شرح الدرس الأول الحركة الدورية Motion Periodic من الوحدة الأولى الاهتزازات والموجات

MAIN IDEA

Periodic motion repeats in a regular cycle.

K *What I Know*	W *What I Want to Find Out*	L *What I Learned*

Essential Questions

- What is simple harmonic motion?
- How much energy is stored in a spring?
- What affects a pendulum's period?

Vocabulary

Review

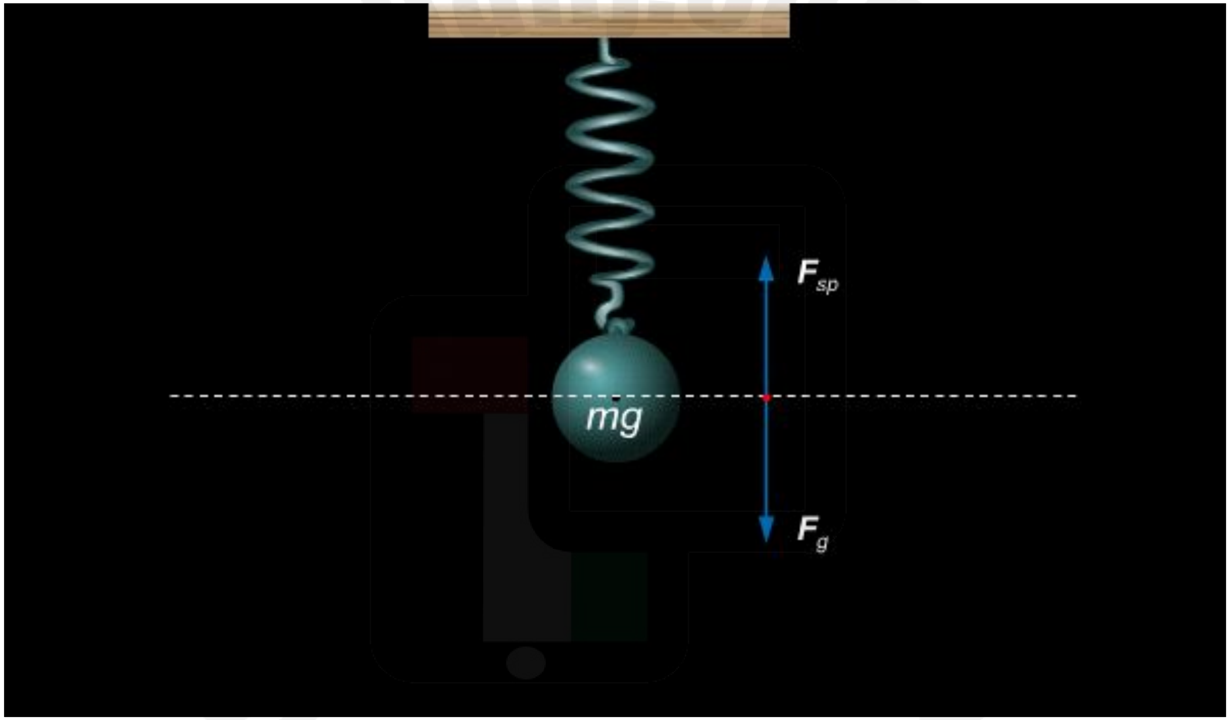
- gravitational field (g)

New

- periodic motion
- period
- amplitude
- simple harmonic motion
- Hooke's law
- simple pendulum
- resonance

