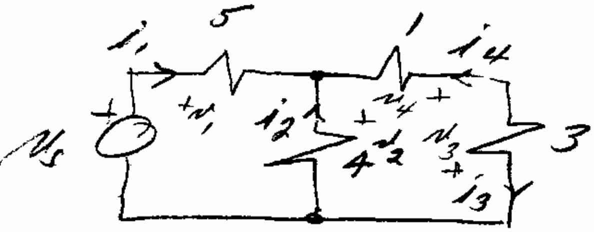
ES 332

Homework 1

1.7



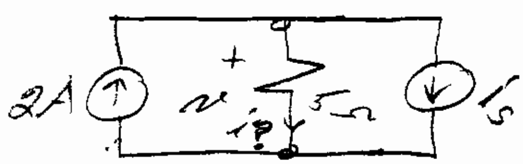
a) $i_1 = 4$; $\boxed{v_1 = 20V}$

b) $i_2 = -2$; $\boxed{v_2 = 8V}$

c) $i_3 = 2$; $\boxed{v_3 = -6V}$

d) $i_4 = -2$; $\boxed{v_4 = -2V}$

1.16



$\boxed{\text{KCL}}$ $i_? = 2 - i_s$

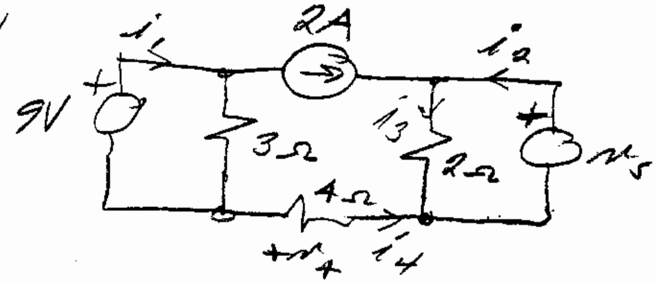
a) $i_s = 1,\ i_? = 1 \therefore \boxed{v = 5V}$

b) $i_s = 2,\ i_? = 0 \therefore \boxed{v = 0V}$

c) $i_s = 3,\ i_? = -1 \therefore \boxed{v = -5V}$

ES 332 Homework 2

1.18



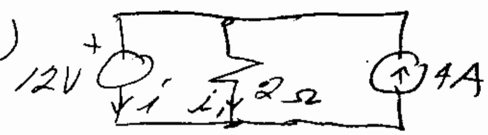
$2 = i_3 - i_2$

a) $v_s = 2V$; $i_3 = \frac{v_s}{2} = 1A$; $i_4 = i_2 - i_3 = -2$; $\therefore$ $v_4 = 4i_4 = \underline{-8V}$

b) $v_s = 4V$ but i_4 still is $i_2 - i_3 = -2$ $\therefore$ $\boxed{v_4 = -8V}$ ←

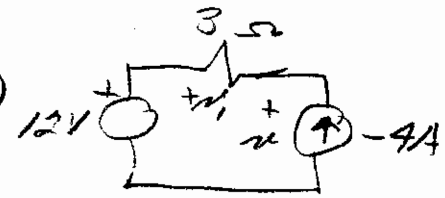
c) $v_s = 6V$ " $\therefore$ $\boxed{v_4 = -8V}$ ←

1.26 a)



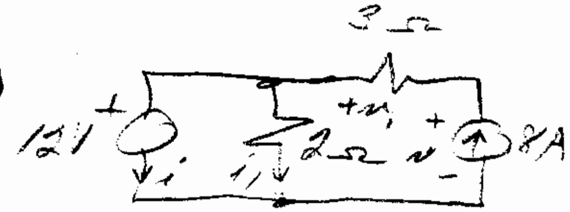
$$\left.\begin{aligned} i_1 &= \frac{12}{2} = 6A \\ i &= 4 - i_1 = -2A \end{aligned}\right\} \leftarrow$$

b)



$$\left.\begin{aligned} v_1 &= -(-4)3 = 12V \\ \text{KVL} \quad v &= 0 \end{aligned}\right\} \leftarrow$$

c)



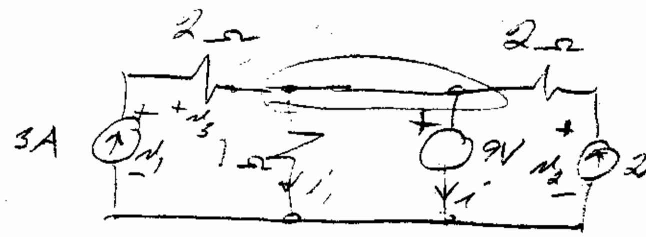
$i_1 = \frac{12}{2} = 6A$

$i = -i_1 + 8 = 2A$ ←

$v_1 = -3 \times 8 = -24V$ ←

$-12 + v_1 + v = 0$ or $v = 12 - v_1 = 36V$. ←

d)



$-v_1 + v_3 + 9 = 0$ $\therefore$ $v_1 = 15V$ ←

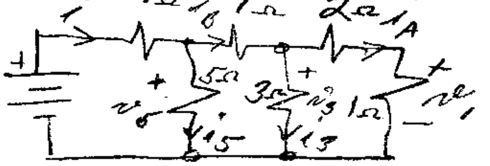
(KCL) $i = 3 + 2 - i_1 = -4A$ ←

$i_1 = 9A$; $-9 - 2 \times 2 + v_2 = 0$ → $v_2 = +9 + 4 = +13V$ ←

$v_3 = 6V$

ES 332 Homework 3

1.33



a) $v_1 = 2V \therefore i_A = \frac{v_1}{1} = 2A$

$v_3 = 3 i_A = 6V$; $i_3 = \frac{v_3}{3} = 2A$

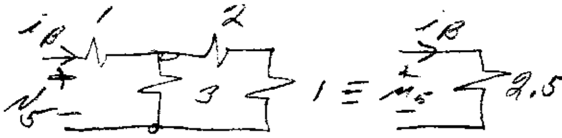
so $i_B = i_3 + i_A = 4A$; $v_5 = i_B \times 1 + v_3 = 10V$

$i_5 = \frac{v_5}{5} = 2A$ $\therefore$ $i = i_5 + i_B = 6A$ and $\boxed{V_s = i \times 1 + v_5 = 16V}$

b) $i_3 = 3A$; $v_3 = 9V$; $i_A = 3A$; $i_B = 6A$; $v_5 = 6 + 9 = 15V$; $i_5 = 3A$

$i = i_B + i_5 = 9A$ so $\boxed{V_s = 9 \times 1 + v_5 = 24V}$

c) $i_5 = 4A$; $v_5 = 20V$;

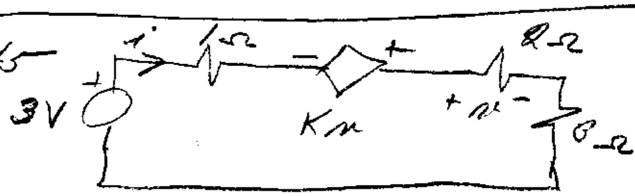


$i_B = \frac{20}{2.5} = 8A$

$i = i_5 + i_B = 4 + 8 = 12A$; $\boxed{V_s = i \times 1 + v_5 = 32V}$

d) $\boxed{\frac{V_s}{i} = \frac{24}{9} = \frac{8}{3}\,\Omega}$ (same for all $= R_{eq}$ seen by source)

1.45



a) $K = 2$; $v = 2i$

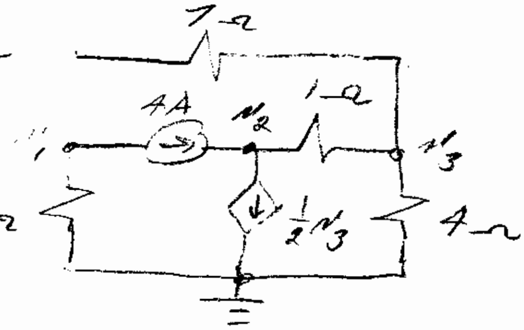
KVL: $-3 + i - 2v + 2i + 3i = 0$

$\therefore$ $i - 2(2i) + 2i + 3i = 3 \Rightarrow 2i = 3$; $\boxed{i = \frac{3}{2}}$

b) $K = 4$; $-3 + i - 4(2i) + 2i + 3i = 0 \Rightarrow -2i = +3$; $\boxed{i = -\frac{3}{2}}$

