حل أوراق عمل الدرس الأول Motion Periodic الحركة الدورية من الوحدة الأولى

إعداد: Jarwan Mutasem

المزيد من الملفات بحسب الصف العاشر المتقدم والمادة فيزياء في الفصل الأول

5	عرض بوربوينت القسم الخامس السالبية الكهربائية والقطبية

Grade 10 ADV Physics

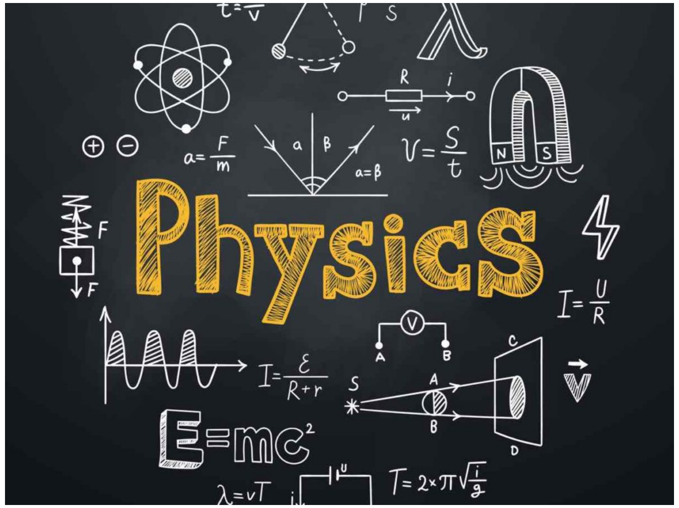
مؤسسة الإمارات للتعليم المدرسي
EMIRATES SCHOOLS ESTABLISHMENT

unit 1 | Vibrations And Waves

1. Periodic Motion

Part A

Periodic Motion And Hooke's Law



Mutasem Jarwan

Learning objectives:

Textbook Chapter	Ch 1 – Vibrations and Waves

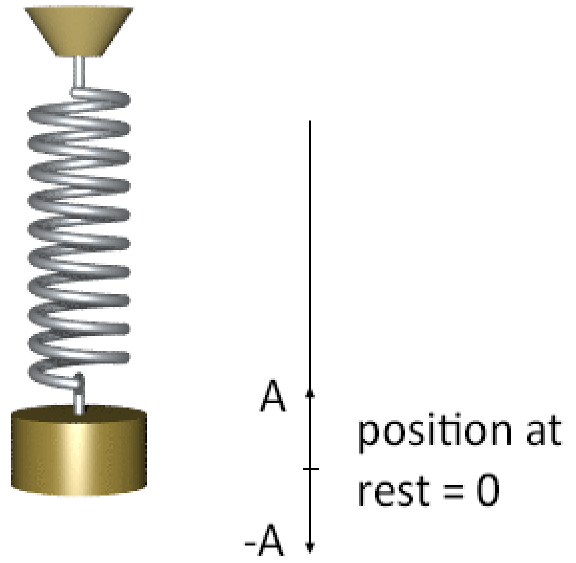
Learning Outcomes	Performance Indicators
Define periodic motion and vibrational motion	1. Define periodic motion and quantities associated with periodic motion like period and amplitude. 2. Describe the characteristics of simple harmonic motion.
Analyze data obtained from digital meters of an experiment to describe simple harmonic motion as a vibration where restoring force is proportional to displacement from equilibrium but in the opposite direction, and express that in a mathematical equation	1. State and describe Hooke's Law ($F = -kx$). 2. Apply Hooke's law to calculate the force exerted by a spring, the spring constant, or the distance by which a spring is stretched or compressed. 3. Calculate the spring constant graphically from the slope of force vs extension graph.

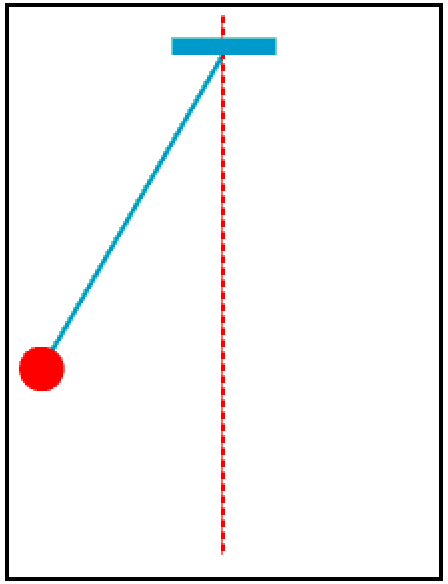
Periodic motion

Define periodic motion and quantities associated with periodic motion like period and amplitude.

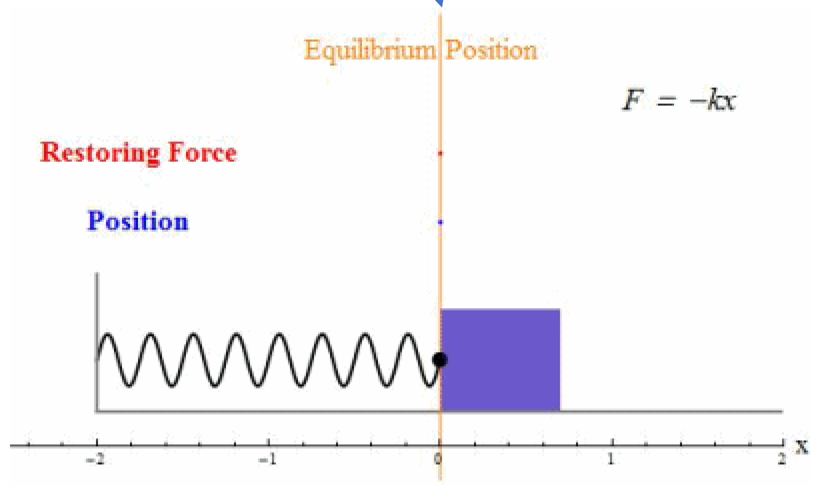
Periodic motion:

The motions, which all repeat in a regular cycle.





At the equilibrium position the net force on the object is zero.



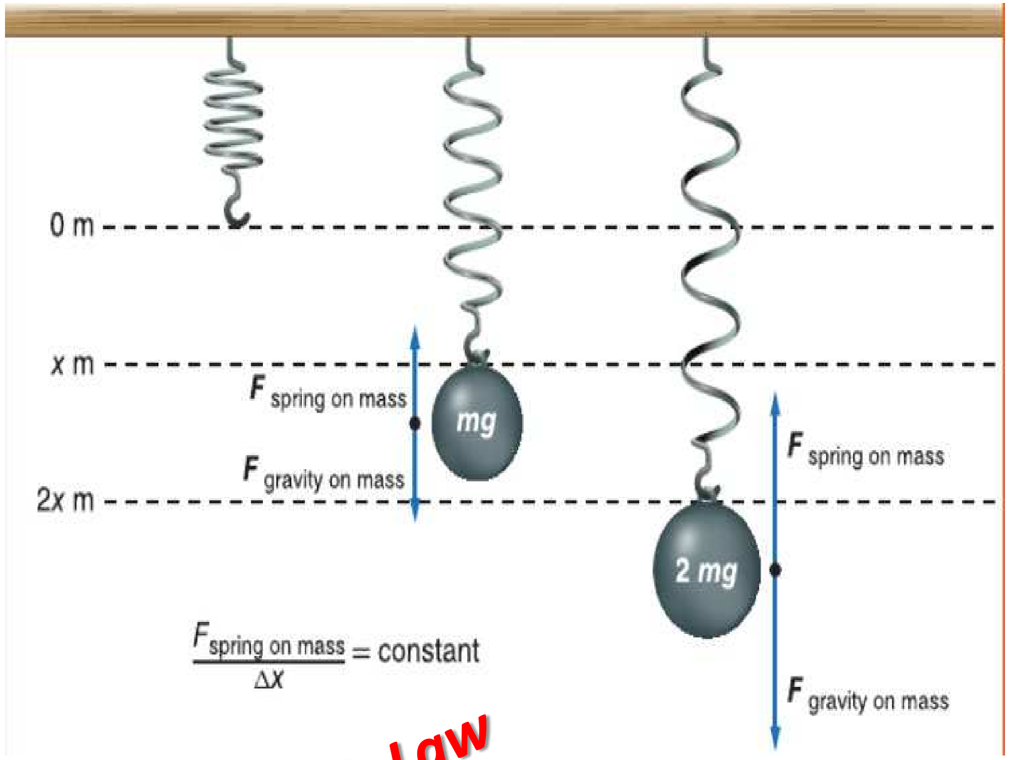
Amplitude: of the motion is the maximum distance the object moves from the equilibrium position

Whenever the object moves away from its equilibrium position, the net force on the system becomes nonzero

Period (T): is the time needed for an object to repeat one complete cycle of the motion.

