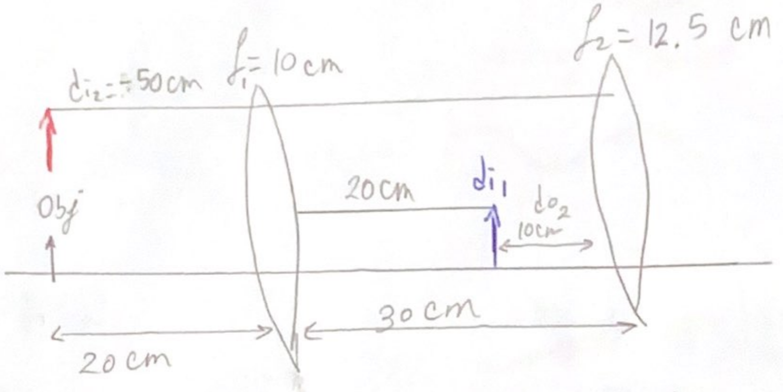
Phy 2054 Final Review Solutions

1.



$d_{o_1} = 20$cm

$f_1 = 10$cm

$$\frac{1}{f_1} = \frac{1}{d_{o_1}} + \frac{1}{d_{i_1}}$$

$$d_{i_1} = \left(\frac{1}{f_1} - \frac{1}{d_{o_1}}\right)^{-1}$$

$d_{i_1} = 20$ cm $\Rightarrow d_{o_2}$

*This image becomes an object for the 2nd lense

$d_{o_2} = 10$cm (left of 2nd lense)

$$\frac{1}{d_{o_2}} + \frac{1}{d_{i_2}} = \frac{1}{f_2}$$

$$d_{i_2} = \left[\frac{1}{f_2} - \frac{1}{d_{o_2}}\right]^{-1}$$

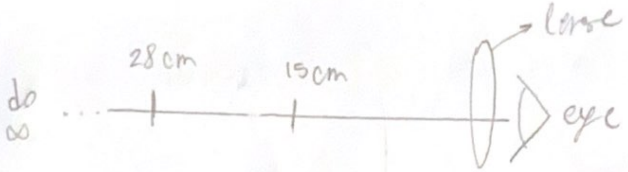
$d_{i_2} = -50$ cm

Answer

↳This is 0cm away from the original object

* − values of di mean that the image is virtual.

2.



imagine $d_o = \infty$

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$$

$$\frac{1}{f} = \frac{1}{-28cm} + \boxed{\frac{1}{\infty}} \rightarrow \text{approaches } 0$$

$\therefore f = -28cm$ of lense

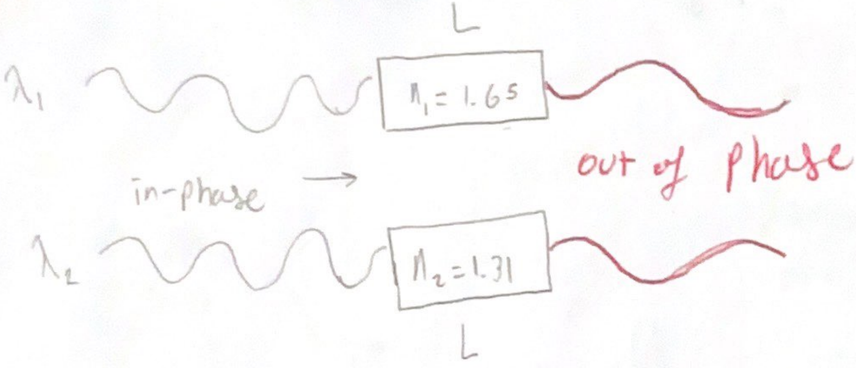
Minimum distance in cm that he'll see an object clearly?

$$\frac{1}{f} = \frac{1}{-15cm} + \frac{1}{d_o}$$

$d_o = ?$
$f = -28cm$

$\boxed{d_o = 32.31 \text{ cm}}$ Answer

3.



$$L_{min} = \frac{\lambda}{(n_1 - n_2)} \cdot \frac{1}{2} \rightarrow \text{not in formula sheet}$$

$$\boxed{L_{min} = 764.71 \text{ nm}} \text{ answer}$$

Bonus!

