Science Lab Report

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Performed the experiment on: ______________ **Name of the tutor:** _______________ ***Accepted:***

Yes No

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on: _______________

Title:

The Spring Pendulum

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Remarks of the tutor: ____

I. Purpose

The purpose of the experiment is to determine the spring constant, *k* of a single spring, springs in both the parallel and serial connection. We also determine the variation of the spring constant, *k* with mass and time.

II. Setup

The experimental setup consists of ruler, stand , a timer and springs of different colors. The springs are hang on the stand in masses are attached to them and a ruler just besides the stand making sure that the lengths of the springs can be measured with ease.

Figure 1: the experimental setup

III) Evaluation

I. Determination of the spring constant

Step 1:The data

We did hang different springs to the hook and measured the height of the lower end of the spring. Then four 10 gr weights has been attached to the holder and we increased the mass in steps of 50 gr and measured the corresponding heights. We repeated this procedure with 2 other springs.(g=10)

Step 2:The plots

Spring 1(L=4.3 cm, color= purple)							
Mass in g	0	50	100	150	200	250	300
Height in cm	580	535	477	418	360	304	248
Elongation in cm	0	4.1	10.3	16.2	22.0	27.6	33.2
Weight force (F=mg)	0	0.5	1	1.5	2	2.5	3

Spring 2(L=2.5 cm, color= red)							
Mass in g	0	50	100	150	200	250	300
Height in cm	595	563	524	492	456	423	388
Elongation in cm	0	3.2	7.1	10.3	13.9	17.2	20.7
Weight force (F=mg)	0	0.5	1	1.5	2	2.5	3

Spring 3(L=1.4 cm, color= brown)							
Mass in g	0	50	100	150	200	250	300
Height in cm	607	606.9	606.6	606.5	606.2	605.8	605.5
Elongatio n in cm	0	0.1	0.4	0.5	0.8	1.2	1.5
Weight force (F=mg)	0	0.5	1	1.5	2	2.5	3

