

Name: Key  
AP Physics

## Simple Harmonic Motion &amp; Waves

Date \_\_\_\_\_  
SHM & Waves

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

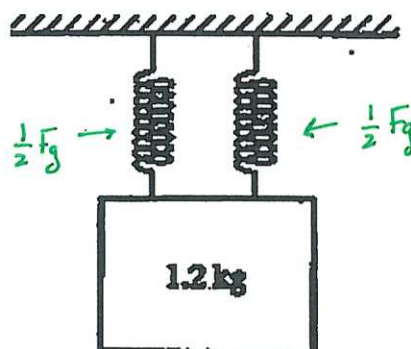
half period  
from  $\frac{1}{4}$  string  
length

- 1) A simple pendulum and a mass hanging on a spring both have a periods of 1 s when set into small oscillatory motion on Earth. They are taken to Planet X, which has the same diameter as Earth but twice the mass. Which of the following statements is true about the periods of the two objects on Planet X compared to their periods on Earth?

- A) Both are the same.  
B) The period of the pendulum is shorter; that of the mass on the spring is the same.  
C) The period of the mass on the spring is shorter; that of the pendulum is the same.  
D) Both are longer.  
E) Both are shorter.

$$T_S = 2\pi \sqrt{\frac{m}{k}} \text{ no change}$$

2)



$$\begin{aligned} \sum F &= 0 \text{ N} \\ F_k + F_k - F_g &= 0 \text{ N} \\ F_k &= \frac{F_g}{2} \end{aligned}$$

Two identical massless springs are hung from a horizontal support. A block of mass 1.2 kilograms is suspended from the pair of springs, as shown above. When the block is in equilibrium, each spring is stretched an additional 0.15 meter.

When the block is set into oscillation with amplitude  $A$ , it passes through its equilibrium point with speed  $v$ . In which of the following cases will the block, when oscillating with amplitude  $A$ , also have speed  $v$  when it passes through its equilibrium point?

- I. The block is hung from only one of the two springs.  
II. The block is hung from the same two springs, but the springs are connected in series rather than in parallel.  
III. A 0.5-kilogram is attached to the block.

- A) II and III only  
B) I, II, and III  
C) I and II only  
D) None  
E) III only

$$T \downarrow \Delta A \text{ more} \\ V_{\max} = A\omega$$

- 3) A simple pendulum consists of a 1.0-kilogram brass bob on a string about 1.0 meter long. It has a period of 2.0 seconds. The pendulum would have a period of 1.0 second if the

- A) string were replaced by one about 0.25 meter long  
B) bob were replaced by a 0.25-kg brass sphere  
C) amplitude of the motion were increased  
D) bob were replaced by a 4.0-kg brass sphere  
E) string were replaced by one about 2.0 meters long

mass no effe  
release no effe  
mass no effe  
double l  
gives  $\frac{1}{2} T$

- 4) An object moves up and down the y-axis with an acceleration given as a function of time  $t$  by the expression  $a = A \sin \omega t$ , where  $A$  and  $\omega$  are constants. What is the period of this motion?

- A)  $\omega$   
B)  $2\pi/\omega$   
C)  $2\pi\omega$   
D)  $\omega/(2\pi)$   
E)  $\omega^2 A$

$$\omega = 2\pi f = \frac{2\pi}{T}$$

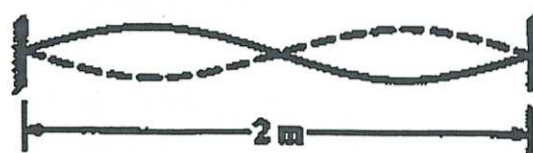
$$T = \frac{2\pi}{\omega}$$

- 5) When an object oscillating in simple harmonic motion is at its maximum displacement from the equilibrium position, which of the following is true of the values of its speed and the magnitude of the restoring force?

