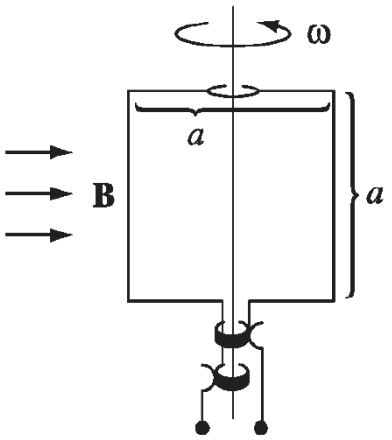
Sheet 1

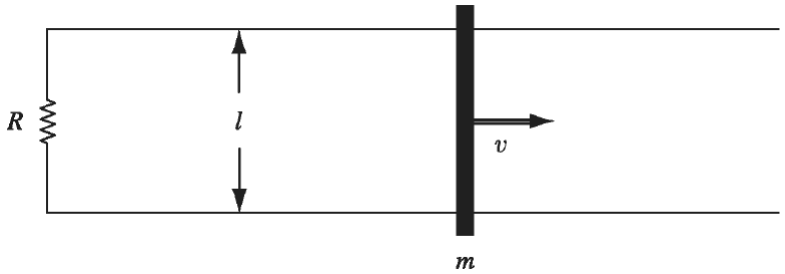
Problem (1)

A square loop (side a) is mounted on a vertical shaft and rotated at angular velocity ω, as shown in the figure. A uniform magnetic field $\mathbf{B}$ points to the right. Find the $\mathcal{E}(t)$ for this alternating current generator.



Problem (2)

A metal bar of mass m slides frictionlessly on two parallel conducting rails a distance l apart as shown in the figure. A resistor R is connected across the rails, and a uniform magnetic field $\mathbf{B}$, pointing into the page, fills the entire region.



(a) If the bar moves to the right at speed v, what is the current in the resistor? In what direction does it flow?

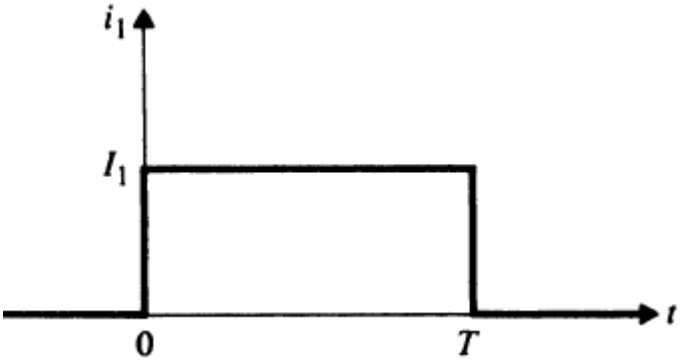
(b) What is the magnetic force on the bar? In what direction?

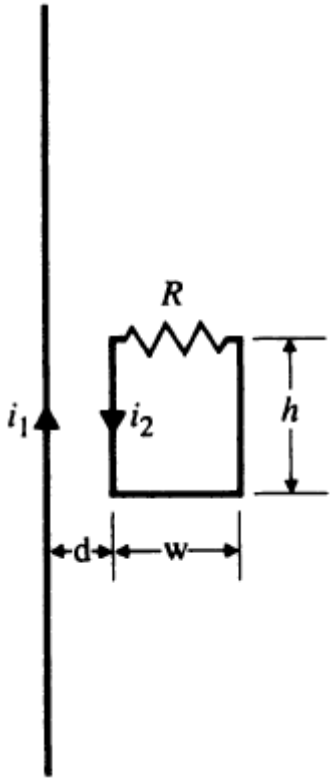
(c) If the bar starts out with speed v_0 at time $t = 0$, and is left to slide, what is its speed at a later time t?

(d) The initial kinetic energy of the bar was, of course, $mv_0^2/2$. Check that the energy delivered to the resistor is exactly $mv_0^2/2$.

