AP Physics - Unit 6 - SHM - KEY

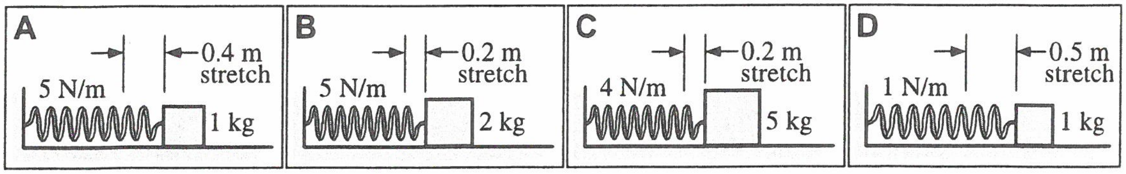
Tipper #1 - unit 6

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.

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

Explain your reasoning.

A > B > D > C $f = \frac{1}{T}$ $T_s = 2\pi\sqrt{\frac{m}{k}}$ formula indicates only m & K matter

↑T f↓

$T_A = 2\pi\sqrt{\frac{1kg}{5N/m}}$ $T_B = 2\pi\sqrt{\frac{2kg}{5N/m}}$ $T_C = 2\pi\sqrt{\frac{5kg}{4N/m}}$ $T_D = 2\pi\sqrt{\frac{1kg}{1N/m}}$

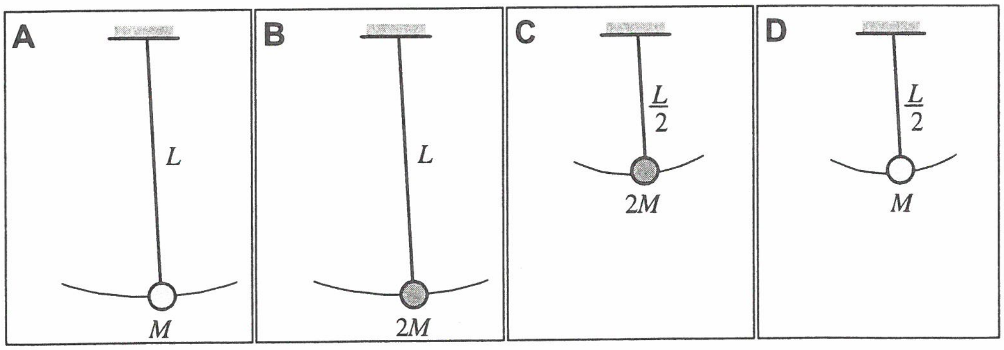
$T_A = 2.8$ $T_B = 4.0$ $T_C = 7.0$ $T_D = 6.3$

$f = 0.36 HZ$ $f = 0.25 HZ$ $f = 0.14 HZ$ $f = 0.16 HZ$

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.

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

Explain your reasoning.

C = D > A = B $T_p = 2\pi\sqrt{\frac{L}{g}}$ $f = \frac{1}{T}$ ∴ mass doesn't matter

∴ A = B , C = D

* greater period

↓T f↑ $T_p = 2\pi\sqrt{\frac{\frac{L}{2}}{g}}$

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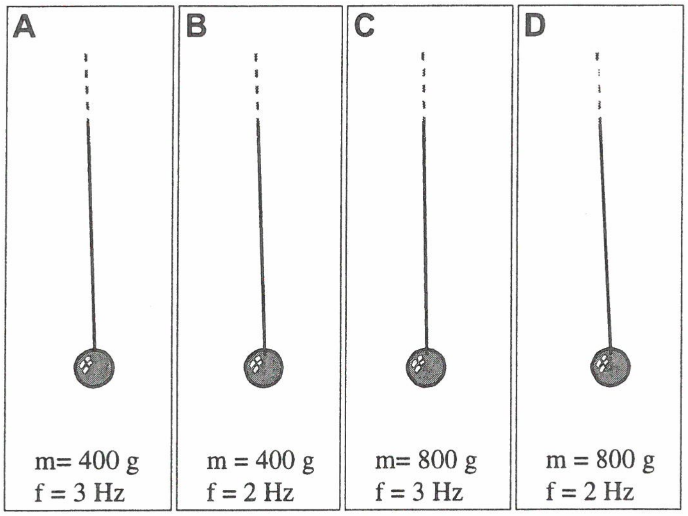
#3

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.

S
Period

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

Explain your reasoning.

