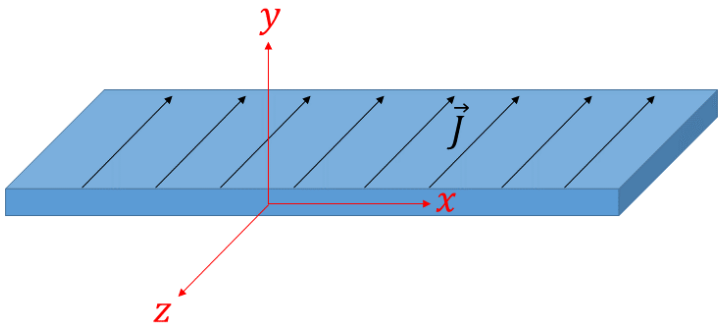
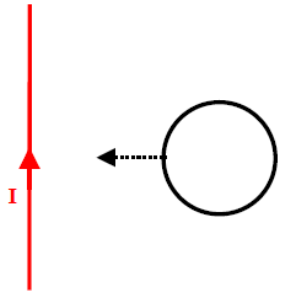
Homework 5: Ampere's, Faraday & Lentz's laws

1. An infinite conducting sheet of thickness T lies in the $xz-$ plane and carries a uniformly distributed current density $\vec{J}$ in the $-z$ direction as shown in the Figure. What is the magnitude and direction of the magnetic field at distance d above the sheet (in the $+y\ direction$)?



2. A long straight wire carries current I. Nearby and lying in the same plane is a circular loop, as shown in the Figure. If the loop is moved toward the wire, what will be the direction of the current induced in the loop (if any) and what will be the direction of any electromagnetic force exerted on the loop?

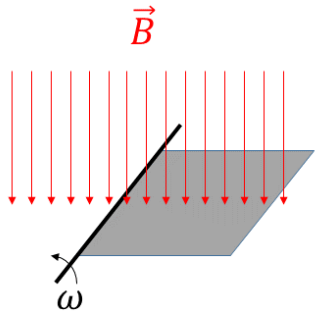


3. A magnetic field given by $B(t) = at + b$ with $a = 1\,T/s$ and b = -1 T is directed perpendicular to the plane of a circular coil of 10 turns and radius 0.2 m. If the coil's total resistance is $1.58\ Ohms$, how much power (in Watts) is dissipated at time $t = 1s$?

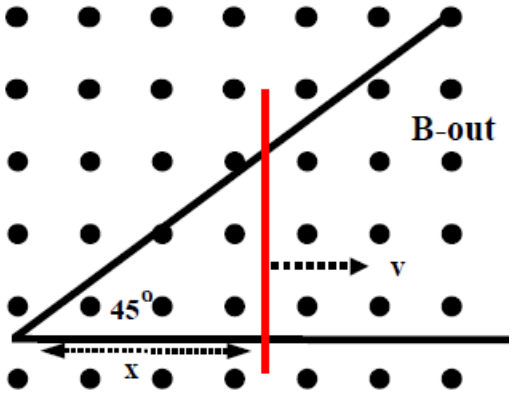
4. A 25-turn coil of resistance $3\ Ohms$ has area of $8\ cm^2$. Its plane is perpendicular to a magnetic field given by $B(t) = 0.4t - 0.3t^2$ (where B is in Tesla and t is in seconds). What is the induced current in the coil at $t = 1s$?

5. A uniform time dependent magnetic field given by $B(t) = at^2$ with $a = 0.3\,T/s^2$ is directed perpendicular to the plane of a square wire loop with sides of length $0.5\ m$. If the total resistance of the square wire is $0.4\ Ohms$, how much total energy (in Joules) is dissipated by heat in the wire during the time from $t = 0$ to $t = 10$s?