What is the 2nd smallest L needed for waves to cancel out?

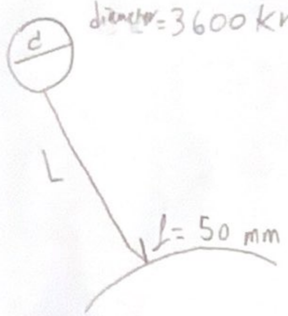
$$L_{2min} = \frac{\lambda}{n_1 - n_2} \cdot \frac{3}{2} \rightarrow \text{not } \frac{1}{2}$$

4.

diameter = 3600 km

$L = 384000\text{ km}$
$= d_o$

diameter of image $= ?$



$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\frac{1}{0.050\text{m}} = \frac{1}{384000000\text{m}} + \frac{1}{d_i}$$

$$\boxed{d_i = \frac{1}{20}\text{ m}}$$

$$M = \frac{-d_i}{d_o} = \frac{h_i}{h_o}$$

* you can use height as your diameter!

$$M = \frac{-0.05\text{m}}{3.84 \times 10^8\text{ m}} = \frac{\text{diameter (image)}}{\text{Moon's diameter}}$$

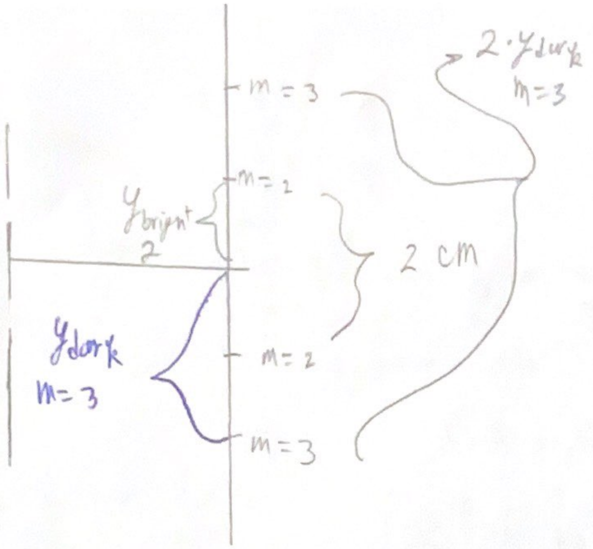
$$\text{diameter image} = -0.00046\text{ m}$$

$\sim -0.0005\text{m}$

Answer: $= -0.5\text{ mm}$

– sign just means it's flipped

5.



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

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

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

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

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

$$\underline{y_{\underset{m=3}{dark}}} = 1.75$$

$$\boxed{\underset{\text{between 2}}{\text{Seperation}} = 3.5cm}$$

6.

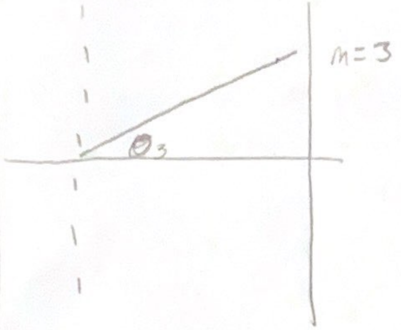
8000 slits over 2.54 cm

$\lambda = 546\ nm$

$m = 3$

$\theta_3 = ?$

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

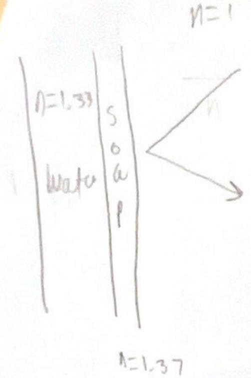


$$d \sin\theta_3 = m \cdot \lambda$$

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

$$\boxed{\theta_3 = 31.06^\circ}$$ answer

7.



