
General Physics: Electromagnetism, Problem Set 10

Exercise 1 :

A conductive rod of length l , mass m and resistance R slides down on a vertical conductive frame from the height $H \gg l$ in the presence of homogeneous magnetic field B which is perpendicular to the frame (Figure 1). Estimate:

- Kinetic energy of the rod, when it hits the grass.
- How much heat energy W was delivered in the rod?

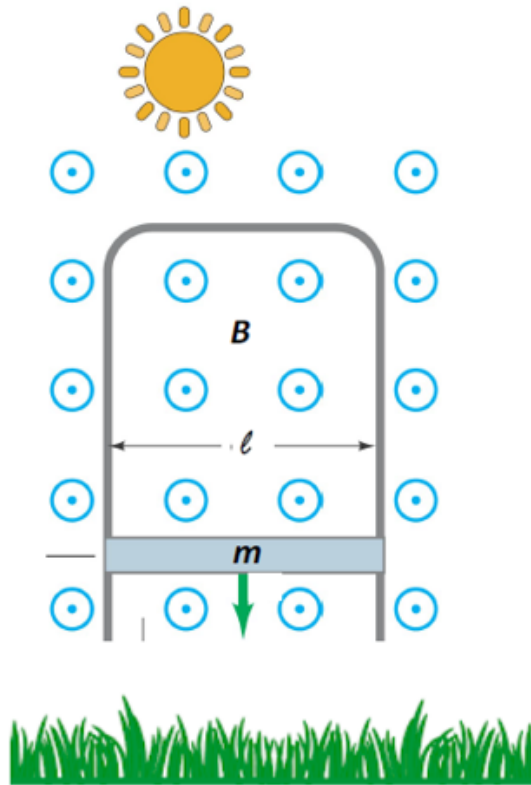


Figure 1: Conductive rod sliding down a conductive frame in a homogeneous magnetic field.

Exercise 2 :

A square $b \times b = 5 \times 5$ cm conductive frame is moved by an external force with constant velocity $v = 1$ m/s through the area of width $d = 20$ cm of homogeneous magnetic field $B = 1$ T, which is orthogonal to v (see Figure 2). The external work required to pass the field was $W = 2.5 \cdot 10^{-3}$ J. What is the resistance R of the frame?

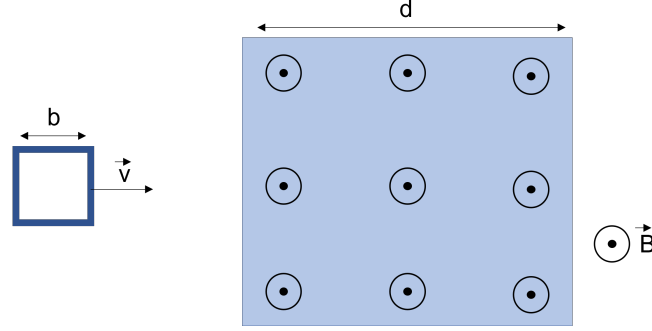


Figure 2: Conductive frame moved by an external force with constant velocity in a homogeneous magnetic field.

Exercise 3 :

Consider a conductive rod of mass m and resistance R that can freely slide along a horizontal solid conductive frame of width w and length l , which is much longer than the width (Figure 3). The homogeneous magnetic field B is orthogonal to the frame. The field is changing with time t as $B = B_0 t$. In which direction and by what distance Δl will the rod be displaced from its initial position at $t = 0$ after a short time $t = T$, assuming that the displacement is small compared to l ?

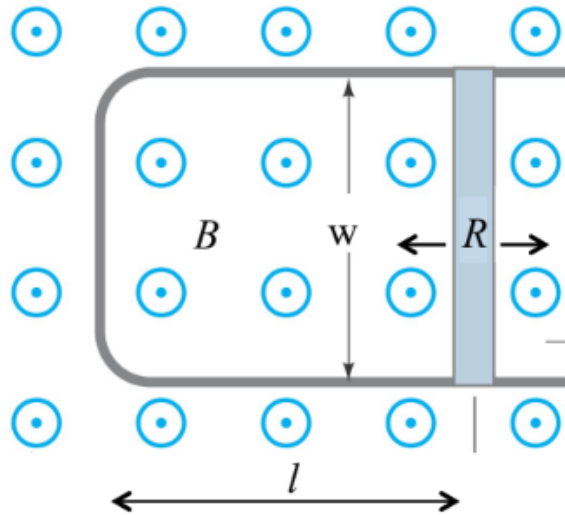


Figure 3: Conductive rod sliding along a conductive frame in a homogeneous magnetic field.

Exercise 4 :

A solenoid S with a diameter $D = 3.2$ cm has 200 turns/cm and carries a sinusoidal current $I = I_0 \sin(2\pi ft)$ (See Figure 5). In the center, we put a coil C of 130 tight turns with a diameter $d = 2.1$ cm. The amplitude of the current is $I_0 = 1.5$ A and the frequency is $f = 50$ Hz. What is the amplitude of the *emf* induced in the coil C ?

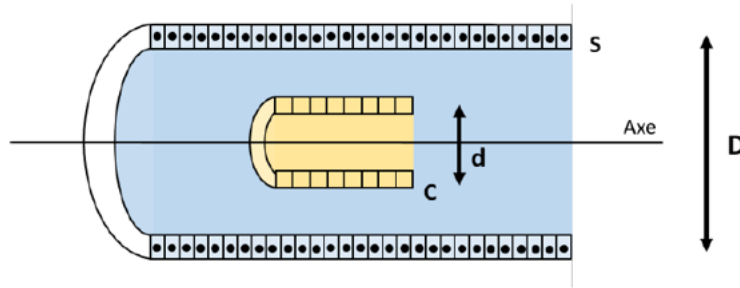


Figure 4: Solenoid S with sinusoidal current containing a coil C .

Exercise 5 :

A circular loop of radius r_0 rotates with angular speed ω in a fixed magnetic field as shown in the Figure below.

- Find an expression for the emf induced in the loop.
- If the magnitude of the magnetic field is $25 \mu\text{T}$, the radius of the loop is 1 cm, the resistance of the loop is 25Ω and the rotation rate ω is 3 rad/s, what is the maximum current in the loop?

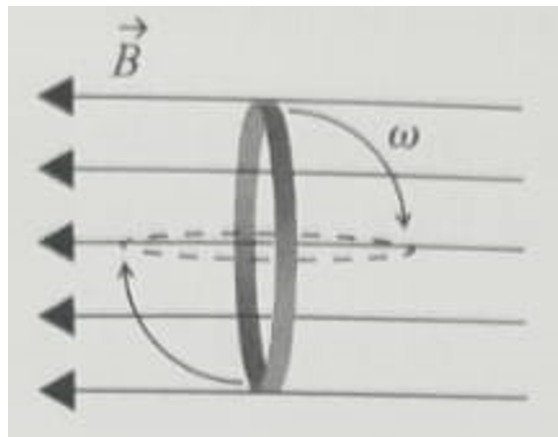


Figure 5: Circular loop rotating in a homogeneous magnetic field at an angular speed ω .