6. A single wire square loop with area $A = 100\ cm^2$ rotates with a constant angular velocity in the magnetic field of the earth (about $100\ \mu T$). The axis of rotation goes through one side of the square loop (in the plane of the loop) and is perpendicular to the magnetic field as shown in the Figure. If the period of the rotation is one second, what is the maximum EMF generated in the loop



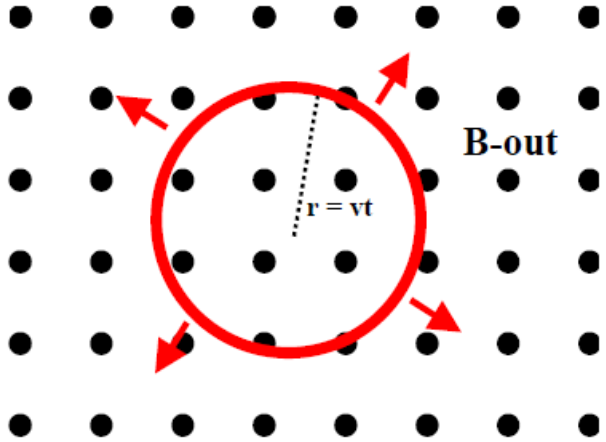
7. A moveable (massless and frictionless) bar is being moved at a constant velocity of $3\ m/s$ from left to right along two conducting rails as shown in the Figure. The two conducting rails make an angle of $45°$ with each other and together with the moving bar form a right triangle. If the system is immersed in a uniform magnetic field (out of the paper) with magnitude $B = 0.5\ Tesla$ and if the bar was at $x = 0$ at $t = 0$, what is the magnitude of the induced EMF in the right triangle at $t = 2s$?



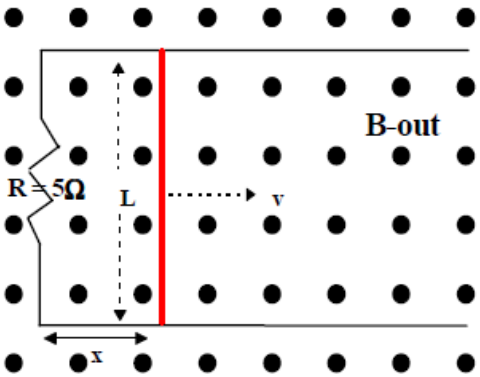
8. A wire circular loop with a resistance per unit length of $0.5\ Ohms/meter$ is placed in a uniform magnetic field given by $\vec{B} = B_0\hat{z}$, with $B_0 = 2\ Tesla$, as shown in the Figure (z is out of the paper). If the radius of the circular loop is increasing at a constant rate given by $r(t) = vt$ with $v = 0.5\ m/s$,

(a) what is the magnitude of the induced EMF at t = 10s?

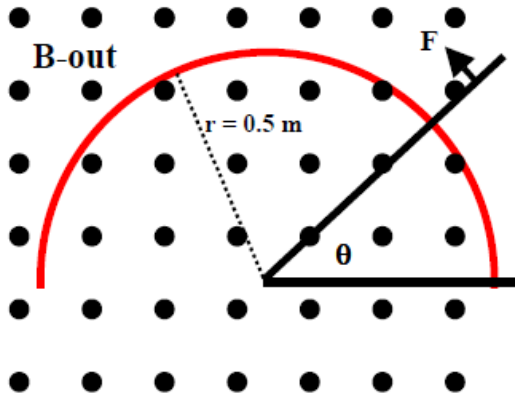
(b) what is the magnitude and direction of the induced current in the loop at $t = 10s$?



9. A moveable (massless and frictionless) bar with a length of $L = 1$ meter is being moved at a constant velocity of $10\ m/s$ from left to right along two conducting rails by an external force, F, as shown in the Figure. If the system is immersed in a uniform magnetic field (out of the paper) with magnitude $B = 2\ T$, what is the induced current in the $5\ Ohm$ resistor?



10. A moveable (massless and frictionless) conducting rod is pulled by an external force so that it rotates with a constant angular velocity ω along a semicircular loop of wire with radius of $r = 0.5\ m$ as shown in the Figure. The rotating rod is connected at the center of the semicircular loop to a stationary rod that is also in contact with the semicircular loop. If the entire system is placed in a uniform $2\ Tesla$ magnetic field (out of the page), and if it takes $1s$ for the angle between the two rods to go from $\theta = 0$ to $\theta = 90°$, what is the magnitude of the induced EMF in the circuit?


B-out
F
r = 0.5 m
θ