1 phase reversal = light reflecting off matter w/ higher n then what light is currently traveling in.

★

light

dark

* assume m=1

★ 1 phase reversal

$$2t = \frac{\lambda}{n}\left(m+\frac{1}{2}\right)$$

$$\boxed{2t = \frac{m\lambda}{n}}$$

$$t = \frac{1 \cdot 600nm}{2 \cdot 1.37}$$

$$\boxed{t = 219nm}$$

answer

0, 2, 4, etc.

$$2t = \frac{\lambda m}{n}$$

$$2t = \left(m+\frac{1}{2}\right)\frac{\lambda}{n}$$

8

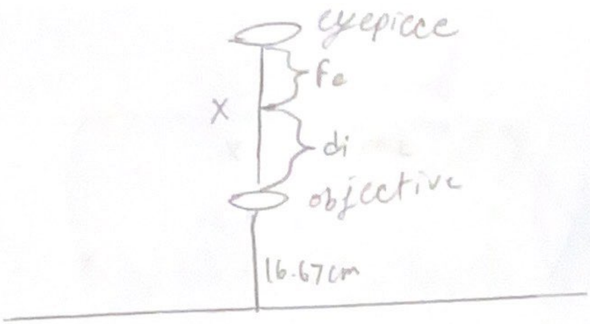
$f_o = 10cm$

$f_e = 20cm$

$d_o = 16.67cm$

$X = ?$

d_i = distance between image & objective lense



$$\frac{1}{f_o} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$d_i = \left[\frac{1}{f_o} - \frac{1}{d_o}\right]^{-1}$$

$d_i = 24.99$ cm

X = length between lenses

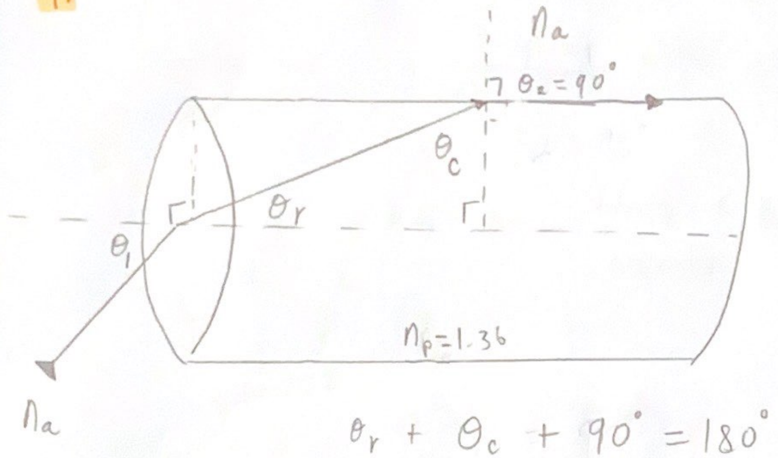
important formula

$$\boxed{\text{length between lenses} = d_i + f_e}$$

$X = 24.99cm + 20cm$

$$\boxed{X = 45cm}$$ answer

9.



$$n_p \cdot \sin\theta_c = n_a \cdot \overbrace{\sin 90°}^{1}$$

$$\theta_c = \arcsin\left(\frac{n_a}{n_p}\right)$$

$$= \arcsin\left(\frac{1.00}{1.36}\right)$$

$$\theta_c = 47.33°$$

$$\theta_r + \theta_c + 90° = 180°$$

$$\therefore \theta_r = 42.67°$$

$$n_a \cdot \sin\theta_1 = n_p \cdot \sin\theta_r$$

$$\theta_1 = \arcsin\left(\frac{n_p \cdot \sin\theta_r}{n_a}\right)$$

$$\boxed{\theta_1 = 67.2°}$$ answer

10.

