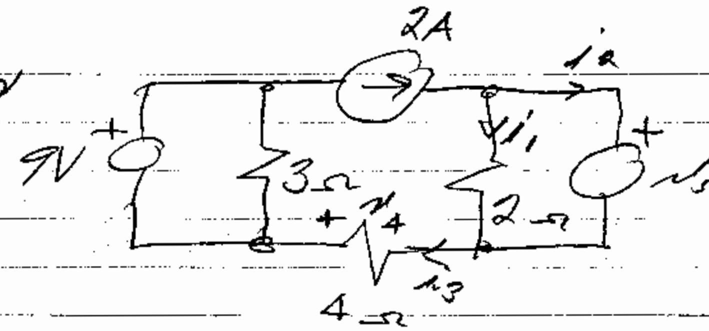
ES 332 Homework 2

1.18



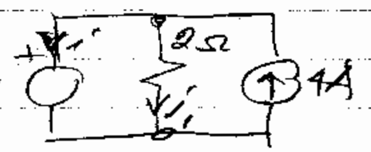
a) $v_s = 2V$, $i_1 = 1A$, $i_2 = 2-1 = 1A$, $i_3 = i_1 + i_2 = 2A$

$\therefore \boxed{v_4 = -2\times 4 = -8V}$

b) $v_s = 4V$, $i_1 = \frac{4}{2} = 2A$ so $i_3 = 2$ and $\boxed{v_4 = -8V}$

c) $v_s = 6V$, $i_1 = \frac{6}{2} = 3A$ so $i_3 = 2$ and $\boxed{v_4 = -8V}$

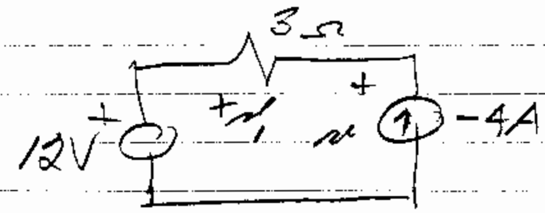
1.26 a)



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

$\boxed{i = 4 - i_1 = -2A}$

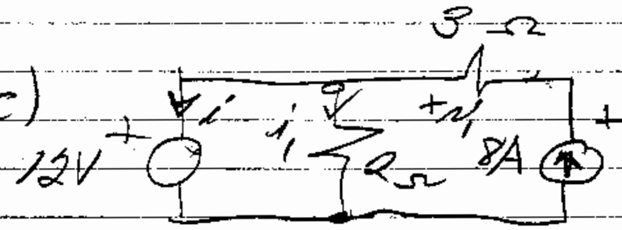
b)



$\boxed{v_1 = 3\times 4 = 12V}$

$\boxed{v = 12 - 12 = 0}$

c)



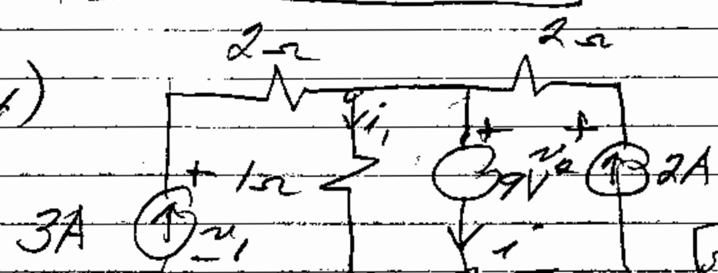
$i_1 = \frac{12}{2} = 6A$

$\therefore \boxed{i = 8 - i_1 = 2A}$

$\boxed{v_1 = -3\times 8 = -24V}$

$\boxed{v = 12 - v_1 = 36V}$

d)