Simple harmonic motion:

The type of motion that occurs when force acting to restore an object to its equilibrium position is directly proportional to the displacement of the object and acts towards the object's equilibrium position



Hooke's Law

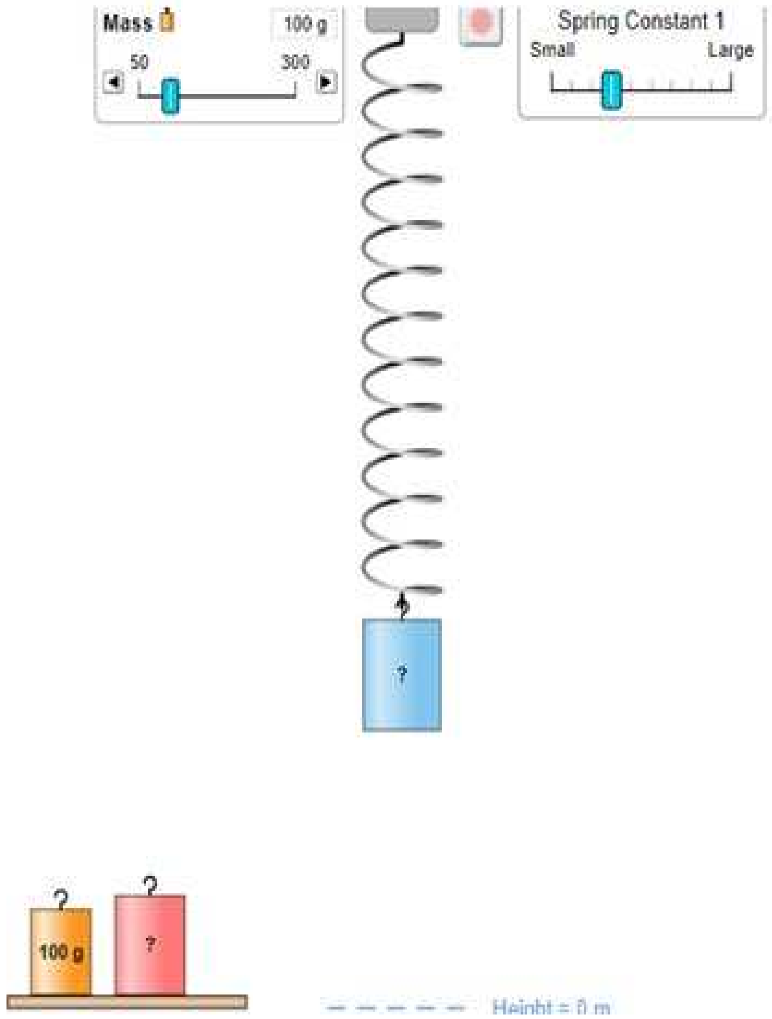
In Figure 1, the force exerted by the spring is directly proportional to the distance the spring is stretched.

If you pull the mass down and release it, the mass will bounce up and down through the equilibrium position.

Finding the spring constant

https://phet.colorado.edu/sims/html/masses-and-springs/latest/masses-and-springs_en.html

	Mass	Force	Stretch (X)
	$m_{(kg)} = \frac{m_{(g)}}{1000}$	$F = mg$ $g = 9.8\ m/s^2$	$x_{(m)} = \frac{x_{(cm)}}{100}$
	(Kg)	(N)	(m)
1			
2			
3			
4			
5			



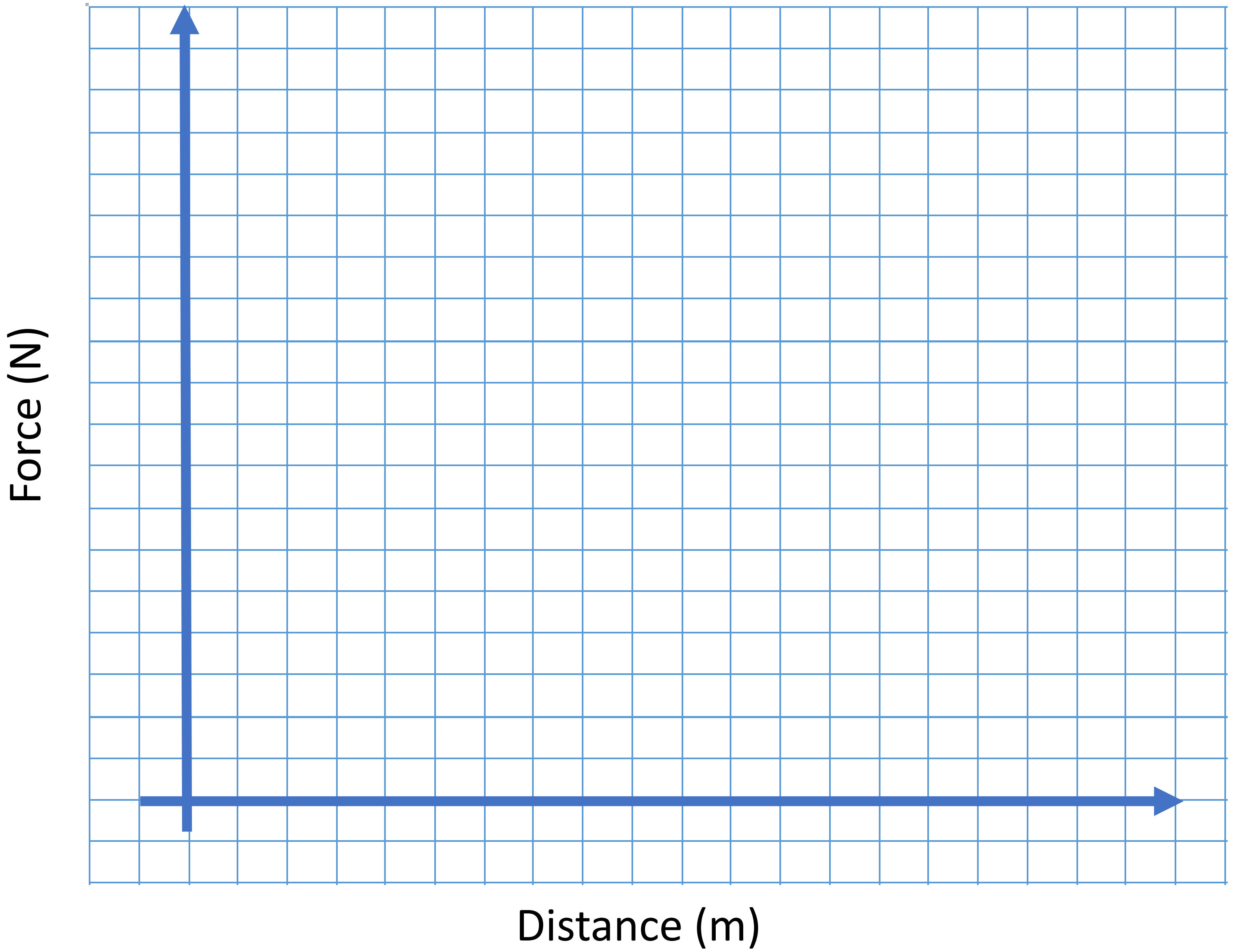
Hooke's Law

Describe and apply Hooke's Law

	Mass (Kg)	Force (N)	Stretch (X) (m)
1			
2			
3			
4			
5			

$$\frac{Force}{\Delta x} = Constant$$

$$Slope = \frac{rise}{run} =$$

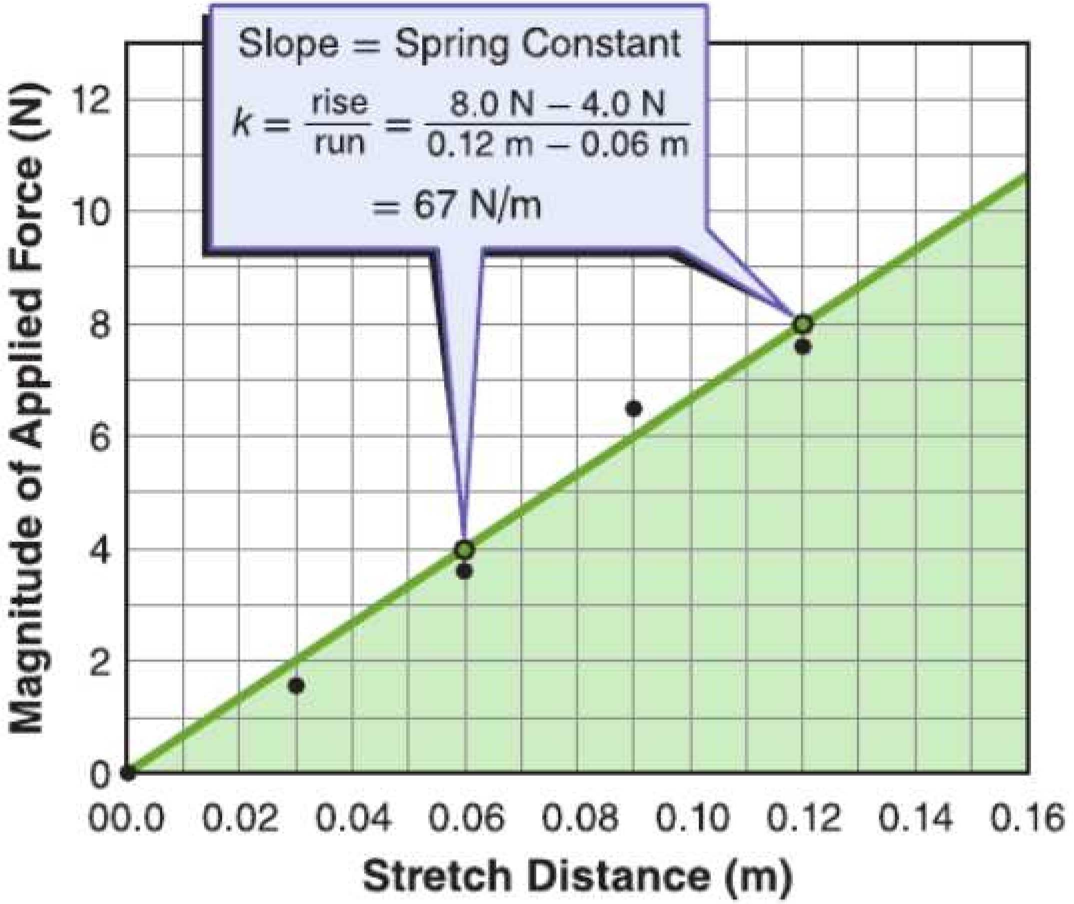


A spring that exerts a force directly proportional to the distance stretched obeys Hooke's law.

