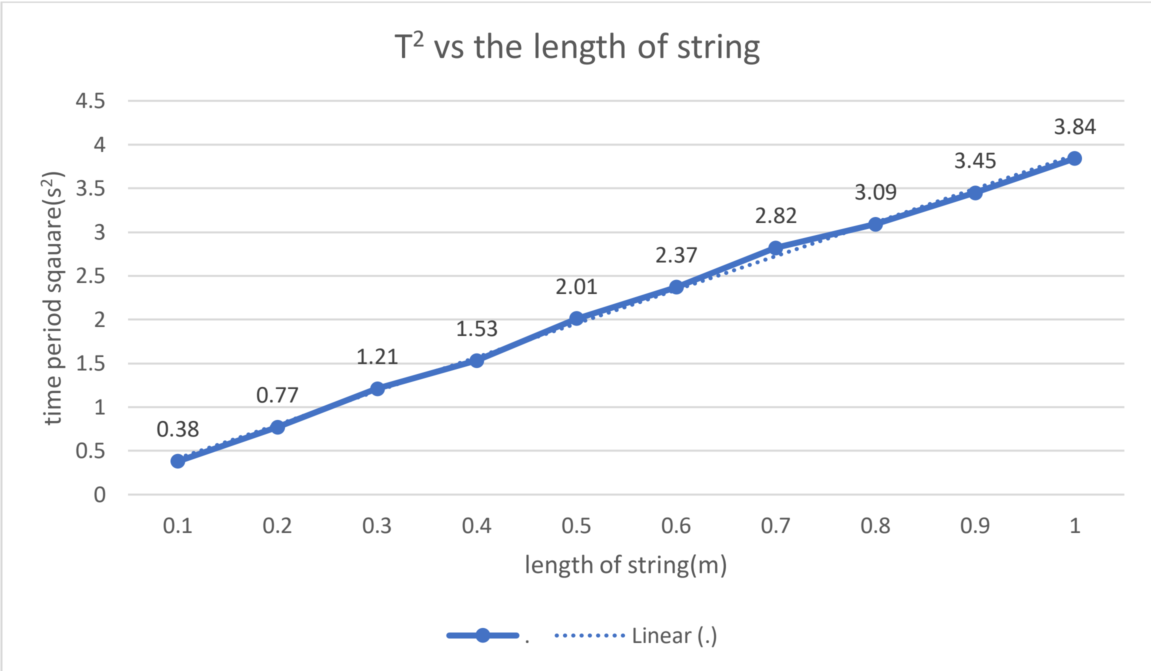
- Measure the weight of the helical spring and attach it to a rigid support.
- Add 300 grams of weight to it and pull it slightly downwards. It will go in a simple harmonic motion(SHM).
- Use the stop watch to count the time taken for 30 oscillations.
- Repeat it again for the same load and get the average time.
- Repeat the experiment again for 6 more times going up to 550 grams by adding 50 grams each time.
- Plot the graph for T^2 vs M_t and the slope will give the spring constant K.
- Find the uncertainties in readings.

Results and calculations

Part A

Length(m)	**Oscillations**	**Time(s)**	**Time period(s)**	**Time squared(s^2)**
0.1	50	31	0.62	0.38
0.2	50	44	0.88	0.77
0.3	50	55	1.10	1.21
0.4	50	62	1.24	1.53

0.5	50	71	1.42	2.01
0.6	50	77	1.54	2.37
0.7	50	84	1.68	2.82
0.8	50	88	1.76	3.09
0.9	50	93	1.86	3.45
1.0	50	98	1.96	3.84



