Useful Equations:

$$T = 2\pi\sqrt{\frac{m}{k}}, \qquad f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}, \qquad \omega_o = \sqrt{\frac{k}{m}}, \qquad \gamma = \frac{b}{2m}. \qquad (6), (7)^*$$

$$m\ddot{x} + b\dot{x} + kx = 0; \qquad \ddot{x} + 2\gamma\dot{x} + \omega_o{}^2 x = 0, \qquad \omega_d = \sqrt{\omega_o{}^2 - \gamma^2}, \qquad \gamma_d = \sqrt{\gamma^2 - \omega_o{}^2}. \qquad (11)$$

$$x = e^{-\gamma t}\left(Ae^{-\gamma_d t} + Be^{\gamma_d t}\right), \qquad A = -\frac{(\gamma - \gamma_d)x_o + v_o}{2\gamma_d}, \qquad B = \frac{(\gamma + \gamma_d)x_o + v_o}{2\gamma_d}. \qquad (12),(13)$$

$$x = e^{-\gamma t}\left(A\cos\omega_d t + B\sin\omega_d t\right), \qquad A = x_o, \qquad B = \frac{v_o + \gamma x_o}{\omega_d}. \qquad (14),(15)$$

$$x = (A + Bt)e^{-\gamma t}, \qquad A = x_o, \qquad B = \gamma x_o + v_o. \qquad (16),(17)$$

$$\left|\frac{\Delta E}{E}\right| \cong \frac{4\pi\gamma}{\omega_d} \cong \frac{4\pi\gamma}{\omega_o}, \qquad \left|\frac{\Delta E_{\text{per radian}}}{E}\right| = \frac{2\gamma}{\omega_o}, \qquad Q = \frac{\omega_o}{2\gamma}, \qquad E = E_0 e^{-2\gamma t}. \quad (27)\text{-}(30)$$

$$F = F_o\cos\omega t, \qquad x = A'\cos(\omega t + \varphi), \qquad A' = \frac{F_o/m}{\omega_o{}^2 - \omega^2}, \qquad (33)$$

$$A' = \frac{F_o/m}{\sqrt{\left(\omega^2 - \omega_o{}^2\right)^2 + (2\gamma\omega)^2}}, \qquad \tan\varphi = \frac{2\gamma\omega}{\omega^2 - \omega_o{}^2}, \qquad A' \cong \frac{F_o/2m\omega_o}{\sqrt{(\omega_o - \omega)^2 + \gamma^2}}. \qquad (37),(41)$$

$$x = e^{-\gamma t}\left(A\cos\omega_d t + B\sin\omega_d t\right) + A'\cos(\omega t + \varphi). \qquad (45)$$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \cdots.$$

$$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \cdots, \qquad \cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \cdots.$$

$$\frac{1}{2\pi}\int_0^{2\pi}\sin^2 x\,dx = \frac{1}{2\pi}\int_0^{2\pi}\cos^2 x\,dx = \frac{1}{2}.$$

$$y(x,t) = A\cos\left[2\pi\left(\frac{x}{\lambda} - ft\right)\right] = A\cos\left[2\pi\left(\frac{x}{\lambda} - \frac{t}{T}\right)\right] = A\cos\left[2\pi f\left(\frac{x}{c} - t\right)\right]$$

$$= A\cos(kx - \omega t) = A\cos\left[\omega\left(\frac{x}{c} - t\right)\right]. \qquad c = \sqrt{\frac{F}{\mu}}.$$

$$E = \int\left[\frac{1}{2}\mu\left(\frac{\partial y}{\partial t}\right)^2 + \frac{1}{2}F\left(\frac{\partial y}{\partial x}\right)^2\right]dx, \qquad P = -F\left(\frac{\partial y}{\partial x}\right)\left(\frac{\partial y}{\partial t}\right).$$

* Numbers refer to equations in Chapter 5 of the notes *The Harmonic Oscillator*.