

Electromagnetism-II, Problem set 1

Due date: Monday, Feb. 13 2009

Please explain your reasoning clearly and show the steps in your calculations

1. Consider an electrostatic potential given by

$$\phi(\vec{r}) = \frac{1}{4\pi\epsilon_0} \frac{\vec{p} \cdot \vec{r}}{r^3},$$

where, $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$, $r = (x^2 + y^2 + z^2)^{1/2}$. Moreover, $\vec{p} = p_x\hat{i} + p_y\hat{j} + p_z\hat{k}$ is a constant vector. Calculate the components E_x , E_y and E_z of the electric field for $r \neq 0$.

2. Two electrons are moved in from infinity and held stationary at a distance of 20 nm from each other. (1) Calculate the work done in the process. (2) Find the acceleration of each electron at the moment that they are allowed to move freely. (3) Find the velocity of each electron when they have reached a separation of 60 nm.
3. A copper wire with circular cross section of diameter 1.6 mm and length 2.5 m is connected to a 4.5 V battery. Compute the magnitude of the electric field E and current density J in the wire.
4. The potential difference between the plates of a parallel plate capacitor is V and the distance between the plates is $3d$. Between the plates is placed a dielectric slab of thickness d and relative permittivity 2. Find the magnitude of the electric field E between the plates both inside and outside the dielectric. Write the expression for the capacitance C assuming that the area of the plates is A .
5. Show that if $\vec{E} = -\vec{\nabla}\Phi$, then one always has $\vec{\nabla} \times \vec{E} = 0$. Similarly, show that if $\vec{B} = \vec{\nabla} \times \vec{A}$, then one always has $\vec{\nabla} \cdot \vec{B} = 0$. (hint: you can simply use the expression for $\vec{\nabla}$ in cartesian coordinates and carry out the manipulations.)