Table 1
Force Magnitude-Stretch Distance in a Spring

Stretch Distance (m)	Magnitude of Force Exerted by Spring (N)
0.0	0.0
0.030	1.9
0.060	3.7
0.090	6.3
0.12	7.8

Finding the spring constant



HOOKE'S LAW

The magnitude of the force exerted by a spring is equal to the spring constant times the distance the spring is stretched or compressed from its equilibrium position.

$$F = -kx$$

$\boldsymbol{k}$: The spring constant has the units (N/m)

(K) Depends on:

The stiffness and other properties of the spring,

X: is the distance the spring is stretched from its equilibrium position.

The negative sign in Hooke's law indicates that the force is in the direction opposite the stretch or compression direction.

The force exerted by the spring on the mass is always directed toward the spring's equilibrium position.

Hooke's law and real springs

- Not all springs obey Hooke's law. For example, rubber bands do not.

- Those that do obey Hooke's law are called elastic springs.

- Even for elastic springs, Hooke's law only applies over a limited range of distances.

- If a spring is stretched too far, that spring can become so deformed that the force is not proportional to the displacement.

We say the spring has exceeded its elastic limit.

Practice problems (page 7)

1. What is the spring constant of a spring that stretches 12 cm when an object weighing 24 N is hung from it?

$x = 12\ cm = 0.12\ m$

$F = 24\ N$

$k = ??$

$$F = -kx$$

$$k = -\frac{F}{x} = -\frac{-24}{0.12} = 200\frac{N}{m}$$

3. A spring has a spring constant of 56 N/m. How far will it stretch when a block weighing 18 N is hung from its end?

$x = ??$

$F = 18\ N$

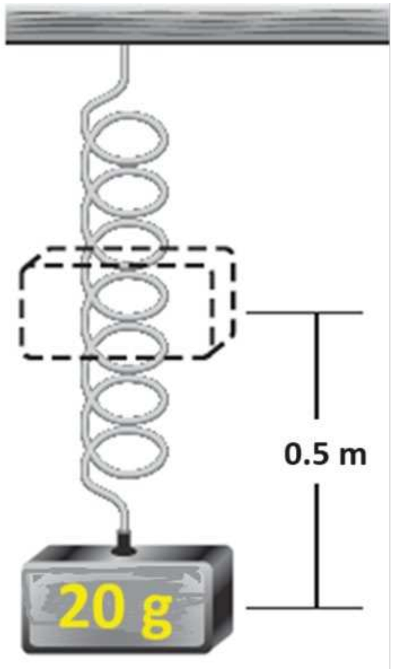
$k = 56\ N/m$

$$F = -kx$$

$$x = -\frac{F}{k} = -\frac{-18}{56} = 0.321\ m$$

Extra question

1. A mass stretches a spring as it hangs from the spring as shown in the figure below. What is the spring constant?



$x = 0.5\ m$

$m = 20\ g$

$k = ??$

$$F = mg$$

$$F = \left(\frac{20}{1000}\right)(9.8) = 0.196\ N$$

$$F = -kx$$

$$k = -\frac{F}{x} = -\frac{-0.196}{0.5} = 0.392\ \frac{N}{m}$$

Practice question

Apply Hooke's law to calculate the force exerted by a spring, the spring constant, or the distance by which a spring is stretched or compressed.

Extra questions

2. What is periodic motion? Give three examples of periodic motion.

Periodic motion is motion that repeats in a regular cycle.

Examples include oscillation of a spring, swing of a simple pendulum, and uniform circular motion.

3. What is the difference between frequency and period? How are they related?

Frequency is the number of cycles or repetitions per second.

period is the time required for one cycle.

Frequency is the inverse of the period.

4. What is simple harmonic motion? Give an example of simple harmonic motion.

Simple harmonic motion is periodic motion that results when the restoring force on an object is directly proportional to its displacement.

A block bouncing on the end of a spring is one example.

5. If a spring obeys Hooke's law, how does it behave?

The spring stretches a distance that is directly proportional to the force applied to it.

6. How can the spring constant of a spring be determined from a graph of force magnitude versus displacement?

The spring constant is the slope of the graph of F versus x.

Extra questions

7. **Car Shocks** Each of the coil springs of a car has a spring constant of 25,000 N/m. How much is each spring compressed if it supports one-fourth of the car's 12,000 N weight?

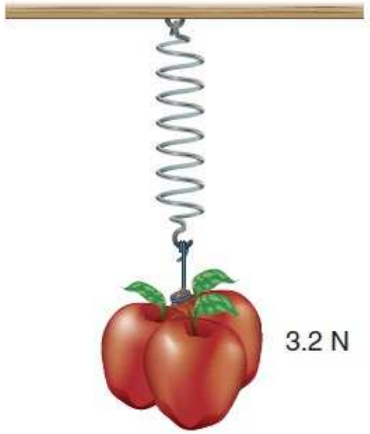
$$F = -kx$$

$$x = -\frac{F}{k} = -\frac{-3000}{25000} = 0.12\,m$$

8. A spring stretches 0.12 m when some apples are suspended from it, as shown in **Figure 21.** What is the spring constant of the spring?

$$F = -kx$$

$$k = -\frac{F}{x} = -\frac{-3.2}{0.12} = 27\,\frac{N}{m}$$



Apply Hooke's law to calculate the force exerted by a spring, the spring constant, or the distance by which a spring is stretched or compressed.

8. What is the magnitude of the force acting on a spring with a spring constant of 275 N/m that is stretched 14.3 cm?

A- 2.81 N

B- 19.2 N

C- 39.3 N

D- 40.2 N

$x = 14.3\ cm$

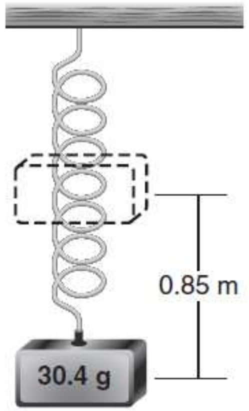
$F = ??$

$x = 14.3\ cm = \frac{14.3}{100} m = 0.143\ m$

$F = -kx$

$F = -(275)(0.143) = -39.325\ N$

9. A mass stretches a spring as it hangs from the spring as shown in the figure below. What is the spring constant?



A- 0.25 N/m

B- 0.35 N/m

C- 26 N/m

D- 35 N/m

$x = 0.85\ m$

$m = 30.4\ g$

$k = ??$

$F = mg$

$F = \left(\frac{30.4}{1000}\right)(9.8) = 0.298$

$F = -kx$

$k = -\frac{F}{x} = -\frac{-0.298}{0.85} = 0.35\ \frac{N}{m}$

Grade 10 ADV Physics

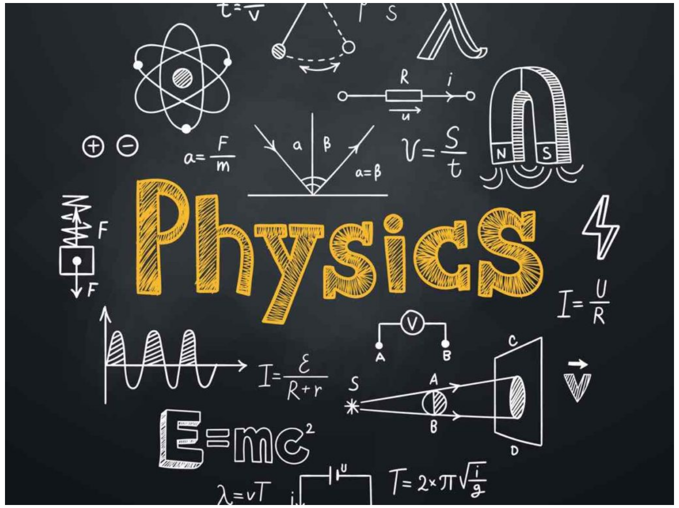
مؤسســة الإمـارات للتعليـم المدرسي
EMIRATES SCHOOLS ESTABLISHMENT

unit 1 | *Vibrations And Waves*

1. Periodic Motion

Part B

Potential energy stored in a spring



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Learning objectives:

Textbook Chapter	Ch 1 – Vibrations and Waves

Learning Outcomes	Performance Indicators
Analyze data obtained from digital meters of an experiment to describe simple harmonic motion as a vibration where restoring force is proportional to displacement from equilibrium but in the opposite direction, and express that in a mathematical equation	4. Derive the equation for potential energy stored in a spring ($PE_{spring} = \frac{1}{2}kx^2$). 5. Apply the equation ($PE_{spring} = \frac{1}{2}kx^2$) to calculate the elastic potential energy stored in a spring or any other unknown quantities. 6. Calculate the potential energy stored in a spring graphically from the area under a force vs extension graph. 7. Describe simple harmonic motion (mass – spring oscillator and a simple pendulum) at maximum displacement and at equilibrium positions in terms of velocity, acceleration, restoring force, and kinetic and potential energy. 8. Apply the law of conservation of energy for both a horizontal oscillating mass – spring system and simple pendulum to relate the total energy of each system at one instant to the total energy at another instant. 9. Describe the energy transformations between potential energy and kinetic energy for both a horizontal oscillating mass – spring system and a simple pendulum. 10. Solve problems related to an oscillating mass – spring system and a simple pendulum to calculate different physical quantities (velocities, kinetic energy, potential energy, period or length of simple pendulum...)

