

8.02X Electricity and Magnetism

Problem Set 8

Issued: Sat, Apr 2

Due: ~~Fri, Apr 8, 4PM < note Date + Time!~~

~~Note that the exp MF write-up from both lab partners is also due on 4/8 4PM!~~

~~Reading suggestions (from Young & Freedman)~~

~~Mon: Electromagnetic Induction I~~

~~Wed: Electromagnetic Induction II~~

~~Fri: Quiz 3 Review~~

~~Homework Problems (30 points total)~~

Problem 1 (10 points) Two parallel wires carrying currents in the same direction are found to attract each other.

- Give a step-by-step explanation of why the wires attract each other, due to the field created by moving electric charges and the forces on moving charges. Use pictures and words, but not equations
- Again using pictures and words show that you get repulsion if the currents in the two wires run anti-parallel.

~~**Problem 2 (10 points)** You have a horizontal cathode ray tube (CRT) in a lab room which has been adjusted such that the electron beam should produce a single spot in the center of the front screen. However, you find that the spot is offset to the right, when viewed from the front.~~

- ~~You realize that the offset could be caused by an electric or magnetic field or by a misalignment of the cathode. How can you determine the cause of the problem without any instruments to detect electric or magnetic fields and without removing the CRT from the room?~~
- ~~If the cause was an magnetic field, what direction would the field have, relative to the original direction of the electron beam?~~

~~**Problem 3 (10 points)** The Large Hadron Collider at CERN, Geneva, will accelerate lead nuclei to an energy of 2.8 TeV/nucleon. The nuclei will follow a circular trajectory of 27km circumference~~

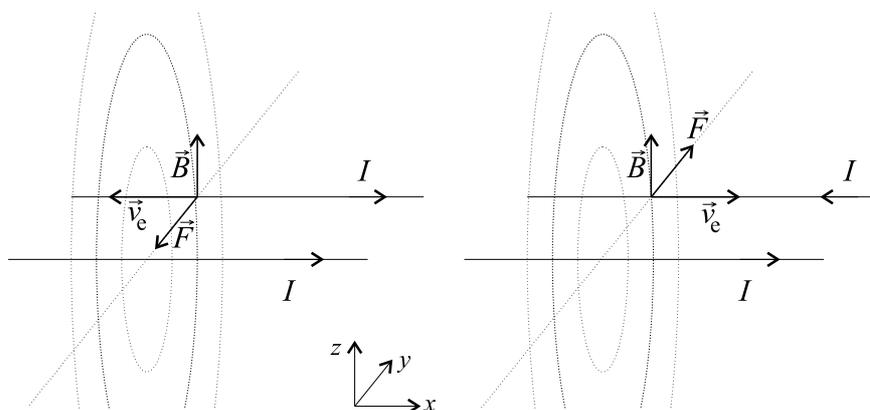
- ~~What is the momentum of each nucleus [note: The relativistic relationship between energy and momentum is $E = \sqrt{p^2 c^2 + m_0^2 c^4}$]?~~
- ~~How big is the magnetic field of the dipole magnets that hold the nuclei on their trajectory?~~

8.02x – Problem Set 8 Solutions

Problem 1 (10 points)

a) The currents run in the same direction \hat{x} . The field created by the first wire has direction \hat{z} at the place of the second wire. The *electrons* in the second wire move to $-\hat{x}$ (opposite the current), so the Lorentz force on them has direction $-\hat{y}$, towards the first wire. The wires attract each other.

b) Now the currents run in opposite directions. Replace the velocity of *electrons* in the second wire by $-\vec{v}$, so we get force $-\vec{F}$ (in the \hat{y} direction). The wires thus repel each other.



Problem 2 (10 points)

~~The electrons in the CRT tube are deflected to the right, when looking from the front. This could be caused by an electric field pointing horizontally to the left, or a magnetic field pointing vertically upwards. Let's try to distinguish these cases by moving the apparatus around.~~

~~If we rotate the apparatus in the horizontal plane, and the beam is still deflected to the right \Rightarrow the problem-causing field is a *vertical magnetic field*.~~

~~If we rotate the apparatus in the horizontal plane and find that the deflection changes, and that there are two (opposite) orientations for which it is zero \Rightarrow the villain is the *horizontal electric field*.~~