PHYS 1Cb

Spring 2014

Quiz 1 Solution

*Please note that the order of the questions differs among different test versions.

1. Consider a mass on a spring moving horizontally on a frictionless surface in simple harmonic motion. In this simple harmonic motion system, the magnitude of the velocity is greatest when:

   a. the displacement is maximal.
   b. the displacement is zero.
   c. the absolute value of the acceleration is maximal.
   d. the absolute value of the force is maximal.
   e. the absolute value of the acceleration is exactly half of its maximum value.

Ans. b

The magnitude of the velocity (the speed) is maximum at the equilibrium point, where the displacement is zero (x=0).

2. In an engine, a piston oscillates with simple harmonic motion so that its position varies according to the expression: $x(t) = (7.5 \text{ cm}) \sin(4.0t + \pi/2)$, where x is in centimeters and t is in seconds. At $t = 0$ seconds, the magnitude of the velocity of the piston is:

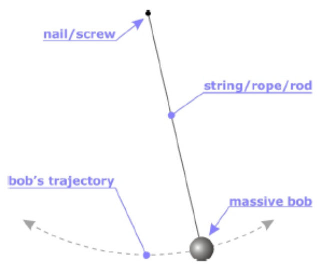
   a. zero.
   b. 7.5 cm/s.
   c. 30 cm/s.
   d. 120 cm/s.
   e. 0.21 cm/s.

Ans. a

Since x(t)=7.5*sin(4t+pi/2), by differentiating with respect to time we have v(t)=30*cos(4t+pi/2), plugging t=0 we have v(t=0)=v(0)=30*cos(0+pi/2)=30*cos(pi/2)=30*0=0

3. A pendulum consists of a massive bob at the end of a string (as shown to the right). If the mass of the bob is halfed, what happens to the period of the pendulum?

   a. The period of the pendulum will decrease.
   b. The period of the pendulum will increase.
   c. The period of the pendulum will remain the same.



Ans. c

The period of the simple pendulum $T = 2\pi\sqrt{\frac{L}{g}}$ only depends on the length of the string and the gravitational constant g. It is not affected by the mass of the bob.

4. A mass on a spring is undergoing simple harmonic motion with a frequency of 0.20 Hz. At time $t = 0$ it is at the equilibrium point. At which one of the ***following*** times is it closest in distance to the equilibrium point?

a. $t = 8.0$ seconds.
b. $t = 7.0$ seconds.
c. $t = 6.0$ seconds.
d. $t = 5.0$ seconds.
e. $t = 4.0$ seconds.

Ans. d

From f=0.2 Hz we can calculate the period of the wave: T=1/f=5 (s).

At time t=0 the mass is at the equilibrium, therefore the mass will visit the equilibrium every half period: 2.5s, 5s, 7.5s, 10s, ……

5. A Physics 1C student is creating water waves by throwing pebbles with a frequency of 2.0 Hz into a pool of water. If she now decreases the frequency of throwing the pebbles, what will happen to the velocity and the wavelength of the resulting water waves?

a. The wavelength of the water waves will increase and the velocity of the water waves will remain the same.
b. The wavelength of the water waves will decrease and the velocity of the water waves will remain the same.
c. The wavelength of the water waves will remain the same and the velocity of the water waves will increase.
d. The wavelength of the water waves will remain the same and the velocity of the water waves will decrease.
e. Both the wavelength of the water waves and the velocity of the water waves will remain the same.

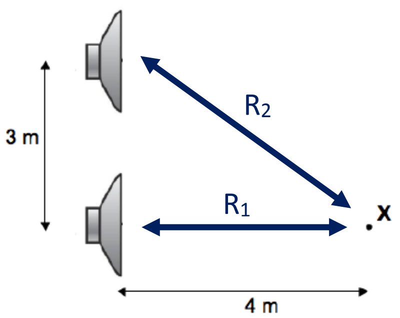
Ans. a

The speed of the wave depends on the medium (the water). In this case, the water doesn't change its properties, so the speed of the wave will remain the same.