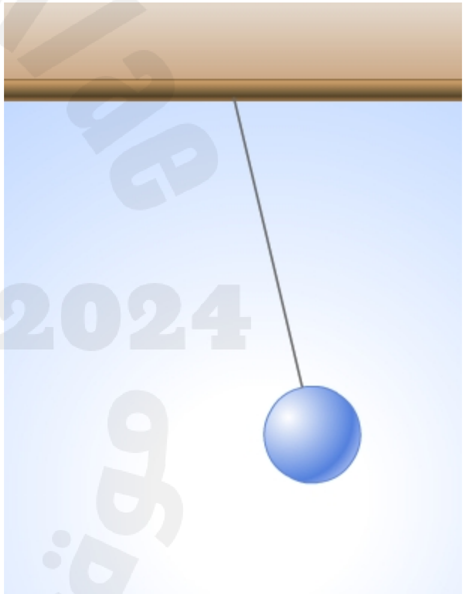
Mass on a Spring

Go to your ConnectED resources to play ***Animation: Mass on a Spring.***



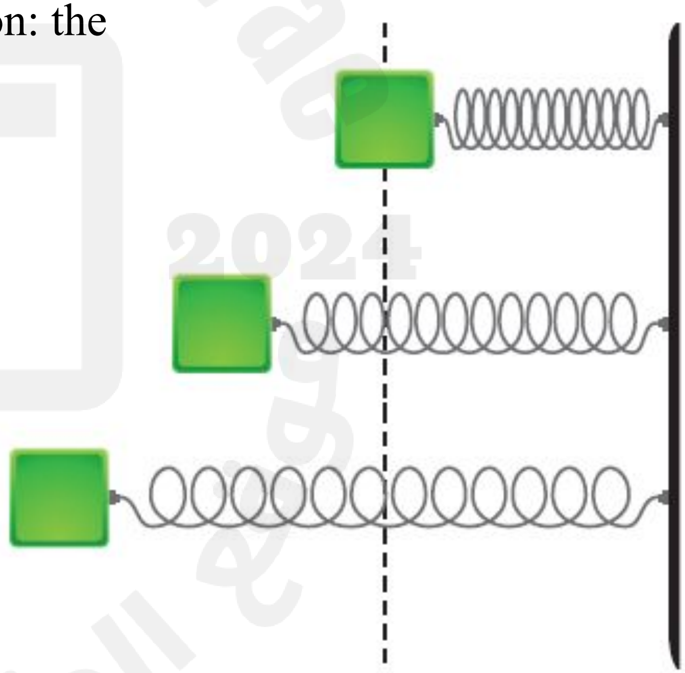
Mass on a Spring

- Oscillatory motion is the movement of an object back and forth between two opposing points.
- Any motion that repeats in a regular cycle is an example of periodic motion.
- Examples of periodic motion
  - a mass bobbing up and down on a spring
  - a pendulum
  - a vibrating guitar string
  - a tree swaying in the wind
- In each example, the object has one position at which the net force on it is zero. At that position, the object is in equilibrium.



