

SI Physics - Full Discipline Demo

Hooke's Law - Digital

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Physics - Full Discipline Demo
Course	SI Physics - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term to the best description.

Spring constant	Pulls or pushes toward the equilibrium position	1
Restoring force	Force equals a negative constant times displacement	2
Springs in parallel	Indicator of stiffness	3
Hooke's law	Each experiences the same force	4
Springs in series	Each experiences the same displacement	5

Correct answers:

- 1 Restoring force 2 Hooke's law 3 Spring constant
4 Springs in series 5 Springs in parallel

Identify each statement as true or false.

⚡ An object stretched within its elastic limit follows Hooke's law	
⚡	
Spring potential energy can be positive or negative, depending on the sign of the displacement	
⚡ Spring potential energy varies with the square of the displacement	
⚡ The equilibrium position of a spring is the unstretched length	
⚡ The restoring force and the displacement are always in the same direction	
True	False
1	2

Correct answers:

1 An object stretched within its elastic limit follows Hooke's law

Spring potential energy varies with the square of the displacement

The equilibrium position of a spring is the unstretched length

2

Spring potential energy can be positive or negative, depending on the sign of the displacement

The restoring force and the displacement are always in the same direction

Exploration

The restoring force is proportional to the displacement from the equilibrium.

- ☒ True
- ☐ False



The restoring force always points away from the equilibrium position.

- ☐ True
- ☒ False

The spring constant indicates the ____ of the spring.

- ☐ length
- ☐ mass
- ☒ stiffness
- ☐ None of the above

Springs combined in parallel will each experience the same ____.

- ☒ displacement
- ☐ force
- ☐ spring constant
- ☐ All of the above

A spring stretched beyond its elastic limit will ____.

- ☐ return to its original length
- ☒ remain deformed
- ☐ still follow Hooke's law
- ☐ None of the above

The change in spring potential energy of a spring is equal to the amount of ____ on the spring.

- ☒ work done
- ☐ weight
- ☐ mass
- ☐ All of the above

Spring potential energy is conserved for a hanging mass on a spring at rest.

☐ True

☒ False



Exercise 1

Is the effective spring constant for springs in parallel larger or smaller than the spring constant of each individual spring? Is the effective spring constant for springs in series larger or smaller than the spring constant of each individual spring? Explain your answers.

The effective spring constant for springs in parallel is equal to the sum of the spring constants for each individual spring, so it is larger than each individual spring constant. The effective spring constant for springs in series is the inverse of the sum of the inverse of the spring constants for each individual spring, so it is smaller than any individual spring constant.

What is the relationship between the applied force of a hanging mass on a spring and the spring force of the spring?

The applied force is equal in magnitude and points in the opposite direction as the spring force for the spring in all cases, regardless of the spring constant as is demonstrated by the values for the applied force and spring force respectively of 20 and -20 N, for example.

Compare the effective spring constants calculated in Data Table 1 and Data Table 2 and the spring constants derived from the graphs in Graph 1 and Graph 2. Which method gives more reliable results and why?

The effective spring constants calculated from the equations in the data tables are essentially identical to the effective spring constants determined from the graphs. Those calculated from the

equations are theoretical, while those from the graphs are experimental. Experimental results are a more reliable indicator of the actual conditions of the experiment, so the effective spring constants found from the graph are more reliable. However, since this was a simulation, the theoretical and experimental data match exactly.

What is the relationship between the spring potential energy of a spring and the spring constant of the spring? Use the data in Data Table 4 to support your answer.

For a given displacement, and/or applied force, the potential energy increases as the spring constant increases. When the spring constant doubles from 100 N/m to 200 N/m for a displacement of 0.20 m, the spring potential energy also doubles from 2 J to 4 J. This is a linearly proportional relationship.

Compare the graph in Graph 3 to the Energy Plot in the Energy page of the simulation. What do these two graphs tell you about the relationships between potential energy, displacement, and spring force?

