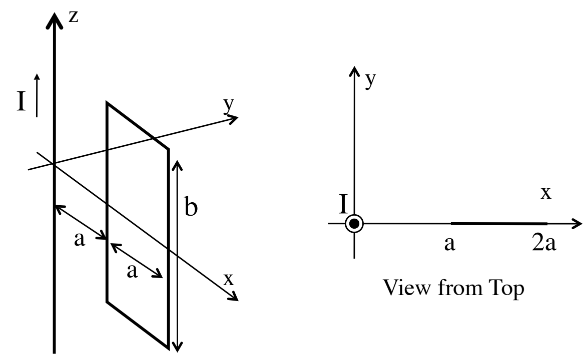
Phys 210A: Problems for HW 8

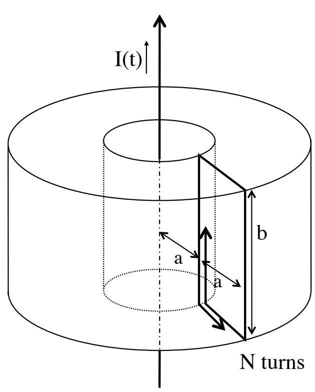
C. Gwinn, W2010

1 HW9 Problem 1

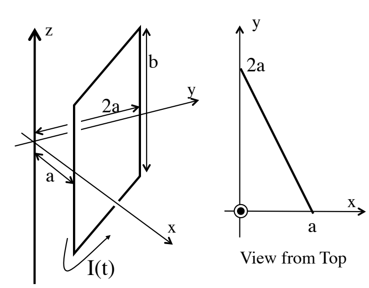
A very long straight wire carries current I toward $+\hat{z}$.



a) A rectangular wire loop at a distance a away from the wire has width a and height b. Find the magnetic flux Φ_B through the loop.



9.1-b



9.1-c

b) The loop is one of N loops, joined in series in a toroidal coil surrounding the wire. Suppose that the current in the long straight wire I increases at a constant rate, $dI/dt = c$ with $c > 0$. • What emf is induced around the toroidal coil? • What is the direction of the current flow in the loop? Explain. • Find the mutual inductance of the wire and the toroidal coil.

c) Consider a single, rectangular loop containing a vertical segment of length b at $x = a$, $y = 0$; and a second, vertical segment of length b at $y = 2a$, $x = 0$. The top and bottom of the loop are at constant z. Suppose that the loop carries a counterclockwise current $I(t)$, increasing at a constant rate: $dI/dt = c$. Find the emf induced in the vertical wire running along the z-axis. Which end of the wire is at higher potential, $z \to +\infty$ or $z = -\infty$? What is the direction of current flow? Explain your answer.

2 HW9 Problem 2

To spin up a uniformly charged sphere, you must exert torque, even if the sphere has zero mass. Find the torque required to achieve angular acceleration $\alpha = \dot{\omega}$. Suppose that the sphere has radius a and surface charge $\sigma = q/(4\pi a^2)$.

What is the total work required, to accelerate the sphere from rest, $\omega = 0$, to angular velocity $\omega = \Omega$? Can this energy be recovered, and if so, how?

3 HW9 Jackson Problems

5.21, 5.29

Note: For problem 5.29, you may assume that the fields around the transmission lines do not depend on z. More precisely, you are to assume that the the fields vary with z over much larger length scales than along x or y.