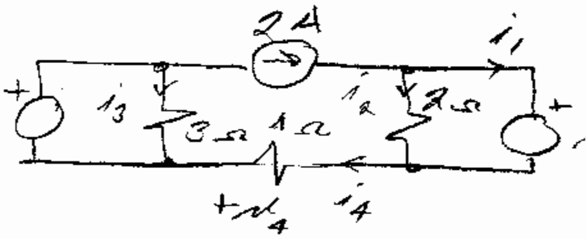
ES 332 Homework 1

1-18

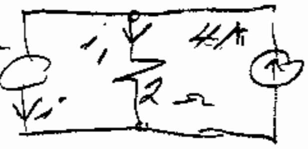


a) $v_s = 2V$; $i_4 = i_2 + i_1 = 2$ ∴ $\boxed{v_4 = -4 i_4 = -8V}$

b) $v_s = 4V$ i_4 does not change ∴ $\boxed{v_4 = -8}$

c) $v_s = 6V$ $i_4 = 2$ $\boxed{v_4 = -8}$

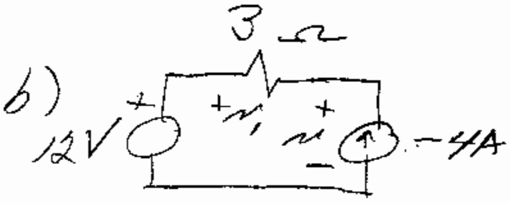
1-26 a)



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

$i = 4 - i_1 = -2A$

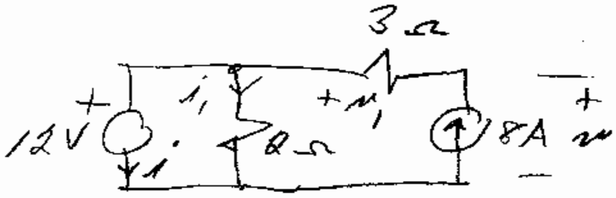
b)



$v_1 = -(-4) \times 3 = 12V$

$-12 + v_1 + v = 0$ ∴ $v = 0$

c)



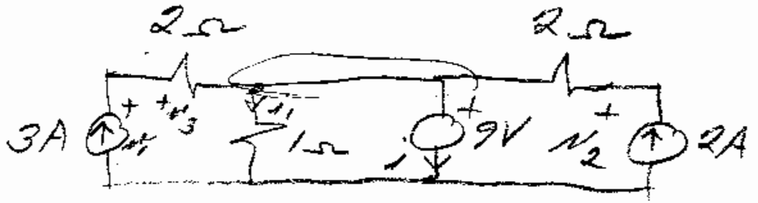
$v_1 = -3 \times 8 = -24V$

$i_1 = 6A$ ← did not ask in this

∴ $i = 8 - i_1 = 2A$

$-12 + v_1 + v = 0$ so $v = 12 + 24 = 36V$

d)



$\boxed{\begin{array}{l} i_1 = 9A \\ v_3 = 6V \end{array}}$

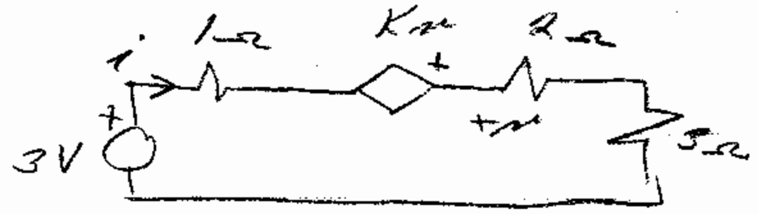
$-v_1 + v_3 + 9 = 0$ ∴ $v_1 = 9 + v_3 = 15V$

KCL $-3 + i_1 + i - 2 = 0$ $i = 5 - i_1 = 5 - 9 = -4A$

KVL $-v_1 + v_3 - 4 + v_2 = 0$ ⇒ $v_2 = 4 + v_1 - v_3 = 4 + 15 - 6 = 13V$

ES332 Homework 2

1.45



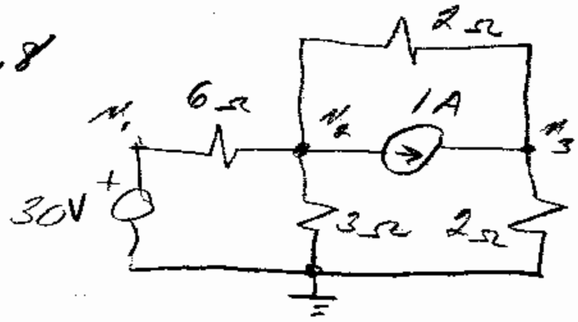
a) K=2 $-3+i\overset{-4i}{-2v}+5i=0$ but $v=2i$

∴ $2i=3$ or $\boxed{i=\frac{3}{2}A}$ ←

b) K=4 $-3+i-4(2i)+5i=0$; $-2i=3$

$\boxed{i=-\frac{3}{2}A}$ ←

2.8



$\boxed{v_1=30V}$

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

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

$-\frac{1}{2}$

∴ $-\frac{v_1}{6}+v_2\left(\frac{1}{6}+\frac{1}{3}+\frac{1}{2}\right)-\left(1+\frac{v_2}{2}\right)\frac{1}{2}=-1$

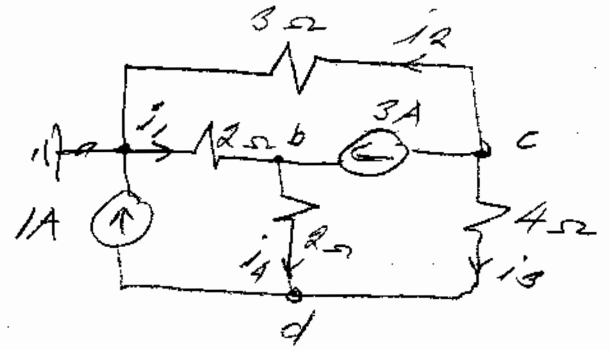
$-\frac{v_1}{6}+v_2\left(\frac{9}{12}\right)=-\frac{1}{2} \Rightarrow v_2\frac{9}{12}=-\frac{1}{2}+5$