The graphs both show a parabolic shape which indicates a squared polynomial relationship between the potential energy and the displacement as well as the spring force.

Data Table 1: Intro
(SAMPLE ANSWER BELOW)

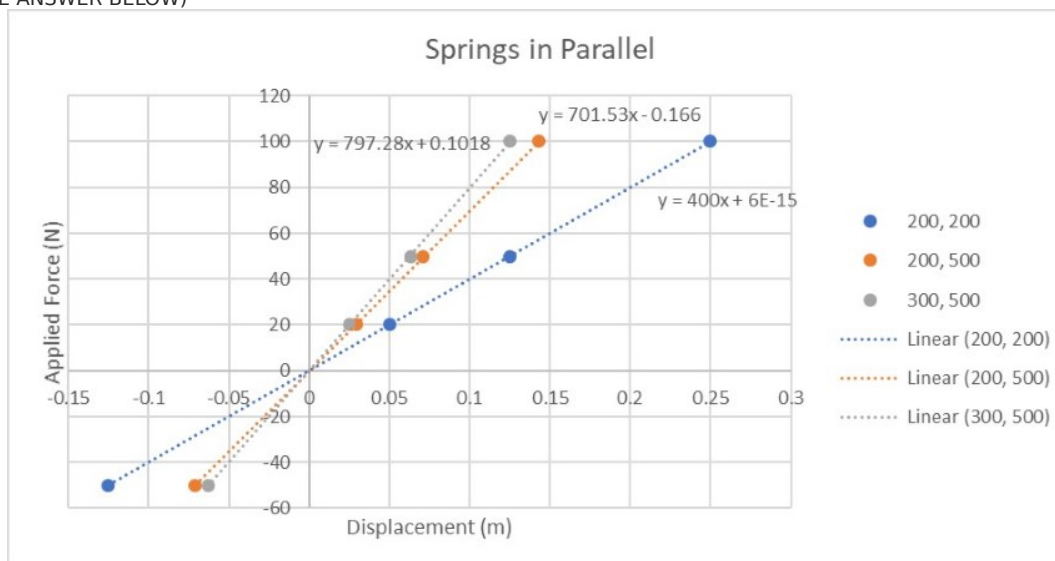
Applied Force (N)	Spring Force (N)	Displacement (m)
k = 200 N/m		
20	-20	0.100
50	-50	0.250
100	-100	0.500
-50	50	-0.250
k = 100 N/m		
20	-20	0.200
50	-50	0.500
100	-100	1.000
-50	50	-0.500
k = 500 N/m		

20	-20	0.040
50	-50	0.100
100	-100	0.200
-50	50	-0.100

Data Table 2: Springs in Parallel
(SAMPLE ANSWER BELOW)

Applied Force (N)	Top Spring Force (N)	Bottom Spring Force (N)	Displacement (m)	Spring Constant (N/m)
Top Spring Constant = 200 N/m, Bottom Spring Constant = 200 N/m				
20	-10.0	-10.0	0.050	400
50	-25.0	-25.0	0.125	
100	-50.0	-50.0	0.250	
-50	25.0	25.0	-0.125	
Top Spring Constant = 200 N/m, Bottom Spring Constant = 500 N/m				
20	-5.7	-14.3	0.029	700
50	-14.3	-35.7	0.071	
100	-28.6	-71.4	0.143	
-50	14.3	35.7	-0.071	
Top Spring Constant = 300 N/m, Bottom Spring Constant = 500 N/m				
20	-7.5	-12.5	0.025	800
50	-18.8	-31.3	0.063	
100	-37.5	-62.5	0.125	
-50	18.7	31.2	-0.063	

Graph 1: Spring Constant for Springs in Parallel
(SAMPLE ANSWER BELOW)

