AP Physics C - SHM Lab

Ben Feuer and Kwame Addison

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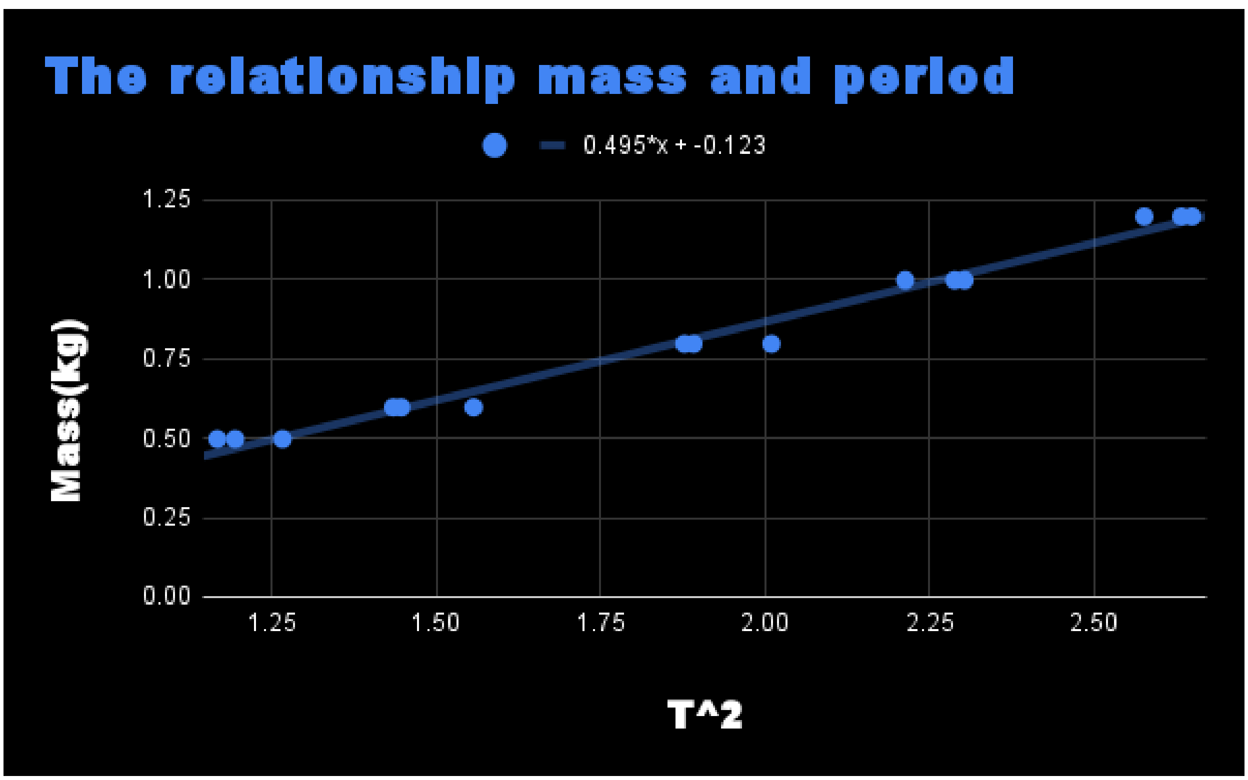
Part 1: Measure the effective spring constant of two springs

Data Table

Trial #	Mass(kg)	4 * T (s)	T(s)	$T^2(s^2)$
1	0.497	4.32	1.08	1.1664
2	0.497	4.37	1.0925	1.19355625
3	0.497	4.5	1.125	1.265625
4	0.597	4.99	1.2475	1.55625625
5	0.597	4.81	1.2025	1.44600625
6	0.597	4.79	1.1975	1.43400625
7	0.797	5.48	1.37	1.8769
8	0.797	5.67	1.4175	2.00930625
9	0.797	5.5	1.375	1.890625
10	0.997	6.07	1.5175	2.30280625
11	0.997	6.05	1.5125	2.28765625
12	0.997	5.95	1.4875	2.21265625
13	1.197	6.49	1.6225	2.63250625
14	1.197	6.42	1.605	2.576025
15	1.197	6.51	1.6275	2.64875625

Graph



Result

The slope of the line of best fit is k = 19.54181671 N/m as it is equal to the slope of the line of best fit in the graph above multiplied by $4\pi^2$.

