Electrical Engineering Department
School of Engineering
University of Jordan

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Electrical Circuits (1) (EE211)
Second Exam
3rd Term, 2016-2017
July 6th, 2017. ⌛ 14:00 – 15:30

Key

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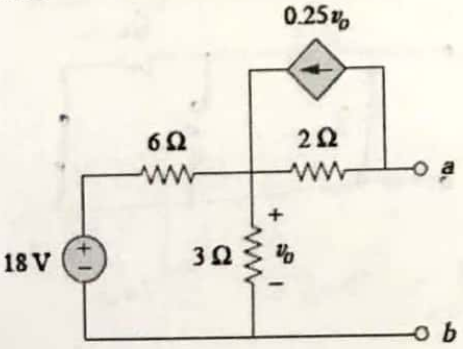
Reg. No.: .....

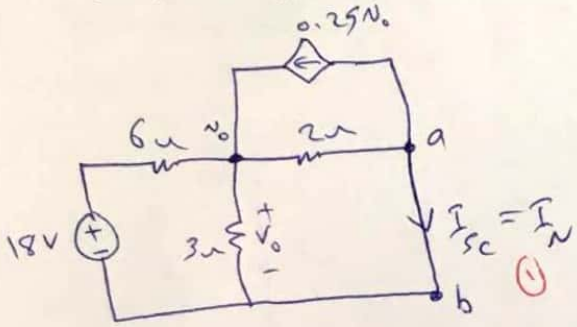
Problem 1: (5 points)

Consider the given circuit and answer the following questions:

a) (2 points) find the equivalent Norton current seen between a and b.
b) (2 points) find the equivalent Thevenin voltage seen between a and b.
c) (1 point) find the equivalent Norton resistor seen between a and b.



a)



(1)

Nodal:

$$\frac{V_o - 18}{6} + \frac{V_o}{3} + \frac{V_o}{2} - \frac{V_o}{4} = 0 \Rightarrow \boxed{V_o = 4\,V}$$

KCL at (a):

$$I_{sc} = \frac{V_o}{2} - \frac{V_o}{4} = 2 - 1 \Rightarrow \boxed{I_N = 1A} \quad (1)$$

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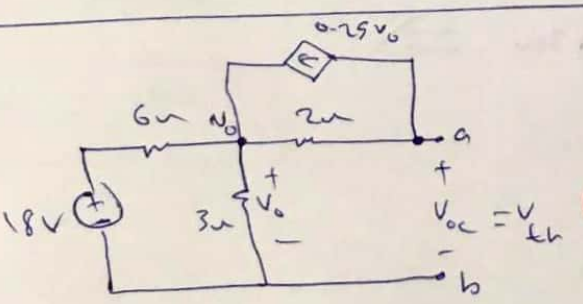
b)



(1)

Nodal:

$$\frac{V_o - 18}{6} + \frac{V_o}{3} + \frac{V_o - V_{oc}}{2} - \frac{V_o}{4} = 0 \quad -(1)$$

$$\frac{V_{oc} - V_o}{2} + 0.25\,V_o = 0 \quad -(2)$$

(2) in (1)

$$\frac{V_o}{2} = 3 \Rightarrow \boxed{V_o = 6V}$$

KVL:

$$*\frac{V_{oc}}{2} = -\frac{V_o}{4} + \frac{V_o}{2} = \frac{V_o}{4}$$

$$V_{oc} = \frac{V_o}{2} = \boxed{3V} \quad (1)$$

c) $$\boxed{R_{th} = \frac{V_{th}}{I_N} = 3\,\Omega} \quad (1)$$

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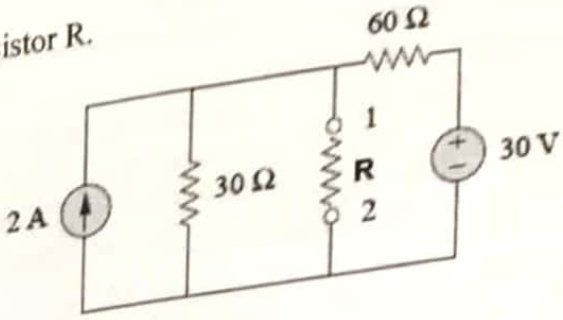
Problem 2: (5 points)

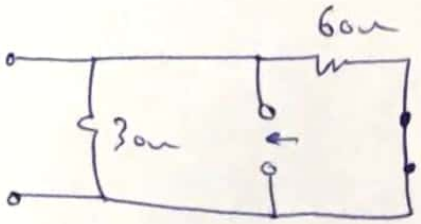
Consider the given circuit and answer the following questions:

a. (2 points) Find the value of the resistor R connected between 1 and 2 to get the maximum power transfer to this resistor.

b. (3 points) Find the maximum power transfer to the resistor R.



