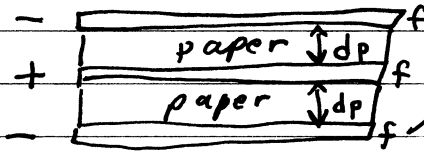
# PHYS 141 Unit 24 Homework

SP 24-1) $w = 8.0\ cm$ $d_p = 0.025\ mm$
$C = 9.5 \times 10^{-8}\ F$ $L = ?$ $d_f = 0.0035\ mm$
$K = 3.7$

Because the strips are rolled up, this acts as a double-layer capacitor:




* use both sides of same foil strip → effective area is doubled

$$C = \frac{K\varepsilon_0 A}{d} \rightarrow A = \frac{C d}{K \varepsilon_0}$$

$$\frac{A}{2} = w \times L \qquad A = \frac{(9.5\times10^{-8}\ F)(2.5\times10^{-5}\ m)}{(3.7)(8.85\times10^{-12}\ C^2/N\cdot m^2)}$$

$$L = \frac{A}{2w} \leftarrow A = 0.0725\ m^2$$

$$L = \frac{0.0725\ m^2}{2(0.08\ m)} = \boxed{0.45\ m}$$

SP 24-2) $C = 4.5 \times 10^{-3}\ \mu F$
initial charge: $Q_0 = 6.7\ \mu C$ $R = 1600\ \Omega$

(a) $I = ?$ @ $t = 7.5\ \mu s$

$$I = -\frac{dq}{dt}$$

$$q = Q_0 e^{(-t/RC)}$$

$$I = -\frac{d}{dt}\left(Q_0 e^{(-t/RC)}\right) = \frac{Q_0}{RC} e^{(-t/RC)}$$

$$I = \frac{6.7 \times 10^{-6} C}{(1600\Omega)(4.5 \times 10^{-9} F)} e^{-\left(\frac{7.5 \times 10^{-6} s}{(1600\Omega)(4.5 \times 10^{-9} F)}\right)}$$

$$I = (0.931\ C/s)\quad(0.353)$$

$$\boxed{I = 0.33\ A}$$

(b) $$q = Q_0 e^{(-t/RC)}$$

$$q = (6.7 \times 10^{-6} C)\, e^{-\left(\frac{6.0 \times 10^{-6} s}{(1600\Omega)(4.5 \times 10^{-9} F)}\right)}$$

$$\boxed{q = 2.9 \times 10^{-6} C}$$

(c) $I_{max} = ?$ $\quad I = \frac{Q_0}{RC} e^{(-t/RC)}$

$I_{max}$ occurs @ $t = 0$ : $I_{max} = \frac{Q_0}{RC}$

$$I_{max} = \frac{(6.7 \times 10^{-6} C)}{(1600\Omega)(4.5 \times 10^{-9} F)}$$

$$\boxed{I_{max} = 0.931 A}$$

SP 24-3) 55% of max in $t = 0.72\,s$

$\tau = RC = ?$

$$q = Q_0 e^{(-t/RC)}$$

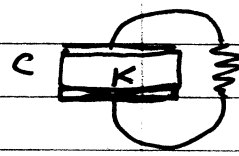
$$\frac{q}{Q_0} = e^{(-t/RC)}$$

$$0.55 = e^{(-0.72s/RC)}$$

$$\ln 0.55 = \frac{-0.72s}{RC}$$

$$\boxed{\tau = RC = 1.2\,s}$$

SP 24-4) $C = 4.7\,\mu F$ $\quad V \rightarrow \frac{V_0}{2}$ @ $t = 3.0s$




$$V = V_0 e^{(-t/RC)}$$

$$\frac{V_0}{2} = V_0 e^{\left(-(3.0s)/R(4.7\times10^{-6}F)\right)}$$

$$\frac{1}{2} = e^{\left(-\frac{6.38\times10^{5}\,\Omega}{R}\right)}$$

$$\ln\left(\frac{1}{2}\right) = -\frac{(6.38\times10^{5}\,\Omega)}{R}$$

$$\boxed{R = 9.2\times10^{5}\,\Omega}$$