Virtual Learning

Physics

Hooke's Law Simulation Part II

April 30 , 2020

Physics

Hooke's Law Simulation Part II: April 30,2020

Objective/Learning Target:

Students will use a computer simulation to examine Hooke's Law.

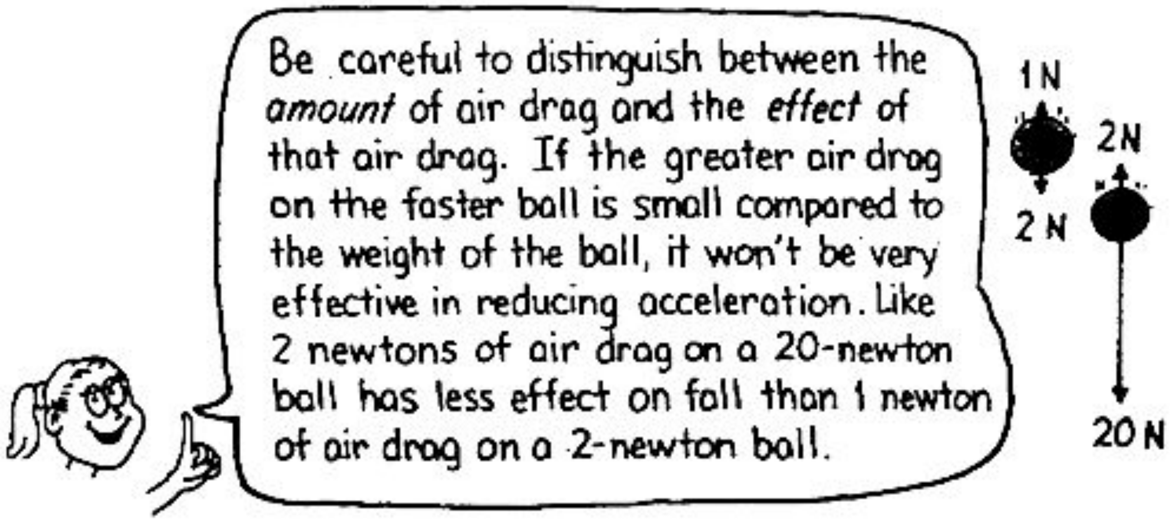
Quick Review #1

Two smooth balls of exactly the same size, one made of wood and the other of iron, are dropped from a high building to the ground below. The ball to encounter the greater force of air resistance on the way down is the

a) Wooden ball
b) Iron ball
c) Both the same

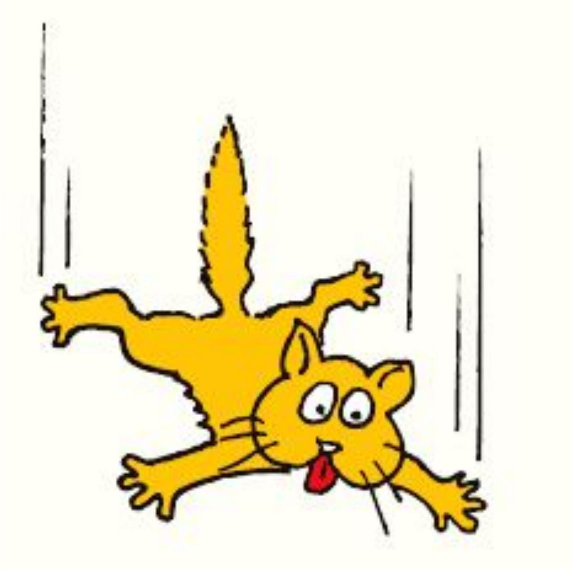
Quick Review #1 Answer

Air resistance depends on both the size and speed of a falling object. Both balls have the same size, but the heavier iron ball falls faster through the air and encounters more air resistance in its fall.



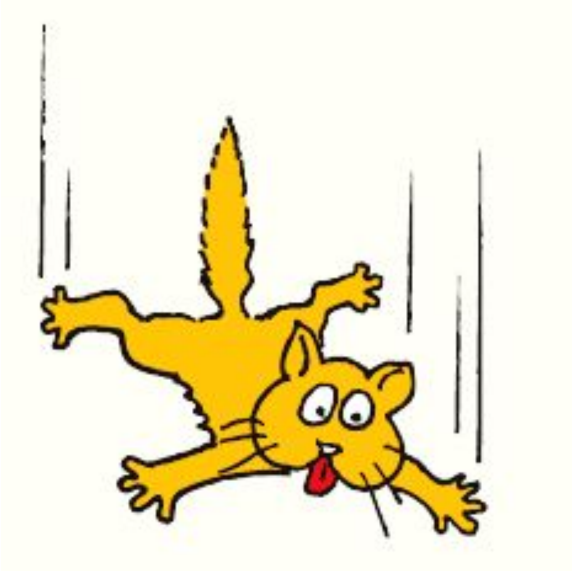
Quick Review #2

Why does a cat that accidentally falls from the top of a 50-story building hit a safety net below no faster than if it fell from the 20th story?

