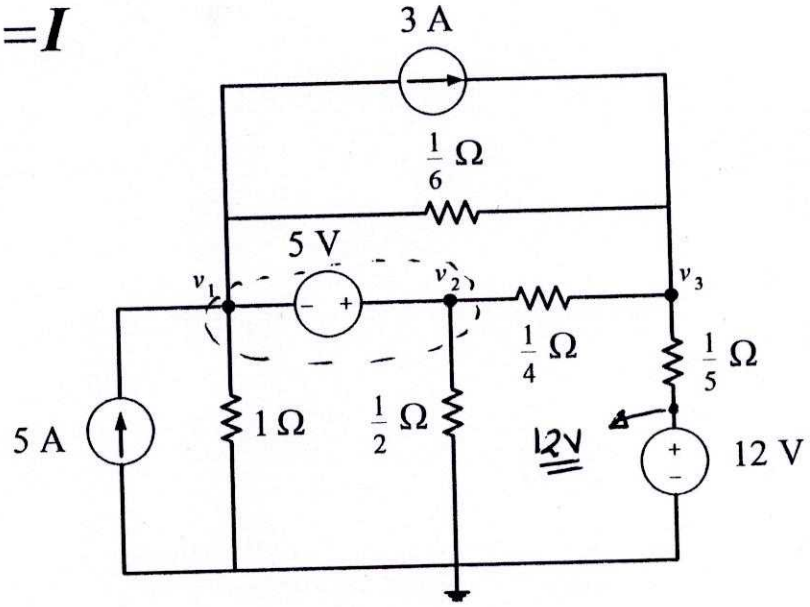
Problem 1:

a) For the circuit shown above find the node equations necessary to solve (**DO NOT SOLVE THE EQUATIONS**) for the nodes v_1, v_2 and v_3 then write them in the matrix form $GV = I$ where

$$V = \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix}$$



$$V_2 - V_1 = 5 \quad -(1)$$

KCL on Supper Node

$$\frac{V_1}{1} - 5 + \frac{V_1 - V_3}{1/6} + 3 + \frac{V_2}{1/2} + \frac{V_2 - V_3}{1/4} = 0$$

$$\Rightarrow 7V_1 + 6V_2 - 10V_3 = 2 \quad -(2)$$

KCL on Node U_3

$$\frac{V_3 - V_2}{1/4} + \frac{V_3 - 12}{1/5} + \frac{V_3 - V_1}{1/6} - 3 = 0$$

$$\Rightarrow -6U_1 - 4U_2 + 15U_3 = 63 \quad -(3)$$

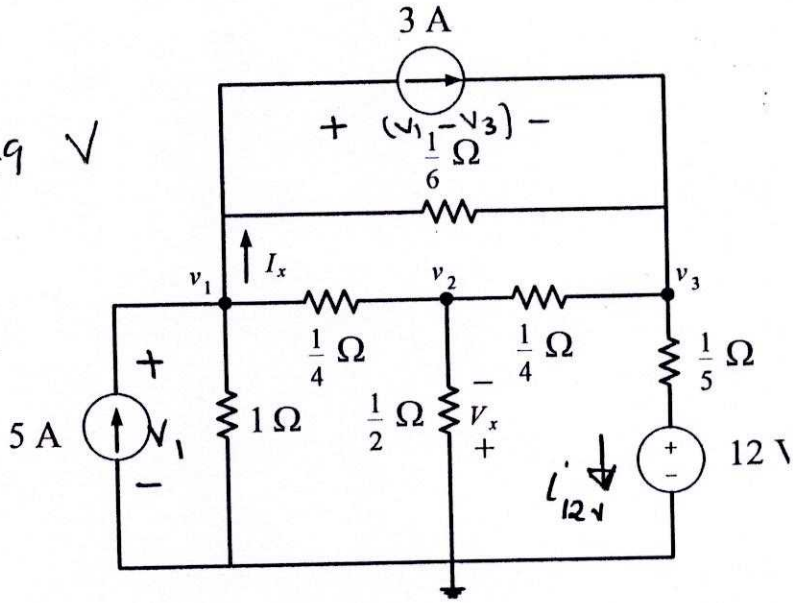
$$\begin{bmatrix} -1 & 1 & 0 \\ 7 & 6 & -10 \\ -6 & -4 & 15 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 5 \\ 2 \\ 63 \end{bmatrix}$$

b) For the circuit shown, if the nodes voltages are found to be

$v_1 = 7.4135$ V $v_2 = 6.5279$ V $v_3 = 8.9062$ V

Find the following:

1. The voltage V_x and the current I_x ?
2. The power **absorbed** by each of the three independent sources?



$$V_x = -V_2 = -6.5279 \text{ V}$$

$$I_x = 5 + \frac{0 - V_1}{1} + \frac{V_2 - V_1}{1/4}$$

$$= 5 - V_1 - 4(V_1 - V_2)$$

$$= -5.9559 \text{ A}$$

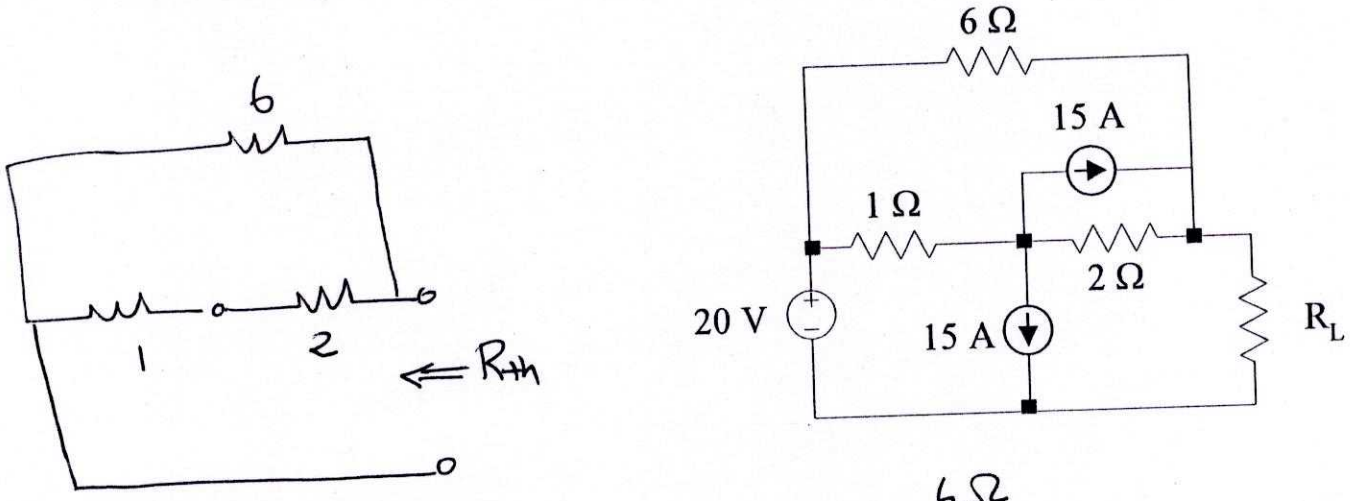
$$P_{5A} = -(V_1)(5) = -37.0675 \text{ W}$$

$$P_{3A} = (V_1 - V_3)(3) = -4.4781 \text{ W}$$

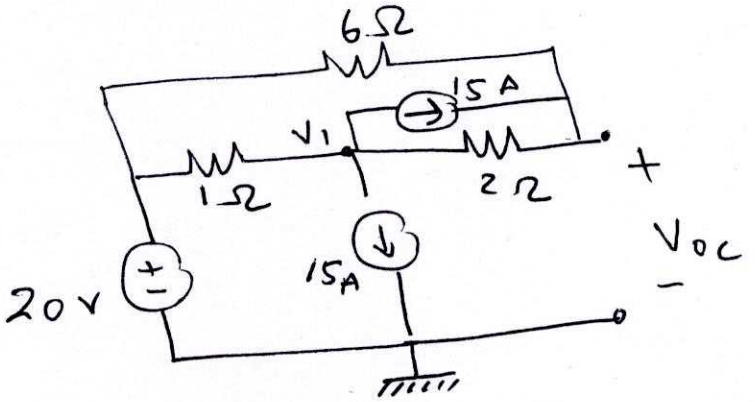
$$P_{12V} = 12\, i_{12V} = 12\left[\frac{V_3 - 12}{1/5}\right] = -185.628 \text{ W}$$