ES 332 Homework 3 (solution-pages)

2.5



$$\frac{v_1}{1} + \frac{v_1 - v_3}{7} + 4 = 0$$

$$-4 + \frac{1}{2}v_3 + \frac{v_2 - v_3}{1} = 0$$

$$\frac{v_3 - v_1}{7} + \frac{v_3 - v_2}{1} + \frac{v_3}{4} = 0$$

$$\frac{8}{7}v_1 \qquad - \frac{1}{7}v_3 = -4$$

$$v_2 - \frac{1}{2}v_3 = 4$$

$$-\frac{1}{7}v_1 - v_2 + v_3\left(\frac{1}{7} + 1 + \frac{1}{4}\right) = 0 \qquad \scriptstyle 4 + 28 + 7$$

$$8v_1 - v_3 = -28 \qquad v_1 = \frac{v_3 - 28}{8}$$

$$2v_2 - v_3 = 8 \qquad v_2 = \frac{v_3 + 8}{2}$$

$$-4v_1 - 28v_2 + 39v_3 = 0$$

so $-4\left(\frac{v_3 - 28}{8}\right) - 28\left(\frac{v_3 + 8}{2}\right) + 39v_3 = 0$

$$v_3\left(-\frac{1}{2} - 14 + 39\right) = -14 + 4 \times 28$$

$$\boxed{v_3 = \frac{98 \times 2}{49} = 4V}$$

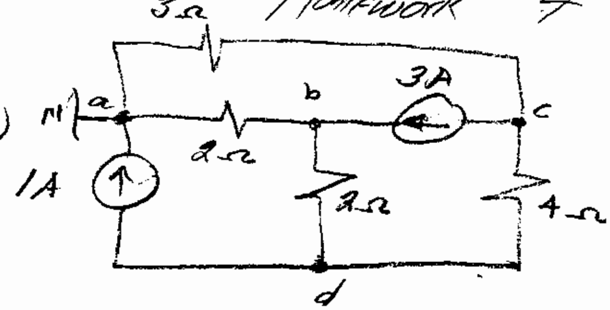
$$\boxed{v_1 = \frac{4 - 28}{8} = -3V}$$

$$\boxed{v_2 = \frac{4 + 8}{2} = 6V}$$

probably a better [illegible] problem

ES332 Homework 4

2.4a)



node b $\dfrac{V_b}{2} + \dfrac{V_b - V_d}{2} = 3$

node c $\dfrac{V_c}{3} + \dfrac{V_c - V_d}{4} = -3$

node d $\dfrac{V_d - V_b}{2} + \dfrac{V_d - V_c}{4} = -1$

$$\left\{\begin{aligned} &V_b - \tfrac{1}{2}V_d = 3 \\ &\tfrac{7}{12}V_c - \tfrac{1}{4}V_d = -3 \\ &\tfrac{3}{4}V_d - \tfrac{1}{4}V_c - \tfrac{1}{2}V_b = -1 \end{aligned}\right.$$

$$\left\{\begin{aligned} &2V_b - V_d = 6 && (1) \\ &7V_c - 3V_d = -36 && (2) \\ &3V_d - V_c - 2V_b = -4 && (3) \end{aligned}\right.$$

from (1) $V_b = \dfrac{6+V_d}{2} = 3 + \tfrac{1}{2}V_d$

from (2) $V_c = \dfrac{3V_d - 36}{7}$

$$\begin{bmatrix} 2V_b & & -V_d = 6 \\ & 7V_c & -3V_d = -36 \\ -2V_b & -V_c & +3V_d = -4 \end{bmatrix}$$

$\therefore$ $V_b = \dfrac{V_d + 6}{2}$; $V_c = \dfrac{3V_d - 36}{7}$

so $-V_d - 6 - \frac{3}{7}V_d + \frac{36}{7} + 3V_d = -4 \Rightarrow V_d\left(-1 - \frac{3}{7} + 3\right) = \left(-4 - \frac{36}{7} + 6\right)$

$$V_d = \frac{-22}{11} = -2V$$

$$V_b = 2V$$

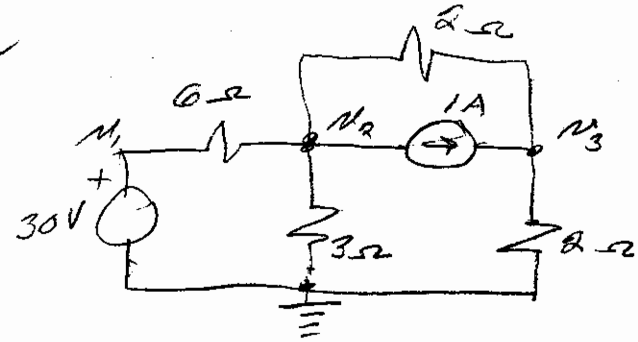
$$V_c = -\frac{42}{7} = -6V$$

$$V_b = \frac{\begin{vmatrix} 6 & 0 & -1 \\ -36 & 7 & -3 \\ -4 & -1 & +3 \end{vmatrix}}{\begin{vmatrix} 2 & 0 & -1 \\ 0 & 7 & -3 \\ -2 & -1 & +3 \end{vmatrix}} = \frac{6(21-3) - 1(36+28)}{2(21-3) - 1(14)} = \frac{108-64}{36-14} = \frac{44}{22} = 2V$$

$$V_c = \frac{\begin{vmatrix} 2 & 6 & -1 \\ 0 & -36 & -3 \\ -2 & -4 & +3 \end{vmatrix}}{22} = \frac{2(-108-12) - 2(-18-36)}{22} = \frac{-240+108}{22} = -6V$$

$$V_d = \frac{\begin{vmatrix} 2 & 0 & 6 \\ 0 & 7 & -36 \\ -2 & -1 & -4 \end{vmatrix}}{22} = \frac{2(-28-36) + 6(14)}{22} = \frac{-128+84}{22} = -2V$$

2.8



$$\boxed{v_1 = 30}$$

$$\frac{v_2 - 30}{6} + \frac{v_2}{3} + \frac{v_2 - v_3}{2} + 1 = 0$$

$$\frac{v_3 - v_2}{2} - 1 + \frac{v_3}{2} = 0$$

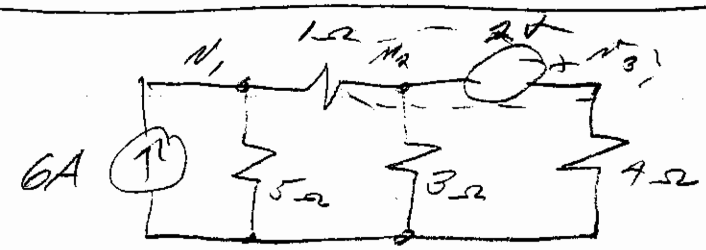
or
$$v_2\left(\frac{1}{6} + \frac{1}{3} + \frac{1}{2}\right) - \frac{1}{2}v_3 = 4$$
$$-\frac{1}{2}v_2 + v_3\left(\frac{1}{2} + \frac{1}{2}\right) = 1$$

$$v_2 - \frac{1}{2}v_3 = 4 \qquad 2v_2 - v_3 = 8$$
$$-\frac{1}{2}v_2 + v_3 = 1 \qquad -v_2 + 2v_3 = 2$$

$$v_2 = \frac{\begin{vmatrix} 8 & -1 \\ 2 & 2 \end{vmatrix}}{\begin{vmatrix} 2 & -1 \\ -1 & 2 \end{vmatrix}} = \frac{16+2}{4-1} = \frac{18}{+3} = \boxed{+6V}$$

$$v_3 = \frac{\begin{vmatrix} 2 & 8 \\ -1 & 2 \end{vmatrix}}{3} = \frac{4+8}{3} = \boxed{4V}$$

2.9.