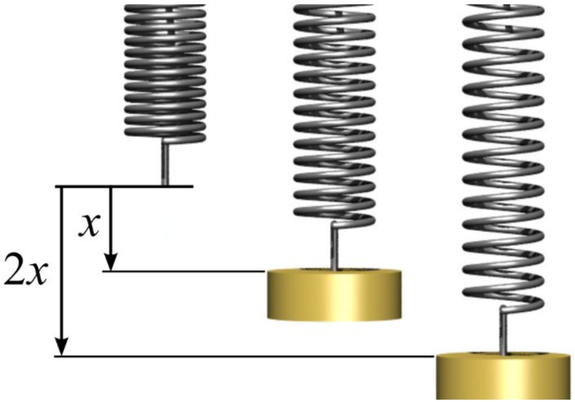


Quick Review #2 Answer

The cat reaches terminal velocity just around 20 stories, so the additional fall from 50 stories wouldn’t result in a faster velocity for the cat.



Hooke's Law Part II



Introduction

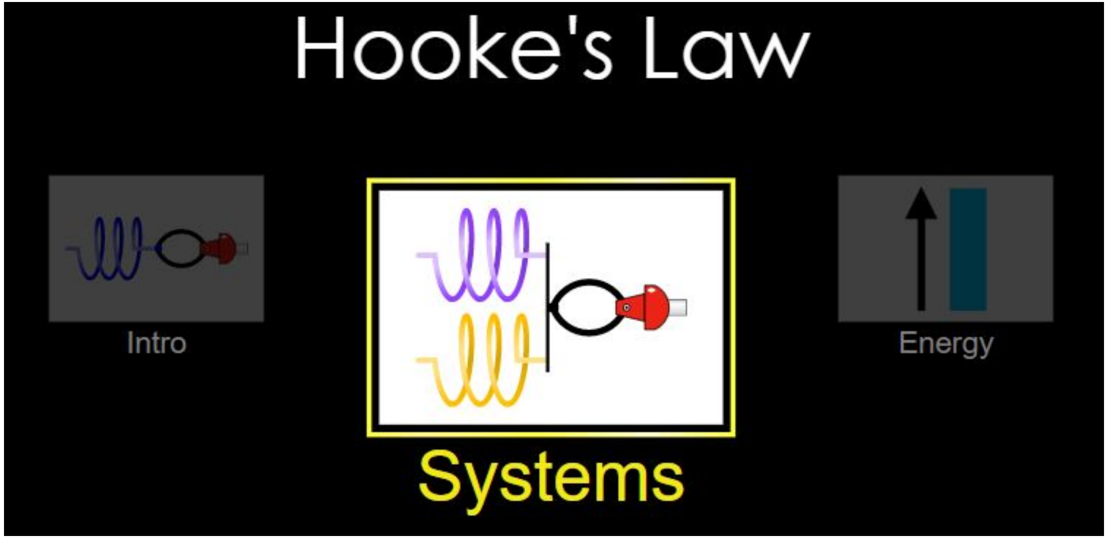
You will use a computer simulation today to investigate Hooke's Law. Since this is "inquiry based", you're not supposed to know everything going in, but learn as we walk through the lesson. **You must read the following slides carefully.** Let's get started!

