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NS1001 Applied Physics

Assignment #4

Q1 (a) $v = \frac{dx}{dt}$

$x = 5\cos(9.9t)$

$v = \frac{d}{dt} x$

$v = -49.5\sin(9.9t)$

$v = 49.5\ cm/s$

(b) The max speed first occurs after

$t = \frac{3\pi}{19.8}\ s$

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

$a = \frac{d}{dt}(-49.5\sin(9.9t))$

$a = -490.05\cos(9.9t)$

$a = 490.05\ cm/s^{-2}$

Q2 (a) $x(0) = A\cos(\theta)$

$4 = A\cos(\theta)$ —(i)

For phase constant (θ)

$v_x(t) = -A\omega\sin(\omega t + \theta)$

$-25 = -A\omega\sin(\theta)$

$A\sin(\theta) = 25$ —(ii)

$16 + 625 = A^2\cos^2(\theta) + A^2\sin^2(\theta)$

$641 = A^2$

$A = 25.3\ cm$

$\tan\theta = \frac{25}{4}$

$\theta = 81.87^\circ$

(b) $x(t) = \sqrt{641}\cos(8t + 81.87)$

$81.87 \times \frac{\pi}{180} = 1.43\ rad$

$x(t) = \sqrt{641}\cos(8t + 1.43)$

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Q3(a) $E = KE + P.E$

$E = \frac{1}{2}(mv^2 + kx^2)$

$E = \frac{3\pi^2 \times 0.04^2}{2} = 0.02J$

(b) $K.E_{max} = E$

$\frac{1}{2}mv^2 = 0.02$

$v = 0.154\ ms^{-1}$

(c) $v(x) = \frac{1}{2}v$

$v_{max} = 0.154$

$v_{max} = \frac{1}{2}(0.154)$

$x_1 = 2$

Q4(a) $PE = \frac{1}{2}kA^2$

$KE = \frac{1}{2}mv^2$

$v = \sqrt{\frac{kA^2}{m}}$

(b) $\omega = \sqrt{\frac{k}{m}}$

(c) $A = \sqrt{\frac{2km}{\omega^2}}$

Q5: $m = 2kg$ $x = 10$ when $t = 0$

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

$-7.5 = 10\sin(\phi)$

$\phi = 48.59$

$\omega = \frac{2\pi}{T} = \frac{2\pi}{0.2} = 31.41$

$\omega = \sqrt{\frac{k}{m}}$

$k = 31.415^2 \times 2$

$k = 1973.92$

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$v_{max} = \omega x_m = 314.15$

$a_{max} = \omega^2 x_m = 9869.02$

$T.E = \frac{1}{2} m\omega^2 x_m^2$

$T.E = 98690.22$

$x(t) = 10 \sin(31.45t - 48.59)$

Q6: No

Reason: If resistive force is large compared to restoring force of spring. The system will be over damped and will not oscillate.

Q7 (a) $T = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{2.23}{9.8}} = 35$

(b) $E_T = \frac{1}{2}mv^2 = \frac{1}{2}(6.74)(2.06) = 14.3 J$

(c) $E_T = PE$

$= mg(L - L\cos\theta)$

$= mgL(1 - \cos\theta)$

$\cos\theta = \frac{1 - E_T}{mgL}$

$\theta_{max} = 0.443$

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Q8 : $a_{max} = \mu g = 3.92 ms^{-2}$

Given:

$x_{max} = \frac{m_1 + m_2}{k} = 22 cm$

Q9: angle $= \cancel{\theta} = \omega t$

$x = A\cos \cancel{\phi}\theta$

$x = A\cos \omega t$

$x = A\cos(\cancel{\theta}t + \phi)$

Q10. Energy of pendulum

$E_1 = \frac{1}{2} k A^2 = 45 j$ — i

$E_2 = \frac{1}{2} k A^2 = 15 j$ — ii

$\frac{A_1}{A_2} = \sqrt{3}$

Damped:

$m x + b x + c x = 0$

Amp:

$A(t) = A_0 e^{-bt/2m} \cos(\omega t + \phi)$

$\frac{A_2}{A_1} = e^{-\frac{b_1 st}{2m}}$

$\frac{b}{m}$ damp constant

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$$\frac{A_1}{A_2} = e^{bt/2m}$$

$$\frac{15b}{2m} = \ln\left(\frac{A_1}{A_2}\right)$$

$$\frac{b}{m} = \frac{2}{15}\ln 3$$

Q11. $E(t) = E(0) \times e^{(-bt/2m)}$

$E(t) = \frac{1}{2} \times E(0)$

$$\frac{1}{2} \times E(0) = E(0) \times e^{(-bt/2m)}$$

$$\frac{1}{2} = e^{-bt/2m}$$

$$\ln\frac{1}{2} = \ln e^{-bt/2m}$$

$$\ln\frac{1}{2} = -\frac{bt}{2m}$$

$t = (-2m/\ln(1/2)) \times \ln(1/2b)$

$t = \left(\frac{-2 \times 2}{\ln(1/2)}\right) \times \ln\left(\frac{1}{2}b\right)$

$t = -1.8587$ s

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Q12. $x(t) = A\cos(\omega t + \theta)$

$v(t) = -v_{max}\sin(\omega t + \theta)$

$A = \frac{v_{max}}{\omega}$

$x_1(t_1) = \frac{v_{max}}{\omega}\cos(\omega t_1)$

$x_2(t_2) = \frac{v_{max}}{\omega}\cos(\omega t_2)$

$v_1(t) = -v_{max}\sin(\omega t_1)$

$v_2(t) = -v_{max}\sin(\omega t_2)$

$v_{max}^2 = v_1^2 + x_1^2 \cdot \omega^2$

$v_{max}^2 = v_2^2 + x_2^2 \cdot \omega^2$

$v_{max} = 102.1 cms^{-1}$

Q3: $x = A\cos(\omega t + \theta)$

$x(0) = 0 \rightarrow \theta = \pm \frac{\pi}{2}$

$\phi = -\frac{\pi}{2}$

$\omega = \frac{2\pi}{T} = \frac{2\pi}{4} = \frac{\pi}{2}$

$x = A\cos\left(\frac{\pi}{2}t - \frac{\pi}{2}\right) = A\sin\left(\frac{\pi}{2}t\right)$

$x = A\sin\left(\frac{\pi}{2}t\right)$

$0.06 = 0.10\sin\frac{\pi}{2}t$

$t = 0.6$ seconds.