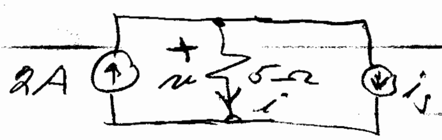
ES 332 Homework 1

1.7 a) $v_1 = 5 i_1 = 20$ Volts ✓

b) $v_2 = -4 i_2 = 8$ Volts ✓

c) $v_3 = -3 i_3 = -6$ Volts

d) $v_4 = i_4 = -2$ Volts

1.16 

$\boxed{i = 2 - i_s}$

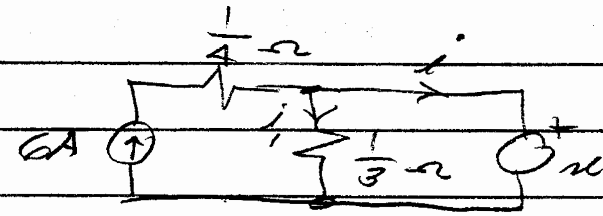
a) $i_s = 1 \therefore i = 1$ and $\boxed{v = 5V}$

b) $i_s = 2 \therefore i = 0$ and $\boxed{v = 0V}$

c) $i_s = 3 \therefore i = -1$ and $\boxed{v = -5V}$

ES 332 Homework 2 (Solutions)

1.17



a) $v = 1$

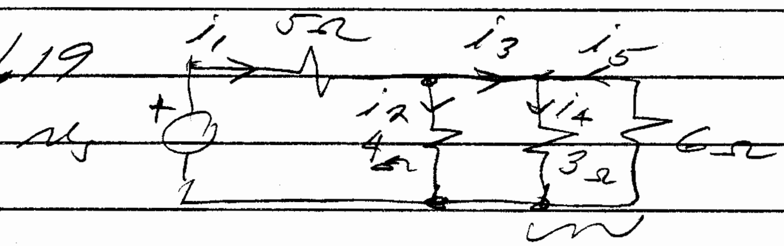
$i = 6 - i_1 = 6 - 3v$

$\therefore \boxed{i = 3 \text{ Amperes}}$

b) $v = 2 \quad \therefore \quad \boxed{i = 6 - 6 = 0 \text{ Amperes}}$

c) $v = 3 \quad \therefore \quad \boxed{i = 6 - 9 = -3 \text{ Amperes}}$

1.19



$\boxed{i_1 = 6}$

$R_{eq} = \frac{3 \times 6}{9} = 2\,\Omega$

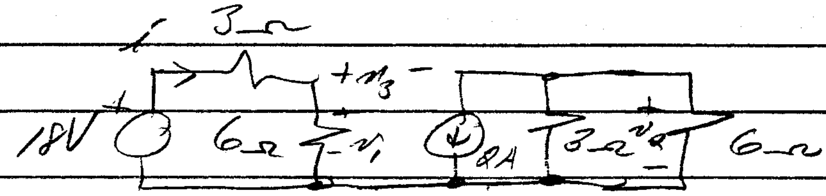
$\therefore i_2 = 6\,\frac{2}{6} = \boxed{2 \text{ Amperes}}$

$i_3 = 6\,\frac{4}{6} = \boxed{4 \text{ Amperes}}$

$i_4 = i_3\,\frac{6}{9} = \boxed{\frac{8}{3} \text{ Amperes}}$

$\boxed{i_5 = -i_3\,\frac{3}{9} = -\frac{4}{3}}$

ES 332 Homework 3 (Solutions)

1.32


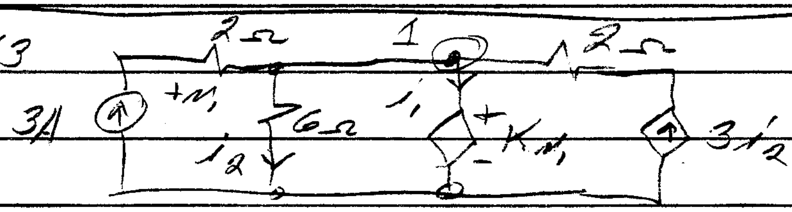
a) $i = \frac{18}{9} = 2A$

$v_1 = 2 \times 6 = 18V$

$v_2 = -2\,\frac{18}{9} = -4V$

$v_3 = v_1 - v_2 = 22V$

b) $i, v_1,$ and v_2 are the same!

1.43


a) $K = -3$; $v_1 = 6$ Volts $\therefore Kv_1 = -18$

so $i_2 = \frac{Kv_1}{6} = -3$; KCL @ node1 $-3 + i_2 + i_1 - 3i_2 = 0$

$\therefore \boxed{i_1 = 2i_2 + 3 = -6 + 3 = -3A}$

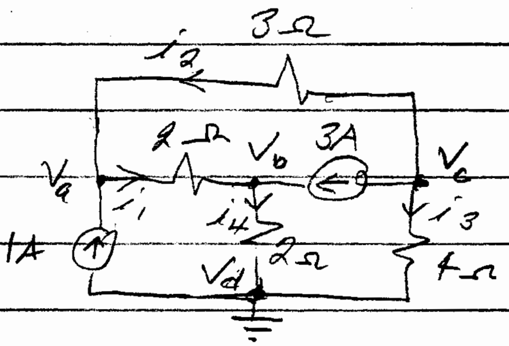
Node Voltages $-3 + i_2 + i_1 - 3i_2 = 0$

or $i_1 = 3 + 2i_2 = 3 + 2\,\frac{Kv_1}{6} = 3 + \frac{(-3)\,6}{3}$

$i_1 = -3A$

ES 332 Homework 3 (Solution - page 2)

2.1



$$\frac{V_a - V_b}{2} + \frac{V_a - V_c}{3} = 1$$

$$\frac{V_b - V_a}{2} + \frac{V_b}{2} = 3$$

$$\frac{V_c - V_a}{3} + \frac{V_c}{4} = -3$$

or

$$V_a\left(\frac{5}{6}\right) - V_b\left(\frac{1}{2}\right) - V_c\left(\frac{1}{3}\right) = 1$$
$$-V_a\left(\frac{1}{2}\right) + V_b = 3$$
$$-V_a\left(\frac{1}{3}\right) + V_c\left(\frac{7}{12}\right) = -3$$

$$\left.\right\} \quad \begin{aligned} 5V_a - 3V_b - 2V_c &= 6 \\ -V_a + 2V_b &= 6 \\ -4V_a + 7V_c &= -36 \end{aligned}$$

a)

$$V_b = \frac{\begin{vmatrix} 5 & 6 & -2 \\ -1 & 6 & 0 \\ -4 & -36 & 7 \end{vmatrix}}{\begin{vmatrix} 5 & -3 & -2 \\ -1 & 2 & 0 \\ -4 & 0 & 7 \end{vmatrix}} = \frac{-2\overbrace{(36+24)}^{60} + 7\overbrace{(30+6)}^{36}}{-2(8) + 7(10-3)} = \boxed{\frac{132}{33} = 4}$$

$$V_a = \frac{\begin{vmatrix} 6 & -3 & -2 \\ 6 & 2 & 0 \\ -36 & 0 & 7 \end{vmatrix}}{33} = \frac{\overbrace{-2(72)}^{-144} + \overbrace{7(12+18)}^{210}}{33} = \boxed{2\,V}$$

$$V_c = \frac{\begin{vmatrix} 5 & -3 & 6 \\ -1 & 2 & 6 \\ -4 & 0 & -36 \end{vmatrix}}{33} = \frac{\overbrace{-4(-18-12)}^{+120} \overbrace{-36(10-3)}^{252}}{33} = \boxed{-4}$$

b)

$$i_1 = \frac{V_a - V_b}{2} = -1\ A$$

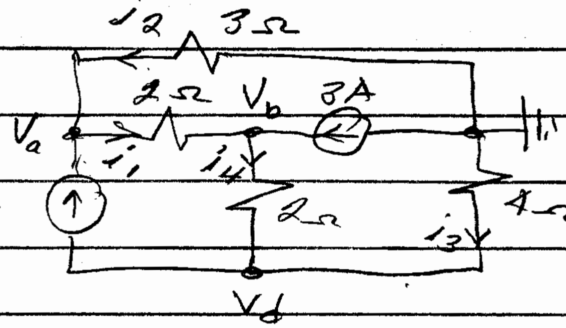
$$i_2 = \frac{V_c - V_a}{3} = -2\ A$$

$$i_3 = \frac{V_c}{4} = -1\ A$$

$$i_4 = \frac{V_b}{2} = 2\ A$$

ES 332 Homework 3 (Solution - page 3)

