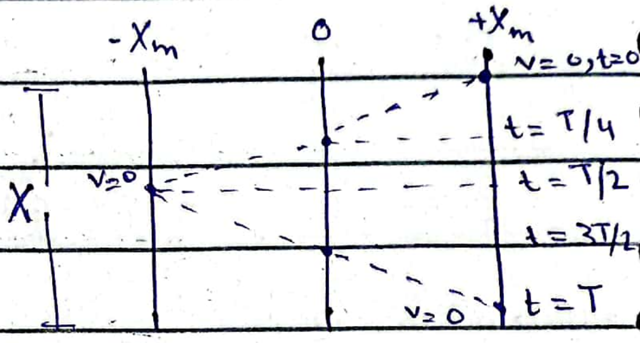
Chapter # 15 Oscillations

Exercise Problems: 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 13.

1) $t = 0.25s$

$X = 36cm$



(a) $T = ?$

$t = T/2$

$T = 2t$

$T = 2(0.25)$

$\boxed{T = 0.5s}$

(b) $f = ?$

$f = \frac{1}{T} = \frac{1}{0.5}$

$\boxed{f = 2Hz}$

(c) $X_m = ?$

$X_m = X/2 = 36/2$

$\boxed{X_m = 18cm}$

2) $m = 0.12kg$

$X_m = 8.5cm = 0.085m$

$t = 0.2s$

(a) maximum force is related to the acceleration amplitude. By Newton's second law.

$$F_{max} = m a_m$$

$$a_m = \omega^2 X_m$$

$$F_m = m\omega^2 X_m$$

$$\omega = 2\pi f$$

$$f = \frac{1}{T} = \frac{1}{0.2}$$

$$\boxed{f = 5\ Hz}$$

$$\omega = 2\pi(5)$$

$$\boxed{\omega = 10\pi\ rad/s}$$

Now,

$$F_m = (0.12\,kg)(10\pi\ rad/s)^2(0.085\,m)$$

$$\boxed{F_m = 10N}$$

(b) $$\omega = \sqrt{\frac{K}{m}} \Rightarrow \omega^2 = \frac{K}{m}$$

$$K = \omega^2 m$$

$$= (10\pi\ rad/s)^2(0.12\,kg)$$

$$\boxed{K = 1.2\times10^2\ N/m}$$

3) $X_m = 2.2cm = 0.022m$

$f = 6.60\ Hz$

$a_m = ?$

$a_m = \omega^2 X_m$

$\omega = 2\pi f = 2\pi(6.60)$

$\boxed{\omega = 41.46}$

$a_m = (41.46)^2 (0.022)$

$\boxed{a_m = 37.8\ m/s^2}$

4) Frequency of four springs is.

$f = 3\ Hz$

mass of car

$m_{car} = 1450\ kg$

mass of each five pessengers that added. = 73

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

$\boxed{\omega = 6\pi\ rad/s}$

$K = ?$

Each spring is considered to support one fourth of the mass of car

$$\omega = \sqrt{\frac{K}{m_{car}/4}}$$

$$K = \frac{1}{4} m_{car} \omega^2$$

$$K = \frac{1}{4} (1450)(6\pi)^2$$

$$\boxed{K = 1.29 \times 10^5 \ N/m}$$

(b) New mass being supported by the four springs is:

$$m_{total} = [1450 + 5(73)] = 1815$$

$$\omega_{new} = \sqrt{\frac{K}{m_{total}/4}}$$

$$\omega_{new} = 2\pi f_{new}$$

$$f_{new} = \frac{\omega_{new}}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{K}{m_{total}/4}}$$

$$f_{new} = \frac{1}{2\pi}\sqrt{\frac{\cancel{2.68}\ 1.29 \times 10^5}{1815/4}}$$

$$\boxed{f_{new} = 2.68 \ Hz}$$

5) Displacement $D = 20\,mm = 0.001\,m$

$x_m = ?$, $v_m = ?$, $a_m = ?$

$f = 120\,Hz$

(a) The amplitude x_m is half the range of the displacement D.

$$x_m = D/2 = 0.001/2$$

$$\boxed{x_m = 1.0 \times 10^{-3}\,m}$$

(b) $v_m = \omega x_m = (2\pi f)\, x_m$

$$= 2\pi(120)(1.0 \times 10^{-3})$$

$$\boxed{v_m = 0.75\,m/s}$$

(c) $a_m = \omega^2 \cancel{x}_m = (2\pi f)^2 \cancel{x}_m$

$$= (2\pi(120))^2\, 1.0 \times 10^{-3}$$

$$\boxed{a_m = 5.7 \times 10^2\,m/s^2}$$

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6) $m = 1.00 \times 10^{-20}\,kg$

