Classical Electrodynamics (Physics course 503)

Problem set #10

Due date: 6pm, May 22 (Tue), 2018

Submission: HW box in physics building.

***1.*** A uniform solenoidal winding of *n* turns per unit length is placed around a nonmagnetic rod having a circular cross section of radius *R* and a conductivity *σ.* The solenoid carries a sinusoidal current of angular frequency *ω* and maximum value . Assume that the solenoidal winding is long compared with *R.*

(a) Show that the magnetic induction inside the rod is uniform and find its value. (Assume that the conductivity σ is small enough that the current induced in the rod makes a negligible contribution to the magnetic induction inside the rod. Also neglect the displacement current.)

(b) What is the current density in the rod as a function of radial position?

(c) What is the average rate of joule heating in the rod per unit length?

(d) Find a condition on σ such that the current induced in the rod can be neglected in part (a) when finding the magnetic induction.

***2.*** An electron moves along the Z-axis in the +Z-direction with speed *.* A small wire loop of area *A* and resistance *R* lies in the XZ-plane at (-d, 0, 0).

(a) Find the current in the loop as a function of time.

(b) Find the position of the electron when the magnitude of the current is a maximum.

The effect on the electron of the magnetic field produced by the current

in the loop may be ignored. The self-inductance of the loop may also be

ignored.

***3.*** A parallel-plate condenser is constructed from circular plates of area *A* separated by a material of uniform dielectric constant , permeability *μ,* and conductivity σ. It is initially charged to *±q* on the two plates and then it discharges slowly through the material between the plates. Find the electric field and magnetic induction vectors in the region between the plates as a function of position and time. Neglect the fringing fields.

***4.*** A permanently magnetized needle of length *L* and cross-sectional area *A* is made to move at constant velocity *v (v* << *c)* along the axis of a circular coil of radius *a.* The magnetization M, which is uniform throughout the needle, is parallel to the velocity and oriented along the length of the needle. The coil consists of *N* turns of wire with total electrical resistance *R* and is short circuited. The diameter of the needle is much smaller than *L* and *a.* Neglect the inductance of the coil. It is not necessary to evaluate nontrivial integrals.

(a) Find the magnetic flux through the coil as a function of time. (Take *t =* 0 to be the instant when the center of the magnet passes through the plane of the coil.)

(b) Find the total work done on the magnet in forcing it through the

coil.

***5.*** Jackson 5.5