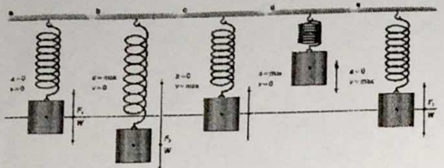
Name: Key Pd: ____

Springs PhET Lab - Periodic Motion and Hooke's Law



Introduction:

To stretch a spring, a force must be applied. Hooke's Law gives us the formula for how much force we need to apply to stretch or compress a spring. The spring constant "k" is the variable we use to express how stiff a spring is. A spring with a large spring constant requires a large force to compress it. A car's springs have very large spring constants. Does the spring in a ballpoint pen have a large or small spring constant?

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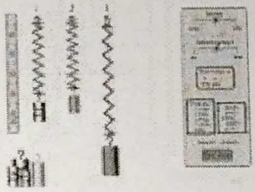
When a mass is attached to a spring vertically. As in the diagram above, the force that extends the spring is the mass's weight. The greater the weight (force, F) applied to the spring, the larger the spring's extension displacement (x).



Masses & Springs

Important Formulas: Hooke's Law: $\boxed{F = kx}$ Period of a Spring: $\boxed{T = 2\pi\sqrt{\frac{m}{k}}}$

Procedure: *Play with the Sims → Motion → Masses and Springs* Run Now!

Part I: Determine the spring constant of spring #1

Hang a 50g mass from the first spring and measure the displacement (x) in meters. Change the mass and repeat. Fill out the table below:

	Mass used (kg)	Weight, **W** = **F** (N)	Displacement, **x** (m)	Spring 1's spring constant, **k**	
3	.050 kg	$\times 9.81\frac{m}{s^2} = 0.49$ N	.09 m	$K = \frac{F}{X} = \frac{0.49N}{.09m}$	$= 5.5\frac{N}{m}$
3	.100 kg.	$\times 9.81\frac{m}{s^2} = 0.98$ N	.18 m	$K = \frac{F}{X} = \frac{0.98N}{.18m}$	$= 5.5\frac{N}{m}$
3	.250 kg	$\times 9.81\frac{m}{s^2} = 2.45$ N	.46 m	$K = \frac{F}{X} = \frac{2.45N}{.46m}$	$= 5.3\frac{N}{m}$

Now using the spring's constant you just found, determine the unknown mass of the red, green, and yellow masses.

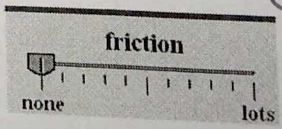
	Spring 1's average Constant, **k**	Displacement, **x** (m)	Weight, W (N)	Mass used, m (kg)	
10	$5.4\frac{N}{m}$	.11 m	$F = KX = 5.4\frac{N}{m} \cdot .11$	Green 0.59N $m = \frac{F}{a} =$	$\frac{0.59N}{9.8\frac{m}{s^2}} = .061$ Kg
		.29m	$F = KX = 5.4\frac{N}{m} \cdot .29m$	Yellow = 1.57N $m = \frac{F}{a} = \frac{1.57N}{9.8\frac{m}{s^2}}$	= 0.160 Kg
		.60 m	$F = KX = 5.4\frac{N}{m} \cdot .60m$ 3.24N	Red $m = \frac{F}{a} = \frac{3.24N}{9.8\frac{m}{s^2}}$	= 0.33Kg

Now hang a 100g mass from spring 1. Using the buttons on the right, determine the acceleration of gravity on Jupiter. (hint…use **k** and **x** to find **F**…then use **F** and **m** to find **a** (Recall… $\boxed{W = mg}$ or $\boxed{F = ma}$)

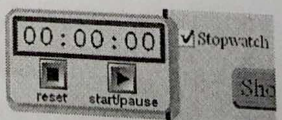
Spring 1's average Constant, k	Displacement, **x** (m)	Weight (N)	mass	acceleration (m/s^2) *g*	
$5.4\frac{N}{m}$	.18m	**.98 N**	**.100 kg**	Earth **9.8** $\frac{m}{s^2}$	
	.48m	$F = KX = 5.4\frac{N}{m} \cdot .48m$ 2.6N	**.100 kg**	Jupiter $a = \frac{F}{m} = \frac{2.6N}{0.100Kg}$	$= 25.9\frac{m}{s^2}$
	.03m	$F = KX = 5.4\frac{N}{m} \cdot .03m =$ 0.16N	**.100 kg**	Moon $a = \frac{F}{m} = \frac{0.16N}{0.100Kg}$	$= 1.6\frac{m}{s^2}$

Part 2: Harmonic Motion of Springs ***…BACK TO EARTH…***

Period is the time for one complete cycle of movement. In this case, the time for one complete down and up (before the next down).



1. Remove the friction using the button on the right for this part of the investigation.
2. Activate the stopwatch.
3. Get the 50g mass bouncing on spring and record the time it takes for 30 cycles.



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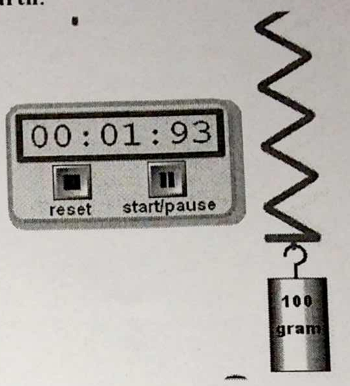
4. Fill in the chart below to determine the period of motion for each of the masses on **earth**.