Problem 2:

a) In the circuit shown, determine the value of the resistor R_L that absorbs maximum power from the circuit.
b) Calculate the maximum power that is absorbed by R_L



$R_L = R_{th} = 3 \| 6 = \boxed{2\ \Omega}$



Using Nodal analysis to find V_{oc}

$$\frac{V_1 - 20}{1} + 15 + 15 + \frac{V_1 - V_{oc}}{2} = 0$$

$$\Rightarrow 3V_1 - V_{oc} = -20 \quad -(1)$$

$$\frac{V_{oc} - V_1}{2} + \frac{V_{oc} - 20}{6} = 15$$

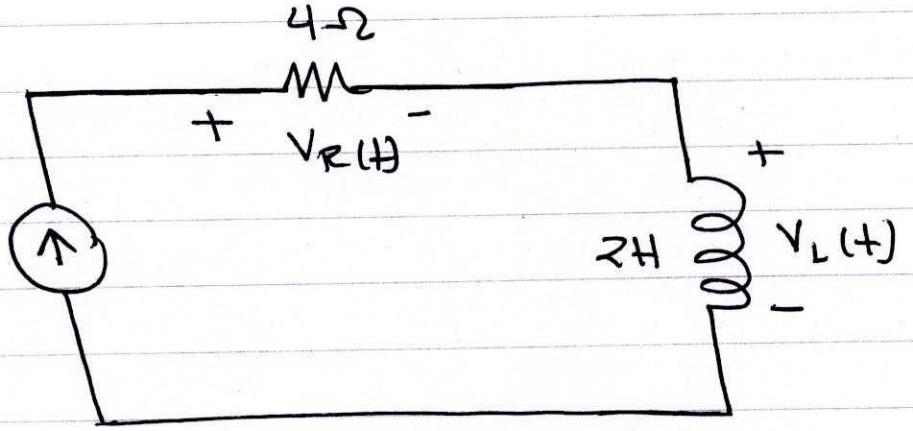
$$\Rightarrow -3V_1 + 4V_{oc} = 110 \quad -(2)$$

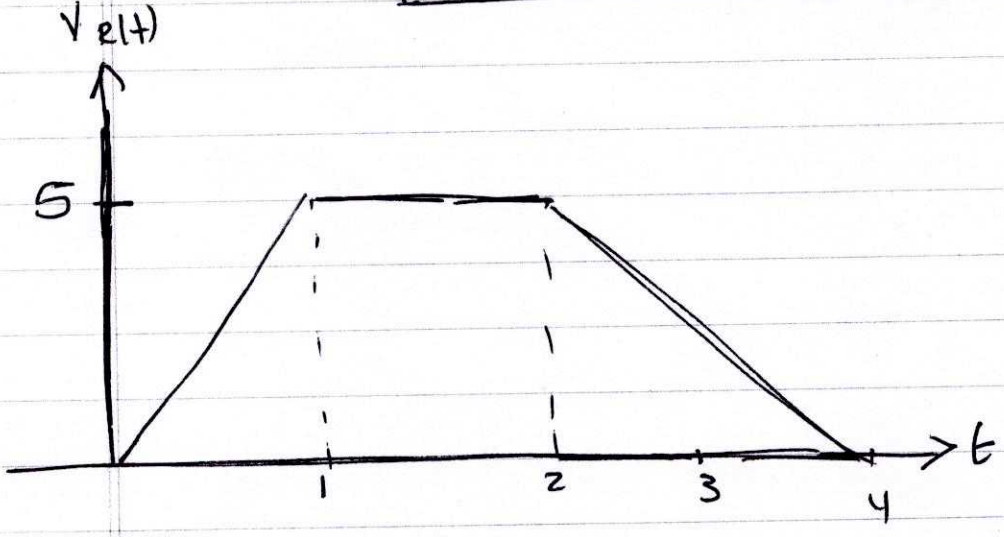
From (1) and (2) $\Rightarrow 3V_{oc} = 90 \Rightarrow V_{oc} = \boxed{30\ V}$

$$\Rightarrow P_{max} = \frac{V_{oc}^2}{4R_{th}} = \frac{(30)^2}{4(2)} = \boxed{112.5\ W}$$