$\boxed{v_2=\frac{\overset{2}{4}}{3}\left(\frac{\overset{3}{9}}{2}\right)=6V}$ ←

and $\boxed{v_3=1+\frac{v_2}{2}=4V}$ ←

ES 332 Homework 3

2.4a



Node voltage analysis

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

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

$$\frac{V_d - V_b}{2} + \frac{V_d - V_c}{4} = -1$$

or

$$V_b - \frac{1}{2}V_d = 3$$
$$\frac{7}{12}V_c - \frac{1}{4}V_d = -3$$
$$-\frac{1}{2}V_b - \frac{1}{4}V_c + \frac{3}{4}V_d = -1$$

$$2V_b - V_d = 6$$
$$7V_c - 3V_d = -36$$
$$-2V_b - V_c + 3V_d = -4$$

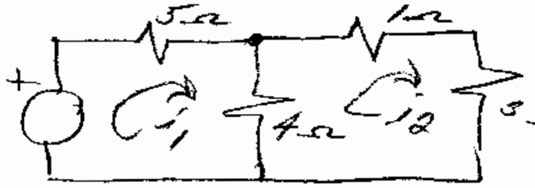
∴ $V_b = \frac{V_d + 6}{2}$; $V_c = \frac{3V_d - 36}{7}$

so $-V_d - 6 - \frac{3V_d - 36}{7} + 3V_d = -4$

$$V_d\underbrace{\left(-\overset{7/7}{1} - \frac{3}{7} + \overset{21/7}{3}\right)}_{11/7} = \overset{42/7}{6} - \overset{28/7}{4} - \frac{36}{7} = -\frac{22}{7}$$

$$V_d = -2\,V$$
$$V_b = -1 + 3 = 2\,V$$
$$V_c = -\frac{42}{7} = -6\,V$$

2.19



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

or $9i_1 - 4i_2 = 28$

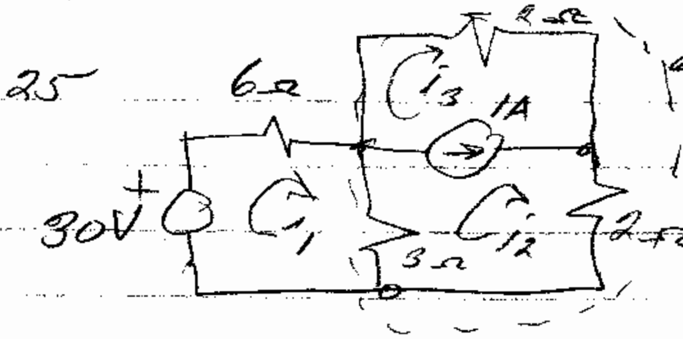
$-4i_1 + 8i_2 = 0$

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

$$i_2 = \frac{\begin{vmatrix}9 & 28\\ -4 & 0\end{vmatrix}}{56} = \frac{4\times 28}{56} = \frac{112}{56} = 2\,A$$

ES 332 Homework 4

Q:25



← supermesh

$i_2 - i_3 = 1$

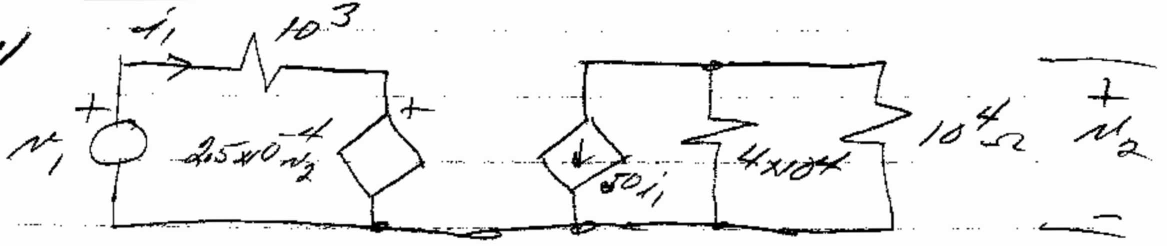
$\hookrightarrow i_3 = i_2 - 1$

$$\left.\begin{array}{l} -30 + 6i_1 + 3(i_1 - i_2) = 0 \\ 3(i_2 - i_1) + 2\underset{i_2 - 1}{i_3} + 2i_2 = 0 \end{array}\right\} \quad \begin{array}{l} 9i_1 - 3i_2 = 30 \\ -3i_1 + 7i_2 = 2 \end{array}$$

$$i_1 = \frac{\begin{vmatrix} 30 & -3 \\ 2 & 7 \end{vmatrix}}{\begin{vmatrix} 9 & -3 \\ -3 & 7 \end{vmatrix}} = \frac{210 + 6}{63 - 9} = \frac{216}{54} \boxed{= 4\,A} \leftarrow$$

$$i_2 = \frac{\begin{vmatrix} 9 & 30 \\ -3 & 2 \end{vmatrix}}{54} = \frac{18 + 90}{54} = \frac{108}{54} \boxed{= 2A} \leftarrow$$

Q,11



a) $-v_1 + 10^3 i_1 + 2.5 \times 10^{-4} v_2 = 0$; $v_2 = -50 i_1 \frac{4 \times 10^8}{5 \times 10^4} = -40 \times 10^4 i_1$

$\therefore -v_1 + 10^3 \left(\frac{v_2}{-40 \times 10^4} \right) + 2.5 \times 10^{-4} v_2 = 0$

$$-v_1 = (2.5 \times 10^{-3} - 2.5 \times 10^{-4}) v_2 = 2.25 \times 10^{-3} v_2$$