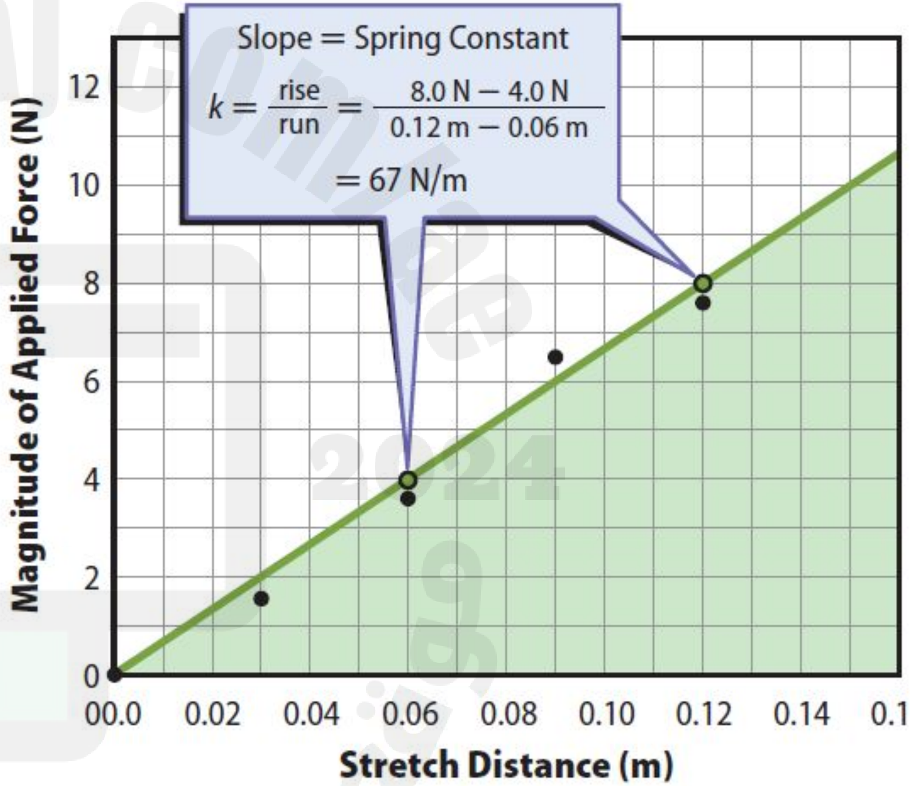
Mass on a Spring

- Whenever the object is pulled away from its equilibrium position, the net force on the system becomes nonzero and pulls the object back toward equilibrium.
- Any system in which the force acting to restore an object to its equilibrium position is directly proportional to the displacement of the object shows simple harmonic motion.
- Two quantities describe simple harmonic motion: the period and the amplitude of the motion.
- The period (*T*) is the time needed for an object to repeat one complete cycle of the motion.
- The amplitude of the motion is the maximum distance the object moves from the equilibrium position.



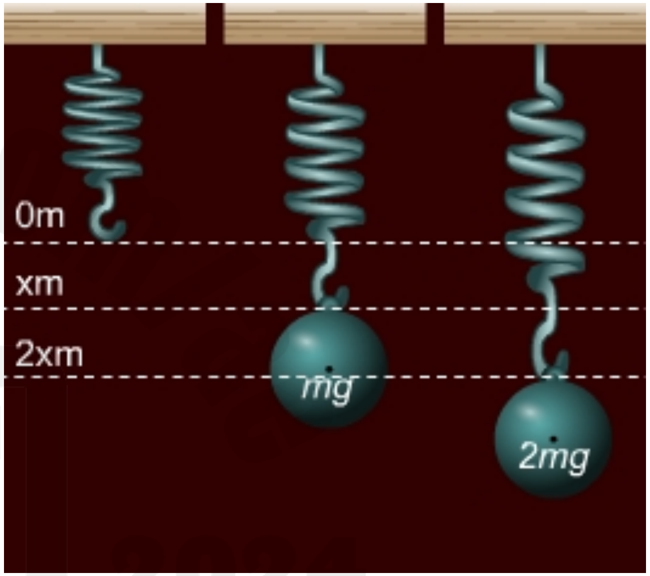
Hooke's Law

- When a force is applied to stretch a spring, such as by hanging an object on its end, there is a direct linear relationship between the exerted force and the displacement.
- The slope of the graph is equal to the spring constant, given in units of newtons per meter.
- The area under the curve represents the work done to stretch the spring and, therefore, equals the elastic potential energy that is stored in the spring as a result of that work.



Hooke's Law

- A spring that exerts a force directly proportional to the distance stretched obeys Hooke's law.