Part 2: Measure the spring constant of a each individual spring

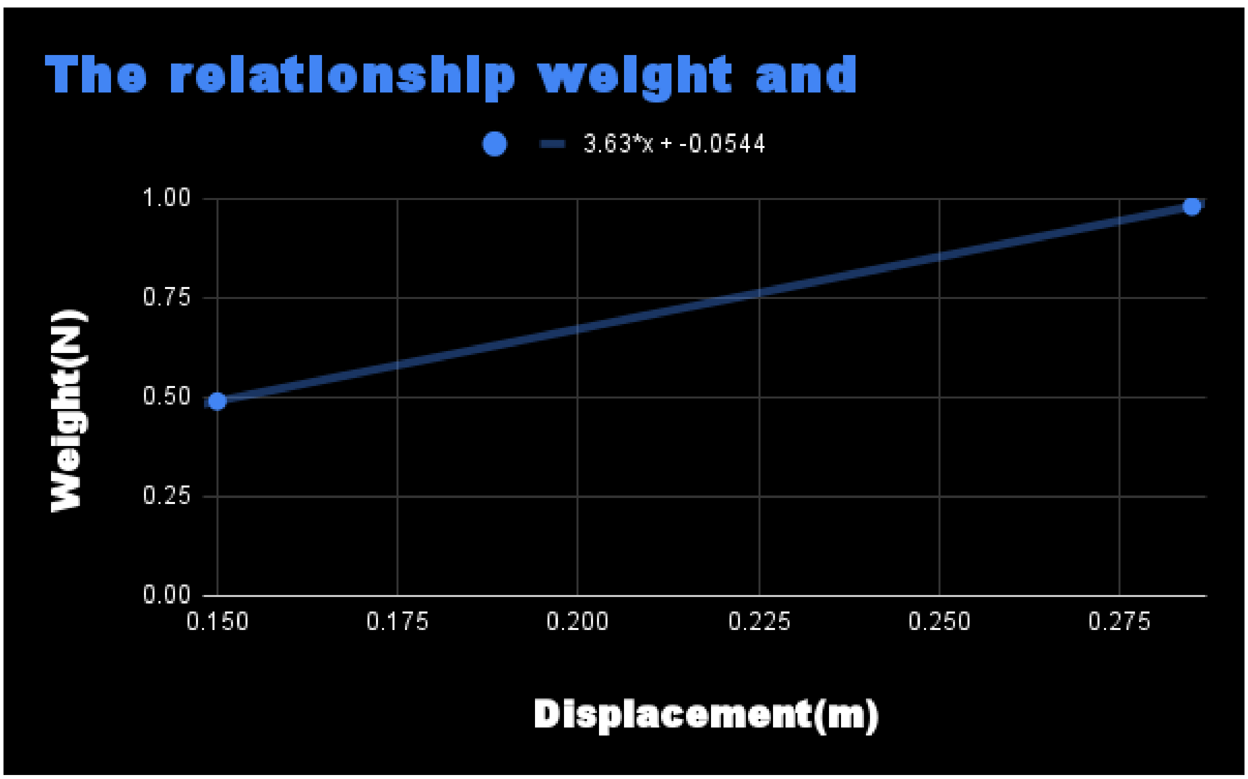
Data Table for Spring 1

Mass(kg)	Force(N)	Displacement(m)
0.05	0.49	0.15
0.1	0.98	0.285

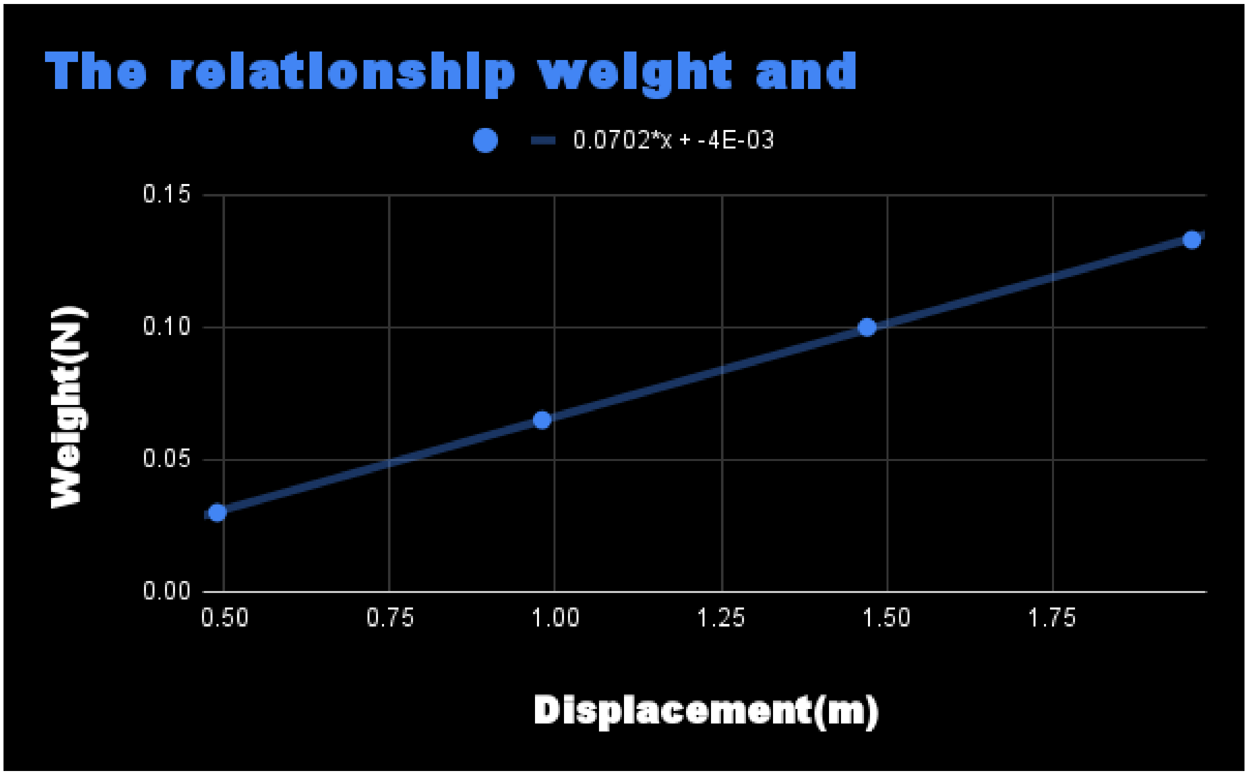
Data Table for Spring 2

Mass(kg)	Force(N)	Displacement(m)
0.05	0.49	0.03
0.1	0.98	0.065
0.15	1.47	0.1
0.2	1.96	0.133

Graph for Spring 1



Graph for Spring 2

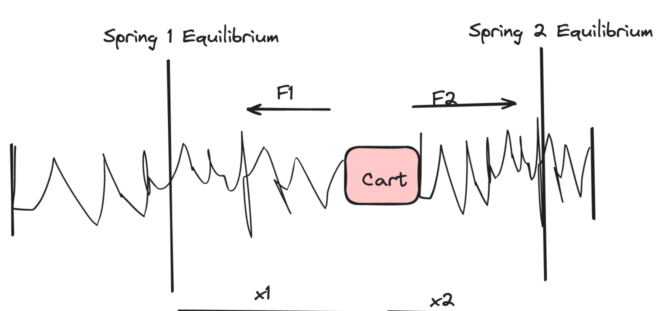


Result

Using the slope of the line of best fit for each graph, we can calculate the spring constant for each spring. For spring 1, the spring constant is $k = 3.63$ N/m. For spring 2, the spring constant is $k = 0.07$ N/m (it may be hard to see the values in the graph due to its low resolution).

Part 3: Find k_{eff} for the two springs using Newton's Laws

Diagram of the System



Derivation of k_{eff}

At the system equilibrium position, $F_{net} =$. If you pull the cart towards spring 1, then spring 2 will pull with an additional force $k_2 x$ and spring 1 will have a reduced force of $-k_1 x$ and therefore $F_{net} = k_2 x - (-k_1 x) = (k_2 + k_1)x$. Therefore, $k_{eff} = k_1 + k_2$.

Error Anlysis

Because, using Part Two of the lab, we found the values of k_1 and k_2, we can calculate k_{eff} which is $3.63 + 0.07 = 4N/m$. This value is very different than the value we got from Part One of the lab: $19.54N/m$. This means our percent error is equal to:

$$\%E = \frac{4 - 19.54}{19.54} * 100\% = -79.5\%$$

This large error is attributable to inaccurate measurings, and the effect of the mass of the spring. The non-zero mass of the spring when implemented in part one of the lab means that the period is larger as it is part of the period equation: $T = 2\pi\sqrt{\frac{m}{k}}$. Therefore, the mass of the springs is directly attributable to the error.