EE231 ELECTRIC CIRCUITS
SUMMER-2014

MIDTERM #2

Aug. 14, 2014
Total Time Allowed: 1.5 hours

1. Closed book exam.
2. You can use a calculator. NO cell phone or computer.
3. If you put down the wrong answer, partial credits will be given only if you show the correct steps.
4. Points will be taken off for answers without units.

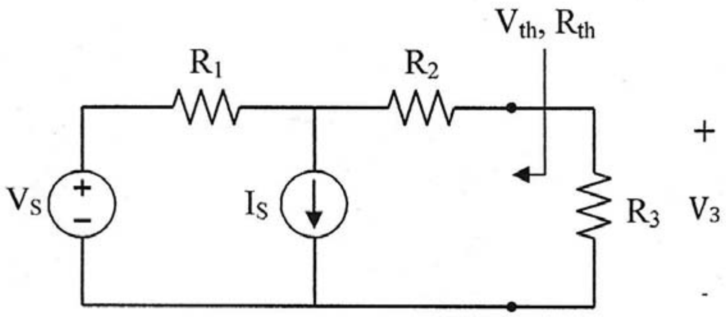
Name: ___________________________

Student ID: ______________________

Signature: _______________________

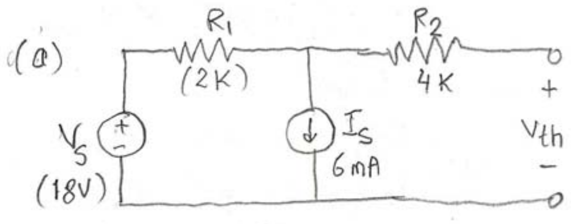
QUESTIONS

1- For the circuit given below, calculate V_3 using Thevenin and Norton equivalent circuits.

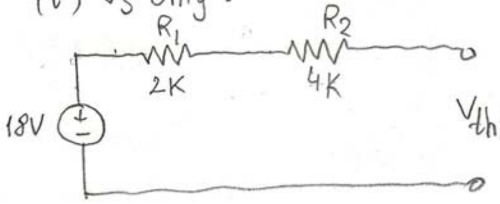


Circuit Parameters
$V_S = 18$ V
$I_S = 6$ mA
$R_1 = 2$ kΩ
$R_2 = 4$ kΩ
$R_3 = 6$ kΩ

(a)

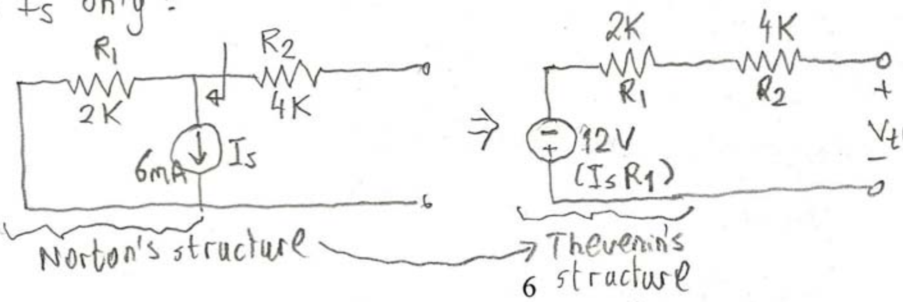


(i) V_S only :



$V_{th1} = 18$V (= V_S, since no current flows through R_1 & R_2)

(ii) I_s only:



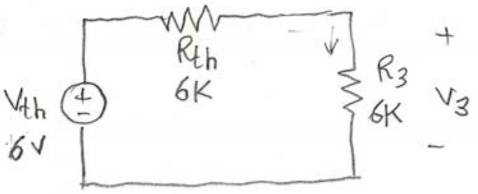
$V_{th2} = -12\,V$

(Since no current is flowing through R_1 and R_2.)