$$P_o = 1.2\ D = \frac{1}{f_e}$$

$$\therefore f_o = 0.83\ m$$

$$P_e = +5\ D = \frac{1}{f_o}$$

$$\therefore f_e = 0.20\ m$$

$L = ?$

$M_o = ?$

$$\boxed{L = f_o + f_e}$$ important formula

$$= \frac{1}{P_o} + \frac{1}{P_e}$$

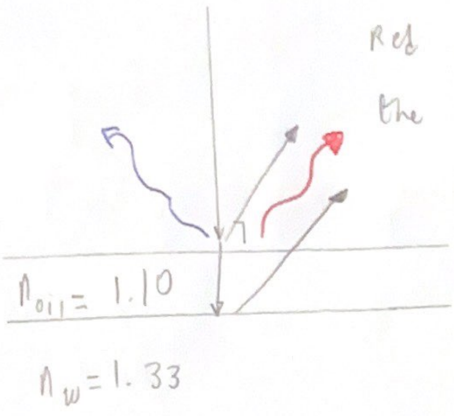
$$L = 1.03\ m$$

$$\frac{-f_o}{f_e} = \frac{0.83}{0.20} = M_o = 4.17$$

Answer: 4.17, 1.03 m

11.

Blue light ($\lambda = 458$ nm) &
Red light ($\lambda = 687$ nm) are
the only colors <u>enhanced</u>



$*$ 2 phase changes $\rightarrow$ $2t = \dfrac{\lambda m}{n}$

$m_b = ?$ $\quad m_{Red} = ?$

$$t = \frac{\lambda_b m_b}{\cancel{2n}} = \frac{\lambda_{red} \cdot m_{red}}{\cancel{2n}}$$

$$\frac{\lambda_b}{\lambda_{red}} = \frac{m_{red}}{m_b} = \frac{458 \text{ nm}}{687 \text{ nm}} = \frac{2}{3} \quad \therefore \quad \boxed{\begin{matrix} m_{red} = 2 \\ m_b = 3 \end{matrix}}$$

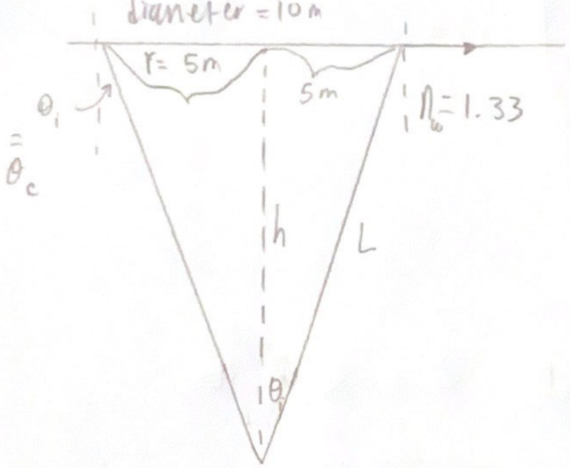
$$t = \frac{\lambda_b \cdot m_b}{2n} = \frac{458 \times 10^{-9} \text{ m} \cdot 3}{2 \cdot 1.10}$$

$\boxed{t = 625 \text{ nm}}$ answers

12.

$n_a = 1$

$h = ?$



$n_w \cdot \sin\theta_c = n_a \cdot \cancel{\sin 90^\circ}$

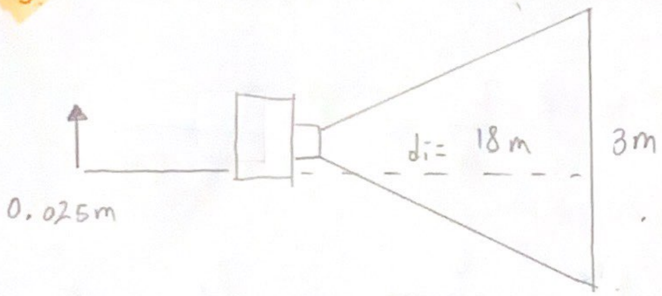
$\theta_c = \arcsin\left[\frac{n_a}{n_w}\right]$

$\theta_c = 48.75^\circ = \theta_i$

$\tan\theta_i = \frac{5m}{h}$

$\boxed{h = 4.38\ m \approx 4.4\ m}$ answer

13.