B=D > A=C

Period is one Complete swing

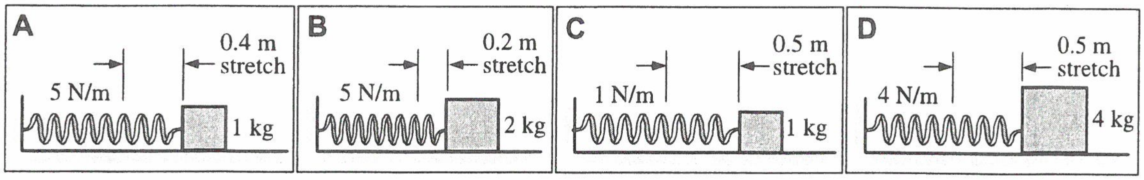
$T_P = 2\pi\sqrt{\frac{L}{g}}$, mass doesn't matter for pendulum

$T_A = \frac{1}{3}$ $T_B = \frac{1}{2}$ $T_B = \frac{1}{3}$ $T_C = \frac{1}{2}$

#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.

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

Explain your reasoning.

C=D > B > A

$T_s = 2\pi\sqrt{\frac{m}{K}}$

The period is Independent of the Amplitude

$T_A = 2\pi\sqrt{\frac{1}{5}}$ $T_B = 2\pi\sqrt{\frac{2}{5}}$ $T_C = 2\pi\sqrt{1/1}$ $T_D = 2\pi\sqrt{\frac{4}{4}}$

$T_A = .89\pi$ $T_B = 126\pi$ $T_C = 2\pi$ $T_D = 2\pi$

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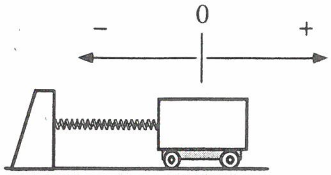
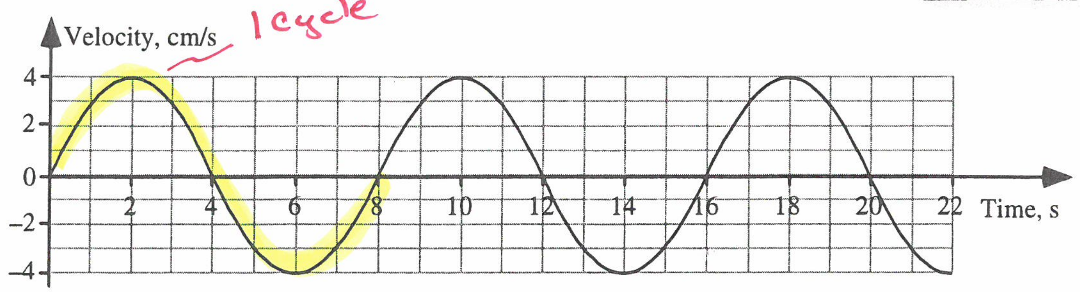
#5

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. 8secs, 1 complete cycle, means Returning to start location

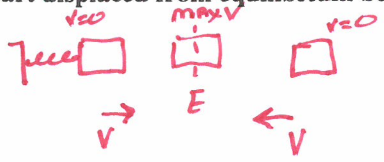
(b) What is the frequency of the motion for this cart?

Explain your reasoning. $T = 8 sec$

$f = \frac{1}{T} = \frac{1}{8} Hz$

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

Explain your reasoning.



The graph shows a positive velocity, ∴ The cart must be moving toward the Right. So it was Displaced to the Left

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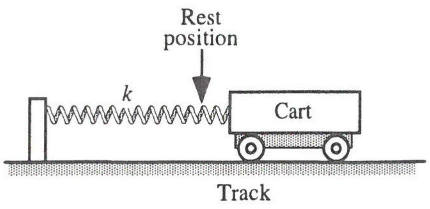
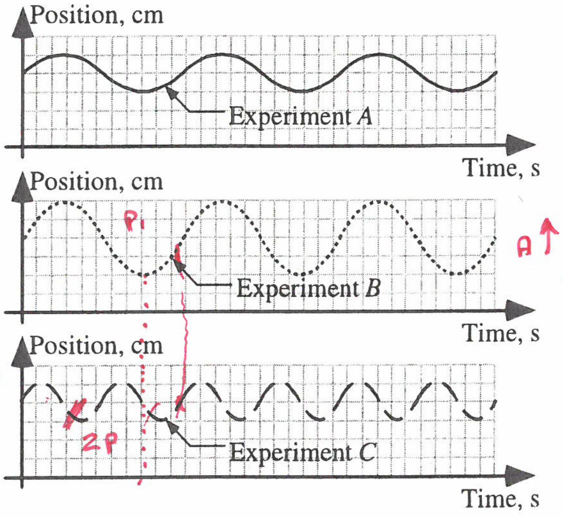
#6 B7-QRT05: POSITION-TIME GRAPH OF A CART ATTACHED TO A SPRING—MASS AND PERIOD



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 ↑ T same
∴ f same

(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.