2.2



@ V_a: $\dfrac{V_a - V_b}{2} + \dfrac{V_a}{3} = 1$

@ V_b: $\dfrac{V_b - V_a}{2} + \dfrac{V_b - V_d}{2} = 3$

@ V_d: $\dfrac{V_d - V_b}{2} + \dfrac{V_d}{4} = -1$

or

$$\left.\begin{aligned} \tfrac{5}{6}V_a - \tfrac{1}{2}V_b &= 1 \\ -\tfrac{1}{2}V_a + V_b - \tfrac{1}{2}V_d &= 3 \\ -\tfrac{1}{2}V_b + \tfrac{3}{4}V_d &= -1 \end{aligned}\right\} \quad \begin{aligned} 5V_a - 3V_b &= 6 \\ -V_a + 2V_b - V_d &= 6 \\ -2V_b + 3V_d &= -4 \end{aligned}$$

$$V_a = \frac{\begin{vmatrix} 6 & -3 & 0 \\ 6 & 2 & -1 \\ -4 & -2 & 3 \end{vmatrix}}{\begin{vmatrix} 5 & -3 & 0 \\ -1 & 2 & -1 \\ 0 & -2 & 3 \end{vmatrix}} = \frac{\overset{24}{6(6-2)} + \overset{42}{3(18-4)}}{\underset{20}{5(6-2)} + \underset{-9}{3(-3)}} = \frac{66}{11} = \underline{\underline{6\,V}}$$

$$V_b = \frac{\begin{vmatrix} 5 & 6 & 0 \\ -1 & 6 & -1 \\ 0 & -4 & 3 \end{vmatrix}}{11} = \frac{\overset{70}{5(18-4)} - \overset{18}{6(-3)}}{11} = \underline{\underline{8\,V}}$$

$$V_d = \frac{\begin{vmatrix} 5 & -3 & 6 \\ -1 & 2 & 6 \\ 0 & -2 & -4 \end{vmatrix}}{11} = \frac{\overset{20}{5(-8+12)} + \overset{24}{(12+12)}}{11} = \underline{\underline{4\,V}}$$

$\therefore$ $i_1 = \dfrac{V_a - V_b}{2} = -1\,A$

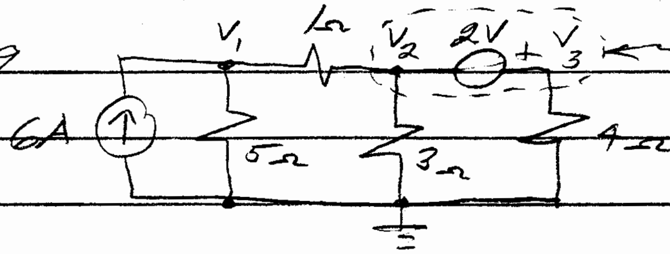
$i_2 = -\dfrac{V_a}{3} = -2\,A$

$i_3 = -\dfrac{V_d}{4} = -1\,A$

$i_4 = \dfrac{V_b - V_d}{2} = 2\,A$

ES 332 Homework 4 (Solutions)

2.9



← supernode?

node 1: $\dfrac{V_1}{5} + \dfrac{V_1 - V_2}{1} = 6$

supernode: $\dfrac{V_2 - V_1}{1} + \dfrac{V_2}{3} + \dfrac{V_3}{4} = 0$

$V_3 - V_2 = 2 \Rightarrow V_3 = V_2 + 2$

$$\frac{6}{5}V_1 - V_2 = 6$$

$$-V_1 + \underbrace{\frac{4}{3}V_2 + \frac{V_2}{4}}_{\frac{19}{12}V_2} = -\frac{1}{2}$$

or

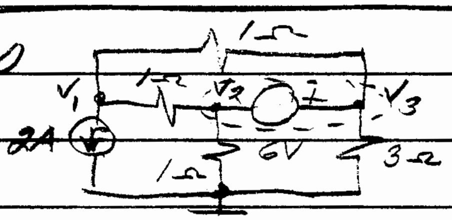
$$\left[\begin{array}{l} 6V_1 - 5V_2 = 30 \\ -12V_1 + 19V_2 = -6 \end{array}\right]$$

$$V_1 = \frac{\begin{vmatrix} 30 & -5 \\ -6 & 19 \end{vmatrix}}{\begin{vmatrix} 6 & -5 \\ -12 & 19 \end{vmatrix}} = \frac{540}{54} = \boxed{10\ \text{Volts}} \leftarrow$$

$$V_2 = \frac{\begin{vmatrix} 6 & 30 \\ -12 & -6 \end{vmatrix}}{54} = \frac{324}{54} = \boxed{6\ \text{Volts}} \leftarrow$$

$$V_3 = V_2 + 2 = \boxed{8\ \text{Volts}} \leftarrow$$

2.10



$\dfrac{V_1 - V_3}{1} + \dfrac{V_1 - V_2}{1} = -2$

$\dfrac{(V_2 - V_1)}{1} + \dfrac{V_2}{1} + \dfrac{V_3 - V_1}{1} + \dfrac{V_3}{3} = 0$

$V_3 - V_2 = 6$

$$2V_1 - V_2 - V_3 = -2$$
$$-2V_1 + 2V_2 + \frac{4}{3}V_3 = 0$$
$$-V_2 + V_3 = 6$$

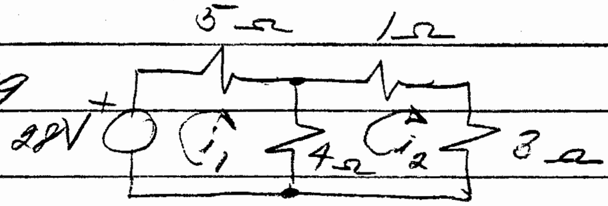
$$V_1 = \frac{\begin{vmatrix} -2 & -1 & -1 \\ 0 & 2 & 4/3 \\ 6 & -1 & 1 \end{vmatrix}}{\begin{vmatrix} 2 & -1 & -1 \\ -2 & 2 & 4/3 \\ 0 & -1 & 1 \end{vmatrix}} = \frac{-2\left(2+\frac{4}{3}\right) + 6\left(-\frac{4}{3}+2\right)}{2\left(2+\frac{4}{3}\right) + 2(-1-1)} = \frac{-\frac{8}{3}}{\frac{20}{3} - \frac{12}{3}} = \boxed{-1\,V} \leftarrow$$

$$V_2 = \frac{\begin{vmatrix} 2 & -2 & -1 \\ -2 & 0 & 4/3 \\ 0 & 6 & 1 \end{vmatrix}}{8/3} = \frac{2(-8) + 2(-2+6)}{8/3} = \boxed{\frac{-8 \times 3}{8} = -3} \leftarrow$$

$$\boxed{V_3 = 6 + V_2 = 3V} \leftarrow$$

ES 332 Homework 4 (Solutions page 2)

