P214 Formula Sheets: Prelim II

Complex numbers

$$e^{ix} = \cos(x) + i\sin(x)$$
$$|\underline{A}|^2 = A_r^2 + A_i^2 = \underline{A}^*\underline{A}$$
$$|\underline{A}\cdot\underline{B}| = |\underline{A}|\cdot|\underline{B}|$$
$$|\underline{A}/\underline{B}| = |\underline{A}|/|\underline{B}|$$

Basic wave relationships

$$f = 1/T \qquad \kappa = 1/\lambda$$
$$\omega = 2\pi f \qquad k = 2\pi\kappa$$
$$\omega = 2\pi/T \qquad k = 2\pi/\lambda$$
$$c = \lambda f \qquad c = \omega/k$$

Wave physics

Quantity	String	Sound	E&M
Dynamical law(s)	$F_y = \pm\tau\frac{\partial y}{\partial x}$	$P = P_o - B\frac{\partial s}{\partial x}$	$\begin{cases} \frac{\partial E_y}{\partial x} = -\frac{\partial B_z}{\partial t} \\ \frac{\partial B_z}{\partial x} = -\mu_0\epsilon_0\frac{\partial E_y}{\partial t} \end{cases}$
Wave equation	$\tau\frac{\partial^2 y}{\partial x^2} = \mu\frac{\partial^2 y}{\partial t^2}$	$B\frac{\partial^2 s}{\partial x^2} = \rho\frac{\partial^2 s}{\partial t^2}$	$\frac{1}{\mu_0}\frac{\partial^2 E_y}{\partial x^2} = \epsilon_0\frac{\partial^2 E_y}{\partial t^2}$
Impedance	$Z = \frac{\tau}{c} = \sqrt{\tau\mu}$	$Z = \frac{B}{c} = \sqrt{B\rho}$	$Z = \frac{\frac{1}{\mu_0}}{c} = \sqrt{\epsilon_0/\mu_0}$

Electromagnetic Waves in Vacuum

Relative Field strengths:	$\lvert\vec{E}\rvert = c\lvert\vec{B}\rvert$ (for a plane wave)
Direction of propagation:	$\vec{E}\times\vec{B}$

Wave equation and solutions

$$c^2 \frac{\partial^2 y}{\partial x^2} = \frac{\partial^2 y}{\partial t^2}$$

$$\mp c \frac{\partial y}{\partial x} = \frac{\partial y}{\partial t} \quad \text{(pulse Eq.)}$$

$$y(x,t) = f(x-ct) + g(x+ct)$$

$$y(x,t) = h(x+ct) - h(-(x-ct)) \quad \text{reflection from fixed BC}$$

$$y(x,t) = h(x+ct) + h(-(x-ct)) \quad \text{reflection from free BC}$$

Reflection and transmission at boundary

$$\underline{R}_{0\to 1} = \frac{Z_0 - Z_1}{Z_0 + Z_1}$$

$$\underline{T}_{0\to 1} = \frac{2Z_0}{Z_0 + Z_1}$$

Interference

Constructive: $\Delta\phi = k\Delta R = 2\pi n$

Destructive: $\Delta\phi = k\Delta r = (2n+1)\pi$,

where $\Delta\phi$ is the phase difference between paths, and n is an integer.

Double Slit Interference

Intensity: $I(\theta) = 4I_0 \cos^2(k\Delta R/2)$ where $\Delta R = d \sin\theta$

Minima: $\phi/(2\pi) = \frac{d}{\lambda}\sin\theta = (n + 1/2)$

Maxima: $\phi/(2\pi) = \frac{d}{\lambda}\sin\theta = n$

Physical Constants

Quantity	Symbol	Value
Atomic mass unit	amu	1.66×10^{-27} **kg**
Electronic Mass	m_e	1×10^{-30} **kg**
Electronic Charge	e	1.6×10^{-19} **C**
Permitivity of Free Space	ϵ_0	$8.9 \times 10^{-12}\ \mathbf{C^2/(N \cdot m^2)}$
Permeability of Free Space	μ_0	$4\pi \times 10^{-7}\ \mathbf{Ns^2/C^2}$
Speed of Light	c	3×10^8 **m/s**