Solutions S12 practice final PHY2005

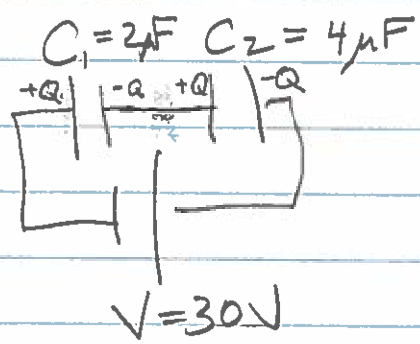
(1) 1st of all, figure is wrong, should be +3C at origin, acc. to text of problem.

Given this, $E = 0$ at $x = -2$ means

$$E = \frac{kq_1}{r_1^2} + \frac{kq_2}{r_2^2} = k\left(\frac{3}{2^2} + \frac{Q}{4^2}\right) = 0$$

$$\Rightarrow \quad Q = -12\ C$$

(2)



Examine potential drop across each capacitor separately!

$Q = C_1 V_1 \qquad Q = C_2 V_2$

Q is same on both caps, since connection is neutral!

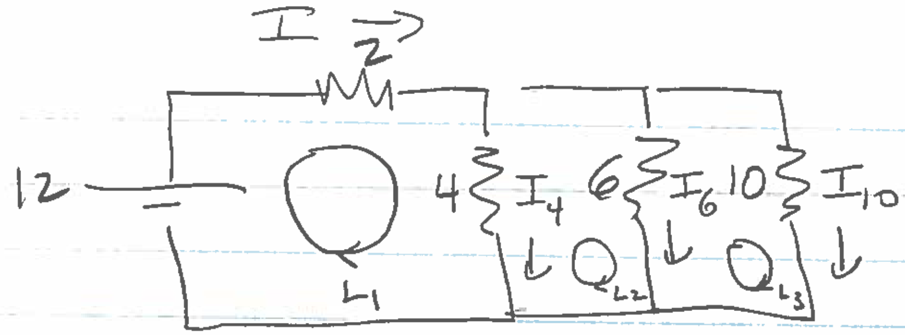
Sum of potential drops must equal total 30V.

$$\frac{Q}{C_1} + \frac{Q}{C_2} = Q\left(\frac{1}{C_1} + \frac{1}{C_2}\right) = V$$

$$Q = \left(\frac{1}{C_1} + \frac{1}{C_2}\right)^{-1} V = \underbrace{\left(\frac{1}{2} + \frac{1}{4}\right)^{-1} 10^{-6}}_{C_{eq} \text{ for series caps.}} \cdot 30$$

$$= 40\ \mu C$$

(3.)



node: $I = I_4 + I_6 + I_{10}$

L_2: $-6I_6 + 4I_4 = 0 \quad \Rightarrow \quad I_6 = \frac{2}{3} I_4$

L_3: $-10I_{10} + 6I_6 = 0$

L_1: $12 - 2I - 4I_4 = 0 \quad \Rightarrow \quad I = 6 - 2I_4$

$L_1 + L_2 \Rightarrow \quad 4I_4 = 10I_{10} \qquad I_{10} = \frac{2}{5} I_4$

L_1 + nodes: $6 - 2I_4 = I_4 + I_6 + I_{10}$

$+L_2$: $3I_4 + I_6 + I_{10} = 6$

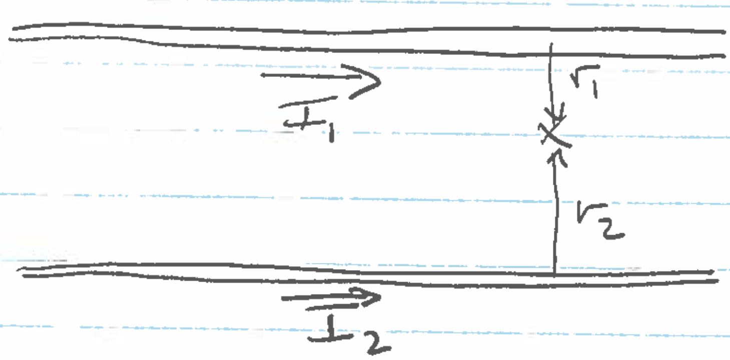
$3I_4 + \frac{2}{3}I_4 + I_{10} = 6$

$\times 3$ $\quad 11 I_4 + 3I_{10} = 18$

$$11 I_4 + 3\left(\frac{2}{5}\right) I_4 = 18$$

$$I_4 = \frac{18}{11 + 6/5} = 1.48\,A$$

(4)



By rh rule, fields at x are in opp. direction field near current carrying wire:

