1.

$^{12}C = 1$
$^{16}O = 2$

From question: $V_1 = V_2$; $q_1 = q_2 = -e$; $2(r_2) = 5m \rightarrow r_2 = 2.5m$

$$r = \frac{mV}{qB} \rightarrow r_1 = \frac{m_1 V_1}{q_1 B_1} \qquad r_2 = \frac{m_2 V_2}{q_2 B_2}$$

$$B_1 = B_2 = B$$

$$r_1 = \frac{m_1 V}{qB} \qquad r_2 = \frac{m_2 V}{qB}$$

$$\frac{r_1}{m_1} = \frac{V}{qB} \qquad \frac{r_2}{m_2} = \frac{V}{qB}$$

$$\frac{r_1}{m_1} = \frac{r_2}{m_2}$$

$m_1 = 12m_p \quad m_2 = 16m_p$

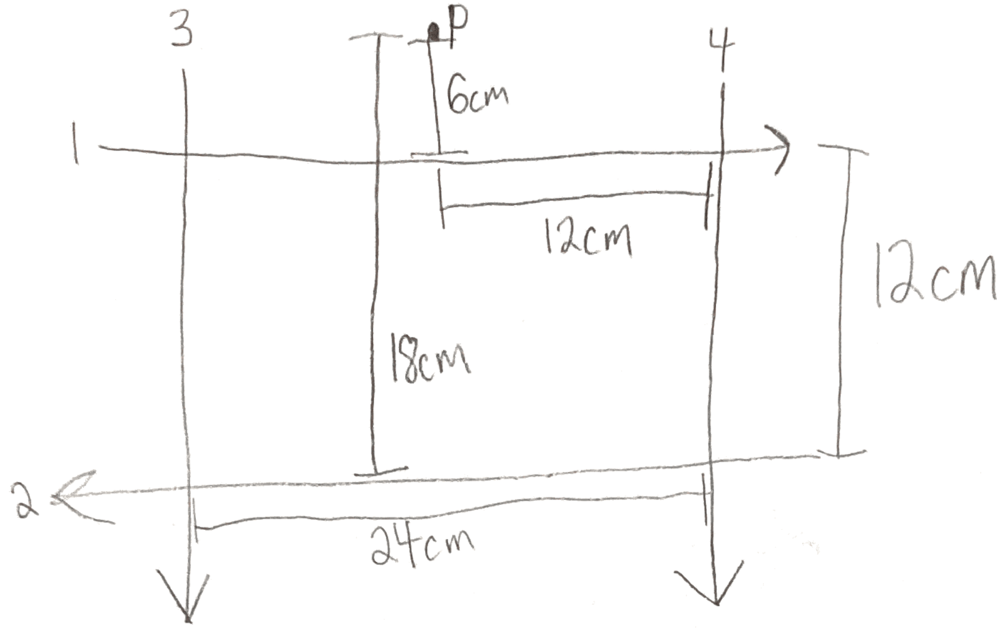
$$r_1 = \frac{m_1 r_2}{m_2} = \frac{(12m_p)(2.5m)}{(16m_p)} = \frac{(12)(2.5m)}{(16)}$$

$$r_1 = 1.875m$$

$$d = 2r_1 = 2(1.875m)$$

$$\boxed{d = 3.75m}$$

2.