2.19



$$5i_1 + 4(i_1 - i_2) = 28$$
$$4(i_2 - i_1) + i_2 + 3i_2 = 0$$

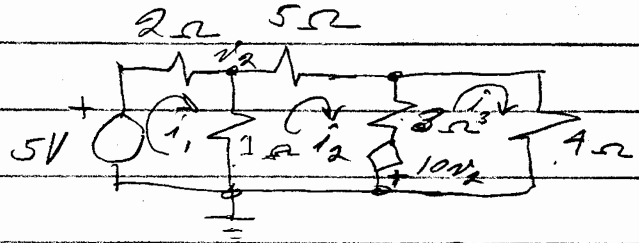
$$\left.\begin{array}{l} 9i_1 - 4i_2 = 28 \\ -4i_1 + 8i_2 = 0 \end{array}\right\} \quad \begin{array}{l} 9i_1 - 4i_2 = 28 \\ -i_1 + 2i_2 = 0 \end{array}$$

$$i_1 = \frac{\begin{vmatrix} 28 & -4 \\ 0 & 2 \end{vmatrix}}{\begin{vmatrix} 9 & -4 \\ -1 & 2 \end{vmatrix}} = \frac{2 \times 28}{18 - 4} = \frac{2 \times \cancel{28}^{2}}{\cancel{14}} = \boxed{4A}$$

$$i_2 = \frac{\begin{vmatrix} 9 & 28 \\ -1 & 0 \end{vmatrix}}{14} = \frac{28}{14} = \boxed{2A}$$

ES 332 Homework 5 (Solutions)

2.20



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

$(i_2 - i_1) + 5i_2 + 3(i_2 - i_3) - 10v_2 = 0$

$10v_2 + 3(i_3 - i_2) + 4i_3 = 0$

$v_2 = i_1 - i_2$

giving:

$3i_1 - i_2 = 5$

$-11i_1 + 19i_2 - 3i_3 = 0$

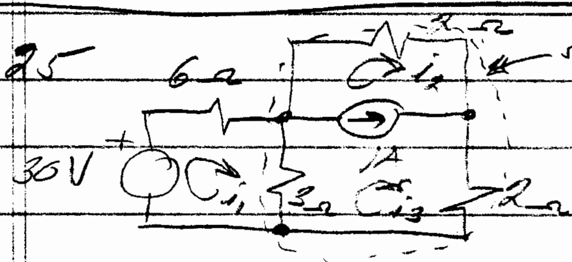
$10i_1 - 13i_2 + 7i_3 = 0$

$$i_1 = \frac{\begin{vmatrix} 5 & -1 & 0 \\ 0 & 19 & -3 \\ 0 & -13 & 7 \end{vmatrix}}{\begin{vmatrix} 3 & -1 & 0 \\ -11 & 19 & -3 \\ 10 & -13 & 7 \end{vmatrix}} = \frac{5(133-39)}{3(133-39)+(-77+30)} = \frac{470}{282-47} = \boxed{2A}$$

$$i_2 = \frac{\begin{vmatrix} 3 & 5 & 0 \\ -11 & 0 & -3 \\ 10 & 0 & 7 \end{vmatrix}}{235} = \frac{-5(-77+30)}{235} = \boxed{1A}$$

$$i_3 = \frac{\begin{vmatrix} 3 & -1 & 5 \\ -11 & 19 & 0 \\ 10 & -13 & 0 \end{vmatrix}}{235} = \frac{5(143-190)}{235} = \boxed{-1A}$$

2.25



$i_3 - i_2 = 1 \Rightarrow \boxed{i_3 = 1 + i_2}$

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

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

giving:

$9i_1 - 3i_2 = 33$

$-3i_1 + 7i_2 = -5$

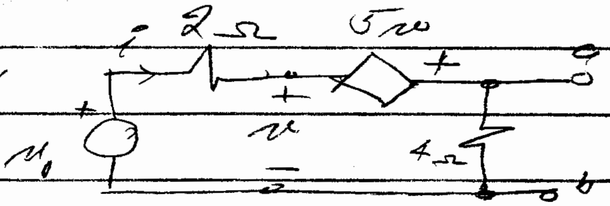
$$i_1 = \frac{\begin{vmatrix} 33 & -3 \\ -5 & 7 \end{vmatrix}}{\begin{vmatrix} 9 & -3 \\ -3 & 7 \end{vmatrix}} = \frac{231-15}{63-9} = \frac{216}{54} = \boxed{4A}$$

$$i_2 = \frac{\begin{vmatrix} 9 & 33 \\ -3 & -5 \end{vmatrix}}{54} = \frac{-45+99}{54} = \boxed{1A}$$

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

ES 332 Homework 6 (Solutions)

2.44



$v_1 = 6i - 5v$

$v = v_1 - 2i$

$\therefore\ v_1 = 6i - 5(v_1 - 2i) \Rightarrow 6v_1 = 16i\ ;\ i = \frac{3}{8} v_1$

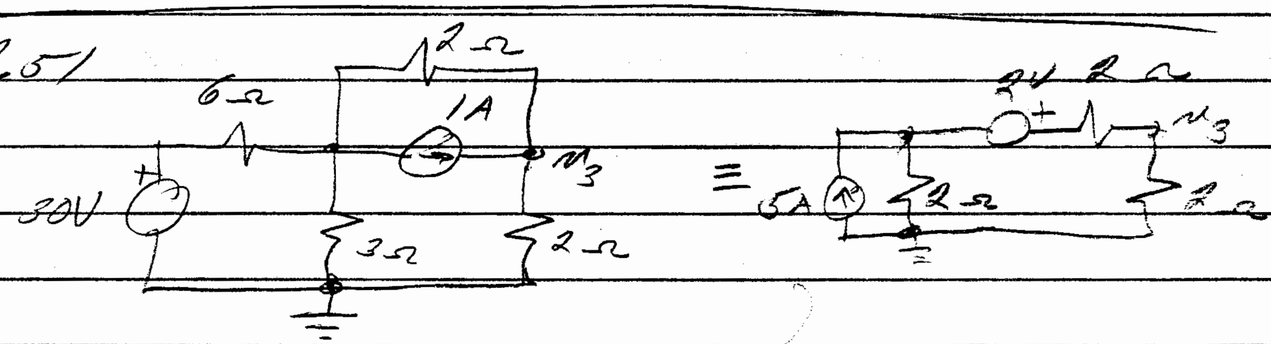
so $\boxed{V_{oc} = V_{Th} = 4i = \frac{3}{2} v_1}$

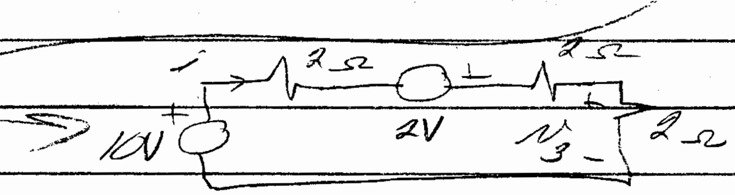
for I_{sc}: $v_1 = 2I_{sc} - 5v = 2I_{sc} - 5(v_1 - 2I_{sc})$

$6v_1 = 12 I_{sc}\ ;\ \boxed{I_{sc} = \frac{1}{2} v_1}$

thus $\boxed{R_{Th} = \frac{V_{oc}}{I_{sc}} = 3\ \Omega}$

2.51



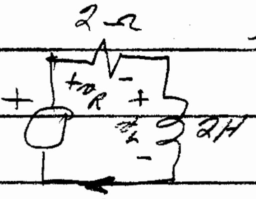


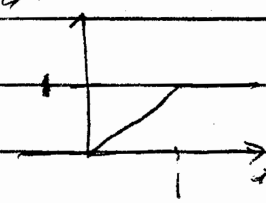
$i = \frac{12}{6} = 2$

$\therefore\ \boxed{v_3 = 4\ \text{Volt}}$

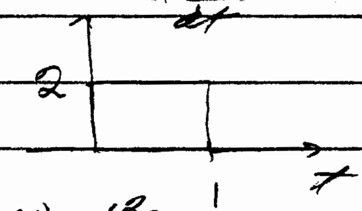
ES 332 Homework 7 (Solutions)