$$v_3 - v_2 = 2$$
$$-6 + \frac{v_1}{5} + \frac{v_1 - v_2}{1} = 0$$
$$\frac{v_2 - v_1}{1} + \frac{v_2}{3} + \frac{v_3}{4} = 0$$

$$-v_2 + v_3 = 2$$
$$\frac{6}{5}v_1 - v_2 = 6$$
$$-v_1 + \frac{4}{3}v_2 + \frac{1}{4}v_3 = 0$$

$$-v_2 + v_3 = 2$$
$$6v_1 - 5v_2 = 30$$
$$-12v_1 + 16v_2 + 3v_3 = 0$$

$$v_1 = \frac{\begin{vmatrix} 2 & -1 & 1 \\ 30 & -5 & 0 \\ 0 & 16 & 3 \end{vmatrix}}{\begin{vmatrix} 0 & -1 & 1 \\ 6 & -5 & 0 \\ -12 & 16 & 3 \end{vmatrix}} = \frac{2(-15) - 30(-3-16)}{1(18) + 1(96-60)} = \frac{-30-570}{18+36} = \frac{540}{54} = \boxed{10V}$$

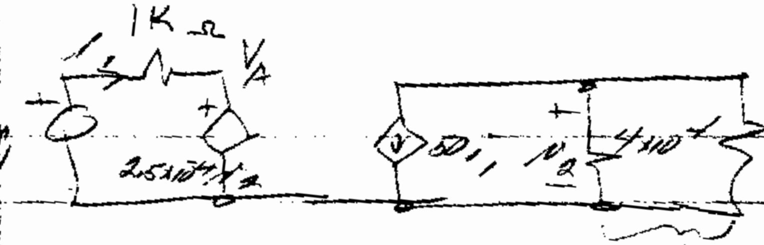
$$v_2 = \frac{\begin{vmatrix} 0 & 2 & 1 \\ 6 & 30 & 0 \\ -12 & 0 & 3 \end{vmatrix}}{54} = \frac{-2(18) + (12 \times 30)}{54} = \frac{-36+360}{54} = \boxed{6V}$$

$$v_3 = \frac{\begin{vmatrix} 0 & -1 & 2 \\ 6 & -5 & 30 \\ -12 & 16 & 0 \end{vmatrix}}{54} = \frac{1(30 \times 12) + 2(96-60)}{54} = \frac{360+72}{54} = \boxed{8V}$$

ES 332 Homework 5

2.11

a)



$$\frac{4}{5}\times10^4 = 8\times10^3 = R_{eq}$$

$$V_A = 2.5\times10^{-4} v_2$$

$$i_1 = \frac{v_1 - V_A}{10^3} = \frac{v_1 - 2.5\times10^{-4} v_2}{10^3}$$

$$50 i_1 + \frac{v_2}{8\times10^3} = 0 = 50\left(10^{-3} v_1 - 2.5\times10^{-7} v_2\right) + 0.125\times10^{-3} v_2$$

$$\therefore \quad 50\times10^{-3} v_1 = 50\times2.5\times10^{-7} v_2 - 0.125\times10^{-3} v_2$$

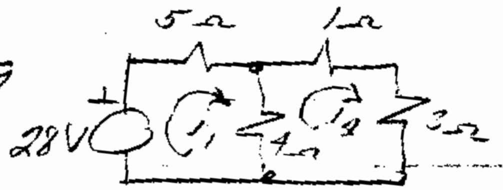
$$v_1 = \left(2.5\times10^{-4} - \overset{0.25\times10^{-3}}{2.5\times10^{-3}}\right) v_2 = -2.25\times10^{-3} v_2$$

$$\frac{v_2}{v_1} = -\frac{1}{2.25\times10^{-3}} = \boxed{-444.44} \leftarrow$$

b) $$i_1 = \frac{v_1 - V_A}{10^3} = \frac{v_1 - 2.5\times10^{-4} v_2}{10^3} = \frac{v_1 - 2.5\times10^{-4}(-444.44) v_1}{10^3}$$

$$\text{so} \quad \frac{v_1}{i_1} = \frac{10^3}{1 + 0.1111} = \boxed{900\ \Omega} \leftarrow$$

2.19



$$28 = 5 i_1 + 4(i_1 - i_2)$$

$$0 = 4(i_2 - i_1) + 4 i_2$$

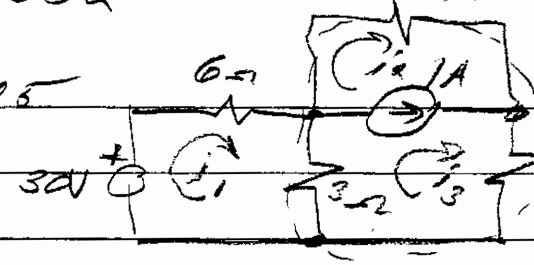
or $$\begin{bmatrix} 9 i_1 - 4 i_2 = 28 \\ -4 i_1 + 8 i_2 = 0 \end{bmatrix}$$

$$i_1 = \frac{\begin{vmatrix} 28 & -4 \\ 0 & 8 \end{vmatrix}}{\begin{vmatrix} 9 & -4 \\ -4 & 8 \end{vmatrix}} = \frac{28\times8}{72-16} = \frac{224}{56} = \boxed{4A} \leftarrow$$

$$\begin{vmatrix} 9 & 28 \\ -4 & 0 \end{vmatrix} \qquad \frac{4\times28}{} = \boxed{2A} \leftarrow$$

ES 332 Homework 5 (solutions – page 2)

2.25



← supermesh

$i_3 - i_2 = 1$

$6i_1 + 3(i_1 - i_3) = 30$

$3(i_3 - i_1) + 2i_2 + 2i_3 = 0$

or
$$\begin{cases} -i_2 + i_3 = 1 \\ 9i_1 - 3i_3 = 30 \\ -3i_1 + 2i_2 + 5i_3 = 0 \end{cases}$$

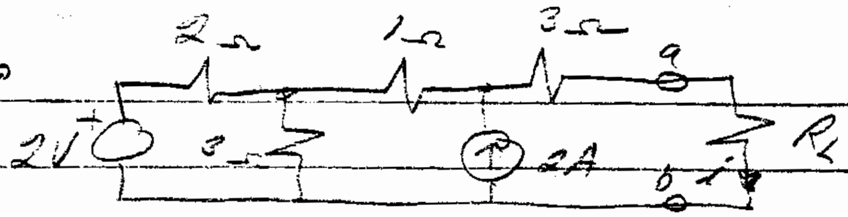
$$i_1 = \frac{\begin{vmatrix} 1 & -1 & 1 \\ 30 & 0 & -3 \\ 0 & 2 & 5 \end{vmatrix}}{\begin{vmatrix} 0 & -1 & 1 \\ 9 & 0 & -3 \\ -3 & 2 & 5 \end{vmatrix}} = \frac{1 \times 6 - 30(-5-2)}{1(45-9) + 1 \times 18} = \frac{6+210}{36+18} = \frac{216}{54} = \boxed{4A}$$

$$i_2 = \frac{\begin{vmatrix} 0 & 1 & 1 \\ 9 & 30 & -3 \\ -3 & 0 & 5 \end{vmatrix}}{54} = \frac{-1(45-9) + 1 \times 90}{54} = \frac{54}{54} = \boxed{1A}$$

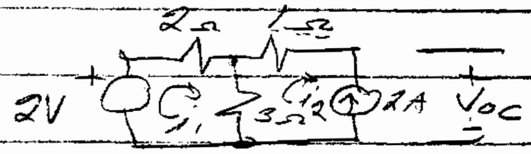
$i_3 = 1 + i_2 = \boxed{2A}$

ES 332 Homework 6

2.39



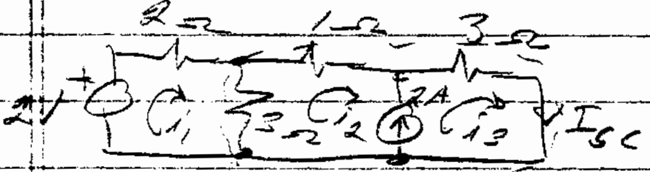
a) $V_{oc} = V_{Th}$



$i_2 = -2A$

$2 = 2i_1 + 3(i_1 - i_2) = 5i_1 - 3(-2)$ or $5i_1 = -4$; $\boxed{i_1 = -\frac{4}{5}}$