Magnetic Field from a wire: $B_{wire} = \frac{\mu_0 I}{2\pi r}$

$I_1 = I_2 = I_3 = I_4 = I = 12A$

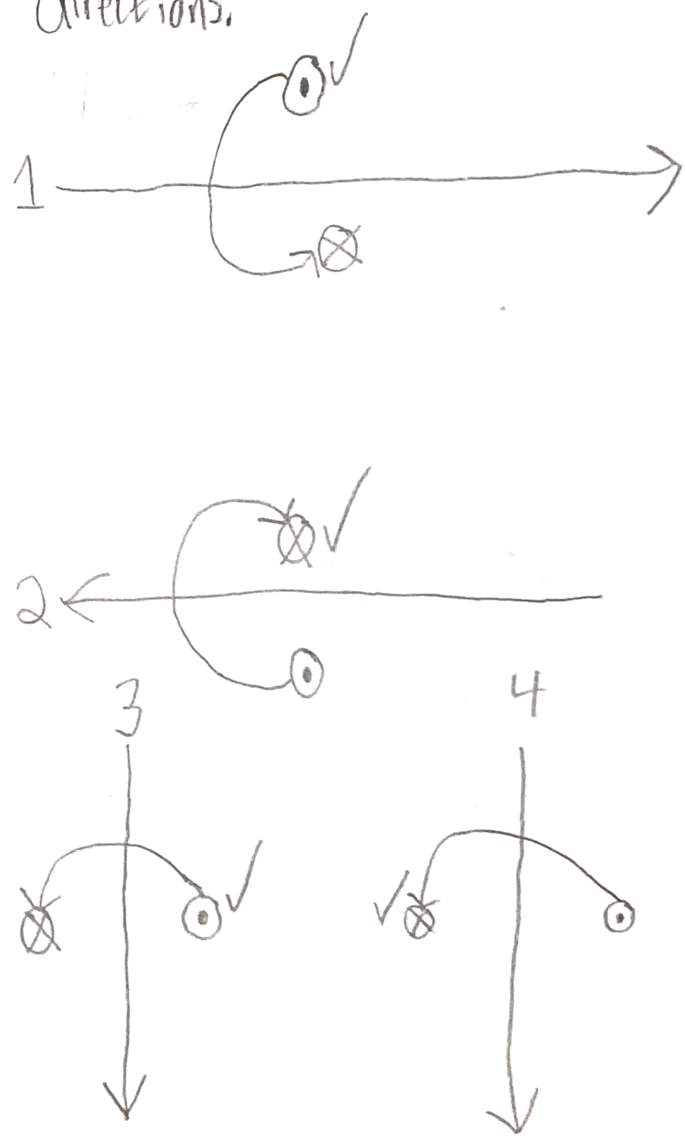
$$B_{net} = \frac{\mu_0 I}{2\pi r_1} - \frac{\mu_0 I}{2\pi r_2} + \frac{\mu_0 I}{2\pi r_3} - \frac{\mu_0 I}{2\pi r_4}$$

$$= \frac{\mu_0 I}{2\pi}\left(\frac{1}{r_1} - \frac{1}{r_2} + \frac{1}{r_3} - \frac{1}{r_4}\right)$$

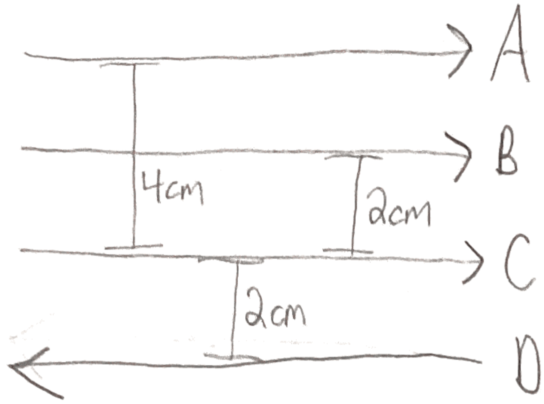
$$= \frac{(4\pi\times10^{-7})(12)}{2\pi}\left(\frac{1}{.06} - \frac{1}{.18} + \frac{1}{.12} - \frac{1}{.12}\right)$$

$$B_{net} = 2.7\times10^{-5}\,T$$

Use right-hand rule for directions:



3.



Force on a wire: $F_{B,wire} = ILB\sin\alpha$

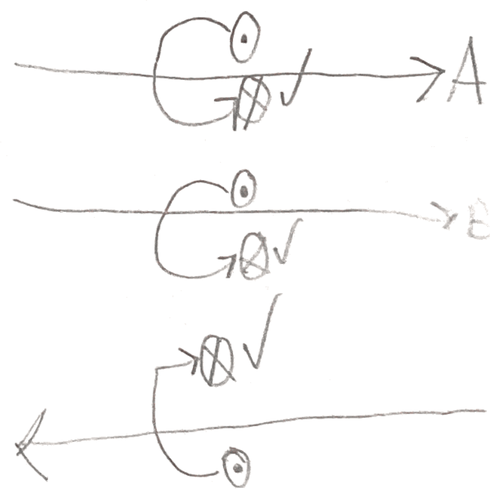
$$\frac{F}{L} = IB\sin\alpha$$

$$B = B_A + B_B + B_D$$

Magnetic field from a wire: $\frac{\mu_0 I}{2\pi r}$

$I_A = I_B = I_C = I_D = I = 12A$

Use right-hand rule for directions.