3.1

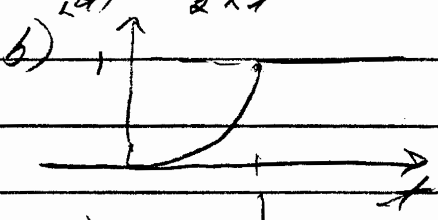




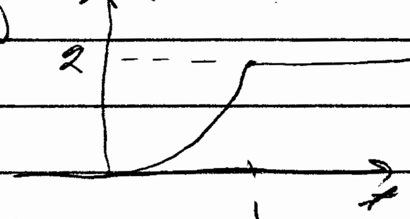
a) $v_L(t) = 2\frac{di}{dt}$



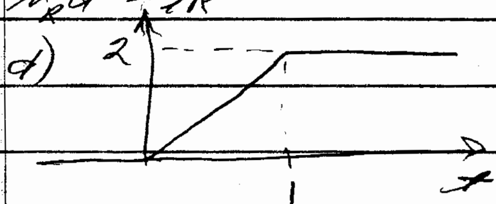
b) $w_L(t) = \frac{1}{2}Li^2$



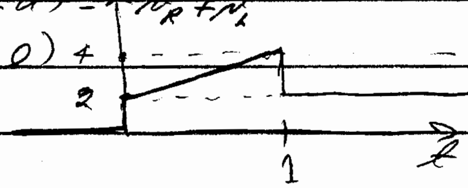
c) $p_R(t) = i^2R$



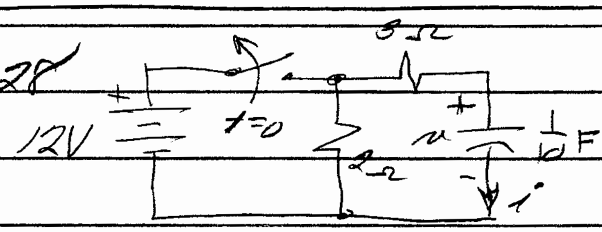
d) $v_R(t) = iR$



e) $v_s(t) = v_R + v_L$



3.28



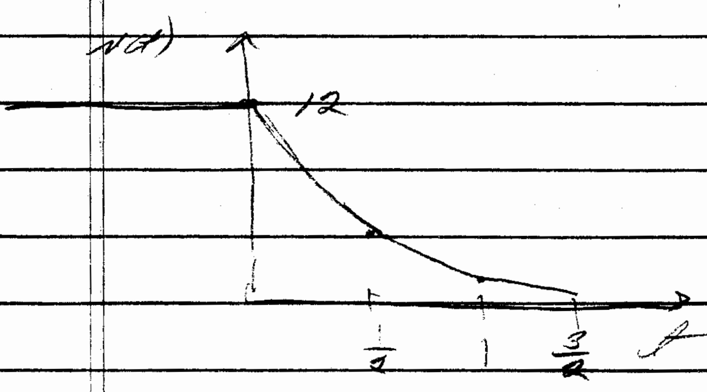
$v(0) = 12$

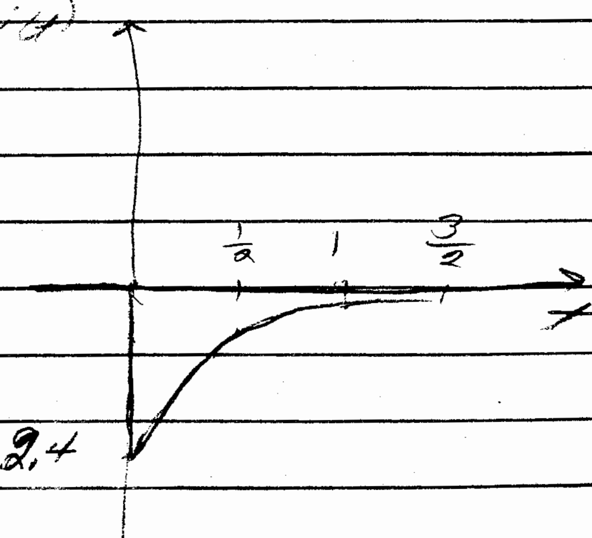
$\frac{v}{5} + \frac{1}{10}\frac{dv}{dt} = 0$

or $\frac{dv}{dt} + 2v = 0 \quad v = Ae^{st} \Rightarrow s = -2$

$\therefore v = Ae^{-2t}$ but $v(0) = 12 \therefore \boxed{v = 12e^{-2t}}$

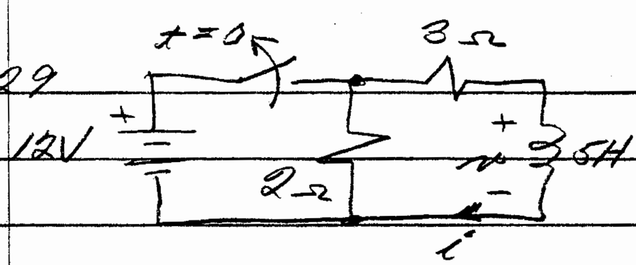
$i = C\frac{dv}{dt} = \frac{1}{10}(-24)e^{-2t} = \boxed{-2.4e^{-2t}}$





ES 332 Homework 8 (Solutions)

3.29

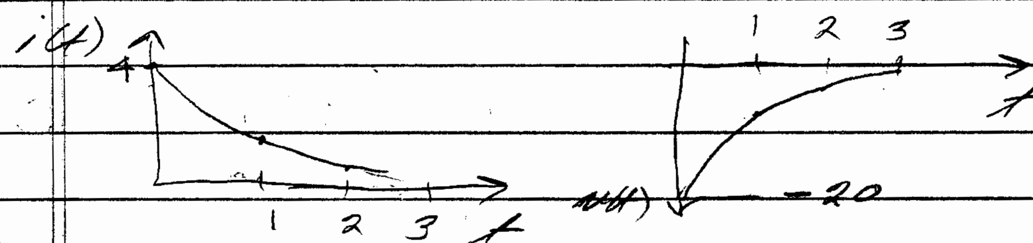


$i(0) = \frac{12}{3} = 4A$

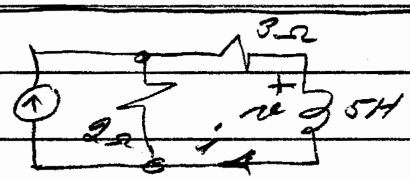
for $t > 0$ $\quad 5i + 5\frac{di}{dt} = 0 \quad ; \quad i = Ae^{st} \Rightarrow s = -1$

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

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



3.30



$i_s(t) = 10$ for $t < 0$

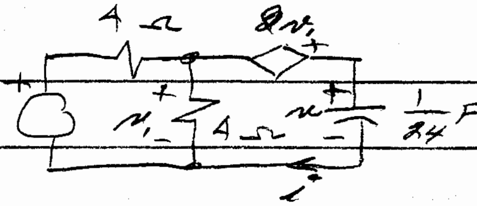
$i_s(t) = 0$ for $t \geq 0$

$\therefore \; i(0) = 10\,\frac{2}{5} = 4$

so we see that for $t > 0$ this is the same as problem 3.29 !

