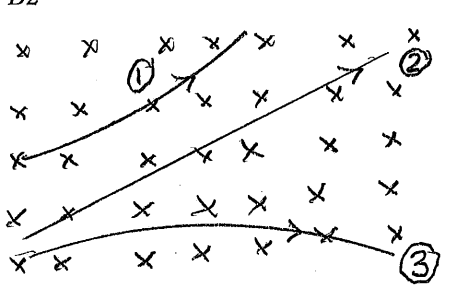
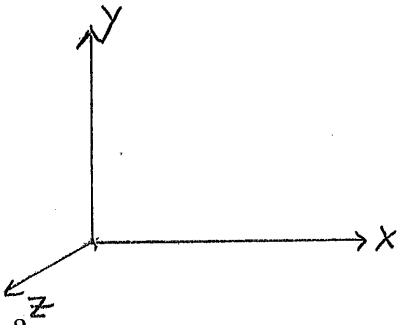
Problems: Week 8

8-1. The curves show the paths (in xy-plane) of three particles in the presence of a constant $\underset{\rightarrow}{B}$ field $\underset{\rightarrow}{B} = -B\hat{z}$

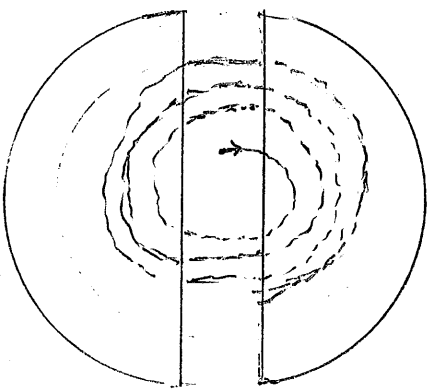


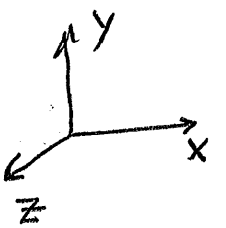


what can you say about the charge carried by each particle? Why?

8-2. What is the force experienced by a conductor aligned along the z-axis if it carries a current of 10amps and is located in a $\underset{\rightarrow}{B} = -0.1T\hat{z}$ field? Why?

8-3. A cyclotron has an oscillator frequency of 12MHz and a DEE radius of 53cm. What value of $\underset{\rightarrow}{B}$ would you need to accelerate deuterons (positive charge $1.6\times10^{-19}C$).

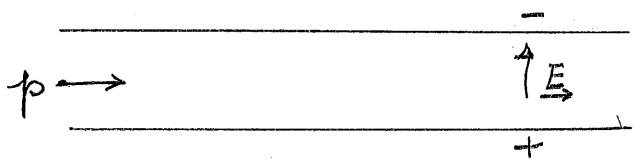




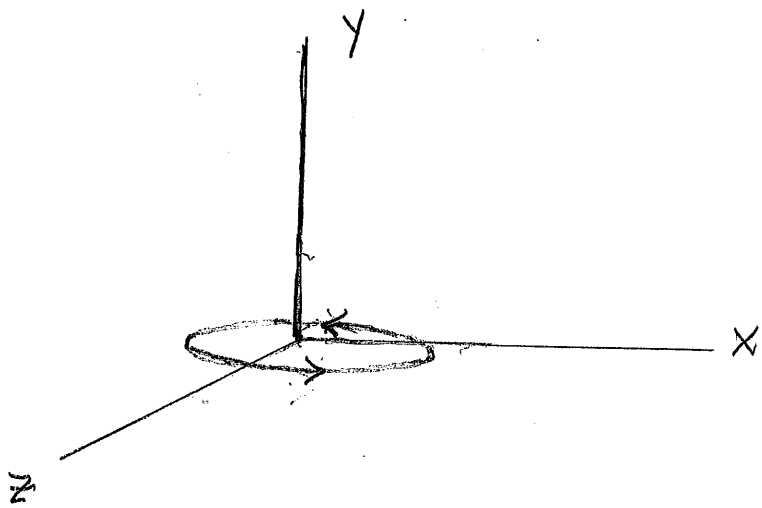
8-4. In a constant $\underset{\rightarrow}{B}$ field a charge with velocity $\underset{\rightarrow}{V} \perp \underset{\rightarrow}{B}$ has a circular path of radius $r = \frac{MV}{qB}$.

(i) If $\underset{\rightarrow}{B} \parallel \hat{z}$ what is the plane of the path. (ii) If you double V what happens to the angular velocity of the charge? Why?

8-5. A proton travelling at $10^5 m/s\ \hat{x}$ is introduced between two parallel plates which have an $\underset{\rightarrow}{E} = 100N/C\ \hat{y}$. What $\underset{\rightarrow}{B}$ field would you apply so that the proton goes through undeflected? [This is the principle of the velocity selector].



8-6. A 5-turn coil of radius 50cm is lying flat in the xz-plane. If it carries a current of 10amps flowing counter clockwise, what is the magnetic moment (magnitude and direction).