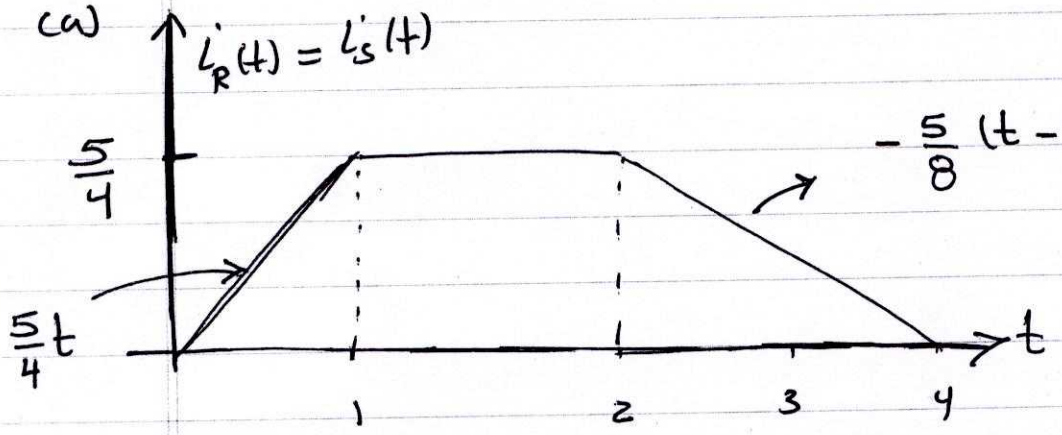
Problem 3

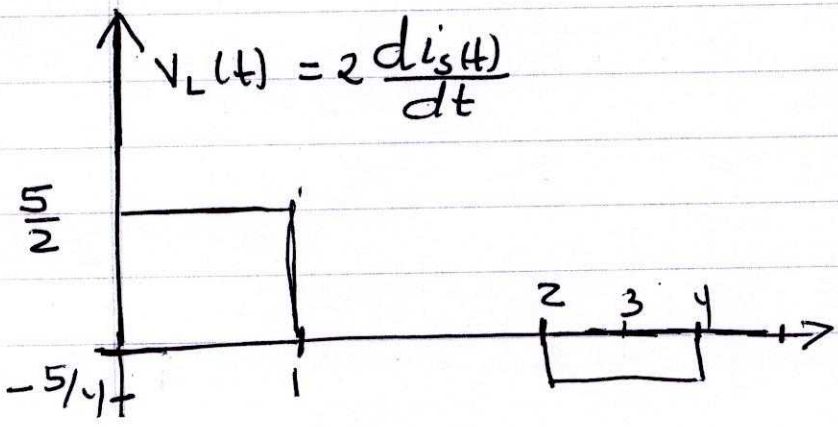
(a)

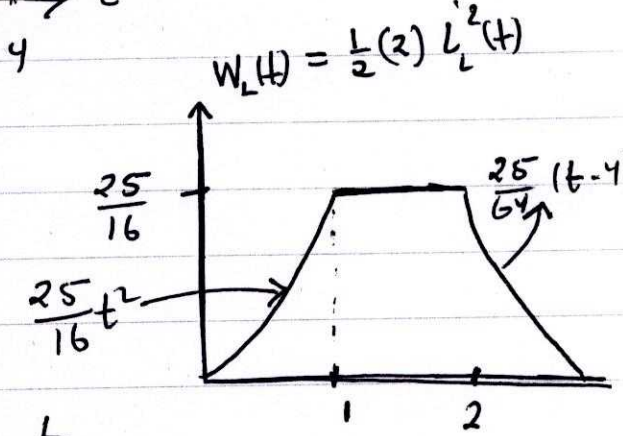

4Ω
+
$V_R(t)$
−
+
2H
$V_L(t)$
−
$i_s(t)$


$V_R(t)$
5
1
2
3
4
t

(a)