ES 332 Homework 9 (Solutions)

3.34

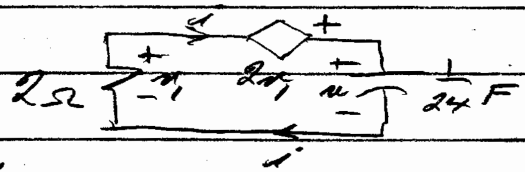


$v_s(t)=12$ for $t<0$

$v_s(t)=0$ for $t\geq 0$

$\boxed{v_1(0)=6 \quad \text{so } v(0)=18 \text{ Volts}}$

for $t\geq 0$ we have

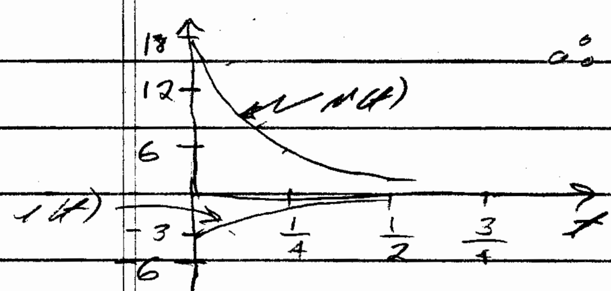


$v_1=-2i$

(1) $2i\overbrace{-2v_1}^{4i}+24\int_0^t i\,dt+18=0 \Rightarrow 6\frac{di}{dt}+24i=0$

$i=Ae^{-4t}$

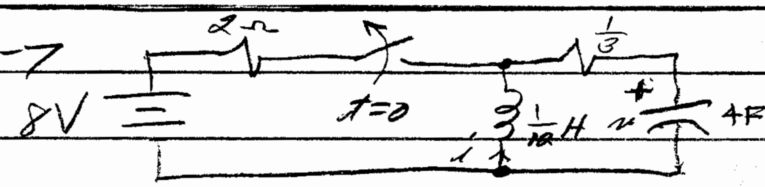
from (1) $6i(0)=-18$ or $i(0)=-3$



$\therefore i=-3e^{-4t}$

$v=3v_1=-6i=18e^{-4t}$

3.57



$v(0)=0$

$i(0)=-4$

for $t>0$ $\quad \frac{1}{12}\frac{di}{dt}+\frac{1}{3}i+\frac{1}{4}\int_0^t i\,dt=0 \quad$ (1)

or $\frac{d^2i}{dt^2}+4\frac{di}{dt}+3i=0$; $i=Ae^{st}$

$s^2+4s+3=0$ or $s_{1,2}=-2\pm\sqrt{4-3}=-3,-1$

so $i(t)=A_1e^{-3t}+A_2e^{-t}$ but $i(0)=-4$ $\therefore$ $-4=A_1+A_2$

from (1) $\left.\frac{di}{dt}\right|_{t=0}=-4i(0)=16=-3A_1-A_2$

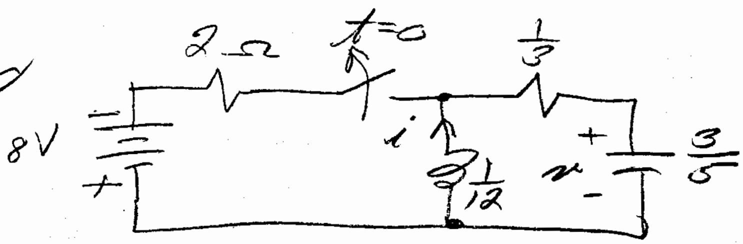
$\therefore$ $16=-3(-4-A_2)-A_2=12+2A_2$ or $A_2=2$ & $A_1=-6$

$\boxed{i(t)=-6e^{-3t}+2e^{-t}}$

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

ES 332 Homework 10 (Solutions)

3.58



$i(0) = +4$

$v(0) \equiv 0$

for $t > 0$ $\quad \frac{1}{12}\frac{di}{dt} + \frac{1}{3}i + \frac{5}{3}\int_0^t i\,dt = 0$ $\qquad (1)$

or $\quad \frac{d^2 i}{dt^2} + 4\frac{di}{dt} + 20i = 0 \quad$ for $i = Ae^{st}$

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

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

but $i(0) = +4 \quad \therefore \quad \boxed{+4 = A_1}$

from (1) $\quad \left.\frac{di}{dt}\right|_{t=0} = -4i(0) = -16$

so $-16 = +4\left[-2\times e^{-2t}\cos 4t - 4\times e^{-2t}\sin 4t\right]_{t=0} + \left[-2A_2 e^{-2t}\sin 4t + 4A_2 e^{-2t}\cos 4t\right]_{t=0}$

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

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

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

$\boxed{v(t) = \frac{5}{3}e^{-2t}\sin 4t}$

ES 332 Homework 11 (Solutions)

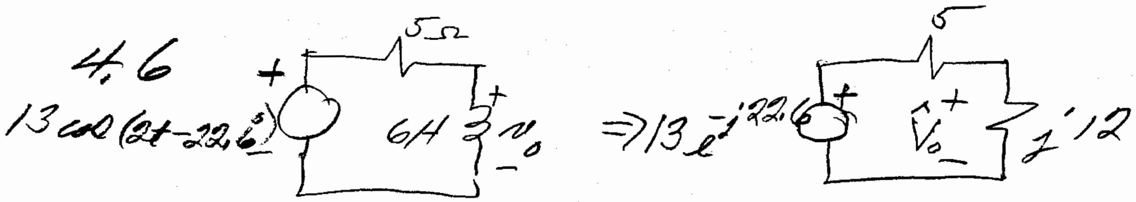
4.1 a) $4+j7 = 8.06\, e^{j60.25^\circ}$ e) $4 = 4e^{j0^\circ}$

b) $3-j5 = 5.83\, e^{-j59.04^\circ}$ f) $-5 = 5e^{j180^\circ}$

c) $-2+j3 = 3.6\, e^{j123.7^\circ}$ g) $j7 = 7e^{j90^\circ}$

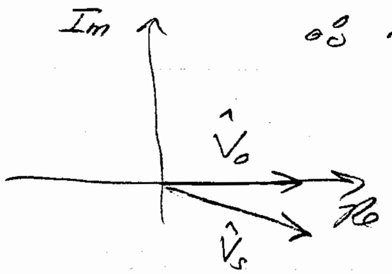
d) $-1-j6 = 6.08\, e^{j260.5^\circ}$ h) $-j2 = 2e^{-j90^\circ}$

4.6



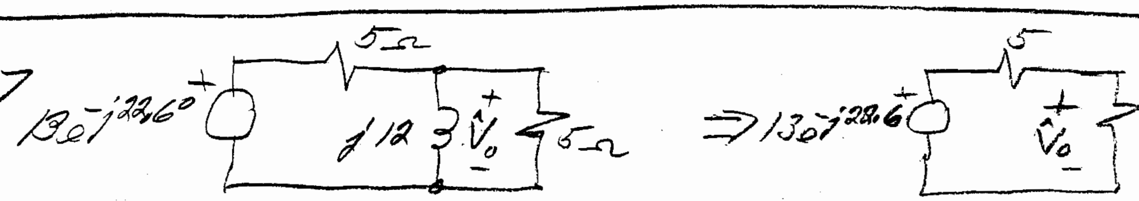
$$\hat{V}_o = 13e^{-j22.6^\circ}\,\frac{j12}{5+j12} = \frac{13\times 12\, e^{j(90^\circ-22.6^\circ)}}{13\, e^{j67.38^\circ}} = \boxed{12e^{j0.02^\circ}}$$

