Physics 405

Problem Sessions: Questions

1. 25 January, 2006

a. Calculate the following quantities: $\frac{\partial \hat{r}}{\partial \varphi}$, $\nabla \cdot \hat{\theta}$, $\nabla \vec{r}$,

b. Problems 1.60a and 1.55

2. 1 February, 2006

a. Problems 2.4, 2.10, 2.20

b. Problem 2.25b; however, then also take the limit of the potential as the length of the rod goes to infinity.

c. Determine whether or not the electric field presented as such in Prob. 2.42 actually has vanishing curl, so that it may be agreed that it is a possible electric field.

d. A sphere of wax has radius a and a constant volume charge density, ρ. Use Gauss' Law to find the electric field at all points in space, and then determine the associated electric potential.

e. A spherical shell has area charge density, σ. Again find the electric field and then the electric potential, at all points in space.

3. 8 February, 2006

a. Problems 2.35 and 2.37. In 2.35, also please draw the appropriate field lines.

b. For two concentric, metallic, spherical shells of radii a and $b > a$, with charge Q at a and charge $-Q$ at b, please find the electric field and the potential difference between the two shells.

c. There are two infinitely-long lines of charge, one with charge per unit length λ and the other with charge per unit length $-\lambda$. There is an origin of coordinates between them, and they are each a distance a from that origin, on either side, along the $\hat{y}$-axis. At an arbitrary point in the y, z-plane, find the potential they generate. Use this to draw in the equipotential curves for this system. Also use this to determine the electric field they generate.

d. Take a positive charge q and a negative one, $-q$, and place them at a distance a on either side of an origin, along the $\hat{x}$-axis. Find the potential they generate at an arbitrary point, $\vec{r}$, in 3-dimensional space. Take the case where $r >> a$ and find the first non-zero term in the expansion of the potential.

4. 15 February, 2006

a. We had the first exam during this time.

5. 22 February, 2006

a. Problems 3.3b, 3.12, 3.13b, and 3.14b

6. 1 March, 2006

a. Problems 3.22 (outside only), 3.25, 3.27, 3.39

b. 3.37, but just write out form with B.C., but don't bother to calculate the explicit non-zero coefficients. Answer should be $V(r,\theta) = a(V_0/r) + (\beta^3 - a^3)c\cos\theta/(3\epsilon_0 r^2)$, where β is he smaller of r or b.

7. 8 March, 2006

a. Problems 4.5 and 4.29, to determine torques and forces caused by a dipole on another orthogonal dipole.

b. Determine the volume and surface bound charge distributions described by a polarization $\vec{P} = (c/r^2)\hat{r}$ inside a sphere of radius a.

c. Determine the force on a dipole, of amount $\vec{p}$ when placed a distance h above an infinite, conducting, grounded sheet. Do this at least for the case when the dipole is parallel to the normal, but one could also consider the case when the dipole's direction is perpendicular to that normal.

8. 22 March, 2006

a. There is a system for which the following is its potential function:

$$V(x,y,z) = 4V_0\pi \sum_{n\mathrm{odd}} \frac{1}{n}\frac{\sinh n\pi x/a}{\sinh n\pi b/a} \sin n\pi y/a \ .$$

Please describe the system in question.

b. Another system has a potential that must be described in two parts:

$$V(r,\theta,\varphi) = \begin{cases} \dfrac{a\sigma_0}{\epsilon_0} \,, & r \le a \,, \\ \dfrac{a^2\sigma_0}{\epsilon_0 r} \,, & r \ge a \,. \end{cases}$$

Again please desribe the system.

c. a portion of Problem 4.19b. Consider the potential difference V between the plaes as given (and constant), and determine the capactitance of the system.

d. Problem 4.21

e. Problem 4.28. In terms of a fixed, constant potential difference between the two cylinders, called V_0, find the height to which the oil rises out of the reservoir into the space between those cylinders, because of the attractive force on the dielectric material.

9. 29 March, 2006

a. Second Exam will be at this time.

10. 5 April, 2006

a. Problems 5.9, 5.10a, 5.12, 5.13 (both parts), and 5.16

11. 12 April, 2006

a. Given the magnetic vector potential for a pure dipole, namely

$$\vec{A}(\vec{r}) = \frac{\mu_0}{4\pi}\frac{\vec{m}\times\hat{r}}{r^2} \,,$$

find the associated magnetic field, $\vec{B}(\vec{r})$.

b. Prob. 5.45, given a half circle's worth of wire, of radius a, carrying current I, find the magnetic field at any point (located by an angle) on the other half of the circle.

c. Using the Biot-Savart Law, write out the integrals that one would have to perform in order to determine $\vec{B}(\vec{r})$ caused by a current, I, along a circular loop of radius a. Choosing axes so that the arbitrary field point $\vec{r}$ has no $\hat{x}$-component, show that $B_x(\vec{r}) = 0$, but simply obtain integrals for the other components. You should be able to show that both those other components agree with our already-known results when $\vec{r}$ is only in the $\hat{z}$-direction.

d. Using what we know about the vector potential for a pure dipole, and for a rotating, hollow, charged sphere, determine its magnetic dipole moment, which is

$$\vec{m} = \frac{4\pi}{3}\sigma a^4 \vec{\omega} \; .$$

Then use this information to determine the magnetic dipole moment of a rotating, solid sphere, which can be given by

$$\vec{m} = \frac{1}{5} Q R^2 \vec{\omega} \; .$$

12. 19 April, 2006

a. Probs. 6.16, 6.18, and 6.24

b. Determine a general formula for the force on a (pure) magnetic dipole, with moment $\vec{m}_1$, that is caused by another magnetic dipole, $\vec{m}_2$, when the vector between the two of them, i.e., between their "centers," is given by $\vec{r}$.

13. 26 April, 2006

a. The third exam was held this day, which covered Chs. 5 and 6.

14. 3 May, 2006

a. Probs., 7.11, 7.13, 7.29, and 7.30