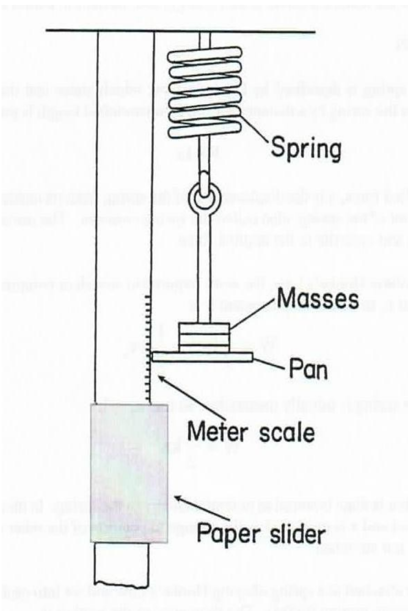
Physics 1D03: Lab 2

HOOKE'S LAW

Lab Objectives

- Understand the theory behind Hooke's Law and the physics behind springs.
- Experimentally determine a spring constant through Hooke's Law, Conservation of Energy, and measuring period.
- Learn more about Excel and calculating functions.
- Justify the spring constant and springs mass with theoretical predictions.
- Working with uncertainties when recording measurements.

Equipment



Spring-Mass system

Stop-Watch

Part 1: Force vs. Displacement

Part 1: Force vs. Displacement

- Goal is to first find the spring constant, k, and no-load position of the spring, x_0

- Place the metal pan (***<u>without any additional masses</u>***) on the spring
  - Refer to image for an example of the set-up

- Using the ruler, measure the position of the bottom edge of the pan
  - Record this value in your report

Part 1: Force vs. Displacement

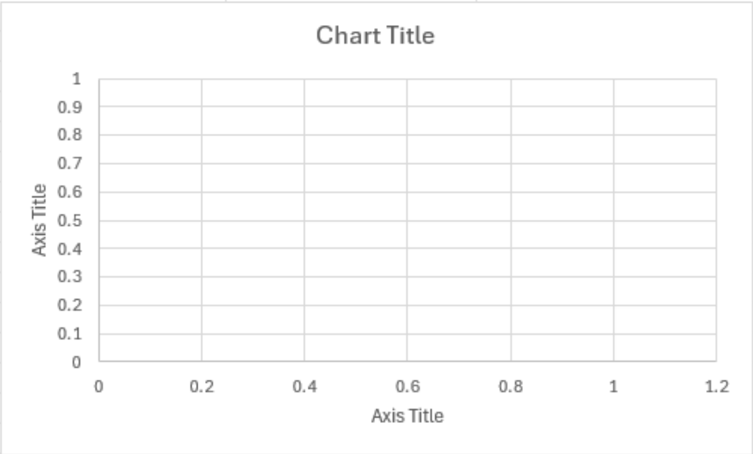
- After taking the measurement, add a 20gm mass to the pan and record the new position (include an uncertainty measurement)
  - Note: Do **<u>not</u>** measure the difference of position, just record only the values you see on the ruler
  - Record this value in your report

- Add another 20gm mass and repeat the above steps until you have a total of 10 measurements

- We can now use Excel to plot our results

Part 1: Force vs. Displacement

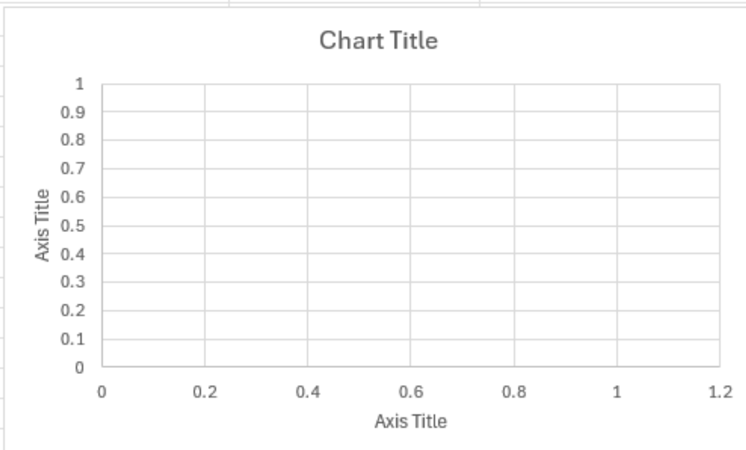
Mass (kg)	Mass Uncertainty (kg)	Load (kg*m/s^2)	Load Uncertainty (kg*m/s^2	Pan Position (m)
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	



