

Final Exam (Fall 2018)

PHYS 320: Electricity and Magnetism I

Date: 2018 Dec 11

1. (10 points.) Evaluate

$$(\hat{\mathbf{r}} \cdot \nabla) \frac{1}{r^3}. \quad (1)$$

2. (20 points.) Using Gauss's law find the electric field inside and outside a uniformly charged hollow sphere of radius R with total charge Q .
3. (20 points.) A grounded perfectly conducting thin plate is placed at $z = 0$ plane. A positive charge q is placed at $\mathbf{r}_0 = a\hat{\mathbf{z}}$. Find the electric field at the point $\mathbf{r} = 2a\hat{\mathbf{z}}$. What is the electric field at the point $\mathbf{r} = -2a\hat{\mathbf{z}}$?
4. (20 points.) Two charges with charge $+q$ each are placed at $(a, 0, 0)$ and $(-a, 0, 0)$. A third charge with charge $-2q$ is placed at the origin. Find the monopole moment, the dipole moment, and the quadrupole moment, of this configuration of three charges.
5. (20 points.) Consider a uniformly polarized half-slab, that occupies half of space, and has the direction of its polarization transverse to the direction $\hat{\mathbf{z}}$ normal to the surface of slab, described by

$$\mathbf{P}(\mathbf{r}) = \sigma \hat{\mathbf{x}} \theta(-z), \quad (2)$$

where σ is the polarization per unit area of the slab. Determine the effective charge density by evaluating

$$\rho_{\text{eff}}(\mathbf{r}) = -\nabla \cdot \mathbf{P}. \quad (3)$$

Determine the electric field inside and outside the slab?