Theoretical Physics
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Chapter E Homework. Differential Form for the Maxwell Equations

HW-E1. Infinite Plane of Charge. An x-y infinite plane at z = 0 has a constant areal surface charge density σ. Use Gauss's Law to calculate the electric field above the plane. Note that this calculation is found in Section D4. Simply include the sketch and the short calculation that leads to $E = \frac{\sigma}{2\varepsilon_0}$. Then express your electric field in the form $\vec{E} = E_x \hat{i} + E_y \hat{j} + E_z \hat{k}$ and use the del operator in Cartesian coordinates to calculate the divergence for your electric field above the plane, i.e., calculate $\nabla \cdot \vec{E}$. Show all steps always in homework. Comment on why you expected your answer.

HW-E2. Infinite Line of Charge. An infinite line of charge is situated along the z axis with a constant linear charge density λ. Use Gauss's Law to calculate the electric field at some nonzero distance r away from the wire using cylindrical coordinates. Note that this calculation is found in Section D1. Simply include the sketch and the short calculation that leads to $E = \frac{1}{2\pi r}\frac{\lambda}{\varepsilon_0}$. Express your electric vector field in Cartesian coordinates using $r = \sqrt{x^2 + y^2}$ and $\hat{r} = \frac{x\hat{i} + y\hat{j}}{\sqrt{x^2 + y^2}}$. Then calculate the divergence for this electric field using your Cartesian coordinates for the electric field and the del operator in Cartesian coordinates. Comment on why you expected your answer.

HW-E3. Point Charge. A point charge Q is situated at the origin. Use Gauss's Law to calculate the electric field a distance r from the charge. You can simply reverse the steps we did in class in deriving Gauss's Law. Express your electric vector field in Cartesian coordinates using $r = \sqrt{x^2 + y^2 + z^2}$ and $\hat{r} = \frac{x\hat{i} + y\hat{j} + z\hat{k}}{\sqrt{x^2 + y^2 + z^2}}$. Then calculate the divergence for this electric field at some nonzero distance away from the charge using your Cartesian form for the electric field and the del operator in Cartesian coordinates. Comment on why you expected your answer.