Version 9/3/06

EECS 210 Applied Electromagnetic Theory

Fall 2006 **Office Hours** **Prof. A. R. Neureuther,**
Tu, Th 12:30-2 **M, (W), 11AM** **509 Cory Hall, 2-4590**
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Homework # 2: Due start of class Th Sep 14th

2.1) **Surface charge singularity contribution**: Consider the potential due a continuous distribution of charge on a smooth surface as an observation point $\bar{x}_o^{'}$, that is ε away from the surface approaches an observation point $\bar{x}_0$ on the surface. Consider a small disk in the surface centered on $\bar{x}_0$ of radius **a** over which the charge density can be approximated as constant. Break up the integral for the potential at $\mathbf{x}_0$ into a part outside the circle and a part over the circle. Show that when ε << a the integral for the potential (written out as a function of $\left|\vec{x}_{surface} - \vec{x}_0^1\right|$) over the circular disk integrates to a factor of $2\pi\sigma/\varepsilon_0$.

2.1) **Surface Charge Density, Force, Capacitance and Stored Energy**: Consider a charge q at a distance **a** along the z axis from a conducting plane at z = 0. Use the image charge solution to help make calculations.
a) Find the surface charge density on the conducting plane as a function of the radial distance in the z = 0 plane.
b) Show that there is no force parallel to the surface of the conductor.
c) Show that the net force perpendicular to the conductor adds up in magnitude to the force on the charge q.
d) Assume that the charge q sits on a sphere of radius a/1000 so that the voltage is defined and the fields on the plane do not change much. Evaluate the mutual capacitance to the ground plane. Be sure to eliminate the capacitance of the sphere to infinity without the ground plane.
e) Using the point source, find the stored energy by finding the total energy and eliminating the self-energy.

2.3) **Equivalence Theorem**: Consider a charge q at a distance **a** along the z axis from a conducting plane at z = 0 and you result for surface charge density.
a) Form an integral equation for the potential at an observation in the solution region in terms of a volume integral and a surface charge integral on z = 0.
b) Plug in the free space Green's function.
c) Show is be contributed by the image charge in the image charge solution method.
d) Show at the image point location (outside the solution region), that the surface integral gives a potential contribution that is equal to and opposite in sign to that from the charge in free space and hence the field is zero.
e) Bonus: For any arbitrary locations z < 0, find an algebraic way to manipulate the integrand to show that the surface charge always makes a contribution that exactly cancels that made directly by charge q and hence the potential is zero everywhere for z < 0.