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BSE-1B

AP Assignment 3

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Q1.

a) $x = 5\cos(2t + \frac{\pi}{6})$

at $t = 0$

$x = 5\cos(\frac{\pi}{6})$

$x = 4.33\ cm$

b) $v = \frac{dx}{dt}$

$v = -10\sin(2t + \frac{\pi}{6})$

at $t = 0$, $v = -5\ cm/s$

c) $a = \frac{dv}{dt}$

$a = -20\cos(2t + \frac{\pi}{6})$

at $t = 0$, $a = -17.3\ cm/s^2$

d) $T = \frac{2\pi}{w} = \frac{2\pi}{2} = 3.14\ s$

Amplitude is 5 cm from equation of x

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Q2. $x = 4\cos(3\pi t + \pi)$

a) $\omega = 3\pi = 2\pi f$

$3\pi = 2\pi f$

$f = \frac{3}{2}$

$f = 1.5\ Hz$

$T = \frac{2\pi}{\omega} = \frac{2\pi}{3\pi}$

$T = \frac{2}{3}\ sec$

b) Amplitude $= x_m$

$= 4m$

c) phase constant $= \pi$

d) $x = 4\cos(3\pi(0.25) + \pi)$

$x = 2.82m$

Q3. a) $T = \frac{12}{5} = 2.4\ sec$

b) $f = \frac{1}{T} = \frac{1}{2.4} = 0.417\ Hz$

c) $\omega = 2\pi f = 2\pi(0.417)$

$\omega = 2.62\ rad/s$

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Q4. $m = 200\,g$, $T = 0.25\,s$ $E = 2\,J$

a) $\omega = \frac{2\pi}{T} = \frac{2\pi}{0.25} = 25.1\ rad/s$

$K = m\omega^2 = 0.2(25.1)^2$

$= 126\ N/m$

b) $E = \frac{kA^2}{2}$; $A = \sqrt{\frac{2E}{k}} = \sqrt{\frac{2(2)}{126}}$

$A = 0.178\ m$

Q5. a) $K = \frac{|F|}{|x|} = \frac{20}{0.2} = 100\ N/m$

b) $\omega = \sqrt{\frac{k}{m}} = \sqrt{50}\ rad/s$

$f = \frac{\omega}{2\pi} = 1.13\ Hz$

c) $V_{max} = \omega A = \sqrt{50} \times 0.2 = 1.41\ m/s$

Maximum speed occurs when object passes through its equilbrium position at $x = 0$

d) $a_{max} = \omega^2 A = 50(0.2) = 10\ m/s^2$

Maximum acceleration occurs where object reverses direction which is where its distance from equilbrium is maximum

at $x = \pm A = \pm 0.2\ m$

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Q5 e) $E = 2\,J$

f) $|v| = \omega\sqrt{A^2 - x^2}$

$= \sqrt{50}\sqrt{\frac{8}{a}(0.2)^2} = 1.33\ m/s$

g) $|a| = \omega^2 x$

$= 50\left(\frac{0.2}{3}\right) = 3.33\ m/s^2$

Q6. $m = 2kg$

$F = 3\sin(2\pi t)$

$K = 20\ N/m$

a) $\omega = \sqrt{\frac{K}{m}} = \sqrt{\frac{20}{2}} = \sqrt{10}\ rad/s$

$T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{10}} = 2\ sec$

b) $A = \frac{F_0/m}{\omega^2 - \omega_0^2} = 0.0509 = 5.09\ cm$

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Q7. a) $\omega = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$

$2\pi f = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$

$2\pi f = \sqrt{\frac{205 \times 10^4}{10.6} - \frac{3^2}{4 \times 10.6^2}}$

$f = 7 \text{ Hz}$

b) $x = x_m e^{-bt/2m} \cos(\omega t + \theta)$

for 1 cycle

$A e^{-(3 \times 1 / 2 \times 10.6)} \cos(0)$

$= 0.98 \text{ A}$

$(1 - 0.98) \times 100 = 2\%$

amplitude reduced by 2%.

c) Energy decreased by 5%.

$E = \frac{1}{2} k x^2$, $E = \frac{1}{2} k (x e^{-bt/2m})^2$

$0.05 \times \frac{1}{2} k x^2 = \frac{1}{2} k (x e^{-bt/2m})^2$

$0.05 x^2 = x^2 (e^{-bt/2m})^2$

$0.05 = e^{-bt/10.6}$

$\ln 0.05 = \ln e^{-3t/10.6}$

$2.99 = \frac{3t}{10.6}$

$t = 10.6 \text{ sec}$

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Q8. $v_m = \omega x_m = 5\ cm/s$

at $t = 0$, $v_0 = 4\ cm/s$

$$v = -\omega x_m \sin(\omega t + \phi)$$

$$\phi = \sin^{-1}\left(\frac{-4}{5}\right) = -0.927\ rad/s \text{ or } 5.36\ rad/s$$

Q9. mechanical energy = kinetic energy at $x = 0$

$$\frac{1}{2} mv^2 = \frac{1}{2}(0.2)(0.85)$$

$$= 0.72\ J$$

$$U\ (at\ x = 10) = 0.5\ J$$

$$U_x = bx^2$$

$$b = 5 \times 10^{-3}$$

$U_x = 0.72\ J$ when $x = 12\ cm$

mass does turn back before reaching $x = 15\ cm$

It turns back at $x = 12cm$.