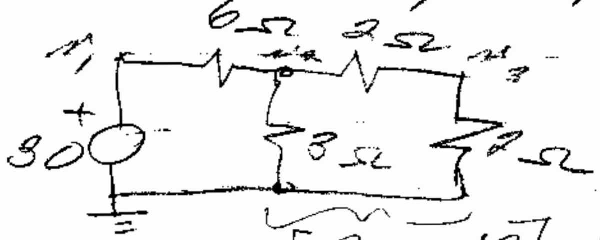
$$\boxed{\frac{v_2}{v_1} = -\frac{1}{2.25 \times 10^{-3}} = -444.44} \leftarrow$$

b) $\frac{v_1}{i_1} = ? = \frac{v_1 \times 10^3}{v_1 - \underbrace{2.5 \times 10^{-4}(-444.44)}_{0.111} v_1} = \boxed{0.900 \times 10^3 = 900\,\Omega}$

ES 332 Homework 5

Problem 2.8 using superposition

[Voltage Source]



$\left[R_{eq} = \frac{12}{7}\right]$

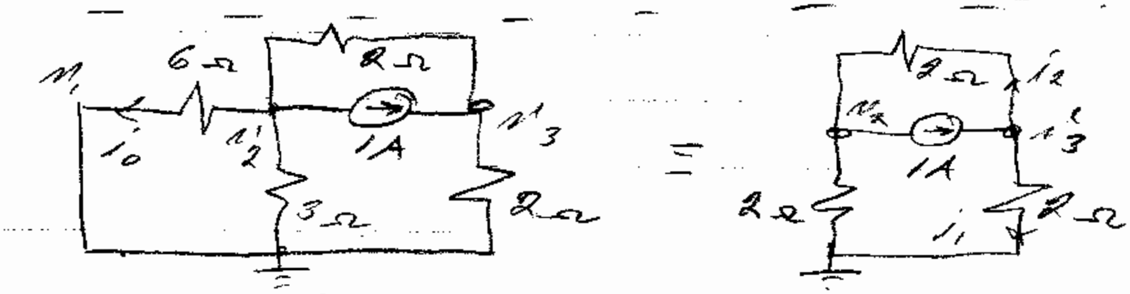
$\boxed{v_1 = 30}$

voltage division ↓

$$\therefore v_2 = 30 \frac{\frac{12}{7}}{\frac{54}{7}} = \overset{15}{\cancel{30}} \frac{12}{\underset{27}{\cancel{54}}} = \frac{20}{3}$$

$$\boxed{v_3 = v_2 \frac{2}{4} = \frac{90}{27} = \frac{10}{3}}$$

[Current Source]



$i_1 = 1 \times \frac{2}{6} = \frac{1}{3} A$; $i_2 = 1 \frac{4}{6} = \frac{2}{3} A$

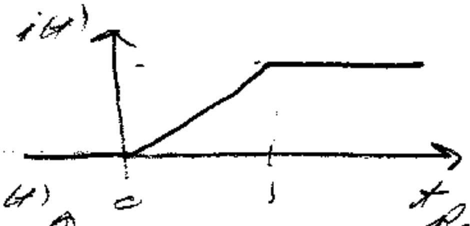
$\therefore$ $\boxed{v_3 = 2 i_1 = \frac{2}{3} V \ ; \ v_2 = -\frac{2}{3} V \ ; \ v_1 = 0}$ ←

So the results are

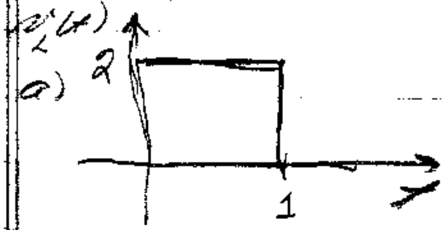
$$\left.\begin{aligned} v_1 &= 30 \\ v_2 &= \frac{20}{3} - \frac{2}{3} = \frac{18}{3} = 6V \\ v_3 &= \frac{10}{3} + \frac{2}{3} = 4V \end{aligned}\right\} \leftarrow$$

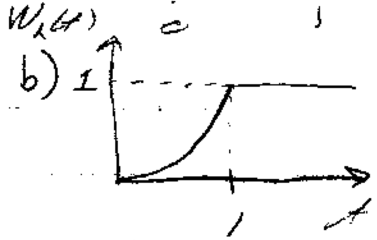
ES 332 Homework 6

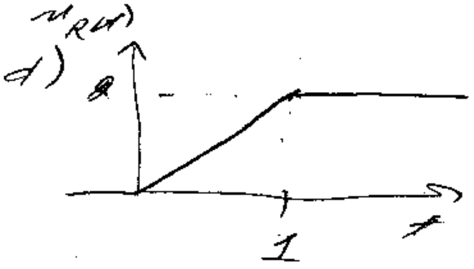
3.1

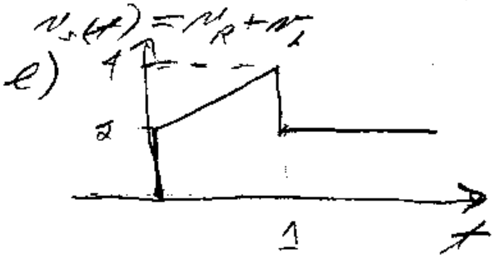


$v = L\frac{di}{dt}$

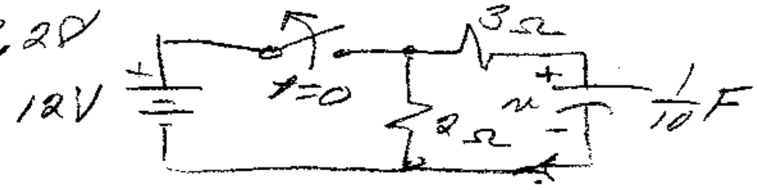






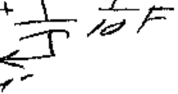


3.20



$v(0) = 12V$

for $t > 0$ we have



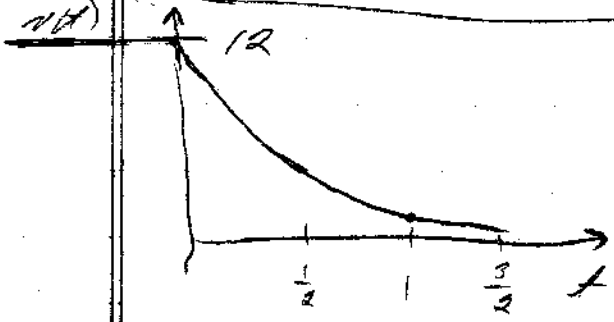
(1) $5i + 10\int_0^t i\,dt + \overset{12}{\overset{\shortparallel}{v(0)}} = 0 \Rightarrow 5\frac{di}{dt} + 10i = 0$