Input data in these boxed (Note what units you should be entering the data in)

Part 1: Force vs. Displacement

Mass (kg)	Mass Uncertainty (kg)	Load (kg*m/s^2)	Load Uncertainty (kg*m/s^2	Pan Position (m)
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	



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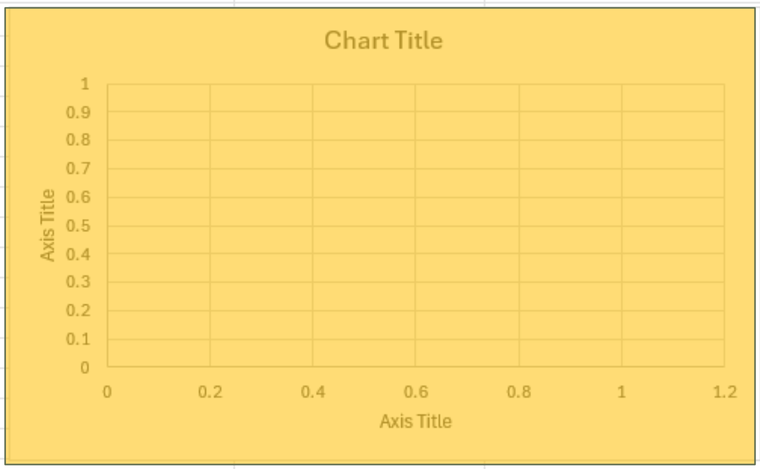
Part 1: Force vs. Displacement

Mass (kg)	Mass Uncertainty (kg)	Load (kg*m/s^2)	Load Uncertainty (kg*m/s^2	Pan Position (m)
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	
	0	0	0	



Plot for ‘mg’ vs. ‘Position of Pan’ appears here
(Remember to label/rescale)

Part 1: Force vs. Displacement

- Copy data from Excel sheet into your lab report

- Generate a line of best fit on your Excel graph and use that to find the spring constant, k, and no-load position of the spring, x_0
  - Hint: Consider how your line of best fit is related to Hooke's Law

$$F = k\Delta x$$

  where Δx is the displacement from the no-load position. What would F be in this case?

Part 2: Energy vs Displacement

Part 2: Energy vs. Displacement

- We now want to measure the potential energy of the spring using the displacement of the mass
- Energy conservation tells us that the energy before/after the mass is dropped is given by