$\boxed{v_2 = 9 + 2\times 2 = 13V}$

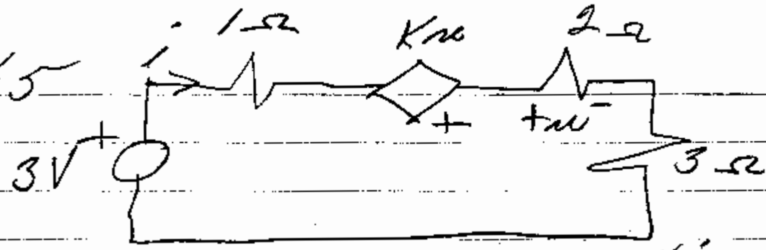
$i_1 = 9A$

$\boxed{\text{so } i = 2 - i_1 + 3 = -4A}$

$\boxed{v_1 = 3\times 2 + 9 = 15V}$

ES 332 Homework 2

1.45



$v = 2i$

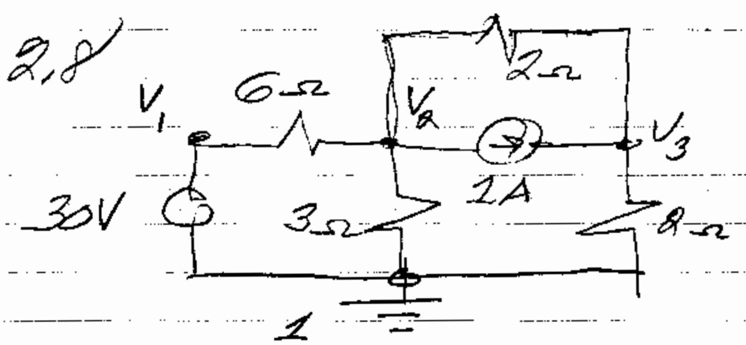
a) $K=2$ $\quad -3 + i - \underbrace{2v}_{-4i} + 2i + 3i = 0$

$2i = 3 \quad \boxed{i = \frac{3}{2}\,A}$

b) $K=4$ $\quad -3 + i - 8i + 5i = 0\ ;\ -2i = 3$

$\boxed{i = -\frac{3}{2}}$

2.8



$\boxed{V_1 = 30\,V}$

$$\frac{V_2 - 30}{6} + \frac{V_2}{3} + \frac{V_2 - V_3}{2} = -1$$

$$\frac{V_3 - V_2}{2} + \frac{V_3}{2} = 1$$

or $V_2\underbrace{\left(\frac{1}{6} + \frac{1}{3} + \frac{1}{2}\right)}_{1} - \frac{1}{2}V_3 = 4$ $\qquad 2V_2 - V_3 = 8 \quad (1)$

$-\frac{1}{2}V_2 + V_3 = 1$ $\qquad -V_2 + 2V_3 = 2 \quad (2)$

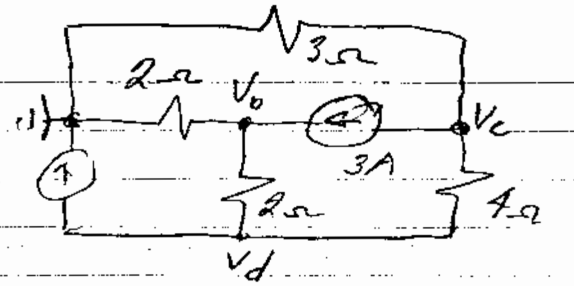
$$V_2 = \frac{\begin{vmatrix} 8 & -1 \\ 2 & 2 \end{vmatrix}}{\begin{vmatrix} 2 & -1 \\ -1 & 2 \end{vmatrix}} = \frac{16+2}{4-1} = \frac{18}{3} = \boxed{6\,V}$$

from (2) $\boxed{V_3 = \frac{2 + V_2}{2} = 4V}$

$$\text{or} \quad V_3 = \frac{\begin{vmatrix} 2 & 8 \\ -1 & 2 \end{vmatrix}}{\begin{vmatrix} 2 & -1 \\ -1 & 2 \end{vmatrix}} = \frac{4+8}{3} = \frac{12}{3} = 4V$$

ES 332 Homework 3 (2.19)

2.4a



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

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

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

or

$$V_b - \tfrac{1}{2}V_d = 3 \qquad 2V_b - V_d = 6$$

$$\tfrac{7}{12}V_c - \tfrac{1}{4}V_d = -3 \qquad 7V_c - 3V_d = -36$$

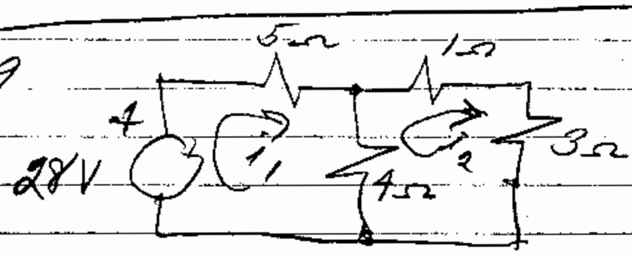
$$-\tfrac{1}{2}V_b - \tfrac{1}{4}V_c + \tfrac{3}{4}V_d = -1 \qquad -2V_b - V_c + 3V_d = -4$$

