Physics SHM problems

In this activity we see some examples on the use of the environment to create physics questions on SHM.

1 Answer these multiple choice questions

Question 1 *A mass on a spring undergoes SHM. When the mass is at its maximum displacement from equilibrium, its instantaneous velocity*

Solution

(a) is maximum

(b) is less than maximum, but not zero

(c) is zero ✓

(d) cannot be determined from the information given

Hint: *where is the displacement zero?*

Question 2 *A mass on a spring undergoes SHM. When the mass passes through the equilibrium position, its instantaneous velocity*

Solution

(a) is maximum ✓

(b) is less than maximum, but not zero

(c) is zero

(d) cannot be determined from the information given

Question 3 *A mass is attached to a vertical spring and bobs up and down between points A and B. Where is the mass located when its kinetic energy is a minimum?*

Solution

(a) at either A or B ✓

(b) midway between A and B

(c) one-fourth of the way between A and B

(d) none of the above

Question 4 *A mass on a spring undergoes SHM. When the mass is at maximum displacement from equilibrium, its instantaneous acceleration*

Solution

(a) is zero

(b) is a maximum ✓

(c) is less than maximum, but not zero

(d) cannot be determined from the information given

Question 5 *A mass is attached to a vertical spring and bobs up and down between points A and B. Where is the mass located when its potential energy is a maximum?*

Solution

(a) midway between A and B

(b) one-fourth of the way between A and B

(c) at either A or B ✓

(d) none of the above

Question 6 *A mass oscillates on the end of a spring, both on Earth and on the Moon. Where is the period the greatest?*

Solution

(a) Earth

(b) the Moon

(c) same on both Earth and the Moon ✓

(d) cannot be determined from the information given

Question 7 *When the mass of a simple pendulum is tripled, the time required for one complete vibration*

Solution

(a) increases by a factor of 3

(b) decreases to one-third of its original value

(c) decreases to $1/\sqrt{3}$ of its original value

(d) does not change ✓

Question 8 *A mass undergoes SHM with amplitude of* 4 *cm. The energy is* 8.0 *J at this time. The mass is cut in half and the system is again set if motion with amplitude* 4.0 *cm. What is the energy of the system now?*

Solution

(a) 2.0 J

(b) 4.0 J

(c) $8.0J$ ✓

(d) 16 J

Short answer questions

Question 9 *A* 2.00 *kg pumpkin oscillates from a vertically hanging light spring once every* 0.65 *s. Write down the equation giving the pumpkin's position y (+ upward) as a function of time t, assuming it started by being compressed* 18 *cm from the equilibrium position (where $y = 0$) and released.*

Solution Since we are compressing the pumpkin to 18 cm from its equilibrium position, the general equation for SHM $y = A\cos\left(\frac{2\pi t}{T}\right)$ gives us

$$y = (0.18 \text{ m})\cos\left(\frac{2\pi t}{0.65 \text{ s}}\right),$$

for the position function. $y = 0.18\cos\left(\frac{2\pi t}{0.65}\right)$

How long will it take to get into the equilibrium position for the first time?

Solution The time to return back to the equilibrium position is one-quarter of a period.

$$t = \frac{1}{4}T = \frac{1}{4}(0.65 \text{ s}) = \boxed{0.16 \text{ s}}$$

0.16 s

What will be the pumpkin's maximum speed?

Solution Here we have

$$v_{\max} = \omega A = \frac{2\pi}{T}A = \frac{2\pi}{0.65 \text{ s}}(0.18 \text{ m}) = \boxed{1.7 \text{ m/s}}$$

1.7 m/s

What will be its maximum acceleration and where will that first be attained?

Solution This is given by

$$\begin{aligned} a_{\text{max}} &= \omega^2 A = \left(\frac{2\pi}{T}\right)^2 A \\ &= \frac{4\pi^2}{(0.65\text{ s})^2}(0.18\text{ m}) \\ &= \boxed{17\text{ m/s}^2}. \end{aligned}$$

The maximum acceleration is first attained at the point of release of the pumpkin. 17 m/s^2, at $t = 0$

Question 10 *A 300 g mass vibrates according to the equation $x = 0.38 \sin 6.50t$, where x is in meters and t is in seconds. Determine the amplitude.*

Solution This is $A = x_{\text{max}} = \boxed{0.38\text{ m}}$ 0.38 m

the frequency

Solution We can find this as follows

$$\omega = 2\pi f = 6.50\ s^{-1} \rightarrow f = \frac{6.50\ s^{-1}}{2\pi} = \boxed{1.03\text{ Hz}}$$

1.03 Hz

the period

Solution Here

$$T = \frac{1}{f} = \frac{1}{1.03\text{ Hz}} = \boxed{0.967\text{ s}}$$

0.967 s

the total energy

Solution This is

$$\begin{aligned} E_{\text{total}} &= \frac{1}{2}mv_{\text{max}}^2 = \frac{1}{2}m(\omega A)^2 \\ &= \frac{1}{2}(0.300\text{ kg})\left[(6.50\ s^{-1})(0.38\text{ m})\right]^2 \\ &= 0.9151\text{ J} \approx \boxed{0.92\text{ J}} \end{aligned}$$

0.92 J

The KE and PE when x is 9.0 cm.

Solution The potential energy is given by

$$\begin{aligned} E_{\text{potential}} &= \frac{1}{2}kx^2 = \frac{1}{2}m\omega^2 x^2 = \frac{1}{2}(0.300\text{ kg})(6.50\ s^{-1})^2(0.090\text{ m})^2 \\ &= 0.0513\text{ J} \approx \boxed{5.1 \times 10^{-2}\text{ J}} \end{aligned}$$

The kinetic energy is given by

$$\begin{aligned} E_{\text{kinetic}} &= E_{\text{total}} - E_{\text{potential}} = 0.9151 \text{ J} - 0.0513 \text{ J} \\ &= 0.8638 \text{ J} \approx \boxed{0.86 \text{ J}}. \end{aligned}$$

$KE = 0.86$ J, $PE = 0.051$ J