$t = 1.00 \times 10^{-5}\,s$

$v_m = 1.00 \times 10^{3}\,m/s$

$\omega = ?$

$x_m = ?$

(a) $\omega = 2\pi f = \frac{2\pi}{T} = \frac{2\pi}{1.00 \times 10^{-5}}$

$$\boxed{\omega = 6.28 \times 10^{5} \text{ rad/s}}$$

(b) $V_m = \omega X_m$

$$X_m = \frac{V_m}{\omega} = \frac{1.00 \times 10^{3} \text{ m/s}}{6.28 \times 10^{5} \text{ rad/s}}$$

$$\boxed{X_m = 1.59 \times 10^{-3} \text{ m}}$$

7) $x_m = 1 \mu m = 1 \times 10^{-6}$ m

(a) magnitud a of the diaphragm's accelerations equal to g.

$$a = \omega^2 X_m$$

$$g = \omega^2 x_m$$

$$\omega = \sqrt{g/x_m}$$

$$\omega = 2\pi f \Rightarrow f = \frac{1}{2\pi}\sqrt{g/x_x} = \frac{1}{2\pi}\sqrt{\frac{9.8}{1 \times 10^{-6}}}$$

$$\boxed{f = 498 \text{ Hz}}$$

(b) As we can see. $f \propto \sqrt{g}$

For frequencies greater than 498 Hz, the a exceeds g for some part of the motion.

9) $x(t) = (6.0m)(\cos((3\pi)t + \pi/3))$

$t = 2.0s$

(a) $x = ?$

$x(2.0) = (6.0)\cos(3\pi(2.0) + \pi/3)$

$\boxed{x = 3.0m}$

(b) $v = ?$

$$v = \frac{dx}{dt} = -3\pi(6.0)\sin((3\pi)t + \pi/3)$$

$v(2.0) = -3\pi(6.0)\sin(3\pi(2.0) + \pi/3)$

$\boxed{v = -49\ m/s}$

(c) $$a = \frac{dv}{dt} = -(3\pi)^2(6.0)\cos(3\pi(t) + \pi/3)$$

$a(2.0) = -(3\pi)^2(6.0)\cos(3\pi(2.0) + \pi/3)$

$\boxed{a = -2.7 \times 10^2\ m/s^2}$

(d) The phase of the motion is:

$(3\pi(t) + \pi/3)$

At $t = 2s$.

$3\pi(2) + \pi/3 \approx \boxed{20\ rad}$

(e) $\omega = 3\pi$

$\omega = 2\pi f$

$f = \frac{\omega}{2\pi} = \frac{3\cancel{\pi}}{2\cancel{\pi}}$

$\boxed{f = 1.5\ Hz}$

(f) $T = \frac{1}{f} = \frac{1}{1.5}$

$\boxed{T = 0.67\,s}$

10) $t = 0.75s$

(a) $T = ?$

The problem describes the time taken to execute one cycle of the motion. The period is.

$\boxed{T = 0.75s}$

(b) $f = ?$

$f = \frac{1}{T} = \frac{1}{0.75}$

$\boxed{f = 1.3\ Hz}$

(c) $\omega = 2\pi f = 2\pi(1.3)$

$$\boxed{\omega = 8.4 \text{ rad/s}}$$

11) Two identical springs constant k =

$K = 7580$

$m = 0.245$ kg

$f = ?$

$F = -2Kx$

$ma = -2Kx$

$$m\frac{d^2x}{dt^2} = -2kx$$

$$m\frac{d^2x}{dt^2} + 2Kx = 0$$

$$\frac{d^2x}{dt^2} + \frac{2k}{m}x = 0$$

$$\frac{d^2x}{dt^2} + \omega^2 x = 0$$

$$\omega^2 = 2K/m$$

$$\omega = \sqrt{\frac{2k}{m}}$$

$$2\pi f = \sqrt{\frac{2K}{m}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{2K}{m}}$$

$$= \frac{1}{2\pi}\sqrt{\frac{2(7580)}{0.245}}$$

$$\boxed{f = 39.6\ Hz}$$

13) $m = 0.500\ kg$

$X_m = 35\ cm = 0.35\ m$

$t = 0.500\ s$

(a) $T = ?$

The motion repeats every 0.5s so period must be

$$\boxed{T = 0.5\ s}$$

(b) $f = ?$

$$f = \frac{1}{T} = \frac{1}{0.5}$$

$$\boxed{f = 2.0\ Hz}$$

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

$$\boxed{\omega = 12.6\ rad/s}$$

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(d) $k = ?$

$k = m\omega^2 = (0.5\ kg)(12.6)^2$

$\boxed{K = 79.0\ Nm}$

(e) $V_m = ?$

$V_m = \omega X_m = (79)(0.35)$

$\boxed{V_m = 4.40\ m/s}$

(f) $F_m = k X_m = (79)(0.35)$

$\boxed{F_m = 27.6\ N}$