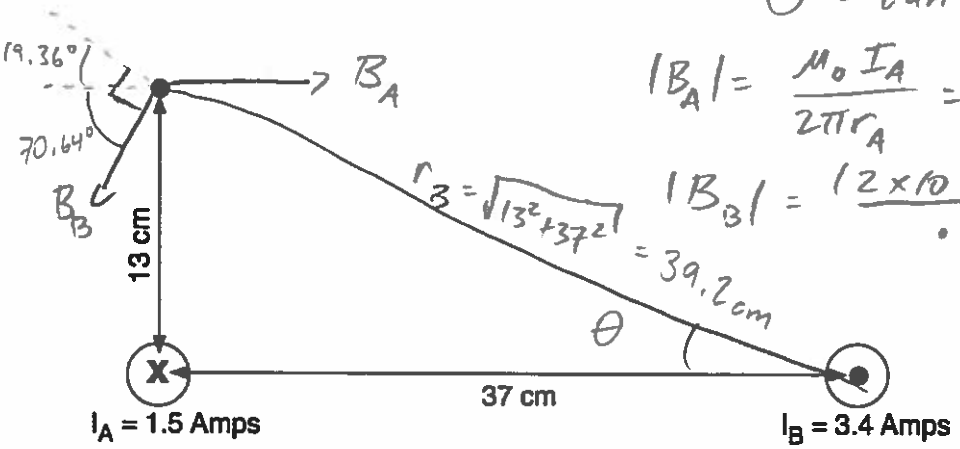
Physics 10164 – Exam 2A

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. (35 pts) Wire A is located at the origin and carries a current of 1.5 Amps into the page. Wire B is located at coordinate x = 37 cm and carries a current of 3.4 Amps out of the page. Find the magnitude and direction of the total magnetic field due to these two wires at y = 13 cm.

$$\theta = \tan^{-1}\left(\frac{13}{37}\right) = 19.36^\circ$$



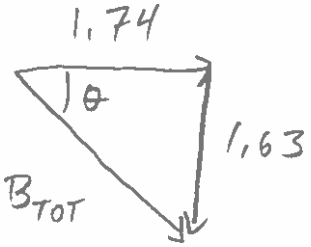
$$|B_A| = \frac{\mu_0 I_A}{2\pi r_A} = \frac{(2\times10^{-7})(1.5)}{.13} = 2.3\,\mu T$$

$$|B_B| = \frac{(2\times10^{-7})(3.4)}{.392} = 1.73\,\mu T$$

$B_{A,x} = 2.31$ $\quad B_{A,y} = 0$

$B_{B,x} = -1.73\cos 70.64^\circ = -0.57$ $\quad B_{B,y} = -1.73\sin 70.64^\circ = -1.63$

$B_{TOT,x} = 1.74$ $\quad B_{TOT,y} = -1.63$

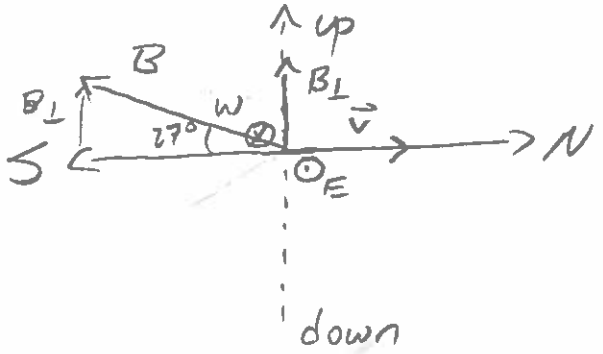


$$B_{TOT} = \sqrt{1.74^2+1.63^2} = \boxed{2.4\,\mu T}$$

$$\theta = \tan^{-1}\left(\frac{1.63}{1.73}\right) = \boxed{43^\circ \text{ below } +x}$$

2. (35 pts) A 1.2-meter long thin conducting rod oriented East-West moves North with a speed of 7500 m/s through a 4.5 μT magnetic field that points 27° vertically above due South.

a) What is the magnitude of the induced EMF in the rod?
b) Which end of the rod is positive, East or West?
c) If current flows through the rod in the direction that positive charges are forced, what is the magnitude and direction of the magnetic force on the rod?