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

$$V_c = \frac{\begin{vmatrix} 2 & 6 & -1 \\ 0 & -36 & -3 \\ -2 & -4 & 3 \end{vmatrix}}{22} = \frac{\overset{-240+108=}{2(-108-12) - 2(-18-36)}}{22} = -\frac{132}{22} = \boxed{-6V}$$

$$V_d = \frac{\begin{vmatrix} 2 & 0 & 6 \\ 0 & 7 & -36 \\ -2 & -1 & -4 \end{vmatrix}}{22} = \frac{\overset{-124+84=}{2(-28-36) + 6(+14)}}{22} = -\frac{44}{22} = \boxed{-2V}$$

2.19



$$28 = 5i_1 + 4(i_1 - i_2) = 9i_1 - 4i_2$$

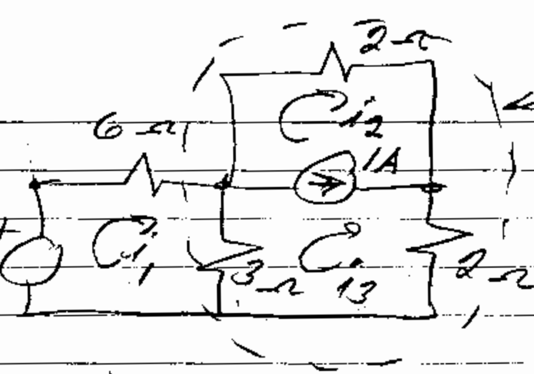
$$0 = 4(i_2 - i_1) + 4i_2 = -4i_1 + 8i_2$$

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

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

ES 332 Homework 4

2.25



← super mesh

$$\boxed{i_3 - i_2 = 1} \quad (1)$$

$$-i_2 + i_3 = 1$$

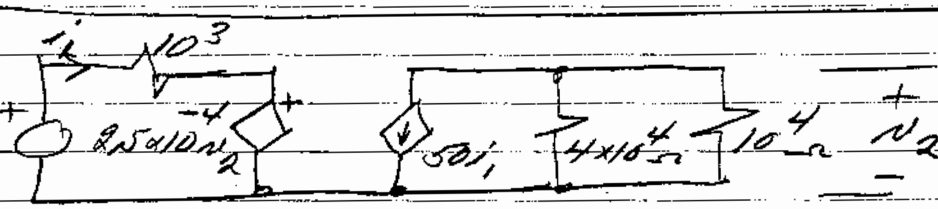
$$\left.\begin{aligned} &6i_1 + 3(i_1 - i_3) = 30 \\ &3(i_3 - i_1) + 2i_2 + 2i_3 = 0 \end{aligned}\right\} \Rightarrow \begin{aligned} &9i_1 - 3i_3 = 30 \\ &-3i_1 + 2i_2 + 5i_3 = 0 \end{aligned}$$

$$i_1 = \frac{\begin{vmatrix} 1 & -1 & 1 \\ 30 & 0 & -3 \\ 0 & 2 & 5 \end{vmatrix}}{\begin{vmatrix} 0 & -1 & 1 \\ 9 & 0 & -3 \\ -3 & 2 & 5 \end{vmatrix}} = \frac{-2(-33)+5(30)}{1(45-9)+1(18)} = \frac{216}{54} = \boxed{4A}$$

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

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

2.11



$$-v_1 + 10^3 i_1 + 2.5\times10^{-4} v_2 = 0 \quad ; \quad v_2 = -50 i_1 \left(\tfrac{4}{5}\right)\times10^4 = -40\times10^4 i_1$$

$$\therefore -v_1 + 10^3\left(-\frac{v_2}{4\times10^5}\right) v_2 + 2.5\times10^{-4} v_2 = 0$$

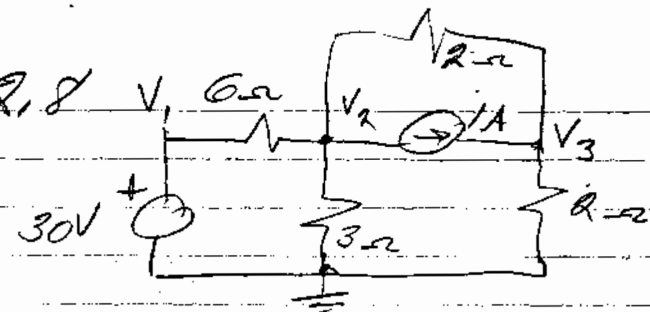
$$\text{or } -v_1 = v_2\left(0.25\times10^{-2} - 2.5\times10^{-4}\right) = 2.25\times10^{-3} v_2$$

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

b) $$\frac{v_1}{i_1} = R_{in} = \frac{-v_1\times4\times10^5}{v_2} = \frac{4\times10^5}{444.44} = \boxed{900\,\Omega}$$

