**Hooke's Law and Simple Harmonic Motion Remote Lab**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Part I:** Watch the video: [Hooke’s Law](https://www.youtube.com/watch?v=fQqqTCQyl84)

**Purpose:** To verify Hooke’s law and determine the spring constants of elastic springs.

Theory: Think about stretching a spring. The more stretching force you apply, the more stretch you get. Robert Hooke (1635-1703), a British physicist, discovered this empirical relationship between the restoring force (F) and the stretch (x), known as Hooke's law,

                 $F=-kx$.



According to Hooke's law, the magnitude of the stretching force is given by:

 Stretching Force = (Spring constant) $×$ Stretch.

The stretching force is provided by the added mass, and is equal in this case the weight. You can also plot Stretching Force VERSUS Stretch. Hooke’s law is verified when there is a linear relationship between Stretching Force & Stretch.

The Spring Constant is given by the slope of the Stretching Force versus Stretch graph.

**Procedure:** Open the following simulator and click the lab option:

<https://phet.colorado.edu/sims/html/masses-and-springs/latest/masses-and-springs_en.html>



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| **I**1. Choose the lowest Spring Constant 1, by moving the slider to the left. Place the 100g mass onto the spring. The spring will begin to oscillate up and down. Stop this by clicking on the stop next to the top of the spring
2. Click the ‘Displacement’ and ‘Movable Line’ options on the right.Adjust the movable red line to the tip of the green arrow.

1. Use the ruler tool (the units are in mm) on the bottom right to measure the stretch of

the spring with the 100g mass. Convert this mass to a weight (use $g=9.8 ms^{-2}$) and add this data to table 1. 1. Using the mass slider at the top, change the mass and record 4 more results of weight.

The spring will begin to oscillate up and down. Stop this by clicking on the stop next to the top of the spring, adjust the movable red line to the tip of the green arrow, and record the extension using the ruler tool. Calculate the stretching force for each mass. Add your results to table 1.

|  |  |  |  |
| --- | --- | --- | --- |
| **Mass added (g)** | **Weight (N)** | **Stretching force (N)** | **Stretch (mm)** |
| 100 |  |  |  |
| 150 |  |  |  |
| 200 |  |  |  |
| 250 |  |  |  |
| 300 |  |  |  |

 ***Table 1***1. Plot a graph using Excel for the stretching Force (y-axis) against extension (x-axis). Add a trend line, set the intercept to zero, and display the equation. Insert your graph below

Determine the spring constant in N/m**K= N/m****II**. On the top right of the simulation, there is spring constant slider; change the spring constant to medium (figure below), and repeat the simulation.a) Using the mass slider at the top, change the mass and record 5 more results of weight. The spring will begin to oscillate up and down. Stop this by clicking on the stop next to the top of the spring, adjust the movable red line to the tip of the green arrow, and record the stretch using the ruler tool. Calculate the stretching force for each mass. Add your results to table 1.

|  |  |  |  |
| --- | --- | --- | --- |
| **Mass added (g)** | **Weight (N)** | **Stretching force (N)** | **Stretch (mm)** |
| 100g |  |  |  |
| 150 |  |  |  |
| 200 |  |  |  |
| 250 |  |  |  |
| 300 |  |  |  |

 ***Table 2***b) Plot a graph using Excel for the stretching Force (y-axis) against extension (x-axis). Add a trend line, set the intercept to zero, and display the equation. Insert your graph belowc) Determine the spring constant in N/m **K= N/m****III.** Now change the spring constant to large using the slider, and repeat the simulation for different masses.a) Using the mass slider at the top, change the mass and record 5 more results of weight. The spring will begin to oscillate up and down. Stop this by clicking on the stop next to the top of the spring, adjust the movable red line to the tip of the green arrow, and record the extension using the ruler tool. Calculate the stretching force for each mass. Add your results to table 1.   |  |  |  |
|

|  |  |  |  |
| --- | --- | --- | --- |
| **Mass added (kg)** | **Weight (N)** | **Stretching force (N)** | **Extension (mm)** |
| 100g |  |  |  |
| 150 |  |  |  |
| 200 |  |  |  |
| 250 |  |  |  |
| 300 |  |  |  |

***Table 3*** |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  b) Plot a graph using Excel for the stretching Force (y-axis) against extension (x-axis). Add a trend line, set the intercept to zero, and display the equation. Insert your graph below. |  |  |  |  |  |  |  |  |  |  |  |  |

c) Determine the spring constant in N/m

**K= N/m**

**Write a conclusion for Part I:**

 **Part II: Simple Harmonic Oscillator**

Purpose: Investigate a simple harmonic motion using a simulator.

Apparatus: <https://www.desmos.com/calculator/zxexbcmea1>

Theory:

A mass, *m* is attached to the end of an elastic spring of spring constant, *k* and made to oscillate in simple harmonic motion of amplitude, *xm* and period, *T*.
 The displacement is given by, , where .
 The period (in terms of mass and spring constant) is also given by,

 

 The velocity is given by, .

The magnitude of the maximum velocity is given by, 
  or 

The acceleration is given by, .

 The magnitude of the maximum acceleration is given by, 
  or 

**Procedure:**

1. Open the following simulator: <https://www.desmos.com/calculator/zxexbcmea1>

2. In the simulation all the values are given in SI units. Write down Amplitude (*A*), Spring Constant (*k*), Mass (*m*), and Length of Spring at equilibrium, *Leq* under Data below.

3. Press Play (2 on the leftmost column) and run the simulation for about 18 s.

4. From the simulation obtain the amplitude, the period, also calculate the period (using mass and spring constant), and find the percent difference.

5. To display velocity, turn on the velocity graph by clicking on velocity graph (24 on the leftmost column).

6. From the velocity graph, obtain the maximum velocity, and calculate the period using the maximum velocity and amplitude.

7. To display force vector, turn on the force vector graph by clicking on Turn in Force Vector (17 on the leftmost column).

**Data:**

Amplitude = *A* = *xm*=\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Spring Constant = *k* = \_\_\_\_\_\_\_\_\_\_\_\_

Mass = *m* = \_\_\_\_\_\_\_\_\_\_\_\_\_\_ Length of Spring at equilibrium = *Leq* = \_\_\_\_\_\_\_\_\_\_\_

Amplitude from simulation =\_\_\_\_\_\_\_\_\_\_\_\_\_

 Period from simulation =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Period, calculated using mass & spring constant = \_\_\_\_\_\_\_\_\_\_\_\_\_\_

 [% Difference](https://www.calculatorsoup.com/calculators/algebra/percent-difference-calculator.php) for Period = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Maximum velocity from simulation = *vmax*= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Period, calculated using maximum velocity & amplitude =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Circle the answers for following questions, by looking at position, velocity, and force graphs of the simulation:

1. During the oscillation when the mass is at the equilibrium position, what is the,

1. Velocity: maximum OR zero b. Force: maximum OR zero

2. During the oscillation when the velocity of the mass is zero, what is the,

1. Position: equilibrium OR crest/trough b. Force: maximum OR zero

3. During the oscillation when the force of the mass is zero, what is the,

1. Position: equilibrium OR crest/trough b. Velocity: maximum OR zero