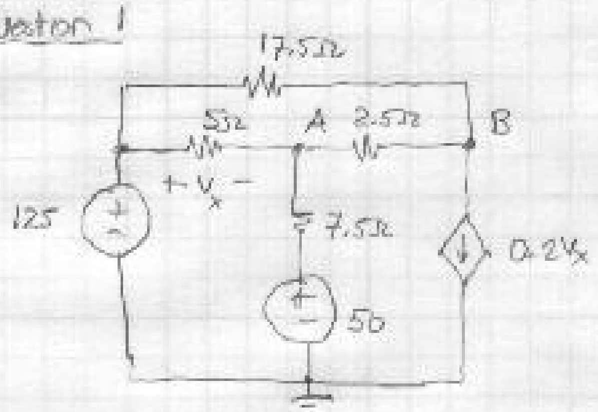
Question 1



Node-voltage equations

A: $\dfrac{V_A - 125}{5} + \dfrac{V_A - 50}{7.5} + \dfrac{V_A - V_B}{2.5} = 0$

B: $\dfrac{V_B - V_A}{2.5} + \dfrac{V_B - 125}{17.5} + 0.2V_x = 0$

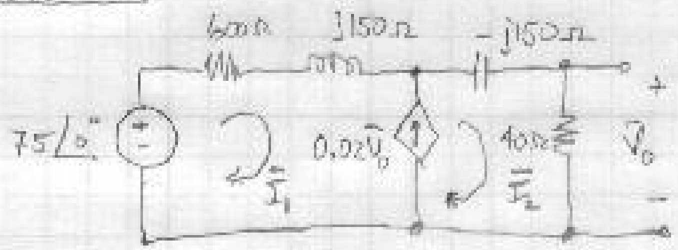
We also have $V_x = 125 - V_A$

Solve to find $V_A = 77.02$, $V_B = 62.02$

Current in the dependent source: $I = 0.2V_x = 0.2(125 - 77.02)$
$= 9.6$ A

so $P = +9.6\,V_B = 595\,W$ (absorbed)

Question 2



Try mesh-current method to find $\bar{V}_L = \bar{V}_0$.

$\bar{I}_1 / \bar{I}_2$: $-75 + (600 + j150)\bar{I}_1 + (40 - j150)\bar{I}_2 = 0$

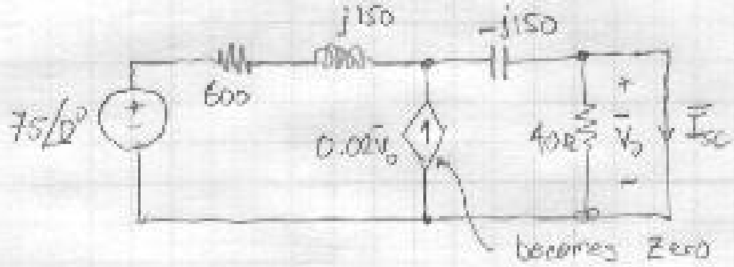
Between meshes $\bar{I}_2 - \bar{I}_1 = 0.02\bar{V}_0$

and we also have $\bar{V}_0 = 40\,\bar{I}_2$

Solve to get $\bar{I}_1 = 0.06 + j0.045$, $\bar{I}_2 = 0.3 + j0.225$

So $\bar{V}_o = 40\bar{I}_2 = 12 + j9 = 15\angle 25.35^\circ$

Thevenin impedance must be determined using short-circuit current



Have $\bar{V}_o = 0$

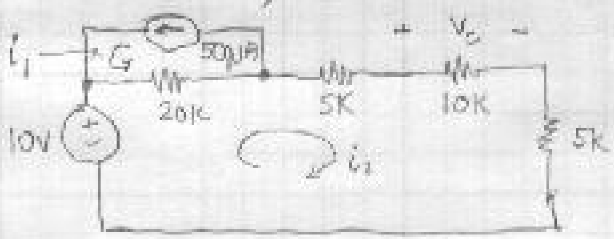
We has $\bar{I}_{sc} = \dfrac{75}{600 + j150 - j150} = 0.125$ A

