OUTLINES OF PHYSICS 112A & B
(Draft by L. Chen)

112A

(I) Electrostatics

- Electrostatic-field – Coulomb Law, principle of superposition, field, continuous charge distribution.
- $\underset{\sim}{\nabla}$ Operator
- $\underset{\sim}{\nabla} \cdot \underset{\sim}{E}$ - divergence, Gauss's Law, $\underset{\sim}{\nabla} \cdot \underset{\sim}{E}$, applications (symmetry constraint).
- $\underset{\sim}{\nabla} h$ - Gradient operator.
- Potential – Poisson's eqn., Laplace eqn., localized charge distribution, boundary conditions.
- Work & field energy – work, energy of a point vs. a continuous charge distribution.
- Conductors – basic properties, induced charge, surface charges (force), capacitors.

(II) Calculating Potentials

- Laplace eqn. – Dirichlet vs. Neumann boundary conditions, uniqueness theorems.
- Separation of variables – Cartesian coordinates, expansion in terms of orthonormal basis functions.
- Multipole expansion – far-field approximation technique, $\underset{\sim}{E}$ of a dipole.

(III) Magnetostatics

- Biot & Savart Law – Currents, $\underset{\sim}{B}$ of a steady current.
- $\underset{\sim}{\nabla} \cdot \underset{\sim}{B}$ and $\underset{\sim}{\nabla} \times \underset{\sim}{B}$- Ampere's law and its applications (emphasizing symmetry constraints.)
- Magnetic vector potential – vector Poisson's eqn., boundary conditions; solutions of $\underset{\sim}{B}$ using scalar potentials in current-free regions; multipole expansion of $\underset{\sim}{A}$.

(IV) Fields in Matters

- Electrostatic field in matter – polarization, bound charges (physical picture), electric displacement, Gauss's law (symmetry constraint), linear dielectric, force on a dielectric.
- Magnetostatic field in matter – magnetization, bound currents (physical picture), auxiliary field $\underset{\sim}{H}$, Ampere's law (symmetry constraint), linear medium, force on a magnetic dipole.

(V) Electrodynamics

- Electromotive force – Ohm's law, emf, motional emf.
- Faraday's law – induction (moving reference frame), inductance, magnetic field energy.

112B

- Maxwell's Eqn. – in vacuum; displacement current; inside matter; boundary conditions.
- Potential formulation – gauges & gauge transformation.
- Energy & momentum – Poynting theorem, Maxwell's stress tensor (brief discussions on tensor properties); momentum conservation.

(VI) Electromagnetic Waves

- Monochromatic plane waves in vacuum – energy & momentum conservation, propagation in linear dielectrics, reflection & transmission at normal incidence.
- EM waves in conductors – skin depth, reflection and transmission.
- Guided waves – rectangular wave guides, coaxial transmission line.
- Reflection and transmission at oblique incidence – Snell's law.

(VII) EM Radiation

- Retarded Potentials
- Dipole radiation (Feynman 21-4)
- Lienard-Wiechert Potential (Feynman 21-5)

(VIII) Relativistic Electrodynamics (Feynman 25 & 26)

- Lorentz transformation and 4-vectors
- Lorentzian invariant (scalar product).
- 4-dim $\underset{\sim}{\nabla}$ vector
- Maxwell's eqn. in 4-vector notation
- Rederiving the Lienard-Wiechert potentials.
- Transformation of fields – field tensor, transformation of $\underset{\sim}{E}$ & $\underset{\sim}{B}$.