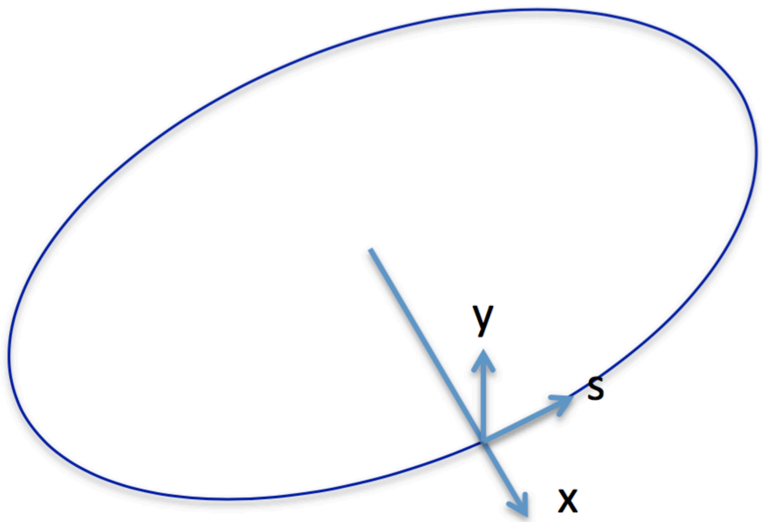
HOMEWORK 1. PHY 564 September 10, 2017
Due September 17, 2017

Problem 1. 5 points. Plane symmetry and plane trajectories.

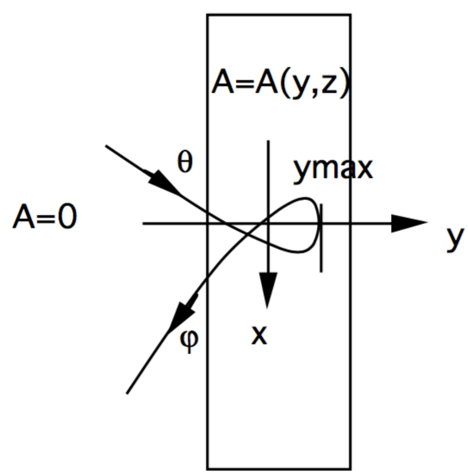


(a) Plane reference orbit (torsion κ=0) requires that total out-of plane force is equal zero. Find ratio between radial (x, horizontal) magnetic field and of-plane (vertical, y) electric field to satisfy this condition. What's happens when both of them are equal zero?
(b) Define full set of condition on EM field providing that all in-plane trajectries (e.g. all trajectroies with y=0 and y'=0, but otherwise arbitrary) to stay in-plane, i.e. y=0 is a solutions. Consider that particles have different energies.

Hint: use Lorentz force

Problem 2. 10 points. Magnetic Mirror: An electron propagates through a magnetic field with vector potential $\vec{A} = \vec{A}(y,z)$. Find an additional invariant of motion caused by independence of vector potential on x. Write explicit expression for p_x using this invariant. Consider a magnet with mid-plane symmetry ($\vec{H} = \hat{e}_z H(y)\ at\ z = 0$; z is perpendicular to the plane of figure) shown below with $\vec{A} = \vec{A}(y,z)$ inside the magnet and $\vec{A} = 0$ outside the magnet. Let's consider an electron entering the magnet in the middle plane $z = 0$ with mechanical momentum $\vec{p} = \hat{e}_x p_x + \hat{e}_y p_y = p(\hat{e}_x \cos\theta + \hat{e}_y \sin\theta)$ $(\vec{A} = 0)$ laying in the x-y plane, making turn in the magnet and coming out.

1. Show that trajectory of electron remains in the plane $z = 0$;
2. Find angle φ of out-coming trajectory of the electron (reflected angle).
3. Find equation defining depth of penetration of electron inside the magnet y_{max} using $A(y, z = 0)$.



Clues: use Lorentz force to find (1), Use canonical momentum to connect mechanical momentum with $\vec{A} = \vec{A}(y,z = 0)$ for (2,3)