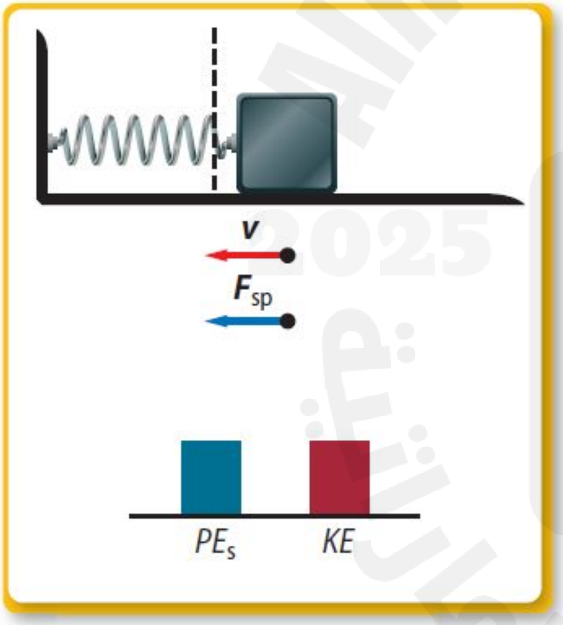
Hooke's Law $F = -kx$

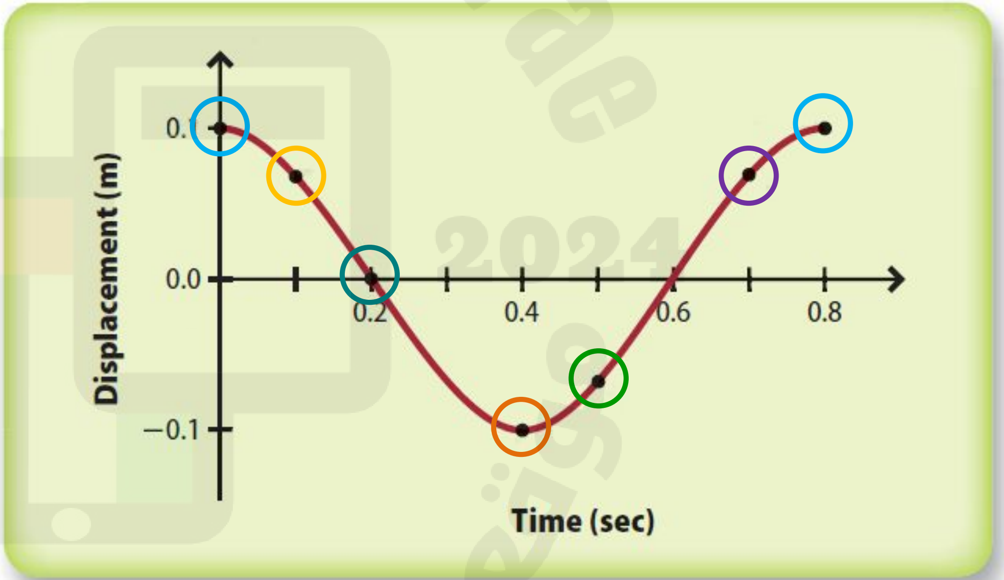
- k is the spring constant, which depends on the stiffness and other properties of the spring
- x is the distance that the spring is stretched from its equilibrium position

Hooke's Law

- The potential energy stored in a spring that obeys Hooke's law is proportional to the displacement squared.

Potential Energy in a Spring $PE_{sp} = \frac{1}{2}kx^2$





Click to begin.

Hooke's Law

ADDITIONAL IN-CLASS EXAMPLE

Use with Example Problem 1.

Problem

A 560-N cyclist sits on a bicycle seat and compresses the two springs that support it. The spring constant equals 2.2×10^4 N/m for each spring.

a. How much is each spring compressed?

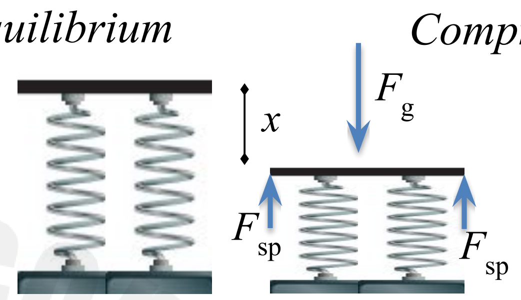
b. By how much does the compression increase each spring's elastic PE?

Response

SKETCH AND ANALYZE THE PROBLEM

- Sketch the situation. Draw a force diagram.
- List the knowns and unknowns.

