Midterm Exam 1

Ch. 14

Standing wave:

$$z(x,t) = Z_0 \sin(kx+\delta)\cos(\omega t+\phi)$$

Transverse wave on string:

$$T\frac{\partial^2 z}{\partial x^2} = \mu\frac{\partial^2 z}{\partial t^2}$$

$$\omega = \frac{2\pi}{\tau} = \frac{2\pi}{\lambda}\sqrt{\frac{T}{\mu}} = 2\pi f \quad ; \quad k = \frac{2\pi}{\lambda}$$

Wave equation:

$$\frac{\partial^2 z}{\partial x^2} = \frac{1}{\mathrm{v}^2}\frac{\partial^2 z}{\partial t^2}$$

Sinusoidal traveling wave in x-direction:

$$z(x,t) = Z_0 \sin(kx-\omega t+\phi)$$

$$\mathrm{v} = \lambda f = \frac{\lambda}{\tau} = \frac{\omega}{k} = \sqrt{\frac{T}{\mu}}$$

Energy density:

$$\frac{dE}{dx} = \mu\omega^2 z_0^2 \cos^2(kx-\omega t)$$

Average power delivered by wave:

$$\langle P\rangle = \frac{1}{2}\mu\omega^2 z_0^2 v = IA$$

$$\mathrm{v}_{\text{sound}} = \sqrt{\frac{\gamma P_0}{\rho_0}}$$

$$\beta = 10\log_{10}\left(\frac{I}{I_0}\right) \qquad \text{where } I_0 = 10^{-12} \text{ W/m}^2$$

$$\lambda' = \frac{\mathrm{v}-\mathrm{v}_s}{f_0} \qquad \mathrm{v}' = \mathrm{v}-\mathrm{v}_r$$

$$f' = \frac{\mathrm{v}'}{\lambda'} = \left(\frac{v-v_r}{v-v_s}\right) f_0$$

Trig. Identities

$$\sin(\theta_1 \pm \theta_2) = \sin\theta_1 \cos\theta_2 \pm \cos\theta_1 \sin\theta_2$$

$$\cos(\theta_1 \pm \theta_2) = \cos\theta_1 \cos\theta_2 \mp \sin\theta_1 \sin\theta_2$$

For a right triangle:

$$(\text{leg 1})^2 + (\text{leg 2})^2 = (\text{hypotenuse})^2$$

Circumference of circle: $C = \pi(\text{diameter})$

Area of circle: $A = \pi(\text{radius})^2$

Area of sphere: $A = 4\pi(\text{radius})^2$

Volume of sphere: $V = \frac{4}{3}\pi(\text{radius})^3$

$$\langle\cos^2(\phi)\rangle = \langle\sin^2(\phi)\rangle = \frac{1}{2}$$

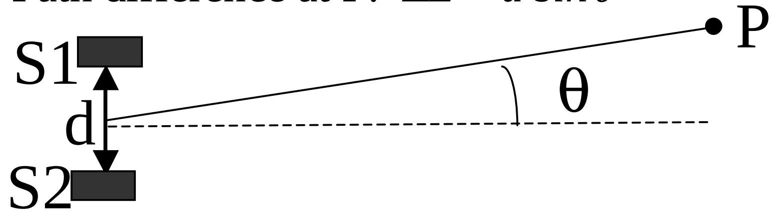
averaging over 1 period of ϕ

Ch. 15

$$f_{\text{beat}} = \frac{1}{2}(f_1 - f_2) = \frac{1}{2} f_{\text{pulse}}$$

Interference due to two sources

Path difference at P: $\Delta L = d\sin\theta$



if two sources are in phase ($\Delta\phi = 0$):

for maxima: $\Delta L = n\lambda$

for minima: $\Delta L = \left(n+\frac{1}{2}\right)\lambda$

where $n = 0, \pm1, \pm2, \pm3\ldots$

$$\frac{\mu_1\omega_i^2 A_i^2 v_i}{2} = \frac{\mu_1\omega_r^2 A_r^2 v_r}{2} + \frac{\mu_2\omega_t^2 A_t^2 v_t}{2}$$

$v_i = v_r = v_1$ and $v_t = v_2$ $\qquad \omega_i = \omega_r = \omega_t$

Ch 35

$$\mu_0\varepsilon_0\frac{\partial^2 E_x}{\partial t^2} = \frac{\partial^2 E_x}{\partial z^2}$$

in the case where E_z=0 and B_z=0, the waves propagate along the z-direction.

$$v^2 = \frac{1}{\mu_0\varepsilon_0}$$

$$v = c \simeq 3\times10^8 \text{ m/s}$$

$v = \frac{c}{\sqrt{\kappa}} = \frac{c}{n}$ where $n = \sqrt{\kappa}$ is the index of refraction

$$E_x = E_0\cos(kx-\omega t+\phi) \;,\; B_y = B_0\cos(kx-\omega t+\phi)$$

$$E = cB$$

$$\mathbf{E}\bullet\mathbf{B} = 0$$

Energy density of electromagnetic waves is

$$u = \frac{1}{2}\left(\frac{B^2}{\mu_0} + \varepsilon_0 E^2\right)$$

EM also carry momentum, with momentum density $\mathbf{S}/c^2$, where **S** is the Poynting vector which represents the energy flux

$$\mathbf{S} = \frac{1}{\mu_0}\mathbf{E}\times\mathbf{B}$$

$$\frac{S}{c} = u$$

$$I = \langle S\rangle = \frac{\langle P\rangle}{A} = c\varepsilon_0\langle E^2\rangle = \frac{1}{2}c\varepsilon_0 E_0^2$$

accelerating charge $\rightarrow S \propto \frac{\sin^2\theta}{r^2}$

Polarizer

$$E = E_0\cos\theta$$

$$I = I_0\cos^2\theta$$

Brewster angle

$$\tan\theta_B = n$$

Photons: $E_\gamma = hf \qquad p = \frac{E_\gamma}{c}$