Hooke’s Law Part II

Website: [Hooke's Law Simulation]

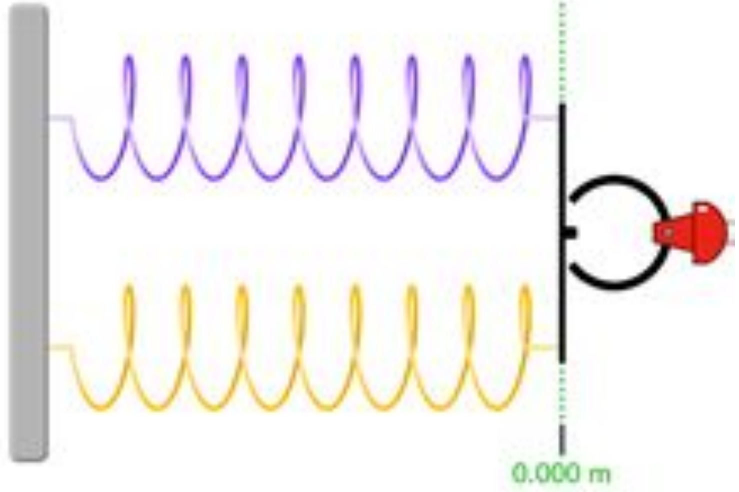
Make sure to use the HTML5 version.

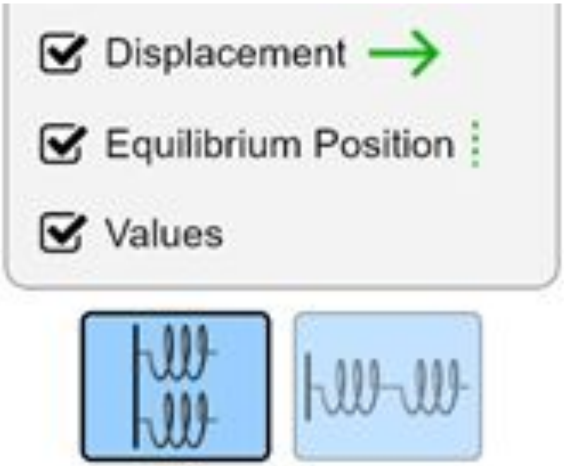
Select the Systems icon and double click to start.



Hooke’s Law Part II

Select the options ‘Displacement’, ‘Equilibrium Potion’ and ‘Values’. Make sure the option of <u>two springs in parallel</u> is selected so that the springs look like the setup in the image below.





Hooke's Law Part II

1. Keep the top spring constant k_T = 200 N/m and the bottom spring constant k_B = 200 N/m. Apply 100N of force to the right.

2. Measure the extension and determine the total spring constant of the two springs in parallel (Force/extension). Record the results in the data table.

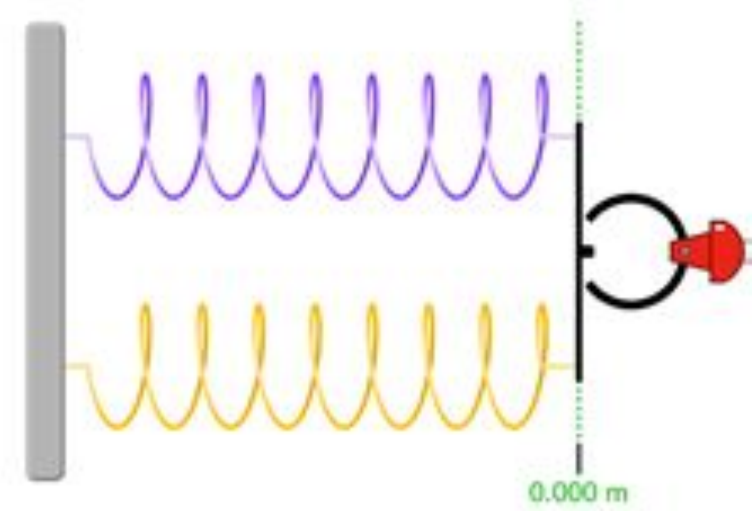
3. Repeat steps 1 & 2 three more times by changing the values of the spring constants. Be sure to select some constants that are not equal. Record the results in the table.

k_T (N/m)	k_B (N/m)	F (N)	Ext (m)	k_{tot} (N/m)
		100		
		100		
		100		
		100		

Hooke's Law Part II

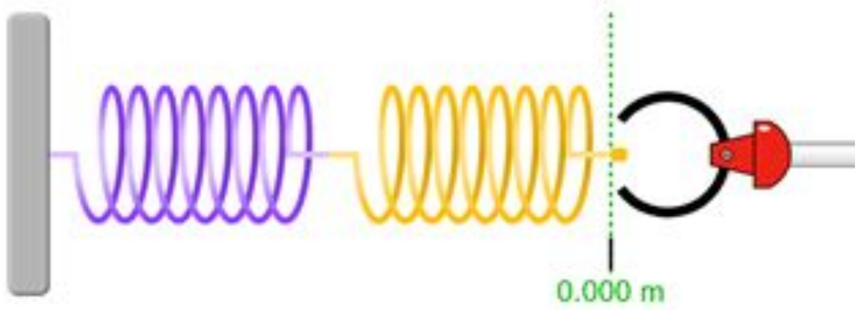
Describe the relationship between the individual spring constants k_T and k_B, and the total spring constant for springs in parallel.

