



Physics Lab 211

Experiment No. 5

The Helical Spring

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Data Sheet:

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

$g = 9.8 \text{ m/s}$

Part I:

$y_0 = 0.419 \text{ m}$

$m \text{ (kg)}$	$y \text{ (m)}$	$\Delta y \text{ (m)}$
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

Part II:

$m \text{ (kg)}$	$T \text{ (s)}$	$T^2 \text{ (s}^2\text{)}$
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**).

$$k_1 = \text{slope} = 26.576 \text{ N/m}$$

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

$$\rightarrow k_1 = (26.576 \pm 0.261) \text{ N/m}$$

From part II:

The force constant:

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

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

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

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

$$\text{Uncertainty in the slope} = 0.013 \text{ N/m}$$

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

$$\rightarrow k_2 = (27.492 \pm 0.249) \text{ N/m}$$

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

$$T = 2\pi \sqrt{\frac{m + m_{eff}}{k}}$$
$$T^2 = \frac{4\pi^2}{k} m + \frac{4\pi^2}{k} m_{eff}$$

y-intercept

From (**Graph II**):

$$y - \text{intercept} = 0.016 \text{ s}^2$$

$$\Delta y_{\text{-intercept}} = 0.013 \text{ s}^2$$

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

$$\frac{\Delta m_{\text{eff}(\text{exp})}}{m_{\text{eff}(\text{exp})}} = \frac{\Delta y_{\text{-intercept}}}{y_{\text{-intercept}}} + \frac{\Delta k}{k} = \frac{0.013}{0.016} + \frac{0.249}{27.492} \approx 0.822$$

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

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

The average value of the spring constant:

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

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

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

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

Results & Conclusions:

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

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

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} :

