جامعة بيرزيت

BIRZEIT UNIVERSITY

# Physics Lab 211

## Experiment No. 5

## The Helical Spring

**Name:** Laith Marzouka **ID:** 1160827

**Partner:** Ahmed Awawda **ID:** 1163113

**Advisor:** Dr. Areej Abdel Rahman

**Date:** July 4, 2018

## Data Sheet:

$Mass\ of\ the\ spring = (0.042 \pm 0.002)\ kg$

$g = 9.8\ m/s$

### $\boldsymbol{Part\ I}$:

**$y_0 = \boldsymbol{0.419\ m}$**

| $\boldsymbol{m}\ (\boldsymbol{kg})$ | $\boldsymbol{y}\ (\boldsymbol{m})$ | $\boldsymbol{\Delta y}\ (\boldsymbol{m})$ |
|---|---|---|
| 0.05 | 0.401 | 0.018 |
| 0.10 | 0.383 | 0.036 |
| 0.15 | 0.363 | 0.056 |
| 0.20 | 0.346 | 0.073 |
| 0.25 | 0.326 | 0.093 |
| 0.30 | 0.310 | 0.109 |
| 0.35 | 0.290 | 0.129 |

### $\boldsymbol{Part\ II}$:

| $\boldsymbol{m}\ (\boldsymbol{kg})$ | $\boldsymbol{T}\ (\boldsymbol{s})$ | $\boldsymbol{T^2}\ (\boldsymbol{s^2})$ |
|---|---|---|
| 0.10 | 0.417 | 0.174 |
| 0.15 | 0.474 | 0.225 |
| 0.20 | 0.539 | 0.291 |
| 0.25 | 0.608 | 0.370 |
| 0.30 | 0.674 | 0.454 |
| 0.35 | 0.723 | 0.523 |

## Calculations:

### From part I:

The force constant is the slope of (**Graph I**).

$k_1 = slope = 26.576\ N/m$

$Uncertainty\ in\ the\ k_1 = Uncertainty\ in\ the\ slope = 0.261\ N/m$

$$\boxed{\rightarrow \boldsymbol{k_1} = \ (\mathbf{26.576 \pm 0.261})\ \boldsymbol{N/m}}$$

--------------------------------------------

### From part II:

The force constant:

$$k_2 = \frac{4\,\pi^2}{slope}$$

The slope of (**Graph II**) = $1.436\ s^2/kg$

$$k_2 = \frac{4\pi^2}{1.436} = 27.492\ N/m$$

Uncertainty in $k_2$: $\Delta k_2 = \frac{\Delta\ slope}{slope} \times k_2$

$Uncertainty\ in\ the\ slope = 0.013\ N/m$

$$\Delta k_2 = \frac{0.013}{1.436} \times 27.492 = 0.249\ N/m$$

$$\boxed{\rightarrow \boldsymbol{k_2} = \ (\mathbf{27}.492 \pm 0.249)\ \boldsymbol{N/m}}$$

The effective mass ($m_{eff}$) can be obtained from the y-intercept from (**Graph II**).

$$T = 2\pi\sqrt{\frac{m + m_{eff}}{k}}$$

$$\boldsymbol{T^2} = \frac{4\pi^2}{k}\boldsymbol{m} + \underbrace{\frac{4\pi^2}{k}m_{eff}}_{y\_intercept}$$

From (**Graph II**):

$y - intercept = 0.016\ s^2$

$\Delta$ y$_intercept = 0.013\ s^2$

$m_{eff(\exp)} = \frac{y-intercept \times k}{4\pi^2} = \frac{0.016\times 27.492}{4\pi^2} = 0.011\ kg$

$$\frac{\Delta m_{eff(exp)}}{m_{eff(\exp)}} = \frac{\Delta\ y\_intercept}{y\_intercept} + \frac{\Delta k}{k} = \frac{0.013}{0.016} + \frac{0.249}{27.492} \approx 0.822$$

$\Delta m_{eff(\exp)} \approx 0.009\ kg$

$\boxed{\rightarrow \boldsymbol{m_{eff(exp)}} = (\mathbf{0.011} \pm \mathbf{0.009})\boldsymbol{kg}}$

--------------------------------------------

The average value of the spring constant:

$k_{avg} = 26.877\ N/m$

From the standard deviation we can find the error in $k_{avg}$:

$$\frac{\sigma_m}{\sqrt{N}} = \frac{0.648}{\sqrt{2}} = 0.458\ N/m$$

$\boxed{\rightarrow \boldsymbol{k_{avg}} = (\mathbf{26.877} \pm \mathbf{0.458})\ \boldsymbol{N/m}}$

--------------------------------------------

## Results & Conclusions:

$\boldsymbol{k_{avg} = (26.877 \pm 0.458)\ N/m}$

$\boldsymbol{m_{eff(exp)} = (0.011 \pm 0.009) kg}$

From the first graph, the y-intercept must equal to zero. So the y-intercept we obtained is an indicative of how accurate the data is.