Since $v = f\lambda$, if the frequency is decreased, the wavelength will increase.

6. Two small identical speakers are connected to the same source (*i.e.* they are in phase with one another). The speakers are 3.0 meters apart and at ear level. An observer stands at point X, 4.0 meters in front of one speaker as shown in the diagram. For which of the following wavelengths will the sound she hears be most intense (*i.e.* constructive interference) ?

a. 5.0 meters.
b. 4.0 meters.
c. 3.0 meters.
d. 2.0 meters.
e. 1.0 meters.



Ans. e

R_1=4m, R_2=5m (see the picture)

$\Delta R = |R_1 - R_2| = 1$ m

In order to have a constructive interference, $\Delta R = 1$ m$=\lambda$, 2λ or 3λ,…

Possible wavelengths are 1m, 0.5m, 1/3 m, ……

7. In a transverse wave on a spring, the coils of the spring vibrate:

   a. in directions parallel to the length of the spring.
   b. in directions anti-parallel to the length of the spring.
   c. in directions perpendicular to the length of the spring.
   d. only at the nodes.
   e. in directions parallel and anti-parallel to the length of the spring.

Ans. c

Please refer to the textbook.

8. The period of a simple pendulum on Earth is 2.00 seconds. When brought to another planet where g is one fortieth that on Earth, its period becomes:

   a. 1.00 seconds.
   b. 0.316 seconds.
   c. 0.100 seconds.
   d. 10.0 seconds.
   e. 3.16 seconds.

Ans. d

$$\mathrm{T} = 2\pi\sqrt{\frac{L}{g}} \propto \frac{1}{\sqrt{g}}$$

If g is multiplied by a factor of $\frac{1}{40}$, T will be multiplied by a factor of $\frac{1}{\sqrt{\frac{1}{40}}} =$

$\sqrt{40}$

$2 \times \sqrt{40} = 12.6\ s.$

Option d is the closest answer.

9. An 80kg person on waterskis is accelerated by a speed boat. The two are connected by a 15m cable with mass 8kg. A disturbance created by the skier on the end of the rope will travel to the boat in 0.25 seconds. What is the acceleration of the boat?

   a. 5 m/s^2
   b. 10 m/s^2
   c. 20 m/s^2
   d. 30 m/s^2
   e. 40 m/s^2

Ans. c

The speed of the wave along the string is $\mathrm{v} = \frac{15\ (m)}{0.25\ (s)} = 60\ m/s.$

From equation $v = \sqrt{\frac{T}{\mu}}$, the tension of the string (the force that pulls the person on the waterskis) is:

$$T = v^2\mu = 60^2 \times \frac{8\ (kg)}{15\ (m)} = 1920\ N$$

By Newton's 2nd Law, $T = ma$, therefore $a = \frac{T}{m} = \frac{1920\ N}{80\ kg} = 24\ m/s^2$

C is the closest answer.

10. A block attached to a spring undergoes simple harmonic motion on a horizontal frictionless surface. Its total energy is 100.0 J. When the displacement is half the amplitude, the kinetic energy is:

a. 25.0 J.
b. 37.5 J.
c. 50.0 J.
d. 62.5 J.
e. 75.0 J.

Ans. e

The total energy of the SHM is $E_{total} = \frac{1}{2}kA^2 = 100\ J$

When the displacement is half the amplitude, $\Delta x = \frac{1}{2}A$, the elastic potential energy is $U_s = \frac{1}{2}k(\Delta x)^2 = \frac{1}{2}k\left(\frac{1}{2}A\right)^2 = \frac{1}{4} \times \frac{1}{2}kA^2 = \frac{1}{4} \times E_{total} = 25\ J$

Because of conservation of energy, kinetic energy is therefore

$$K = E_{total} - U_s = 100 - 25 = 75\ J$$