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Ex. 3

The tip of a tuning fork ...

$f = \dfrac{440 \text{ osc.}}{0.5 \text{ sec}} = 880 \dfrac{\text{cycles}}{\text{sec}} = 880 \text{ Hz}$

$\omega = 2\pi f = 2\pi(880\ s^{-1}) = \boxed{5.53 \times 10^{3} \text{ rad/s}}$

$T = \dfrac{1}{f} = \dfrac{1}{880\ s^{-1}} = \boxed{1.14 \times 10^{-3}\ s}$

Ex. 9

When an object of unknown mass is attached to an ideal spring....

$k = 120 \text{ N/m}$

$f = 6.00 \text{ Hz}$

a.) $T = ?$ $T = \dfrac{1}{f} = \dfrac{1}{6.00\ s^{-1}}$

$\boxed{T = 0.16\overline{66} \text{ sec.}}$

b.) $\omega = 2\pi f = 2\pi(6.00\ s^{-1}) \Rightarrow \boxed{\omega = 37.7 \text{ rad/s}}$

c.) $m = ?$ $\omega^2 = \dfrac{k}{m}$ $m = \dfrac{k}{\omega^2} = \dfrac{120 \text{ N/m}}{(37.7 \text{ rad/s})^2} = \boxed{0.0844 \text{ kg}}$

Ex. 11

An object is undergoing SHM with a period of 0.900 sec. and amplitude of 0.320 m.

$x_i = 0.320 \text{ m}$ @ $t_i = 0.0$ $V_x = 0.00 \text{ m/s}$

a.) $x_f = 0.160 \text{ m}$ @ $t_f = ?$ $x = A\cos(\omega t)$ $\omega = \dfrac{2\pi}{T} = \dfrac{2\pi}{0.900 s}$

$\omega = \dfrac{2\pi}{T}$

$\dfrac{\overset{0.320}{x_i} = \cancel{A}\cos(\omega(0))}{0.160 \rightarrow x_f = \cancel{A}\cos(\omega t)} \Rightarrow 2 = \dfrac{1}{\cos(\omega t)}$

$\cos(\omega t) = \frac{1}{2}$ $\omega t = \cos^{-1}\left(\frac{1}{2}\right)$ $t = \dfrac{1}{\omega} \overbrace{\cos^{-1}(1/2)}^{\pi/3}$

$t = \dfrac{T}{2\pi}\dfrac{\pi}{3} = T/6 = \dfrac{0.900 s}{6}$ $\boxed{t = 0.150 \text{ sec}}$

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Ex. 11 Cont'd b.) Δt for $x_i = 0.160\text{ m} \rightarrow x_f = 0.00\text{ m}$.

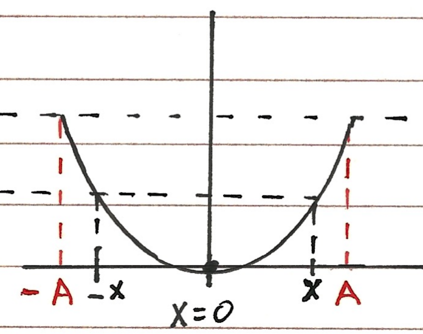
$t_i = T/6$ $\qquad$ $t_f = T/4$

One can argue that by symmetry, the time $t = T/4$ when the object crosses the origin ($x_f = 0.00\text{ m}$)

$$\Delta t = t_f - t_i = \frac{T}{4} - \frac{T}{6} = \frac{2T}{24} = \frac{T}{12} = \frac{0.900\text{ s}}{12} = \boxed{0.0750\text{ s}}$$

Ex. 28 A harmonic oscillator has angular frequency ω and amplitude A.

a.) Find x and v_x when $K = U$.



