Physics 301-24
Assignment 7

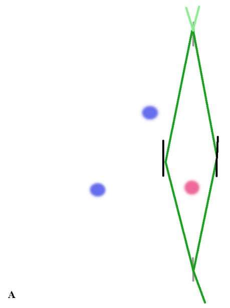
1) [8] Given the diagram of a system being used to detect the Aharonov Bohm effect:

In which cases will a change in the strength B of the magnetic field in the "solenoids" change the ratio of the scalar field coming out of the two ports of the final beamsplitter? Why do you answer as you do?

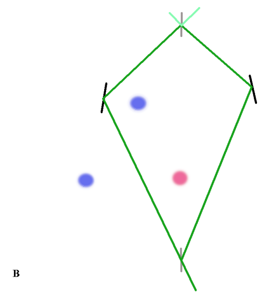
(Be careful with figure C)

The blue indicates a magnetic field of magnitude B pointing out of the page, while the red indicates a magnetic field of same magnitude B pointing into the page.

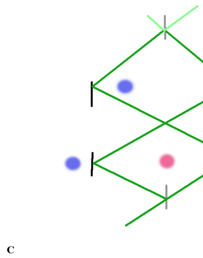
You may assume that the lenths of the paths from input to output of the scalar field are the same in each diagram



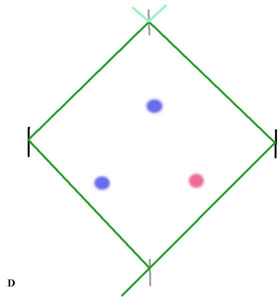
(a) A



(b) B



(c) C



(d) D

2.[4] Given the elecro- and magneto-statics equations

$$< E > (x) = \nabla < \phi_f > (x) \quad < B > (x) = \nabla \times < \vec{A} > \tag{1}$$

$$\nabla \cdot < \vec{D} >(x) =< \rho_f > (x) \quad \nabla \times \vec{<}H > (x) =< \vec{J}_f > (x) \tag{2}$$

For a linear medium, we also have

$$< \vec{D} > (x) := \epsilon(x) < \vec{E} > \quad < \vec{B} >:= \mu(x) < \vec{H} > (x) \tag{3}$$

$$< \vec{D} >= \epsilon_0 E + < vecP > \quad < \vec{H} >= \frac{1}{\mu_0} < \vec{B} > - < \vec{M} > \tag{4}$$

Assume that there are no free charges or currents.

a) Show that the $\vec{D}_\perp$, the perpendicular component of D is continuous at a surface of discontinuous dielectric property, and the parallel component of E is continuous. (Use Gausses and Stokes thms)

b) We have two parallel metal plates, area A and separation $d << \sqrt{A}$– much closer together than their lateral dimensions, with a charge of $\pm Q$ on each plate. What is the voltage between the plates, Now insert ultra pure water between the plates (you can assume that there is a tiny air gap between the metal and the water everywhere) . (relative permativity or dielectric constant ϵ/ϵ_0 of about 80). What will the ratio of charge to voltage be for this new configuration?

3)[6] a) Consider a region where J equals zero. Show that you can introduce a potential $\Psi(x)$ so that $\vec{B} = -\nabla\Psi$. Recall how we showed that in the discussion of the Aharonov Bohm effect we showed that if we had a region where $\vec{B}$ was zero, we could find a gauge to make $\vec{A}$ equal to 0.

b) Given the Magnetostatic equations, show that one can introduce a potential for H in each region where J_{free} is zero and where μ is constant.
