43. (a) If neutrons from a cosmic-ray interaction one light-year from the earth were to reach here with a probability of $1/e$ or greater, what must their minimum energy be? (b) If they then decay, what is the maximum angle to the flight path at which their decay electrons could be produced? (c) What is the maximum angle for the decay neutrinos? (d) At the angle calculated in (c), what is the maximum energy of the neutrino?

44. A precession of the perihelion of planetary trajectories has been derived from the general theory of relativity. However, even the special theory of relativity predicts such an effect because of the dependence of inertial mass on velocity. Derive a formula for the *special-relativistic* precession for a planet of given angular momentum L, rest mass m, and energy E, moving in the gravitational potential of the sun. [*Hint:* Use polar coordinates $u = 1/r$ and θ, and find a differential equation involving u and θ, but not involving the time explicitly.]

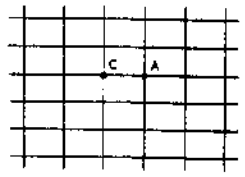
45. A helium-filled balloon floats inside a closed container filled with air at STP, in interstellar space. The container accelerates in a given direction, with acceleration equal to that due to gravity at the surface of the earth. Which way does the balloon move relative to the acceleration?

3

ELECTROMAGNETISM

1. The edges of a cube consist of equal resistors of resistance R, which are joined at the corners. Let a battery be connected to two opposite corners of a face of the cube. What is the effective resistance?

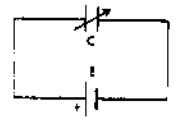
2. A rectangular wire mesh of infinite extent in a plane has 1 A of current fed into it at a point A, as in the diagram, and 1 A taken from it at point C. Find the current in the wire AC.



3. Given two iron bars, identical in appearance, one magnetized, the other not. Tell how to distinguish them without using external magnetic fields. (You are allowed to measure forces.)

4. A conductor is charged by repeated contacts with a metal plate which, after each contact, is recharged to a quantity of charge Q. If q is the charge of the conductor after the first operation, what is the ultimate charge on the conductor?

5. A variable capacitor is connected to a battery of *emf* E. The capacitor initially has a capacitance C_0 and charge q_0. The capacitance is caused to change with time so that the current I is constant. Calculate the power supplied by the battery, and compare it with the time rate-of-change of the energy stored in the capacitor. Account for any difference.



6. When a capacitor is immersed in a medium having conductivity g, a resistance R is measured between the terminals. Show that, regardless of