Physics 222  Midterm Exam Review  Winter 2002  Instructor: John McGill

The exam will cover Chapters 23-26 from the text. You will be allowed one 8.5 x 11 inch sheet 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, (Date: Tue., Feb. 12, 12:00 PM)

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 x 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 \( q_0 \)
  \[ F_E = q_0 E; \quad E = \frac{F_E}{q_0} \]
- 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 Field Lines**: point along the direction of the electric field.

**Chapter 24 Gauss’ Law**

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

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

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

**Permittivity of free space, \( \varepsilon_o \)**
- \( k_e = 1/4\pi\varepsilon_o = 8.99 \times 10^9 \text{ Nm}^2/\text{C}^2 \)
- \( \varepsilon_o = 8.85 \times 10^{12} \text{ C}^2/\text{Nm}^2 \)
Chapter 25 Electric potential (Unit = Volt = Joule/Coulomb)

Electric Potential Energy, \( \Delta U_e = -\int F_E \cdot ds \)

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

\[ \Delta V = \Delta U_e/q_o = -\int E \cdot ds \] is change in electrical potential energy/unit test charge

\[ V(r) = V_o - \int E \cdot ds \] 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):

\[ V = k_e Q/r \]

\( V \rightarrow 0 \) as \( r \rightarrow \infty \), \( Q = q_{enc} \) for a distribution

Superposition:

\[ V = k_e q_1/r_1 + k_e q_2/r_2 + k_e q_3/r_3 + \ldots \]

Uniform Ring of radius, \( R \): (along axis)

\[ V = k_e Q/(z^2 + R^2)^{1/2} \]

Q = charge of ring

"Infinite Sheets of charge"

Uniform Electric Fields - \( \Delta V = Ed \)

where \( d \) = the displacement along the direction opposite the electric field

Finding the electric field from the potential:

\[ E = -\nabla V \]

\[ E = -\nabla V = -(\partial V/\partial x) i + (\partial V/\partial y) j + (\partial V/\partial z) k \]

or \( E = -dV/dl \) where \( l \) is the length along the electric field line

Equipotential Surface

Surfaces along which the potential is constant, \( \Delta V = 0 \)

Electric field lines are everywhere perpendicular to Equipotential surfaces.

Isolated, static conductors

The electric potential inside an isolated, static (no current) conductor is everywhere the same.

Chapter 26 Capacitors

Capacitor: \( Q = CV_c \)

Two equal and oppositely charged conductors separated by an insulator. \( Q \) is the charge on the positive conductor, \( V_c \) is voltage difference between the two conductors. \( C \) is the capacitance.

Unit of Capacitance: Farad = Coulomb/Volt

Parallel Plate Capacitor: \( C = \varepsilon_o A/d \)

\( A \) is the area of one of the plates, \( d \) is the separation of the plates

Concentric Spherical Shells: \( C = 4\pi \varepsilon_o ab/(b-a) \)

\( a \) = inner radius, \( b \) = outer radius

Capacitors in Series: \( C_s = 1/(1/C_1+1/C_2+1/C_3+\ldots) \)

\[ C_1 \quad C_2 \quad C_3 \quad \ldots \quad = \quad C_s = 1/(1/C_1+1/C_2+1/C_3+\ldots) \]

Capacitors in Parallel: \( C_p = C_1+C_2+C_3+\ldots \)

\[ C_1 \quad C_2 \quad C_3 \quad \ldots \quad = \quad C_n = C_1+C_2+C_3+\ldots \]