

Physics 374 Homework Due Nov. 30

1. Consider the situation discussed in class in which an elliptical conductor of major axis α and minor axis β is held at potential V while surrounding the ellipse is a grounded circle of radius R . (You may think of this as 2-dimensional problem or as a 3-dimensional problem independent of z). Supposing that the $R=10\alpha$ and $\beta = 1.2\alpha$ find an approximate expression for the potential between the plates by writing the multipole expansion and matching with fixed points on the surface. You may work up to a maximum m of 2 which means 2 points on the surface. You may choose these two points to be at $\phi=0$ and $\phi=\pi/2$ on each surface.
 - a) What are the multipole coefficients?
 - b) Make a contour plot of the potential.
 - c) Find the electric field expressed in Cartesian coordinates.

2. Consider the same problem in 1.
 - a) This time choose the points at $\phi=\pi/6$ and $\phi=\pi/3$ on each surface. What are the multipole coefficients? How do they compare to the coefficients in 1.? Is this sensible?
 - b) This time work up to a maximum m of 4 picking your points at $\phi=0$, $\phi=\pi/4$ and $\phi=\pi/2$ on each surface. Are the $m=0$ and $m=2$ multipole coefficients essentially unchanged from problem 1? What does this tell us about the convergence of our series.
 - c) Without calculating, explain whether picking a maximum m of 4 rather than 2 would be a bigger or smaller effect if instead of the problem 1. we considered the case $R=10\alpha$ and $\beta = 1.4\alpha$

3. Consider the same problem as in 1. (viewing it as a 3-dimensional problem).
 - a) Find the total charge per unit length (in the z direction) on the inner conducting surface. (Hint: You should be able to read this off a single multipole coefficient)
 - b) Find the capacitance per unit length of this configuration.