Table 1: The heights of the springs after adding masses to them

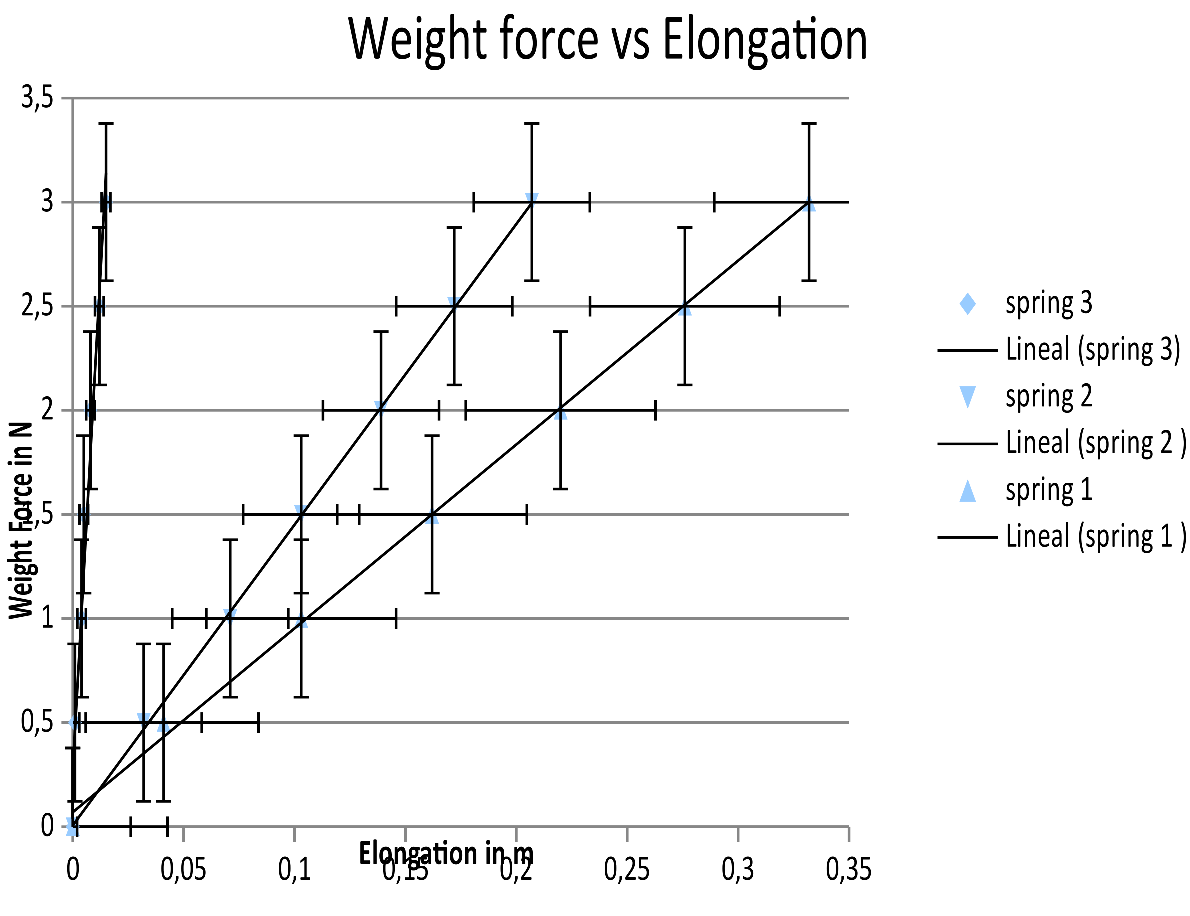

Figure 2: The weight force against elongation plot

The regression lines are given by:

Spring1: F_1 = $(a_1 \pm s\,a_1)\,\Delta l + (b_1 \pm s\,b_1) = (8.83114 \pm 0.1505)\,\Delta l + (0.06935 \pm 0.02974)$

Spring2: F_2 = $(a_1 \pm s\,a_1)\,\Delta l + (b_1 \pm s\,b_1) = (14.443 \pm 0.11905)\,\Delta l + (0.00618 \pm 0.01482)$

F_3 = $(a_1 \pm s\,a_1)\,\Delta l + (b_1 \pm s\,b_1) = (191.154 \pm 15.1823)\,\Delta l + (0.27115 \pm 0.12507)$

Spring constant of the three springs:

Spring constant 1: (D_1 ± u(D_1)) =(8.83114 ± 0.1505) N/m

Spring constant 2: (D_2 ± u(D_2)) = (14.443 ± 0.11905) N/m

Spring constant 3: (D_3 ± u(D_3)) = (191.154 ± 15.1823) N/m

II. Determination of spring constant for a serial and parallel connection

Step 1:The data

We did the same experiment like the first part but 2 springs have been chosen and put together with parallel and serial connections.(g=10)

Serial connections with spring 1 and spring 2							
Mass in g	0	50	100	150	200	250	300
Height in cm	533	524.8	515.3	506.4	496.8	487.6	478.3
Elongation in cm	0	8.2	17.7	26.6	36.2	45.4	54.7
Weight force (F=mg)	0	0.5	1	1.5	2	2.5	3

parallel connections with spring 1()							
Mass in g	0	50	100	150	200	250	300
Height in cm	526	505	475	446	419	390	360
Elongation in cm	0	2.1	5.1	8.0	10.7	13.6	16.6
Weight force (F=mg)	0	0.5	1	1.5	2	2.5	3

Table 2: The heights of the springs with added masses when connected in both parallel and serial connections

Step 2:The plots

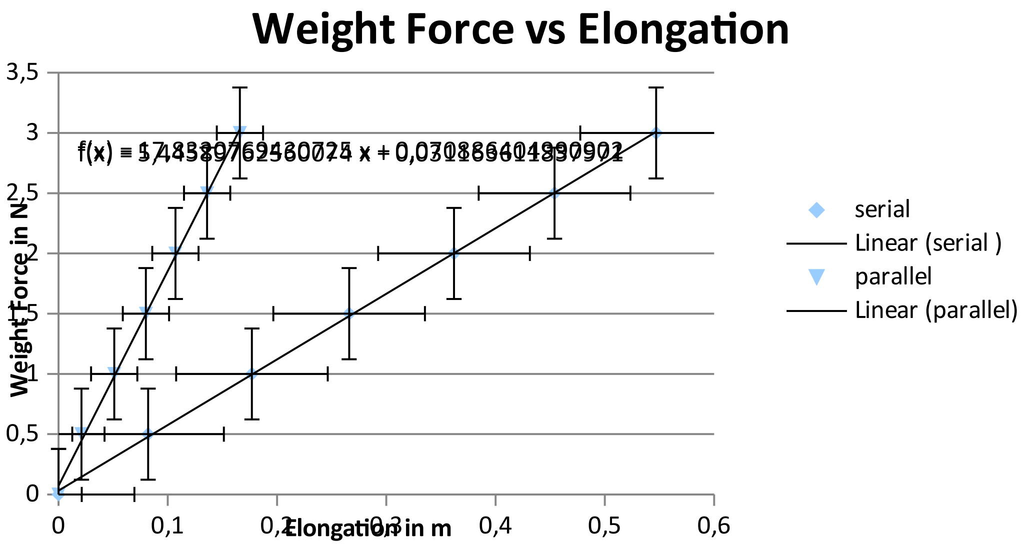

Figure 3: the weight force against elongation plot for springs in parallel and in series

