PHYS 212, Honors Section, Spring 2011 – Review Material

Part 2/2, Chapters 29-40

Chapter 29: Magnetic Fields

- Magnetic force: On a moving charge $\mathbf{F} = q\,\mathbf{v} \times \mathbf{B}$, on a current $\mathbf{F} = I\,\mathbf{L} \times \mathbf{B}$, or $F = ILB \sin\theta$.
- Path of a particle: In a constant magnetic field, a particle moves on a circle with $r = mv/|q|B$.
- Torque on a current loop: The magnetic dipole moment and torque on the loop are $\boldsymbol{\tau} = \boldsymbol{\mu} \times \mathbf{B}$, $\boldsymbol{\mu} = NI\mathbf{A}$.

Chapter 30: Sources of the Magnetic Field

- Biot-Savart law: For a wire element d$\mathbf{s}$, $d\mathbf{B} = (\mu_0/4\pi)\,(I\,d\mathbf{s} \times \mathbf{r})/r^2$, where $\mu_0 = 4\pi \times 10^{-7}$ T·m/A.
- Examples: For a long straight wire, $B = (\mu_0/2\pi)\, I/r$; For a circular wire $B = (\mu_0/4\pi)\, I\, \phi/r$.
- Magnetic force between wires carrying currents: For two long straight wires $F = (\mu_0/2\pi)\,(I_1 I_2/a)\, L$.
- Ampère's law: For any closed loop C in space enclosing a current $I_{\rm enc}$, $\int_C \mathbf{B} \cdot d\mathbf{s} = \mu_0\, I_{\rm enc}$.
- Magnetic field of a long solenoid: The magnitude of the field is $B = \mu_0 nI$ $(n = N/L)$.

Chapter 31: Faraday's Law

- Magnetic flux: The flux of $\mathbf{B}$ through a surface S is $\Phi_B = \int_S \mathbf{B} \cdot d\mathbf{A}$.
- Faraday's law: When Φ_B changes in time, $\mathcal{E} = -N\, d\Phi_B/dt$, or $\int_C \mathbf{E} \cdot d\mathbf{s} = -\, d\Phi_B/dt$.
- Motional emf: The potential difference induced across a moving conductor, $\mathcal{E}$ = â€“Blv .

Chapter 34: Electromagnetic Waves

- Maxwell's equations: They contain all information on how electric and magnetic fields are produced,

$$\int_S \mathbf{E} \cdot d\mathbf{A} = q_{\rm enc}/\varepsilon_0 \,,\; \int_C \mathbf{E} \cdot d\mathbf{s} = -\, d\Phi_B/dt \,,\; \int_S \mathbf{B} \cdot d\mathbf{A} = 0 \,,\; \int_C \mathbf{B} \cdot d\mathbf{s} = \mu_0 I_{\rm enc} + \mu_0 \varepsilon_0\, d\Phi_E/dt \,.$$

- Electromagnetic waves: Plane harmonic waves $E = E_{\rm max} \cos(kx - \omega t)$ and $B = B_{\rm max} \cos(kx - \omega t)$, with $k = 2\pi/\lambda$, $\omega = 2\pi f$ and, as for all waves, $\lambda f = v$, the speed; $E/B = c$, $c = (\mu_0 \varepsilon_0)^{-1/2} = 3.00 \times 10^8$ m/s .
- Energy, momentum: Poynting vector $\mathbf{S} = (1/\mu_0)\, \mathbf{E} \times \mathbf{B}$, $P = S/c$ or $2S/c$ (absorbing or reflecting surface).

Chapter 35, 36: The Nature of Light and Ray Optics, and Image Formation

- Reflection: The law of reflection, $\theta_1' = \theta_1$.
- Refraction: Index of refraction $n = c/v$; The law of refraction, $n_1 \sin\theta_1 = n_2 \sin\theta_2$.
- Curved mirrors: Focal length $f = R/2$; Mirror equation $1/p + 1/q = 1/f$; and $M = h'/h = -q/p$.

Chapters 37, 38: Wave Optics and Diffraction Patterns and Polarization

- Interference pattern: For two thin slits, bright fringes are located at $d \sin\theta = m\lambda$, with $m = 0, \pm1, \pm2, \ldots$
- Diffraction pattern: For a narrow slit, dark fringes are located at $a \sin\theta = m\lambda$, with $m = \pm1, \pm2, \ldots$

Chapters 39, 40: Relativity and Introduction to Quantum Physics

- Length contraction, time dilation: $L = L_{\rm p}/\gamma$, and $\Delta t = \gamma\, \Delta t_{\rm p}$, $\gamma = 1/(1 - v^2/c^2)^{1/2}$.
- Light as particles: $E = hf$, where $h = 6.63 \times 10^{-34}$ J·s is Planck's constant; Wavelength $\lambda = h/p$.
- Uncertainty principle: $\Delta x\, \Delta p \geq (1/2)\, h/2\pi$.