Potential energy:

When you stretch a spring you transfer energy to the spring, giving it elastic potential energy.

The work done by an applied force is equal to the area under the force – distance graph

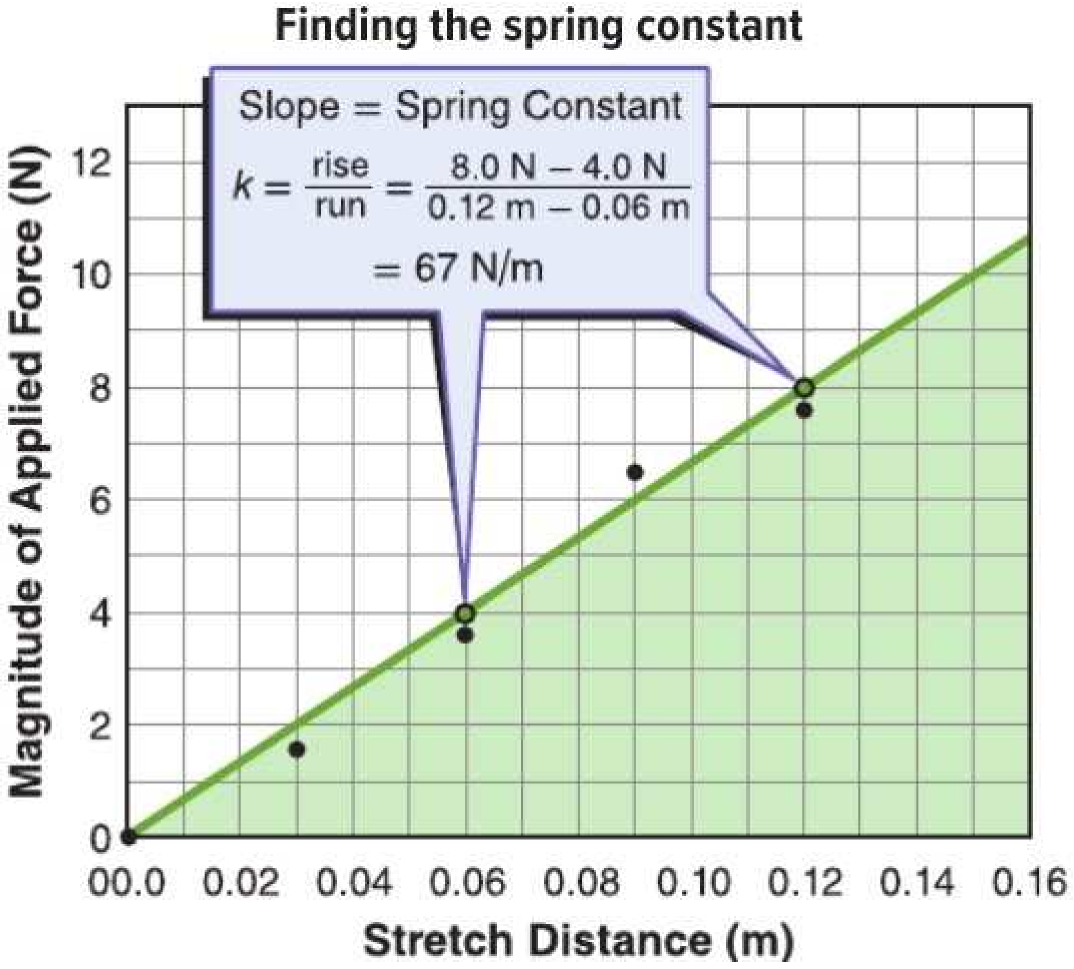
P.E = Area under the graph

P.E = ____________________

POTENTIAL ENERGY IN A SPRING

The potential energy in a spring is equal to one-half times the product of the spring constant and the square of the displacement.