$$B = \frac{\mu_0 I}{2\pi r_A} + \frac{\mu_0 I}{2\pi r_B} + \frac{\mu_0 I}{2\pi r_C}$$

$$= \frac{\mu_0 I}{2\pi}\left(\frac{1}{.04} + \frac{1}{.02} + \frac{1}{.02}\right)$$

$$B = \frac{\mu_0 I}{2\pi}\left(\frac{5}{.04}\right)$$

$$\frac{F}{L} = IB\sin\alpha \qquad \alpha = 90^\circ$$

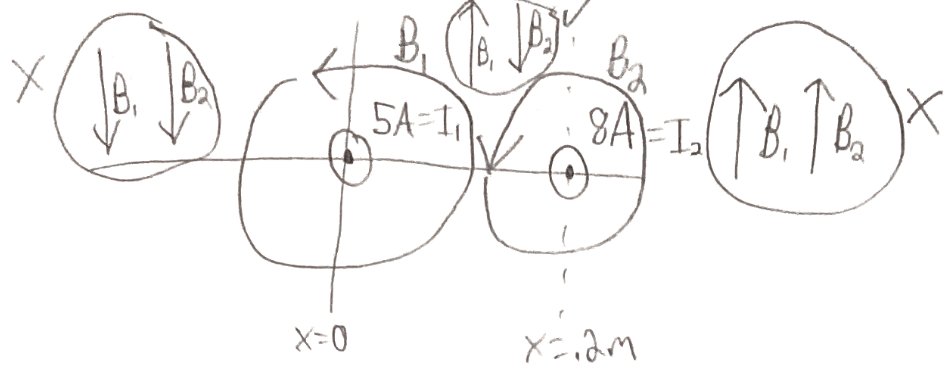
$$= I\left(\frac{\mu_0 I}{2\pi}\left(\frac{5}{.04}\right)\right)\sin(90^\circ)$$

$$= \frac{\mu_0 I^2}{2\pi}\left(\frac{5}{.04}\right)$$

$$= \frac{(4\pi\times10^{-7})(12)^2}{2\pi}\left(\frac{5}{.04}\right)$$

$$\boxed{\frac{F}{L} = 3.6\times10^{-3}\,N/m}$$

4.



Magnetic field from a wire: $B = \frac{\mu_0 I}{2\pi r}$

$$B_{net} = \frac{\mu_0 I_1}{2\pi r_1} - \frac{\mu_0 I_2}{2\pi r_2} = 0$$

$r_1 = x$

$r_2 = .2m - x$

$$\frac{\mu_0 I_1}{2\pi r_1} = \frac{\mu_0 I_2}{2\pi r_2}$$

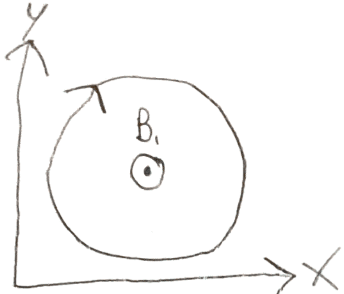
$$\frac{I_1}{r_1} = \frac{I_2}{r_2}$$

$$\frac{5}{x} = \frac{8}{.2 - x}$$

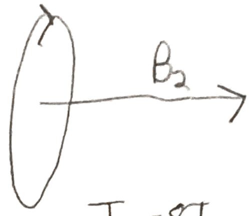
$$1 - 5x = 8x$$

$$\boxed{x = .077m}$$

5.