$$mgh = \frac{1}{2}kx^2$$

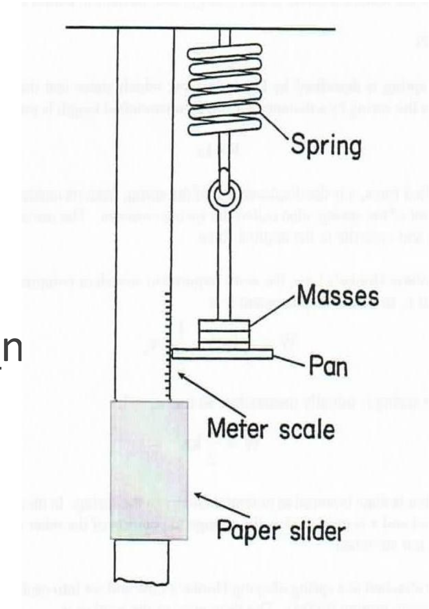
which can be rewritten as

$$\log(mh) = 2\log(\mathrm{h}) + \mathrm{constant}$$

- This equation is what we will use to test energy conservation

Part 2: Energy vs. Displacement

- Start by moving the empty pan up to the no-load position, x_0, measured from Part 1
- Place the paper slider directly below the pan and record its position in the report
- Release the pan, allowing the slider be pushed down
  - Record the mass of the pan and new slider **position (not the displacement)** in your report and Excel file
- Repeat the above steps 5-6 more times, adding an additional 20gm to the pan each time
- We can now use the data to plot $\log(mh)$ $vs.$ $\log(\mathrm{h})$



Part 2: Energy vs. Displacement

Uncertainty in height (m) =		<- record uncertainty in B1
xo (m) =		<- record xo in B2

Mass (kg)	**Uncertainty in mass (kg)**	**Position of paper (m)**	**Change in height h (m)**	**log(h) (m)**	**Uncertainty in log(h) (m)**	**log(mh) (kg*m)**	**Uncertainty in log(mh) (kg*m)**
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
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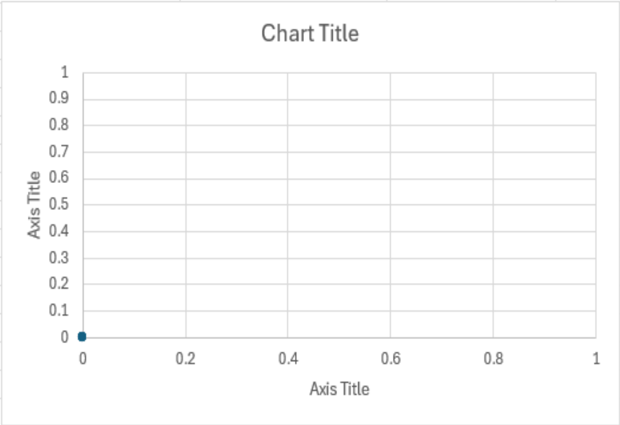
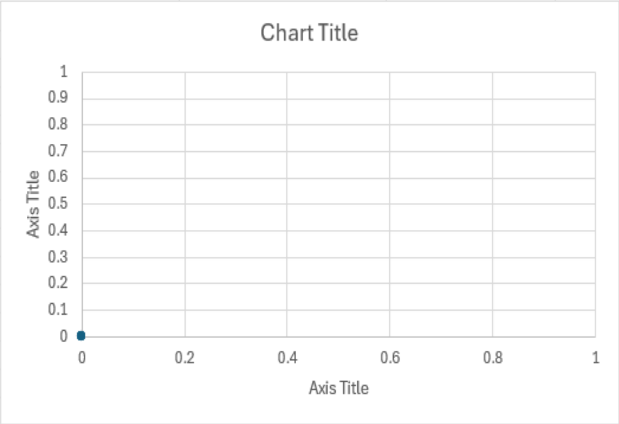


Input data in these boxed

Part 2: Energy vs. Displacement

Uncertainty in height (m) =		<- record uncertainty in B1					
xo (m) =		<- record xo in B2					
Mass (kg)	**Uncertainty in mass (kg)**	**Position of paper (m)**	**Change in height h (m)**	**log(h) (m)**	**Uncertainty in log(h) (m)**	**log(mh) (kg*m)**	**Uncertainty in log(mh) (kg*m)**
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!