$V_{oc} = V_{Th} = -i_2 \times 1 + (i_1 - i_2)3 = 2 + \frac{6}{5} \times 3 = \boxed{\frac{28}{5} V}$



$2 = 2i_1 + 3(i_1 - i_2) = 5i_1 - 3i_2$

$3(i_2 - i_1) + i_2 + 3i_3 = 0 = -3i_1 + 4i_2 + 3i_3$

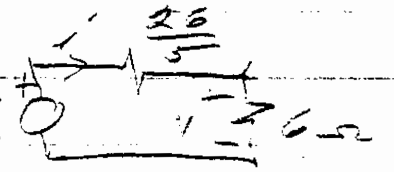
$2 = -i_2 + i_3$

$$I_{sc} = i_3 = \frac{\begin{vmatrix} 5 & -3 & 2 \\ -3 & 4 & 0 \\ 0 & -1 & 2 \end{vmatrix}}{\begin{vmatrix} 5 & -3 & 0 \\ -3 & 4 & 3 \\ 0 & -1 & 1 \end{vmatrix}} = -\frac{2 \times 3 + 2(20-9)}{5(4+3) + 3(-3)} = \boxed{\frac{28}{26} = \frac{14}{13}}$$

$$R_{Th} = \frac{V_{oc}}{I_{sc}} = \frac{\frac{28}{5}}{\frac{14}{13}} = \frac{\cancel{28}^{2} \times 13}{5 \times \cancel{14}} = \boxed{5.2\ \Omega}$$

check $R_{eq} = 3 + 1 + \frac{6}{5} = \frac{26}{5}$?

b)



$$\boxed{i = \frac{\frac{28}{5}}{\frac{56}{5}} = \frac{28}{56} = \frac{1}{2} A}$$

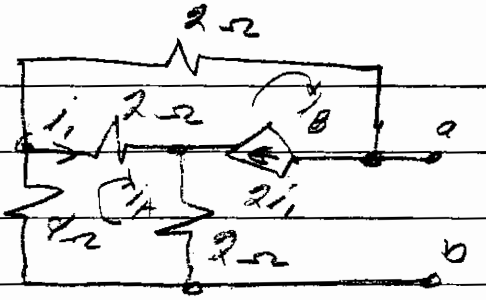
$$\boxed{P_{6\Omega} = i^2 6 = \frac{1}{4} \times 6 = \frac{3}{2}\ \text{Watt}}$$

c) Max power for $R_L = \frac{26}{5}$; $i = \frac{\frac{28}{5}}{\frac{52}{5}} = \frac{28}{52} = 0.538$

$$\boxed{P_{R_{L\,max}} = 1.5077\ \text{Watts}}$$

ES 332 Homework 7

2.43

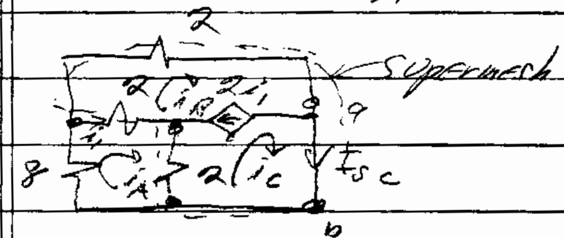


$10i_A + 2(i_A - i_B) = 0$

$i_B = 2i_1 = 2(i_A - i_B) = 2i_A - 2i_B$

$3i_B = 2i_A$ or $\boxed{i_B = \frac{2}{3}i_A}$

$\therefore\ 10i_A + 2i_A - \frac{4}{3}i_A = 0$ so $i_A = i_B = 0$ + $\boxed{V_{oc} = V_{Th} = 0}$



$8i_A + 2(i_A - i_B) + 2(i_A - i_C) = 0$

$2(i_C - i_A) + 2(i_B - i_A) + 2i_B = 0$

$i_B - i_C = 2i_1 = 2(i_A - i_B)$

or $12i_A - 2i_B - 2i_C = 0$

$-4i_A + 4i_B + 2i_C = 0$

$2i_A - 3i_B + i_C = 0$

$i_A = i_B = i_C = 0$ is a solution $\boxed{i_C = I_{sc}}$

$\boxed{R_{Th} = \frac{0}{0}}$ ~~so we are not sure~~

could put 1 amp source where I have labeled I_{sc} above ~~and find resulting V_{ab}~~ then $\frac{V_{ab}}{1} = R_{eq} = R_{Th}$

$\boxed{i_C = 1}$

$$\therefore \begin{cases} 12i_A - 2i_B = 2 \\ -4i_A + 4i_B + V_{ab} = -2 \\ 2i_A - 3i_B = -1 \end{cases}$$

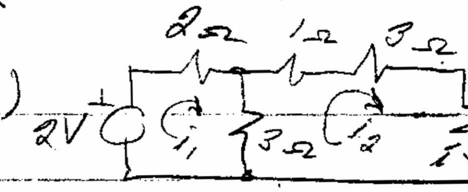
voltage across current source (not shown above)

$$V_{ab} = \frac{\begin{vmatrix} 12 & -2 & 2 \\ -4 & 4 & -2 \\ 2 & -3 & -1 \end{vmatrix}}{\begin{vmatrix} 12 & -2 & 0 \\ -4 & 4 & 1 \\ 2 & -3 & 0 \end{vmatrix}} = \frac{\overset{-120}{12(-4-6)} + \overset{+16}{2(4+4)} + \overset{8}{2(12-8)}}{-1(-36+4)} = \frac{-96}{32} = -3$$

so $\boxed{R_{Th} = -3\ \Omega}$

ES 332 Homework 7 (solutions - page 2)

2.39 b)

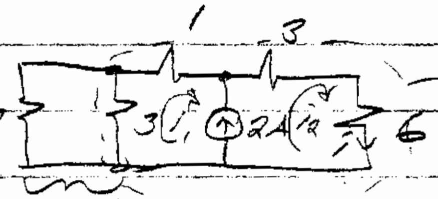


voltage source only

$2 = 5i_1 - 3i_2$

$0 = -3i_1 + 13i_2$

$i_2 = i_{\text{voltage source}} = \dfrac{\begin{vmatrix} 5 & 2 \\ -3 & 0 \end{vmatrix}}{\begin{vmatrix} 5 & -3 \\ -3 & 13 \end{vmatrix}} = \dfrac{6}{65-9} = \dfrac{6}{56} = \boxed{\dfrac{3}{28} A}$



— supermesh $\frac{6}{5}i_1 + i_1 + 3i_2 + 6i_2 = 0$

$i_2 - i_1 = 2$

$R_{eq} = \frac{6}{5}$

or $\left.\begin{array}{l} \frac{11}{5}i_1 + 9i_2 = 0 \\ -i_1 + i_2 = 2 \end{array}\right\}$ $\begin{array}{l} 11i_1 + 45i_2 = 0 \\ -i_1 + i_2 = 2 \end{array}$

$i_2 = \dfrac{\begin{vmatrix} 11 & 0 \\ -1 & 2 \end{vmatrix}}{\begin{vmatrix} 11 & 45 \\ -1 & 1 \end{vmatrix}} = \dfrac{22}{11+45} = \boxed{\dfrac{22}{56} = i_{\text{current source}}}$

$\boxed{i = i_{\text{voltage}} + i_{\text{current}} = \frac{6}{56} + \frac{22}{56} = \frac{28}{56} = \frac{1}{2} A}$

$\boxed{P_{6\Omega} = i^2 \times 6 = \frac{6}{4} = \frac{3}{2} \text{ Watt}}$

Could solve for Thevenin equivalent using superposition and then use result to solve problem with 6Ω load.

from above $V'_{oc_{\text{voltage}}} = 2\,\frac{3}{5} = \frac{6}{5} V$; $V_{oc_{\text{current}}} = 2\left(1 + \frac{6}{5}\right) = \frac{22}{5} V$