$I_1 = 3I$
$r_1 = R$



$I_2 = 8I$
$r_2 = 2R$

$$\vec{B}_{net} = \vec{B}_1 + \vec{B}_2$$

$$B_{net(x)} = B_{1(x)} + B_{2(x)} = 0 + \frac{\mu_0 I_2}{2\pi r_2} = \frac{\mu_0 (8I)}{2\pi(2R)}$$

$$B_{net(y)} = B_{1(y)} + B_{2(y)} = 0 + 0 = 0$$

$$B_{net(z)} = B_{1(z)} + B_{2(z)} = \frac{\mu_0 I_1}{2\pi r_1} + 0 = \frac{\mu_0 (3I)}{2\pi (R)}$$

$$B_{net} = \sqrt{B_{net(x)}^2 + B_{net(y)}^2 + B_{net(z)}^2}$$

$$= \sqrt{\left(\frac{8\mu_0 I}{4\pi R}\right)^2 + 0^2 + \left(\frac{3\mu_0 I}{2\pi R}\right)^2}$$

$$= \sqrt{\left(\frac{4\mu_0 I}{2\pi R}\right)^2 + 0^2 + \left(\frac{3\mu_0 I}{2\pi R}\right)^2}$$

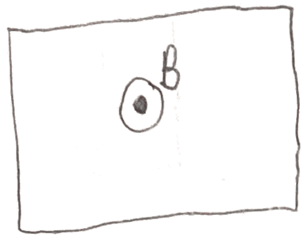
$$= \sqrt{\frac{16}{4}\left(\frac{\mu_0 I}{\pi R}\right)^2 + \frac{9}{4}\left(\frac{\mu_0 I}{\pi R}\right)^2}$$

$$= \sqrt{\frac{25}{4}\left(\frac{\mu_0 I}{\pi R}\right)^2}$$

$$\boxed{B_{net} = \frac{5\mu_0 I}{2\pi R}}$$

6.

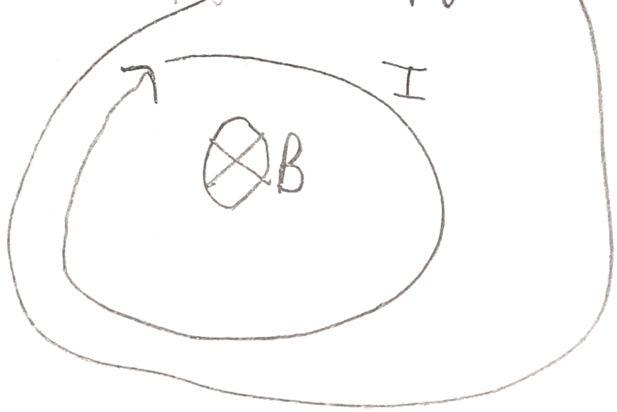
Magnetic field of any bar magnet:



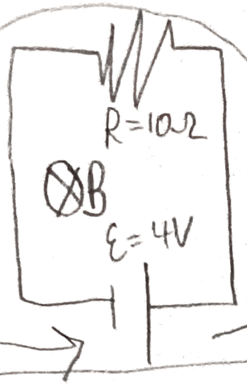
$$\mathcal{E} = -N\frac{\Delta\Phi}{\Delta t}$$

right-hand rule

1. What is Φ? → Out of the page
2. What is $\frac{\Delta\Phi}{\Delta t}$? → Increasing (more out of the page)
3. Add a negative sign (flip the direction) → into the page



7.



$I = .8A$

positive implies CCW

$V = IR = (.8)(10) = 8$

$V = \mathcal{E}_{battery} + \mathcal{E}_{mag} \rightarrow 8V = 4V + \mathcal{E}_{mag} \rightarrow \mathcal{E}_{mag} = 4V$

$$|\mathcal{E}_{magneticfield}| = N\frac{\Delta\Phi}{\Delta t} = N\frac{\Delta(BA\cos\theta)}{\Delta t}$$

$$= AN\cos\theta\left(\frac{\Delta B}{\Delta t}\right)$$

$A = (.12)^2 = .0144m^2$

$N = 1$

$\theta = 0°$

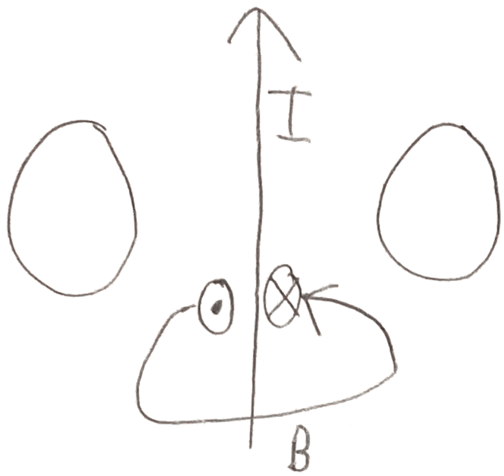
$$\frac{|\mathcal{E}_{mag}|}{AN\cos\theta} = \frac{\Delta B}{\Delta t}$$

$$\frac{(4V)}{(.0144)(1)\cos(0)} = 278 = \frac{\Delta B}{\Delta t}$$

Direction: Work backwards (right-hand rule)