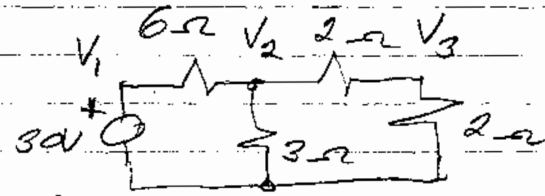
ES 332 Homework 5

2.8



$\boxed{V_1 = 30V}$

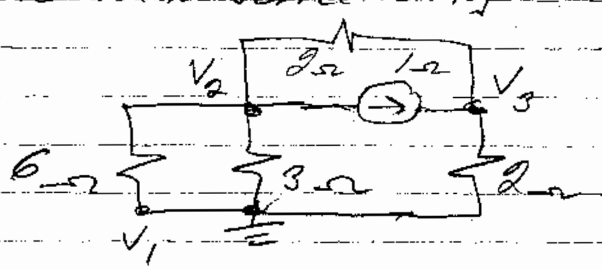
Voltage source only



$$\frac{V_2-30}{6} + \frac{V_2}{3} + \frac{V_2}{4} = 0\ ;\ V_2\underbrace{\left(\frac{1}{6}+\frac{1}{3}+\frac{1}{4}\right)}_{\frac{3}{4}} = 5\ ;\ \boxed{V_2 = \frac{20}{3}}$$

using voltage division $\boxed{V_3 = \frac{10}{3}}$

current source only



$$\frac{V_2}{2} + \frac{V_2 - V_3}{2} + 1 = 0 \qquad V_1 = 0$$

$$\frac{V_3 - V_2}{2} + \frac{V_3}{2} - 1 = 0$$

or $V_2 - \frac{1}{2}V_3 = -1$

$-\frac{1}{2}V_2 + V_3 = 1$

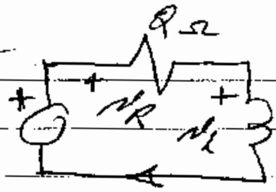
$$V_2 = \frac{\begin{vmatrix} -1 & -\frac{1}{2} \\ 1 & 1 \end{vmatrix}}{\begin{vmatrix} 1 & -\frac{1}{2} \\ -\frac{1}{2} & 1 \end{vmatrix}} = \frac{-1+\frac{1}{2}}{1-\frac{1}{4}} = \frac{-\frac{1}{2}}{\frac{3}{4}} = -\frac{2}{3}V$$

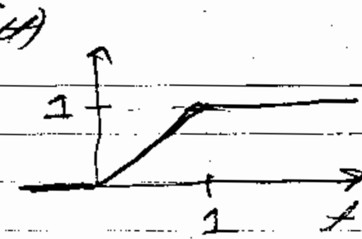
$$V_3 = \frac{\begin{vmatrix} 1 & -1 \\ -\frac{1}{2} & 1 \end{vmatrix}}{\frac{3}{4}} = \frac{1-\frac{1}{2}}{\frac{3}{4}} = \frac{2}{3}V$$

so
$$\left.\begin{aligned} V_1 &= 30 + 0 = 30\ V \\ V_2 &= \frac{20}{3} - \frac{2}{3} = 6\ V \\ V_3 &= \frac{10}{3} + \frac{2}{3} = 4V \end{aligned}\right\}$$

ES 332 Homework 6

3.1

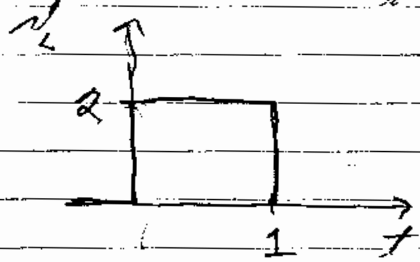




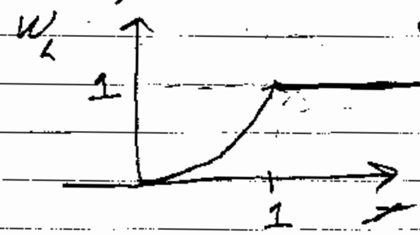
$v_L = L\frac{di}{dt}$

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

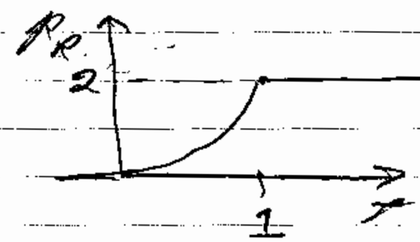
a)