$\therefore V_{Th} = V_{oc} = V_{oc_{\text{voltage}}} + V_{oc_{\text{current}}} = \boxed{\frac{28}{5} V}$

for $I_{sc_{\text{voltage}}}$ set 6Ω above $= 0$ then

$2 = 5i_1 - 3I_{sc}$; $0 = -3i_1 + 7I_{sc}$

$I_{sc} = \dfrac{\begin{vmatrix} 5 & 2 \\ -3 & 0 \end{vmatrix}}{\begin{vmatrix} 5 & -3 \\ -3 & 7 \end{vmatrix}} = \dfrac{6}{35-9} = \dfrac{6}{26} = \dfrac{3}{13}$

$I_{sc_{\text{current}}} = 2\,\dfrac{1+\frac{6}{5}}{4+\frac{6}{5}} = 2\,\dfrac{11}{26} = \dfrac{22}{26}$; $\boxed{I_{sc_{\text{total}}} = \frac{6}{26} + \frac{22}{26} = \frac{28}{26} = \frac{14}{13}}$

$R_{Th} = \dfrac{V_{Th}}{I_{sc}} = \dfrac{26}{5}$

ES332 Homework 8

$v_s = v_R + v_L$

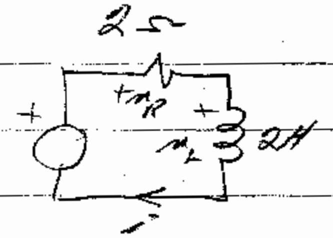
$v_L = L\frac{di}{dt}$

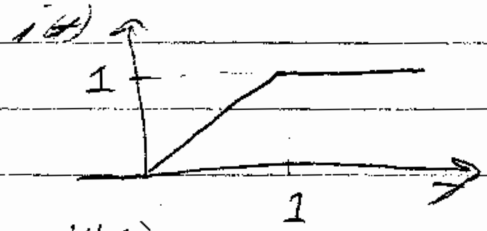
$w_L = \frac{1}{2}Li^2$

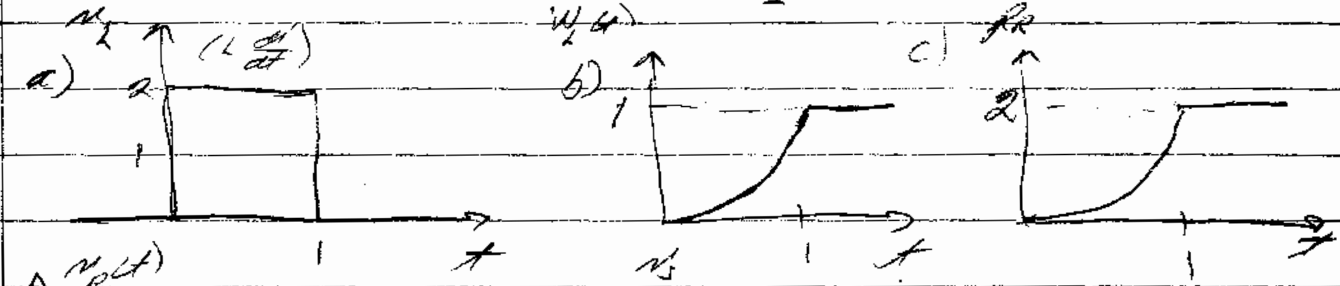
$p_R = i^2R$

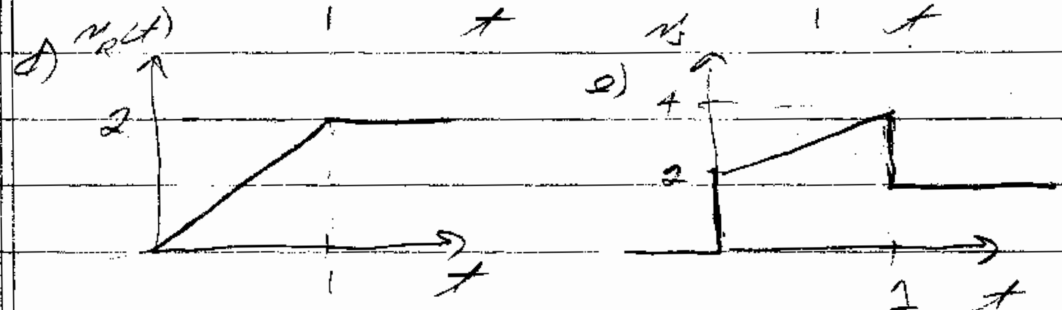
$v_R = iR$

3.1

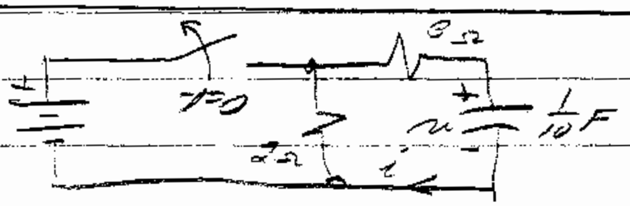








3.28



$\boxed{v_c(0) = 12}$

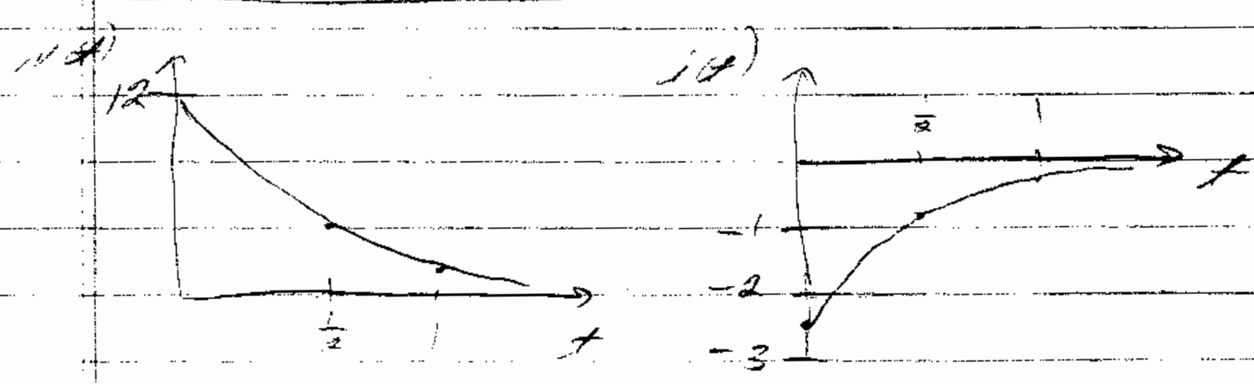
for $t>0$ $\quad 5i + 10\int_0^t i\,dt + 12 = 0$

or $\quad 5\frac{di}{dt} + 10i = 0$; $\quad i = Ae^{st} \quad s = -2 \quad (\tau = \frac{1}{2})$

from initial equation $\quad 5i(0) = -12$ or $i(0) = -\frac{12}{5}$

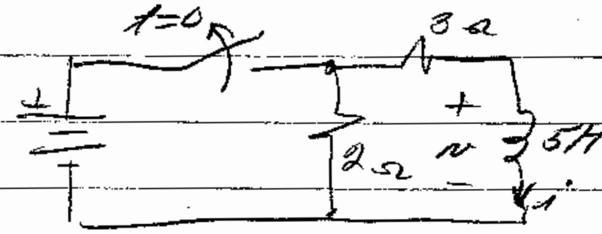
so $\quad \boxed{i(t) = -\frac{12}{5}e^{-2t}}$