KNOWN	UNKNOWN
$F_{sp} = F_g/2 = 280$ N	$x = ?$
$k = 2.2\times10^4$ N/m	$PE_{sp} = ?$



SOLVE FOR THE UNKNOWN

- Use Hooke's law to find the compression of each spring.

$$F_{sp} = kx$$

$$x = \frac{F}{k} = \frac{\frac{1}{2}F_g}{k} = \frac{\frac{1}{2}(560\text{ N})}{2.2\times10^4\text{ N/m}} = 1.3\times10^{-2}\text{ m}$$

- Use the relationship among potential energy, the spring constant, and the displacement.

$$PE_{sp} = \tfrac{1}{2}kx^2$$

$$= \tfrac{1}{2}(2.2\times10^4\text{ N/m})(1.3\times10^{-2}\text{ m})^2 = 1.9\text{ J}$$

EVALUATE THE ANSWER

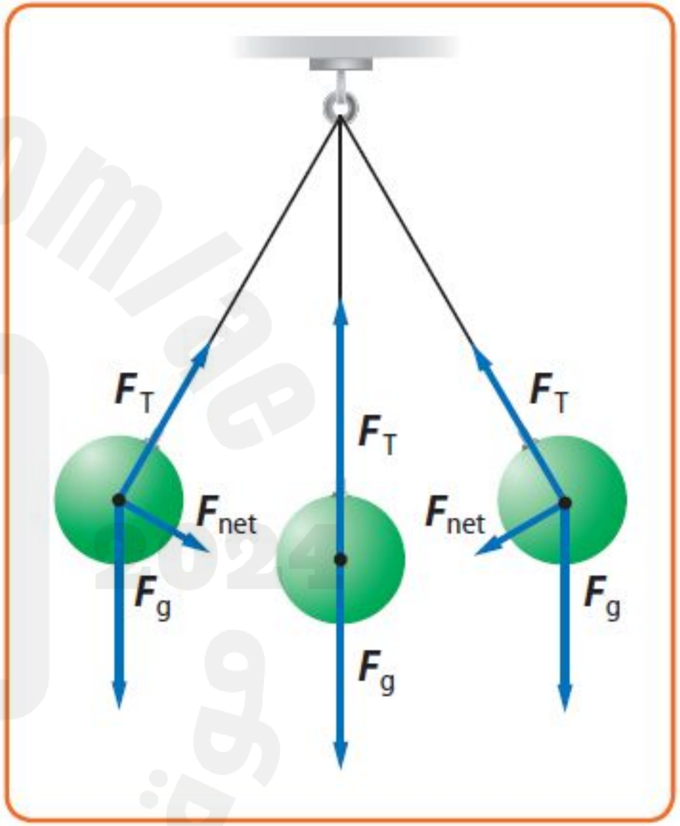
- Displacement is in meters and energy is joules, so the units are correct.

Pendulums

- Simple harmonic motion also can be demonstrated by the swing of a pendulum.
- A simple pendulum consists of a massive object, called the bob, suspended by a string or light rod of length ℓ.
- The period of a pendulum depends on the length of the pendulum and the gravitational field, but not the bob's mass.

Period of a Pendulum

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$



Pendulums

ADDITIONAL IN-CLASS EXAMPLE

Use with Example Problem 2.

Problem

What is the period of a simple pendulum with a length of 0.25 m?

Response

SKETCH AND ANALYZE THE PROBLEM

- Sketch the situation.
- List the knowns and unknowns.

KNOWN
$\ell = 0.25$
UNKNOWN
$T = ?$

SOLVE FOR THE UNKNOWN

- Use the relationship between the period and the length of pendulum.

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

$$= 2\pi\sqrt{\frac{(0.25\ \text{m})}{(9.8\ \text{N/kg})}}$$

$$= 1.0\ \text{s}$$

EVALUATE THE ANSWER

- The period is in seconds, so the units are correct.
- A period of 1 second is reasonable for a 25-cm pendulum.

Resonance

- Resonance occurs when small forces are applied at regular intervals to a vibrating or oscillating object and the amplitude of the vibration increases. The time interval between applications of the force is equal to the period of oscillation.
- Examples of resonance
  - Rocking a car to free it from a snowbank
  - Jumping rhythmically on a trampoline or a diving board

Review

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