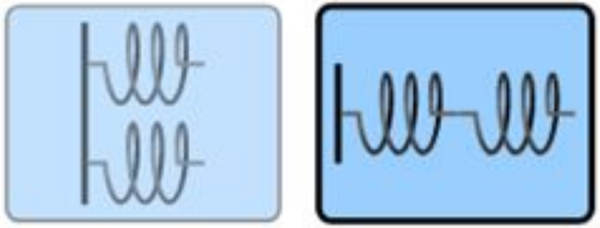
Try to write this in the form of an equation.



Hooke’s Law Part II

Press the series spring button so that the springs change their combination to look like the setup in the image below:





Hooke’s Law Part II

1. Keep the left spring constant k_L = 400 N/m and the right spring constant k_R = 400 N/m. Apply 100N of force to the right.

2. Measure the extension and determine the total spring constant of the two springs in series (Force/extension). Record the results in the data table.

3. Repeat steps 1 & 2 three more times by changing the values of the spring constants. Be sure to select some constants that are not equal. Record the results in the table.

k_L (N/m)	k_R (N/m)	F (N)	Ext (m)	k_{tot} (N/m)
		100		
		100		
		100		
		100		

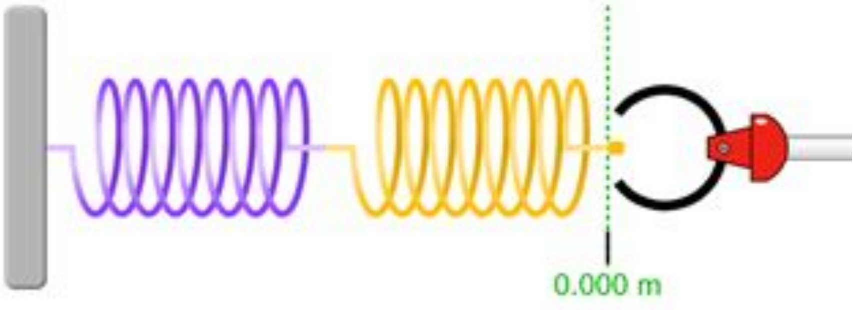
Hooke's Law Part II

Three students offer a model for finding the total spring constant for two springs in series:

Student 1: $k_{tot} = \dfrac{k_L + k_R}{k_L k_R}$

Student 2: $k_{tot} = \dfrac{(k_L + k_R)^2}{k_L + k_R}$

Student 3: $\dfrac{1}{k_{tot}} = \dfrac{1}{k_L} + \dfrac{1}{k_R}$.



Explain which student's model is correct based on your results.

Hooke's Law Part II Answer

For a single spring we know

$$F_{tot} = kx$$

The relationship for two springs in parallel:

$$F_{tot} = k_1x + k_2x$$

$$= (k_1 + k_2)x$$

The total spring constant is equal to the sum of the individual spring constants.

k_T (N/m)	k_B (N/m)	F (N)	Ext (m)	k_{tot} (N/m)
200	200	100	0.250	400
200	400	100	0.167	599
400	600	100	0.100	1000
200	600	100	0.125	800

1: $k_{tot} = \frac{k_L + k_R}{k_L k_R} = \frac{400 + 400}{400 \times 400} = 0.005$

2: $k_{tot} = \frac{(k_L + k_R)^2}{k_L + k_R} = \frac{(400 + 400)^2}{400 + 400} = 800$

3: $\frac{1}{k_{tot}} = \frac{1}{k_L} + \frac{1}{k_R} = \frac{1}{400} + \frac{1}{400} = 200$

Plugging in the first set of values into each equation yielded the results above. Only Student 3 had the right relationship, as the two 400 N/m springs resulted in a k_{tot} of 200N/m.

k_L (N/m)	k_R (N/m)	F (N)	Ext (m)	k_{tot} (N/m)
400	400	100	0.500	200
200	400	100	0.750	133
600	400	100	0.417	240
200	600	100	0.667	150

Additional Practice

Return to the simulation and use the equations to solve for different spring constants and then check your answers using the simulation.