$M = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$

$d_o = -\frac{d_i}{h_i} \cdot h_o$

$d_o = -0.15m$

the - just means it's on the other side.

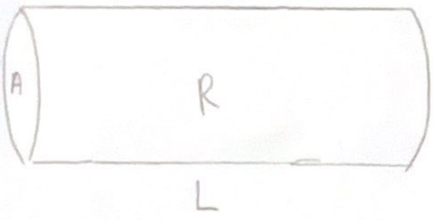
$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

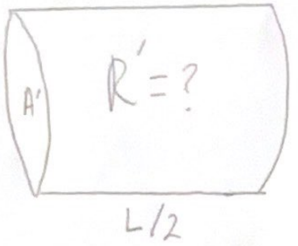
$f = \left[\frac{1}{d_o} + \frac{1}{d_i}\right]^{-1}$

$f = \left[\frac{1}{0.15m} + \frac{1}{18m}\right]^{-1}$

$\boxed{f = 0.15\ m}$ answer

14





$$V_0 = \pi r^2 \cdot L$$
$$= A \cdot L$$

$$R = \rho \cdot \frac{L}{A}$$

$$\boxed{R = \rho \cdot \frac{L}{\pi r^2}}$$

$$V' = V_0$$

$$V' = \frac{\cancel{L}}{2} \cancel{\pi} (r')^2 = V_0 = \cancel{\pi} r^2 \cdot \cancel{L}$$

$$r' = \sqrt{r^2 \cdot 2}$$

$$r' = \sqrt{2} \cdot r$$

$$(r')^2 = 2r^2$$

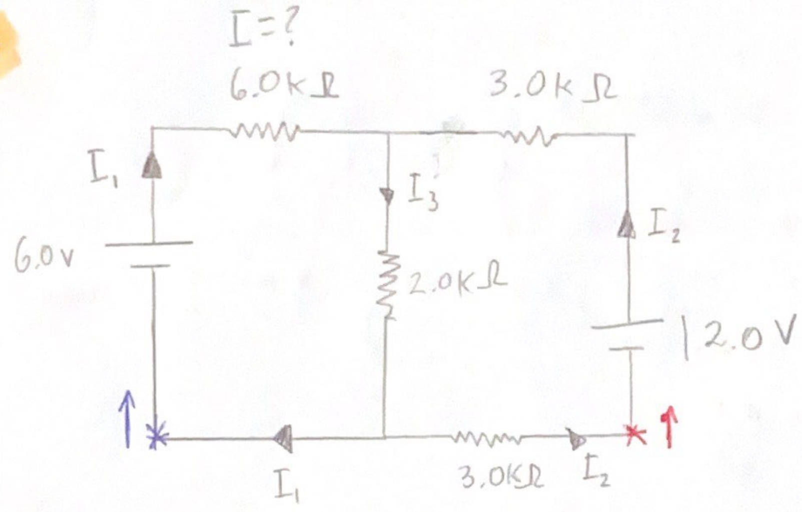
$$R' = \rho \cdot \frac{L/2}{A'} = \rho \cdot \frac{L}{2 \cdot \pi \cdot (r')^2}$$

$$R' = \frac{\rho \cdot L}{2\pi \cdot 2r^2} = \underbrace{\frac{\rho L}{\pi r^2}}_{R} \cdot \frac{1}{4}$$