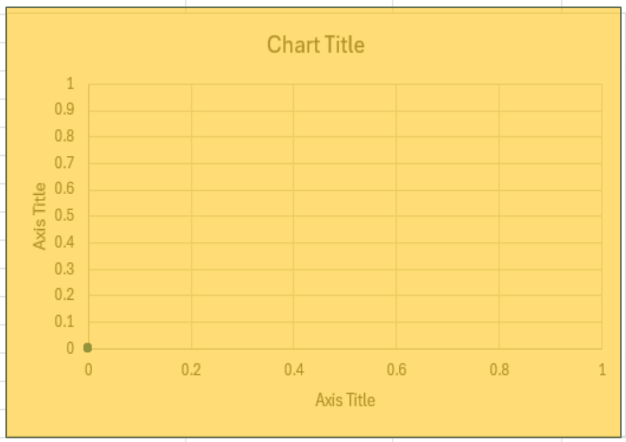


Results will automatically be calculated here

Part 2: Energy vs. Displacement

Uncertainty in height (m) =		<- record uncertainty in B1					
xo (m) =		<- record xo in B2					

Mass (kg)	Uncertainty in mass (kg)	Position of paper (m)	Change in height h (m)	log(h) (m)	Uncertainty in log(h) (m)	log(mh) (kg*m)	Uncertainty in log(mh) (kg*m)
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!



Plot for ‘log(mh)’ vs. ‘log(h)’ appears here
(Remember to label/rescale)

Part 2: Energy vs. Displacement

Uncertainty in height (m) =		<- record uncertainty in B1					
xo (m) =		<- record xo in B2					
Mass (kg)	Uncertainty in mass (kg)	Position of paper (m)	Change in height h (m)	log(h) (m)	Uncertainty in log(h) (m)	log(mh) (kg*m)	Uncertainty in log(mh) (kg*m)
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!
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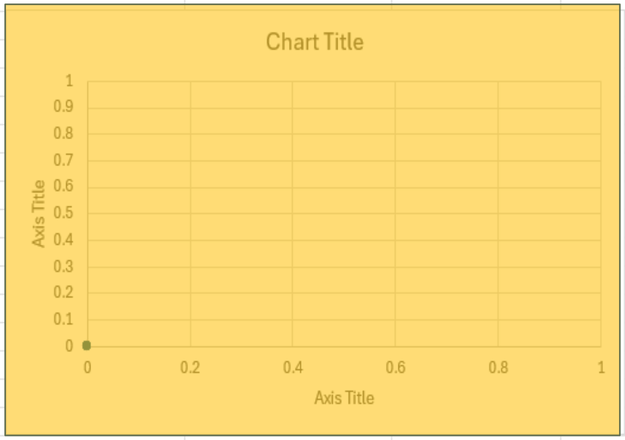
	0		0	#NUM!	#DIV/0!	#NUM!	#DIV/0!



Include a line of best fit, then use that to answer the provided discussion questions.

Remember to copy all the data into your lab report!

Part 3: Mass vs. Natural Frequency

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- Here we want to measure the "*effective spring mass*", m_0

- Starting with 50gm mass, drop the pan from an initial starting position

- Record the time it takes to complete 50 oscillations
  - Record this value in your Excel file/report

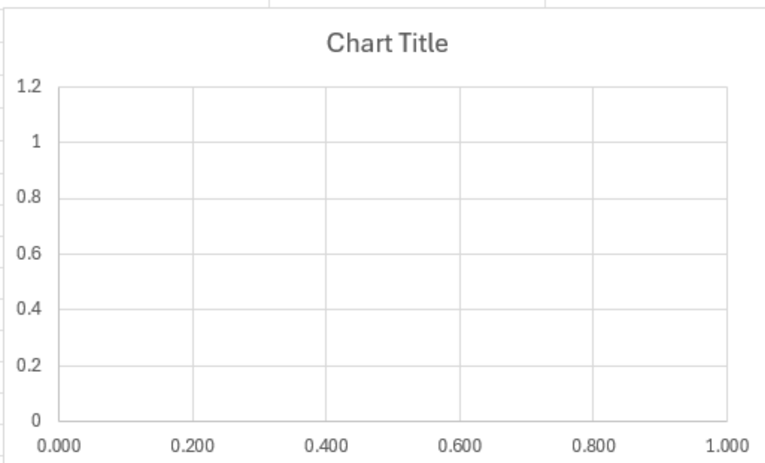
- Repeat 4 more times using 60gm, 70gm, 90gm, and 110gm masses

