Physics 370 Homework 6 Due 10:00 AM Wednesday March 7, 2018

Solutions for this homework will be handed out at the end of class on Wednesday March 7 to facilitate study for the midterm. Therefore, late homeworks will not be accepted after that time!

Reading: Griffiths pages 119 to 160.

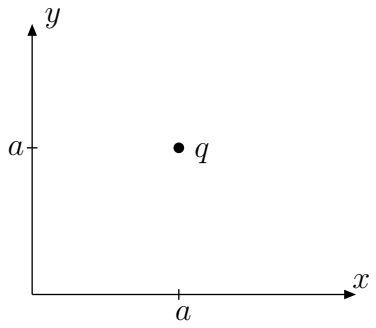
Problem 1 Consider an infinitely long straight wire with constant charge per unit length λ.
(a) Use Gauss' Law to find the electric field everywhere as a function of the distance from the wire r.
(b) Integrate the result from part (a) to find the potential $V(r)$. Use a point at a distance r_0 from the wire as your reference point. [Partial answer: $V(r) = K\lambda \ln(r/r_0)$, where K is a constant that you will determine. Notice that this answer would be ill-defined if you tried to take the reference point either at $r = \infty$ *or* at $r = 0$.]
(c) Check that your answers to (a) and (b) are consistent by computing the gradient and Laplacian of the potential for $r \neq 0$.

Problem 2 An infinite straight wire is placed a distance d above an infinite grounded conducting plane. ("Grounded" means at constant potential $V = 0$, with the reference point at infinity, or anywhere on the plane itself.) The wire carries a uniform charge per unit length λ and runs parallel to the x-axis and directly above it. The infinite conducting plane is the $z = 0$ plane. Use the Method of Images and the result of Problem 1(b) to:
(a) Find the potential in the region above the plane.
(b) Find the charge density σ induced on the conducting plane.
(c) Is the wire attracted or repelled by the plane? Explain, using the image version of the problem.
[Partial answer:

$$V(y,z) = K\lambda \ln\left(\frac{y^2 + (z+d)^2}{y^2 + (z-d)^2}\right)$$

where K is a certain number that you will determine.]

Problem 3 Two half-infinite grounded planes meet at right angles on the z axis. One has $y = 0$ with $x > 0$ and $-\infty < z < \infty$. The other has $x = 0$ with $y > 0$ and $-\infty < z < \infty$. A point charge q is placed between the planes at a distance a from each of them, at the point $(x, y, z) = (a, a, 0)$.



(a) Find the potential $V(x, y)$ everywhere in the regions between the planes (that is, for x and y both positive).
(b) Find the force on the charge q.
[Hint: use the method of images. You will want to use 3 image charges.]

Problem 4 Consider a configuration consisting of three charges on the x-axis. There is a charge $-3q$ at the point $(x, y, z) = (d, 0, 0)$; a charge q at the origin; and a charge $2q$ at the point $(x, y, z) = (-d, 0, 0)$.
(a) Sketch the electric field lines in the xy plane (with $z = 0$). Draw enough lines to give a clear picture of the electric field.
(b) What is the electric dipole moment of the configuration?
(c) What is the electric field in spherical coordinates, for large r?

Problem 5 Consider a solid sphere of radius a with its center at the origin. The top half of the sphere (for $z > 0$) carries a uniform charge density ρ, and the bottom half (for $z < 0$) carries the opposite uniform charge density $-\rho$.
(a) Find the electric dipole moment of the configuration.
(b) Find the electric field in spherical coordinates, for large r.