- A) Speed: zero  
Restoring Force: maximum  
B) Speed: zero  
Restoring Force: zero  
C) Speed: maximum  
Restoring Force:  $\frac{1}{2}$  maximum  
D) Speed: maximum  
Restoring Force: zero  
E) Speed:  $\frac{1}{2}$  maximum  
Restoring Force:  $\frac{1}{2}$  maximum

$x_{\max}$  stop changing direction  
max x so max F+

Questions 6 and 7 refer to the following:



A standing wave of frequency 5 hertz is set up on a string 2 meters long with nodes at both ends and in the center, as shown above.

- 6) The speed at which waves propagate on the string is

A) 5 m/s  
 B) 2.5 m/s  
 C) 0.4 m/s  
 D) 20 m/s  
 E) 10 m/s

$$v = f\lambda$$

$$= (5)(2)$$

$$= 10$$

- 7) The fundamental frequency of vibration of the string is

A) 1 Hz  
 B) 10 Hz  
 C) 2.5 Hz  
 D) 5 Hz  
 E) 7.5 Hz

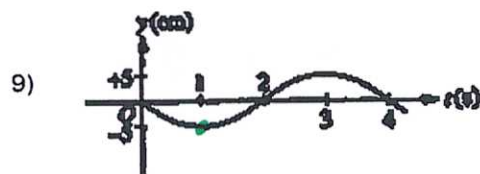
$f$  for  $\frac{1}{2}$  wave

$$f_2 = 2f_1$$

$$5 = 2(f_1)$$

- 8) Sound in air can best be described as which of the following types of waves?

A) longitudinal  
 B) electromagnetic Radio  
 C) polarized  
 D) torsional twisting  
 E) transverse



A particle oscillates up and down in simple harmonic motion. Its height  $y$  as a function of time  $t$  is shown in the diagram above. At what time  $t$  does the particle achieve its maximum positive acceleration?

A) None of the above, because the acceleration is constant  
 B) 4 s  
 C) 3 s  
 D) 1 s  
 E) 2 s

$+a$  when  $x$  is -

max  $a$  when max  $F$  + max  $x$

- 10) A radar operates at a wavelength of 3 centimeters. The frequency of these waves is

A)  $10^{-10}$  Hz  
 B)  $10^8$  Hz  
 C)  $10^{10}$  Hz  
 D)  $10^6$  Hz  
 E)  $3 \times 10^8$  Hz

radar = radiowaves  
 $v = 3 \times 10^8 \text{ m/s}$

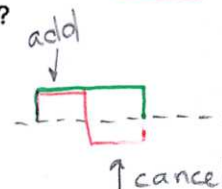
$$f = \frac{v}{\lambda} = \frac{3 \times 10^8 \text{ m/s}}{3 \times 10^{-2} \text{ m}}$$

$$= 1 \times 10^{10} \text{ Hz}$$

11)



The figure above shows two wave pulses that are approaching each other. Which of the following best shows the shape of the resultant pulse when the centers of the pulses, points P and Q, coincide?



2 box high  
 cancel out

- 12) The length of a simple pendulum with a period on Earth of one second is most nearly

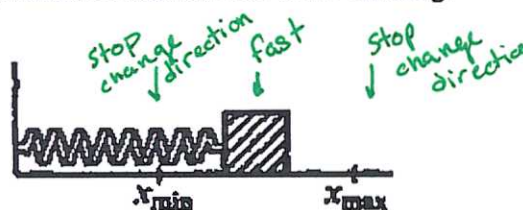
A) 10.0 m  
 B) 0.50 m  
 C) 0.25 m  
 D) 0.12 m  
 E) 1.0 m

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

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

$$= \frac{(1)^2 (10)}{4\pi^2}$$

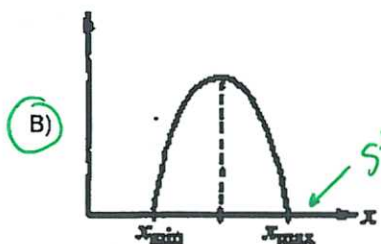
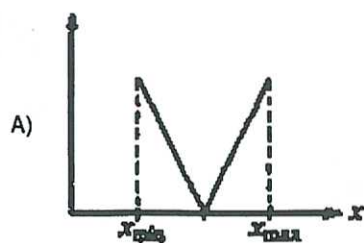
Questions 13 and 14 refer to the following:



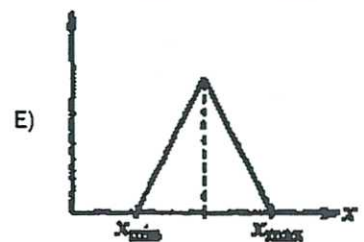
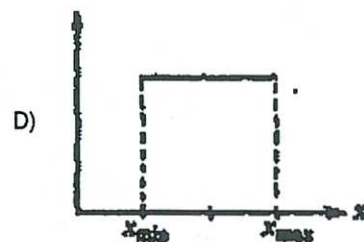
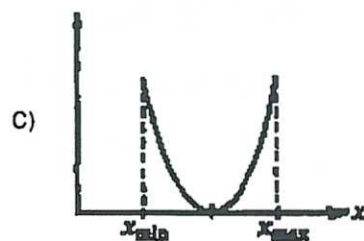
A block oscillates without friction on the end of a spring, as shown above. The minimum and maximum lengths of the spring as it oscillates are, respectively,  $x_{min}$  and  $x_{max}$ .

- 13) Which graph can represent the kinetic energy of the block as a function of  $x$ ?

stop at  
 $x_{\max}$   
+  $x_{\min}$

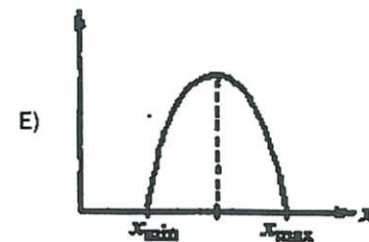
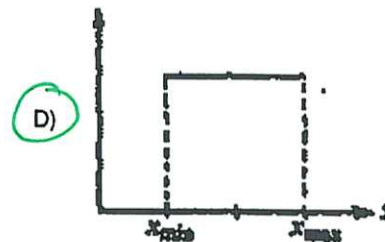
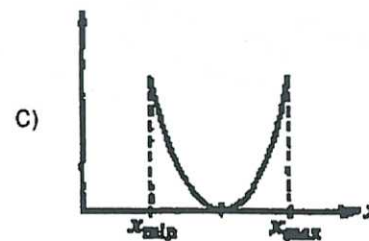
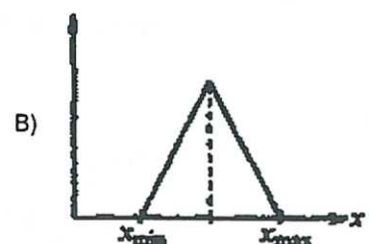
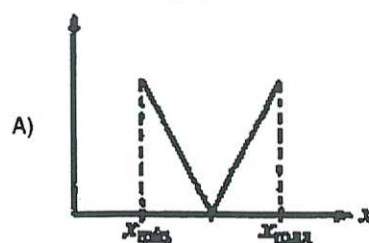


stop  
change  
direction



- 14) Which graph can represent the total mechanical energy of the block-spring system as a function of  $x$ ?

↑  
remains  
same





- 15) An object swings on the end of a cord as a simple pendulum with period  $T$ . Another object oscillates up and down on the end of a vertical spring, also with period  $T$ . If the masses of both objects are doubled, what are the new values for the periods?

- A) Pendulum:  $T/\sqrt{2}$   
Mass on spring:  $T\sqrt{2}$   
B) Pendulum:  $T$   
Mass on spring:  $T$   
C) Pendulum:  $T$   
Mass on spring:  $T\sqrt{2}$   
D) Pendulum:  $T\sqrt{2}$   
Mass on spring:  $T$   
E) Pendulum:  $T\sqrt{2}$   
Mass on spring:  $T/\sqrt{2}$

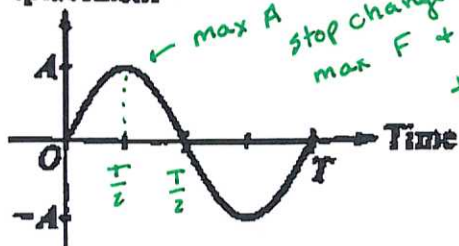
$$T_p = 2\pi\sqrt{\frac{l}{g}} \text{ same}$$

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

double  $m$   $\sqrt{2} T_s$

16)

Displacement



An object is attached to a spring and oscillates with amplitude  $A$  and period  $T$ , as represented on the graph above. The nature of the velocity  $v$  and acceleration  $a$  of the object at time  $T/4$  is best represented by which of the following?