The regression line is given by:

Serial: $F_s = (a_1 \pm s\,a_1)\,\Delta l + (b_1 \pm s\,b_1) = (5.4459 \pm 0.04139)\,\Delta l + (0.03116 \pm 0.01351)$

Parallel: $F_p = (a_1 \pm s\,a_1)\,\Delta l + (b_1 \pm s\,b_1) = (17.832 \pm 0.29899)\,\Delta l + (0.07089 \pm 0.02924)$

Spring constants of serial and parallel connections:

$1/D_s = 1/D_1 + 1/D_2 + \dots + 1/D_n$ (Serial connection) => $1/D_s = 1/8.83 + 1/$ => $D_s = 5.45$

$D_p = D_1 + D_2 + \dots D_n$ (Parallel connection) => $D_p = 8.83 + 8.83$=> $D_p = 17.66$

	Calculated	Measured
Serial connection	$D_s = 5.45$	$(D_s \pm u(D_s)) = ((5.4459 \pm 0.04139))$
Parallel connection	$D_p = 17.83$	$(D_p \pm u(D_p)) = (17.832 \pm 0.29899)$

Table 3: Comparison of calculated D values and Measured D values

We can observe that the calculated values correspond to the values of the regression

III. Determination of spring constant for a serial and parallel connection

Step 1:The data

The 200g mass was attached to spring x and the lower index set at the lower end of the mass. The upper index was then set to X_1=2cm, X_2=4cm, X_3=6cm, X_4=8cm, X_5=10cm and X_6=12cm above the lower index. The mass was then lifted to the upper index and released. The following tables contain the times for 10 oscillations at each point, their mean and uncertainty calculated with the formula;

$$\acute{t} \pm u ¿$$

Spring 1 (l=4.3cm, color: purple) with 200g mass							
amplitude		2cm	4cm	6cm	8cm	10cm	12cm
10T in s	1.	9.16	9.38	9.43	9.50	9.38	9.41
	2.	9.30	9.29	9.38	9.44	9.41	9.53
	3.	9.22	9.28	9.37	9.60	9.53	9.44
1T in s	1.	0.916	0.938	0.943	0.950	0.938	0.941
	2.	0.930	0.929	0.938	0.944	0.941	0.953
	3.	0.922	0.928	0.937	0.960	0.953	0.944
mean, $\acute{t}$ in s		0.923	0.932	0.939	0.951	0.944	0.946
u($\acute{t}$) in s		0.0174	0.0137	0.00800	0.0201	0.0197	0.0155

Table 4: The different times of 10 oscillations at different amplitudes

Step 2:The plots

The plots are obtained by plotting the different times taken to make one oscillation at different amplitudes.

