

Quiz #10: Oscillations

Problem 1 (1.5 points)

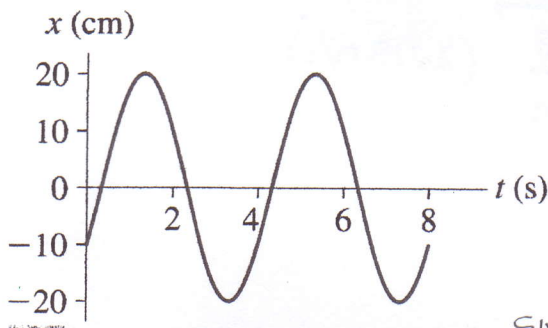
A simple pendulum of length L and mass M has frequency f . To increase its frequency to $2f$:

- D
- a) increase its length to $4L$
 - b) increase its length to $2L$
 - c) decrease its length to $L/2$
 - d) decrease its length to $L/4$
 - e) none of the above

$$f = \frac{1}{2\pi} \sqrt{\frac{g}{L}} \rightarrow f \propto \frac{1}{\sqrt{L}}$$

Problem 2 (1.5 points)

The figure below is the position versus time graph for an object undergoing simple harmonic motion. What is the phase constant? Justify your answer.



$$A = 20 \text{ cm} \quad x_0 = -10 \text{ cm} = -\frac{1}{2}A$$

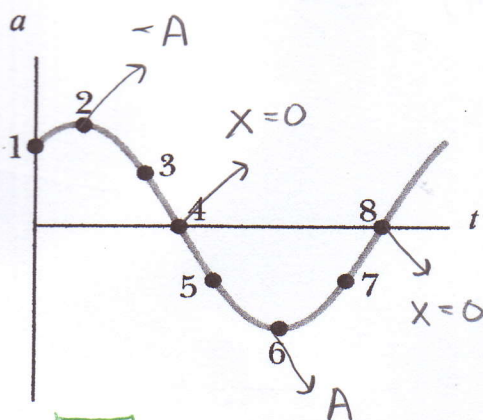
$$x_0 = A \cos \phi_0 = -\frac{1}{2}A$$

$$\phi_0 = \cos^{-1}(-\frac{1}{2}) = \pm 2\pi/3$$

since $v_0 > 0$, $\phi_0 = -2\pi/3$

Problem 3 (3 points)

The acceleration $a(t)$ of a particle undergoing SHM is graphed in the figure below. (a) Which of the labeled points corresponds to the particle at $-A$? (b) At point 5, is the velocity of the particle positive, negative, or zero? (c) At point 7, is the particle at $-A$, at $+A$, at 0, between $-A$ and 0, or between 0 and $+A$?



a) 2

b) +

c) between 0 and +A

Problem 4 (4 points)

A 525 g mass is attached to a horizontal spring ($k = 175 \text{ N/m}$) on a frictionless surface. It is at rest at the equilibrium position. At $t = 0 \text{ s}$, the mass is struck by a hammer, which gives it an initial speed of 2.75 m/s . Determine (a) the frequency of motion, (b) the amplitude, (c) the maximum acceleration, and (d) the total energy.

$$(a) \quad f = \frac{1}{2\pi} \sqrt{\frac{k}{m}} = \frac{1}{2\pi} \sqrt{\frac{175 \text{ N/m}}{0.525 \text{ kg}}} \rightarrow \boxed{f = 2.91 \text{ Hz}}$$

$$(b) \quad x = 0 \text{ m} \quad v = 2.75 \text{ m/s}$$

$$\frac{1}{2} m v^2 + \frac{1}{2} k x^2 = \frac{1}{2} k A^2$$

$$A = \sqrt{\frac{m}{k}} v \rightarrow A = \sqrt{\frac{0.525 \text{ kg}}{175 \text{ N/m}}} (2.75 \text{ m/s})$$

$$\boxed{A = 0.151 \text{ m}}$$

$$(c) \quad a_{\text{max}} = \omega^2 A = \left(\frac{k}{m}\right) A$$

$$a_{\text{max}} = \left(\frac{175 \text{ N/m}}{0.525 \text{ kg}}\right) (0.151 \text{ m}) \rightarrow \boxed{a_{\text{max}} = 50.3 \text{ m/s}^2}$$

$$(d) \quad E = \frac{1}{2} k A^2 = \frac{1}{2} (175 \text{ N/m}) (0.151 \text{ m})^2$$

$$\boxed{E = 2.00 \text{ J}}$$