- We can now use Excel to plot the mass as a function of T^2

Part 3: Mass vs. Natural Frequency

Uncertainty of time (s)	Number of swings n	Error in Period (s)
	50	0

Mass (kg)	Uncertainty in mass (kg)	Time for 50 swings (s)	Period (s)	Period squared (s^2)	Error in Period Squared (s^2)
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000

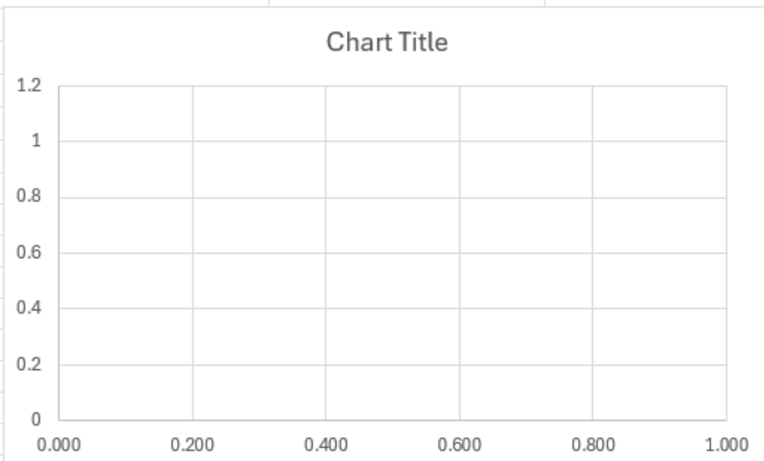


Input data in these boxed

Part 3: Mass vs. Natural Frequency

Uncertainty of time (s)	Number of swings n	Error in Period (s)
	50	0

Mass (kg)	Uncertainty in mass (kg)	Time for 50 swings (s)	Period (s)	Period squared (s^2)	Error in Period Squared (s^2)
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000

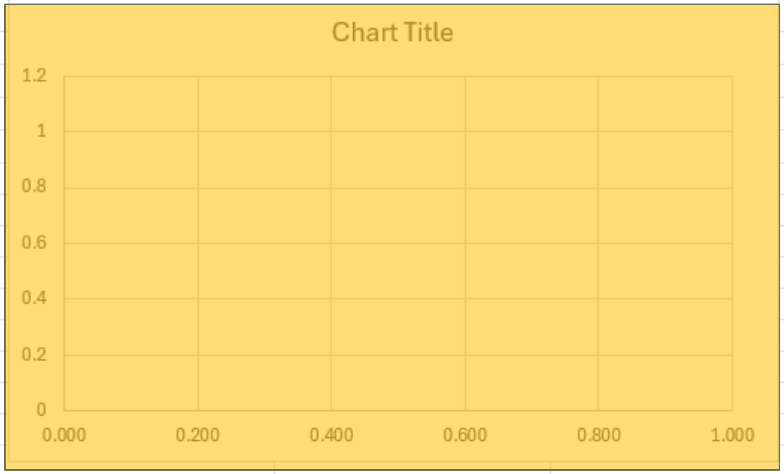


Results will automatically be calculated here

Part 3: Mass vs. Natural Frequency

Uncertainty of time (s)	Number of swings n	Error in Period (s)
	50	0

Mass (kg)	Uncertainty in mass (kg)	Time for 50 swings (s)	Period (s)	Period squared (s^2)	Error in Period Squared (s^2)
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000
	0		0.000	0.000	0.000



Plot for 'Mass' vs. 'Period^2' appears here
(Remember to label/rescale)

Part 3: Mass vs. Natural Frequency

- Copy data from Excel sheet into your lab report

- Generate a line of best fit on your Excel graph and use that to find the effective spring mass, m_0
  - Hint: Since you are plotting m vs. T^2, compare your line of best fit to the equation

$$m = -m_0 + \frac{kT^2}{4\pi^2}$$

Good Luck!