1. What is Φ? → Into the page
2. What is $\frac{\Delta\Phi}{\Delta t}$? Increasing ← Into the page
3. Add negative sign (flip the direction) → Out of the page

8.



$$\mathcal{E} = -\frac{\Delta \Phi}{\Delta t}$$

Left loop:

1. What is Φ? → Out of page
2. What is $\frac{\Delta \Phi}{\Delta t}$? → Decreasing (more into page)
3. Add negative sign (flip direction) → out of page

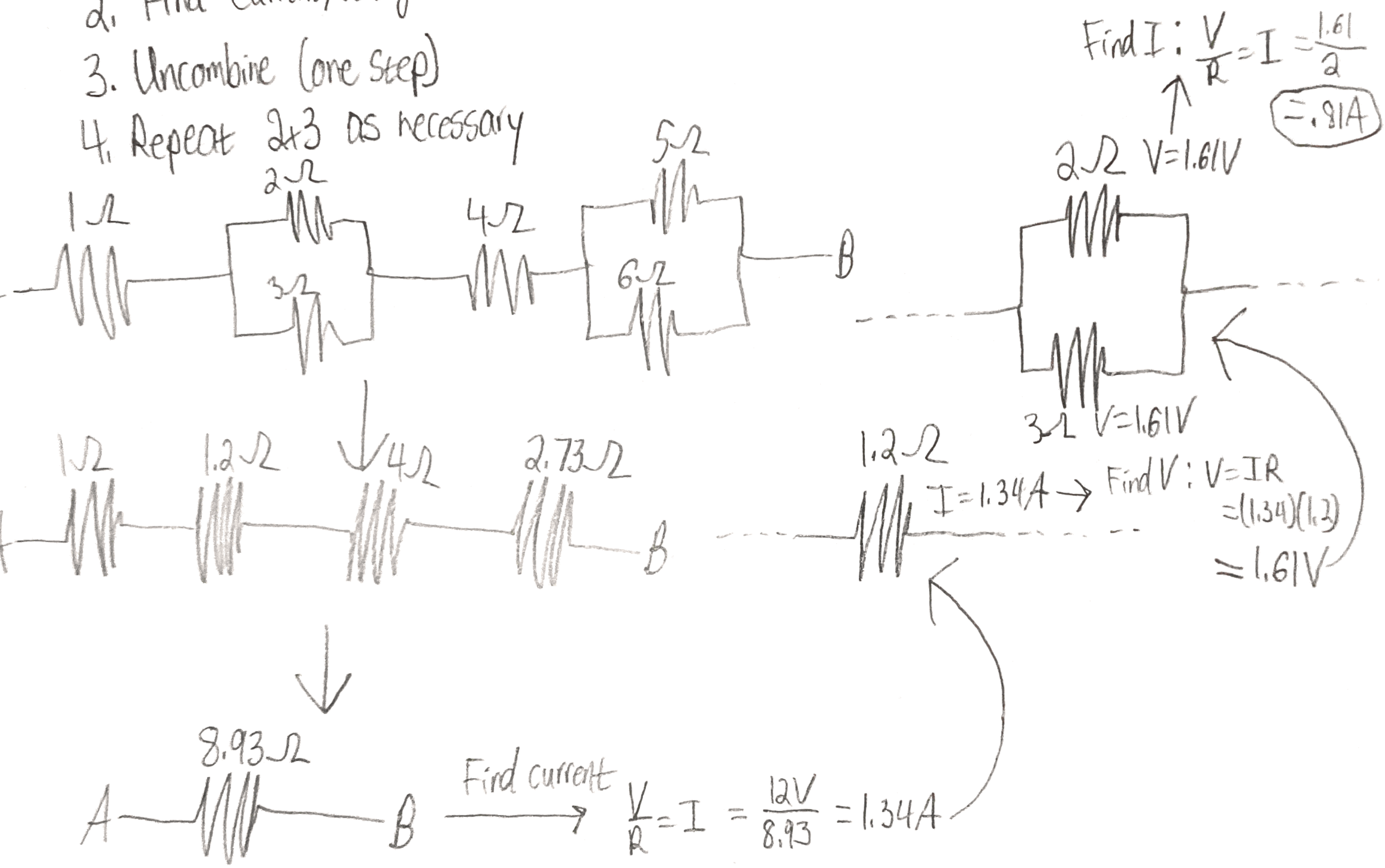
Right loop:

