Set #8 - for Thursday, December 4

Read

HR&K, Vol. 2	Ch. 31, 32, 33
Purcell	Ch. 5: Sec. 5.1 – 5.6, 5.8 – 5.9
	Ch. 6: Sec. 6.1 – 6.6
	Appendix G
Feynman, Vol. 2	Ch. 13

Solve

From HR&K

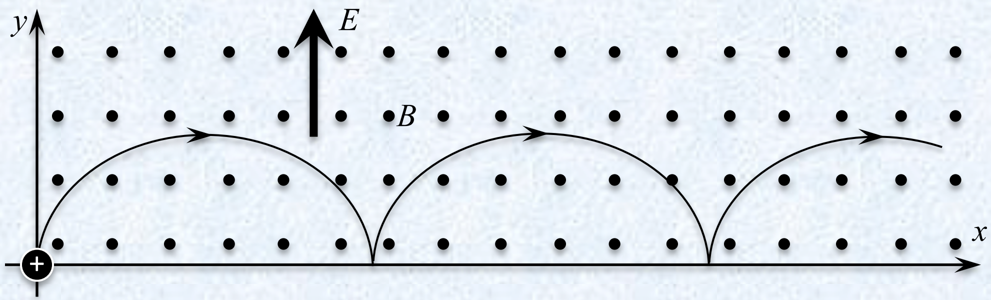
Ch. 31: Exercise 48; Problems 11

Ch. 32: Problems 8, 11, 18, 19

From Purcell

Ch. 5: Problems 5.3, 5.10, 5.14

Ch. 6: Problems 6.30



Problem 1. A particle with charge $+q$ and mass m starts from rest at the origin in the figure shown above. There is a uniform electric field $\vec{E}$ in the $+y$-direction and a uniform magnetic field $\vec{B}$ directed out of the page.

(a) Integrate the equations of motion and show that the path is a "cycloid" with equations:

$$x = \frac{E}{\omega B}\left[\omega t - \sin\omega t\right] \qquad y = \frac{E}{\omega B}\left[1 - \cos\omega t\right]$$

where $\omega = \dfrac{qB}{m}$.

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(b) Prove that the speed at any point is equal to $\sqrt{\frac{2qEy}{m}}$.

(c) Applying Newton's second law at the top point and taking as a given that the radius of curvature here equals $2y$, prove that the speed at this point is $\frac{2E}{B}$.

Problem 2. A point charge Q is moving at constant velocity $\vec{v}$. Calculate (*use the definition of flux*) the flux of the electric field set up by this charge through a sphere centered at the charge and radius r. Is Gauss' law the answer?

Extra Credit. As seen in class, the electric field set up by a charge moving with constant velocity is

$$\vec{E} = k_C \frac{Q}{r^2} \frac{1-\beta^2}{\left(1-\beta^2 \sin^2\theta\right)^{3/2}} \hat{r}.$$

(a) Find the maximum and minimum values of the field and their direction at the distance R from the charge. Show that at low velocities we recover Coulomb's law.
(b) Verify that at angles $\theta = 0°$ and $\theta = 90°$ this equation confirms conditions for x- and y-components that we derived for the electric field vector in the “lab” and “particle” frames.
(c) Show that $\vec{\nabla} \times \vec{E} \neq \vec{0}$. That is, this field cannot be derived from an electrostatic potential alone.

Good Luck, Dr. B