$$U = \tfrac{1}{2}kx^2 = \tfrac{1}{4}kA^2$$

$$\tfrac{1}{2}x^2 = A^2/4 \qquad x^2 = A^2/2$$

$$x = \pm A/\sqrt{2} = \boxed{\pm 0.707A}$$ → They only ask for the magnitude

$$K = \tfrac{1}{2}mv_x^2 = \tfrac{1}{4}kA^2 \qquad v_x^2 = \underbrace{\left(\frac{k}{m}\right)}_{\omega^2}\frac{A^2}{2} \qquad v_x = \pm\omega A/\sqrt{2}$$

$$\boxed{v_x = \pm\frac{\omega A}{\sqrt{2}}}$$ → They only ask for the magnitude

Ex. 36 A proud deep-sea fisherman hangs a 65.0-kg fish from an ideal spring having negligible mass.

a.) $x = 0.180\text{ m}$ $\qquad F = kg$ $\qquad mg = kx$ $\qquad k = \frac{mg}{x} = \frac{(65)(9.8)}{0.180}$

$$\boxed{k = 3539\text{ N/m}} = 3.54 \times 10^3\text{ N/m}$$

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Ex. 36 Cont'd (b.) $T = ?$ $\omega = \sqrt{\frac{k}{m}}$ $\frac{2\pi}{T} = \sqrt{\frac{k}{m}}$

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{65.0\,kg}{3539\,N/m}} = 0.851\text{ sec}$$

c.) $$V_{max} = \underset{5cm}{A}\,\underset{2\pi/T}{\omega} = (0.050\text{ m})\left(\frac{2\pi}{0.851s}\right) = \boxed{0.369\text{ m/s}}$$

Ex. 46 A pendulum on Mars. A certain simple pendulum has a period on earth of 1.60 s.

$T_{mars} = ?$ if $T_{earth} = 1.60\text{ s}$ $\omega = \frac{2\pi}{T} = \sqrt{g/L}$

$$T = 2\pi\sqrt{\frac{L}{g}} \qquad \frac{T_{mars}}{T_{earth}} = \frac{2\pi\sqrt{L/g_{mars}}}{2\pi\sqrt{L/g_{earth}}} = \sqrt{\frac{g_{earth}}{g_{mars}}}$$

$$T_{mars} = T_{earth}\sqrt{\frac{g_{earth}}{g_{mars}}} = 1.60\text{ sec}\sqrt{\frac{9.80}{3.71}} \qquad \boxed{T_{mars} = 2.60\text{ s}}$$

Ex. 50 We want to hang a thin hoop on a horizontal nail and have the hoop make one complete small-angle oscillation...

$T = 2.0\text{ s}$ $I = MR^2 + \underbrace{MR^2}_{\text{Parallel Axis Theorem}} = 2MR^2$ $\omega = \sqrt{\frac{mgR}{I}}$ ← d = dist. to c.m. = R

$$\overset{\omega}{\frac{2\pi}{T}} = \sqrt{\frac{\cancel{m}g\cancel{R}}{2\cancel{m}R^{\cancel{2}}}} = \sqrt{\frac{g}{2R}} \Rightarrow \frac{4\pi^2}{T^2} = \frac{g}{2R} \qquad R = \frac{gT^2}{8\pi^2}$$

$$R = \frac{(9.8\,m/s^2)(2.00\,s)^2}{8\pi^2} = 0.496\text{ m} \qquad \boxed{R = 0.496\text{ m}}$$

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Ex. 57

An unhappy 0.300-kg rodent, moving on the end of a spring with a force constant $k = 2.50$ N/m is acted on by a damping force $F_x = -bv_x$

a.) $b = 0.900$ kg/s $\quad f' = ?$ $\quad \omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}} = 2\pi f'$

$$f' = \frac{1}{2\pi}\sqrt{\frac{2.50}{0.300} - \frac{(0.900)^2}{4(0.300)^2}} = 0.393\ s^{-1}$$

$$\boxed{f' = 0.393\ Hz}$$

b.) $b = ?$ for the motion to be critically damped

$$b = 2\sqrt{km} = 2\sqrt{(2.50\ N/m)(0.300\ kg)} = 1.73\ kg/s$$

$$\boxed{b = 1.73\ kg/s}$$