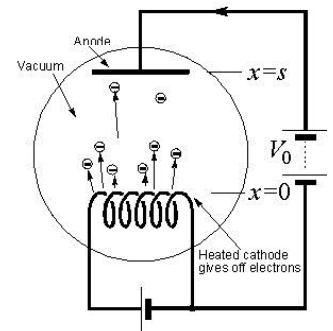


NASSP Honours Electrodynamics Part 1

Tutorial Problem Set 1: Electrostatics

- Q.1.* An electric field points in the z -direction everywhere. What can you conclude about the partial derivatives of E_z with respect to x , to y and to z (i) if the charge density ρ is zero; (ii) if ρ is non-zero?
- Q.2. A sample of diamond (C_6^{12}) has a density of $3.5 \times 10^3 \text{ kg. m}^{-3}$ and a polarization of $1.0 \times 10^{-7} \text{ C. m}^{-2}$. (a) Compute the average dipole moment per atom.
 [$N_0 = 6.02 \times 10^{23}$ atoms/mole; C_6^{12} molar mass = 12 g ;
 you can use this to find the number of atoms per unit volume.]
 (b) Find the average separation between centres of positive and negative charge in the atoms.
 [Note: C_6^{12} tells you that the charges are $\pm 6e$, where $e = 1.6 \times 10^{-19} \text{ C.}$]
- Q.3.* A cube of dielectric material, with side a , centred at the origin, has a 'frozen-in' polarization $\vec{P} = k\vec{r}$, where k is a constant., Find the total volume bound charge and the total surface bound charge. Show that the overall total bound charge is zero.
- Q.4. In a vacuum diode, electrons are emitted by a heated cathode and collected by an anode. Assume the electrodes are plane, parallel and close together, so edge effects can be neglected. The space charge density is given by $\rho = -\frac{4\epsilon_0 V_0}{9s^{4/3}x^{2/3}}$ where V_0 is the voltage at the anode (the voltage at the cathode being zero), s is the distance between the electrodes, and x is the distance of a point from the cathode. So at $x = 0$, $V = 0$, while at $x = s$, $V = V_0$.
 (a) Solve Poisson's equation to find V as a function of x .
 (b) At any point the current density J is ρv , where v is the velocity of the electrons at that point. Use the value of ρv at $x = s$ to find J .
- Q.5. Show that the circulation (line integral) of the magnetic vector potential around a closed loop is equal to the magnetic flux passing through the loop.



* Solutions to be handed in on Friday 28 February at 09:00.
 Please try and attempt the other problems before Friday;
 we will look at these in the Tutorial session.