AP Physics - Unit 6 - SHM

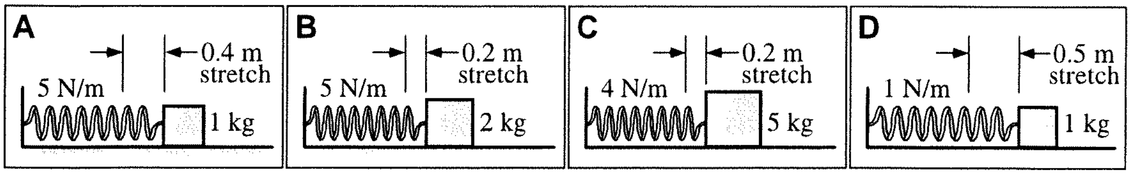
Tipper #1 - unit 6

B7 Oscillatory Motion

#1

B7-RT01: Mass on Horizontal Spring Systems I—Oscillation Frequency

A block rests on a frictionless surface and is attached to the end of a spring. The other end of the spring is attached to a wall. Four block–spring systems are considered. The springs are stretched to the right by the distances shown in the figures and then released from rest. The blocks oscillate back and forth. The mass and force constant of the spring are given for each case.



Rank the frequency of the oscillatory motion of the block.

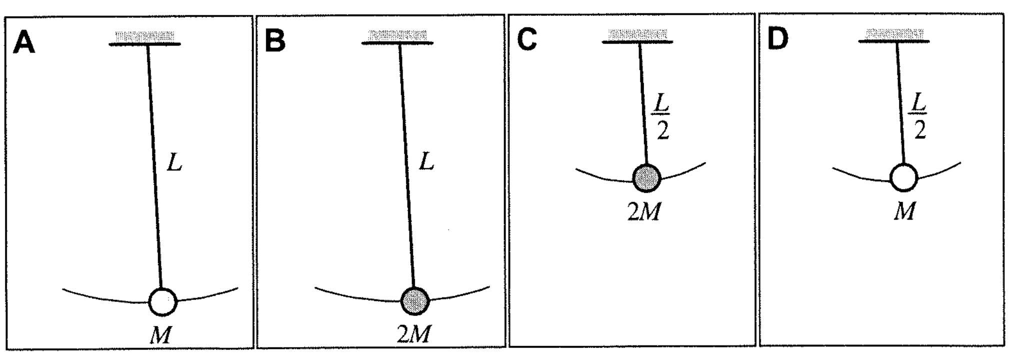
1 Greatest	2	3	4 Least	OR	All the same	All zero	Cannot determine

Explain your reasoning.

#2

B7-RT02: Swinging Simple Pendula—Oscillation Frequency

The simple pendulum shown in Case A consists of a mass *M* attached to a massless string of length *L*. If the mass is pulled to one side a small distance and released, it will swing back and forth. Cases B, C, and D are variations of this system.



Rank the oscillation frequency of the masses.

1 Greatest	2	3	4 Least	OR	All the same	Cannot determine

Explain your reasoning.

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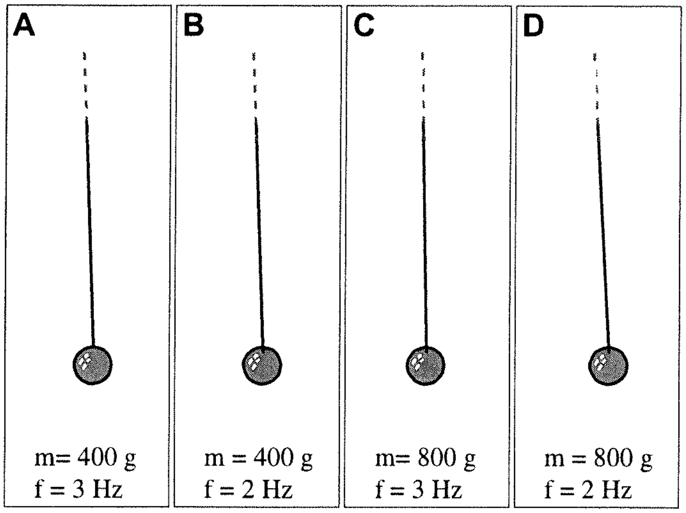
#3 **B7-RT03: SWINGING SPHERE ON LONG STRINGS—TIME FOR ONE SWING**

Metal spheres are hung on the ends of long strings. The spheres have been pulled to the side and released so that they are swinging back and forth. The mass of the sphere and the frequency of the swing are given in each case.