$y\_intercept = 0.0085\ N,$ since it is relatively small we can predict that our obtained data is highly accurate.

This error in y-intercept is mainly due to the effective mass which was not included in the first part.

The theoretical value of the effective mass:

$$m_{eff(theo)} = \frac{1}{3} m_{spring} = \frac{1}{3} \times 0.042 = 0.014\ kg$$

$$\Delta\ m_{eff(theo)} = \Delta\ m_{spring} = 0.002\ kg$$

Discrepancy in $m_{eff}$:

$$m_{eff} = \left| m_{eff(theo)} - m_{eff(exp)} \right| = |0.014 - 0.011| = 0.003\ kg$$

$$2 \times \Delta\ m_{eff(\exp)} >?\ Discrepancy$$

$$2 \times 0.009 >?\ 0.003$$

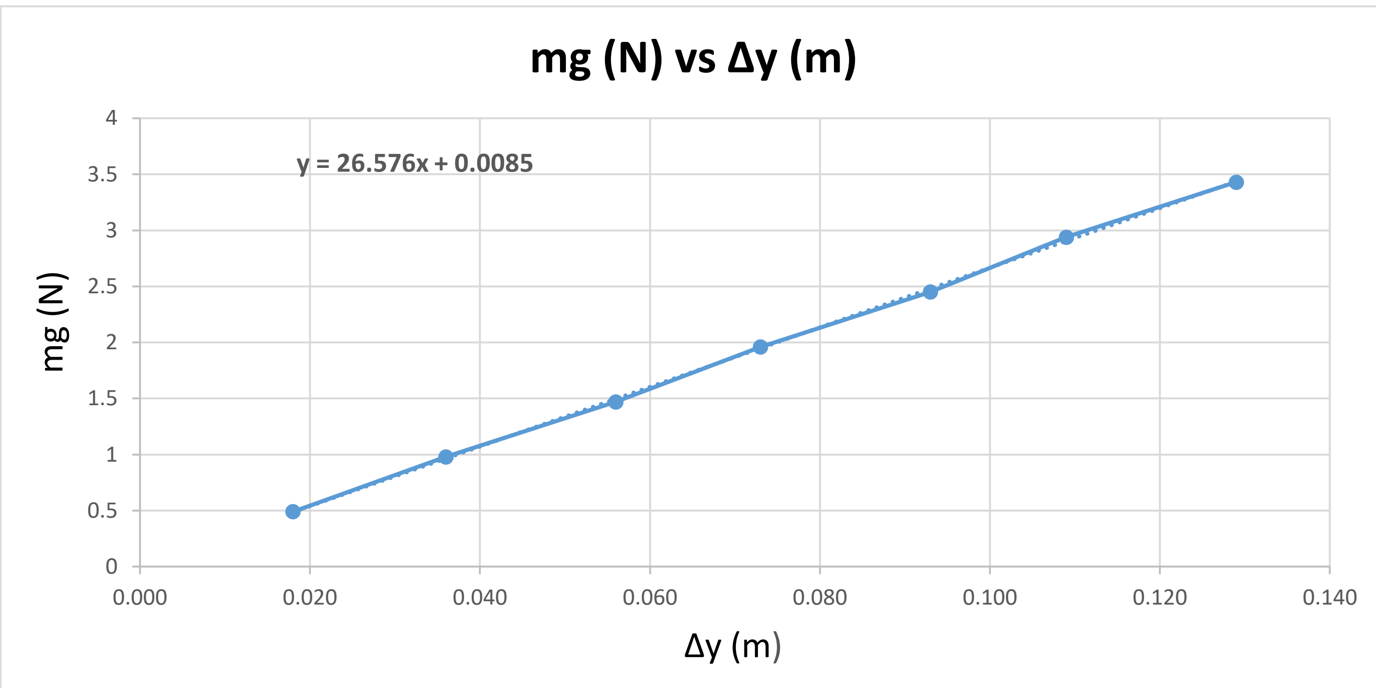
$$0.018 > 0.003$$

Thus, our value $m_{eff}$ of is accepted.