$$\boxed{R' = \frac{R}{4}}$$

answer

15



$$I_1 + I_2 - I_3 = 0 \rightarrow I_2 = I_3 - I_1$$

↑ * $6V - I_1 \cdot 6000\,\Omega - I_3 \cdot 2000\,\Omega = 0$

↑ * $12.0V - I_2 \cdot 3000\,\Omega - I_3 \cdot 2000\,\Omega - I_2 \cdot 3000\,\Omega$

$$12.0V = 6000\,I_2 + I_3 \cdot 2000\,\Omega$$

$$12.0V = 6000\,I_3 - 6000\,I_1 + 2000\,I_3$$

$$12V = 8000\,I_3 - 6000\,I_1$$

$$I_3 = \frac{12V + 6000\,I_1}{8000\,\Omega}$$

$$6V = +6000\,I_1 + 2000\left[\frac{12V + 6000\,I_1}{8000\,\Omega}\right]$$

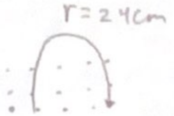
$$6V = 6000\,I_1 + 3V + 1500\,I_1$$

$$3V = 7500\,I_1$$

answer

$$\boxed{I_1 = 0.0004\ A = 0.4\ mA}$$

16



^{9}Be → singly charged ⇒ $q = 1.6\times10^{-19}C$

$V_0 = 0$ Voltage $= 32000V$ $m = 9(1.7\times10^{-27}kg)$

$\boxed{m = 1.53\times10^{-26}kg}$ $* \; m = \underline{9}\cdot(m_{proton})$

$r = 24\,cm$ we can't use

$B = ?$ $r = \frac{mv}{qB}$

$K.E. = \frac{1}{2}mv^2 \Rightarrow U = q\cdot\overline{\underline{V}}$ $qvB = ma_c$

$V = \sqrt{\frac{2q\overline{\underline{V}}}{m}}$ $q\cancel{v}\cdot B = m\cdot\frac{\cancel{v}^2}{r}$

$$\boxed{q\cdot B = \frac{m}{r}\cdot\sqrt{\frac{2q\overline{\underline{V}}}{m}}}$$ might want to memorize

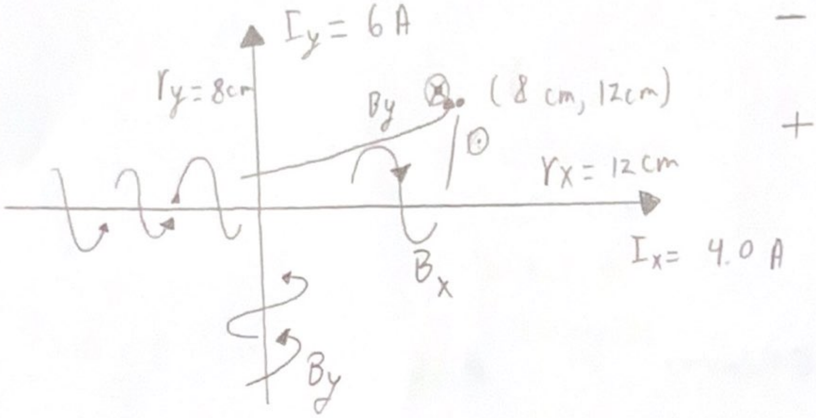
$$B = \frac{m}{r\cdot q}\cdot\sqrt{\frac{2q\cdot\overline{\underline{V}}}{m}}$$

$$B = \sqrt{\frac{\overline{\underline{V}}\cdot m\cdot 2}{q}}\cdot\frac{1}{r}$$

$$B = \sqrt{\frac{32000V\cdot(1.53\times10^{-26}kg)\cdot 2}{1.6\times10^{-19}C}}\cdot\frac{1}{0.24m}$$

$\boxed{B = 0.3265\,T \sim 0.33\,T}$ Answer

17.