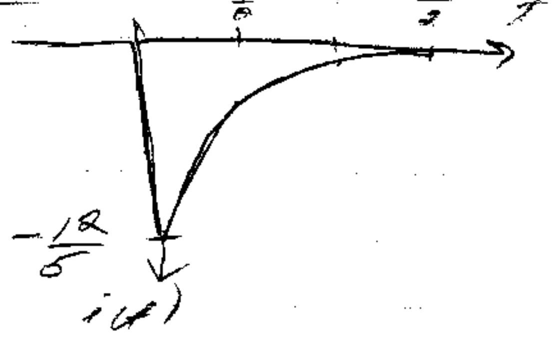
$i = Ae^{st} \Rightarrow 5s + 10 = 0;\ s = -2 \quad (\underline{\tau = \frac{1}{2}\,\text{sec}})$

from (1) $5i(0) = -12;\ i(0) = -\frac{12}{5}$

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

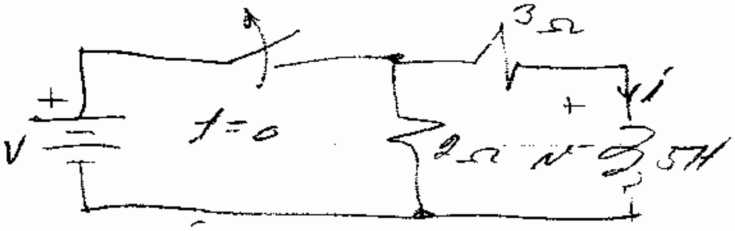
$\boxed{\therefore v(t) = -5i = 12e^{-2t}} \leftarrow$





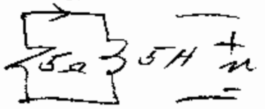
ES 332 Homework 7

3.29



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

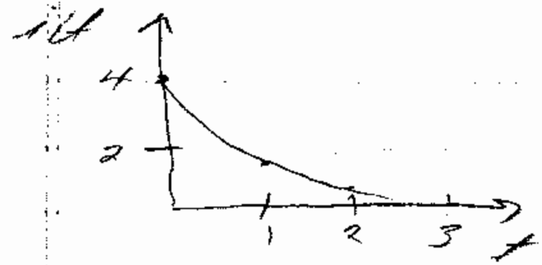
for $t>0$

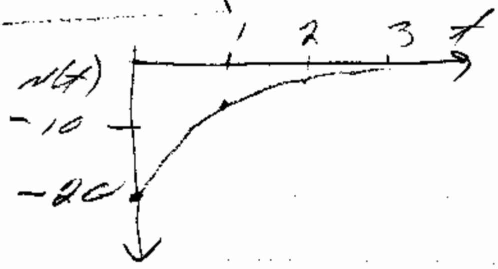


$5i + 5\frac{di}{dt} = 0$; $i = Ae^{st}$

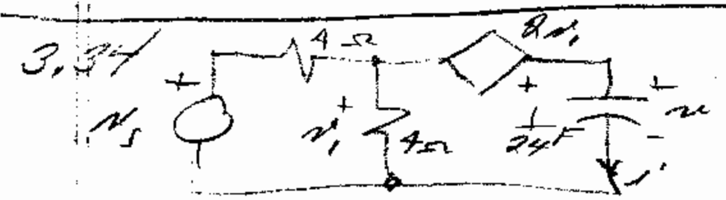
$5+5s=0$; $s=-1$ ∴ $\boxed{i(t) = 4e^{-t}}$ ←

$\boxed{v(t) = -5i' = -20e^{-\frac{2t}{5}}}$ ←





3.37



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

$v_s(t) = 0$ for $t>0$

for $t<0$, $i=0$ so $v_1 = 6V$ $\boxed{\text{and } v = 3v_1 = 18V}$ ←

for $t>0$ we have:

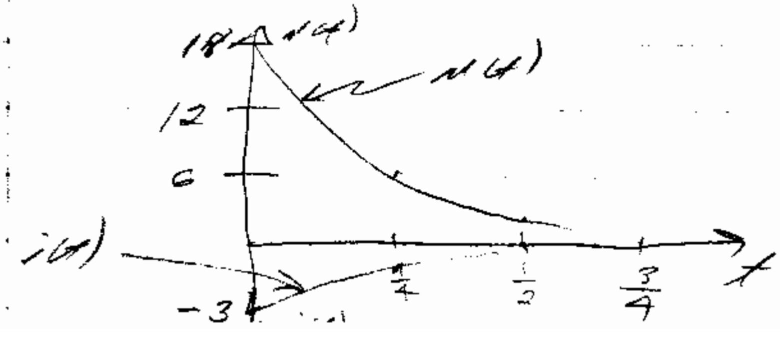
$\boxed{v_1 = -2i}$

(1) $2i - 2\overset{-2i}{v_1} + 24\int_0^t i\,dt + 18 = 0$

or $\frac{di}{dt} + 4i = 0$; $i = Ae^{st}$; $s = -4$

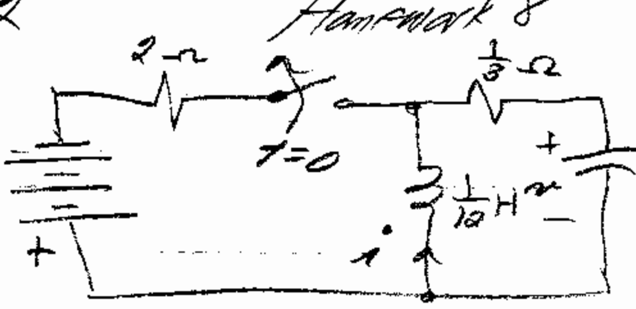
but from (1) $6i(0) = -18$ $i(0) = -3$ ∴ $\boxed{i = -3e^{-4t}}$ ←

