

8.02X Electricity and Magnetism

Problem Set 9

~~Issued: Wed, Apr 7~~

~~Due: Fri, Apr 15, 4PM < note Date + Time!~~

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

~~Mon: Quiz 3~~

~~Wed: Faradays Law, Transformer Action, Inductance: 29-5, 31-6, 30-1 to 30-3~~

~~Fri: AC Circuits, 31-1 to 31-3 (Note: You can ignore phasor diagrams)~~

~~Homework Problems (30 points total)~~

~~**Problem 1 (20 points)** The 1200 dipole magnets of the LHC accelerator at CERN will have a field of 8 Tesla. Approximate the magnet as two square loops of dimension 14m x 0.3 m, with a distance of 10cm between the two loops (similar to the arrangement in question 4 of quiz 3).~~

- ~~(a) What direction should the field have to keep protons going clockwise on a circular trajectory?~~
- ~~(b) What is the current in each loop needed to create a field of 8T in the midplane of the two loops?~~
- ~~(c) Again using pictures and words show that you get repulsion if the currents in the two wires run anti-parallel~~
- ~~(d) Assume that the field is homogenous at 8T over a cross section of 200 cm^2 . What is the total energy stored in the magnetic field of all dipoles combined?~~

Problem 2 (10 points) Explain why power is transformed to high voltages to be transported over power lines

~~For the total 1200 magnet, the energy stored is~~

~~$$U_{tot} = 1200 \mu V = 1200 \frac{B^2}{2\mu_0} V = 1200 \times \frac{8^2}{2 \times 4\pi \times 10^{-7}} \times (14 \times 0.3 \times 0.1) = 1.3 \times 10^{10} \text{ J}$$~~

Problem 2 (10 points) Explain why power is transformed to high voltages to be transported over power lines.

Energy loss (per unit time) in transmission line is due to the resistance of the wires, i.e.

$$P_{loss} = I^2 R_{loss}$$

The power delivered is given by

$$P_{del} = IV$$

For a given delivery power P_{del} ,

$$P_{loss} = \frac{P_{del}^2}{V} R_{loss}$$

Therefore, the higher the voltage, the lower the loss.