PHY2054 Final Exam Formula Sheet

Ampere's Law (complete)

Rick's Lectures: $\oint_{\text{Closed Curve}} \vec{B}\cdot d\vec{l} = \mu_0 I_{enclosed} + \mu_0\varepsilon_0 \frac{d\Phi_E}{dt}$ **Textbook:** $\sum_{\text{Closed Curve}} B_{\parallel}\Delta l = \mu_0 I_{enclosed} + \mu_0\varepsilon_0 \frac{\Delta\Phi_E}{\Delta t}$

Electromagnetic Plane Wave

$\vec{E}(x,t) = E_{\max}\sin(kx-\omega t)\hat{y}$

$\vec{B}(x,t) = B_{\max}\sin(kx-\omega t)\hat{z}$

$E(x,t) = cB(x,t)$

Wavelength (in m): $\boldsymbol{\lambda}$
Wavenumber (in m^{-1}): $\mathbf{k = 2\pi/\lambda}$
Angular Frequence (in rad/s): $\boldsymbol{\omega = 2\pi f}$
Frequency (in Hz): **f**
Period (in s): **T = 1/f**

Speed in Vacuum: $c = \frac{\omega}{k} = f\lambda = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ **Speed in Medium (n = index of refraction):** $v_n = \frac{c}{n} < c$

Wavelength in Medium: $\lambda_n = \frac{\lambda_0}{n}$ (λ_0 = **Wavelength in Vacuum, n = index of refraction)**

Poynting Vector: $\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B}$, $\left|\vec{S}\right| = S = \frac{1}{\mu_0}EB = \frac{E^2}{\mu_0 c} = \frac{P_{power}}{A}$ (units = W/m^2)

Intensity: $I = \langle S\rangle = \frac{\langle P_{power}\rangle}{A} = \frac{E_{rms}^2}{\mu_0 c} = \frac{cB_{rms}^2}{\mu_0} = \frac{E_0^2}{2\mu_0 c} = \frac{cB_0^2}{2\mu_0}$ (units = W/m^2)

Intensity Transmitted by a Polorizer: $I = \frac{1}{2}I_0$ (random) $I = I_0\cos^2\theta$ (polarized)

Relativistic Doppler Shift

(f_0 = frequency at rest with source, λ_0 = wavelength at rest with source, $f_0\lambda_0$ = c)

Source Moving Away from Observer: $\lambda_{away} = \sqrt{\frac{1+\beta}{1-\beta}}\lambda_0$ $f_{away} = \sqrt{\frac{1-\beta}{1+\beta}}f_0$ $\vec{\beta} = \vec{V}/c$ **(V = relative velocity)**

Source Moving Toward the Observer: $\lambda_{toward} = \sqrt{\frac{1-\beta}{1+\beta}}\lambda_0$ $f_{toward} = \sqrt{\frac{1+\beta}{1-\beta}}f_0$ $\vec{\beta} = \vec{V}/c$ **(V = relative velocity)**

Reflection & Refraction

Snell's Law: $n_1\sin\theta_1 = n_2\sin\theta_2$ **Total Internal Reflection in Medium (1):** $\sin\theta_c = n_2/n_1$ ($n_2 < n_1$)

Brewster's Angle in Medium (1): $\tan\theta_B = n_2/n_1$

Mirrors & Thin Lens

Spherical Mirrors (R = radius of curvature): $|f| = R/2$

Object and Image Position (mirrors & thin lens): $\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$

Magnification (mirrors & thin lens): $m = -\frac{q}{p}$, $h' = |m|\cdot h$

f = focal length (>0 concave, <0 convex)
p = objrct distance
q = image distance (>0 real, <0 virtual)
h = object height
h' = image height
m = magnification (>0 upright, <0 inverted)

Reflection & Interference

Reflection in Medium 1: (phase shift $n_2 > n_1$) $\Delta\phi = \pi$ (phase shift $n_2 < n_1$) $\Delta\phi = 0$

Maximal Constructive: (phase shift) $\Delta\phi = 2\pi m$ (lateral shift) $\Delta l = m\lambda$ $m = 0, \pm1, \pm2, \cdots$

Maximal Destructive: (phase shift) $\Delta\phi = 2\pi(m+\frac{1}{2})$ (lateral shift) $\Delta l = (m+\frac{1}{2})\lambda$ $m = 0, \pm1, \pm2, \cdots$

Intensity: (max constructive) $I = I_1 + I_2 + 2\sqrt{I_1 I_2}$ (max destructive) $I = I_1 + I_2 - 2\sqrt{I_1 I_2}$

Single-Slit Minima: $d\sin\theta = m\lambda$ **Resolving Power (lens diameter D:** $\Delta\theta \approx 1.22\lambda/D$

Double-Slit (and grating): (max constructive) $d\sin\theta = m\lambda$ (max destructive) $d\sin\theta = (m+\frac{1}{2})\lambda$