Contemporary Physics
Review Sheet for Exam IV
Chapters 24 - 26

Chapter 24: Magnetic Fields

Force on a moving charge: \( F' = qvB \sin \theta \)

1. Angle \( \theta \) measured between the direction of \( v \) and the direction of \( B \).
2. Direction of \( F \) determined by first right hand rule:
   a. Point fingers in direction of \( v \)
   b. Curl fingers in direction of \( B \)
   c. Thumb points in the direction of \( F \).

Force on a moving current: \( F' = IB \sin \theta \)

1. Angle \( \theta \) measured between the direction of \( I \) and the direction of \( B \).
2. Direction of \( F \) determined by first right hand rule:
   a. Point fingers in direction of \( I \)
   b. Curl fingers in direction of \( B \)
   c. Thumb points in the direction of \( F \).

Magnetic field generated by a moving current in a long straight wire: \( B = \frac{\mu_0 I}{2\pi r} \)

1. \( \mu_0 = 4\pi \times 10^{-7} \) Tm / A
2. \( B \) measured in Tesla [T]
3. \( r \) is the radial distance from the center of the wire to the point where \( B \) is measured.
4. Direction of \( B \) determined by second right hand rule:
   a. Point thumb in direction of \( I \)
   b. Fingers curl in the direction of \( B \) in circles around the current

Magnetic field generated by a moving current in a solenoid: \( B = \mu_0 I n \frac{N}{R} \)

1. \( n \) is the number of turns per unit length
2. \( N \) is the total number of turns. \( R \) is the length of the solenoid.
3. Direction of \( B \) determined by third right hand rule:
   a. Curl fingers in direction of \( I \) around the solenoid
   b. Thumb points in the direction of \( B \) through the solenoid

Magnetic field lines:

1. Start at North poles, end at South poles
2. Never terminate, always go in complete loops
Chapter 25: Electromagnetic Induction

Electromotive force: $\mathbf{g}mf' \quad v RB$

1. $\mathbf{g}mf$ is measured in Volts [V].
2. Equation true only for $v$, $R$, and $B$ mutually perpendicular
3. If $v$, $R$, and $B$ are not mutually perpendicular, then $\mathbf{g}mf$ may be calculated as follows:
   a. $E' \quad v B \sin \theta$, angle $\theta$ measured between $v$ and $B$, direction determined by r.h.r. #1.
   b. $\mathbf{g}mf' \quad E R \cos \theta$, angle $\theta$ measured between $E$ and $R$

Magnetic flux: $\mathbf{\Phi}' \quad BA \cos \theta$

1. $\mathbf{\Phi}$ measured in Webers [Wb] = T m$^2$
2. Angle $\theta$ measured between $B$ and the perpendicular vector to the surface $A$.

Faraday’s Law of Induction: $\mathbf{g}mf' \quad \mathbf{\&} N \frac{\mathbf{\Phi}'}{\mathbf{\Delta}t}$

1. $N$ is number of turns of the coil
2. $\mathbf{\Delta}\Phi/\mathbf{\Delta}t$ is the change in magnetic flux through the coil per unit time
3. Negative sign represents Lenz’s Law: the induced $\mathbf{g}mf$ will always try to counteract change in flux.

Self-Inductance: $L' \quad \frac{\mathbf{\Phi}'}{I}, \quad \mathbf{g}mf' \quad \mathbf{\&} N \frac{\mathbf{I}'\mathbf{\Delta}t}{\mathbf{\Delta}t}$

1. $L$ measured in Henrys [H] = Wb / A
2. $\mathbf{g}mf$ generated by self-inductance called “back $\mathbf{g}mf$” since it opposes changes in external Voltage.

Transformers:

\[
\frac{V_s}{N_s} = \frac{V_p}{N_p} \quad \text{or} \quad \frac{V_s}{V_p} = \frac{N_s}{N_p}
\]

1. $N_p$ = number of turns on primary coil, $N_s$ = number of turns on secondary coil.
2. Power supplied, $P_p = V_p I_p$, Power delivered, $P_s = V_s I_s$, efficiency $e = P_s / P_p$
Chapter 26: Electromagnetism

Lorentz force: \( \mathbf{F} = q \mathbf{E} + q \mathbf{v} \times \mathbf{B} \sin \theta \)

1. \( q \mathbf{E} \) is electric force of a charged particle in an electric field
2. \( q \mathbf{v} \times \mathbf{B} \sin \theta \) is magnetic force of a charged particle in a magnetic field
3. If electric and magnetic forces are opposed, particles are undeflected if \( v = \frac{E}{B} \)
4. Velocity Selector of a mass spectrometer.

Magnetic force: \( \mathbf{F} = q \mathbf{v} \mathbf{B} \sin \theta \), \( m \mathbf{a} = m \frac{v^2}{r} \)

1. Equate centripetal force to magnetic force to determine radius of circle.
2. Detector of a mass spectrometer.

Electric potential and Kinetic Energy: \( KE = \frac{1}{2} m v^2 \)

1. Particle of charge \( e = 1.60 \times 10^{-19} \text{ C} \) accelerated through a potential difference of \( V \) has \( V \) electron volts (eV) of energy.
2. Accelerator of a mass spectrometer.

Electromagnetic Waves: \( \mathbf{v} \times \mathbf{c} = \frac{\mathbf{E}}{B} \)

1. Velocity (in vacuum) = \( c = 3 \times 10^8 \text{ m/s} \).
2. Electric field \( \mathbf{E} \) and magnetic field \( \mathbf{B} \) are mutually perpendicular and perpendicular to \( \mathbf{v} \).
3. \( c = f \lambda \), \( f \) frequency, \( \lambda \) wavelength.