PHYS 212, Honors Section, Spring 2011 – Review Material

Part 1/2, Chapters 23-28

Chapter 23: Electric Fields

- Coulomb's law: $F = k\, q_1 q_2/r^2 = 1/(4\pi\varepsilon_0)\, q/r^2$, $k = 8.99 \cdot 10^9$ N·m²/C², $\varepsilon_0 = 8.85 \times 10^{-12}$ C²/N·m².
- Fundamental charge: Value of the charge of an electron or proton, $e = 1.60 \times 10^{-19}$ C .
- Electric field: $\mathbf{E} = \mathbf{F}/q$; For a point charge, $E = k\, q/r^2 = 1/(4\pi\varepsilon_0)\, q/r^2$.
- Electric field due to a charge distribution: Sum individual contributions or integrate, $\mathbf{E} = k \int (\mathrm{d}q/r^3)\, \mathbf{r}$.

Chapter 24: Gauss' Law

- Electric flux: For constant $\mathbf{E}$, flat surface, $\Phi_E = (E \cos\theta)\, A = \mathbf{E} \cdot \mathbf{A}$. In general, $\Phi_E = \int \mathbf{E} \cdot \mathrm{d}\mathbf{A}$.
- Gauss' law: The electric flux through a closed Gaussian surface is $\Phi_E = q_{\text{in}}/\varepsilon_0$.
- At the surface of a conductor: It has to be perpendicular to the surface, and its magnitude is $E = \sigma/\varepsilon_0$.
- Large plate: Non-conducting $E = \sigma/2\varepsilon_0$ on both sides; Between plates with opposite charges, $E = \sigma/\varepsilon_0$.

Chapter 25: Electric Potential

- Electric potential energy: As for any conservative force, $U = -W_{PO}$.
- Electric potential: Defined as $V = U/q = -W_{PO}/q$; In terms of $\mathbf{E}$, $V(P) = -\int \mathbf{E} \cdot \mathrm{d}\mathbf{s}$ and $E_s = -\partial V/\partial s$.
- Examples: For a point charge $V = k\, q/r$; Potential energy of a 2-point-charge system $U = k\, q_1 q_2/r$; For a charge distribution add the single-charge contributions, or set up an integral, $V = k \int \mathrm{d}q/r$.

Chapter 26: Capacitance and Dielectrics

- Capacitance: Defined by $C = Q/V$; For a parallel-plate capacitor, $C = \varepsilon_0 A/d$.
- Capacitor combinations: In series, $C_{\text{eq}}^{-1} = C_1^{-1} + C_2^{-1} + ...$; In parallel, $C_{\text{eq}} = C_1 + C_2 + ...$
- Electric energy: In a capacitor, $U = \frac{1}{2} QV$; Energy density in an electric field $u = U/\text{volume} = \frac{1}{2} \varepsilon_0 E^2$.
- Dielectrics: The permittivity of the vacuum gets replaced by $\varepsilon = \varepsilon_0 \varkappa$; For example, $C = \varepsilon\, A/d = \varkappa\varepsilon_0\, A/d$.

Chapter 27: Current and Resistance

- Electric current: $I = \mathrm{d}Q/\mathrm{d}t$, or $Q = \int I(t)\, \mathrm{d}t$; Current density defined by $I = \int \mathbf{J} \cdot \mathrm{d}\mathbf{A}$; Also, $\mathbf{J} = ne\mathbf{v}_d$.
- Ohm's law: Relationship between potential difference and current, $I = V/R$; also $\mathbf{E} = \varrho\mathbf{J}$, or $\mathbf{J} = \sigma\mathbf{E}$.
- Resistance: For a uniform block of length L and cross-sectional area A, $R = \varrho L/A$.
- Power: In general, $P = IV$. For current through a resistor, $P = I^2 R = V^2/R$.

Chapter 28: Direct-Current Circuits

- Emf: The amount of amount of work done per unit charge $\mathcal{E} = \mathrm{d}W/\mathrm{d}q$; With internal resistance $V = \mathcal{E} - Ir$.
- Resistor combinations: In series $R_{\text{eq}} = R_1 + R_2 + ...$; In parallel $R_{\text{eq}}^{-1} = R_1^{-1} + R_2^{-1} + ...$
- RC circuits: $\tau = RC$; Charge $V(t) = V_0\, (1 - e^{-t/RC})$ and $q(t) = Q\, (1 - e^{-t/RC})$; Discharge$V(t) = V_0\, e^{-t/RC}$.