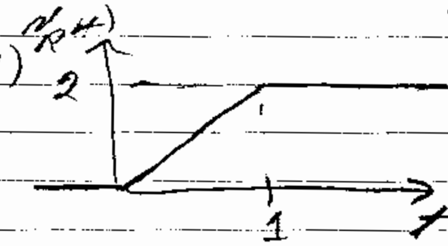
b)



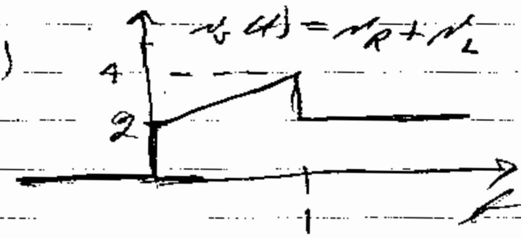
c)



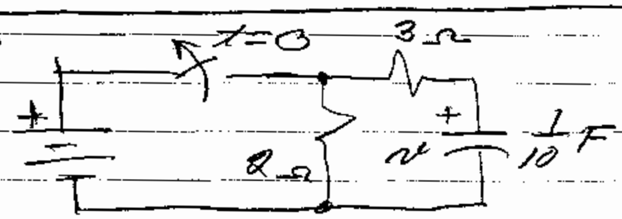
d)



e)

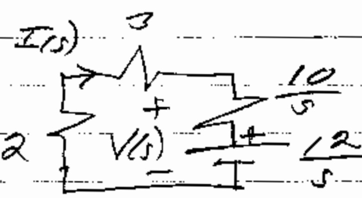


3.28



$\boxed{v(0) = 12V}$

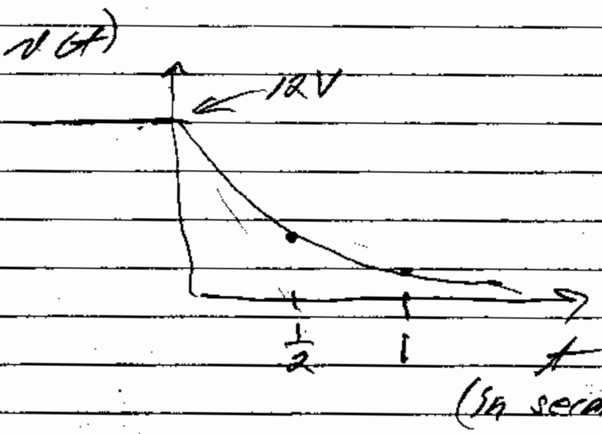
s domain circuit for $t > 0$ ⇒

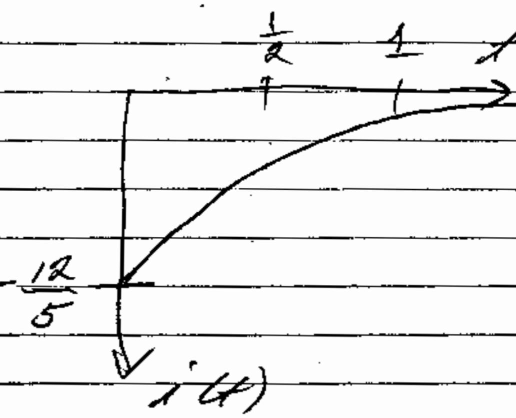


$$I(s)\left[5 + \frac{10}{s}\right] = -\frac{12}{s} \quad ; \quad I(s) = -\frac{12/s}{\frac{5s+10}{s}} = -\frac{12}{5}\cdot\frac{1}{s+2}$$

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

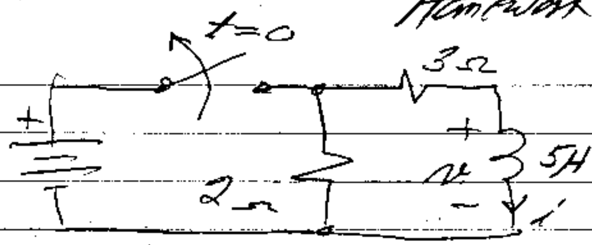
$$v(t) = \boxed{-5\,i(t)} = 12e^{-2t}u(t)$$