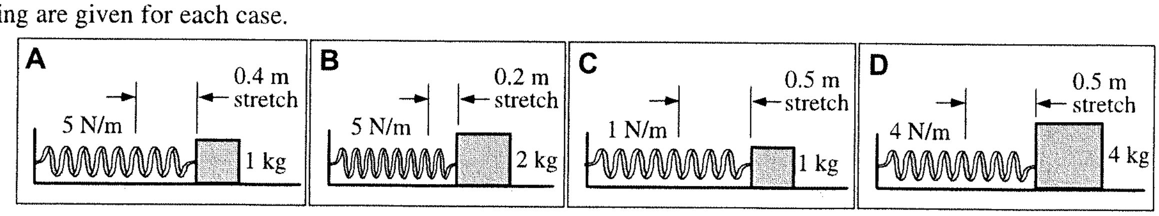
Rank the time it takes to make one complete swing.

☐	☐	☐	☐	OR	☐	☐	☐
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

#4 **B7-RT04: MASS ON HORIZONTAL SPRING SYSTEMS II—PERIOD OF OSCILLATING MASS**

A block rests on a frictionless surface and is attached to the end of a spring. The other end of the spring is attached to a wall. Four block–spring systems are considered. The springs are stretched to the right by the distances shown in the figures and then released from rest. The blocks oscillate back and forth. The mass and force constant of the spring are given for each case.



Rank the period (the time it takes the block to complete one cycle) of the oscillatory motion of the block.

☐	☐	☐	☐	OR	☐	☐	☐
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

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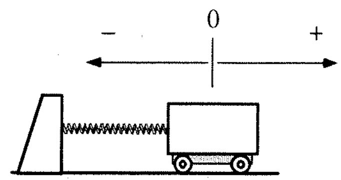
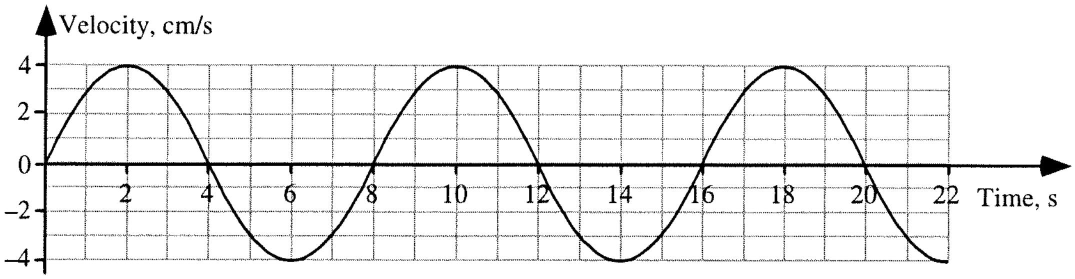
#5

B7-CRT06: VELOCITY-TIME GRAPH—FREQUENCY AND PERIOD

A cart attached to a spring is displaced from equilibrium and then released. There is no friction. A graph of velocity as a function of time for the cart is shown. The arrows and signs above the cart indicate the positive and negative directions for the position of the cart.





(a) What is the period of the motion for this cart?
Explain your reasoning.

(b) What is the frequency of the motion for this cart?
Explain your reasoning.

(c) In which direction was the cart displaced from equilibrium before it was released?
Explain your reasoning.

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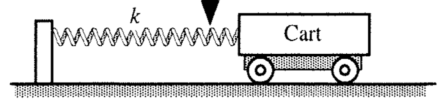
#6 B7-QRT05: Position-Time Graph of a Cart Attached to a Spring—Mass and Period

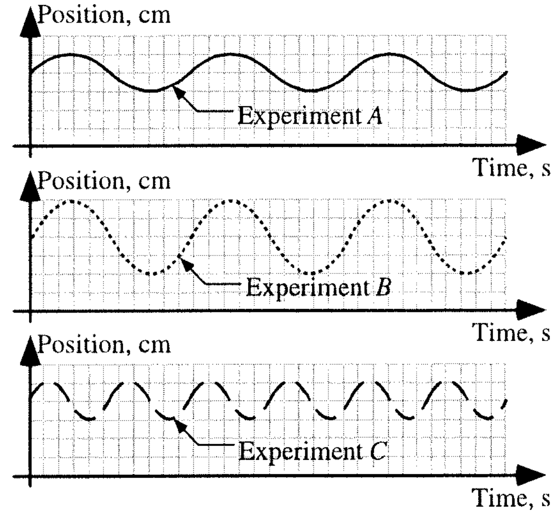
A frictionless cart of mass m is attached to a spring with spring constant k. When the cart is displaced from its rest position and released, it oscillates with a period τ that is given by



$$\tau = 2\pi\sqrt{m/k}$$

The graph of the position of this cart as a function of time is labeled Experiment A. Graphs for two other experiments that use different masses are shown below this. The same spring is used in all three experiments.

