#9 AP-C Electric Potential, Energy and Capacitance

AP-C Objectives (from College Board Learning Objectives for AP Physics)

1. Electric potential due to point charges
   a. Determine the electric potential in the vicinity of one or more point charges.
   b. Calculate the electrical work done on a charge or use conservation of energy to determine the speed of a charge that moves through a specified potential difference.
   c. Determine the direction and approximate magnitude of the electric field at various positions given a sketch of equipotentials.
   d. Calculate the potential difference between two points in a uniform electric field, and state which point is at the higher potential.
   e. Calculate how much work is required to move a test charge from one location to another in the field of fixed point charges.
   f. Calculate the electrostatic potential energy of a system of two or more point charges, and calculate how much work is require to establish the charge system.
   g. Use integration to determine the electric potential difference between two points on a line, given electric field strength as a function of position on that line.
   h. State the relationship between field and potential, and define and apply the concept of a conservative electric field.
2. Electric potential due to other charge distributions
   a. Calculate the electric potential on the axis of a uniformly charged disk.
   b. Derive expressions for electric potential as a function of position for uniformly charged wires, parallel charged plates, coaxial cylinders, and concentric spheres.
3. Conductors
   a. Understand the nature of electric fields and electric potential in and around conductors.
      i. Explain the mechanics responsible for the absence of electric field inside a conductor, and know that all excess charge must reside on the surface of the conductor.
      ii. Explain why a conductor must be an equipotential, and apply this principle in analyzing what happens when conductors are connected by wires.
      iii. Show that the field outside a conductor must be perpendicular to the surface.
   b. Graph the electric field and electric potential inside and outside a charged conducting sphere.
   c. Understand induced charge and electrostatic shielding.
      i. Explain why there can be no electric field in a charge-free region completely surrounded by a single conductor.
      ii. Explain why the electric field outside a closed conducting surface cannot depend on the precise location of charge in the space enclosed by the conductor.
4. Capacitors
   a. Understand the definition and function of capacitance.
      i. Relate stored charge and voltage for a capacitor.
      ii. Relate voltage, charge, and stored energy for a capacitor.
      iii. Recognize situations in which energy stored in a capacitor is converted to other forms.
   b. Understand the physics of a parallel-plate capacitor.
      i. Describe the electric field inside the capacitor and relate the strength of the field to the potential difference and separation between the plates.
      ii. Relate the electric field to the charge density on the plates.
      iii. Derive an expression for the capacitance of a parallel-plate capacitor.
      iv. Determine how changes in the geometry of the capacitor will affect its capacitance.
      v. Derive and apply expressions for the energy stored in a parallel-plate capacitor as well as the energy density in the field between the plates.
      vi. Analyze situations in which capacitor plates are moved apart or closer together, or in which a conducting slab is inserted between capacitor plates.
   c. Describe the electric field inside cylindrical and spherical capacitors.
   d. Derive an expression for the capacitance of cylindrical and spherical capacitors.
5. Dielectrics
   a. Describe how insertion of a dielectric between the plates of a charged parallel-plate capacitor affects its capacitance and the field strength and voltage between the plates.
   b. Analyze situations in which a dielectric slab is inserted between the plates of a capacitor.
6. Capacitors in Circuits
   a. Understand the initial and steady-state behavior of capacitors connected in series or in parallel in order to
      i. Calculate the equivalent capacitance of a series or parallel combination.
      ii. Describe how stored charge is divided between capacitors connected in parallel.
      iii. Determine the ratio of voltages for capacitors connected in series.
      iv. Calculate the voltage or stored charge, under steady-state conditions, for a capacitor connected to a circuit consisting of a battery and resistors.