Then $V_{th} = 18 - 12 = 6\ V$

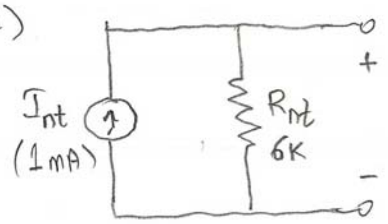
$R_{th} = 2K + 4K = 6K$

(b)



$$V_3 = \frac{R_3}{R_3 + R_{th}} \cdot V_{th} = \frac{6}{12} \cdot 6\ V = 3\ V$$

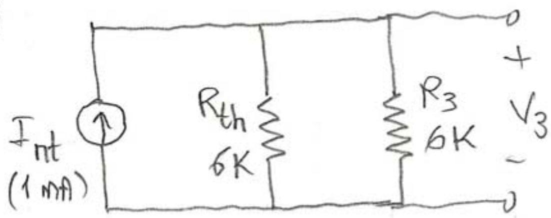
(c)



$$I_{nt} = \frac{V_{th}}{R_{th}} = \frac{6V}{6K} = 1\ mA$$

$R_{nt} = R_{th} = 6\ K$

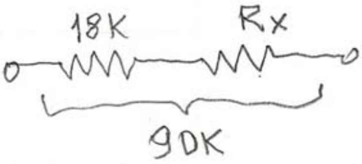
(d)



$$V_3 = I_{nt}(R_{th} /\!/ R_3)$$
$$= (1\ mA)(6K /\!/ 6K)$$
$$= 1\ mA \cdot 3K = 3\ V$$

(e) 18K, 120K, 150 K, 180 K

R = 90 K ?



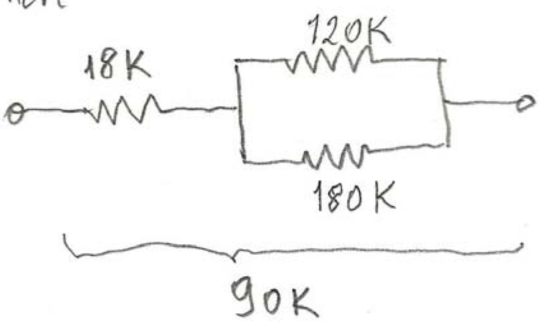
$R_x = 90 - 18 = 72\,K$

$120K /\!/ 150K = 66.67\,K$

$150K /\!/ 180K = 81.82\,K$

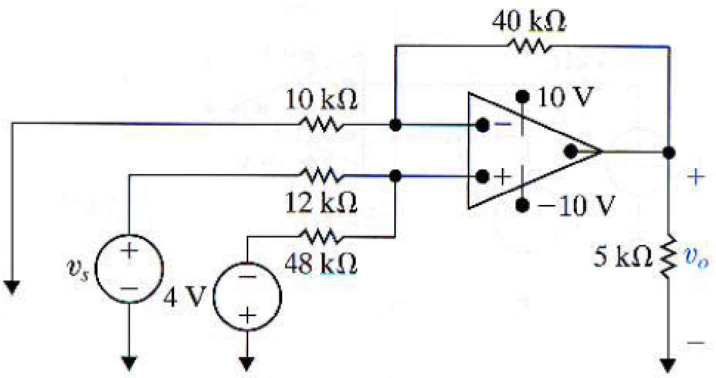
$120K /\!/ 180K = 72\,K$

Then



18K, 120K, 150K, 180K

2- The op-amp in the circuit is ideal.
a) What op-amp circuit configuration is this?
b) Find v_o in terms of v_s.
c) Find the range of values for v_s such that v_o does not saturate and the op amp remains in its linear region of operation.



P 5.19 [a] This circuit is an example of a non-inverting summing amplifier.

[b] Write a KCL equation at v_p and solve for v_p in terms of v_s:

$$\frac{v_p - v_s}{12{,}000} + \frac{v_p + 4}{48{,}000} = 0$$

$$4v_p - 4v_s + v_p + 4 = 0 \qquad \text{so} \qquad v_p = 4v_s/5 - 4/5$$

Now write a KCL equation at v_n and solve for v_o:

$$\frac{v_n}{10{,}000} + \frac{v_n - v_o}{40{,}000} = 0 \qquad \text{so} \qquad v_o = 5v_n$$