(a) Compared to Experiment A, in Experiment B the cart has



(i) *twice* as much mass.
(ii) *four times* as much mass.
(iii) *one-half* the mass.
(iv) *one-fourth* the mass.
(v) *the same* mass.

Explain your reasoning.

(b) Compared to Experiment A, in Experiment C the cart has

(i) *twice* as much mass.
(ii) *four times* as much mass.
(iii) *one-half* the mass.
(iv) *one-fourth* the mass.
(v) *the same* mass.

Explain your reasoning.

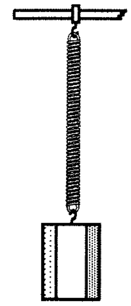
(c) Suppose that in a fourth experiment (Experiment D), the mass used in Experiment A was doubled and the spring was replaced with a spring with spring constant $2k$. The period in Experiment D would be

(i) *the same* as the period in Experiment A.
(ii) *double* the period in Experiment A.
(iii) *four times* the period in Experiment A.
(iv) *one-half* the period in Experiment A.
(v) *one-fourth* the period in Experiment A.

Explain your reasoning.

#7 **B7-SCT07: MASS ON A VERTICAL SPRING—ACCELERATION**

A mass is oscillating up and down at the end of a spring. Three students are discussing the acceleration of the mass:



Aileen: *"I think the acceleration of the mass will be largest when it is at the end of its oscillations turning around. That's where the spring is stretched the most."*

Brigitte: *"No, I don't see how that can be. Its velocity is zero at that point, so its acceleration has to be zero also."*

Chandra: *"I disagree. The acceleration is largest when the mass is halfway between the middle and the end because that is where its speed is changing the most."*

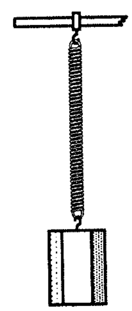
With which, if any, of these students do you agree?

Aileen _____ Brigitte _____ Chandra _____ None of them_____

Explain your reasoning.

#8 **B7-SCT12: MASS OSCILLATING ON A VERTICAL SPRING—ENERGY**

A mass hanging on a vertical spring is pulled down a distance *d* and released. The mass undergoes simple harmonic motion. Three physics students make the following contentions about this situation:



Alexandra: *"The maximum kinetic energy of this mass-spring system is fixed by the properties of the system and does not depend on how far down the mass is pulled. How far the mass is pulled will only affect the frequency of the oscillations."*

Bruno: *"No, that can't be right since increasing the amplitude, or how far down it is pulled, increases the potential energy of the system. I don't think the amplitude has any effect on the frequency."*

Chung: *"I agree in part with both of you. I think the amplitude does affect the maximum kinetic energy, but I also think it affects the frequency of the oscillations."*

With which, if any, of these students do you agree?

Alexandra _____ Bruno _____ Chung _____ None of them_____

Explain your reasoning.

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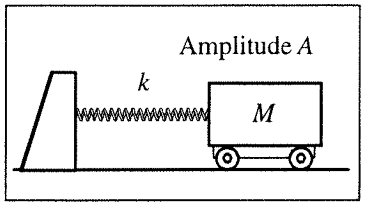
#9

B7-LMCT08: Mass Connected to a Horizontal Spring—Frequency

A mass-spring system consists of a spring with a spring constant (or stiffness) k and unstretched length L, connected to a cart of mass M resting on a horizontal frictionless surface as shown. If the cart is pulled to one side a small distance and released, it will oscillate back and forth with amplitude A and frequency f.



Identify from choices (i)–(iv) how each change described below will affect the frequency of the oscillating mass-spring system.

Compared to the case above, this change will:

(i) ***increase*** the frequency of the system.
(ii) ***decrease*** the frequency of the system.
(iii) ***have no effect*** on the frequency of the system.
(iv) *have an* ***indeterminate*** effect on the frequency of the system.

Each of these modifications is the only change to the initial situation described above.