Hence $Z_t = \dfrac{\bar{V}_o}{\bar{I}_{sc}} = \dfrac{12 + j9}{0.125} = 96 + j72$

(b) Z_t :

$R = 96$ ↗ ← $j\omega L = j72$, so $L = \dfrac{72}{2\pi \times 1000} = 11.46$ mH

3. When $t = 0^-$,

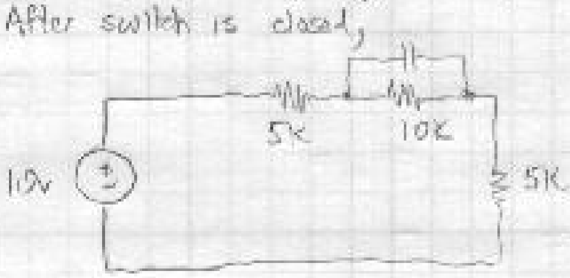


Try mesh-current method.

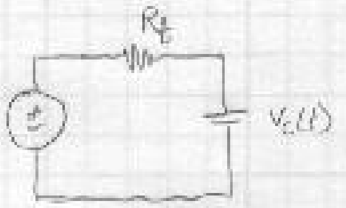
$i_1 = 500\mu A$, and for i_2

$$-10 + 20K(i_2 + i_1) + (5K + 10K + 5K)i_2 = 0$$

Solve to find $i_2 = 0$, so $V_c = 0$. Hence $V_c(0^-) = 0$.
After switch is closed,



We may reduce this to a Thevenin equivalent at the capacitor terminals



$R_t = 10k \,//\, (5k + 5k)$
$= 5k$

$V_t = \dfrac{10k}{10k + 5k + 5k} \times 10 = 5\,v$

We have $v_c(t) = V_t + (V_0 - V_t)e^{-t/R_tC}$

$= 5 - 5e^{-t/(5000 \times 0.4 \times 10^{-6})}$

$= 5 - 5e^{-500t}$

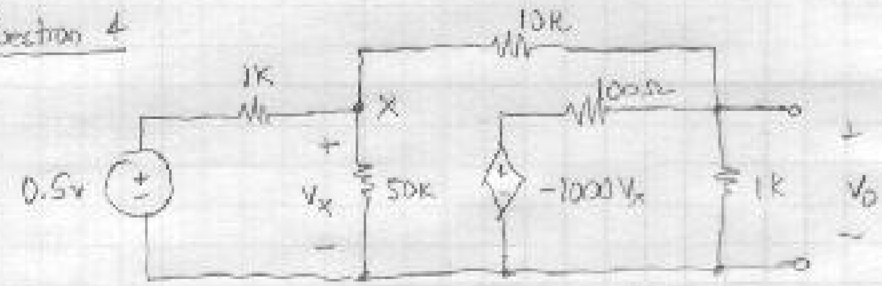
(b) Power in the capacitor $p = vi = vC\dfrac{dv}{dt}$

$= (5 - 5e^{-500t})(2500e^{-500t})$

$= 12{,}500\,(e^{-500t} - e^{-1000t})$

(c) $w = \frac{1}{2}Cv^2$ At $t = 0$, $w = 0$
$t \to \infty$, $w = 5\,\mu J$

Question 4



Node-voltage method:

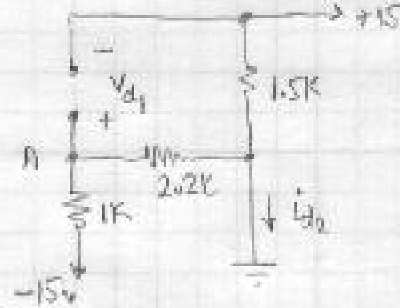
At X: $\dfrac{V_x - 0.5}{1k} + \dfrac{V_x - V_o}{10k} + \dfrac{V_x}{50k} = 0$

At V_o: $\dfrac{V_o - V_x}{10k} + \dfrac{V_o + 1000V_x}{100} + \dfrac{V_o}{1k} = 0$