$\therefore\ v_o(t) = 12\cos(2t)$ ←



$\boxed{\hat{V}_o \text{ leads } \hat{V}_s}$ ←

4.7

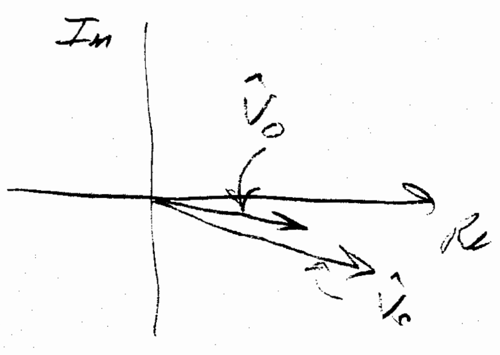


$$\frac{j60}{5+j12} = 4.615\,e^{j22.62}$$

$$\hat{V}_o = 13\,e^{-j22.6}\,\frac{4.615e^{j22.62}}{5+4.615\,e^{j22.62}} = \frac{60}{9.26+j1.775} = \frac{60}{9.428\,e^{j10.85}}$$

$$\hat{V}_o = 6.36\,e^{-j10.85^\circ}$$

$\boxed{v_o(t) = 6.36\cos(2t-10.85^\circ)}$ ←

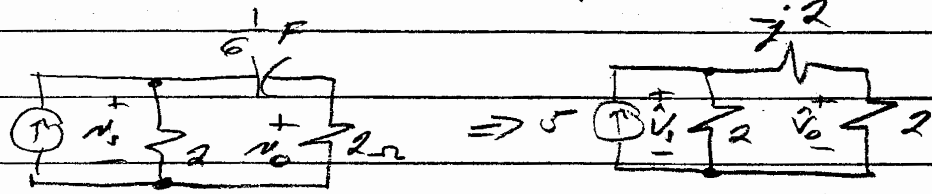


$\boxed{\hat{V}_o \text{ leads } \hat{V}_s}$ ←

ES 332 Homework 12

4.9

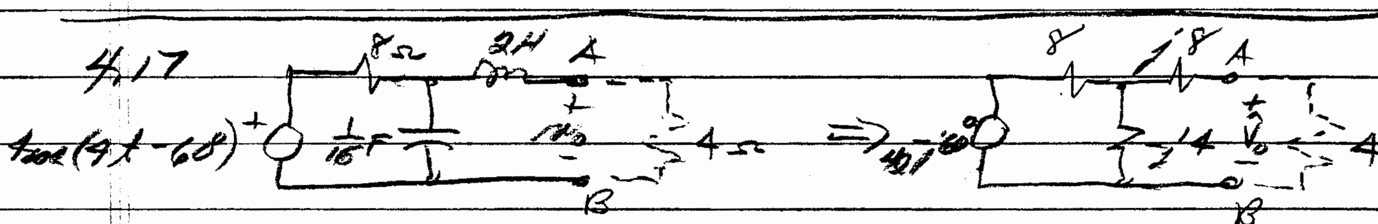
$i_s = 5\cos 3t$



$$\hat{V}_0 = 5\,\frac{2\times 2}{2-j2+2} = \frac{20}{4.472\,e^{-j26.56^\circ}}$$ $\boxed{\therefore\ v_0(t) = 4.472\cos(3t+26.56^\circ)}$

$$\hat{V}_1 = \frac{10(2-j2)}{4-j2} = \frac{10\times 2\times 1.414\,e^{-j45^\circ}}{4.472\,e^{-j26.56^\circ}}$$ $\boxed{\therefore\ v_1(t) = 6.32\cos(3t-18.4^\circ)}$

4.17



(a) A-B $$\hat{V}_{Th} = \frac{4e^{-j60^\circ}(-j4)}{8-j4} = \frac{e^{-j60^\circ}\,4e^{-j90^\circ}}{2.236\,e^{-j26.56^\circ}} = 1.789\,e^{-j123.44^\circ}$$

$$Z_{Th} = j8 + \frac{8(-j4)}{8-j4} = \frac{64j+32-j32}{8-j4} = \frac{32+j32}{8-j4} = \frac{32\times 1.414\,e^{j45^\circ}}{4\times 2.236\,e^{-j26.56}} = 5.059\,e^{j71.56^\circ}$$

8.944

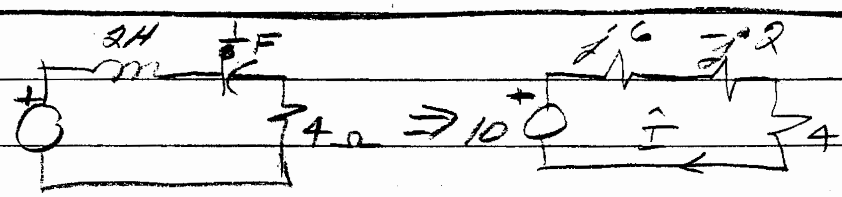
or $Z_{Th} = 1.6 + j4.799$

so $$\hat{V}_0 = \frac{1.789\,e^{-j123.44^\circ}\times 4}{(5.6+j4.799)} = \frac{4\times 1.789\,e^{-j123.44^\circ}}{7.375\,e^{j40.6^\circ}} = 0.97\,e^{-j164^\circ}$$

$\boxed{\text{or } v_0(t) = 0.97\cos(4t-160^\circ)}$

4.28

$10\cos 3t$

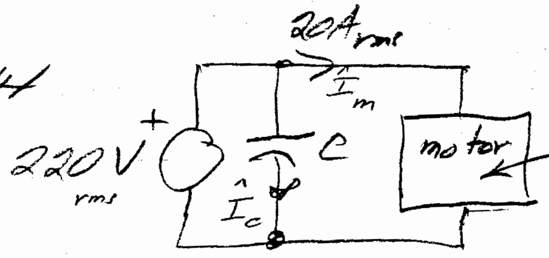


$$\hat{I} = \frac{10}{4+j4} = \frac{5}{2+j2} = \frac{5e^{-j45^\circ}}{2\sqrt{2}}$$

$$P_{ave_{4\Omega}} = \tfrac{1}{2}|\hat{I}|^2 4 = 2\,\frac{25}{8} = \frac{25}{4} = 6.25\ \text{Watts}$$

ES 332 — Homework 13 (Solutions)

4.44



(60 Hz)

pf = 0.75 lagging

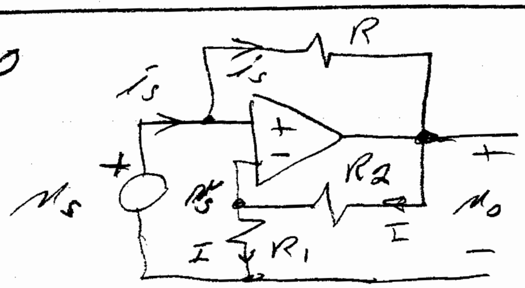
a) $P_{ave} = 220 \times 20 \times 0.75 = \underline{3{,}300 \text{ Watts}}$

b) $\hat{I}_m = 20 e^{-j \cos^{-1}(0.75)} = 20 e^{-j 41.41^\circ} = 15 - j\,13.23$

$\therefore$ need $\hat{I}_c = +j\,13.23 = \dfrac{220}{1/j2\pi 60 C} = j\,2\pi\,60 \times 220\,C$

so $C = \dfrac{13.23}{2\pi \times 60 \times 220} \cong 1.6 \times 10^{-4}\,F = \boxed{160\,\mu F}$

2.30



a) $I = \dfrac{v_s}{R_1}$; $v_o = I(R_1 + R_2)$

$\therefore \boxed{v_o = v_s \dfrac{R_1 + R_2}{R_1}}$

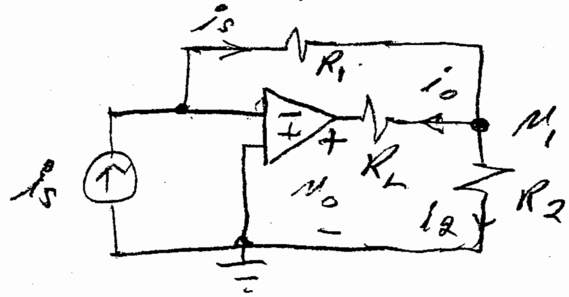
b) $i_s = \dfrac{v_s - v_o}{R} = \dfrac{v_s}{R} - v_s \dfrac{R_1 + R_2}{R R_1} = \dfrac{v_s}{R}\left(1 - \dfrac{R_1 + R_2}{R_1}\right)$

or $i_s = \dfrac{v_s}{R}\left(\dfrac{-R_2}{R_1}\right)$

and $\boxed{\dfrac{v_s}{i_s} = -\dfrac{R_1 R}{R_2}}$

ES 332 Homework 14 (Solutions)