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



ES 332 Homework 8

3.57



$v(0) = 0$

$i(0) = \frac{8}{2} = 4A$

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

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

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

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

∴ $4 = A_1 + A_2$ (2)

evaluating equation (1) @ $t=0$ gives

$\frac{di}{dt}\Big|_{t=0} + 4i(0) = 0$; $\frac{di}{dt}\Big|_{t=0} = -16$

so $+A_1 + 3A_2 = +16$ (3)

combining (2) + (3) gives $4 - A_2 + 3A_2 = 16$

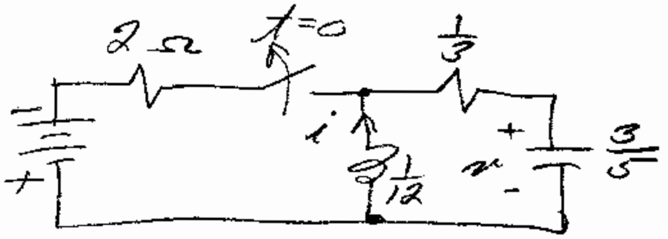
$2A_2 = 12$ so $\boxed{\begin{matrix} A_2 = 6 \\ A_1 = -2 \end{matrix}}$

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

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

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

3,58



$i(0) = +4$

$v(0) = 0$

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

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

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

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

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

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

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

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

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

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

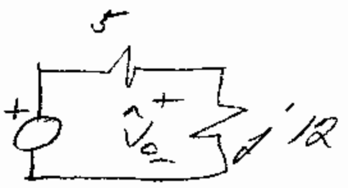
$\boxed{v(t) = \frac{5}{3}e^{-2t}\sin 4t} \leftarrow$

ES 332 Homework 9

#6

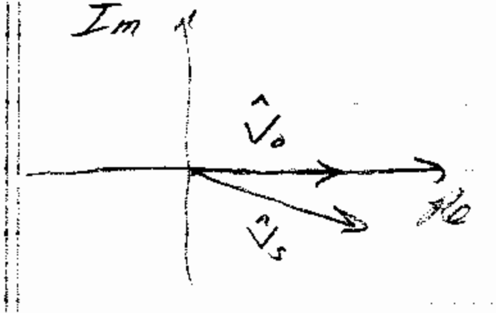
$v_s = 13\cos(2t - 22.6°)$

$\Rightarrow 13e^{-j22.6°}$



$$\hat{V}_o = \frac{j12}{5+j12}\times 13e^{-j22.6°} = \frac{12\times 13 e^{-j22.6°}e^{j90°}}{\cancel{13}e^{j67.38°}} = 12e^{j0°}$$

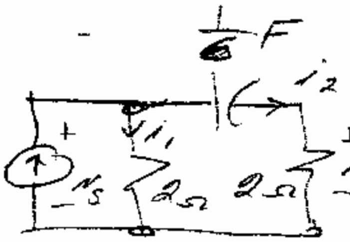
so $v_o(t) = 12\cos(2t)$ ←



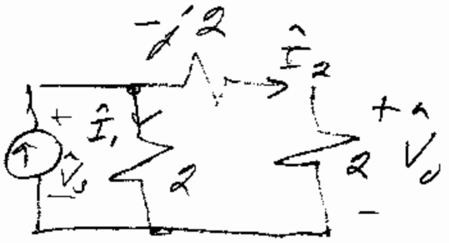
[$\hat{V}_o$ lead $\hat{V}_s$] ←

#9

$5\cos 3t$



$\Rightarrow 5$



$$\hat{V}_s = \hat{I}_1\times 2 = 2\times 5\,\frac{2-j2}{4-j2} = 10\,\frac{2\sqrt{2}e^{-j45°}}{4.472e^{-j26.56°}} = \underline{6.33e^{-j18.4}}$$

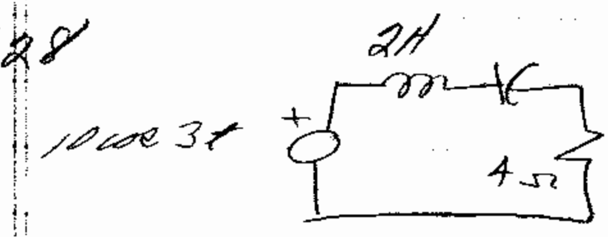
$$\hat{V}_o = \hat{I}_2\times 2 = 2\times 5\,\frac{2}{4-j2} = \frac{20}{4.472e^{-j26.56°}} = \underline{4.472e^{j26.56°}}$$

so $v_s(t) = 6.33\cos(3t - 18.4°)$ ←

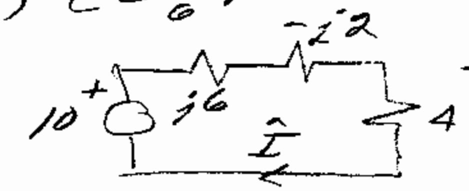
$v_o(t) = 4.472\cos(3t + 26.56°)$ ←

ES 332 Homework 10 4,44

4.28



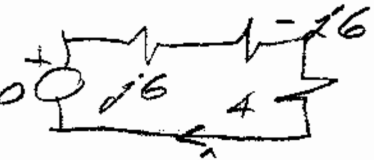
a) $C = \frac{1}{6}F$



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

$P_{ave_{4\Omega}} = \frac{1}{2} Re\left\{\frac{40}{4+j4} \times \frac{10}{4-j4}\right\} = \frac{200}{32} = 6,25$ Watts ←