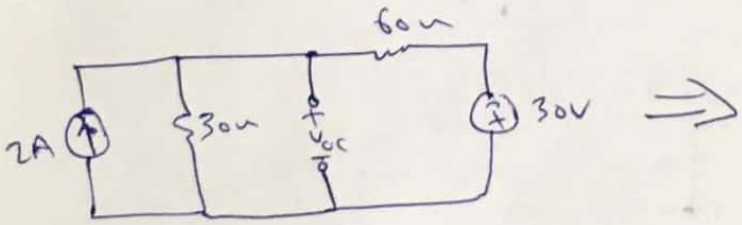
a) $R = R_{th}$ (1)



$R_{th} = 30 \| 60 = 20\Omega$

$\boxed{R = 20\Omega}$ (1)

b) $P_{max} = \dfrac{V_{th}^2}{4R_{th}}$ (1)



nodal:

$$\frac{V_{oc}}{30} - 2 + \frac{V_{oc} + 30}{60} = 0$$

$$\frac{V_{oc}}{20} = 2 + \frac{1}{2} \Rightarrow \boxed{V_{oc} = 50V}$$ (1.5)

$$P_{max} = \frac{(50)^2}{80} = \boxed{31.25\,W}$$ (0.5)

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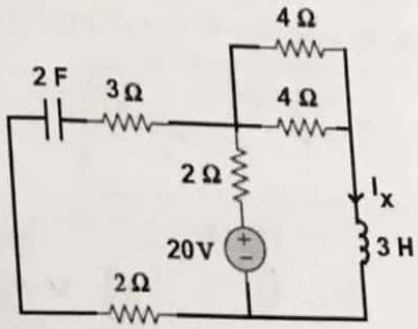
Problem 3: (5 points)

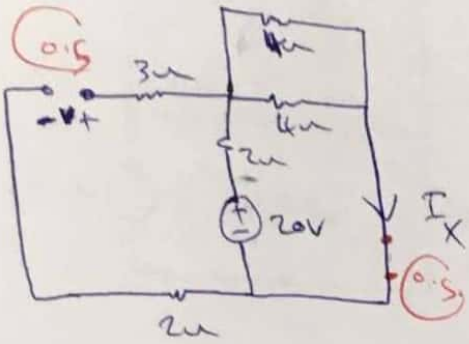
Consider the given circuit and answer the following questions:

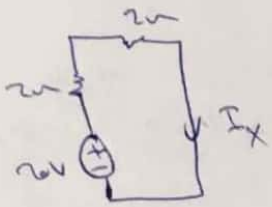
a) (2.5 points) find the current Ix.

b) (2.5 points) find the stored energy in the capacitor.



a)





$\Rightarrow \quad I_x = \frac{20}{4} = \boxed{5A}$ (1.5)

b) $W_c = \frac{1}{2} C V^2$ (1)

KVL: $-V + 2(-I_x) + 20 = 0$

$\boxed{V = 10V}$ (1)

$\boxed{W_c = 100\ J}$ (0.5)

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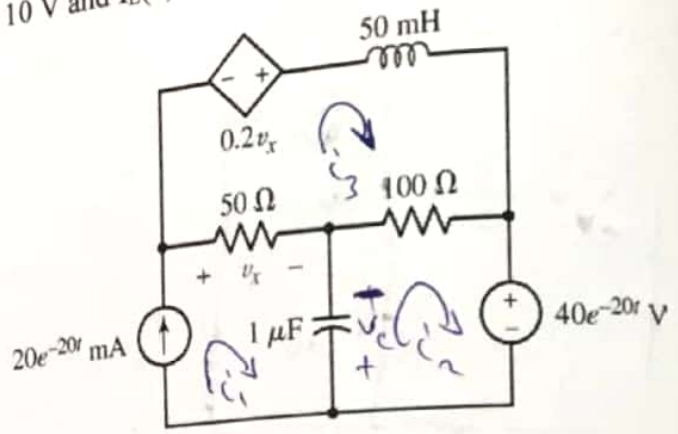
Problem 4: (5 points)