V, The cart has the same mass.
The periods are same $T_A = T_B$
∴ masses have to be the same Also

(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.

period in exp C is $\frac{1}{2}$ of Exp A
$T_S = 2\pi\sqrt{\frac{m}{k}}$, same k
To have $\frac{m}{2}$, with $\sqrt{\ }$ ∴ needs to be $\frac{m}{4}$

(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 2*k*. 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.

The period (T) would be the same in Experiment D as in A

$T_A = 2\pi\sqrt{\frac{m}{k}}$ $T_B = 2\pi\sqrt{\frac{2m}{2k}}$

$T_A = T_B$

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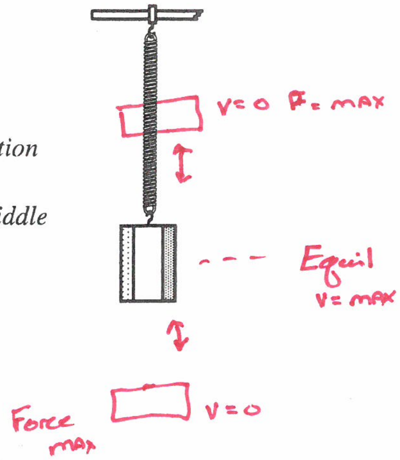
#7

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.

At max displacement, spring is compressed/stretched the most

∴ Force largest $F = ma$

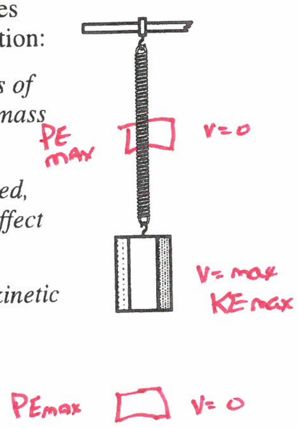
↑ constant

$F_{max} =$ max A

#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.

$KE = \frac{1}{2}mv^2$

The more the spring is compressed or stretch will increase Potential Energy. This will also increase the max KE, ↑ V ∴ ↑ Amplitude

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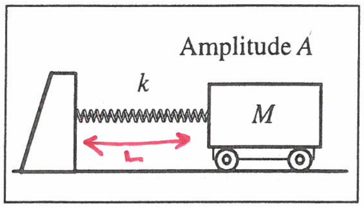
#9 **B7-LMCT08: MASS CONNECTED TO A HORIZONTAL SPRING—FREQUENCY**

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.