$\boxed{v(t) = -5i = 12e^{-2t}}$



ES332 Homework 9

3.29

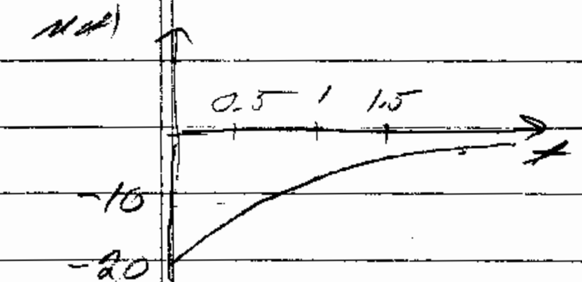


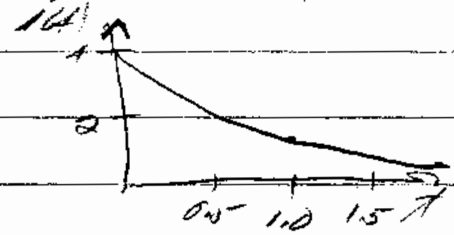
$\boxed{i(0) = 4A}$

$5i + 5\frac{di}{dt} = 0$; $i = Ae^{st}$ $s = -1$

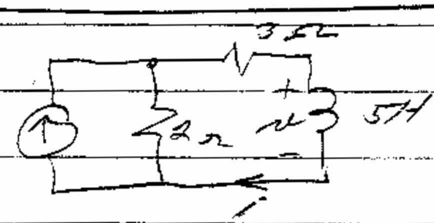
but $i(0) = 4$ so $\boxed{i(t) = 4e^{-t}}$

$\boxed{v(t) = 5\frac{di}{dt} = -20e^{-t}}$





3.30



$i_s = 10$ for $t < 0$

$i_s = 0$ for $t > 0$

this gives $\boxed{i(0) = 10\frac{2}{5} = 4A}$

for $t > 0$ $5i + 5\frac{di}{dt} = 0$ $i = Ae^{-t}$ but $i(0) = 4$

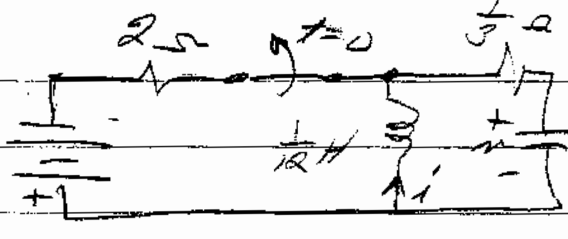
so $\boxed{i = 4e^{-t}}$ ←

$\boxed{\text{and } v(t) = 5\frac{di}{dt} = -20e^{-t}}$

[see curve above]

ES 332 Homework 10

3.57



$i(0) = +4A$

$v(0) = 0V$

(1) $\frac{1}{3} i + \frac{1}{4}\int_0^t i\,dt + \frac{1}{12}\frac{di}{dt} = 0 \Rightarrow \frac{d^2 i}{dt^2} + 4\frac{di}{dt} + 3i = 0$

$s^2 + 4s + 3 = 0 = (s+3)(s+1) \qquad s_{1,2} = -3, -1$

$i(t) = A_1 e^{-3t} + A_2 e^{-t}$ but $i(0) = +4$ ∴ $\boxed{+4 = A_1 + A_2}$

from (1) $+\frac{4}{3} = -\frac{1}{12}\frac{di}{dt}\Big|_{t=0}$ or $\frac{di}{dt}\Big|_{t=0} = \boxed{-16 = -3A_1 - A_2}$

adding two equations for $A_1 + A_2$ gives: $-12 = -2A_1$ or $\boxed{A_1 = 6}$

and $A_2 = \boxed{A_2 = -2}$

∴ $\boxed{i(t) = 6e^{-3t} - 2e^{-t}}$

$v(t) = -\frac{1}{3} i - \frac{1}{12}\frac{di}{dt} = -2e^{-3t} + \frac{2}{3}e^{-t} - \frac{1}{2}(-3)e^{-3t} + \frac{1}{6}(-1)e^{-t}$

$\boxed{v(t) = -\frac{1}{2}e^{-3t} + \frac{1}{2}e^{-t}}$

3.58 same problem with $C = \frac{3}{5}F$ {initial condition the same}

(1) $\frac{1}{3} i + \frac{5}{3}\int_0^t i\,dt + \frac{1}{12}\frac{di}{dt} = 0 \Rightarrow \frac{d^2 i}{dt^2} + 4\frac{di}{dt} + 20 i = 0$

$s^2 + 4s + 20 = 0$; $s_{1,2} = \frac{-4 \pm \sqrt{16 - 80}}{2} = \boxed{-2 \pm j4}$

$i(t) = A_1 e^{-2t}\cos 4t + A_2 e^{-2t}\sin 4t$; $i(0) = +4$; $\boxed{+4 = A_1}$

from (1) $\frac{di}{dt}\Big|_{t=0} = -16 = \left[+4(-2)e^{-2t}\cos 4t + A_2 e^{-2t} 4\cos 4t\right]_{t=0}$

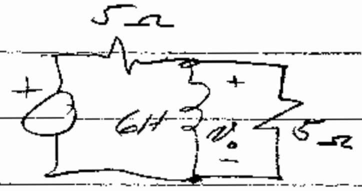
or $-16 = -8 + A_2 4 \Rightarrow \boxed{4A_2 = -8} \Rightarrow A_2 = -2$

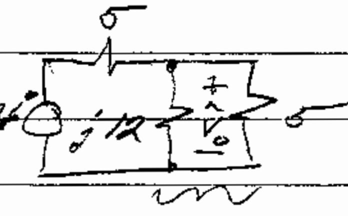
$\boxed{i(t) = +4e^{-2t}\cos 4t - 2e^{-2t}\sin 4t}$

$v(t) = -\frac{1}{3} i - \frac{1}{12}\frac{di}{dt} = \frac{5}{3} e^{-2t}\sin 4t$

ES 332 Homework 11

4.7





$v_s = 13\cos(2t - 22.6^\circ)$

$Z_{eq} = \frac{j60}{5+j12}$

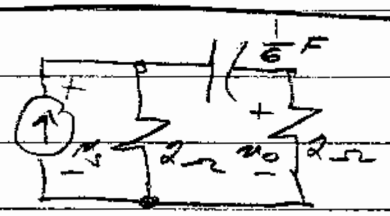
$\hat{V}_0 = 13e^{-j22.6^\circ}\frac{Z_{eq}}{5+Z_{eq}} = 13e^{-j22.6^\circ} \times \frac{j60}{25+j60+j60} = \frac{13\times 60\, e^{j67.4}}{122.5\, e^{j78.23^\circ}}$

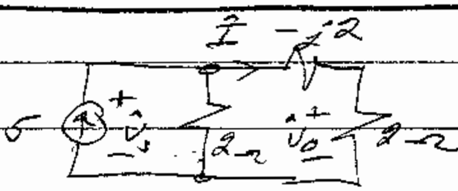
$\hat{V}_0 = 6.37e^{-j10.83^\circ}$

$\boxed{\hat{V}_0 \text{ leads } \hat{V}_s}$

so $v_0(t) = 6.37\cos(2t - 10.83^\circ)$

4.9





$i_s(t) = 5\cos 3t$; $\hat{I} = 5\frac{2}{4-j2}$ so $\hat{V}_0 = 2\hat{I} = \frac{20}{4-j2}$

$\hat{V}_0 = \frac{20}{\sqrt{20}}e^{j26.56^\circ} = \sqrt{20}\,e^{j26.56^\circ} = 4.47e^{j26.56^\circ}$

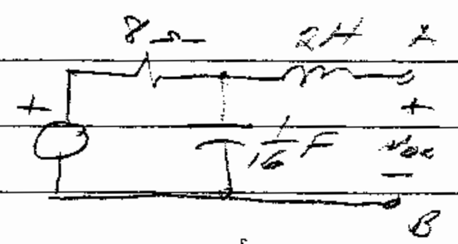
so $v_0(t) = \sqrt{20}\cos(3t + 26.56^\circ)$

$\hat{V}_s = \hat{I}(2-j2) = \frac{10(2-j2)}{4-j2} = \frac{20\sqrt{2}\,e^{-j45^\circ}}{\sqrt{20}\,e^{-j26.56^\circ}} = \sqrt{40}\,e^{-j18.44^\circ}$