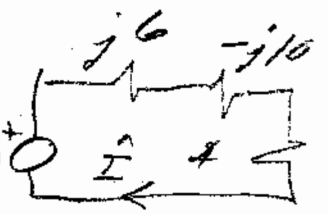
b) $C = \frac{1}{18}$



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

$P_{ave_{4\Omega}} = \frac{1}{2}\left(\frac{5}{2}\right)^2 \times 4 = \frac{25}{2} W$ ←

c) $C = \frac{1}{30}F$

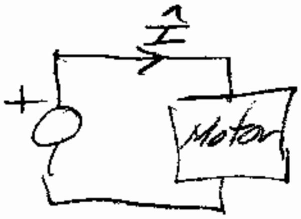


$\hat{I} = \frac{10}{4-j4}$

∴ $\boxed{P_{ave_{4\Omega}} = 6,25 W}$ ←

4.44

60Hz, 220_{rms}



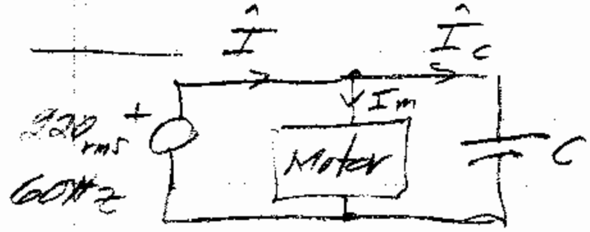
$|\hat{I}| = 20_{rms}$

pf = 0.75 lagging

$\Big\} \hat{I} = 20e^{-j41.41^\circ}$

$P_{ave} = V_{rms} I_{rms} \times 0.75 = \boxed{3,300 \text{ Watts}}$ ←

from above $\hat{I} = 20e^{-j41.41^\circ} = 15 - j13.2288$



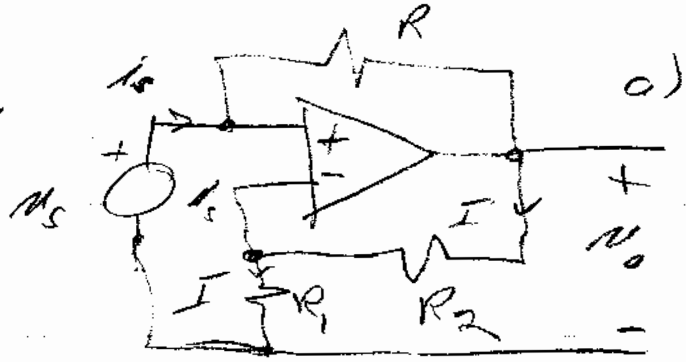
∴ for pf = 1

$\hat{I}_c = +j13.2288 = j220 \times 2\pi \times 60\, C$

or $C = \frac{13.2288}{2\pi \times 60 \times 220} = \boxed{1.59 \times 10^{-4} F}$ ←

ES 332 Homework 11

2.30



a) $I = \frac{v_s}{R_1}$

$v_o = I(R_1+R_2)$

$\therefore v_o = v_s\left(\frac{R_1+R_2}{R_1}\right)$

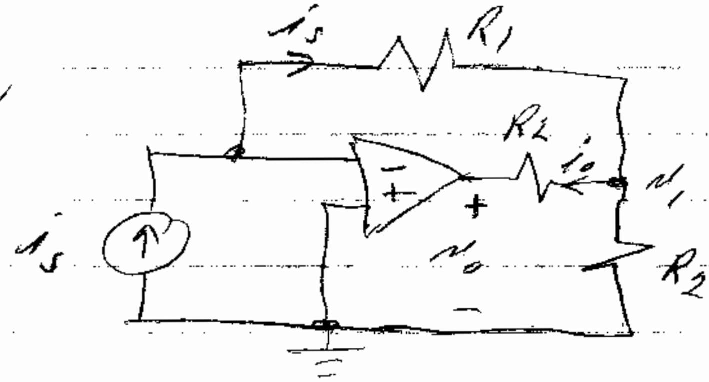
b) $i_s = \frac{v_s - v_o}{R} = \frac{v_s}{R} - \frac{v_s}{R}\left(1+\frac{R_2}{R_1}\right)$

$i_s = v_s\left(\frac{1}{R} - \frac{1}{R} - \frac{R_2}{RR_1}\right) = -\frac{R_2}{RR_1} v_s$

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

ES332 Homework 12

2.28



$v_1 = -i_s R_1$ (1)

KCL @ v_1 gives $-i_s + \frac{v_1 - v_o}{R_L} + \frac{v_1}{R_2} = 0$ (2)

combining (1) + (2) gives $-i_s + \frac{-i_s R_1 - v_o}{R_L} - i_s \frac{R_1}{R_2} = 0$

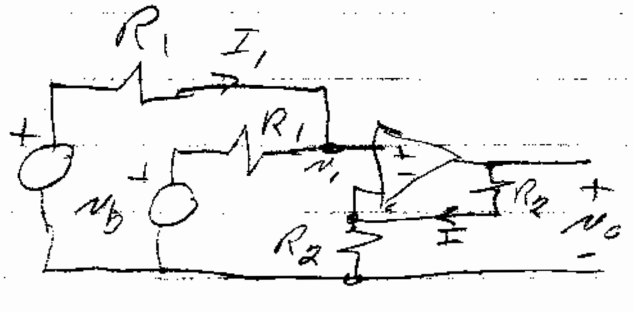
or $i_s\left(-1 - \frac{R_1}{R_L} - \frac{R_1}{R_2}\right) = \frac{v_o}{R_L}$

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

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

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

2-35



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

$v_1 = IR_2 = \frac{v_o}{2}$

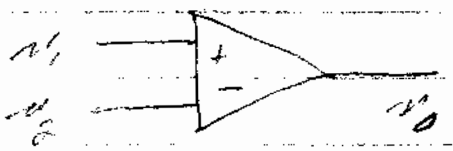
$-v_a + I_1R_1 + I_1R_1 + v_b = 0$ $\therefore$ $I_1 = \frac{v_o - v_b}{2R_1}$