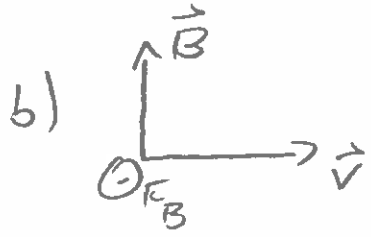
a) $\mathcal{E}_{ind} = B_\perp \ell v$

$B_\perp = (4.5)\sin 27° = 2.043\ \mu T$

$\mathcal{E} = (2.043 \times 10^{-6})(1.2)(7500)$

$= \boxed{0.018 \text{ Volts}}$

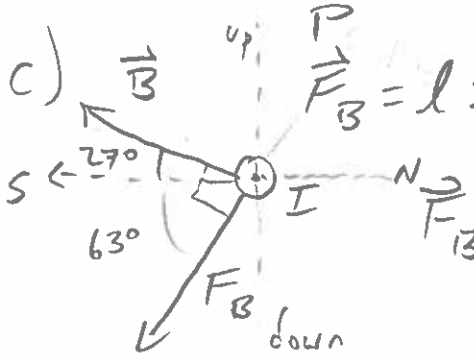
b)



$\vec{F}_B = q\vec{v} \times \vec{B}$ (p, t, f)

F_B points $\boxed{\text{East}}$

c)



$\vec{F}_B = \ell \vec{I} \times \vec{B}$ (p, t, f)

$\vec{F}_B$ points $\boxed{\text{vertically } 63° \text{ below South}}$

$|F_B| = (1.2)(I)(4.5 \times 10^{-6})$

I not given in problem (oops!)
nor is resistance in rod.

#3. (30 pts) A generator delivers an EMF of $\varepsilon(t) = 140 \sin(68\pi t)$ to a circuit containing an inductor and resistor in series. The power dissipated by the 8.0 Ω resistor is 450 Watts.

a) What is the inductance (L) of the inductor?
b) At the instant when the current is equal to zero, what is the magnitude of the voltage drop across (i) the resistor, (ii) the inductor and (iii) the generator? Explain each answer briefly.

a) $2\pi f t = 68\pi t \Rightarrow f = 34\ Hz$

$P_{diss} = I_{rms}^2 R$

$450 = I_{rms}^2 (8) \Rightarrow I_{rms} = 7.5\ A$

$I_{rms} = \frac{\varepsilon_{rms}}{Z} \qquad \varepsilon_{rms} = \frac{\varepsilon_{max}}{\sqrt{2}} = \frac{140}{\sqrt{2}} = 99\ V$

$Z = \frac{\varepsilon_{rms}}{I_{rms}} = \frac{99}{7.5} = 13.2\ \Omega$

$Z = \sqrt{R^2 + X_L^2}$

$13.2^2 = 8^2 + X_L^2$

$110.2 = X_L^2 \Rightarrow$

$X_L = 10.5\ \Omega$

$2\pi f L = 10.5\ \Omega$

$L = \frac{10.5}{2\pi(34)} = \boxed{.049\ H}$

b) $I_{max} = \frac{\varepsilon_{max}}{Z} = \frac{140}{13.2} = 10.61\ A$

$\Delta V_{R,MAX} = I_{max} R = 84.85\ V$

$\Delta V_{L,MAX} = I_{max} X_L = 111.4\ V$

When $I = 0$, $\boxed{\Delta V_R = 0}$ since $\Delta V_R = IR$ in phase with I

$\boxed{\Delta V_L = 110V}$ since $\Delta V_L \propto \frac{\Delta I}{\Delta t}$, which is largest at $I = 0$

$\boxed{\Delta V_\varepsilon = 110V}$ due to loop rule