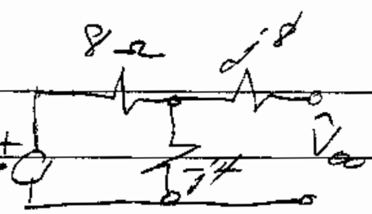
$v_s(t) = \sqrt{40}\cos(3t - 18.44^\circ) = 6.32\cos(3t - 18.44^\circ)$

ES 332 Homework 12

4.17

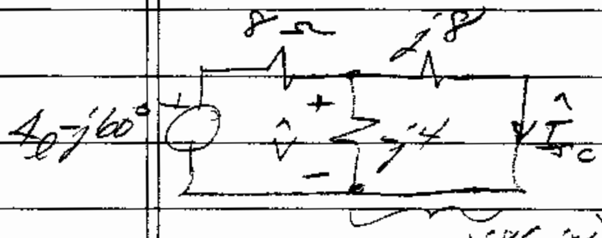


$\Rightarrow$



$v_s = 4\cos(4t - 60°)$

$$\hat{V}_{oc} = \hat{V}_{Th} = \frac{4e^{-j60°}(-j4)}{8 - j4} = \frac{4e^{-j150°}}{\sqrt{5}\, e^{-j26.56°}} = \underline{1.79\, e^{-j123.43°}}$$



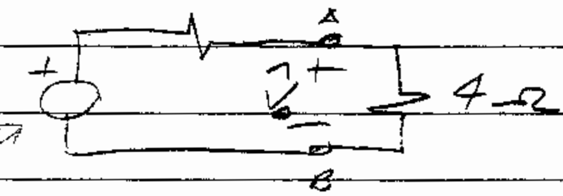
$$\hat{V} = \frac{4e^{-j60°}(-j4)}{8 - j8} = \frac{4e^{-j150°}}{\sqrt{2}\, e^{-j45°}}$$

$$Z_{eq} = \frac{j8(-j4)}{j4} = -j8$$

$$\hat{I}_{sc} = \frac{\hat{V}}{j8} = \frac{4e^{-j150°}}{8e^{j90°}\sqrt{2}\, e^{-j45°}} = \frac{1}{2\sqrt{2}} e^{-j195°}$$

$$Z_{Th} = \frac{\hat{V}_{oc}}{\hat{I}_{sc}} = \frac{1.79e^{-j123.43°}\, 2\sqrt{2}\, e^{j195°}}{1} = 5.06\, e^{j71.57°}$$

so we have:



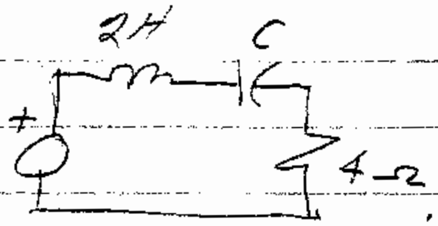
$$\hat{V}_o = 1.79\, e^{-j123.43} \frac{4}{4 + 5.06e^{j71.57°}} = \frac{7.16\, e^{-j123.43°}}{5.6 + j4.8}$$

$$\hat{V}_o = \frac{7.16e^{-j123.43°}}{7.37e^{j40.6°}} = 0.972\, e^{-j164°}$$

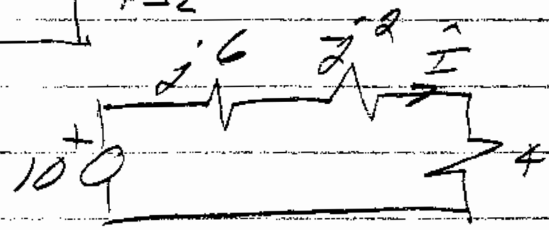
$$\boxed{\therefore\ v_o(t) = 0.972\cos(4t - 164°)}$$

ES 332 Homework 12 (solutions page 2)

4.28



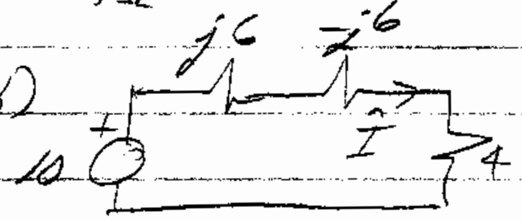
a) $C = \frac{1}{6}\ F$



$$\hat{I} = \frac{10}{4+j4} = \frac{10\, e^{-j45^\circ}}{4\sqrt{2}} = \boxed{1.768\, e^{-j45^\circ}}$$

$$P_{ave_{4\Omega}} = \frac{1}{2}|\hat{I}|^2 4 = 2 \times 1.768^2 = \boxed{6.25 \text{ Watts}} \leftarrow$$

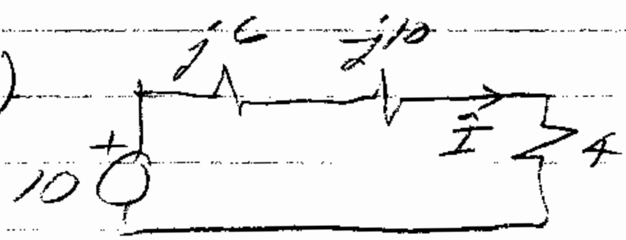
b)



$$\hat{I} = \frac{10}{4} = \frac{5}{2}$$

$$P_{ave_{4\Omega}} = \frac{1}{2} \cdot \frac{25}{\cancel{4}} \cdot \cancel{4} = \frac{25}{2} = \boxed{12.5\ W}$$

c)



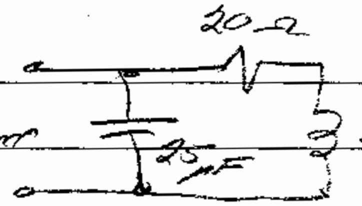
$$\hat{I} = \frac{10}{4-j4}$$

$$\hat{I} = \frac{10}{4\sqrt{2}}\, e^{+j45^\circ}$$

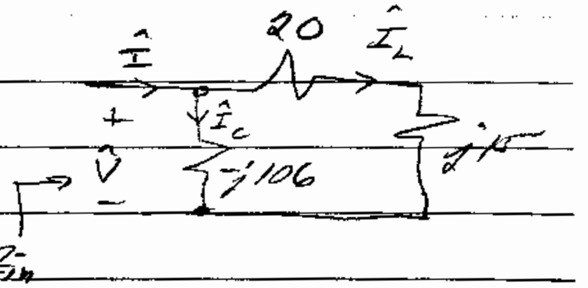
$$P_{ave_{4\Omega}} = \frac{1}{2}|\hat{I}|^2 4 = \boxed{6.25 \text{ Watts}} \leftarrow$$

ES 332 Homework 13

4.41



⇒



$\frac{1}{j\omega C} = -j\frac{1}{2\pi \times 60 \times 25 \times 10^{-6}} \cong -j106.1$

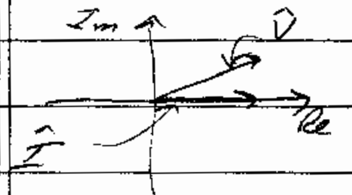
$j\omega L = j\,2\pi \times 60 \times 4 \times 10^{-2} \cong j15$

a) $Z_{in} = \frac{\hat{V}}{\hat{I}} = \frac{-j106(20+j15)}{20-j91} = \frac{106 e^{-j90^\circ}\, 25\, e^{j36.86^\circ}}{93.17 e^{-j77.6^\circ}} = 28.44\, e^{j24.46^\circ}$

so $\theta_v - \theta_i = 24.46^\circ$ (power factor angle)

p.f. $= \cos(24.46^\circ) = 0.91$

b)

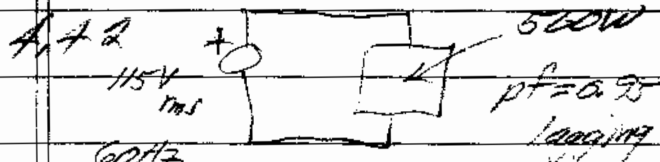


current lags voltage

c) $\hat{I}_L = \frac{\hat{V}}{20+j15} = \hat{V}\,\frac{20-j15}{625}$ ∴ want $\hat{I}_c = +\hat{V}\frac{j15}{625}$

