SIMPLE HARMONIC MOTION

Name:_____ Section:_____

Partner:_____ Date:_____

Spring Constant, k: Measure and record the change in the spring's length for each change in the added weight. Using MKS units, enter the data in the table. Use `Excel` to plot F versus Δx. Then fit a straight line to your data. How will this fit tell you the value of k?

Table 1: Hooke's Law: $F = -k\Delta x$

x (m)	Δx (m)	Δm (kg)	$F = \Delta mg$ (N)
	0	0	0

¿From a simple fit, k =_____ (include units!)

SHM Period: Record the total mass and measured period below:

Total Mass =_____ Period, T_{meas} =_____

Now calculate the theoretical period from your measurement of k and the mass. Compare the theoretical and measured values.

Period, T_{theor} =_____ Ratio, $T_{\text{meas}}/T_{\text{theor}}$ =_____

Equation 6 assumes the spring is massless. In fact, we should add 1/3 the mass of the spring to m. Take the spring mass to be 30 g. Does this improve the agreement?

Period, T_{theor} =_____ Ratio, $T_{\text{meas}}/T_{\text{theor}}$ =_____

Displacement/Velocity Magnitude Relationship: Pick any convenient time on the displacement and velocity graphs, record the values of t, x and v plus the value of A. Substitute your measured values of k, A and x into Eqn. (3) to obtain a predicted velocity. Compare this with the measured velocity

t =_____, x =_____, v_{meas} =_____, A =_____.

v_{pred} =_____ (show work here)

$\frac{v_{\text{meas}}}{v_{\text{pred}}}$ =_____

Displacement/Velocity/Acceleration Phase Relationships: ¿From your pairs of graphs for displacement-velocity and displacement-acceleration, it is obvious that they are all sinusoidal curves. We want to know their phase relationship or relative phase shift. Example: if the maximum peaks coincide, they are in phase; the phase shift, $\Delta theta$ is 0 radians or 0°. If the maximum peaks correspond to the minimum of another they are shifted by $\Delta theta = \pm\pi radians = \pm 180°$.

Record the time of the peaks for distance (displacement) and velocity. Select the first displacement peak, record its time. Then find the closest velocity peak and record its time. Repeat this for the next pair of peaks. Use the period to calculate the phase relationship, $\Delta\theta$ in degrees.

Table 2: Displacement-Velocity Phase Analysis

	Peak pair #1	Peak pair #2	Peak pair #3
Time of Displacement Max.			
Time of Velocity Max.			
$\Delta\theta = 360°(T_V - T_D)/T$			

Determine the average $\Delta\theta$ =_____

Does the velocity lead or lag the displacement, i.e., does it reach its peak value before or after the (nearest) displacement peak?

Do the same analysis for displacement and acceleration.

Table 3: Displacement-Acceleration Phase Analysis

	Peak pair #1	Peak pair #2	Peak pair #3
Time of Displacement Max.			
Time of Acceleration Max.			
$\Delta\theta = 360°(T_V - T_D)/T$			

Determine the average $\Delta\theta =$_____

Does the acceleration lead or lag the displacement?

¿From your analysis complete the following table. For each case, answer whether the displacement, X, is a negative maximum, at 0, or a positive maximum.

Table 4: Summary of Phase Analysis

Case	Displacement (Neg. maximum, 0, or Pos. maximum?)
Velocity is positive Maximum	X is ...
Velocity is 0	X is ...
Velocity is negative maximum	X is ...
Acceleration is positive Maximum	X is ...
Acceleration is 0	X is ...
Acceleration is negative maximum	X is ...

Mass and Amplitude Effects on the Period: Go back and measure the period for several values of the mass. Record your data. Compare your measurements with the theoretical value from Eqn. (5).

Table 5: Mass Dependence

Measured Period T_{meas}	Mass m	Predicted Period T_{pred}	Ratio $T_{\text{meas}}/T_{\text{pred}}$

Measure the period for several amplitudes without changing the mass. Is there any change in the period? What is the theoretical period for your setup?

Table 6: Amplitude Dependence

Amplitude	Period