1. What is Φ → Into page
2. What is $\frac{\Delta \Phi}{\Delta t}$? → Decreasing (more out of page)
3. Add negative sign (flip direction) → into page

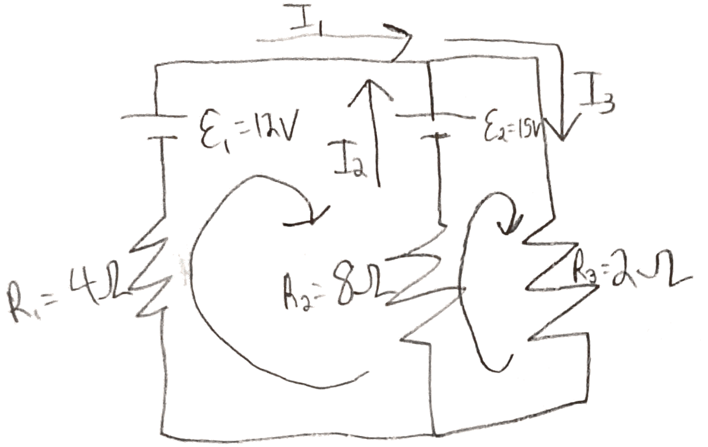
9.

	Resistors
Series	$R_{eq} = R_1 + R_2$; $I_1 = I_2 = I_{eq}$
Parallel	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$; $V_1 = V_2 = V_{eq}$

1. Combine (all steps)
2. Find current/voltage
3. Uncombine (one step)
4. Repeat 2+3 as necessary



10.



1. Assign Current Directions
2. Write down Kirchoff equations
3. Solve
4. Adjust Current Directions, if necessary

Kirchoff Junction Rule: $\Sigma I_{in} = \Sigma I_{out} \rightarrow I_1 + I_2 = I_3$

Kirchoff Loop Rule: Loop 1: $\mathcal{E}_1 - \mathcal{E}_2 + I_2 R_2 - I_1 R_1 = 0$