$\hat{I}_c = \hat{V} j\omega C$ ∴ $j\omega C = j\frac{3}{125}$ or $\boxed{C = \frac{3}{125 \times 2\pi \times 60} = 63.7\,\mu F}$

4.42

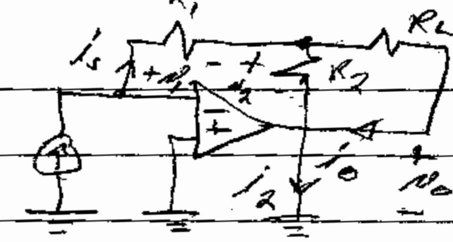


$P_{500} = V_{rms} I_{rms} (p.f.)$

∴ $\boxed{I_{rms} = \frac{P_{500}}{V_{rms}\, 0.95} = \frac{500}{115 \times 0.95} = 4.58\text{ A}}$

ES 332 Homework 14 2.28 2.30

2.28



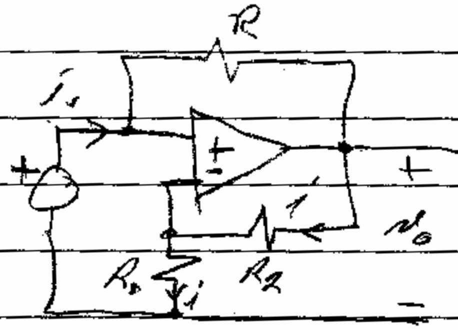
$v_1 = i_s R_1$; $v_2 = -v_1$

$\therefore i_2 = \frac{v_2}{R_2} = -\frac{v_1}{R_2} = -\frac{i_s R_1}{R_2}$

$i_o = i_s - i_2 = i_s + i_s \frac{R_1}{R_2} = i_s\left(1 + \frac{R_1}{R_2}\right) \leftarrow$

$v_o = -i_o R_L + i_2 R_2 = -i_s\left(1+\frac{R_1}{R_2}\right)R_L - i_s R_1 = -i_s\left(R_L + R_1 + \frac{R_1 R_L}{R_2}\right) \leftarrow$

2.30



$i = \frac{v_s}{R_1}$; $v_o = i(R_1 + R_2)$

or $v_o = v_s\left(1 + \frac{R_2}{R_1}\right) \leftarrow$

$i_s = \frac{v_s - v_o}{R} = \frac{v_s\left(\cancel{1} - \cancel{1} - \frac{R_2}{R_1}\right)}{R} = -v_s \frac{R_2}{R_1 R} \leftarrow$

$\therefore \boxed{\frac{v_s}{i_s} = -\frac{R_1 R}{R_2}} \leftarrow$

Assignment 15

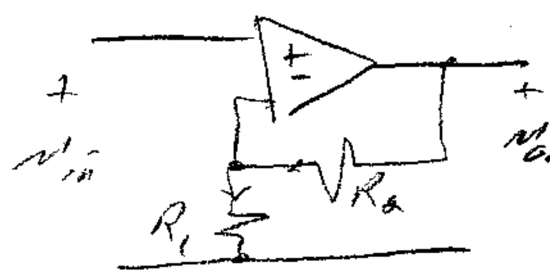
A temperature sensor has an output of 0.01 volts per degree Fahrenheit from T = 0 to T = 100°F (at T = 0 V_{out} = 0). Design an Op-Amp circuit using this sensor that will provide an output voltage of 0 to 10 Volts for a temperature variation of 0 to 100°F.

for sensor @ $T=0$ $V_{out}=0$

@ $T=100°F$ $V_{out}=0.01\times 100 = 1V$

We want output to vary from 0→10 Volts

so we need a circuit with a gain of +10



$i = \frac{v_{in}}{R_1}$

$v_{out} = i(R_1+R_2)$

$\therefore v_{out} = v_{in}\left(1+\frac{R_2}{R_1}\right)$

for a gain of 10, $\boxed{\frac{R_2}{R_1} = 9}$

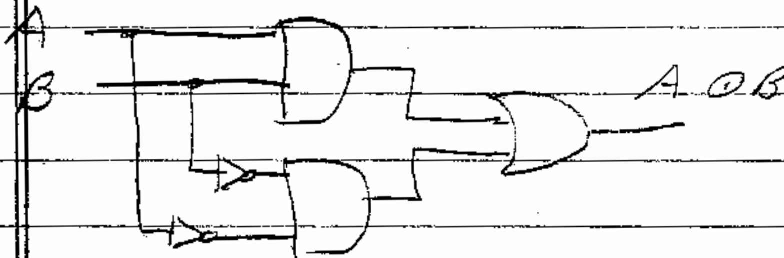
ES 332 Homework 16

11-26

A	B	$A \odot B$
0	0	1
0	1	0
1	0	0
1	1	1

← "exclusive" NOR

$A \odot B = \bar{A}\bar{B} + AB$



ES 332 Homework 17

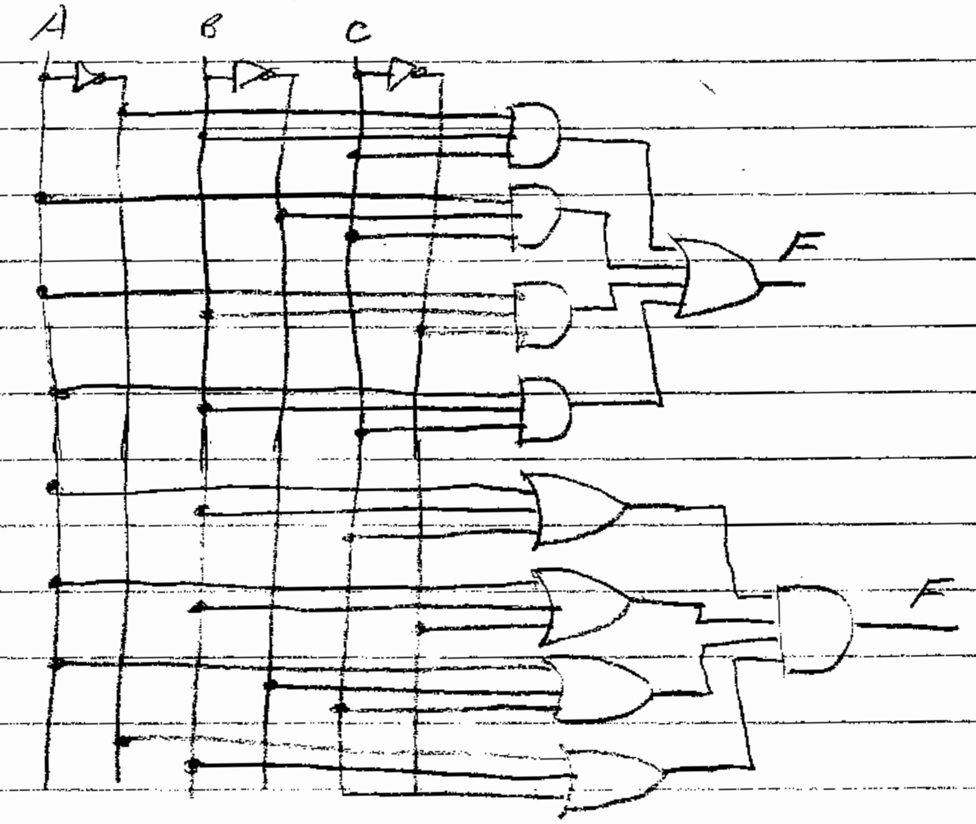
N.44

A	B	C	F
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

a) $F = m_3 + m_5 + m_6 + m_7$

b) $F = M_0 \cdot M_1 \cdot M_2 \cdot M_4$

a)



b)

N.53

A \ BC	00	01	11	10
0	0	1	1	1
1	1	1	0	0

A \ BC	00	01	11	10
0	0	0	0	1
1	1	0	1	1

A \ BC	00	01	11	10
0	1	1	1	1
1	0	1	0	1

$F = \bar{A}C + \bar{A}B + A\bar{B}$; $F = A\bar{C} + AB + B\bar{C}$; $F = \bar{A} + \bar{B}C + B\bar{C}$