2.28



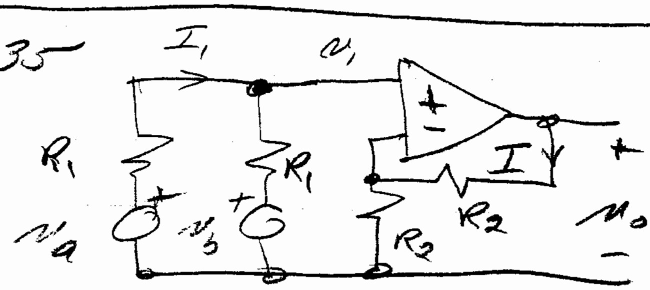
$$v_1 = -i_s R_1$$

$$i_2 = \frac{v_1}{R_2}$$

$$i_o = i_s - i_2 = i_s - \frac{v_1}{R_2} = i_s - \frac{(-i_s R_1)}{R_2} = i_s\left(1 + \frac{R_1}{R_2}\right)$$

$$v_o = -i_o R_L + v_1 = -i_s\left(1 + \frac{R_1}{R_2}\right)R_L - i_s R_1 = -i_s\left(R_L + \frac{R_1 R_L}{R_2} + R_1\right)$$

2.35



$$I = \frac{v_o}{2R_2}$$

$$v_1 = \frac{v_o}{2} \qquad (1)$$

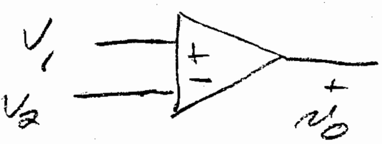
$$-v_a + I_1 R_1 + I_1 R_1 + v_b = 0 \quad \text{so} \quad I_1 = \frac{v_a - v_b}{2R_1}$$

$$v_1 = I_1 R_1 + v_b = \frac{v_a - v_b}{2} + v_b = \frac{v_a + v_b}{2}$$

so from (1) $\boxed{v_o = 2v_1 = v_a + v_b}$

ES 332 Homework 15 (Solutions)

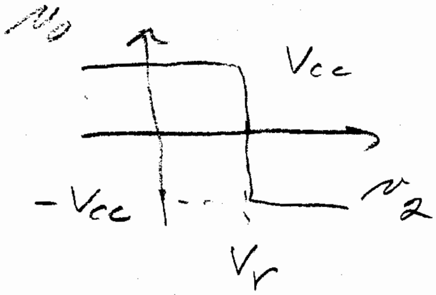
10.67



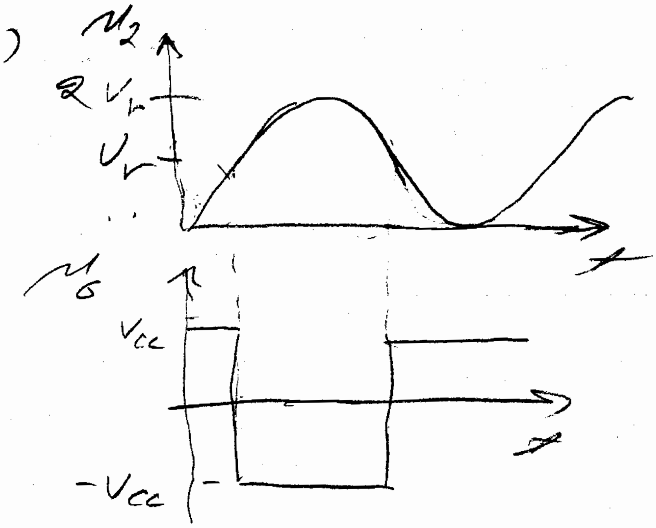
$V_1 = V_r > 0$

$V_2 = v_{in}$

a)



b)



$v_2 = V_r(1 + \sin \omega t)$

10-79 for a 555 timer $f_o = \dfrac{1.44}{(R_1 + 2R_2)C}$

a) $f_o = \dfrac{1.44}{15\times10^3 \times 10^{-7}} = \boxed{960\ Hz}$

b) $1.6\times10^3 = \dfrac{1.44}{15\times10^3 \times C}$; $C = \dfrac{1.44}{15\times10^3 \times 1.6\times10^3} = \boxed{0.06\,\mu F}$

c) $10^4 = \dfrac{1.44}{(R_1 + 2\times10^4)5\times10^{-9}}$; $R_1 \times 5\times10^{-5} = 1.44 - 1$; $R_1 = \dfrac{0.44}{5\times10^{-5}} = \boxed{8.8\times10^3\ \Omega}$

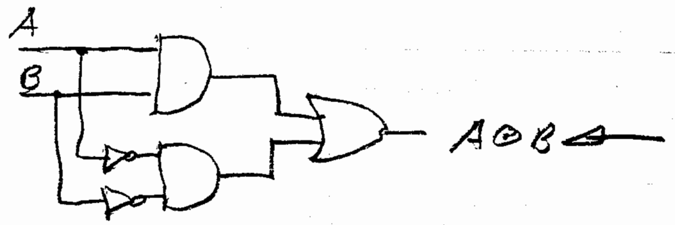
d) $10^4 = \dfrac{1.44}{(10^4 + 2R_2)5\times10^{-9}}$; $R_2 \times 10^{-4} = 1.44 - 0.5$; $R_2 = \boxed{9.4\times10^3\ \Omega}$

ES 332 Homework 16 (Solutions)

11.26

A	B	A ⊙ B
0	0	1
0	1	0
1	0	0
1	1	1

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



11.44

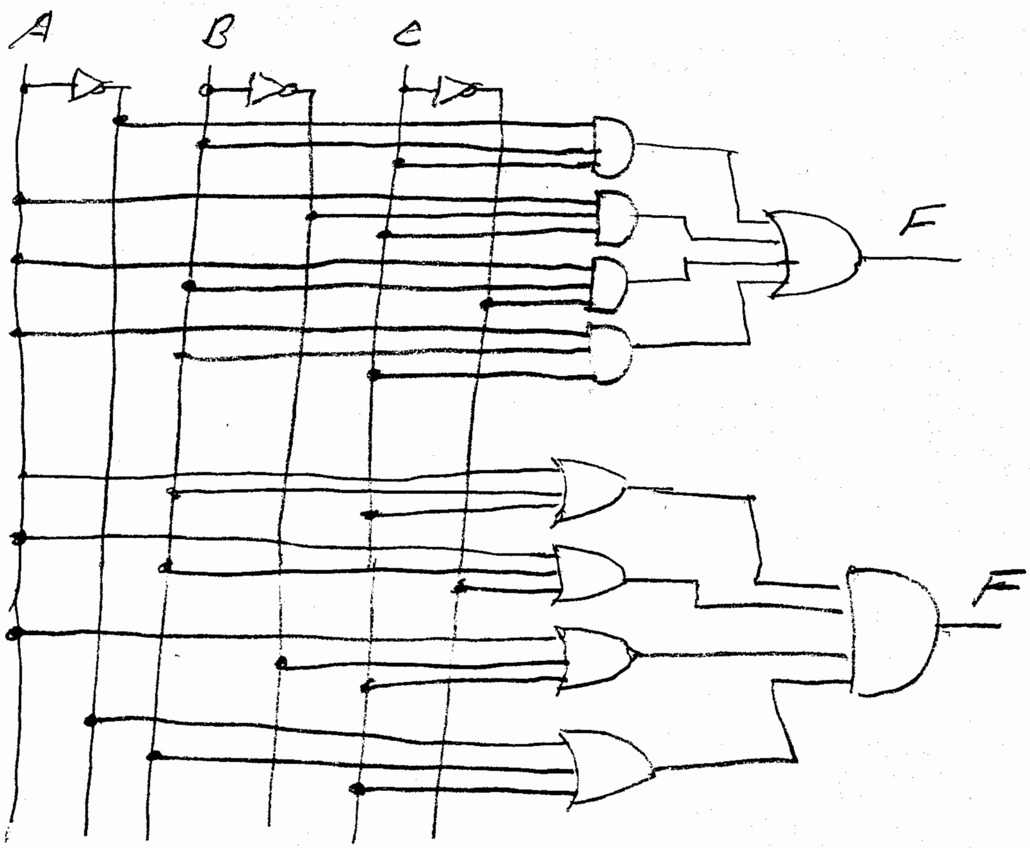
A	B	C	F
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

