Formulas for Waves

Harmonic oscillations:

$f = \frac{1}{T}$ $\omega = 2\pi f$ $x(t) = A\cos(\omega t + \phi)$ $F_x = -kx$ $\omega = \sqrt{\frac{k}{m}}$

$E = \frac{1}{2}mv_x^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2 = const.$

Strings:

$y(x,t) = A\cos(kx \pm \omega t + \phi)$ $\frac{\partial^2 y}{\partial^2 x} = \frac{1}{v^2}\frac{\partial^2 y}{\partial^2 t}$ $k = \frac{2\pi}{\lambda}$ $\omega = \frac{2\pi}{T}$

$v = f\cdot\lambda = \frac{\omega}{k}$ $v = \sqrt{\frac{F}{\mu}}$ $f_n = \frac{nv}{2L}$

$P_{av} = \frac{1}{2}\mu(\omega A)^2 v = \frac{1}{2}\sqrt{\mu F}(\omega A)^2$ $I = \frac{Power}{Area}$

Fluids:

$v = \sqrt{\frac{B}{\rho}}$ $p_{max} = BkA = \rho\omega vA$

Intensities:

$I = \frac{1}{2}\rho(\omega A)^2 v = \frac{1}{2}\sqrt{\rho B}(\omega A)^2 = \frac{{p_{max}}^2}{2\rho v} = \frac{{p_{max}}^2}{2\sqrt{\rho B}}$

$\beta = 10\cdot\log\frac{I}{I_0}$ $I_0 = 10^{-12}\ W/m^2$

Pipes:

$f_n = \frac{nv}{2L}$ $f_n = \frac{nv}{4L}$ $(n\ odd)$

Doppler:

$f_L = \frac{v+v_L}{v+v_S}f_S$

Shock wave:

$$\sin\alpha = \frac{v}{v_S}$$

Electromagnetic waves:

$\vec{E} = c\vec{B}$ $\quad c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ $\quad u_E = \frac{1}{2}\varepsilon_0 E^2$ $\quad u_B = \frac{B^2}{2\mu_0}$

$\vec{S} = \frac{\vec{E}\times\vec{B}}{\mu_0}$ $\quad S_{av} = \frac{E_{max}B_{max}}{2\mu_0} = \frac{{E_{max}}^2}{2\mu_0 c} = \frac{1}{2}\varepsilon_0 c {E_{max}}^2$

Interference:

$\delta = r_2 - r_1 = m\lambda$ $\quad \delta = r_2 - r_1 = \left(m + \frac{1}{2}\right)\lambda$ $\quad \frac{\phi}{2\pi} = \frac{\delta}{\lambda}$

Two-slit interference:

$\delta = d\sin\theta$ $\quad d\sin\theta = m\lambda$ (max) $\quad d\sin\theta = \left(m + \frac{1}{2}\right)\lambda$ (min)

$I = I_0\cos^2\frac{\phi}{2}$ $\quad I_0 =$ intensity in the forward direction $\quad \phi = \frac{2\pi\delta}{\lambda}$

Diffraction:

$a\sin\theta = m\lambda \quad (m \neq 0)$ $\quad I = I_0\frac{\sin^2(\beta/2)}{(\beta/2)^2}$ where $\beta = \frac{2\pi a\sin\theta}{\lambda}$

$I = I_0\cos^2\frac{\phi}{2}\left[\frac{\sin^2(\beta/2)}{(\beta/2)^2}\right]$ $\quad I_0 =$ intensity in the forward direction

Rayleigh's criterion:

$\theta_c = \frac{\lambda}{a}$ (slit) $\quad \theta_c = \frac{1.22\cdot\lambda}{d}$ (round hole)

Grating:

$d\sin\theta = m\lambda$ $\quad R \equiv \frac{\lambda}{\Delta\lambda} = mN$