Since we assume the op amp is ideal, $v_n = v_p$. Thus,

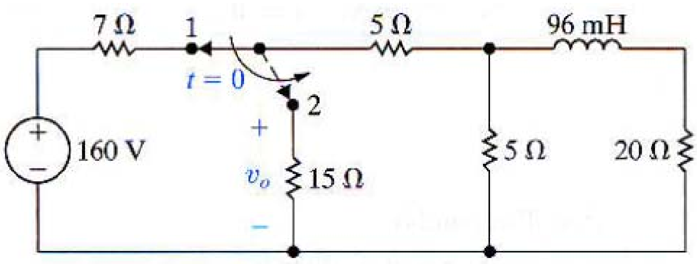
$$v_o = 5(4v_s/5 - 4/5) = 4v_s - 4$$

[c] $4v_s - 4 = 10 \qquad \text{so} \qquad v_s = 3.5\ \text{V}$

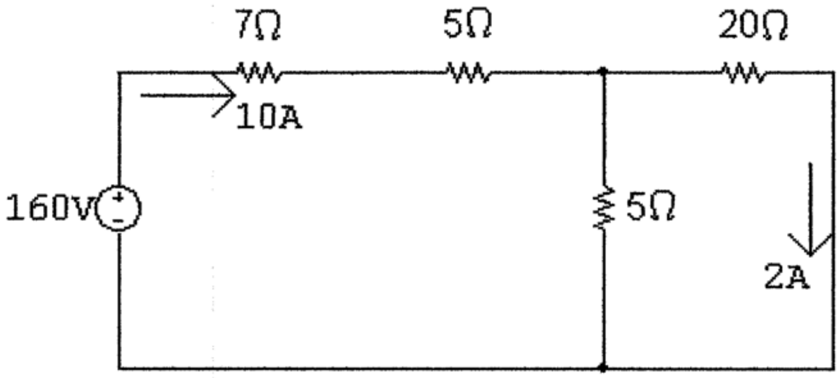
$$4v_s - 4 = -10 \qquad \text{so} \qquad v_s = -1.5\ \text{V}$$

Thus, $-1.5\ \text{V} \le v_s \le 3.5\ \text{V}$.

3- The switch in the circuit has been in position 1 for a long time. At t = 0, the switch moves instantaneously to position 2. Find $v_o(t)$ for t ≥ 0+. Find the power and energy stored in the 20Ω resistor?

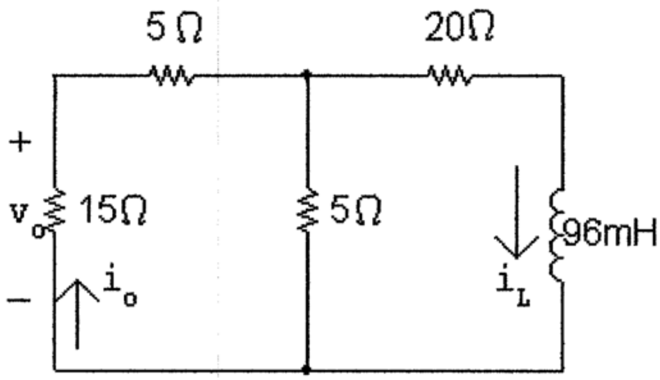


P 7.11 $t < 0$:



$$i_L(0^+) = 2\text{ A}$$

$t > 0$:



$$R_e = \frac{(20)(5)}{25} + 20 = 24\,\Omega$$

$$\tau = \frac{L}{R_e} = \frac{96}{24} \times 10^{-3} = 4\,\text{ms}; \qquad \frac{1}{\tau} = 250$$

$$\therefore \quad i_L = 2e^{-250t}\,\text{A}$$

$$\therefore \quad i_o = \frac{5}{25} i_L = 0.4e^{-250t}\,\text{A}$$

$$v_o = -15 i_o = -6e^{-250t}\,\text{V}, \quad t \geq 0^+$$

P 7.12 $p_{20\Omega} = 20 i_L^2 = 20(4)(e^{-250t})^2 = 80e^{-500t}\,\text{W}$

$$w_{20\Omega} = \int_0^\infty 80e^{-500t}\,dt = 80 \frac{e^{-500t}}{-500} \Big|_0^\infty = 160\,\text{mJ}$$