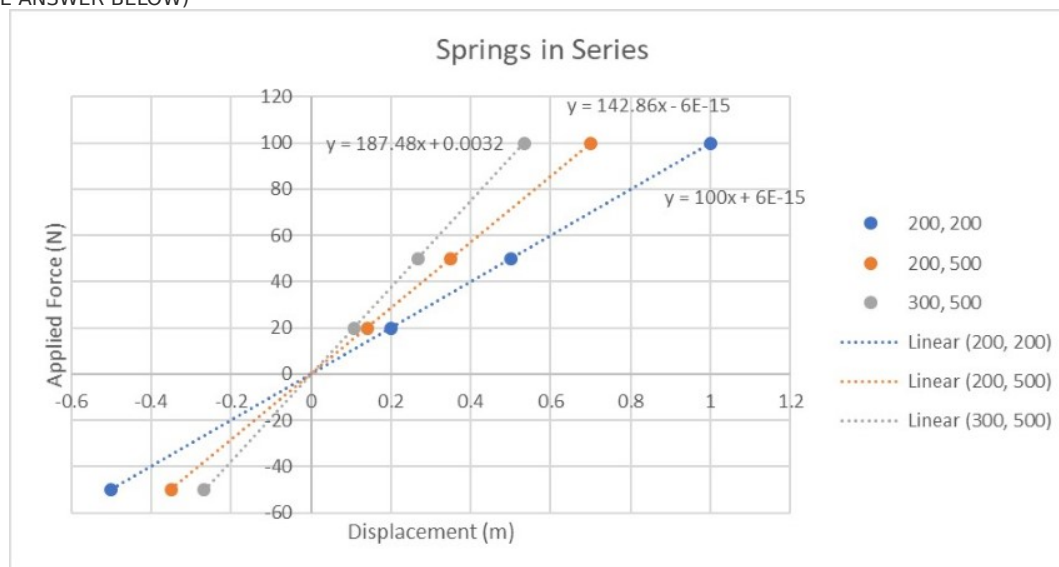


Data Table 3: Springs in Series
(SAMPLE ANSWER BELOW)

(SAMPLE ANSWER BELOW)					
Applied Force (N)	Left Spring Force (N)	Right Spring Force on Applied Force (N)	Right Spring Force on Left Spring(N)	Displacement (m)	Spring Constant (N/m)
Left Spring Constant = 200 N/m, Right Spring Constant = 200 N/m					
20	-20	-20	20	0.200	100
50	-50	-50	50	0.500	
100	-100	-100	100	1.000	
-50	50	50	-50	-0.500	
Top Spring Constant = 200 N/m, Right Spring Constant = 500 N/m					
20	-20	-250	20	0.140	143
50	-50	-50	50	0.350	
100	-100	-100	100	0.700	
-50	50	50	-50	-0.350	
Top Spring Constant = 300 N/m, Right Spring Constant = 500 N/m					
20	-20	-20	20	0.107	188

50	-50	-50	50	0.267
100	-100	-100	100	0.533
-50	50	50	-50	-0.267

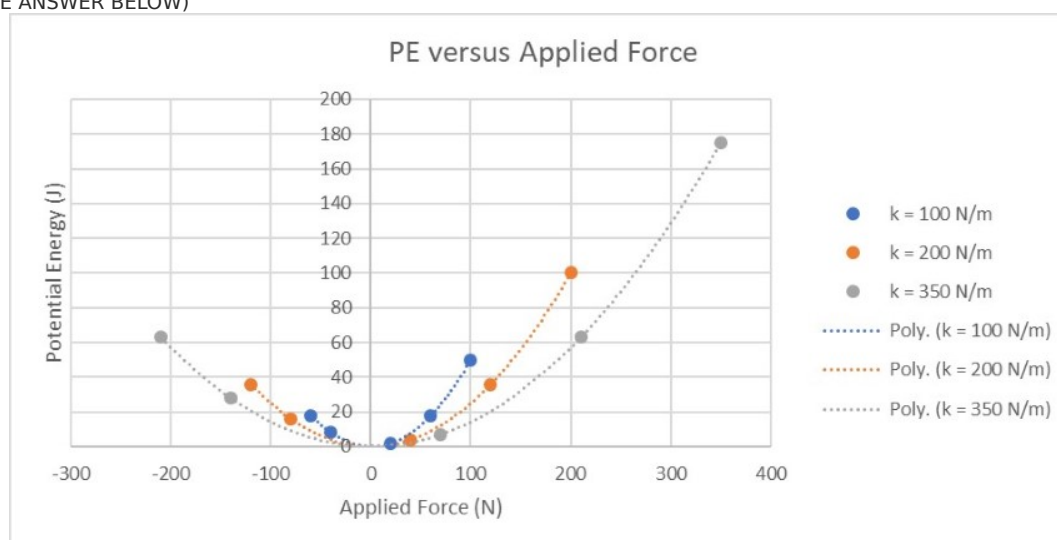
Graph 2: Spring Constant for Springs in Series
(SAMPLE ANSWER BELOW)



