Electrostatics Review

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1 Things to know

- Maxwell's equations in coordinate system of your choice
- Boundary conditions derived from Maxwell equations (Jackson p.16–18)
- Energy in electrostatic fields; forces. (Jackson p.40–42)
- Capacitance: charge over voltage; constant for a given geometry

2 Tools for Eelctrostatics Problems

- Gaussian "pillbox": given the charge distribution, exploit the symmetry of the geometry using Gauss' Law.
- Method of images: use with condutive boundaries, place image charges at symmetric locations so that **E** field is perpendicular to conductors. (Griffiths has a good treatment, including using this method with dielectrics; also Jackson p.57–59)
- From expansion of potential in orthonormal basis functions:
  - 2D/3D, cartesian: sinusioids or sinusoinds and hyperbolic sine/cosine (eqns. 2.56 and 2.61, Jackson p.70–75)
  - 2D, cylindrical coords: sines/cosines, powers and natural log of radial coordinate (eqn. 2.71, Jackson p.75–78)
  - 3D, azimuthal symmetry: Legendre Polynomials with powers of radial coordinate (eqn. 3.33, Jackson p.101–103)
  - 3D, spherical coords: spherical harmonics with powers of radial coordinate (eqn. 3.61, Jackson p.107–111)
- Green Function (advanced): once determined for a given geometry, can use to find the potential given an arbitrary charge distribution. Most powerful, but time consuming unless the Green function can be determined by symmetry.

3 Multipole Expansions

- Take moments of the charge distribution in the most convenient coordinate system. (Jackson, p.145–151)
- Then simply insert the values for the various moments into the general equation for the potential given each moment.
- Most problems will only have a dipole term, occasionally problems will have a quadrupole term.
- This approach will be used again in the context of radiating antenna.

4 Dielectrics

- In general, the polarization is a nonlinear function of the applied **E** field.
- In linear materials, the displacement (**D**) field and **E** are related by the dielectric tensor, which is simply a scalar constant if the material is isotropic and uniform. Remember these assumptions, and check that they apply; if not, use given expressions for the polarization to determine the displacement field.
- Jackson has some surprisingly good examples beginning on page 157.

5 Example Problems

1/06 EM1: dielectric cylinder in external electric field 1/03 EM2: method of images