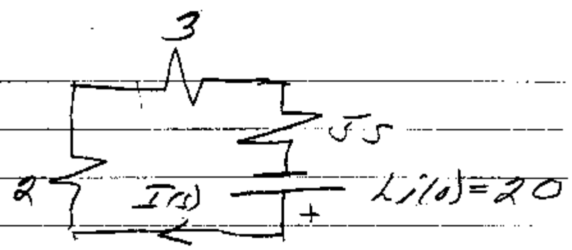




ES 332 Homework 7

3.29



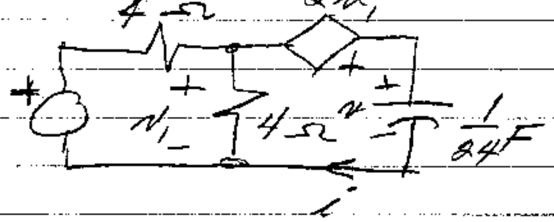


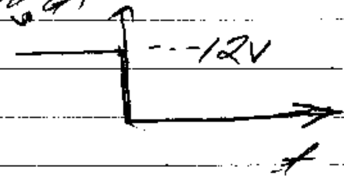
$i(0) = \frac{12}{3} = 4A$

$\therefore\ I(s)[5+5s] = 20$ or $\boxed{I(s) = \frac{4}{s+1};\ i(t) = 4e^{-t}u(t)}$

$V(s) = I(s)\times 5s - 20 = \frac{20s}{s+1} - 20 = -\frac{20}{s+1}$; $\boxed{v(t) = -20e^{-t}u(t)}$

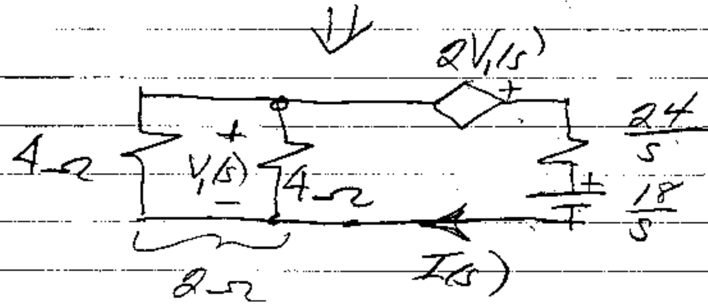
3.34





for $t<0$
$v_1 = 6V$
$\boxed{\text{so } v(0) = 3v_1(0) = 18V}$

$\Downarrow$



$2I(s) - 2V_1 + \frac{24}{s}I + \frac{18}{s} = 0$

$I(s)\{2+\frac{24}{s}\} = 2V_1 - \frac{18}{s}$

but $V_1 = -2I(s)$

$\therefore\ I(s)\{2+\frac{24}{s}+4\} = -\frac{18}{s}$; $I(s) = \frac{-\frac{18}{s}}{6+\frac{24}{s}} = \frac{-18}{6s+24} = \boxed{\frac{-3}{s+4}}$

so $\boxed{i(t) = -3e^{-4t}u(t)}$

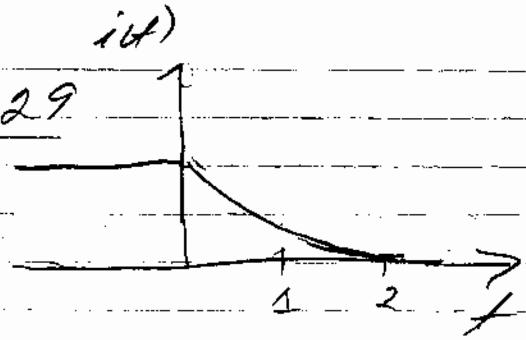
$V(s) = I(s)\times\frac{24}{s} + \frac{18}{s} = \frac{-72}{s(s+4)} + \frac{18}{s} = \cancel{-\frac{18}{s}} + \frac{18}{s+4} + \cancel{\frac{18}{s}}$

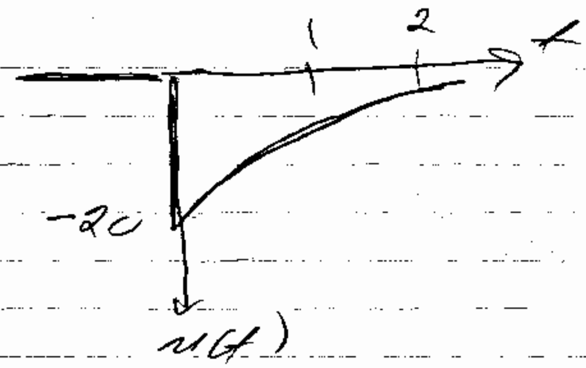
$v(t) = 18e^{-4t}u(t)$

{sketches on next page!}

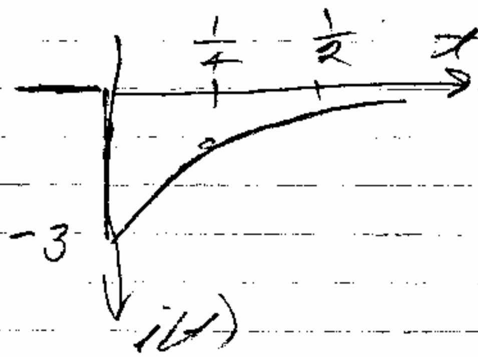
ES 332 Homework 7 (page 2)

