Physics 222   Final Exam Review  Winter 2001      Instructor: John McGill

The exam will cover Chapters 23-31 from the text. You will be allowed two 8.5 x 11 inch sheets of notes to refer to during the exam. (You may write on both sides). You will also need a calculator for the exam. You will have the entire class period to complete the exam, (12:00 - 2:00 PM, Tuesday, March 20, 2001).

The following topics may be helpful in guiding you as you study for the exam:

Chapter 23 Electric Fields

Electric Charge (Unit = Coulomb = C)
- Charge comes in discreet units, \( e = 1.60 \times 10^{-19} \) C:
  - Electron = \(-e\), Proton = \(+e\), Neutron = 0
- The net charge in closed system never changes

Electric Fields
- Electric force on a test charge \( q_o \):
  \[ F_E = q_o E \]
- Coulomb’s Law: point(like) source charge, \( Q \)
  \[ E = \frac{k e Q r}{r^2} \]

Superposition
- When there are more than one source charge, the electric field is equal to the vector sum of the coulomb field from each of the source charges.

Electric Dipole:
- \( p = q d \), along dipole axis \( E = 2k e p/z^2 \)

Chapter 24 Gauss’ Law

Electric Flux,
\[ \Phi_E = \int_A E \cdot d\vec{A} \]
d\( \vec{A} \) is a small piece of the surface.
- the direction of d\( \vec{A} \) is perpendicular to the surface
- Total flux through a closed surface: \( \Phi_E = \int A \cdot dE \)

Gauss’ Law
- \( \Phi_E = \int E \cdot d\vec{A} = q_{enc}/\varepsilon_0 \)
- \( q_{enc} \) is the net charge enclosed inside the surface

Symmetries
- Spherical \( E = k q_{enc}/r^2 \), Direction is radial
- Cylindrical (infinite line) \( E = 2k |\lambda|/r \), Direction is along the shortest distance to the line
- Planar (infinite sheet) \( E = |\sigma|/2\varepsilon_0 \), Direction is perpendicular to the surface

Conductors
- \( E = 0 \) inside an isolated (no current) conductor
- All excess charge is distributed over the outside surface of the conductor.
- The net charge inside a cavity combined with the charge on the wall of the cavity is 0

Chapter 25 Electric potential (Unit = Volt = Joule/Coulomb)

Electric Potential Energy, \( \Delta U = -\int E \cdot ds \)

Electric Potential,
\[ \Delta V = \Delta U/q_o = -\int E ds = \text{change in electrical potential energy/unit test charge} \]

\( V(r) = V_o - \int E ds \) Integrated from reference point where \( V = V_o \) to point of interest \( r \).

Coulomb Potential of a point charge \( Q \) (or outside a spherically symmetric distribution):
- \( V = k Q/r \), \( V \to 0 \) as \( r \to \infty \), \( Q = q_{enc} \) for a distribution

Superposition: \( V = k q_1/r_1 + k q_2/r_2 + k q_3/r_3 + ... \)
- Dipole, Uniform Ring , Uniform, "Infinite Sheets of charge"

Finding the electric field from the potential: \( E = -\nabla V \)
- \( E = -\nabla V = -i(\partial V/\partial x) + j(\partial V/\partial y) + k(\partial V/\partial z) \)
- or \( E = -dV/dl \) where \( l \) is the length along the electric field line

Equipotential Surface
- Isolated, static conductors
Chapter 26 Capacitance
In a capacitor the voltage is proportional to the charge on one side: $Q = CV$. Farad = 1 Coulomb/Volt
Parallel plate capacitor:
$$C = \varepsilon_0 \frac{A}{d}$$
The electric field inside: $E = \frac{V}{d}$
Energy stored in a capacitor
$$U = \frac{1}{2}CV^2 = \frac{1}{2} \frac{Q^2}{C}$$
Capacitors in series: $C_{\text{effective}} = \frac{1}{1/C_1 + 1/C_2 + 1/C_3 + \ldots}$
Capacitors in parallel: $C_{\text{effective}} = C_1 + C_2 + C_3 + \ldots$
Capacitors with a dielectric: $C = \kappa C_0$
Energy density stored in an electric field: $u = \frac{U}{V} = \frac{1}{2} \varepsilon_0 E^2$

Chapter 27 Voltage and Current
Electric Current, $I$ = rate of flow of electric charge, 1A = 1C/s
Ohm's Law (Conductors): $V = IR$
Resistance of a wire: $R = \frac{L}{\rho A}$, $\rho =$ resistivity
Electric Power: $P = VI$

Chapter 28 Electric Circuits
Electro-motive Force, EMF
Kirchhoff's Voltage Law (loop rule) $\sum V = 0$
Kirchhoff's Current Law (Branch Rule) $\sum I_{\text{in}} = \sum I_{\text{out}}$
Resistors in series and parallel: $R_{\text{effective}} = R_1 + R_2 + R_3 + \ldots$, $\frac{1}{R_{\text{parallel}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$

Chapter 29 Magnetic Forces
Magnetic Force on a moving charge, $F = qv \times B$, $|F| = |qvB\sin \theta|$, direction – right hand rule.
Magnetic Force on a length of wire carrying current $I$, $F = IL \times B$, $|F| = |ILB\sin \theta|$, direction-right hand rule
A charged particle moving perpendicular to a magnetic field moves in circle of radius,
$$r = \frac{mv}{|q|B}$$
when the magnetic force is the only force acting

Chapter 30 The origin of magnetic fields
Magnetic fields originate from electric currents
Biot-Savart Law:
$$dB = \frac{\mu_0 I d\vec{\delta} \times \hat{r}}{r^2}$$
Magnetic field due to a long straight wire carrying current $I$: $B = \mu_0 \frac{I}{2\pi r}$ direction-right hand rule
Magnetic field due to a loop of current along axis: $B = \mu_0 \frac{I R^2}{2(R^2 + z^2)^{3/2}}$
Magnetic field due to an arc of current: $B = \mu_0 \frac{I \theta}{4\pi r}$, $\theta$ in radians
Ampere's Law:
$$\oint B \cdot ds = \mu_0 I_{\text{enc}}$$
Magnetic field in a solenoid: $B = \mu_0 I_n$ direction: along axis, right hand rule

Chapter 31 Electro Magnetic Induction
Faraday’s Law: $\mathbf{E} = -\frac{d\Phi_B}{dt}$
Lenz’s Law: Direction of the emf, $\varepsilon$, is so as to oppose the change in flux
Magnetic Flux $\Phi_B = \int BdA$ thru loop
Coil: $\mathbf{E} = -\frac{d\Phi_B}{dt}$