Physics Assignment 2

1a) $x = 4\cos(3\pi t + \pi)$

$\omega = 3\pi$

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

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

$T = \frac{2\pi}{3\pi} = 0.67s$

$f = \frac{1}{T} = \frac{1}{\frac{2}{3}} = 1.5\ Hz$

b) amplitude = 4

c) phase constant = π

d) $x = 4\cos(3\pi(0.250) + \pi)$

$x = 2.83m$

2a) $T = \frac{12}{5} = 2.4s$

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

$f = 0.417\ Hz$

c) $\omega = 2\pi f$ $\omega = 2.62\ rad/s$

$\omega = 2\pi(0.417)$

3) A 200g block is attached to a horizontal spring and executes simple harmonic motion with a period of 0.250s. Total energy is 2.00 J.

a) the force constant of the spring.

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

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

$$\omega = \frac{2\pi}{0.25} = 25.13 \text{ rad/s}$$

$$25.13 = \sqrt{\frac{k}{0.2}}$$

$$k = 126.3 \text{ N/m}$$

b) $$E = \frac{1}{2} k x_m^2$$

$$2 = \frac{1}{2} (126.3)(x_m)^2$$

$$(x_m)^2 = 0.03167$$

$$x_m = 0.178 \text{ m}$$

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4) $x_1 = 0.200\,m$ amplitude $m = 2\,kg$

$F = 20\,N$

a) $F = kx$

$20 = k(0.200)$

$k = 100\ N/m$

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

$\omega = \sqrt{\frac{100}{2}}$

$\omega = 7.07\ rad/s$

$\omega = 2\pi f$

$7.07 = 2\pi f$

$\frac{7.07}{2\pi} = f$

$f = 1.125\ Hz$

c) $v = x_m \omega$

$v = 0.2\,(7.07)$

$v = 1.414\ m/s$

At $x = 0$ there is maximum velocity

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d) $a = -x_m \omega^2$

$a = -0.2\,(7.07)^2$

$a = -9.996 = 10\ m/s^2$

Maximum acceleration occurs at maximum displacement i.e $x = \pm 0.2\ m$

e) $E = \frac{1}{2} k x^2$

$E = \frac{1}{2}(100)(0.2)^2 = 2\ J$

f) $\frac{1}{3}$ of x_m is $= \frac{0.2}{3} = \frac{1}{15}\ m$

$v = \omega\sqrt{x_f^2 - x_i^2}$

~~$v = (50)\sqrt{(0.2)^2 - \left(\frac{1}{15}\right)^2}$~~

$v = (7.07)\sqrt{(0.2)^2 - \left(\frac{1}{15}\right)^2} = 1.33\ m/s$

(i) $a = \omega^2 x$

$a = (7.07)^2\left(\frac{1}{15}\right) = 3.33\ m/s^2$

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5) a) $F = 3\sin(2\pi t)$ $\quad k = 20\ N/m$

$m = 2.0\ kg$

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

$\omega' = \sqrt{\omega^2 - \frac{b^2}{4m^2}}$

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

$2\pi = 2\pi$

$\times T$

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

$T = 1\ s$

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

$\omega = \sqrt{\frac{20}{2}}$

$\omega = 3.162$

$T = \frac{2\pi}{3.162}$

$T = 1.99\ s$

b) $\omega' = 2\pi$

$a = \frac{F}{m}$

$a = \omega^2 x_m$

$\frac{F}{m} = (\omega^2 - \omega_0^2) A$

$\frac{3}{2} = ((2\pi)^2 - (3.16)^2) A$

$A = 0.051\ m$

6 a) ~~$\omega^2 = \omega_0^2 - \left(\frac{b}{2m}\right)^2$~~

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

$\omega = \sqrt{\frac{2.05 \times 10^9}{10.6}}$

$\omega = 43.977$

$\omega = 2\pi f$

$\frac{43.977}{2\pi} = f$

$f = 6.999 = 7\ Hz$

b) $1 - e^{-\pi b/m\omega}$

~~$1 - e^{-\pi(3)/10.6(43.977)} = 0.02$~~

$\frac{x_m - x_m e^{-\pi b/m\omega}}{x_m} \times 100$

$1 - e^{-\pi b/m\omega} \times 100$

$1 - e^{-\pi(3)/(10.6)(43.977)} \times 100 = 2\%$

c) $\frac{1}{2} k \left(A e^{-\frac{bt}{2m}}\right)^2 = \frac{1}{20} \left(\frac{1}{2} k A^2\right)$

$e^{-\frac{bt}{m}} = \frac{1}{20}$

$-\frac{bt}{m} = \frac{1}{20}$

$-\frac{bt}{m} = \ln\left(\frac{1}{20}\right)$

$t = 10.58 = 10.6s$

7) $x = x_m \cos(\omega t + \phi)$

$V = -x_m \omega \sin(\omega t + \phi)$ $\quad V_s = 4 \quad V = 5$

~~$4 = -x_m \omega \sin(\omega t + \phi)$~~

$4 = 5 \sin(\omega(0) + \phi)$

$\frac{4}{5} = \sin(\phi)$

$\phi = 0.927$ rad

8) At equilibrium position

$K.E = \frac{1}{2} m v^2$

$K.E = \frac{1}{2}(2)(85)^2$ $\quad 85\ cm/s = 0.85\ m/s$

$K.E = \frac{1}{2}(2)(0.85)^2 = 0.7225\ J$

$U_x = 2\ J$ at $x = 15\ cm$ $\quad 20$

$U_x = bx^2$

$1 = b(15)^2$ $\quad 2 = b(20)^2$

$b = 5 \times 10^{-3}\ J/cm^2$

$0.7225 = 5 \times 10^{-3} x^2$

$x = 12\ cm$

a) The mass does turn back before reaching 15 cm

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b) It turns back at $x = 12$ cm