	Mass used (kg)	time for 30 T's		Period (T)
2	.050 kg	13.5	sec	$\frac{t}{n} = \frac{13.5 s}{30} = 0.45$ sec
2	.100 kg	18.5	sec	$\frac{t}{n} = \frac{18.5 s}{30} = 0.62$ sec
2	.250 kg	29.7	sec	$\frac{t}{n} = \frac{29.75}{30} = 0.99$ sec



5. Repeat the experiment on the **Jupiter**.

	Mass used (kg)	time for 30 T's		Period (T)
2	.050 kg	13.5	sec	$\frac{t}{n} = \frac{13.5 s}{30} = 0.45$ sec
2	.100 kg	18.5	sec	$\frac{t}{n} = \frac{18.55}{30} = 0.62$ sec
2	.250 kg	29.7	sec	$\frac{t}{n} = \frac{29.75}{30} = 0.99$ sec

6. Find the period of the red, green, and yellow masses and use the formula for a spring's period to determine each unknown's mass. *(Hint: this requires you to do some rad math!)* ***USE EARTH AGAIN…good ol Earth***

$T = 2\pi\sqrt{\frac{m}{K}}$

$T^2 = 4\pi^2 \frac{m}{K}$

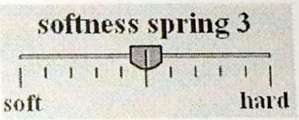
$m = \frac{T^2 K}{4\pi^2}$

	Spring constant found earlier	time for 30 T's	Period (T)	mass (in kg)
10	$5.4 \frac{N}{m}$	15.5 sec	$\frac{t}{n} = \frac{15.5 s}{30} = 0.525$	Green $\frac{(0.525)^2 \cdot 5.4\frac{N}{m}}{4\pi^2} = .036 Kg$
		23.4 sec	$\frac{t}{n} = \frac{23.45}{30} = 0.785$	Yellow $\frac{(.785)^2 \cdot 5.4\frac{N}{m}}{4\pi^2} = .083 Kg$
		33.1 sec	$\frac{t}{n} = \frac{33.15}{30} = 1.15$	Red $\frac{(1.15)^2}{4\pi^2} \cdot 5.4\frac{N}{m} = 0.197 Kg$

7. How do the unknown masses you found here compare to the unknown masses you found in part 1? Close, but not that close,

8. Hang a 100g mass from spring 3 and find its period of motion as its spring constant is changed.

	Draw the softness gauge here	time for 30 T's		Period (T)
9	soft	43.4	sec	$\frac{t}{n} = \frac{43.45}{30} = 1.45$ sec
	middle	18.8	sec	$\frac{t}{n} = \frac{18.85}{30} = 0.63$ sec
	hard	9.5	sec	$\frac{t}{n} = \frac{9.65}{30} = 0.32$ sec



Questions:

Part 1:

2 1. What is the spring constant of spring #1? 5.4 N/m

2 2. What is the gravitational acceleration on Jupiter? 25.9 m/s²

2 3. What is the gravitational acceleration on the moon? 1.6 m/s²

$F = Kx$, so $x = \frac{F}{K}$

2 4. How far would a spring with a constant of 20. be extended with a force of 160 N? $x = \frac{F}{K} = \frac{160N}{20\frac{N}{m}} = \boxed{8m}$

2 5. How much force would be required to stretch a spring (k = 12) 3.6 meters? $F = Kx = 12 \cdot 3.6m = \boxed{43.2N}$

2 6. If a spring stretched .20m when a 200 g mass was hung from it, what is the spring's spring constant? $K = \frac{F}{x} = \frac{1.96N}{.20m} = \boxed{9.8\frac{N}{m}}$

Part 2:

2 7. What is the mass of the green unknown mass? 0.036 kg

2 8. What is the mass of the yellow unknown mass? 0.083 kg

2 9. What is the mass of the red unknown mass? 0.197 kg

1 10. As mass on a spring increases, the period of motion (one full up and down) *[✓ increases] / decreases / remains the same.*

1 11. As gravity (Jupiter) on a spring increases, the period of motion *increases / decreases / [✓ remains the same.]*

1 12. As the spring constant increases, the period of motion *increases / [✓ decreases] / remains the same.*

1 13. Amplitude is the displacement (meters) from the equilibrium position (zero displacement, neutral position). Does the amplitude of a spring's movement depend upon period? *Yes / [✓ No]*

2 14. What is the period of 1.2 kg mass bouncing on a spring with a spring constant of 15? $T = 2\pi\sqrt{\frac{m}{K}} = 2\pi\sqrt{\frac{1.2Kg}{15\frac{N}{m}}} = 1.8$

2 15. What is the period of a 450 gram mass bouncing on a spring with a spring constant of 9.0? $T = 2\pi\sqrt{\frac{m}{K}} = 2\pi\sqrt{\frac{.45Kg}{9.0\frac{N}{m}}} = \boxed{1.4s}$

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