$-B_y$ goes in ⊗

$+B_x$ comes out ⊙

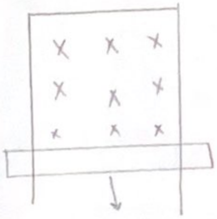
$$B_{total} = B_x - B_y$$

$$B_{total} = \frac{\mu_0 \cdot I_x}{2\pi r_x} - \frac{\mu_0 \cdot I_y}{2\pi \cdot r_y}$$

$$B_{total} = \frac{\mu_0}{2\pi} \cdot \left[\frac{I_x}{r_x} - \frac{I_y}{r_y}\right] = -0.0000083 \text{ T}$$

$$\boxed{B_{Total} = 6.83 \times 10^{-5} \text{ T}}$$ answer

18.



$R = 8\,\Omega$

$m = 0.014$ kg

$L = 1.30$ m

$V_y = 2.5 \frac{m}{s^2}$ $g = 9.8 \frac{m}{s^2}$ → won't accelerate any more ... $a = 0$ ∴

$F_{net} = 0$

$$F_{net} = F_B - mg = 0 \implies mg = ILB$$

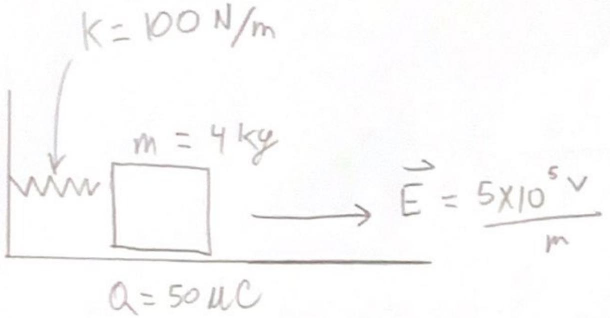
$$F_B = ILB = \frac{\varepsilon}{R} \cdot LB \qquad \varepsilon = BL \cdot v \;\therefore\; F_B = \frac{BL \cdot V}{R} \cdot BL = mg$$

$$mg = \frac{vL^2 \cdot B^2}{R}$$

$$B = \sqrt{\frac{Rmg}{v \cdot L^2}}$$

$\boxed{B = 0.51\,T}$ answer to #18

19.



$F_e = qE = \frac{q^2 \cdot k}{r^2}$

$U_e = qE \cdot r = \frac{q^2 k}{r}$ $r = \Delta x$

$U_e = qE \cdot \cancel{\Delta x} \Rightarrow U_{spring} = \frac{1}{2} k \Delta x^2$

$\Delta x = \frac{2q \cdot E}{K}$

$\boxed{\Delta X = 0.50\,m}$ answer

~~Force diagram~~

~~$F_{net} = 0 = F_e - F_k$~~

~~$F_e = q \cdot E$ $F_k = k \cdot \Delta X$~~

~~$qE = k \cdot \Delta X$~~

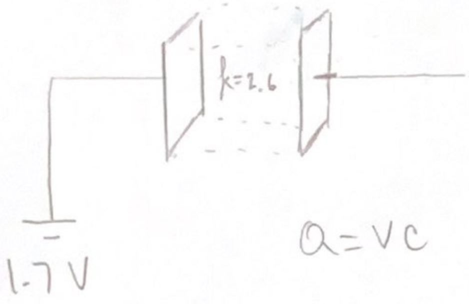
~~$\Delta x = \frac{qE}{k}$~~

~~$\Delta x = \frac{50\times10^{-6}\,C \cdot 5\times10^{5}\,\frac{V}{m}}{100\,\frac{N}{m}}$~~

* Cannot use forces because Fnet when spring is fully stretched doest NOT = 0.

must use energy

20. $C_i = 6.9\ \mu F \longrightarrow k = 2.6$ is now inserted & charges & battery is disconnected $\longrightarrow \cancel{k}$ is removed



$Q = VC$

$C_k = C_i \cdot k = 17.94\ \mu F$

$Q = 1.7V \cdot 17.94\ \mu F$

$\boxed{Q = 30.498\ \mu F}$ answer