Loop 2: $\mathcal{E}_2 - I_3 R_3 - I_2 R_2 = 0$

$12V - 15V + 8I_2 - 4I_1 = 0$

$8I_2 - 4I_1 = 3$

$15 - 2I_3 - 8I_2 = 0 \rightarrow 15 = 2I_3 + 8I_2$

$15 = 2(I_1 + I_2) + 8I_2$

$8I_2 - 4I_1 = 3 \quad 15 = 2I_1 + 10I_2$

$4I_2 - \frac{3}{2} = 2I_1 \quad 15 - 10I_2 = 2I_1$

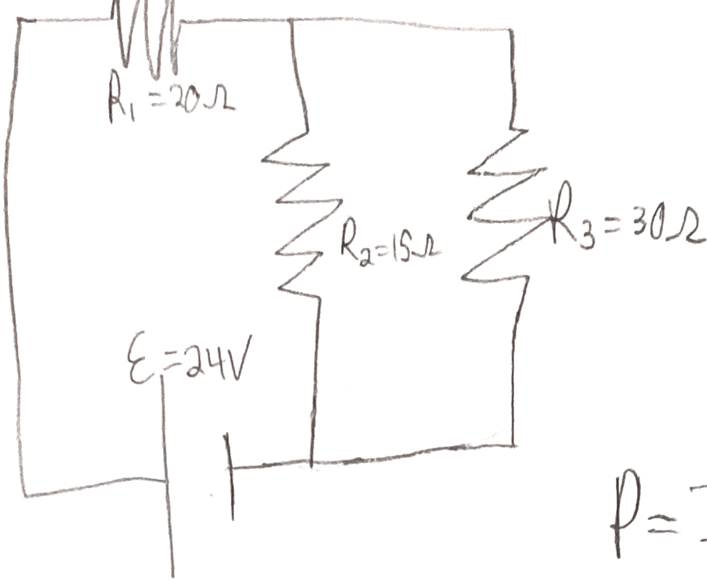
$4I_2 - 3/2 = 15 - 10I_2$

$14I_2 = \frac{33}{2}$

$I_2 = 1.18A$

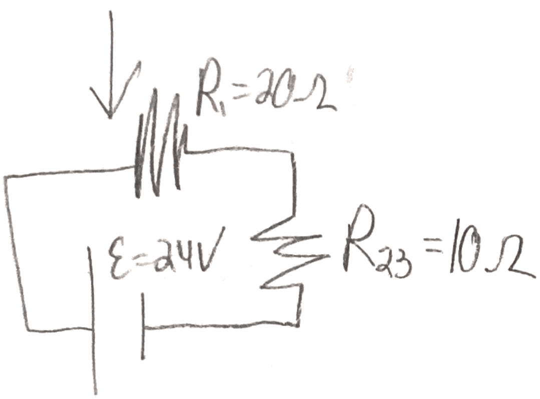
Positive Answer means the direction we assigned is correct

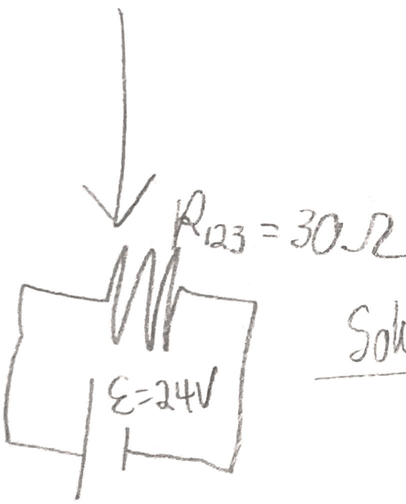
11.



1. Combine (all steps)
2. Solve for current/voltage
3. Uncombine (one step at a time)
4. Repeat 2+3 as necessary

$$P = IV = \frac{V^2}{R} = I^2 R$$

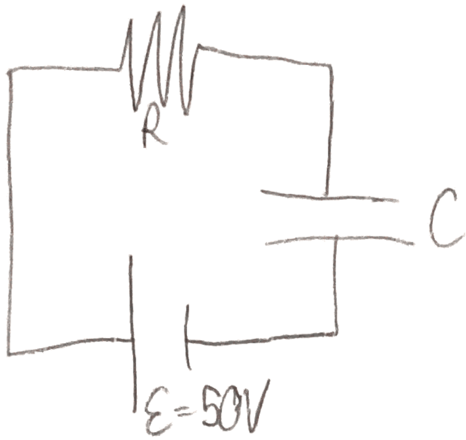




Solve for I $\longrightarrow$ $\frac{V}{R} = \frac{24}{30} = .8A = I_{123} = I_1 = I_{23}$

$$P_1 = I_1^2 R_1$$
$$= (.8)^2 (20)$$
$$P_1 = 12.8\,W$$

12.