(a) The mass is increased. ______
Explain your reasoning.

(b) The spring constant or stiffness is increased. ______
Explain your reasoning.

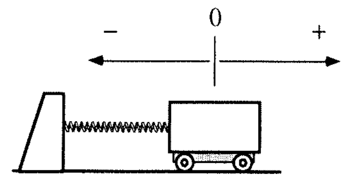
(c) The mass is pulled a little farther and then released. ______
Explain your reasoning.

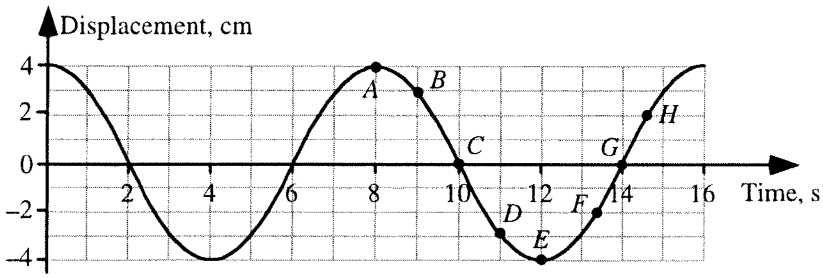
(d) The spring constant is doubled to $2k$ and the mass is reduced to $M/2$. ______
Explain your reasoning.

(e) The amplitude is increased and the mass is increased. ______
Explain your reasoning.

#10 B7-QRT09: OSCILLATION DISPLACEMENT-TIME GRAPH—KINEMATIC QUANTITIES

A cart attached to a spring is displaced from equilibrium and then released. There is no friction. A graph of displacement as a function of time for the cart is shown. The arrows and signs above the cart indicate the positive and negative directions for the position of the cart.





For each question below, choose from the labeled points above, or state "none."

(a) At which point or points is the acceleration positive? _____
Explain your reasoning.

(b) At which point or points does the cart have zero velocity but nonzero net force? _____
Explain your reasoning.

(c) At which point or points is the net force on the cart equal to zero? _____
Explain your reasoning.

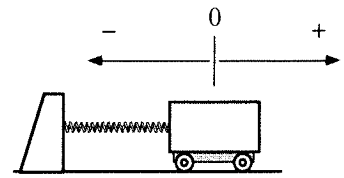
(d) At which point or points are the acceleration, velocity, and displacement all positive? ______
Explain your reasoning.

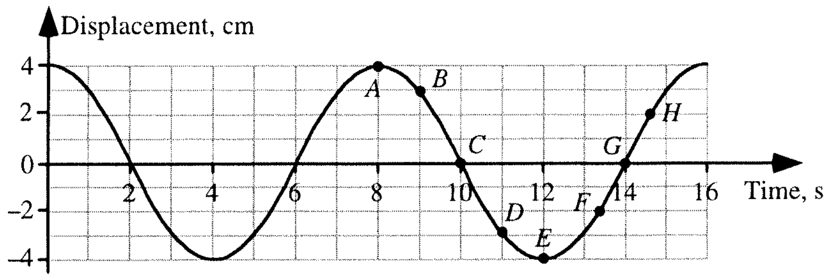
(e) At which point or points is the acceleration nonzero and opposite in sign to the position? _____
Explain your reasoning.

(f) At which point or points is the velocity nonzero and opposite in sign to the acceleration? _____
Explain your reasoning.

B7-QRT13: DISPLACEMENT-TIME GRAPH—ENERGY QUANTITIES

A cart attached to a spring is displaced from equilibrium and then released. A graph of displacement as a function of time for the cart is shown. There is no friction. Points are labeled *A–H* in the graph.





For each question below, choose from the labeled points above or state "none" for the mass-spring-earth system.

(a) At which point or points are the spring potential energy and the cart's kinetic energy both at their maximum values? _____
Explain your reasoning.

(b) At which point or points is the kinetic energy equal to zero? _____
Explain your reasoning.

(c) At which point or points is the total energy at its maximum value? _____
Explain your reasoning.

(d) At which point or points is the spring potential energy negative? _____
Explain your reasoning.

(e) At which point or points is the kinetic energy positive? _____
Explain your reasoning.

(f) At which point or points is the kinetic energy at its maximum value and the spring potential energy at its minimum value? _____
Explain your reasoning.

(g) At which point or points is the kinetic energy at its minimum value and the spring potential energy at its maximum value? _____
Explain your reasoning.