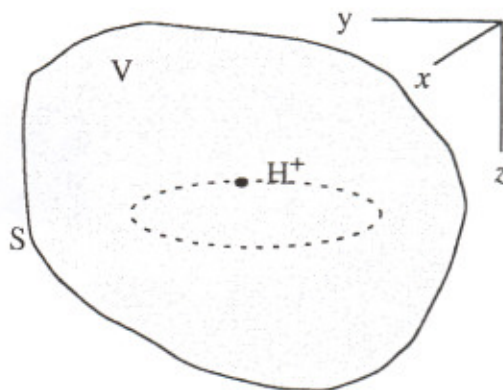


Electricity and Magnetism

Candidacy Exam

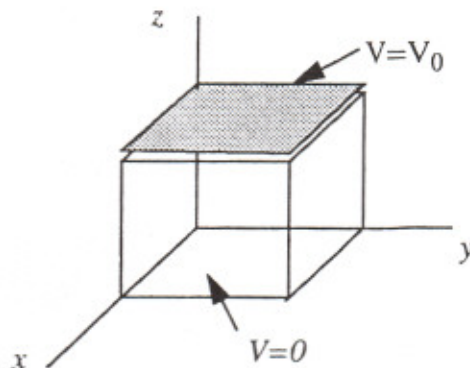
Fall, 2000

1. An ionized hydrogen ion H^+ is inside a volume V bounded by an arbitrary surface S as shown.
 - (a) The ion suddenly begins to move with velocity v ($\sim 0.9c$) in a circular path of radius r while remaining inside S . What is now the flux through S ? (8)
 - (b) The ion stops its circular motion but the surface S and H^+ both move simultaneously with velocity V to the right (i.e., in $-y$ direction) in the lab frame. How does the flux through S change? (7)



2. Consider a uniform spherical *positive* charge distribution of density ρ and radius R centered at a distance of $2R$ from the origin in the xy -plane. Calculate the dipole moment of this system. What quantities does the dipole moment depend on? What is the physical meaning of 'dipole moment' of a distribution that has only positive charges? (8,6,6)
3. (a) A parallel plate capacitor of capacity $10 \mu\text{f}$ is charged to a potential difference of 10V and disconnected from the battery. A slab of material with dielectric constant $\epsilon = 5$ is *slowly* inserted into the capacitor to fill it completely. Calculate the change in the energy stored on the capacitor. Where does the excess energy go/come from? (10)
- (b) The same capacitor is charged to 10V and is *left* connected from the battery. Calculate the change in energy if the same dielectric slab is inserted to fill the capacitor. Where does the excess energy go/come from? (10)

4. Consider a cubical box made of copper. Five of the sides are electrically connected to each other and kept at the ground potential. The top side is insulated from the others and maintained at a potential V_0 with the help of a battery. Calculate the potential inside the box. Assume that the cube edge is of length π . (25)



5. Find the force on a square loop of side a placed as shown, near an infinite straight wire. The currents flowing in the loop and the straight wire are both I . (20)