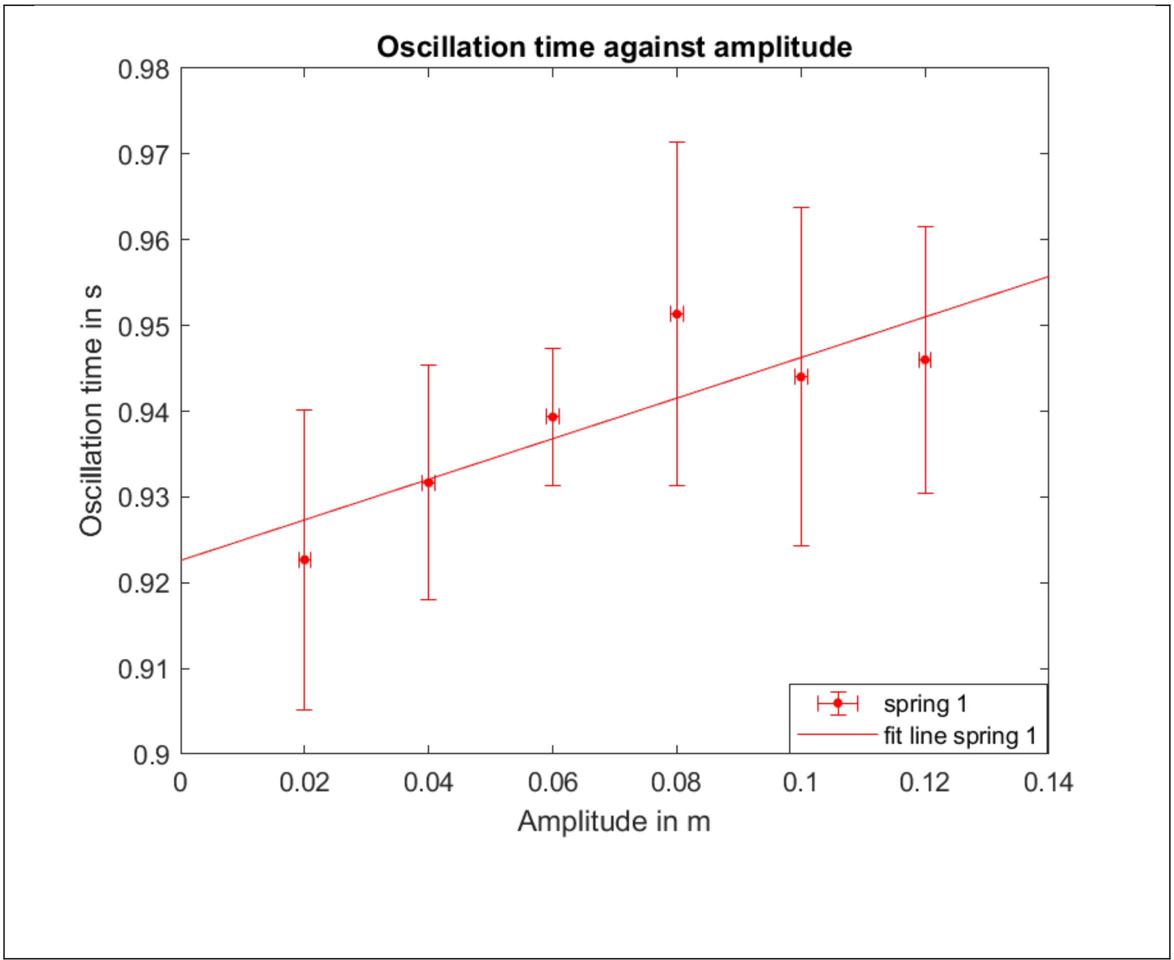

Figure 4: The oscillation against amplitude plot

The regression line is given by:

T(A) = (a$\pm$sa)A + (b$\pm$sb) = (0.2367$\pm$0.2062)A + (0.9226$\pm$0.0161)

The oscillation time does not depend on the amplitude.

IV. Determination of the spring constant using the oscillation time

Step 1:The data

The 1st spring measured on part 1 was hanged on the hook. Then the oscillation time of then oscillations was measured 3 times with weights of 50, 100, 150, 200, 250 and 300 g. This measurement was repeated for the two other springs used in part 1).

Following you can find 3 tables that contain the data collected as well as the calculations of the mean and measurement uncertainty of the oscillation time.

Spring 1 (l: 4.3 cm , color: purple)							
m in g		**50 g**	**100 g**	**150 g**	**200 g**	**250 g**	**300 g**
10T	**1**	2.81	6.31	7.59	8.94	9.91	10.81
	2	3.00	6.28	7.69	8.84	9.87	10.69
	3	2.94	6.12	7.63	8.81	9.81	10.75
mean value (10T) in s		2.92	6.24	7.64	8.86	9.86	10.75
u (10T) in s		0.23	0.52	0.31	0.49	0.41	0.53
T in s		0.292	0.624	0.764	0.886	0.986	1.075
u (T) in s		0.023	0.052	0.031	0.049	0.041	0.053

Spring 2 (l: 2.5 cm , color: red)							
m in g		**50 g**	**100 g**	**150 g**	**200 g**	**250 g**	**300 g**
10T	**1**	3.44	5.04	5.84	7.12	7.66	8.25
	2	3.53	4.88	5.94	7.00	7.62	8.31
	3	3.81	5.25	6.03	6.88	7.71	8.28
mean value (10T) in s		3.67	5.07	5.99	6.94	7.67	8.30
u (10T) in s		0.64	0.77	0.55	0.80	0.28	0.24
T in s		0.367	0.507	0.599	0.694	0.767	0.830
u (T) in s		0.064	0.077	0.055	0.080	0.028	0.024

Spring 3 (l: 1.4 cm , color: brown)							
m in g		**50 g**	**100 g**	**150 g**	**200 g**	**250 g**	**300 g**
10T	**1**	//	1.52	1.81	2.37	2.90	2.81
	2	//	1.67	1.83	2.35	2.71	2.78
	3	//	1.54	1.80	2.32	2.71	2.69
mean value (10T) in s		//	1.58	1.81	2.35	2.77	2.76
u (10T) in s		//	0.10	0.02	0.05	0.25	0.14
T in s		//	0.158	0.181	0.235	0.277	0.276
u (T) in s		//	0.010	0.002	0.005	0.025	0.014

Tables 5, 6, 7: Times for 10 oscillation for different weights.