Write a complete set of mesh equations if $V_c(0) = 10$ V and $i_L(0) = 5$ A. (don't solve the equations)



$i_1 = 20e^{-20t}$ mA (0.5)

$v_x = 50(i_1 - i_3)$ V (0.5)

KVL at mesh (2)

$$\frac{1}{C}\int_0^t (i_2(t) - i_1(t))\,dt + v_c(0) + 100(i_2 - i_3) + 40e^{-20t} = 0 \rightarrow (1)$$

$$10^6 \int_0^t i_2\,dt + 100 i_2 - 100 i_3 = -40e^{-20t} - 10 + 10^6 \int_0^\infty 20e^{-20t} * 10^{-3}\,dt$$

→ (1)

KVL at mesh (3):

$$-0.2 v_x + 50 * 10^{-3} \frac{di_3}{dt} + 100(i_3 - i_2) + 50(i_3 - i_1) = 0 \rightarrow (1)$$

$$-100 i_2 + 160 i_3 + 0.05 \frac{di_3}{dt} = 50(0.02 e^{-20t}) + 10 e^{-20t}$$

$$-100 i_2 + 160 i_3 + 0.05 \frac{di_3}{dt} = 20 e^{-20t} \rightarrow (1)$$

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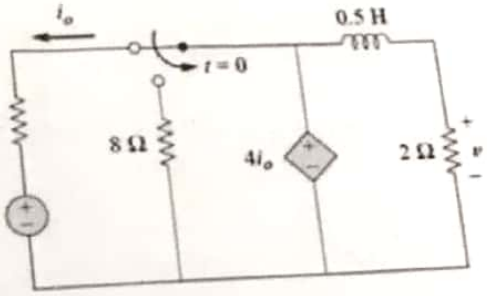
Problem 5: (5 points)
Consider the given circuit and answer the following questions:

a) Find the type of this circuit for $t \geq 0$.
b) Find the time constant.
c) Find $v(0^-)$ and $i_o(0^-)$.
d) Find $v(0^+)$ and $i_o(0^+)$.
e) Find v(t) for all t.



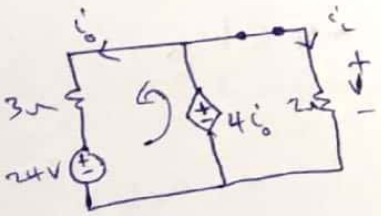
a) source free series RL circuit. (1)

b) $\tau = \frac{L}{R} = \frac{0.5}{2} = \boxed{0.25\ s}$ (1)

c) KVL:

$-4i_o + 3i_o + 24 = 0$

$\Rightarrow t < 0$:



$\boxed{i_o(0) = 24\ A}$, $t < 0$ (0.5)

$v = 4i_o \Rightarrow \boxed{v(0) = 96\ V}$ (0.5)

$i_o = 0$

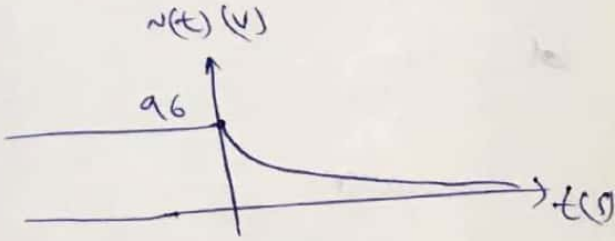
d) $\boxed{i_o(0^+) = 0}$ → open circuit. (0.5)

$\Rightarrow t > 0$:

$v_o(0^+) = 2\, i_L(0^+) = 2\, i_L(0^-)$

$= 2\,\frac{96}{2} = \boxed{96\ V}$ (0.5)

e) $v(t) = \begin{cases} 96, & t < 0 \\ 96\, e^{-4t}, & t > 0 \end{cases}$ (1)