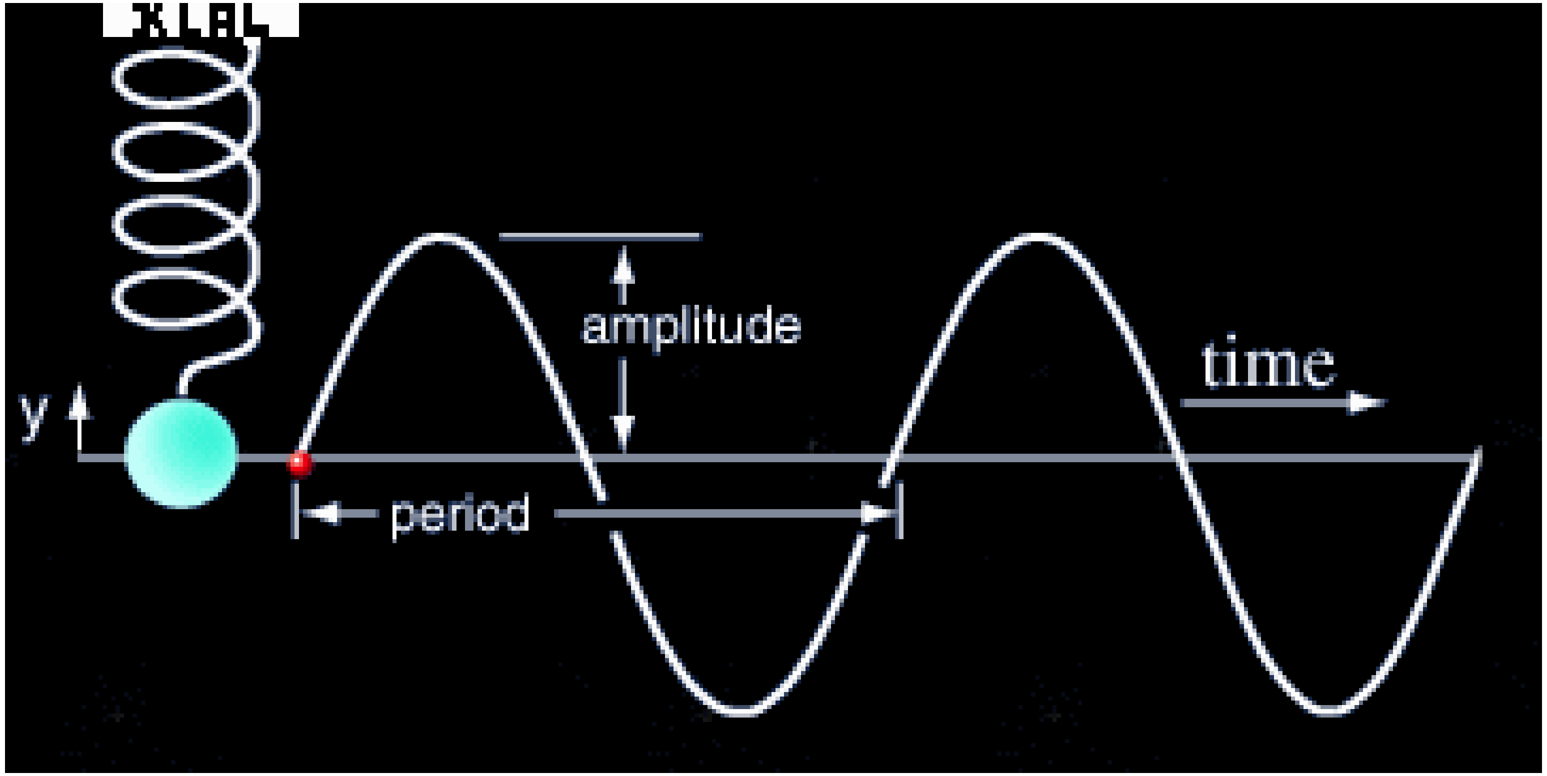
$$PE_{spring} = \frac{1}{2}kx^2$$

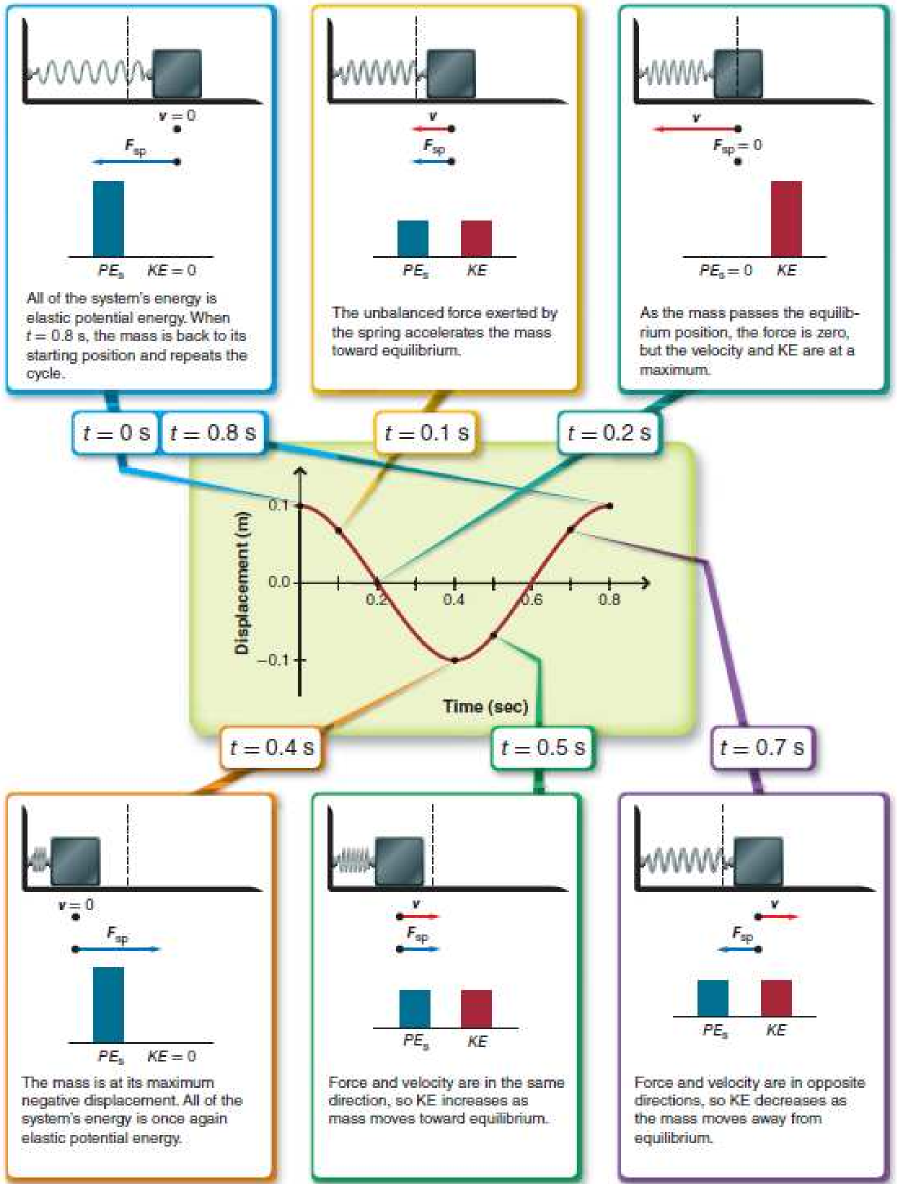


Potential energy in a spring

Derive and apply the equation for potential energy stored in a spring

Mechanical energy of a spring:



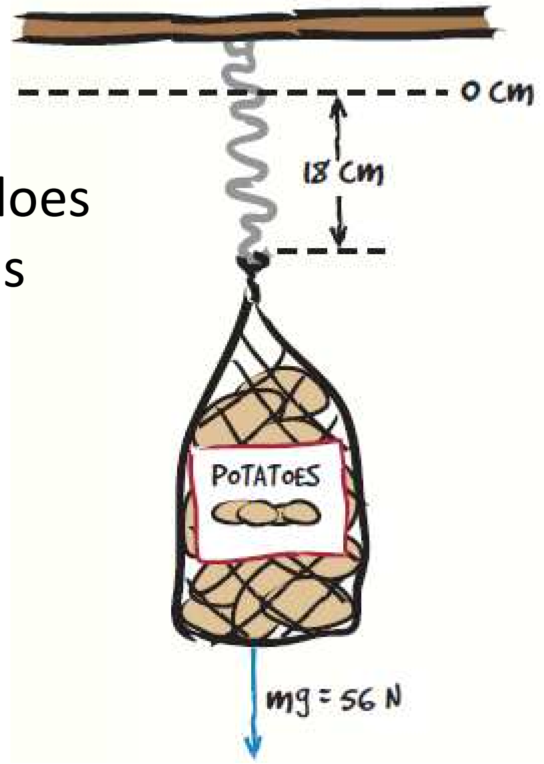


The total mechanical energy of the system is constant throughout the oscillation

Apply the equation ($PE_{spring} = \frac{1}{2}kx^2$) to calculate the elastic potential energy stored in a spring or any other unknown quantities.

Example problem 1 (page 7)

A spring stretches by 18 cm when a bag of potatoes weighing 56 N is suspended from its end.



a. Determine the spring constant.

$x = 0.18\ m$

$F = 56\ N$

$k = ??$

$$F = -kx$$

$$k = -\frac{F}{x} = -\frac{-56}{0.18} = 311\frac{N}{m}$$

b. How much elastic potential energy does the spring have when it is stretched this far?

$$PE_{spring} = \frac{1}{2}kx^2$$

$$PE_{spring} = \frac{1}{2}(3.11)(0.18)^2 = 0.05\ J$$

Apply the equation ($PE_{spring} = \frac{1}{2}kx^2$) to calculate the elastic potential energy stored in a spring or any other unknown quantities.

Practice problems (page 7)

2. A spring with k = 144 N/m is compressed by 16.5 cm. What is the spring's elastic potential energy?

$x = 0.165\ m$

$P.E = ??$

$k = 144\ N/m$

$$PE_{spring} = \frac{1}{2}kx^2$$

$$PE_{spring} = \frac{1}{2}(144)(0.165)^2 = 1.96\ J$$

4. **CHALLENGE** A spring has a spring constant of 256 N/m. How far must it be stretched to give it an elastic potential energy of 48 J?

$x = ??$

$P.E = 48$

$k = 256\ N/m$

$$PE_{spring} = \frac{1}{2}kx^2$$

$$\frac{(2)PE_{spring}}{k} = x^2$$

$$x = \sqrt{\frac{(2)PE_{spring}}{k}} = \sqrt{\frac{(2)48}{256}} = 0.61\ m$$

Apply the equation ($PE_{spring} = \frac{1}{2}kx^2$) to calculate the elastic potential energy stored in a spring or any other unknown quantities.

Extra question

1. Force magnitude-versus-length data for a spring are plotted on the graph in the Figure.

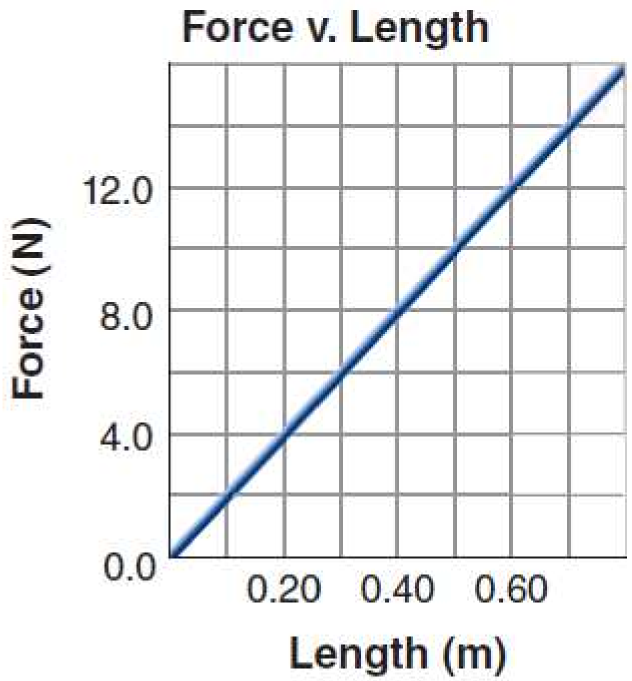
a. What is the spring constant of the spring?

$$k = slope = \frac{12 - 4}{0.6 - 0.2} = 20\ N/m$$

b. What is the spring's potential energy when it is stretched to a length of 0.50 m?

$$PE_{spring} = \frac{1}{2}kx^2$$

$$PE_{spring} = \frac{1}{2}(20)(0.5)^2 = 2.5\ J$$



Practice question

Potential energy in a spring

Apply the equation ($PE_{spring} = \frac{1}{2}kx^2$) to calculate the elastic potential energy stored in a spring or any other unknown quantities.

Extra questions

2. A spring with a spring constant of 27 N/m is stretched 16 cm. What is the spring's potential energy?

$$P.E = \frac{1}{2}kx^2$$

$$P.E = \frac{1}{2}(27)(0.16)^2 = 0.35\ J$$

3. How can a spring's potential energy be determined from a graph of force magnitude versus displacement?

The potential energy is the area under the curve of the graph of F versus x.

4. **Rocket Launcher** A toy rocket launcher contains a spring with a spring constant of 35 N/m. How far must the spring be compressed to store 1.5 J of energy?

$$PE_{spring} = \frac{1}{2}kx^2$$

$$\frac{(2)PE_{spring}}{k} = x^2$$

$$x = \sqrt{\frac{(2)PE_{spring}}{k}} = \sqrt{\frac{(2)1.5}{35}} = 0.29\ m$$

Apply the equation ($PE_{spring} = \frac{1}{2}kx^2$) to calculate the elastic potential energy stored in a spring or any other unknown quantities.