$v_1 = I_1R_1 + v_b = \frac{v_a - v_b}{2} + v_b = \frac{v_a + v_b}{2}$

but $v_o = 2v_1$ $\boxed{= v_a + v_b}$ $\leftarrow$

ES 332 Homework 13

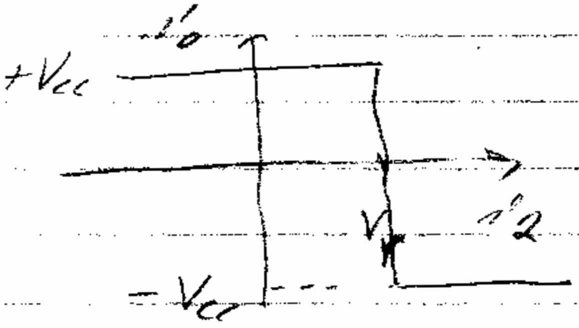
10.67



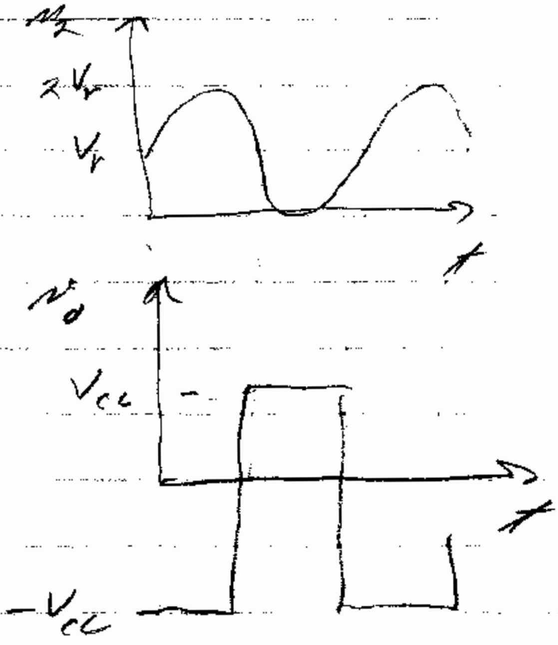
$v_1 = V_r > 0$

v_2 = input

a)



b) $v_2 = V_r + V_r \sin\omega t$



ES 332 Homework 14

10.79 555 timer as astable multivibrator

$$f = \frac{1.44}{(R_1 + 2R_2)C}$$

a) $C = 0.1\mu F$, $R_1 = R_2 = 5K\Omega$

$$f = \frac{1.44}{(15)\times 10^3 \times 10^{-7}} = \boxed{960\ Hz} \leftarrow$$

b) $R_1 = R_2 = 5K\Omega$, $f = 1.6 \times 10^3$

$$C = \frac{1.44}{15\times 10^3 \times 1.6\times 10^3} \boxed{= 0.06\mu F} \leftarrow$$

c) $R_2 = 10^4\Omega$, $C = 5\times 10^{-9}F$, $f = 10^4$

$$(R_1 + 2R_2) = \frac{1.44}{fC} ;\ R_1 = \frac{1.44}{fC} - 2R_2$$

$$R_1 = \frac{1.44}{10^4\times 5\times 10^{-9}} - 2\times 10^4 = 0.288\times 10^5 - 2\times 10^4$$

$$\therefore \boxed{R_1 = 0.88\times 10^4\ \Omega}$$

d) $R_1 = 10K\Omega$, $C = 5\times 10^{-9}F$, $f = 10^4$

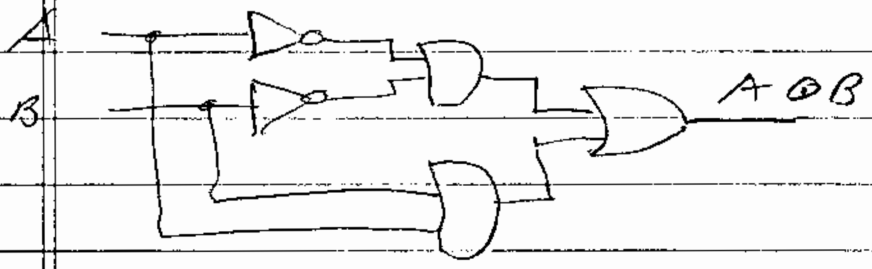
$$R_2 = \frac{1.44}{2fC} - \frac{R_1}{2} = \frac{1.44}{2\times 10^4 \times 5\times 10^{-9}} - \frac{10^4}{2} = (1.44 - 0.5)\times 10^4$$