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

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

$$2 \times 0.009 >? 0.003$$

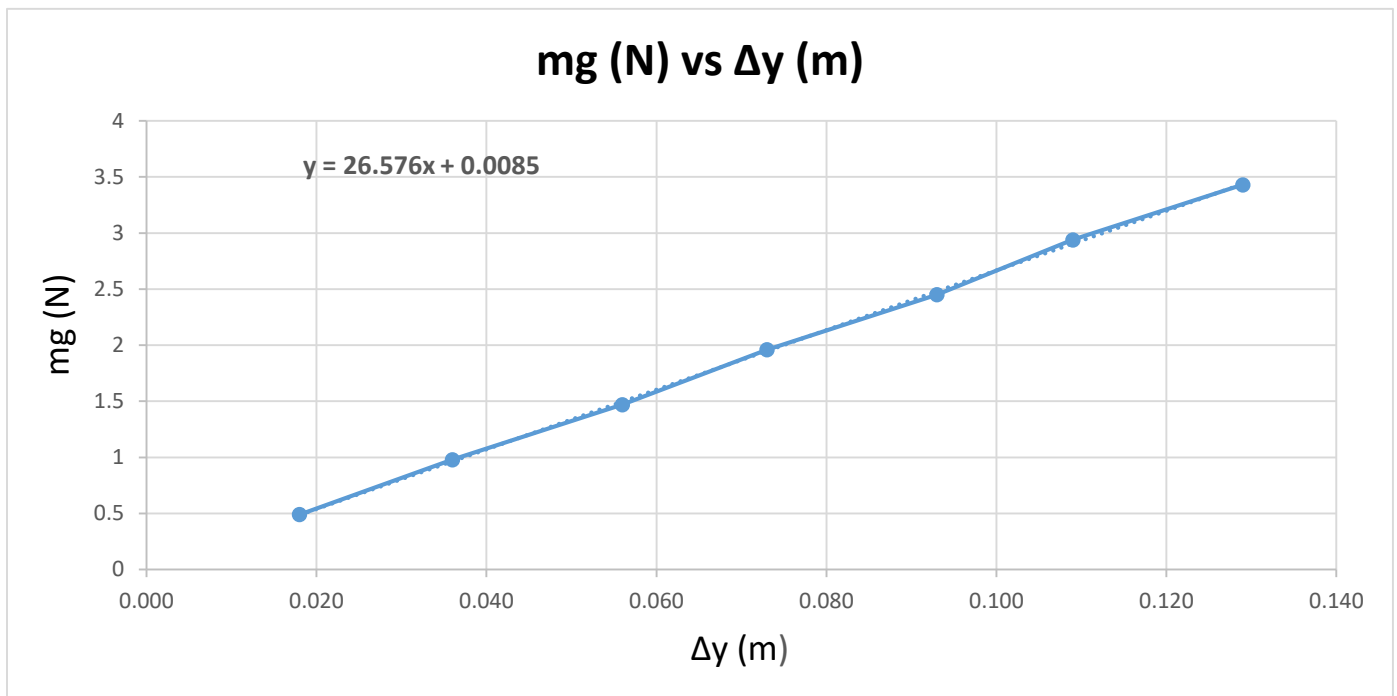
$$0.018 > 0.003$$

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 an old two pan balance which had a significant error.

Graph I

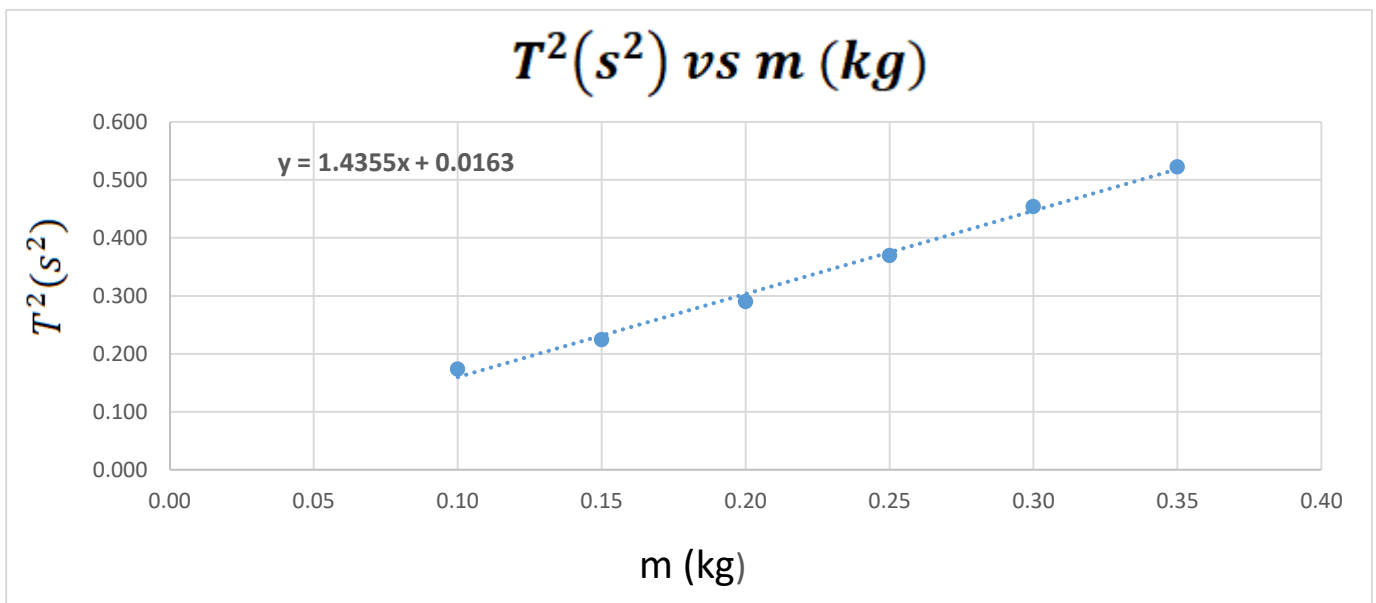
Δy (m)	mg (N)
0.018	0.49
0.036	0.98
0.056	1.47
0.073	1.96
0.093	2.45
0.109	2.94
0.129	3.43



	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