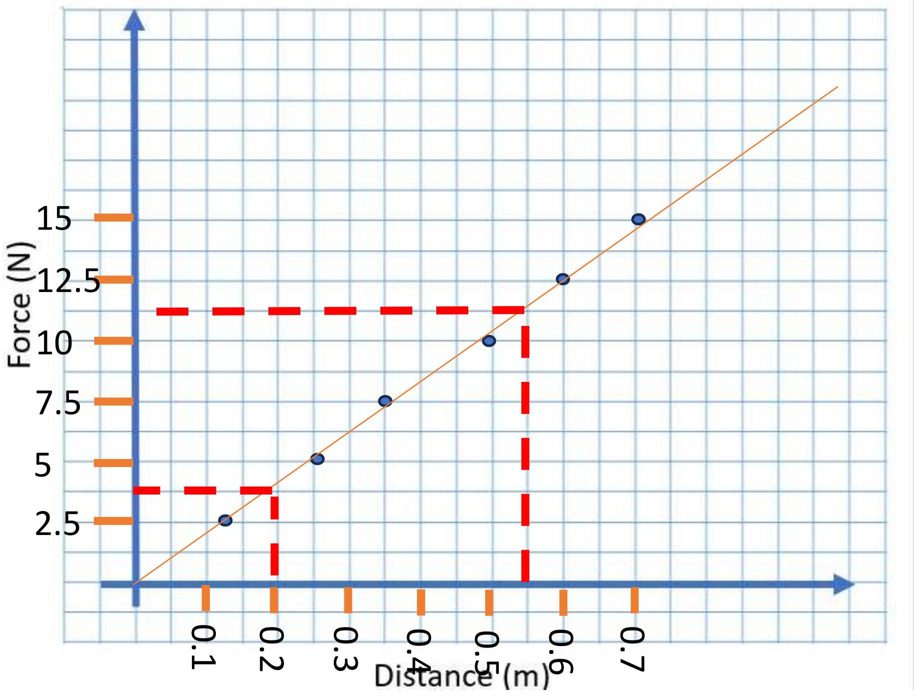
Extra question

5. **Make and Use Graphs** Several weights were suspended from a spring, and the resulting extensions of the spring were measured. **Table 2** shows the collected data.

Table 2 Weights on a Spring

Force magnitude, *F* (N)	Extension, *x* (m)
2.5	0.12
5.0	0.26
7.5	0.35
10.0	0.50
12.5	0.60
15.0	0.71

a. Make a graph of the magnitude of the force applied to the spring versus the spring length. Plot the force on the *y*-axis.



b. Determine the spring constant from the graph.

$$k = slope = \frac{11.25 - 3.75}{0.55 - 0.2} = 21.42\ N/m$$

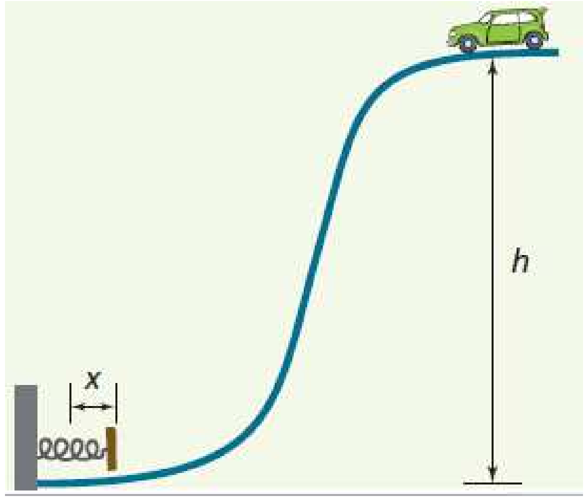
c. Using the graph, find the elastic potential energy stored in the spring when it is stretched to 0.50 m.

$$PE_{spring} = \frac{1}{2}kx^2 \quad = \frac{1}{2}(21.42)(0.5)^2 = 2.68\ J$$

Apply the equation ($PE_{spring} = \frac{1}{2}kx^2$) to calculate the elastic potential energy stored in a spring or any other unknown quantities.

Physics Challenge (page 7)

A car of mass m rests at the top of a hill of height h before rolling without friction into a crash barrier located at the bottom of the hill. The crash barrier contains a spring with a spring constant k, which is designed to bring the car to rest with minimum damage.



1. Determine, in terms of *m, h, k,* and *g,* the maximum distance (*x)* the spring will be compressed when the car hits it.

Conservation of energy implies that the car's gravitational potential energy at the top of the hill will be equal to the spring's elastic potential energy when it has brought the car to rest. The equations for these energies can be set equal and solved for x.

$$PE_g = PE_s \qquad \Longrightarrow mgh = \frac{1}{2}kx^2 \qquad \Longrightarrow x = \sqrt{\frac{2mgh}{k}}$$

2. If the car rolls down a hill that is twice as high, by what factor will the spring compression increase?

The height is doubled, and x is proportional to the square root of the height, so x will increase by $\sqrt{2}$

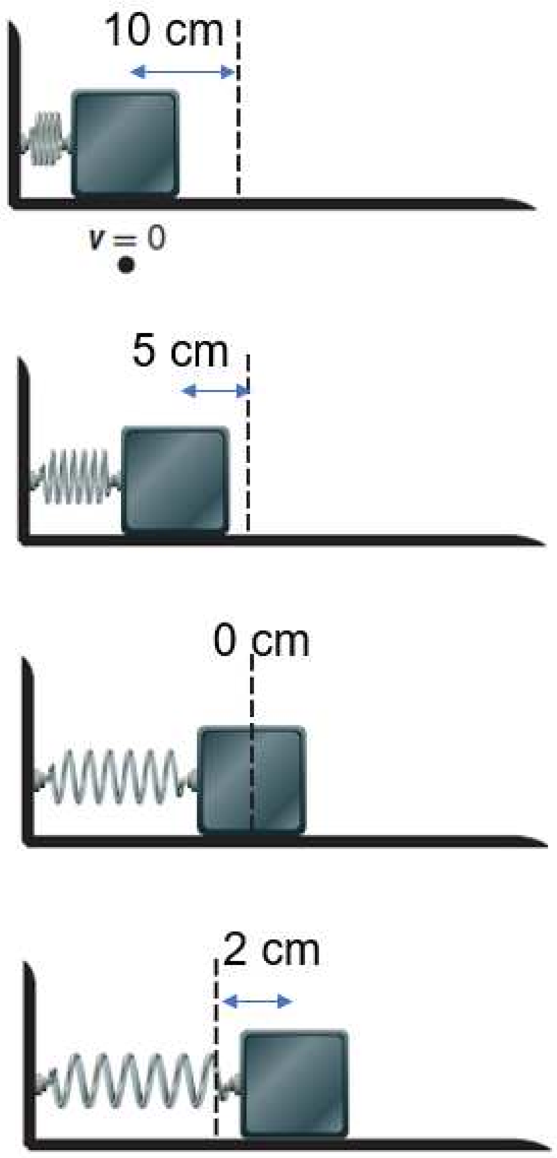
3. What will happen after the car has been brought to rest?

In the case of an ideal spring, the spring will propel the car back to the top of the hill.

Apply the equation ($PE_{spring} = \frac{1}{2}kx^2$) to calculate the elastic potential energy stored in a spring or any other unknown quantities.

Extra question

6. A spring has a spring constant of 300 N/m and a mass of 5 Kg as shown in the picture, the spring is compressed to a distance of 10 cm then it will be released find each of the following:



A- find the P.E and the K.E when the spring is compressed 10 cm:

$$P.E = \frac{1}{2}kx^2 \quad = \frac{1}{2}(300)(0.1)^2 = 1.5\,J$$

$K.E = 0\,J$ not moving

B- find the P.E and the K.E when the spring is compressed 5 cm:

$$P.E = \frac{1}{2}kx^2 \quad = \frac{1}{2}(300)(0.05)^2 = 0.375\,J$$

$$K.E = 1.5 - 0.375 = 1.125\,J$$

C- find the P.E and the K.E when the spring reach the equilibrium position :

$$P.E = 0\,J$$

$$K.E = 1.5\,J$$

D- find the P.E and the K.E when the spring is stretched 2 cm:

$$P.E = \frac{1}{2}kx^2 \quad = \frac{1}{2}(300)(0.02)^2 = 0.06\,J$$

$$K.E = 1.5 - 0.06 = 1.44J$$

Potential energy in a spring

Apply the equation ($PE_{spring} = \frac{1}{2}kx^2$) to calculate the elastic potential energy stored in a spring or any other unknown quantities.

7. A spring with a spring constant of 350 N/m pulls a door closed. How much work is done as the spring pulls the door at a constant velocity from an 85.0 cm stretch to a 5.0 cm stretch?

