Equations – Heat, Light, Sound

SHM - Waves

$f = 1/T = \omega/2\pi = (\sqrt{(\frac{k}{m})})/2\pi$ $T = 2\pi\sqrt{m/k}$ $k = \frac{2\pi}{\lambda}$

$\phi = \omega t + \phi_0$ $\Delta\phi = \omega t$ $\omega = \frac{d\phi}{dt} = 2\pi f = \frac{2\pi}{T}$

$v = \frac{\lambda}{T} = \frac{\omega}{k} = \lambda f = \sqrt{\frac{T_s}{\mu}} = \sqrt{\frac{B}{\rho}}$ $\mu = \frac{T_s}{v^2}$

$x(t) = A\cos(2\pi t/T) = A\cos(\omega t + \phi_0) = A\cos(2\pi f t)$

$v(t) = -v_{max}\sin(2\pi t/T) = -v_{max}\sin(2\pi f t)$

$d(x,t) = A\sin(kx - \omega t + \phi_0)$ (linear) $d_x = A(r)\sin(kx - \omega t + \phi_0)$ (2D or 3D)

$v_y = \frac{dx}{dt} = -\omega A\cos(kx - \omega t + \phi_0)$

$\phi_1 = kx_1 - \omega t + \phi_0$ $\Delta\phi = 2\pi\Delta x/\lambda = \phi_2 - \phi_1 = k(x_1 - x_2)$

$I = P_{source}/A = P/4\pi r^2$ $\beta = (10\text{ dB})\log10\,(I/I_0)$

Standing waves $L = m(\lambda/2)$ $\lambda = 2L/m$ $v = \lambda f$ *L=length, m=mode*

$A(x) = 2A\sin(kx)$ $f = mv/2L = \frac{m}{2L}\sqrt{\frac{T_s}{\mu}}$

Resonance f o/o, c/c $f = mv/2L$ o/c $f = mv/4L$

Doppler	Source	Observer
Approaching	$f_0 = f_0 / (1 - v_s/v)$	$f_0 = f_0 * (1 + v_s/v)$
Receding	$f_0 = f_0 / (1 + v_s/v)$	$f_0 = f_0 * (1 - v_s/v)$

$a(x,t) = d^2x/dt^2 = -\omega^2 A\cos(\omega t + \phi_0)$ $a_x = -\omega^2 x = -k/m\ x$

Light

$v = \frac{c}{n}$ $\lambda_{material} = \frac{\lambda_{vacuum}}{n}$

Lens $\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$ Magnification $m = -\frac{s'}{s} = \frac{f}{f-s}$

Refraction

$\lambda_{material} = \lambda_{vacuum} / n$ $n = c/v$ Snell's law $n_1\sin\theta_1 = n_2\sin\theta_2$ Critical angle $\theta_{critical} = \sin^{-1}(n_2/n_1)$

Difraction

Cent fringe $w = w\lambda L/a$ single slit def $y = p\,\lambda L/a$ double slit def $y = m\,\lambda L/a$

Legend

s, r, d or h = distance or radius or height	θ, Φ = angle	A = area
v = velocity	ω = angular frequency	f = frequency
a = acceleration	α = angular acceleration	g = acceleration of gravity
a_t = tangential acceleration	a_c = centripetal acceleration	G = gravitational constant
F = force	τ = torque	T = period; tension (N)
Q, q = charge (C)	λ = charge/wavelength	η = charge/area
E = Energy; electric field (J; N/C or V/m)	W = work (J)	Φ = electric flux (Vm or Nm^2/C)
U = potential energy	K = Kinetic Energy (J)	P = power (W; J/s)
J = Joules (Nm or kg m^2/s^2)	u_E = elec energy density (J/m^3)	k = wave number (rad/m)
n = index of refraction	I = Intensity (W/m^2)	β = sound intensity (dB)
ρ = density (kg/m^3)	μ = linear density (kg/m); *permeability Const ($4\pi x10^{-7} Tm/A$)*	
B = bulk modulus (Pa or Nm^2)		
ε = permittivity const ($8.85x10^{-12}$ C^2/Nm^2)	$K = 1/2\pi\varepsilon_0$ ($8.99x10^9$ Nm^2/C^2)	κ = dielectric constant
C = capacitance (F)/Coulomb (C)	V = voltage or electrical pot. (V)	p = dipole moment (Cm or D)
I_0 = Threshold of hearing		

Identities

$x = \cos\theta$ $y = \sin\theta$ $\theta = \tan^{-1} y/x$

$\tan\theta = \sin\theta / \cos\theta$

$\sin 2\theta = 2\sin\theta \cos\theta$ p=sq

Other

$$\frac{-b \pm \sqrt{b^2-4ac}}{2a}$$

Constants

$\varepsilon = 8.55x10^{-12}$ C^2/Nm^2 $K=1/2\pi\varepsilon=8.99x10^9$ Nm^2/C^2 $I_0 = 1.0x10^{-12}$ W/m^2

$G=6.67x10^{-11}N$ $(q)e^- = 1.6x10^{-19}C$ $(m)=9.11x10^{-31}kg$ $(m)p^+ = 1.67x10^{-27}$ kg

$\mu_0 = 4\pi x10^{-7} Tm/A$