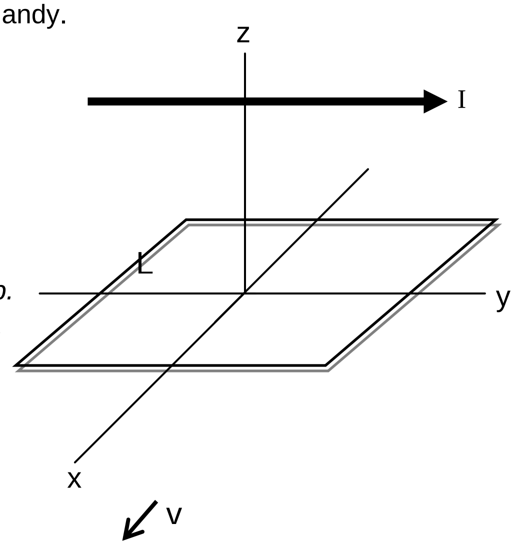
Problems of the Week 8

Always show your work to receive credit (NO WORK=NO CREDIT)

1. A long wire carrying current I=5.0A is parallel to the y-axis at a distance L=0.15m above the xy plane. In the xy-plane there is a square loop of wire of 150 turns and side L with two of its sides parallel to the long wire. The loop of wire is moving in the positive x-direction with constant speed v=20.0m/s. Assuming the resistance of the square loop is 0.250Ω, calculate the induced current in the loop when its center crosses the y-axis. Hint 1: The fundamental theorem for the integral of a derivative might come in handy.



A. 9.6mA
B. 24.0mA
C. 32.0mA
D. 48.0mA
E. 54.0mA

Hint 2: Another Method-Consider a charge in the loop. Since $\vec{F} = q\vec{v} \times \vec{B}$, *the work done each the charge around the loop is* $\vec{F} = \oint \left(q\vec{v} \times \vec{B}\right) \bullet d\vec{s}$ *. But W/q=ΔV, so* $\Delta V = \oint \left(\vec{v} \times \vec{B}\right) \bullet d\vec{s}$ *.*

Hint 3: Another Method-Notice that the change in flux for the area of the loop lying in the region 0≤x≤L/2 is the same as the change in flux for part of the loop lying in the region –L/2≤x≤0, since the z-component of the magnetic field for x<0 is opposite to that for x>0. Moreover, since B changes direction from x<0 to x>0 you must break up the expression for the flux into two integrals.

2. A common method to heat conductors is to place them in a time varying B-field. The changing flux produces eddy currents that heat the conductor. This technique is called induction heating. This method allows one to boil a pot of water, heat treat metals (at high frequencies) or melt large amounts of metals without contaminating them with combustion gases. Furthermore, it is possible to heat conductors in a vacuum. Consider a thin 1.0m long graphite tube of resistivity $\rho=3.5\times10^{-5}$ ohm-meter having a radius of 6.00cm and thickness t=50.0μm that is placed inside a long solenoid having N=5000 turns per meter. The current in the solenoid is I=25.0cos(377t)A (60Hz AC current). Calculate the average power dissipated in the tube. Note-the current flows along the circumference of the tube not its length! Assume the tube is sufficiently thin that the current in the conductor is independent of r within the wall of the tube.

A. 236mW
B. 527mW
C. 849mW
D. 1530mW
E. 2270mW

If this were a solid cylinder the current would vary with r. Thus we would need to write the proper expression for the average power as a function of r. This would involve an integral.