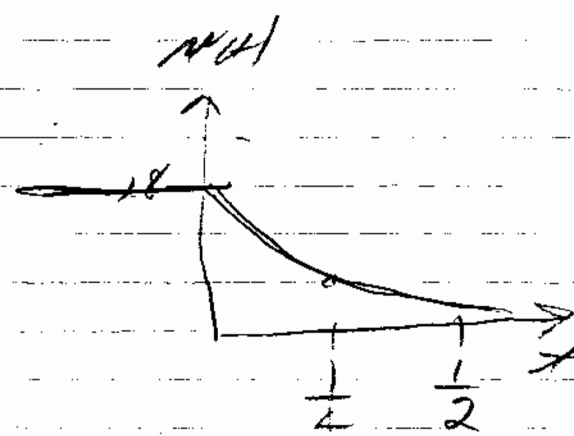
3.29





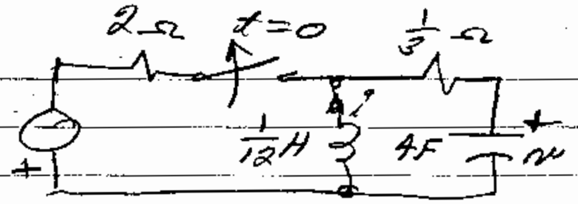
3.34

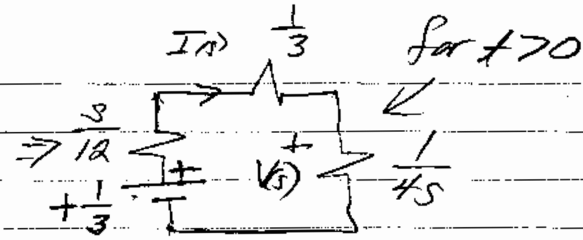




ES 332 Homework 8

3.57





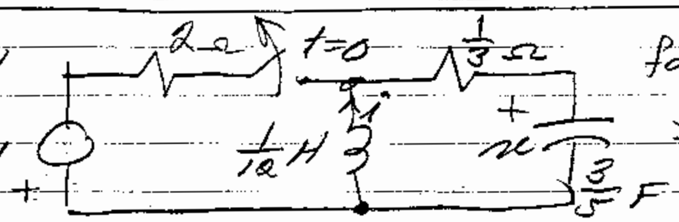
$\boxed{i(0) = +\frac{8}{2} = +4A\ ;\ v(0)=0}$

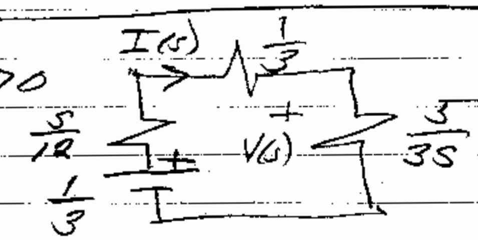
$I(s)\left[\frac{s}{12}+\frac{1}{3}+\frac{1}{4s}\right] - \frac{1}{3} = 0\ ;\ I(s) = \frac{4s}{s^2+4s+3} = \frac{4s}{(s+1)(s+3)}$

$I(s) = \frac{-2}{s+1} + \frac{+6}{s+3}\ ;\ i(t) = \left[-2e^{-t}+6e^{-3t}\right]u(t)$

$V(s) = I(s)\frac{1}{4s} = \frac{1}{(s+1)(s+3)} = \frac{\frac{1}{2}}{s+1}+\frac{-\frac{1}{2}}{s+3}\ ;\ v(t)=\frac{1}{2}\left[e^{-t}-e^{-3t}\right]u(t)$