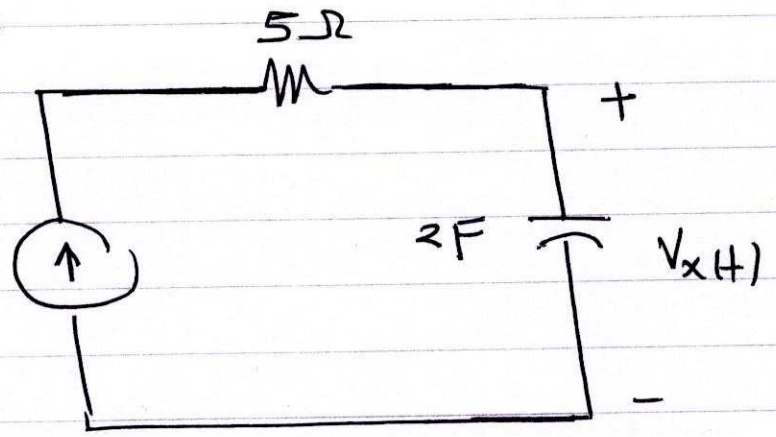

$i_R(t) = i_s(t)$
$\frac{5}{4}$
$\frac{5}{4}t$
$-\frac{5}{8}(t-4)$
1
2
3
4
t

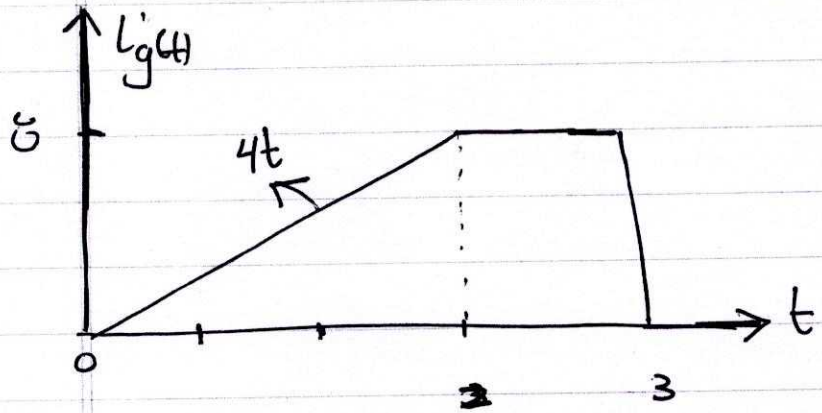

$V_L(t) = 2\frac{di_s(t)}{dt}$
$\frac{5}{2}$
$-5/4$
1
2
3
4
t


$W_L(t) = \frac{1}{2}(2)\, i_L^2(t)$
$\frac{25}{16}$
$\frac{25}{16}t^2$
$\frac{25}{64}(t-4)$
1
2

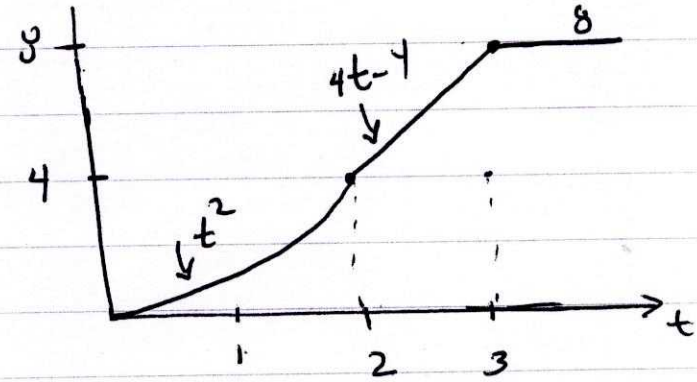
Problem 3

(b)





$$v_x(t) = \frac{1}{C}\int_{-\infty}^{t} i_g(t)\,dt$$



$t < 0 \Rightarrow v_x(t) = 0$

$0 < t < 2 \Rightarrow v_x(t) = \frac{1}{2}\int_0^t (4t')\,dt' = t^2$

$2 < t < 3 \Rightarrow v_x(t) = v_x(2) + \frac{1}{2}\int_2^t 8\,dt' = 4t - 4$

$t > 3 \Rightarrow v_x(t) = v_x(3) + \frac{1}{2}\int_3^t 0\,dt = 8$