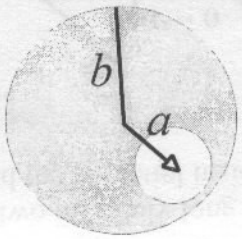
1. A spherical region carries a uniform charge per unit volume ρ. The radius of this spherical region is b.

(a) (5 points) Let $\vec{r}$ be the vector from the center of the sphere to a general point P within the sphere. Show that the electric field at P is given by $\vec{E} = \rho\vec{r}/3\varepsilon_0$.

(b) (5 points) Find the electric field outside the spherical region.

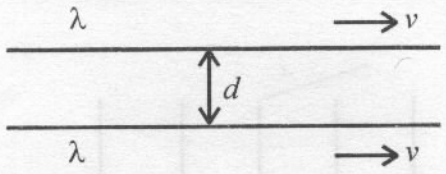
(c) (5 points) Plot the electric field for any point in the space.

(d) (10 points) A spherical cavity is created in the above sphere, as shown below. Using superposition concepts, show that the electric filed at all points within the cavity is $\vec{E} = \rho\vec{a}/3\varepsilon_0$ (uniform field), where $\vec{a}$ is the vector connecting the center of the sphere with the center of the cavity.



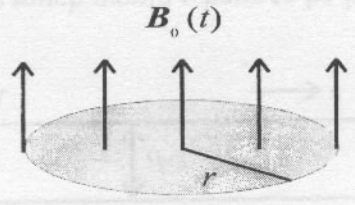
2. (a) (5 points) Find the magnetic field a distance z above an infinite straight line having a linear charge density λ moving at a constant speed v along its length.

(b) (10 points) Consider two infinite straight lines, a distance d apart, carrying identical charge density λ moving at identical speed v, as shown below, find the magnetic force per unit length on either line.



(c) (10 points) How much would v have to be in order for the magnetic attraction to balance the electric repulsion?

3. (a) (10 points) A uniform magnetic field $\boldsymbol{B}_0(t)$, pointing straight up, fills the shaded circular region of radius r as shown below. If it is changing with time, what is the induced electric field?



(b) (10 points) Starting with Maxwell's equations, derive the speed of electromagnetic wave propagating in free space.

(c) (5 points) Suppose there is a moving point charge in a free space. What is the dependence of the radiation power on

(i) its speed v if the moving charge has a constant velocity $\vec{v}$;

(ii) its acceleration a if it accelerates with acceleration $\vec{a}$.

4. (a) (10 points) Suppose a point charge q is held a distance d above an infinite grounded conducting plane. What is the potential in the region above the plane?

(b) (15 points) Two infinitely long grounded metal plates, at $y = 0$ and $y = \pi$, are connected at $x = \pm a$ by two infinitely long metal plates maintained at potential V_0 as shown below. Find the potential inside the resulting rectangular pipe.