$$\boxed{R_2 = 9.4\times 10^3\ \Omega} \leftarrow$$

ES 332 Homework 15

11.26

A	B	$A \odot B = \bar{A}\bar{B} + AB$
0	0	1
0	1	0
1	0	0
1	1	1

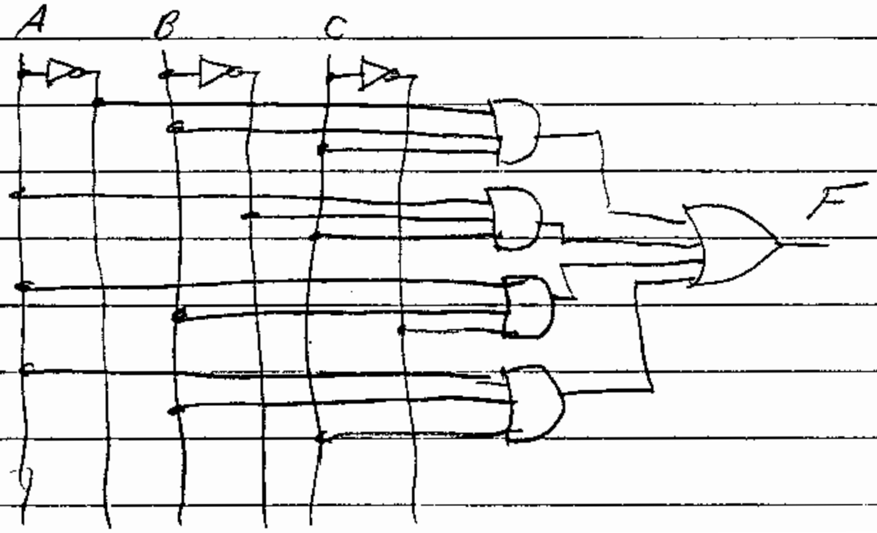


11.44

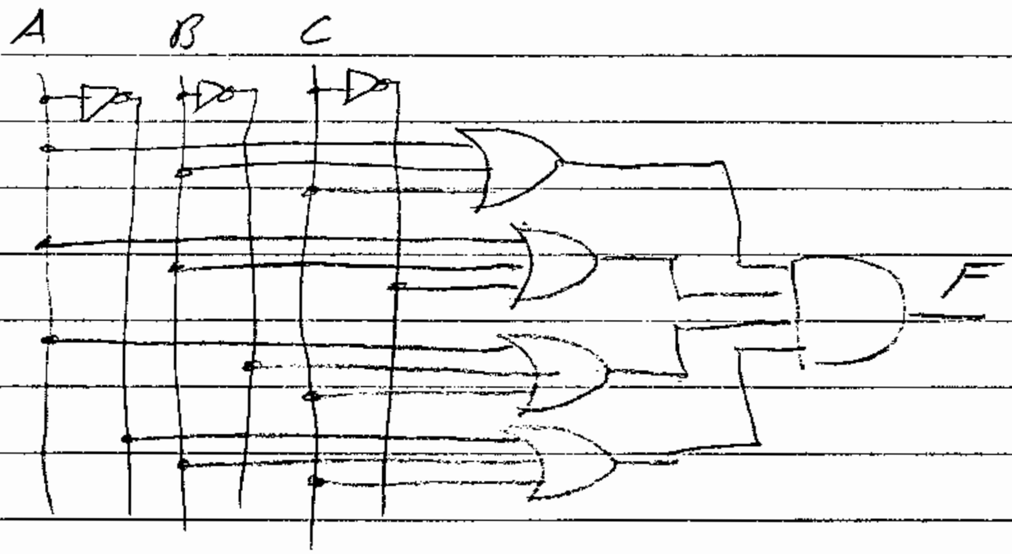
A	B	C	F	
0	0	0	0	m_0
0	0	1	0	m_1
0	1	0	0	m_2
0	1	1	1	m_3
1	0	0	0	m_4
1	0	1	1	m_5
1	1	0	1	m_6
1	1	1	1	m_7

$F = m_3 + m_5 + m_6 + m_7 = \bar{A}BC + A\bar{B}C + AB\bar{C} + ABC$

$F = M_0 \cdot M_1 \cdot M_2 \cdot M_4 = (A+B+C)(A+B+\bar{C})(A+\bar{B}+C)(\bar{A}+B+C)$



ES 332 Homework 15 (Solution-page 2)



ES 332 Homework 16

11.53 a)

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

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

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		1		1

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

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

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

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

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

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

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

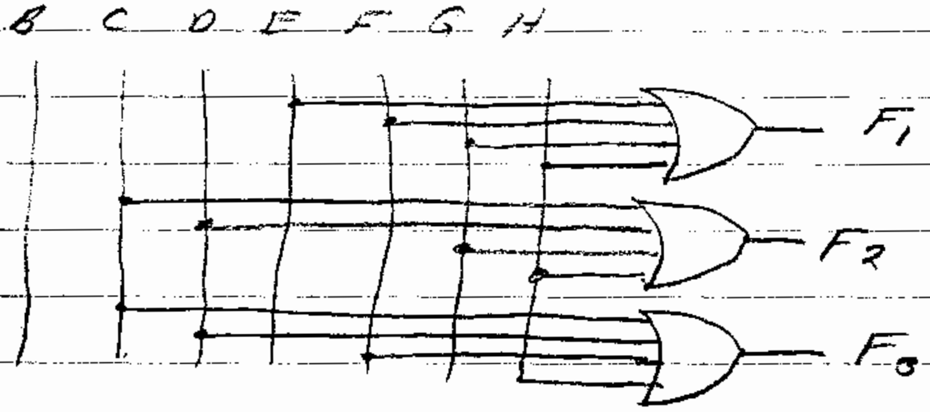
or other combinations

ES 332 Homework 17

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

Ⓓ

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

$D =$

Ⓔ

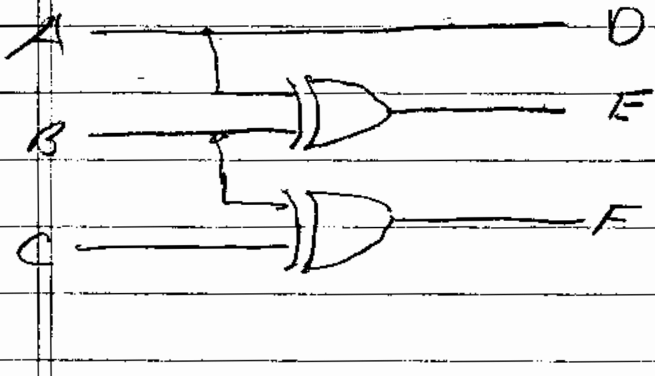
A \ BC	00	01	11	10
0	0	0	1	1
1	1	1	0	0

$E = \bar{A}B + A\bar{B}$
or
$E = A \oplus B$

Ⓕ

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

$F = \bar{B}C + B\bar{C}$
or
$F = B \oplus C$



ES 332 Homework 18

12-42

Input X	Present state Q_1 Q_2	Next state Q_1^+ Q_2^+	Output Y	D_1 D_2
0	0 0	1 1	1	1 1
0	0 1	0 0	0	0 0
0	1 0	0 1	1	0 1
0	1 1	1 0	0	1 0
1	0 0	0 1	1	0 1
1	0 1	1 0	0	1 0
1	1 0	1 1	1	1 1
1	1 1	0 0	0	0 0

(D_1)

X \ Q_1Q_2	00	01	11	10
0	1	0	1	0
1	0	1	0	1

(D_2)

X \ Q_1Q_2	00	01	11	10
0	1	0	0	1
1	1	0	0	1

(Y)

X \ Q_1Q_2	00	01	11	10
0	1	0	0	1
1	1	0	0	1

$$D_1 = \bar{X}\bar{Q}_1\bar{Q}_2 + \bar{X}Q_1Q_2 + X\bar{Q}_1Q_2 + XQ_1\bar{Q}_2 = \bar{X}\cdot\overline{Q_1\oplus Q_2} + X\cdot Q_1\oplus Q_2$$

or $D_1 = \overline{X\oplus(Q_1\oplus Q_2)}$ ←

$D_2 = \bar{Q}_2 = Y$ ←