- A)  $v > 0, a = 0$   
B)  $v = 0, a = 0$   
C)  $v = 0, a < 0$   
D)  $v > 0, a < 0$   
E)  $v > 0, a > 0$
- 17) If the mass of a simple pendulum is doubled but its length remains constant, its period is multiplied by a factor of

- A) 2  
B) 1  
C)  $\sqrt{2}$   
D)  $1/\sqrt{2}$   
E)  $1/2$

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

no change

- 18) Which of the following is true for a system consisting of a mass oscillating on the end of an ideal spring?

- A) The maximum kinetic energy occurs at maximum displacement of the mass from its equilibrium. *stop change direction*  
B) The maximum potential energy is achieved when the mass passes through its equilibrium position. *no stretch*  
C) The kinetic and potential energies are equal to each other at all times.  
D) The maximum kinetic energy and the maximum potential energy are equal, but occur at different times.  
E) The kinetic and potential energies are both constant.

- 19) When a mass is attached to a spring, the period of oscillation is approximately 2.0 seconds. When the mass attached to the spring is doubled, the period of oscillation is most nearly

- A) 2.0 s  
B) 1.0 s  
C) 2.8 s  
D) 1.4 s  
E) 0.5 s

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

double  $m$   $\sqrt{2} T$   
 $2\sqrt{2}$

- 20) A cord of fixed length and uniform density, when held between two fixed points under tension  $T$ , vibrates with a fundamental frequency  $f$ . If the tension is doubled, the fundamental frequency is

- A)  $2f$   
B)  $\sqrt{2} f$   
C)  $f/2$   
D)  $f$   
E)  $f/\sqrt{2}$

$$v = \sqrt{\frac{F_t}{\mu}} \quad \sqrt{\frac{2}{1}} = \sqrt{2}$$

$$f = \frac{v}{\lambda} = \frac{\sqrt{2}}{1} = \sqrt{2}$$

- 21) A vibrating tuning fork sends sound waves into the air surrounding it. During the time in which the tuning fork makes one complete vibration, the emitted wave travels

- A) one wavelength  
B) about 340 meters  
C) a distance directly proportional to the frequency of vibration  
D) a distance directly proportional to the square root of the pressure  
E) a distance directly proportional to the square root of the air density

- 22) A pipe, open at both ends, has length  $L$ . The speed of sound in the air in the pipe is  $v$ . The frequency of vibration of the fundamental (first harmonic) standing wave that can be set up in the pipe is

- A)  $v/(2L)$   
B)  $(4v)/L$   
C)  $L/v$   
D)  $L/(4v)$   
E)  $L/(2v)$

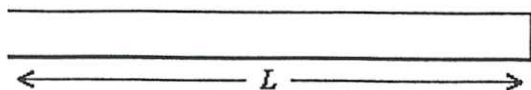


$$L = \frac{1}{2} \text{ wave}$$

$$\lambda = 2L$$

$$f = \frac{v}{\lambda} = \frac{v}{2L}$$

- 23) An organ pipe of length  $L$  is open at one end and closed at the other. The fundamental (lowest frequency) standing sound wave is set up in the pipe.