A- 110 N/m

B- 130 J

C- 220 N/m

D- 1.1×10^3 J

$x_1 = 85\ cm$

$x_2 = 5\ cm$

$W = ??$

$k = 350\ N/m$

$$W = -\Delta PE_{spring}$$

$$W = -\frac{1}{2}k(x_2^2 - x_1^2)$$

$$W = -\frac{1}{2}(350)(0.05^2 - 0.85^2) = 126\ J$$

8. What is the value of the spring constant of a spring with a potential energy of 8.67 J when it's stretched 247 mm?

A- 70.2 N/m

B- 71.1 N/m

C- 142 N/m

D- 284 N/m

$$PE_{spring} = \frac{1}{2}kx^2$$

$$k = \frac{(2)PE_{spring}}{x^2} = \frac{(2)(8.67)}{(0.247)^2} = 284.2\ N/m$$

Grade 10 ADV Physics

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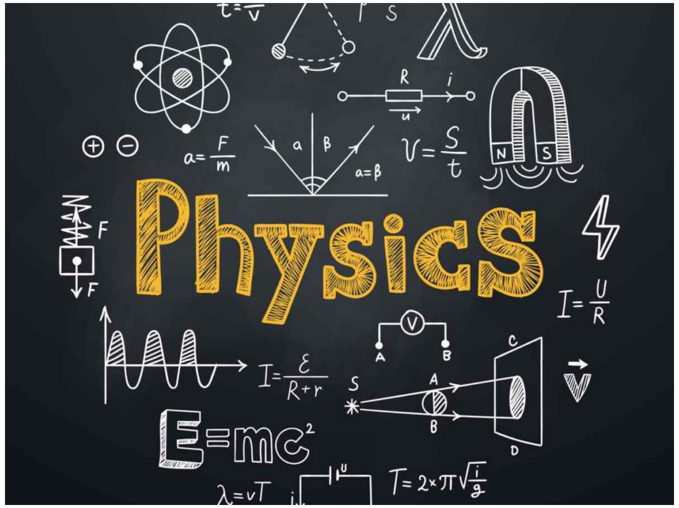
unit 1

Vibrations And Waves

1. Periodic Motion

Part C

Pendulums



Mutasem Jarwan

Learning objectives:

Textbook Chapter	Ch 1 – Vibrations and Waves

Learning Outcomes	Performance Indicators
Develop a kit, experiment, presentation or a simulation to describe simple harmonic motion and determine the factors simple harmonic motion depends on	1. Describe the motion of an oscillating simple pendulum.
Develop a kit, experiment, presentation or a simulation that explains elements that the period of oscillation of a simple harmonic motion depends on	13. Apply the equation ($T = 2\pi\sqrt{\frac{l}{g}}$) to calculate the period of a simple pendulum for small-angle oscillations. 14. Determine what affects the period of a simple pendulum.
Develop a kit, experiment, presentation or a simulation to describe simple harmonic motion and determine the factors simple harmonic motion depends on	2. Define resonance and list some examples and consequences.
Design and make a pendulum clock and use it for measuring time in a race	Conduct a simple experiment to investigate the variables that affect a pendulum's period

Simple pendulum:

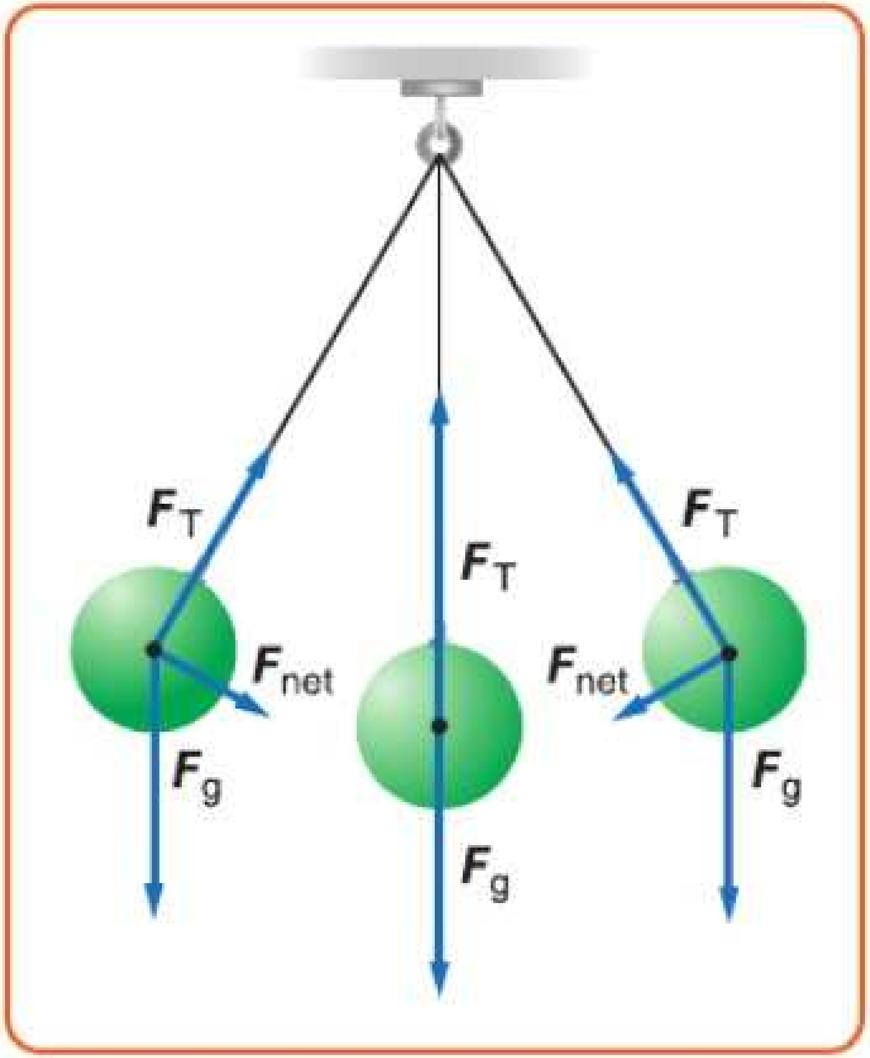
a massive object, called the bob, suspended by a string or a light rod of length l.

What factors the period of a pendulum depend on?

Experiment (make a pendulum) and calculate the time period

____

____

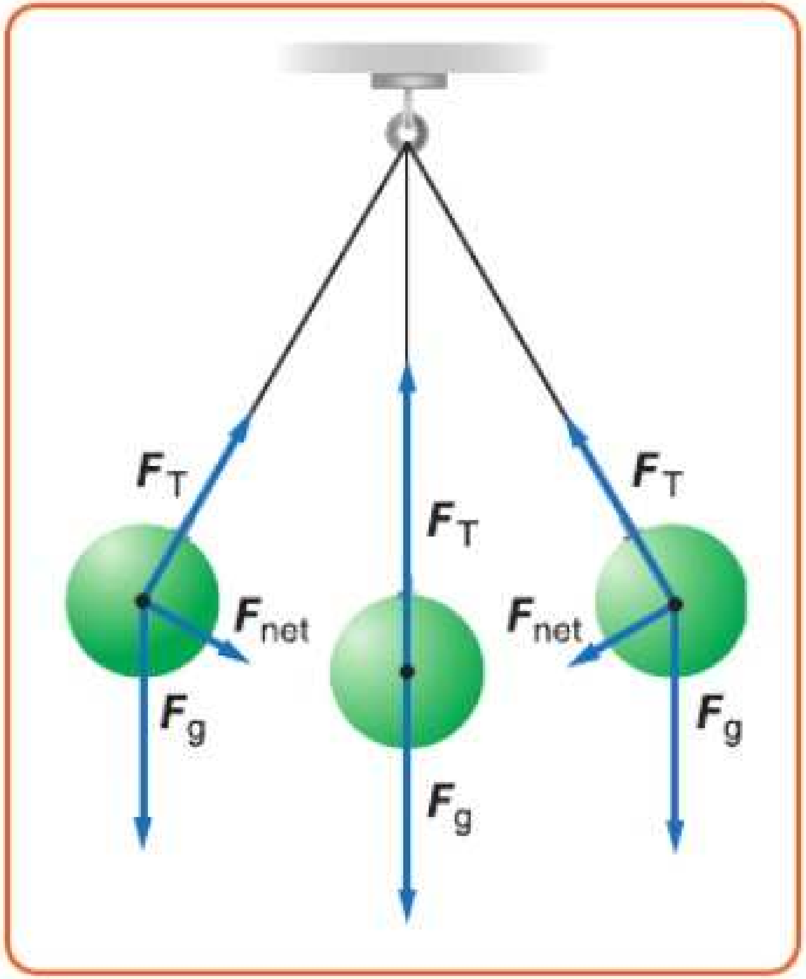


Simple pendulum:

For small angles (less than about 15°), the restoring force is proportional to the displacement from equilibrium.

Similar to the motion of the mass on a spring discussed earlier, the motion of the pendulum is simple harmonic motion.

The period of a pendulum is given by the following equation.



PERIOD OF A PENDULUM

The period of a pendulum is equal to 2π times the square root of the length of the pendulum divided by the gravitational field.