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

or $F = m_3 + m_5 + m_6 + m_7$

$$F = (A+B+C)(A+B+\bar{C})(A+\bar{B}+C)(\bar{A}+B+C)$$

or $F = M_0 \cdot M_1 \cdot M_2 \cdot M_4$



ES 332 Homework 16 (Solution - page 2)

11.53 a)

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

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

b)

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

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

c)

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

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

ES 332 Homework 17 (Solutions)

11.54 a)

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

$\overline{F} = \overline{A}\,\overline{B}\,\overline{C} + AB$

$F = (A+B+C)\cdot(\overline{A}+\overline{B})$ ←

b)

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

$\overline{F} = \overline{A}\,\overline{B} + \overline{A}C + \overline{B}C$

$F = (A+B)\cdot(A+\overline{C})\cdot(B+\overline{C})$ ←

c)

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

$\overline{F} = A\overline{B}\,\overline{C} + ABC$

$F = (\overline{A}+B+C)\cdot(\overline{A}+\overline{B}+\overline{C})$ ←

11.56 a)

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

$F = B\overline{C} + A\overline{C}$ ←

b)

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

$F = A + \overline{B}\,\overline{C}$ ←

c)

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

$F = \overline{B}\,\overline{C} + \overline{A}B$ ←

ES 332 Homework 17 (Solutions - page 2)

11.57

a)

AB \ CD	00	01	11	10
00	0	0	0	0
01	1	1	1	1
11	0	1	1	1
10	0	0	0	1

$$F = \bar{A}B + BD + BC + AC\bar{D}$$

b)

AB \ CD	00	01	11	10
00	0	1	1	1
01	0	0	0	1
11	0	1	0	1
10	0	1	1	1

$$F = C\bar{D} + \bar{B}D + A\bar{C}D$$

c)

AB \ CD	00	01	11	10
00	1	0	1	0
01	0	0	1	1
11	0	1	0	1
10	1	0	0	1

$$F = \bar{B}\bar{C}\bar{D} + \bar{A}CD + BC\bar{D} + AC\bar{D} + AB\bar{C}D$$

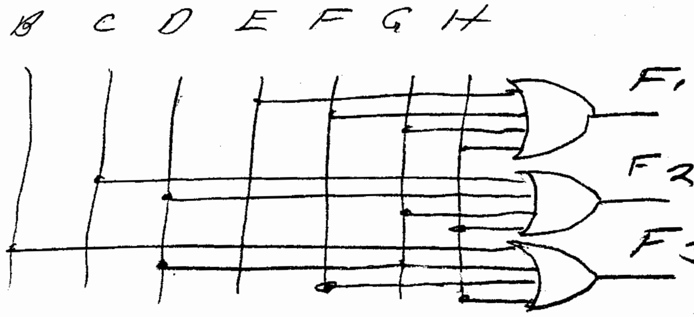
many possible combinations

ES 332 Homework 18 (Solutions)

12.14

A	B	C	D	E	F	G	H	F_1	F_2	F_3
1	0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	0	0	1	0	0	0	0	0	1	1
0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	0	1	0	1	1	0
0	0	0	0	0	0	0	1	1	1	1

$F_1 = E+F+G+H$; $F_2 = C+D+G+H$; $F_3 = B+D+F+H$



12.17

A	B	C	D	E	F
0	0	0	0	0	0
0	0	1	0	0	1
0	1	0	0	1	1
0	1	1	0	1	0
1	0	0	1	1	0
1	0	1	1	1	1
1	1	0	1	0	1
1	1	1	1	0	0

D

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

$D = A$

E

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

$E = \overline{A}B + A\overline{B}$

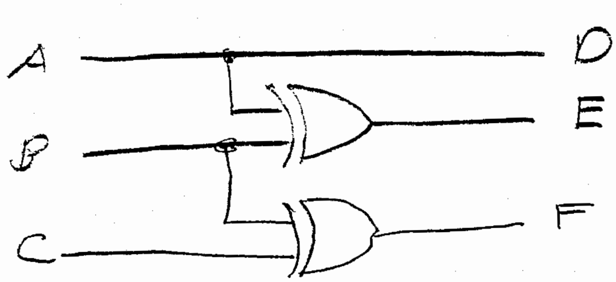
$E = A \oplus B$

F

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

$F = \overline{B}C + B\overline{C}$

$F = B \oplus C$



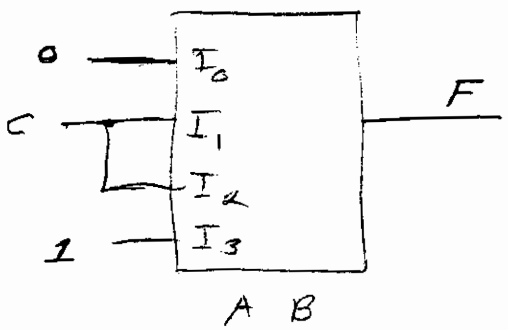
ES 332 Homework 19 (Solutions)

12.19

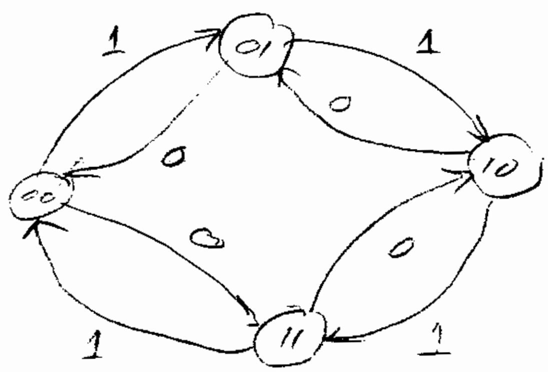
A	B	C	F
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

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

$F = \bar{A}B \cdot C + A\bar{B} \cdot C + AB \cdot 1 + \bar{A}\bar{B} \cdot 0$



12.42 no - outputs



In	Present state Q_0	Q_1	Next state Q_0^+	Q_1^+	D_0	D_1
0	0	0	1	1	1	1
0	0	1	0	0	0	0
0	1	0	0	1	0	1
0	1	1	1	0	1	0
1	0	0	1	0	1	0
1	0	1	1	0	1	0
1	1	0	1	1	1	1
1	1	1	0	0	0	0

D_0

In \ Q_0Q_1	00	01	11	10
0	1	0	1	0
1	0	1	0	1

D_1

In \ Q_0Q_1	00	01	11	10
0	1	0	0	1
1	1	0	0	1

$D_0 = \bar{I_n}\bar{Q_0}\bar{Q_1} + \bar{I_n}Q_0Q_1 + I_n\bar{Q_0}Q_1 + I_nQ_0\bar{Q_1} = \bar{I_n}(\overline{Q_0 \oplus Q_1}) + I_n(Q_0 \oplus Q_1)$

$D_0 = \overline{I_n \oplus (Q_0 \oplus Q_1)}$; $D_1 = \bar{Q_0}\bar{Q_1} + Q_0\bar{Q_1} = \bar{Q_1}$