With the help of the graph, we can easily find the slope

$G=y_2-y_1/x_2-x_1$

=3.84-3.45/1-0.9

=3.9

Also from the formula,

$G=4\pi^2/g$

3.9=4x22x22/7x7xg

$g=10.23m/s^2$

gradient from line of best fit

G'=1.21-0.77/0.3-0.2

=0.44/0.1

$=4.4m/s^2$

Uncertainty between G and G' is represented by ΔG

$\Delta G=+-(G'-G)$

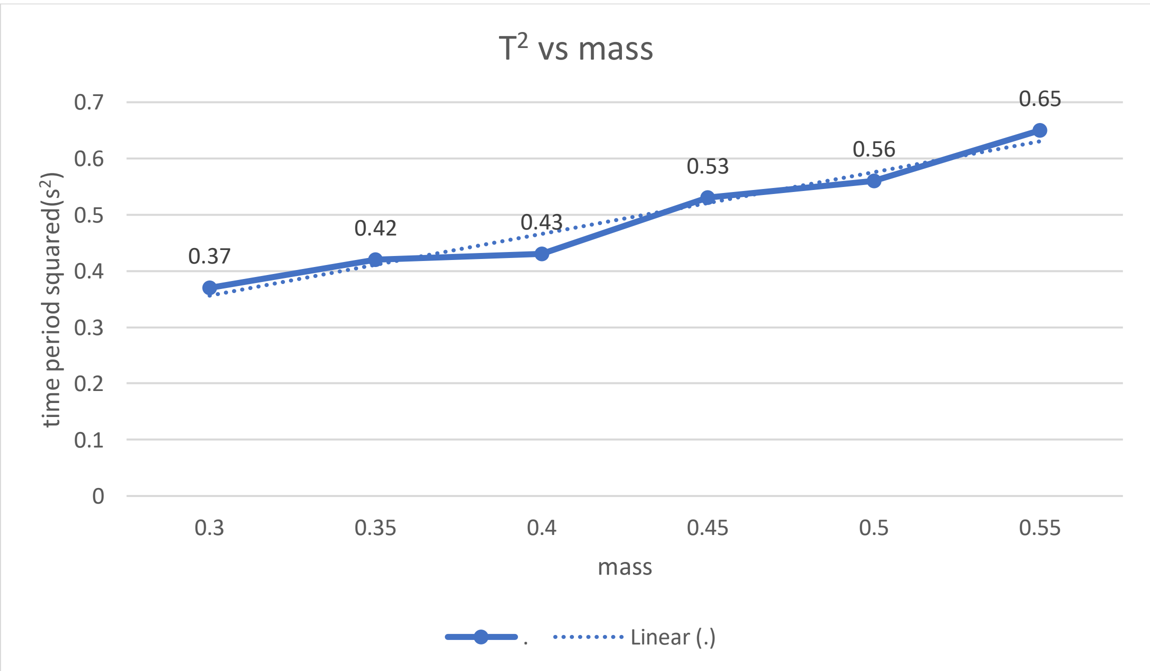
$=+-0.5m/s^2$

The value of g from the experiment is $10.23+-0.5m/s^2$

Part B

weight of spring = 32.59 grams

weight(kilograms)	Total weight (kilograms)	Oscillations	Time 1(seconds)	Time 2(seconds)	Time average(seconds)	Time period(second)	Time squared(s^2)
0.300	0.332	30	19	18	18.5	0.61	0.37
0.350	0.382	30	20	19	19.5	0.65	0.42
0.400	0.432	30	20	20	20.0	0.66	0.43
0.450	0.482	30	22	22	22.0	0.73	0.53
0.500	0.532	30	23	22	22.5	0.75	0.56
0.550	0.582	30	24	25	24.5	0.81	0.65



The slope in the graph is

$S=(y_2-y_1)/(x_2-x_1)$

=0.65-0.37/0.55-0.3

=1.12

From the formula slope is

$S=4\pi^2/k$

1.12=4x22x22/7x7xk

k=35.27

another slope for the line of best fit

S'=0.42-0.37/0.35-0.3

S'=1

Uncertainty in S'

ΔS=+-(S-S')

=+-(1.12-1)

=+-0.12

From practical the determined value of K is 35.27+-0.12kg/s^2

__Discussions__

Part -A

The pendulum experiment helps one to know the value of g or acceleration of a freely falling body. In thins experiment a bob is taken and is allowed to go into back and forth motion. Sometimes the angle was more than 10^o, which might lead to the consideration of the angle and change the result and giving inaccuracies. Furthermore, the bob needs to go for example in only xy plane, but it was sometimes moving in 3-dimensional plane which also led to the change in result. moreover, if we consider different factors such as humidity, temperature and air resistance, the results will never be same as 9.81m/s^2. lastly, scientifically the value of g changes decreases with the increase in altitude. If that is to be considered the value of g will be different for each place.

Part- B

The spring constant should be fixed firmly with the stand otherwise it will wobble in multiple directions which we do not want. While starting the simple harmonic motion, the spring must be slightly pulled so that the weights do not jump up and down which might change the value of k. moreover, heavy weight can not be used for this experiment. If heavy weight are used, it will pull the spring more, changing the young's modulus of spring. More factors like air resistance, temperature and humidity also effect the spring constant. The spring constant is found out by measuring the weight, radius and number of coils in a spring thus it varying the spring constant.

Conclusions

Part A

The value of g is 10.23+-0.5m/s^2 found with the help of a simple pendulum which was in simple harmonic motion.

Part B

The value of k is 35.27+-0.12kg/s^2 found with the help of a helical spring which was in simple harmonic motion.

References

- Deakin university, SEB101 lab manual 2019.
- Fundamentals of physics by Resnik, Halliday and Walker, (10^{th} edition) Topics 15-3 and 15-3