Solving for V_o gives $V_o = -4.99\ v$

Question 5

(a) Assuming D_1 off



Have simple voltage divider at A

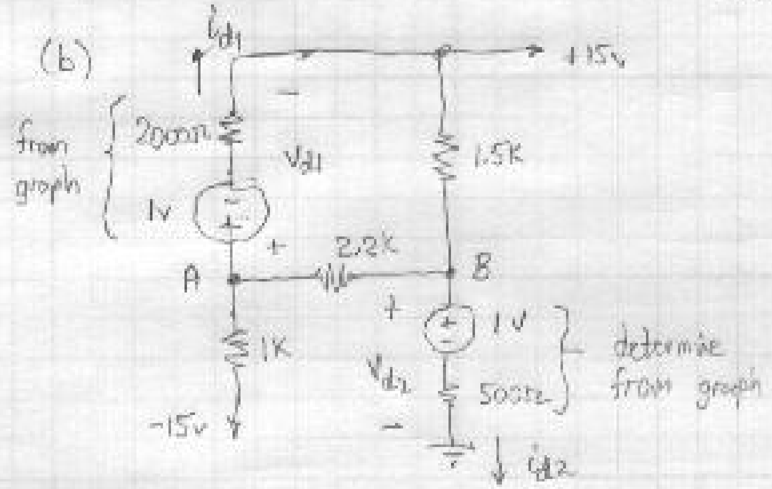
$$V_A = \left(0 - (-15)\right)\frac{1000}{1000 + 2200}$$

so $V_A = -4.69$

therefore, $V_{d_1} = V_A - 15$
$= -19.69$

(confirms reverse biased)

(b)



Node-voltage method: two voltage sources in series

$$A: \quad \frac{V_A - (15+1)}{2000} + \frac{V_A - V_B}{2.2K} + \frac{V_A - (-15)}{1K} = 0$$

$$B: \quad \frac{V_B - 1}{500} + \frac{V_B - V_A}{2.2K} + \frac{V_B - 15}{1.5K} = 0$$

Solve to find $V_A = -2.79$, $V_B = 3.44$

We have $i_{D1} = \dfrac{V_A - (15+1)}{2000} = -9.4$ mA

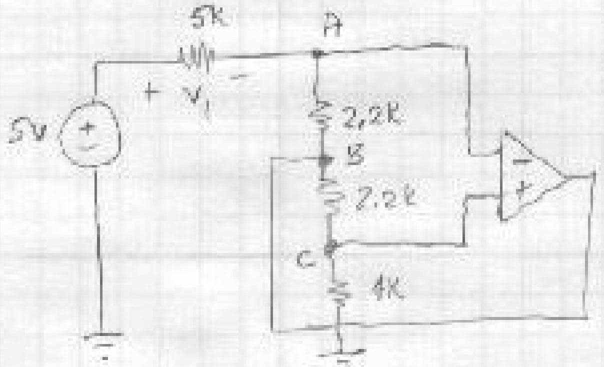
$i_{D2} = \dfrac{V_B - 1}{500} = 4.9$ mA

$V_{D_1} = V_A - 15 = -17.79$ v

$V_{D2} = V_B = 3.44$ v

Question 6

(a)



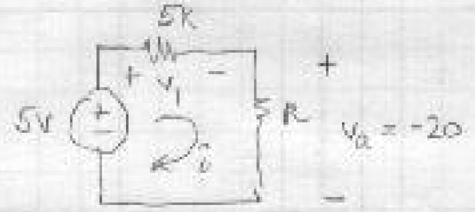
Node-voltage equations at inputs to op amp.

A: $\frac{V_A - 5}{5K} + \frac{V_A - V_B}{2.2K} = 0$

C: $\frac{V_C - V_B}{2.2K} + \frac{V_C}{4K} = 0$ And we know $V_C = V_A$

Solve to find $V_A = -20V$, so $V_1 = 5 - V_A$
$= 25V$

(b)



We have $i = \frac{V_1}{5000} = 5mA$, so $R = \frac{V_a}{i} = \frac{-20}{0.005}$
$= -4000\,\Omega$

(negative resistor?)