$\tau = 1s$

$I_{max} = .5A$

$I_{max} = \frac{V_{max}}{R}$

$R = \frac{V_{max}}{I_{max}} = \frac{50}{.5} = 100\Omega$

$\tau = RC \rightarrow C = \frac{\tau}{R} = \frac{1}{100} = .01F$

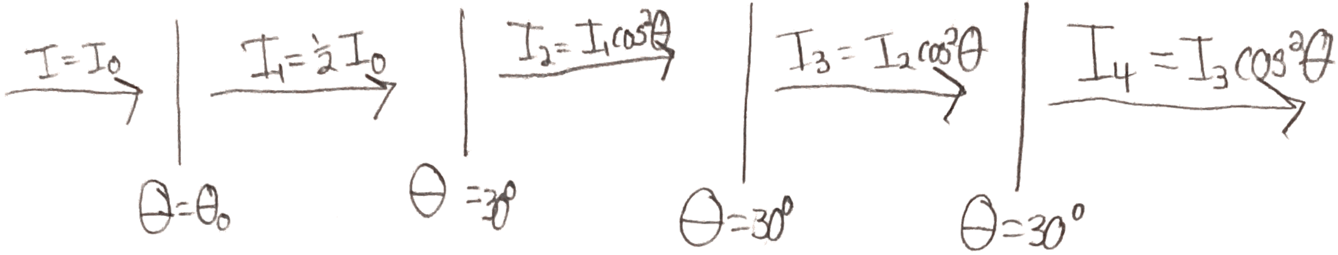
$Q_{max} = V_{max}C$
$= (50)(.01) = .5C$

<u>Charging:</u> $Q(t) = Q_{max}(1 - e^{-t/\tau})$

$Q(t) = (.5)(1 - e^{-2/1}) =$

$Q(t) = .43C$

13.



$$I_4 = I_3 \cos^2(30) = \left(I_2 \cos^2(30)\right)\cos^2(30) = \left(\left(I_1 \cos^2(30)\right)\cos^2(30)\right)\cos^2(30)$$

$$= \left(\left(\left(\tfrac{1}{2} I_0\right)\cos^2(30)\right)\cos^2(30)\right)\cos^2(30)$$

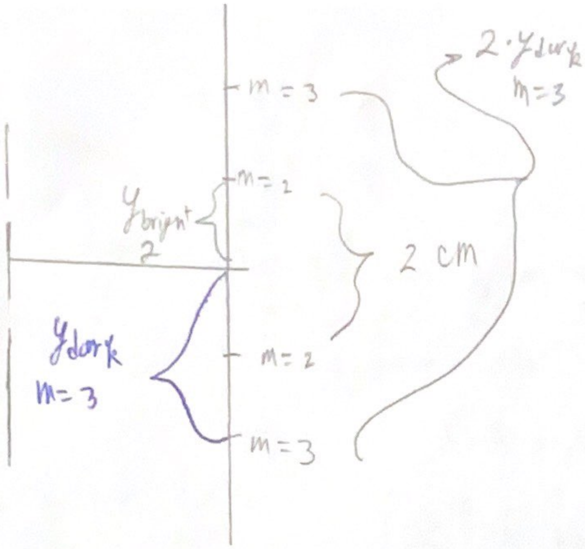
$$= \frac{1}{2} I_0 \cos^6(30)$$

$$\cos(30) = \frac{\sqrt{3}}{2}$$

$$= \frac{1}{2} I_0 \left(\frac{\sqrt{3}}{2}\right)^6 = \frac{27 I_0}{128}$$

$$= .21 I_0$$

14.



$$y_{\text{bright}, m=2} = \frac{\lambda L}{d} \cdot m$$

$$y_{\text{bright}, m=2} = 1\text{cm} = \frac{\lambda L}{d} \cdot 2$$

$$\frac{\lambda L}{d} = 0.5\text{cm}$$

$$y_{\text{dark}, m=3} = \frac{\lambda L}{d}\left(m + \frac{1}{2}\right)$$

$$y_{\text{dark}, m=3} = 0.5\text{cm}\left(3 + \frac{1}{2}\right)$$

$$y_{\text{dark}, m=3} = 1.75$$

Seperation between 2 = 3.5 cm

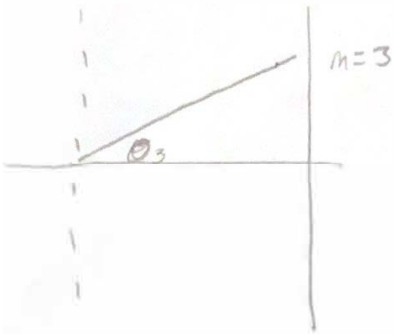
13. 8000 slits over 2.54 cm

$\lambda = 546\ nm$

$m = 3$

$\theta_3 = ?$

$$d = \frac{2.54\,cm}{8000\ slits} = \frac{0.0003175\ cm}{slit} = d$$



$$d \sin \theta_3 = m \cdot \lambda$$

$$\theta_3 = \arcsin\left[\frac{m\lambda}{d}\right]$$

$$\theta_3 = 31.06°$$ answer