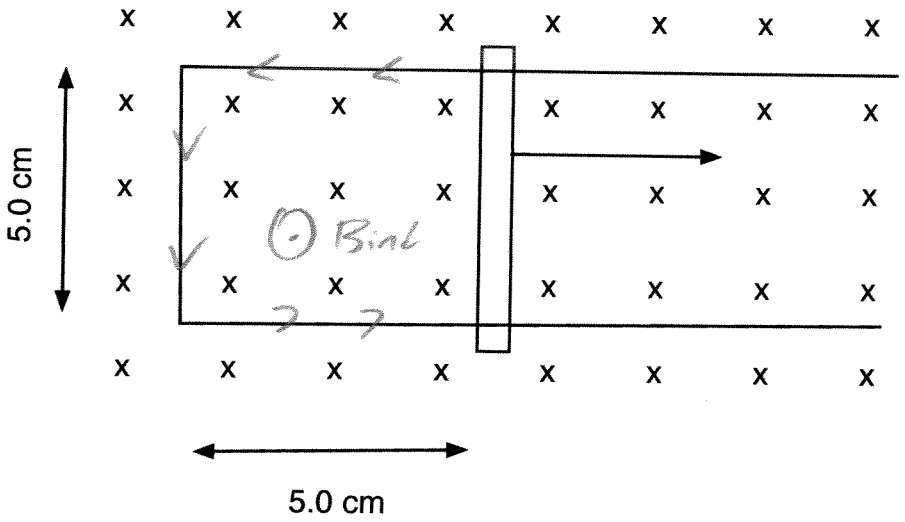
Physics 10164 - Exam 3B

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (30 pts) A U-shaped wire is immersed in a uniform external magnetic field of 3.3 Tesla as shown below. A rod is free to slide along the U-shaped wire, connecting the two sides of the U to form a complete circuit. The rod moves right by 3.0 cm from its initial position in a time 0.14 seconds.

Determine the magnitude and direction of the current in the rod if the loop has a resistance of 0.47 Ohms.



$\mathcal{E}_{ind} = B\ell v \qquad v = \frac{.03\,m}{.14\,s} = 0.2143\ m/s$

$= (3.3)(.05)(.2143) = .035\ V$

$I_{ind} = \mathcal{E}_{ind}/R = .075\ A$

or $\mathcal{E}_{ind} = \frac{\Delta \Phi_B}{\Delta t} = \frac{B\Delta A \cos\theta}{\Delta t} = \frac{(3.3)(.05)(.03)(1)}{.14}$

$= .035\ V$

$\Delta \Phi_B = (\times)$, increasing

$B_{ind} = \odot$, so I_{ind} is ccw

2. (30 pts) An AC source operates at a frequency of 60.0 Hz with an rms voltage of 120 Volts. It is connected in series with a 72 Ohm resistor and an inductor of unknown inductance. The rms current is measured to be 0.54 Amps.

a) What is the value of the inductance?

b) What is the maximum value of the voltage drop across the resistor?

c) What is the maximum value of the voltage drop across the inductor?

d) When the current is equal to zero in the circuit, what is the voltage drop across the resistor, the inductor and the power source? Briefly explain and/or mathematically justify each of your three answers!

a) $I_{rms} = \frac{\mathcal{E}_{rms}}{Z} \Rightarrow 0.54 = \frac{120}{Z} \Rightarrow Z = 222\ \Omega$

$Z^2 = R^2 + X_L^2$ $\Rightarrow$ $X_L = 210\ \Omega$

$222^2 = 72^2 + X_L^2$ $\Rightarrow$ $210 = 2\pi(60)L$

$L = 0.56\ H$

b) $I_{max} = \sqrt{2}\, I_{rms} = 0.764\ A$

$\Delta V_{R,MAX} = I_{max} R =$ 55 Volts

c) $\Delta V_{L,MAX} = I_{max} X_L =$ 160 Volts

d) When $I = 0$, $\frac{\Delta I}{\Delta t}$ is max

ΔV_R is in phase with I, so $\Delta V_R = 0$

ΔV_L is max since $\frac{\Delta I}{\Delta t}$ largest, $\Delta V_L = 160\ V$

Loop rule $\Delta V_\mathcal{E} = \Delta V_R + \Delta V_L =$ 160 V

3. (20 pts) A flat coil enclosing an area of 140 cm^2 is rotating at a rate of 45 rev/sec with its axis of rotation perpendicular to a 0.81 Tesla magnetic field. The coil contains 750 turns. Given the generator equation that the EMF as a function of time is NBAw sin (wt)...

a) What is the maximum voltage induced in the coil?

b) Is the area vector of the coil ~~parallel~~ perpendicular to the external field or parallel to the external field when this maximum voltage occurs? Explain your answer.

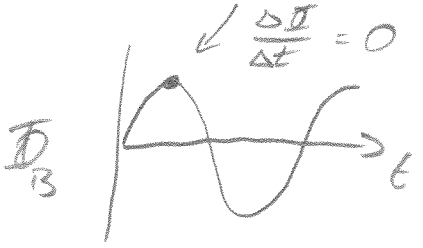
a) $A = 140 \times 10^{-4}\ m^2$

$\omega = 45 \frac{rev}{sec} \cdot \frac{2\pi rad}{rev} = 283\ rad/s$

$\mathcal{E}_{max} = NBA\omega = (750)(.81)(140 \times 10^{-4})(283)$

$= \boxed{2400\ Volts}$

b) When $\vec{A}$ is parallel to $\vec{B}$, Φ_B is at a maximum and not changing quickly.



When $\vec{A} \perp \vec{B}$, $\Phi_B = 0$ and $\frac{\Delta\Phi_B}{\Delta t}$ is large

So $\mathcal{E}_{ind}$ is maximized when $\boxed{\vec{A} \perp \vec{B}}$ or plane of loop is parallel to $\vec{B}$

4. (20 pts) A step-down transformer is used to connect a smart phone to a 120 Volt (rms) household circuit. The smart phone uses a current of 0.40 Amps and receives 1.6 Watts of power from the transformer.

a) If the secondary coil of the transformer has 15 turns, how many turns are in the primary coil?

b) What is the current supplied from the household circuit as input into the transformer?

a) $I_s \Delta V_s = 1.6 \text{ Watts}$

$\Delta V_s = \frac{1.6}{.40} = 4.0 \text{ Volts}$

$\frac{\Delta V_p}{\Delta V_s} = \frac{N_p}{N_s}$

$\frac{120}{4} = \frac{N_p}{15} \Rightarrow N_p = 450 \text{ turns}$

b) $I_p \Delta V_p = I_s \Delta V_s = 1.6 \text{ Watts}$

$I_p (120) = 1.6$

$I_p = .013 A$