3.58





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

$$I(s) = \frac{\frac{1}{3}}{\frac{s}{12}+\frac{1}{3}+\frac{5}{3s}} = \frac{4s}{s^2+4s+20} = \frac{4(s+2)-8}{(s+2)^2+16}$$

and $i(t) = \left[4e^{-2t}\cos 4t - 2e^{-2t}\sin 4t\right]$

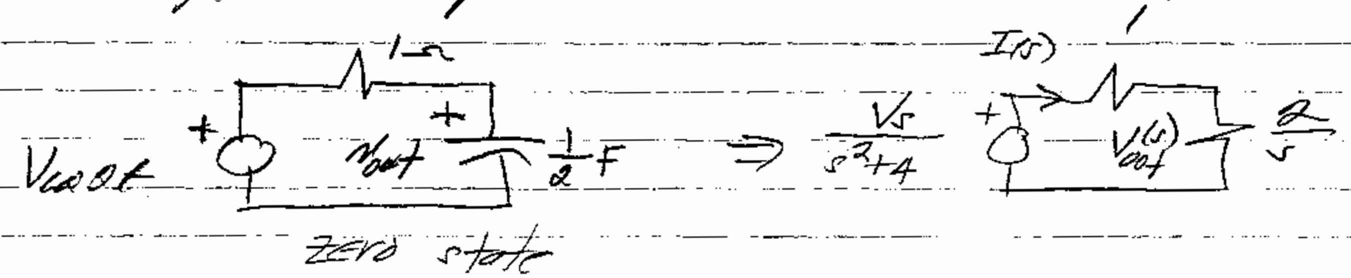
$$V(s) = I(s)\times\frac{5}{3s} = \frac{20}{3}\cdot\frac{1}{s^2+4s+20} = \frac{20}{3}\cdot\frac{1}{(s+2)^2+16}$$

$$v(t) = \left[\frac{\cancel{20}^{\,5}}{3\times\cancel{4}} e^{-2t}\sin 4t\right]u(t)$$

$$v(t) = \left[\frac{5}{3}e^{-2t}\sin 4t\right]u(t)$$

ES 332 Homework 9

Special problem



$$\frac{Vs}{s^2+4} = I(s)\left[1+\frac{2}{s}\right] \therefore I(s) = \frac{\frac{Vs}{s^2+4}}{\frac{s+2}{s}} = \frac{Vs^2}{(s+2)(s^2+4)}$$

$$I(s) = \frac{K_1}{s+2} + \frac{K_2 s + K_3}{s^2+4} \quad ; K_1 = \frac{4V}{8} = \frac{V}{2}$$

$$\text{so } Vs^2 = \frac{V}{2}(s^2+4) + (K_2 s + K_3)(s+2)$$

s^2 terms $\quad V = \frac{V}{2} + K_2 \quad$ or $K_2 = \frac{V}{2}$

s terms $\quad 0 = 2K_2 + K_3 \quad$ or $K_3 = -2K_2 = -V$

$$I(s) = \frac{V/2}{s+2} + \frac{V/2 \times s - V}{s^2+4}$$

$$\boxed{i(t) = \left[\frac{V}{2}e^{-2t} + \frac{V}{2}\cos 2t - \frac{V}{2}\sin 2t\right]u(t)}$$

$$V_{out}(s) = I(s)\frac{2}{s} = \frac{2sV}{(s+2)(s^2+4)} = \frac{A}{s+2} + \frac{Bs+C}{s^2+4}$$

$$A = \frac{-4V}{8} = -\frac{V}{2}$$

$$2sV = -\frac{V}{2}(s^2+4) + (Bs+C)(s+2)$$

s^2 terms $\quad 0 = -\frac{V}{2} + B \quad \therefore B = \frac{V}{2}$

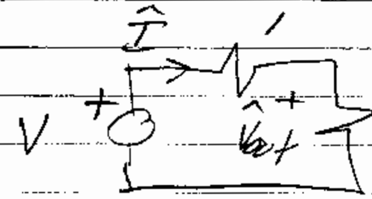
s terms $\quad 2V = C + 2B = C + V \quad \therefore C = V$

$$\text{and } V_{out}(s) = \frac{-V/2}{s+2} + \frac{V/2\, s + V}{s^2+4}$$

$$\boxed{v_{out}(t) = \left[-\frac{V}{2}e^{-2t} + \frac{V}{2}\cos 2t + \frac{V}{2}\sin 2t\right]u(t)}$$

Homework 9

<u>Sinusoidal steady state solution</u> to special prob.



$$\hat{I} = \frac{V}{1-j} = \frac{V}{\sqrt{2}} e^{j45^\circ}$$

$$i(t) = Re\{\hat{I} e^{j2t}\} = \frac{V}{\sqrt{2}} \cos(2t + 45^\circ)$$

$$\hat{V}_{out} = -j \hat{I} = e^{-j90^\circ} \frac{V}{\sqrt{2}} e^{j45^\circ}$$

$$\text{so } v_{out}(t) = \frac{V}{\sqrt{2}} \cos(2t - 45^\circ)$$