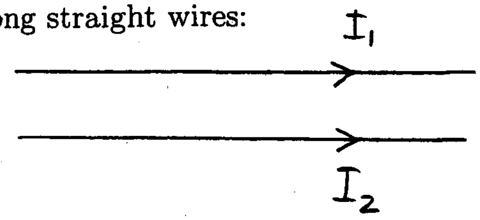
1) Some short questions:

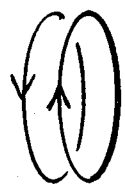
(*a*) For each of the following, state whether the magnetic force is attractive, repulsive or zero.

i) Long straight wires:



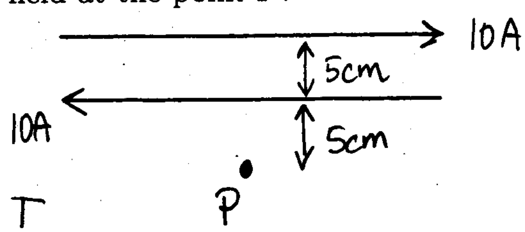
Answer: Attractive

ii) Two loops of wire:



Answer: Repulsize

(*b*) Find the magnitude and direction of the net magnetic field at the point P.



field from upper wire into page

" " lower " out of "

$$B_u = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi\times10^{-7})}{2\pi}\ \frac{10A}{0.10\,m} = 2.0\times10^{-5}\ T$$

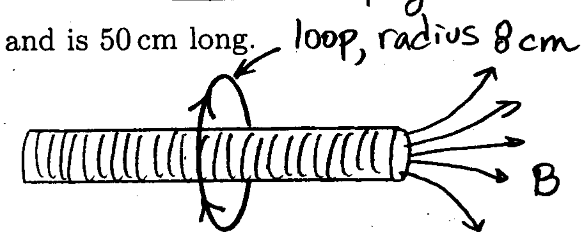
$$B_\ell = \frac{(4\pi\times10^{-7})}{2\pi}\ \frac{10A}{0.05m} = 4\times10^{-5}\ T$$

$$B_{TOT} = 4\times10^{-5}\ T - 2\times10^{-5}T$$

Magnitude: $2\times10^{-5}T$

Direction: out of page

(*c*) A solenoid with a radius of 5 cm has 2000 loops of wire and is 50 cm long.



i) Find the magnetic field inside the solenoid when the current is 10 A.

$$B = \mu_0 n I = \mu_0 \frac{2000}{0.5m}\cdot 10A$$

$$= 5.03\times10^{-2}\ T$$

Answer: $5.03\times10^{-2}\ T$

ii) Find the magnitude of the induced EMF in the loop of wire if the solenoid current goes from 0 to 10 A in 3 seconds. The field exists only inside the solenoid

so Φ = mag flux @ 10 A $= B\cdot A = (5.03\times10^{-2}T)(\pi)(0.05m)^2$

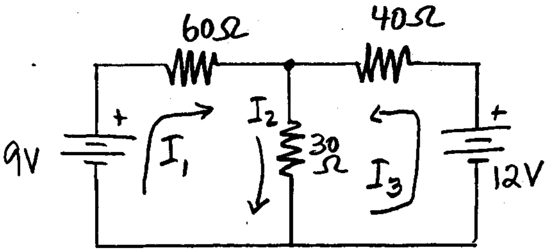
$= 3.95\times10^{-4}\ T\cdot m^2$

$$\mathcal{E} = N\frac{\Delta\Phi}{\Delta t} = (1)\frac{(3.95\times10^{-4})}{3s}$$

Answer: $1.32\times10^{-4}\ V$

iii) Show with an arrow in the drawing above the direction of the induced current in the loop. The induced current needs to produce a field to the left

2) In the circuit shown, the current I_1 is 0.05 A. Find I_2 and I_3.