Problem (3)

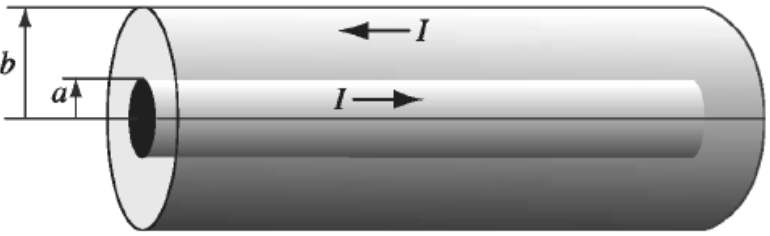
(Cheng P.7-3) A rectangular loop of width w and height h is situated near a very long wire carrying a current i_1 as shown in the figure. Assuming $i_1$to be a rectangular pulse as shown in the figure, find the induced current current i_2 in the rectangular loop whose self-inductance is L.





Problem (4)

A long coaxial cable carries current I (the current flows down the surface of the inner cylinder, radius a, and back along the outer cylinder, radius b) as shown in the figure. Find the magnetic energy stored in a section of length l.

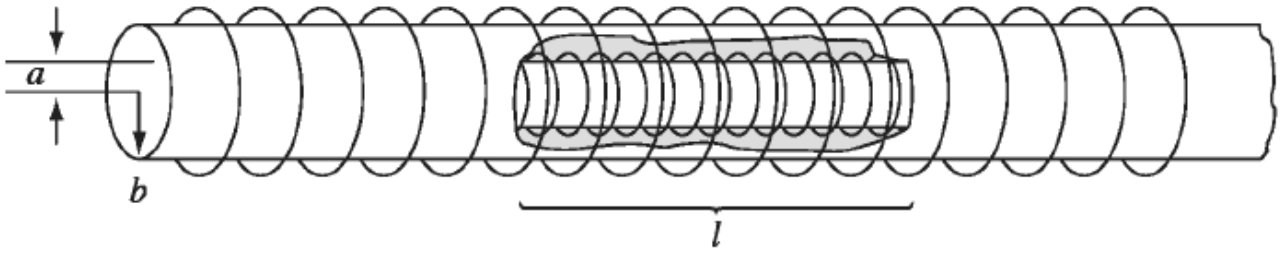


Problem (5)

Find the self-inductance of a toroidal coil with rectangular cross section (inner radius a, outer radius b, height h), that carries a total of N turns.

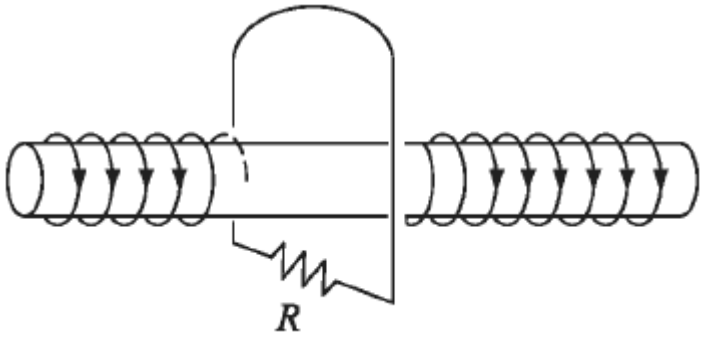
Problem (6)

A short solenoid (length l and radius a, with n_1 turns per unit length) lies on the axis of a very long solenoid (radius b, n_2 turns per unit length) as shown in the figure. Current I flows in the short solenoid. Calculate the mutual inductance between the two solenoids.



Problem (7)

A long solenoid of radius a, carrying n turns per unit length, is looped by a wire with resistance R, as shown in the figure.



(a) If the current in the solenoid is increasing at a constant rate ($dI/dt = k$), what current flows in the loop, and which way (left or right) does it pass through the resistor?

(b) If the current I in the solenoid is constant but the solenoid is pulled out of the loop (to a place far from the loop), what total charge passes through the resistor?

Problem (8)

Suppose,

$$\mathbf{E}(\mathbf{r},t) = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\theta(vt-r)\,\hat{\mathbf{r}}; \qquad \mathbf{B}(\mathbf{r},t) = \mathbf{0}$$

(The theta function is Heaviside unit step function which is 0 for negative argument and 1 otherwise.) Show that these fields satisfy all of Maxwell's equations, and determine ρ and $\mathbf{J}$. Describe the physical situation that gives rise to these fields.

Problem (9)

(Griffiths problem 10.11) An infinite straight wire along z-axis carries the current,

$$I(t) = q\delta(t).$$

Find the resulting electric and magnetic fields.