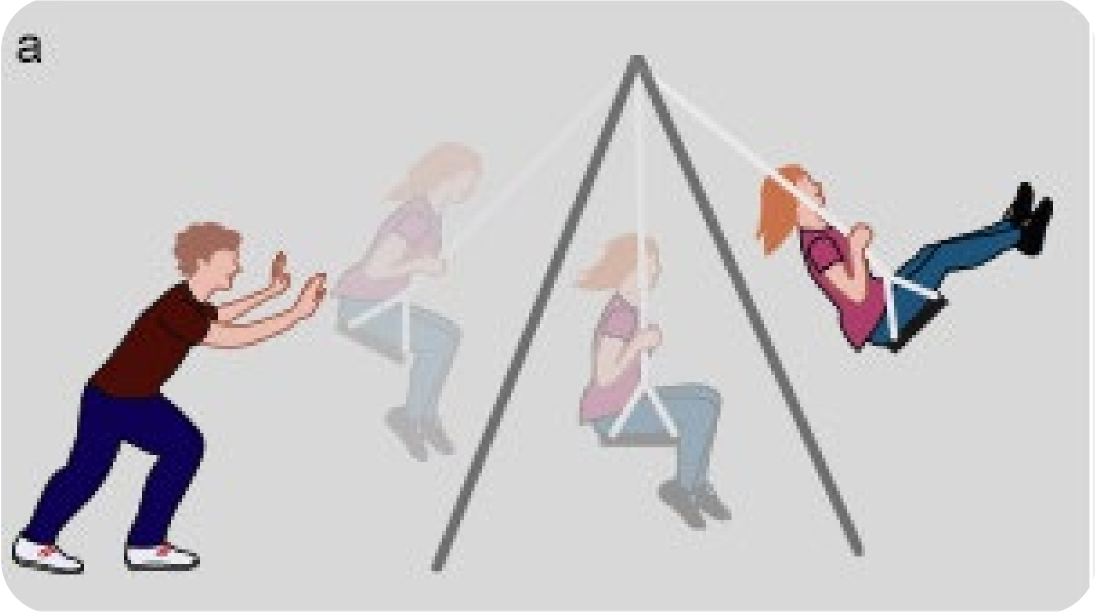
$$T = 2\pi\sqrt{\frac{l}{g}}$$

The period depends only on the length of the pendulum and the gravitational field, not on the mass of the bob or the amplitude of oscillation.

Resonance :

Occurs when forces are applied to a vibrating or oscillating object at time intervals equal to the period of oscillation

As a result, the amplitude of the vibration increases.



Example problem 2 (page 9)

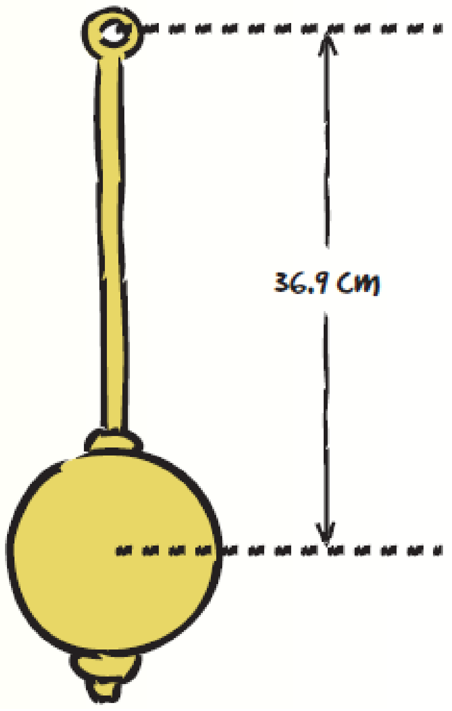
A pendulum with a length of 36.9 cm has a period of 1.22 s. What is the gravitational field at the pendulum's location?

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

$$T^2 = 4\pi^2\frac{l}{g}$$

$$g = 4\pi^2\frac{0.369}{(1.22)^2} = 9.78\ N/kg$$

$$g = 4\pi^2\frac{l}{T^2}$$



Practice problems (page 9)

5. What is the period on Earth of a pendulum with a length of 1.0 m?

$$T = 2\pi\sqrt{\frac{l}{g}} \qquad = 2\pi\sqrt{\frac{1}{9.8}} = 2\ s$$

6. How long must a pendulum be on the Moon, where g = 1.6 N/kg, to have a period of 2.0 s?

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

$$T^2 = 4\pi^2\frac{l}{g}$$

$$gT^2 = 4\pi^2 l$$

$$l = \frac{gT^2}{4\pi^2}$$

$$l = \frac{(1.6)(2)^2}{4\pi^2} = 0.16\ m$$

Practice problems (page 9)

7. **CHALLENGE** On a planet with an unknown value of g, the period of a 0.75 m long pendulum is 1.8 s. What is g for this planet?

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

$$T^2 = 4\pi^2\frac{l}{g}$$

$$g = 4\pi^2\frac{0.75}{(1.8)^2} = 9.1\ N/kg$$

$$g = 4\pi^2\frac{l}{T^2}$$

Practice question

Extra questions

1. What conditions are necessary for resonance to occur?

Resonance will occur when a force is applied to an oscillating system at the same frequency as the natural frequency of the system.

2. Does the period of a pendulum depend on the mass of the bob? The length of the string? The amplitude of oscillation? What else does the period depend on?

mass of the bob: No

length of the string : yes

amplitude of oscillation : No

What else

The acceleration of gravity, g

3. How long must a pendulum be to have a period of 2.3 s on the Moon, where g = 1.6 N/kg?

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

$$T^2 = 4\pi^2\frac{l}{g}$$

$$gT^2 = 4\pi^2 l$$

$$l = \frac{gT^2}{4\pi^2}$$

$$l = \frac{(1.6)(2.3)^2}{4\pi^2} = 0.21\ m$$

Extra questions

4. **Ranking Task** Rank the following pendulums according to period, from least to greatest. Specifically indicate any ties.

A. 10 cm long, mass = 0.25 kg

B. 10 cm long, mass = 0.35 kg

C. 20 cm long, mass = 0.25 kg

D. 20 cm long, mass = 0.35 kg

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

The period of the pendulum doesn't depend on the mass, and directly proportional to the length of the pendulum (higher length higher period)

(C = D) > (A = B)

5. What is the length of a pendulum that has a period of 4.89 s?

A- 5.94 m

B- 11.9m

C- 24.0 m

D- 37.3 m

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

$$T^2 = 4\pi^2\frac{l}{g}$$

$$gT^2 = 4\pi^2 l$$

$$l = \frac{gT^2}{4\pi^2}$$

$$l = \frac{(9.8)(4.89)^2}{4\pi^2} = 5.94\ m$$

6. What is the correct rearrangement of the formula for the period of a pendulum to find the length of the pendulum?

A- $l = \frac{4\pi^2 g}{T^2}$

B- $l = \frac{gT}{4\pi^2}$

C- $l = \frac{T^2 g}{(2\pi)^2}$

D- $l = \frac{Tg}{2\pi}$

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

$$T^2 = 4\pi^2\frac{l}{g}$$

$$gT^2 = 4\pi^2 l$$

$$l = \frac{gT^2}{4\pi^2}$$

Check Your Progress (page 9)

8. Periodic Motion Explain why a pendulum is an example of periodic motion.

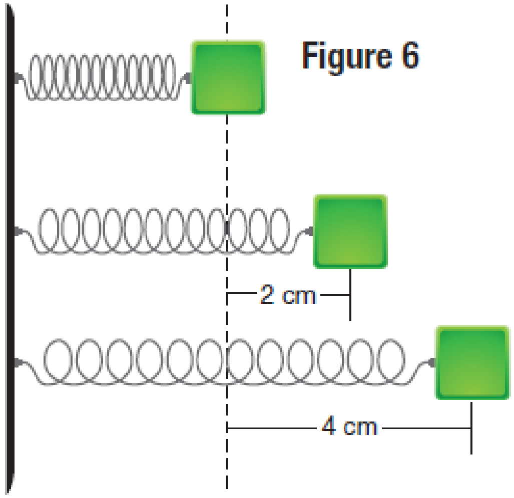
The pendulum swings back and forth, following the same path each cycle and requiring the same amount of time to complete each cycle.

9. Energy of a Spring The springs shown in **Figure 6** are identical. Contrast the potential energies of the bottom two springs.

The energy of the bottom spring is 4.0 times greater than the energy of the middle spring.

$$\frac{P.E_1}{P.E_2} = \frac{\frac{1}{2}kx_1^2}{\frac{1}{2}kx_2^2}$$

$$\frac{P.E_1}{P.E_2} = \frac{x_1^2}{x_2^2} = \frac{0.4^2}{0.2^2} = 4$$



Check Your Progress (page 9)

10. Hooke's Law Objects of various weights are hung from a rubber band that is suspended from a hook. The weights of the objects are plotted on a graph against the stretch of the rubber band. How can you tell from the graph whether the rubber band obeys Hooke's law?

If the graph is a straight line, the rubber band obeys Hooke's law. If the graph is curved, it does not.

11. Pendulum How must the length of a pendulum be changed to double its period? How must the length be changed to halve the period?

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

$$\frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}}$$

To double the period

$$\frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}} = 2$$

$$\frac{l_2}{l_1} = 4$$

The length must be quadrupled

To halve the period

$$\frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}} = \frac{1}{2}$$

$$\frac{l_2}{l_1} = \frac{1}{4}$$

The length must be reduced to ¼ of its original length

Check Your Progress (page 9)

12. Resonance If a car's wheel is out of balance, the car will shake strongly at a specific speed but not at a higher or lower speed. Explain.

At that speed, the tire's rotation frequency matches the resonant frequency of the car.

13. Critical Thinking How is uniform circular motion similar to simple harmonic motion? How are they different?

Both are periodic motions.

In uniform circular motion, the accelerating force is not proportional to the displacement.

Also, simple harmonic motion is one-dimensional and uniform circular motion is two-dimensional.