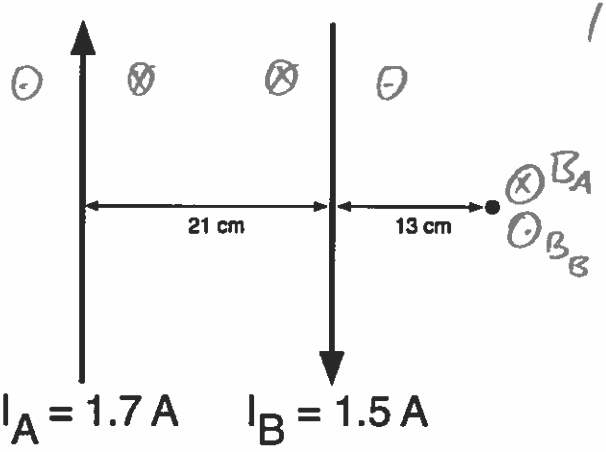
Physics 10164 – Exam 2B

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) Wires A and B are in the plane of the page, separated by 21 cm. Wire A carries a current of 1.7 A toward the top of the page (North), and wire B carries a current of 1.5 A toward the bottom of the page (South).

a) What is the magnitude and direction of the magnetic field at point P, which is 13 cm to the East of wire B?

b) If a singly-charged positive ion is moving through point P in the plane of the page in a direction 35° South of East with a speed of 3.0×10^5 m/s, what is the magnitude and direction of the magnetic force acting on that ion?

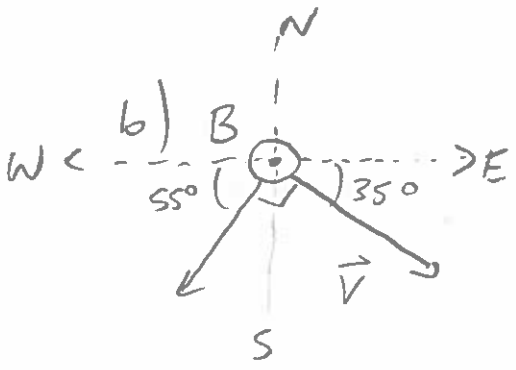


$$|B_A| = \frac{\mu_0 I_A}{2\pi r_A} = \frac{(2\times10^{-7})(1.7)}{.34} = 1.0\ \mu T$$

$$|B_B| = \frac{(2\times10^{-7})(1.5)}{.13} = 2.31\ \mu T$$

a) $B_{TOT} = +2.31\ \mu T - 1.00\ \mu T = \boxed{1.31\ \mu T,\ \odot}$

b)



$$\vec{F}_B = q\vec{v}\times\vec{B}$$

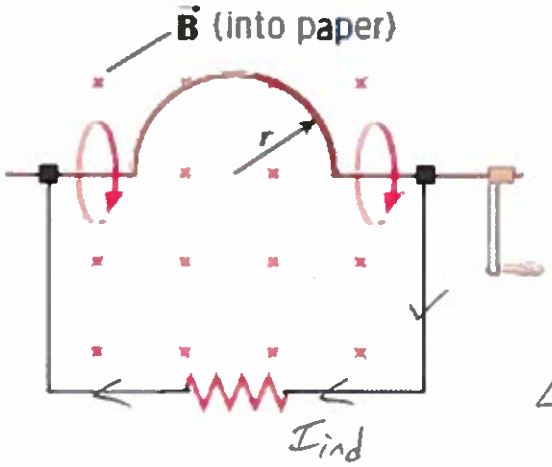
$$|F_B| = (1.60\times10^{-19})(3.0\times10^5)(1.31\times10^{-6})\sin 90°$$

$$= \boxed{6.3\times10^{-20}\ N}$$

$$\text{Dir: } \boxed{55°\text{ South of West}}$$

2. (35 pts) The dimensions of the single-turn rectangular loop below are 7.0 cm x 12 cm. The semi-circular section has a radius r = 3.0 cm. The external magnetic field in which the loop is immersed has a magnitude of 0.84 T and is directed into the page, perpendicular to the plane of the loop.

The semi-circular piece of the loop rotates half a revolution in 0.15 seconds, initially coming out of the page. Only the semi-circular piece is rotating, not the entire loop. What is the magnitude and direction of the resulting induced current in the 0.050 Ω resistor shown?



$$|\mathcal{E}_{ind}| = N\frac{\Delta\Phi_B}{\Delta t}$$

$$= \frac{N B \Delta A \cos\theta}{\Delta t}$$

$$\Delta A = \pi r^2 = .002827$$

$$|\mathcal{E}_{ind}| = \frac{(1)(0.84)(.002827)(1)}{.15}$$

$$= .016 \text{ Volts}$$

$$I_{ind} = \mathcal{E}_{ind}/R = \boxed{0.32 A}$$

Since $\Phi_B = \otimes$, decreasing

$B_{ind} = \otimes$

So I flows | clockwise, to the left through resistor

#3. (30 pts) A generator has an EMF of $\varepsilon(t) = 170 \sin(120\pi t)$ and is connected in series to a 0.13 Ω resistor, a 78 mH inductor and a 65 μF capacitor.

a) What is the maximum value of the current in this circuit?
b) What is the average power dissipated by the resistor?
c) At the resonant frequency of this circuit, what is X_C?
d) At the resonant frequency, what is X_L?
e) At the resonant frequency, what is the power dissipated by the resistor?

a) $2\pi f t = 120\pi t \Rightarrow f = 60\,Hz$

$R = 0.13$

$X_L = 2\pi(60)(.078) = 29.41\,\Omega$

$X_C = \frac{1}{2\pi(60)(65\times10^{-6})} = 40.81\,\Omega$

$Z = \sqrt{.13^2 + (11.40)^2} = 11.4\,\Omega$

$I_{max} = \varepsilon_{max}/Z = 170/11.4 = $ **15 A**

b) $I_{rms} = I_{max}/\sqrt{2} = 10.54$ $\quad P_{Avg} = (10.54)^2(.13)$

$= $ **14 Watts**

c) $f_0 = \frac{1}{2\pi\sqrt{(.078)(65\times10^{-6})}} = 70.683\,Hz$

$X_C = \frac{1}{2\pi(70.683)(65\times10^{-6})} = 34.64 \approx$ **35 Ω**

d) $X_L = 2\pi(70.683)(.078) = 34.64 \approx$ **35 Ω**

e) $I_{rms} = \varepsilon_{rms}/R$ since $Z = R$

$= 120/.13 = 923\,A$

$P_{diss} = (923)^2(.13)$

$= $ **110,000 Watts**