Physics 2220 (Schroeder)

Electrodynamics Study Guide

You should understand the definition of emf (work per unit charge), and how an emf can be caused by either electric or magnetic forces according to the "flux rule",

$$\mathcal{E} = -\frac{d\Phi_B}{dt}.$$

When the magnetic field itself changes, the emf is the same as the circulation of $\vec{E}$ around the loop, and this equation is called Faraday's law. You should be able to determine the direction of induced emfs (and the associated currents), using Lenz's law or some other method.

The inductance L of a circuit element is defined by the relation

$$(\text{induced emf}) = -L\frac{dI}{dt},$$

where I is the current passing through the element. Given the formula for the magnetic field inside a solenoid (which you need not memorize), you should be able to derive the formula for the inductance.

You should know (or be able to figure out) the definitions of all the electrical units: coulomb, volt, farad, ampere, ohm, tesla, henry. Using unit analysis, you should be able to guess the formulas for the time constants and oscillation frequencies of RC, RL, and LC circuits. (You need not know where to put the factors of 2π in these formulas.) You should be able to describe qualitatively the behavior of simple circuits containing resistors, capacitors, inductors, and direct or alternating voltage sources.

You should know, or be able to guess (using unit analysis), the formulas for energy stored in a capacitor and in an inductor:

$$U_{\text{capacitor}} = \frac{1}{2}C(\Delta V)^2 = \frac{1}{2C}Q^2, \qquad U_{\text{inductor}} = \frac{1}{2}LI^2.$$

You should also know (or be able to guess) the more general formulas for the energy per unit volume stored in electric and magnetic fields:

$$\frac{U_E}{\text{volume}} = \frac{\epsilon_0}{2}|\vec{E}|^2, \qquad \frac{U_B}{\text{volume}} = \frac{1}{2\mu_0}|\vec{B}|^2.$$

You should have a pictorial understanding of all four of Maxwell's equations for the flux (through any closed surface) and circulation (around any closed loop) of $\vec{E}$ and $\vec{B}$:

$$(\text{flux of } \vec{E}) = \frac{1}{\epsilon_0}Q_{\text{enclosed}} \qquad (\text{circulation of } \vec{E}) = -\frac{d\Phi_B}{dt}$$

$$(\text{flux of } \vec{B}) = 0 \qquad (\text{circulation of } \vec{B}) = \mu_0 I_{\text{enclosed}} + \mu_0\epsilon_0\frac{d\Phi_E}{dt}$$

The most important consequence of these equations is that accelerating charged particles create waves in the electromagnetic field, which break free and travel away at the speed of light,

$$c = \frac{1}{\sqrt{\epsilon_0\mu_0}} = 3.00 \times 10^8 \text{ m/s}.$$

Polarization and Ray Optics Study Guide

Important equations:

$$I_{\text{transmitted}} = I_0 \cos^2\theta \qquad \text{(intensity transmission by an ideal polarizer)}$$

$$\theta_r = \theta_i \qquad \text{(law of reflection)}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \qquad \text{(Snell's law of refraction)}$$

$$n = \frac{\text{speed of light in vacuum}}{\text{speed of light in material}}$$

You should understand how a polarizing filter ("polaroid") works, and be able to derive the equation given above for the transmitted intensity. You should also know that an ideal polarizer transmits 50% of the intensity of *un*polarized light.

You should be able to draw ray diagrams and locate images formed by refraction or reflection, either directly from the basic laws or by making use of the given focal length of a lens or mirror. You need not memorize any formulas for focal lengths, image locations, or magnification.

You should understand the following terms/concepts:

- reflection
- refraction
- dispersion
- total internal reflection
- focal point (real or virtual)
- focal length
- image (real or virtual)
- polarization