$B = \frac{\mu_0 I}{2\pi r}$ → here

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

$I_1 = 5A$
$I_2 = 8A$

$r_2 I_1 = r_1 I_2$ $\quad 5r_2 = 8r_1$

$r_1 + r_2 = 40$ cm

$\left(r_1 + \frac{8}{5} r_1\right) = 40$

$r_1 = \frac{40}{1 + 8/5}$

$= 15.4$ cm from 5-A wire

(5) $V_{ind} = -\frac{\Delta\Phi}{\Delta t} = -\frac{NA\,\Delta B}{\Delta t}$

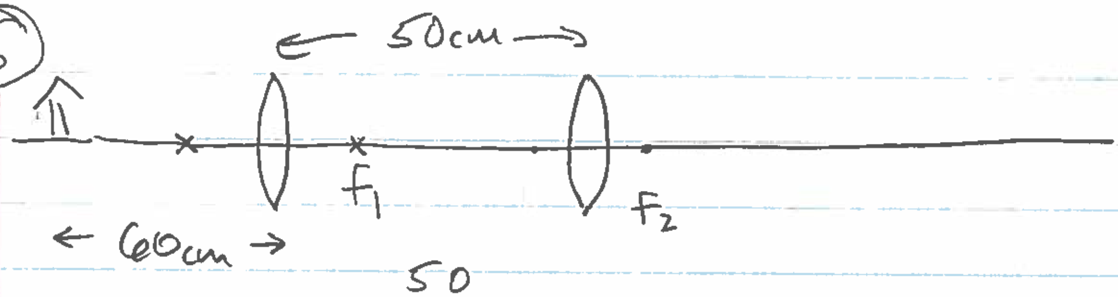
$= \frac{-4\cdot(0.02\,m^2)(25-10)(10^{-3}\,T)}{(5\times10^{-3}\,s)}$

$= 0.24\,V$

$I = \frac{V_{ind}}{R} = \frac{0.24}{8} = 0.03 = 30\,mA$

$f_1 = 15\text{ cm} \quad f_2 = 10\text{cm}$

(6)



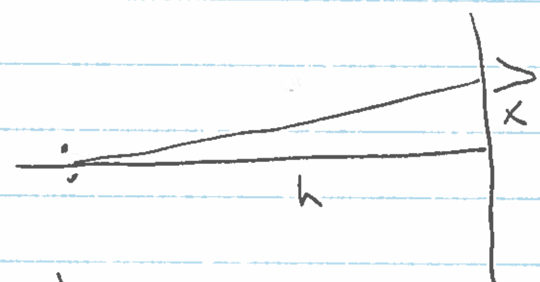
$$\frac{1}{p_1} + \frac{1}{q_1} = \frac{1}{60} + \frac{1}{q_1} = \frac{1}{15} \Rightarrow \frac{1}{q_1} = \frac{1}{20}$$

$$q_1 = 20 \Rightarrow p_2 = 50 - q_1 = 30$$

$$\frac{1}{p_2} + \frac{1}{q_2} = \frac{1}{30} + \frac{1}{q_2} = \frac{1}{10} \Rightarrow \frac{1}{q_2} = \frac{1}{15}$$

$$q_2 = 15\text{ cm}$$

(7) $d = 2.5 \times 10^{-5}\text{ m}$



$$\Delta r = d\sin\theta = m\lambda$$

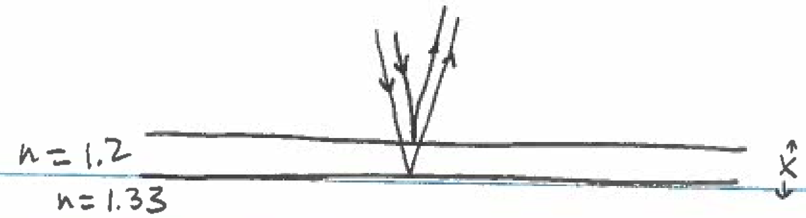
$$\cong d\frac{x}{h}$$

Between successive bright fringes is m to $m+1$ so $\Delta x = h\lambda/d$

$$\lambda = \frac{d\Delta x}{h} = \frac{(2.5\times10^{-5})(2.3\times10^{-2})}{1}$$

$$= 5.75\times10^{-7}\text{ m} = 575\text{ nm}$$

(8)



"strongly reflects" => constructive interference of 2 outgoing rays.

$\lambda_{vac} = 550\ nm \Rightarrow \lambda_{med} = \frac{550}{1.2} = 458\ nm$

constructive interference $\Delta x = 2x = m\lambda$

$m = 1 \quad x = \lambda_{med}/2 = 229\ nm$

(9) – (11) ch. 29

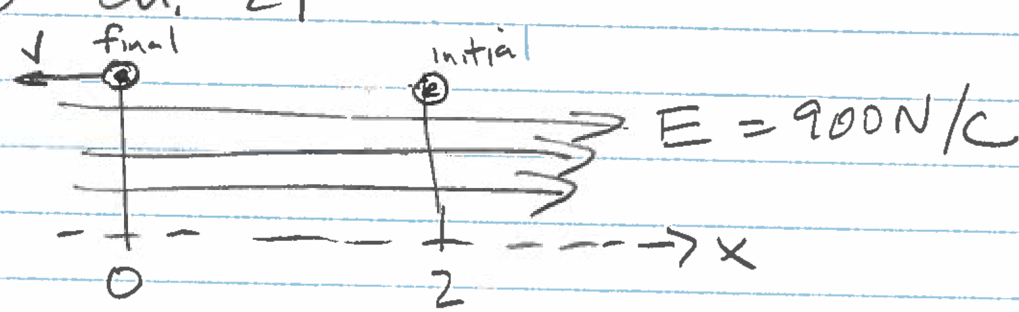
(12) $R = \rho\, L/A \Rightarrow \rho = \frac{RA}{L}$