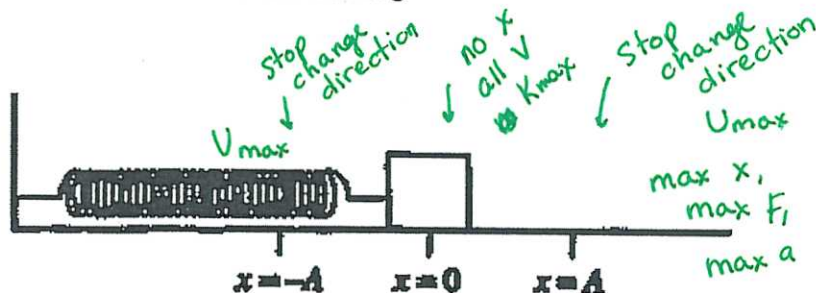


$$\lambda = 4L$$

What is the wavelength of the fundamental, in terms of the length  $L$  of the pipe? Ignore any end correction.

- A)  $L$   
 B)  $4L$   
 C)  $L/4$   
 D)  $2L$   
 E)  $L/2$

Questions 24 and 25 refer to the following:



A block on a horizontal frictionless plane is attached to a spring, as shown above. The block oscillates along the  $x$ -axis with simple harmonic motion of amplitude  $A$ .

- 24) Which of the following statements about the block is correct?

- A) At  $x = A$ , its displacement is at a maximum.  
 B) At  $x = 0$ , its acceleration is at a maximum.  $a = 0$   
 C) At  $x = 0$ , its velocity is zero.  $\text{max } v$   
 D) At  $x = A$ , its acceleration is zero.  $\text{max } a$   
 E) At  $x = A$ , its velocity is at a maximum.  $\text{stop change direction}$

- 25) Which of the following statements about energy is correct?

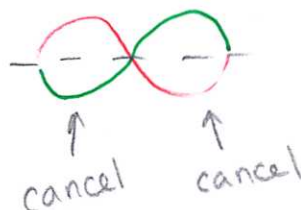
- A) The kinetic energy of the block is at a minimum at  $x = 0$ .  $\text{max } K$   
 B) The kinetic energy of the block is always equal to the potential energy of the spring.  $\text{switch back + forth}$   
 C) The potential energy of the spring is at a minimum at  $x = A$ .  $\text{max } U_s$   
 D) The potential energy of the spring is at a minimum at  $x = 0$ .  
 E) The kinetic energy of the block is at a maximum at  $x = A$ .  $\text{stop change direction}$

26)

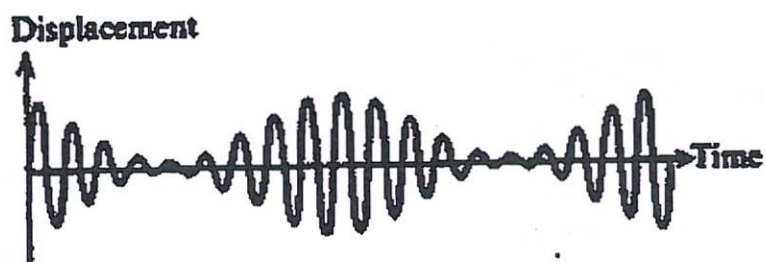


Two wave pulses, each of wavelength  $\lambda$ , are traveling toward each other along a rope as shown above. When both pulses are in the region between points X and Y, which are a distance  $\lambda$  apart, the shape of the rope is

- A)
- B)
- C)
- D)
- E)



27)



Two sinusoidal functions of time are combined to obtain the result shown in the figure above. Which of the following can best be explained by using the figure?

- A) Simple harmonic motion
- B) Polarization
- C) Beats
- D) Doppler effect
- E) Diffraction

*Alternate in/out phase, alternate constructive + destructive*

- |    |   |    |   |    |   |    |   |    |   |    |   |    |   |    |   |    |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |     |   |
|----|---|----|---|----|---|----|---|----|---|----|---|----|---|----|---|----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|
| 1) | B | 2) | D | 3) | A | 4) | B | 5) | A | 6) | E | 7) | C | 8) | A | 9) | D | 10) | C | 11) | B | 12) | C | 13) | B | 14) | D | 15) | C | 16) | C | 17) | B | 18) | D | 19) | C | 20) | B | 21) | A | 22) | A | 23) | B | 24) | A | 25) | D | 26) | B | 27) | C |
|----|---|----|---|----|---|----|---|----|---|----|---|----|---|----|---|----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|-----|---|