Department of Physics
Physics 2049 (Rabson) Spring semester, 1999

Homework for Weeks 11–12
Due Friday, 9 April
note: no homework due 2 April

32.1Q, 32.14Q
32.8P, 32.29E, 32.32P, 32.39P, 32.40E
33.1Q, 33.2Q, 33.7Q, 33.13Q(b)
33.1E, 33.5E, 33.7E, 33.14E, 33.19P, 33.33P, 33.38E, 33.49E(a), 33.55P, 33.65P, 33.69E (use U.S. household root-mean-square voltage of 120v instead of 100v), 33.76E, 33.81P, 33.84P, 33.86E, 33.89P

Solutions from week 10: I. The magnetic field inside the solenoid is directly proportional to the number of turns per unit length (n) as well as to the current. Thus cases 1 and 2 tie, while 3 has a lower field. II. In the problem, the wire loop fell without rotating (a) about a horizontal axis in the plane of the page partway between top and bottom of the loop, (b) about a vertical axis, or (c) about an axis perpendicular to the page. The last of these does not change the flux and so should not yield a torque. The other two kinds of tilting both decrease the flux at any given time. I found three ways to show that falling vertically is an unstable equilibrium with respect to rotations of these sorts. First, using Lenz’s law to find the sense of induced electro-motive force (and hence current) in the falling loop, I applied the I × B force rule (equation 29-26) to see that forces on all three wire segments exposed to the magnetic field are inward. While the loop remains in the plane of the paper, this yields no torque. However, any small rotation puts opposite pairs of wires outside the plane of the page, giving a net torque. Second, I calculated the magnetic moment μ induced in the loop. While the loop remains in the plane, μ is antiparallel to B. The vanishing of the cross product for antiparallel vectors ensures zero torque. However, a small rotation introduces an angle between μ and −B. The two vectors will still be almost antiparallel, so the angle from μ to B will be close to but slightly less than 180°; in this sector, the sine in the cross product is positive. Application of the right-hand rule for the cross product gives a torque that makes the loop continue turning. Finally, consider the energy −μ · B of the dipole moment μ in the external field B. The configuration of the problem maximizes this energy. Although there is no torque exactly at maximum, any small deviation from the maximum results in a torque that attempts to lower the energy further. The loop is analogous to a ball sitting at the top of a round hill. So long as it stays exactly at the top, there is no net force to make it roll one way or the other. It is at equilibrium. However, as soon as it moves a small distance away from the top, there is a definite force directed down-hill.

Minor clarifications on quiz solutions: (i) On the front cover of quiz 3, I left off the minus sign in Faraday’s law (Lenz’s law). This did not affect any questions on the quiz. I apologize for the error. (ii) On the (pink) solution sheet for quiz 2, the initial current in part 1a should be 12 mA, not 12 mV. (iii) Alternative solutions exist for problem 3 on quiz 2 and problem 3 on quiz 3, for which I awarded full credit.

Quiz results: 50% of the class earned A or B on quiz 2; only 12% did so on quiz 3. These are the absolute scores, not the curved scores.