NASSP Honours Electrodynamics Part 1

Revision Example Set 1: Electrostatics and Magnetostatics

1. Suppose the potential of an electric field is given by $V(x, y, z) = x^2 + 2xy + yz^3$. Find the electric field (vector!).

2. Find the charge density distribution associated with the electric field $\vec{E} = (x^2+y^2)\hat{x} + z\hat{y} + (x^2+y^2+z^2)\hat{z}$

3. Determine whether the following fields could be electrostatic:
   (i) $\vec{E} = (x^2 + y)\hat{x} + (y^2 + z)\hat{y} + (z^2 + x)\hat{x}$
   (ii) $\vec{E} = y\hat{x} + x\hat{y}$

4. Why is it impossible to obtain the potential $V = A(x^2+y^2+z^2)$ [A = constant] in a region containing no charge?

5. Could the following be magnetostatic fields?
   (i) $\vec{B} = (x^2+y^2)\hat{x} + x\hat{y} - 2xz\hat{z}$
   (ii) $\vec{B} = (x^2+y^2z^2)\hat{y} + (y^2-z^2)\hat{z}$

6. If the magnetic vector potential in a region is given by $\vec{A} = 3(y^2\hat{x} + x^2\hat{y})$, determine the field as a function of position.

7. Determine the current density distribution associated with the magnetic field $\vec{B} = (xy + z^2)\hat{x} + (x^2 + y^2)\hat{z}$.

8. An ion beam of uniform charge density ρ passes between a pair of parallel plates, one at $x = 0$, at zero potential, the other at $x = a$ at potential V_0. Neglect the motion of the ions as well as edge effects; assume that the beam completely fills the space between the plates. Use Poisson's equation (1D) to find V and the transverse electric field E_x as functions of x.