Data Table 4: Energy
(SAMPLE ANSWER BELOW)

Displacement (m)	Applied Force (N)	Spring Potential Energy (J)
Spring Constant = 100 N/m		
0.200	20	2.0
0.600	60	18.0
1.000	100	50.0
-0.400	-40	8.0
-0.600	-60	18.0
Spring Constant = 200 N/m		
0.200	40	4.0
0.600	120	36.0
1.000	200	100.0
-0.400	-80	16.0
-0.600	-120	36.0
Spring Constant = 350 N/m		
0.200	70	7.0
0.600	210	63.0
1.000	350	175.0
-0.400	-140	28.0
-0.600	-210	63.0

Graph 3: Energy versus Force
(SAMPLE ANSWER BELOW)



Competency Review

A mass on a spring is subject to Hooke's law.

- ☐ True
- ☐ False



_____ is the position where a spring is neither stretched nor compressed.

- ☐ Displacement
- ☐ Elastic limit
- ☐ Equilibrium
- ☐ None of the above



The ____ indicates the stiffness of a spring.

- ☐ applied force
- ☒ spring constant ✓
- ☐ spring force
- ☐ All of the above

Two or more springs aligned in series or in parallel have a single equivalent spring constant.

- ☒ True ✓
- ☐ False

Any material that is subject to a restoring force is considered to be ____.

- ☐ springy
- ☐ flexible
- ☒ elastic ✓
- ☐ All of the above

The applied force points in the same direction as the restoring force of Hooke's law.

- ☐ True
- ☒ False ✓

The spring potential energy is calculated using the equation ____.

- ☐ $U_{sp} = \frac{1}{2}k\Delta x$
- ☐ $U_{sp} = mgy$
- ☒ $U_{sp} = \frac{1}{2}k\Delta x^2$ ✓
- ☐ None of the above

The effective spring constant for springs in parallel is equal to the ____ of the individual spring constants.

- ☒ sum ✓
- ☐ difference
- ☐ product
- ☐ None of the above

A spring of spring constant 25 N/m is hung vertically and a 0.300 kg mass is attached to one end, causing a displacement of the end of the spring of ____ m.

- ☐ 0.01
- ☒ 0.12 ✓
- ☐ 0.77
- ☐ All of the above

Extension Questions

A spring on Earth has a 0.500 kg mass suspended from one end and the mass is displaced by 0.3 m. What will the displacement of the same mass on the same spring be on the Moon, where the acceleration due to gravity is one sixth that of Earth? Show your work. (SAMPLE ANSWER BELOW)

The spring constant is found from Hooke's law: $F = mg = -kx$, or $k = mg/x = 0.5 \cdot 9.8 / 0.3 = 16.33$ N/m. The spring constant and mass won't change on the Moon, so the new displacement can be found using these constants and the new $g = 9.8/6 = 1.63 \text{ m/s}^2$: $x = mg/k = 0.5 \cdot 1.63 / 16.33 = 0.05 \text{ m}$. The spring will stretch 0.05 m or 5 cm on the Moon.