Exam II PH361

NAME

Please explain your answers in detail. What you write is all I have to grade the problem. Little credit will be given if your explanations involves generic phrases (such as "use Hamiltons principle") without a detailed explanation.

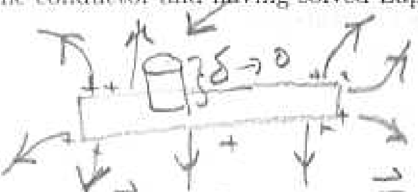
1. Explain why you can or cannot trap a particle with static charges.

- Need a restoring force. An opposite pt charge provides such a force. ⊖→ ⊕ ← ⊖ However this has $\vec{\nabla} \cdot E_{\oplus} \neq 0$.

- in free space $\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0} = 0$. So $\vec{E}$ cannot provide a restoring force in free space

Choose a very small Gaussian surface so conductor looks like ∞ plane.

2. Explain how you would determine the surface charge at the boundary of a conductor, given the voltage on the conductor and having solved Laplace's equation.

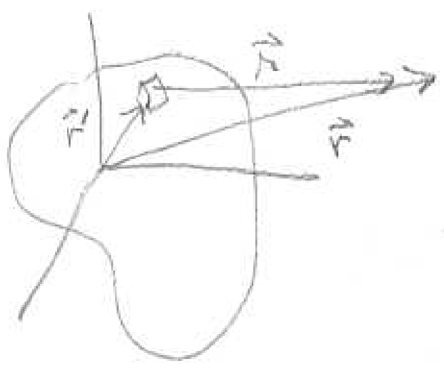


Use Gauss's law.

$$\oint \vec{E} \cdot d\vec{a} = E_{top} A = \sigma \frac{A}{\epsilon_0} \qquad \sigma = E_{top} \epsilon$$

Find $\vec{E}_{top}$ from $\vec{E} = -\vec{\nabla} V$ where V is known from having solved Laplaces eqn. $\vec{E} = -\left(\hat{x} \frac{\partial}{\partial x} V + \hat{y} \frac{\partial V}{\partial y} + \hat{z} \frac{\partial V}{\partial z}\right)$

3. Derive an integral expression for the voltage at an arbitrary point from a small volume element of a material whose dipole moment per unit volume is known.



$$V_{dipole} = \frac{1}{4\pi\epsilon_0} \frac{\vec{p} \cdot \hat{r}}{r^2}$$

$\vec{r} \to \vec{\mathscr{r}}$

$\vec{p}$ for small volume is $\vec{P} d\tau$ where P is dipole moment/vol which is given.

$$V = \frac{1}{4\pi\epsilon_0} \frac{\vec{P}(x', y', z') \cdot (\vec{r} - \vec{r}')}{|\vec{r} - \vec{r}'|^3} \Delta x' \Delta y' \Delta z'$$