Electricity and Magnetism I (PHY 321)

Electric Potential problems

Problem 1 Write an expression for the electric potential $V(\mathbf{r})$ at a point $\mathbf{r} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$ produced by a point charge q located at $\mathbf{r}_1 = a\hat{\mathbf{i}} + b\hat{\mathbf{j}} + c\hat{\mathbf{k}}$. Take the negative gradient of your electric potential to find the electric field.

Problem 2 Write an expression for the electric potential $V(\mathbf{r})$ at a point $\mathbf{r} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$ produced by a point charge q_1 located at $\mathbf{r}_1 = x_1\hat{\mathbf{i}} + y_1\hat{\mathbf{j}} + z_1\hat{\mathbf{k}}$ and a point charge q_2 located at $\mathbf{r}_2 = x_2\hat{\mathbf{i}} + y_2\hat{\mathbf{j}} + z_2\hat{\mathbf{k}}$. Take the negative gradient of your electric potential to find the electric field.

Problem 3 Write an expression for the electric potential $V(\mathbf{r})$ at a point $\mathbf{r} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$ produced by a point charge q located at $\mathbf{r}_1 = \frac{d}{2}\hat{\mathbf{k}}$ and a point charge $-q$ located at $\mathbf{r}_2 = -\frac{d}{2}\hat{\mathbf{k}}$. Take the negative gradient of your electric potential to find the electric field.

Problem 4 Consider an infinite charged plate with surface charge density σ_0 lying in the xy plane. Find the electric potential at a point $z\hat{\mathbf{k}}$ on the z axis. Make sure that your expression for electric potential works for both positive and negative values of z. (Hint: First find the electric field produced by the plate. Take the zero of electric potential to be on the plate itself.)

Problem 5 A parallel-plate capacitor is composed of an infinite plate with surface charge density σ_0 at $z = d/2$ and a second plate with surface charge density $-\sigma_0$ at $z = -d/2$. Find the electric potential at a point $z\hat{\mathbf{k}}$ on the z axis. Make sure that your expression for electric potential works for both positive and negative values of z. (Hint: Find the electric field first.)

Problem 6 Consider an infinite plane of charge with uniform surface charge density σ lying in the xz plane, and another infinite plane of charge with uniform surface charge density $-\sigma$ lying parallel to the xz plane, in the plane $y = a$ ($a > 0$). Give an expression for the electric potential $V(\mathbf{r})$ at a point $\mathbf{r} = x\hat{\mathbf{i}} + y\hat{\mathbf{j}} + z\hat{\mathbf{k}}$ produced by these two planes of charge.

Problem 7 Consider a uniformly charged spherical ball with radius R and total charge Q. The charge is uniformly distributed throughout the volume of the ball. Find the electric field everywhere. Also, find the electric potential everywhere.

Problem 8 Consider a fat slab of charge with uniform charge density ρ between the planes $z = -d/2$ and $z = d/2$. Find the electric field $\mathbf{E}(\mathbf{r})$ produced by this charge at an arbitrary point in space. Give an expression for the electric potential $V(\mathbf{r})$ produced by this charge at an arbitrary point in space.

Problem 9 Consider a uniformly charged circular ring with radius R. The linear charge density on the ring is λ.

(a) Give an expression for the total charge Q on the ring.

(b) If a coordinate system is chosen so that the ring lies in the xy plane, centered at the origin, find the electric potential at any point z on the z axis.