1) Write the loop equation for the left-hand inner loop

$$9V - I_1 \cdot 60\Omega - I_2 \cdot 30\Omega = 0$$

$$I_2 \cdot 30\Omega = 9V - I_1 \cdot 60\Omega = 9V - (0.05A)(60\Omega) = 6V$$

$$I_2 = 6V / 30\Omega = 0.20\ A$$

2) Use the junction rule

$$I_1 + I_3 = I_2$$

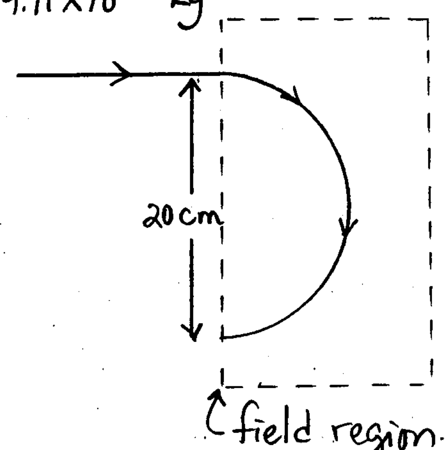
$$I_3 = I_2 - I_1 = 0.20A - 0.05A$$

I_2: 0.20 A

I_3: 0.15 A

3) An electron moving at a speed of 6×10^5 m/s enters a region of space in which there is a uniform and constant magnetic field. The electron follows a circular path as shown in the drawing. Find the magnitude and direction of the magnetic field that produces this motion.

$q = -1.6 \times 10^{-19} C$
$m = 9.11 \times 10^{-31} kg$



The radius of curvature in a uniform field is $r = \frac{mv}{qB}$ so

$$B = \frac{mv}{q \cdot r} = \frac{(9.11 \times 10^{-31} kg)(6 \times 10^5 m/s)}{(1.6 \times 10^{-19} C)(0.1 m)}$$

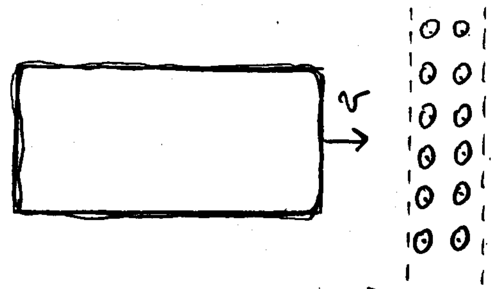
$$= 3.42 \times 10^{-5} T$$

Remember that q is negative. By the usual right hand rule B into the page gives $v \times B$ upward $\Rightarrow$ $F = q v \times B$ downward as needed

Magnitude: $3.42 \times 10^{-5} T$

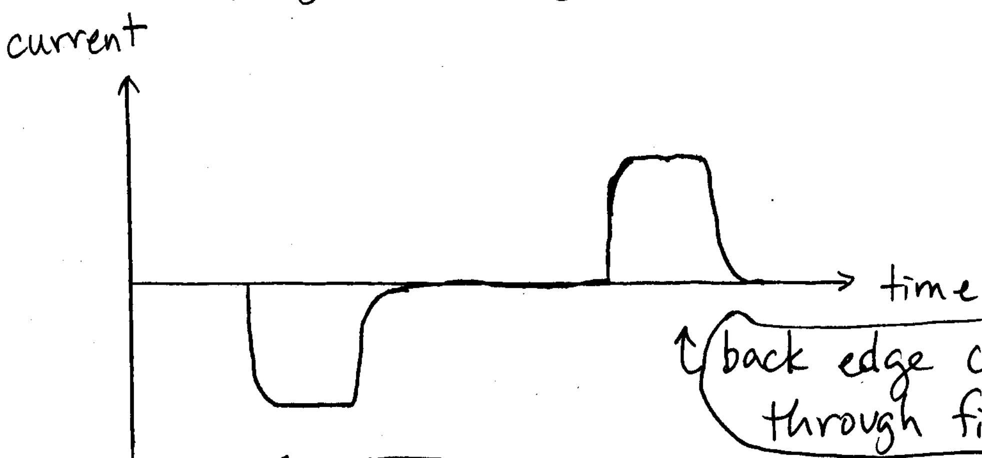
Direction: Into page

4) A rectangular coil consists of 50 loops of wire, each 80 cm wide by 30 cm high. The coil has a total resistance of 10 Ω, and moves to the right at a speed of 5 m/s across a region of space in which there is a uniform magnetic field, $B = 0.75\,\mathrm{T}$. The field is confined to an area that is just 20 cm across.