8-7. If you apply a $\underrightarrow{B}$ field of 0.1T, at an angle of 30° with respect to the y-axis, to the coil of problem 8-6, what is the torque (magnitude and direction) on the coil?

8-8. The Biot-Savart law tells us that a current I flowing through a conducting wire of length $\underrightarrow{\Delta\ell}$, produces a $\underrightarrow{B}$-field at $\underrightarrow{r}(\perp \underrightarrow{\Delta\ell})$ given by

$$\underrightarrow{\Delta B} = \frac{\mu_0}{4\pi} I \frac{\underrightarrow{\Delta\ell} \times \underrightarrow{r}}{r^3}$$

Show that the $\underrightarrow{B}$-field lines circulate around the current.

8-9. Since the $\underrightarrow{B}$-field due to a current swirls around it (like water circulates as it flows out of a bath tub) Ampere taught us that the circulation of the $\underrightarrow{B}$-field around a closed loop

$$\Sigma_C \underrightarrow{B} \cdot \underrightarrow{\Delta\ell}$$

is determined solely by the currents flowing through the surface on which the loop is drawn. That is,

$$\Sigma_C \underrightarrow{B} \cdot \underrightarrow{\Delta\ell} = \mu_0 \Sigma I_i$$

where μ_0 is a fundamental constant

$$\mu_0 = 4\pi \times 10^{-7} \frac{T-m}{A}$$

Supposing we have a single current I flowing along the y-axis. Please use ampere's law and the symmetry of the problem to show that the $\underrightarrow{B}$-field at a point P in the xz- plane is given by

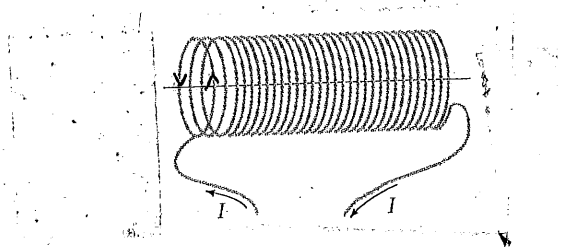
$$\underrightarrow{B}(r) = \frac{\mu_0 I}{2\pi r} \hat{\Phi}$$

where r is distance between P and the y-axis?

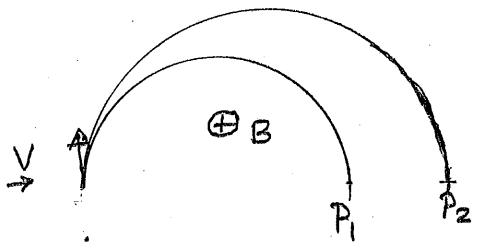
8-10. A tightly wound long solenoid consists of a large number of closely spaced rings with a common axis (see figure). It produces a uniform field inside it. Use Ampere's law to show that for the case shown (ccw current in solenoid)

$$\underset{\rightarrow}{B} = -\mu_0 nI\hat{x}$$

where n= No. of turns/meter of the solenoid. (n= N/L)

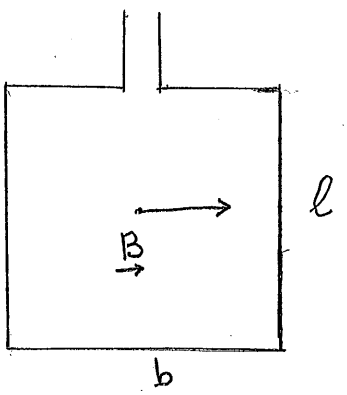


8-11. In a mass spectrometer, the beam at 0 consists of two kinds of particles with same mass (M) but different charges q_1, q_2 entering with a velocity $\underset{\rightarrow}{v} = v\hat{y}$. For $\underset{\rightarrow}{B} = -B\hat{z}$ and the paths shown, what is the sign of the charge (+ive or –ive)? Where will the larger charge land, P_1 or P_2? Justify your answer.



8-12. Why do two parallel currents attract one another?

8-13. Shown is a coil of width b and length ℓ suspended vertically in a $\underset{\rightarrow}{B}$-field. How would you make it work like a motor? The coil is free to rotate about its vertical axis.



$\underset{\rightarrow}{B} = B\hat{x}$

8-14. A coil of cross-section $\underset{\rightarrow}{A} = (2\times 3)m^2\hat{n}$ is being rotated about the vertical in the presence of a constant $\underset{\rightarrow}{B} = 0.2Tz$. What is the maximum and minimum flux of $\underset{\rightarrow}{B}$ through the coil? Why?

8-15. Imagine that a cube of side 1m is located at a height of 10m above the Earth's surface. If the flux of $\underset{\rightarrow}{B}$ through 3 of the faces is $90\mu T - m^2$ what must be the flux through the other three? Why?

8-16. Write an essay on

"What is a Bar Magnet"

Starting from the idea that a single electron is a "bar magnet" of magnetic moment $9.27\times 10^{-24} A - m^2$.

8-17. Why does a bar magnet attract a piece of iron?