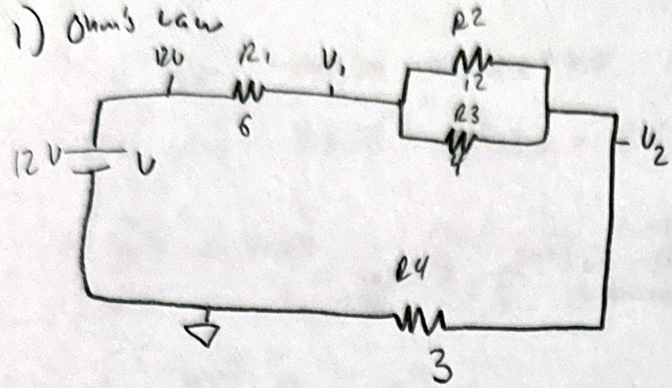
Phys 1502 Review 2

1) Ohm's Law



$V = IR$

$R_{eq} = 6 + 3 + \left(\frac{1}{12} + \frac{1}{4}\right)^{-1} = 12\,\Omega$

$12\,V = I \cdot 12\,\Omega$

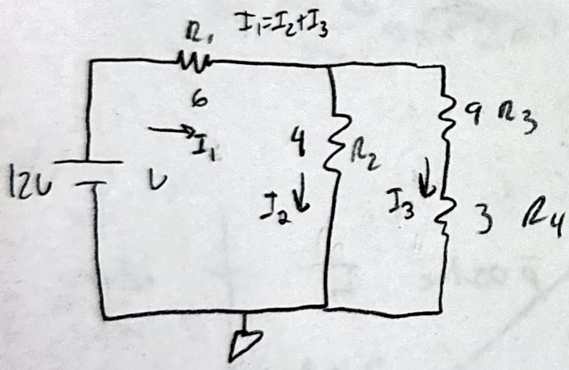
$I = 1A$

$V_1: \; 12V - 6 \cdot 1 = 6V$

$V_2: \; 6V - 1 \cdot \underbrace{\left(\frac{1}{4} + \frac{1}{12}\right)^{-1}}_{3\Omega} = 3V$

$V_3(g): \; 3V - 3 \cdot 1 = 0V$

2) Kirchoff's Law



$I_1 = I_2 + I_3$

Loop 12

$12 = 6I_1 + 4I_2$

$12 = 6(I_2 + I_3) + 4I_2$

$12 = 6I_2 + 6I_3 + 4I_2$

$12 = 10I_2 + 6I_3$

Loop 134

$12 = 6I_1 + 12I_3$

$12 = 6(I_2 + I_3) + 12I_3$

$12 = 6I_2 + 6I_3 + 12I_3$

$12 = 6I_2 + 18I_3$

$12 = 10I_2 + 6I_3$

This should be (-)

$10I_2 = 12 + 6I_3$

$I_2 = 1.2 + .6I_3$

$12 = 6(1.2 + .6I_3) + 18I_3$

$12 = 7.2 + 3.6I_3 + 18I_3$

$12 = 7.2 + 21.6I_3$

$4.8 = 21.6I_3$

$\frac{2}{9} = I_3$

$I_2 = 1.2 + .6I_3$

$I_2 = 1.2 + .6\left(\frac{2}{9}\right)$

$I_2 = 4/3$

$I_1 = I_2 + I_3$

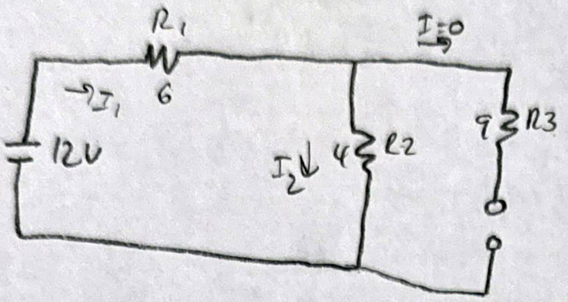
$I_1 = \frac{2}{9} + \frac{12}{9}$

$I_1 = 14/9$

3) RC Circuits

a) Same process as last question can use voltage or current law

b)



No voltage drop

4) Magnetic Force

Strategy

We want gravitational force to equal magnetic force

Solution

$$mg = I\ell B$$

$$I = \frac{mg}{\ell B} = \frac{(0.01kg)(9.8m/s^2)}{(0.5m)(0.5T)} = .39A$$

RHR → magnetic force points up, so positive I

5) Forces on a current loop

Strategy

Dipole moment equals current time area of loop

Torque on the loop and PE are calculated from magnetic moment, magnetic field + angle in field

a) moment $\mu = IA = (2E-3)(\pi(.02)^2) = 2.5E-6\ Am^2$

b) $\tau = |\vec{\mu} \times \vec{B}| = \mu B \sin\theta = (2.5E-6)(.5)\sin 30 = 6.3E-7\ Nm$

c) $U = -\vec{\mu} \cdot \vec{B} = -\mu B\cos\theta = -(2.5E-6)(.5)\cos(30) = -1.1E-6\ J$

b) Amperes Law

For any circular path of radius r centered on the wire

$$\oint \vec{B} \cdot d\vec{l} = \oint B\,dl = B\oint dl = B(2\pi r)$$

Current enclosed in the wire ($r \leq a$), current density (J) inside the path equals the current density of the whole wire ($I_0/\pi a^2$)