There are many sources of random errors in this experiment. In the first part, the reading of the spring displacement is not so accurate since there is a gap between the spring and the scale. In the second part, the time measured for 10 revolutions has errors, since there is a delay in stopping the stop watch. Also, the oscillations were not completely vertical. As well as, the spring was twisted from the middle which had remarkable effects on the results, and its mass was measured by and old two pan balance which had a significant error.

# Graph I

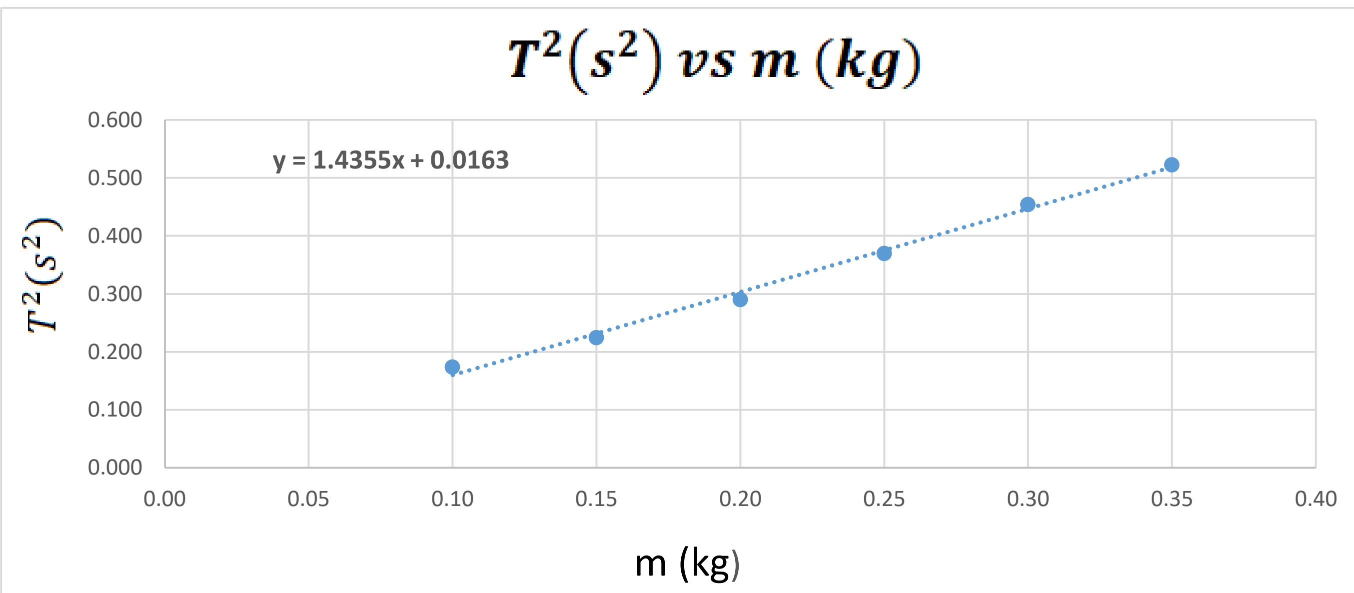
| Δy (m) | mg (N) |
|---|---|
| 0.018 | 0.49 |
| 0.036 | 0.98 |
| 0.056 | 1.47 |
| 0.073 | 1.96 |
| 0.093 | 2.45 |
| 0.109 | 2.94 |
| 0.129 | 3.43 |




| | slope | y-int |
|---|---|---|
| | 26.576 | 0.009 |
| **error** | 0.261 | 0.021 |

# Graph II

| m (kg) | $T^2$ $(s^2)$ |
|---|---|
| 0.10 | 0.010 |
| 0.15 | 0.023 |
| 0.20 | 0.040 |
| 0.25 | 0.063 |
| 0.30 | 0.090 |
| 0.35 | 0.123 |




| | slope | y-intercept |
|---|---|---|
| | 1.436 | 0.016 |
| error | 0.054 | 0.013 |