Step 2:The plots

The following plot contains a coordinate system with the square root of the mass (horizontal) compared to the oscillation time (vertical), with it’s corresponding regression lines and error-bars.

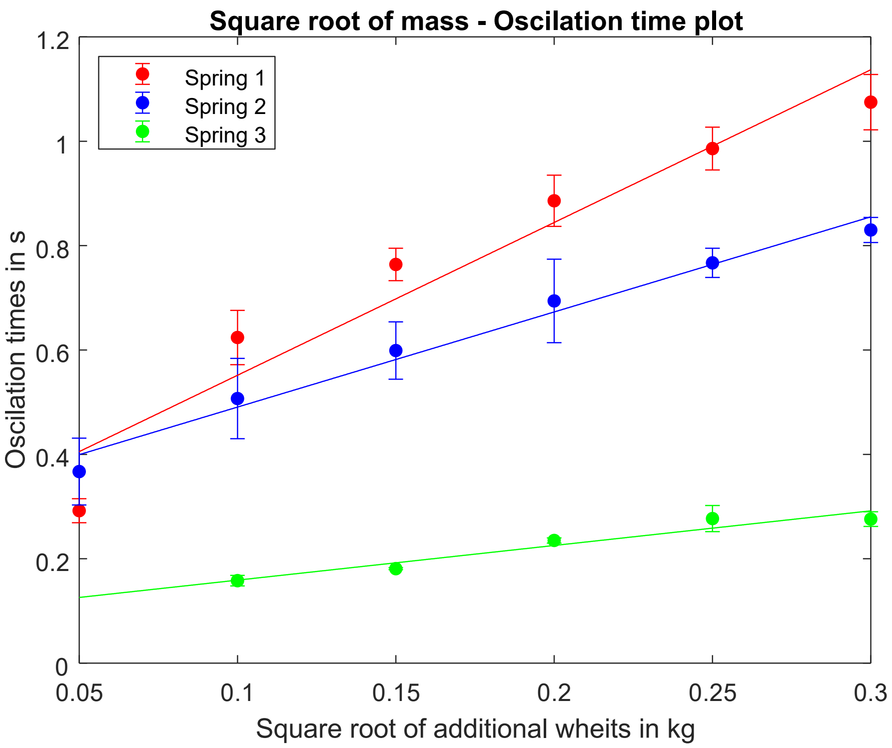

Figure 5: Square root of mass against oscillation times.

The regression lines given by:

T1 = (a1 ± sa1) √ m + (b1 ± sb1) = (2.927 ± 4.039) √ m + (0.04248 ± 0.4753)

T2 = (a2 ± sa2) √ m + (b2 ± sb2) = (1.823 ± 2.168) √ m + (0.2411 ± 0.3756)

T3 = (a3 ± sa3) √ m + (b3 ± sb3) = (0.664 ± 0.9941) √ m + (0.0926 ± 0.1621)

Step 3: Questions

- What are the spring constants you obtain now? Compare them with the spring constants measured in 1) and explain any differences

The following spring constants were obtained using this formula: $T = 2\pi\sqrt{\frac{m + \frac{m_s}{3}}{k}}$

Spring constant 1: (D_1) = 10.1496 N/m

Spring constant 2: (D_2) = 16.1634 N/m

Spring constant 3: (D_3) = 153.2157 N/m

Compared to he values obtained in measurement 1) we can see a slight difference probably due to the uncertainty or to an error in the measurement of the times or length. However as it's a not so big difference wee can confirm that the spring constant is similar even when obtained though different formulas.

V. Measurement of the oscillation time for a non neglectable mass of a spring

Step 1:The data

The oscillation time of ten oscillations were measured for different attached masses (20 g and 30 g) Before this, the mass of the soft spring (k = 3 N/m) was measured. In the tabla bellow you can find both the data collected data, as well as the mean values and ratio T20g/T30g of both mean values.

	Soft spring with mass m = 14.4g			
20g of mass	10T in s	5.09	5.13	5.31
	1T in s	0.509	0.513	0.531
Mean in s	1T in s	0.512		
30g of mass	10T in s	5.90	5.97	6.00
	1T in s	0.590	0.597	0.600
Mean in s	1T in s	0.596		
T_{20g}/T_{30g}	0.859			