$= \frac{(\pi (0.02\,m)^2)(3.2 \times 10^{-5}\,\Omega)}{0.8}$

$= 5 \times 10^{-8}\ \Omega\text{-}m$

(13) – (14) ch. 29

(15)



initial : $KE = 0 \quad PE = qEd = (1.6 \times 10^{-19})(900)\,2$

$= 2.88 \times 10^{-16}\ J$

final: $KE = \frac{1}{2}mv^2 \quad PE = 0$

Energy conservation $\Rightarrow \frac{1}{2}mv^2 = 2.88 \times 10^{-16}\ J$

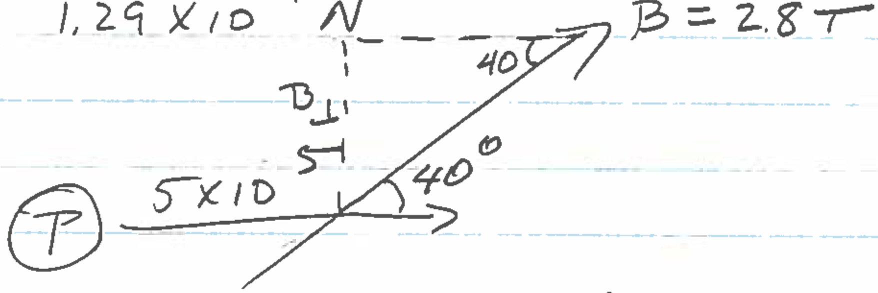
$$v = \sqrt{\frac{(2)(2.88 \times 10^{-16})}{9.11 \times 10^{-31}}} = 2.5 \times 10^{7}\ m/s$$

(16) Total charge $-2.0 + 3.2 = 1.2\ \mu C$
Charge on each sphere is $1/2$ since they are identical, so $Q = 0.6\ \mu C$
Force at 5 m

$$F = \frac{kQ^2}{r^2} = \frac{(9 \times 10^{9})(0.6 \times 10^{-6})^2}{5^2}$$

$$= 1.29 \times 10^{-4}\ N$$

(17)



$$F = qvB_{\perp} = (1.6 \times 10^{-19})(5 \times 10^{5})(2.8 \sin 40^\circ)$$

$$= 1.44 \times 10^{-13}\ N$$

(18) $$NA\frac{\Delta B}{\Delta t} = \frac{(500)(0.08)^2(1.5 - 0)}{3}$$

$$= 16\ V$$

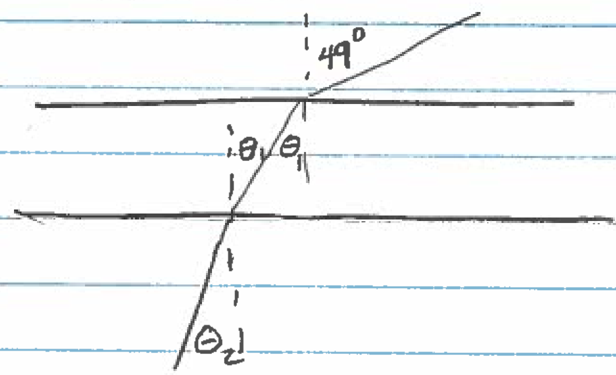
(19) $p = 24 \qquad M = \frac{1}{4} = \frac{-q}{p} \quad \Rightarrow \frac{1}{q} = -\frac{4}{p}$

convex $\Rightarrow$ $f < 0$

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} = \frac{1}{p} - \frac{4}{p} = -\frac{3}{p} = \frac{-3}{24}$$

$$f = -8\,cm$$

(20)



$n = 1$ (air)

$n = 1.176$ (oil)

$n = 1.33$ (water)

Snell: $\sin 49° = 1.176 \sin\theta_1 = 1.33 \sin\theta_2$

↑ 1st interface ↑ 2nd interface

so $\theta_2 = \sin^{-1}\left(\frac{\sin 49°}{1.33}\right) = 34.5°$

But (I now realize) we're asked for θ_1 "angle of incidence at oil-to-water surface"

$$\theta_1 = \sin^{-1}\left(\frac{\sin 49°}{1.176}\right) = 39°$$