~~$v(t) = 48(1 + 48\, e^{-4t}\, u(t))$~~

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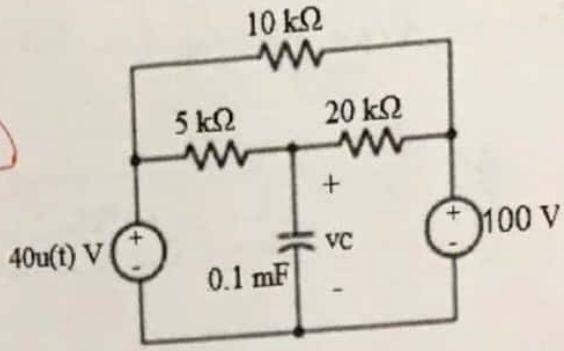
Problem 6: (5 points)

a) Find the type of this circuit for $t \geq 0$.
b) Find the time constant.
c) Find $v_c(0)$.
d) Find $v_c(t)$ for all t.
e) Sketch $v_c(t)$ for all t.



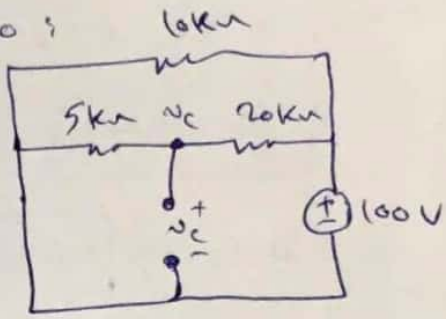
a) Driven RC parallel circuit. (1)

b) $\tau = R_{th} C$

$R_{th} = 5k \,||\, 20k = 4k\Omega$ (0.5)

$\boxed{\tau = 0.4\,s}$ (0.5)

$t<0$:



c) $v_c(0) = v_c(0^-) = v_c(0^+)$

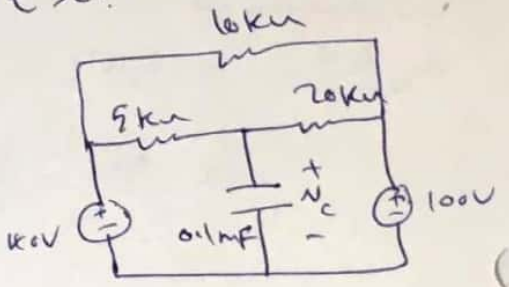
$v_c(0) = ?$

Nodal:

$$\frac{v_c}{5000} + \frac{v_c - 100}{20000} = 0$$

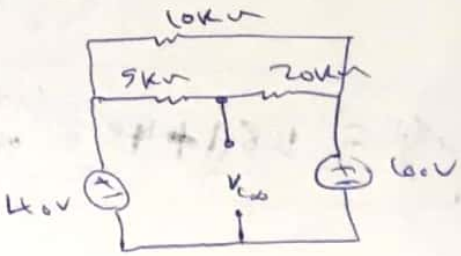
$$\frac{5}{20000}\, v_c = \frac{1}{200} \Rightarrow \boxed{v_c(0) = 20V}$$ (1)

$t>0$:



d) $v_{c\infty} =$

at $t = \infty$



Nodal at $t = \infty$

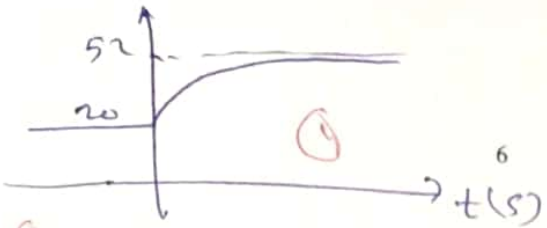
$$\frac{v_{c\infty} - 40}{5000} + \frac{v_{c\infty} - 100}{20000} = 0$$

$$\frac{v_{c\infty}}{4} = 8 + 5 \Rightarrow \boxed{v_{c\infty} = 52V}$$

$$v_c(t) = 52 - (52 - 20)\, e^{-t/0.4}\ V$$

$$\boxed{v_c(t) = 52 - 32\, e^{-t/0.4}\ V,\ t>0}$$ (1)

$v_c(t)$ (V)



(1)

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