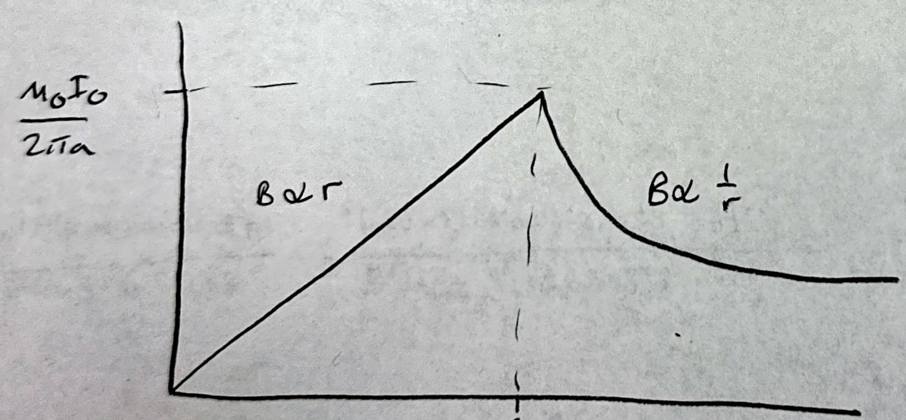
$$I = \frac{\pi r^2}{\pi a^2} I_0 = \frac{r^2}{a^2} I_0$$ since J is constant

$$B(2\pi r) = \mu_0 \left(\frac{r^2}{a^2}\right) I_0$$

magnetic field $\Rightarrow$ $B = \frac{\mu_0 I_0}{2\pi} \cdot \frac{r}{a^2}$ $(r \leq a)$

Outside the wire, it is equivalent to infinitely thin wire

$B = \frac{\mu_0 I_0}{2\pi r}$ $(r \geq a)$



6) Biot - Savart Law

strategy

Use the Biot-Savart Law $\vec{B} = \frac{\mu_0}{4\pi} \int_{wire} \frac{I d\vec{l} \times \hat{r}}{r^2}$

Since the current segment is a small part of an infinite wire, we can drop the integral and $dl \to \Delta l$

Solution

trig

$\Delta \vec{l} \times \hat{r} = \Delta l r \sin\theta$ $\theta = \tan^{-1}\left(\frac{1m}{.01m}\right) = 89.40$

Biot Savart Law

$B = \frac{\mu_0}{4\pi} \frac{I \Delta l \sin\theta}{r^2} = (1E-7\, Tm/A)\left(\frac{2A(0.01m)\sin(89.4°)}{(1m)^2}\right) = 2E-9T$

RHR $\to$ directed into page

7) Magnetic Fields of Current carrying loops

strategy

Use Biot - Savart Law $\to$ since current is flowing in opposite directions, they cancel

Solution

$B = \frac{\mu_0 I R_1^2}{2(y_1^2 + R_1^2)^{3/2}} - \frac{\mu_0 I R_2^2}{2(y_2^2 + R_2^2)^{3/2}} = \frac{(4\pi E-7\, Tm/A)(0.01A)(0.5m)^2}{2((0.25m)^2 + (0.5m)^2)^{3/2}} - \frac{(4\pi E-7\, Tm/A)(0.01A)(1m)^2}{2((0.75m)^2 + (1m)^2)^{3/2}}$

$B = 5.77E-9\,T$ to the right

To get the equation for B:

$dB = \frac{\mu_0}{4\pi} \cdot \frac{I dl \overbrace{\sin\pi/2}^{\text{from } d\vec{l}\times\hat{r}}}{r^2} = \frac{\mu_0}{4\pi} \frac{I dl}{y^2 + R^2}$

dB' from $Id\vec{l}'$ which opposes $Id\vec{l}$ y axis cancels

$\vec{B} = \hat{j} \int_{loop} dB \cos\theta = \hat{j} \frac{\mu_0 I}{4\pi} \int_{loop} \frac{\cos\theta \, dl}{y^2 + R^2}$

Since $\cos\theta = \frac{R}{\sqrt{y^2 + R^2}} \to \vec{B} = \hat{j} \frac{\mu_0 I R}{4\pi (y^2 + R^2)^{3/2}} \int dl = \frac{\mu_0 I R^2}{2(y^2 + R^2)^{3/2}} \hat{j}$

$\int_{loop} dl = 2\pi R$

$\vec{\mu} = IA\hat{n}$

$A = \pi R^2$

$B = \frac{\mu_0 \mu \hat{j}}{2\pi (y^2 + R^2)^{3/2}}$