$T_s = 2\pi\sqrt{\frac{m}{K}}$ $f = \frac{1}{T}$

↑T f↓

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

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

ii) decrease f

$T_s = 2\pi\sqrt{\frac{m\uparrow}{K}}$

$T\uparrow \therefore \downarrow f$

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

i) increase f

$T_s = 2\pi\sqrt{\frac{m}{K\uparrow}}$

$T_s\downarrow \therefore f\uparrow$

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

iii) No effect

$T_s = 2\pi\sqrt{\frac{m}{k}}$, Changing Amplitude, No Effect on T

∴ f unchange

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

i) increase f

$T_s = 2\pi\sqrt{\frac{\frac{m}{2}}{2K}}$

$T_s \downarrow \frac{1}{2}$ $\therefore f\uparrow$

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

Δ Amp ⇒ No effect on T or f

ii) decrease in f

$T_s = 2\pi\sqrt{\frac{\uparrow m}{K}}$

$T\uparrow \therefore \downarrow f$

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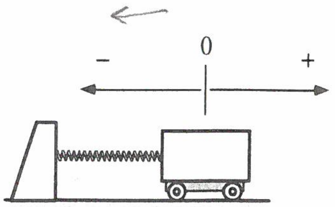
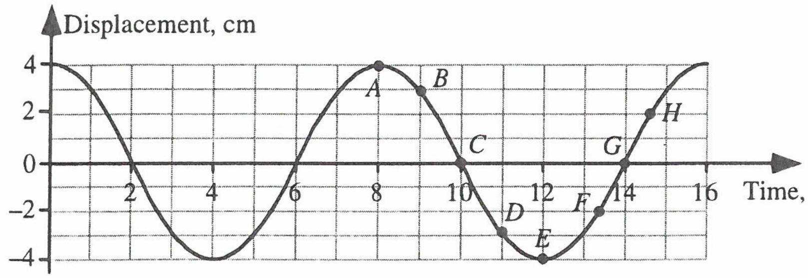
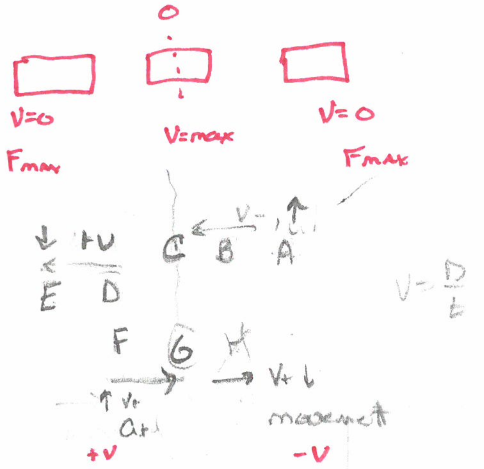
KEY

#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? _____ D, E, F

Explain your reasoning.

a is + when V is + ~~and~~ and Increasing

a is + when V is – and decreasing

(b) At which point or points does the cart have zero velocity but nonzero net force? _____ A & E

Explain your reasoning.

V=0

$F_{net} = ma$

occur at MAX displacement where direction is changing
∴ V=0
Spring compressed or stretch
∴ Force

(c) At which point or points is the net force on the cart equal to zero? _____ C & G

Explain your reasoning.

at point C & G, slope of position ~~constant~~ constant ∴ V=0 ∴ a=0

$F = m\cancel{a}^{0}$

or C & G is Equilibrium & spring Exerts no force

(d) At which point or points are the acceleration, velocity, and displacement all positive? _____

Explain your reasoning. None

force is Always working toward Equilibrium pt
So a is – when displacement is +
or a is + when diplacement is –

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

a>0 &

Explain your reasoning.

A, B, D, E, F, H

Acceleration is Always opposite in sign to the position

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

Explain your reasoning.

D & H

when CArt is slowing down, the Velocity & accel are opposite in direction

KEY

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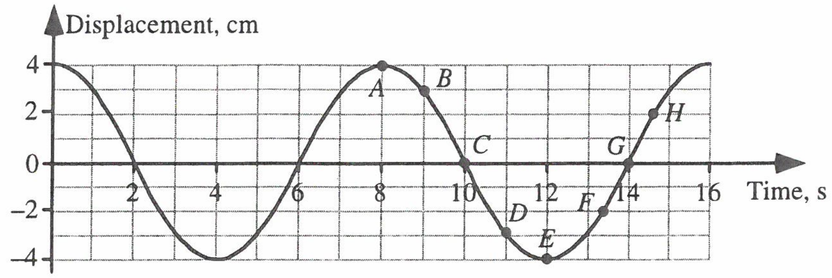
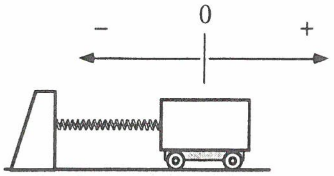
#11

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.



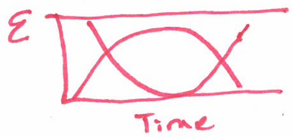


For each question below, choose from the labeled points above or state "none" for the mass-spring-earth system.

(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.

Never



The KE + Ug Always Add up to Total Energy, which is Constant. So win one ↑ the other ↓

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

Explain your reasoning.

A + E

The slope at these points are zero ∴ V = 0
Points A + E Are also max compression, stretch. Cart is stopped + Changing direction

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

Explain your reasoning.

A, B, C, D, E, F, G, H All the points, Energy is Max, Because it is Constant

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

Explain your reasoning.

NONE

$U_{sp} = \frac{1}{2}Kx^2$

Squared Distance so Always Positive

(e) At which point or points is the kinetic energy positive? _____

Explain your reasoning.

B, C, D, F, G, H

$KE = \frac{1}{2}mv^2$

KE is Always Positive or Zero

(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.

KE max ? + Ug min

at Equilibrium, max V + Least stretch on spring

(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.

KE min + Ug max ??

A + E

when Cart is At at its max displacement (spring max stretched or compressed)
+ KE is zero (Stopped for momement)