(a) Make a sketch showing the current in the wire as a function of time as the coil moves across the field region from the left side to the right side. Graph counterclockwise currents as positive numbers and clockwise currents as negative. The graph should be neat and accurate.

EMF generated only as flux is changing $\vec{B}$ out of page



back edge cutting through field

front edge of coil cutting through the field ⇒ Φ increasing

Induced current makes B into page ⇒ clockwise

(b) How large is the current at it's maximum?

1) By Faraday's Law.

Maximum $\Phi = B \cdot A = (0.75\mathrm{T}) \cdot \underset{\text{high}}{(0.3\mathrm{m})} \cdot \underset{\text{across}}{(0.2\mathrm{m})} = 0.045\ \mathrm{T \cdot m^2}$

Δt = time for front edge to cross field region

$\Delta t = 0.2\,\mathrm{m} / 5.0\,\mathrm{m/s} = 0.04\,\mathrm{s}$

$\mathcal{E} = 50\,\dfrac{0.045\,\mathrm{T \cdot m^2}}{0.04\,\mathrm{s}} = 56.25\ \mathrm{V}$

2) By Motional EMF

$\mathcal{E} = vBl = (5\,\mathrm{m/s}) \cdot (0.75\mathrm{T})(0.3\mathrm{m}) = 1.125\mathrm{V}$

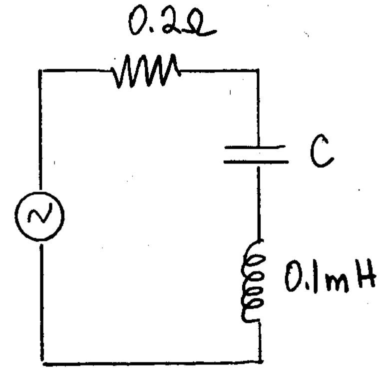
We get this much EMF from each loop ⇒

$\mathcal{E}_{TOT} = 50 \times 1.125\mathrm{V} = 56.25\mathrm{V}$

$I = \mathcal{E}/R$

$\boxed{5.625\ \mathrm{A}}$

5) A series LRC circuit has a resistance of $0.2\,\Omega$ and an inductance of $0.1\,\mathrm{mH}$.



(a) What value of C is needed to tune the resonant frequency of the circuit to the frequency of an AM radio station that broadcasts at $f = 970\,\mathrm{kHz}$?

The resonance condition is $X_L = X_C \Rightarrow$

$$2\pi f = \frac{1}{\sqrt{LC}} \qquad \frac{1}{LC} = (2\pi f)^2$$

$$C = 1/L\cdot(2\pi f)^2 = 1/[10^{-4}\text{H}\,(2\pi)^2(970\times10^3)^2]$$

$$= 2.69\times10^{-10}\,\text{F}$$

$$\boxed{2.69\times10^{-10}\,\text{F}}$$

(b) Suppose this circuit is driven at the resonant frequency by a weak sinusoidal voltage $v_{\text{RMS}} = 10^{-5}\,\text{V}$. Find the resulting RMS current in the circuit.

On Resonance $X_L = X_C$ so $Z = [R^2 + (X_L - X_C)^2]^{\frac{1}{2}} = R$

$$V = IR \rightarrow V_{RMS} = I_{RMS}\cdot Z$$

$$I_{RMS} = 10^{-5}\,\text{V} / 0.2\,\Omega$$

$$\boxed{5\times10^{-5}\,\text{A}}$$

(c) Use $\Delta V_L = IX_L$ to find the RMS voltage across the inductor.

$$X_L = 2\pi f\cdot L = 2\pi\,(970\times10^3\,\text{Hz})(10^{-4}\,\text{H}) = 609.5\,\Omega$$

$$\Delta V = (5\times10^{-5}\,\text{A})(609.5\,\Omega)$$

$$\boxed{3.05\times10^{-2}\,\text{V}}$$