Color: IVORY

University of Arizona
Department of Electrical & Computer Engineering

ECE 220 Basic Circuits

Examination 2

March 3, 2005

Closed book/notes, calculators allowed up to level of TI89, HP48.

Part I: 6 questions Part II: 6 questions.
Part II is worth twice as much as Part I. 18 POINTS TOTAL

On the SCANTRON write and bubble-in your:

1. **Name** (Last, first)
2. **1-3 digit ID number** which was given to you at the first exam. Write this left-justified under columns A-C under IDENTIFICATION NUMBER.
3. Write the **color of your exam paper** (IVORY or GREEN) on the top left margin of the SCANTRON.

Place your UA picture ID card on the adjacent desk where it can be easily seen.

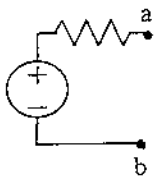
When the 9:30 bell rings, begin the examination. All work should be done on the examination paper. Allow for reasonable amounts of roundoff error, and **carefully** mark one choice for each problem on the SCANTRON answer sheet.

e.g. 1 A (1) B (2) C (●) D (4) E (5) if the answer for Question 1 is C.

All SCANTRON forms and examinations will be collected at or before 10:30. You will be asked to stop writing and hand in your papers/answer sheets. **Failure to comply promptly may result in disqualification from the exam.**

NAME: RNS

SIGNATURE: SOLUTIONS



Use this template for the polarity of Thevenin/Norton equivalent ckts with respect to terminals a-b

Write your ECE 220 ID number here and on the SCANTRON:

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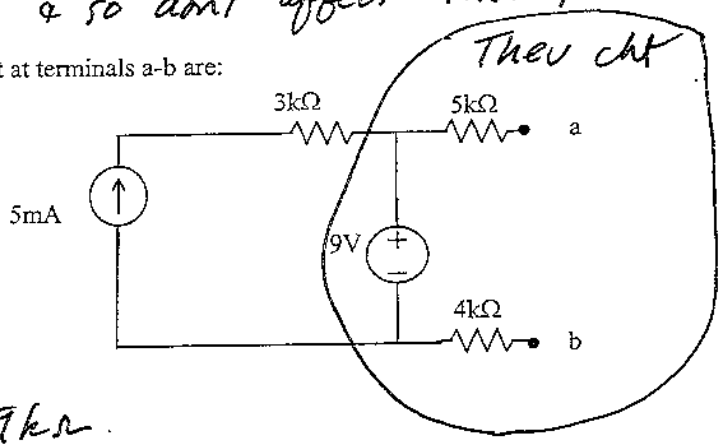
5mA, 3kΩ are in parallel with 9V source & so don't affect Thev params.

Part I ~10 min

1. The parameters of the Thevenin equivalent circuit at terminals a-b are:

(a) $V_{Th} = 9V,\ R_{Th} = 9k\Omega$
(b) $V_{Th} = 24V,\ R_{Th} = 9k\Omega$
(c) $V_{Th} = -6V,\ R_{Th} = 12k\Omega$
(d) $V_{Th} = 9V,\ R_{Th} = 2.25k\Omega$
(e) None of these

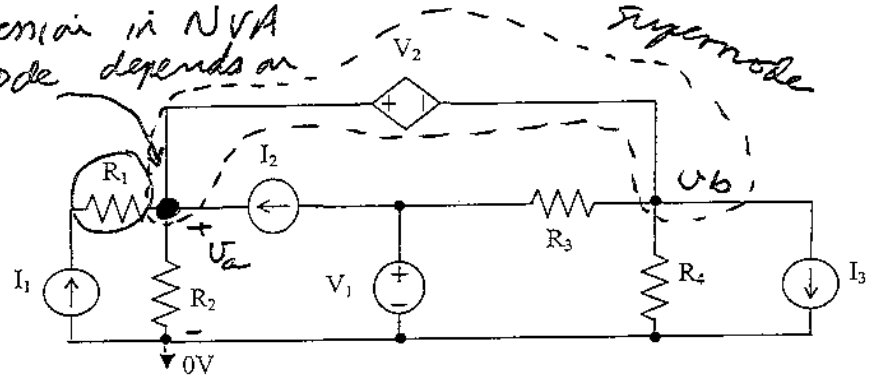


Also, method 2 easily shows that $V_{Th} = 9V$ & $R_{Th} = 5+4 = 9k\Omega$.

2. Identify one element that has no effect on the node voltages in this ckt.

(a) I_1
(b) I_2
(c) R_1
(d) R_2
(e) V_2

KCL expression in NVA at this node depends on I_1 but not on R_1.

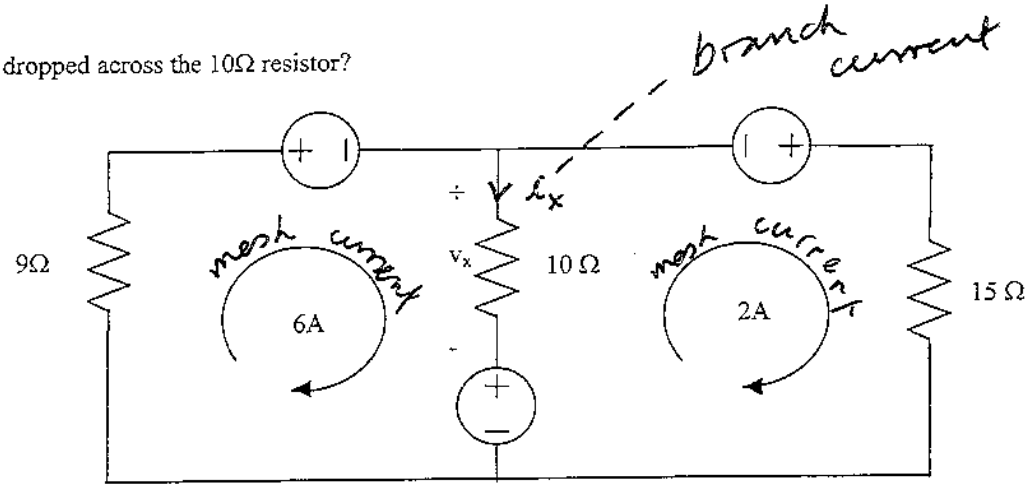


i.e. $\frac{V_a}{R_2} + \frac{V_b - V_1}{R_3} + \frac{V_b}{R_4}$

$= I_1 + I_2 - I_3$

3. What is the voltage v_x dropped across the 10Ω resistor?

(a) 60V
(b) -40V
(c) -80V
(d) 40V
(e) None of these



$V_x = 10\, i_x$

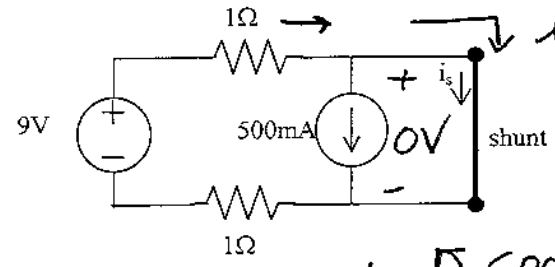
$= 10(6-2) = 40\ V$

Part I **10 min**

4. How much current (i_s) would flow through the shunt wire (short ckt) in this ckt?

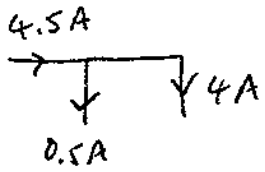
(a) -500mA
(b) 4.5A
(c) 4 A
(d) 5A
(e) None of these

$\frac{9}{1+1} = 4.5\,A$



$i_s = 4.5 - 0.5 = 4A$

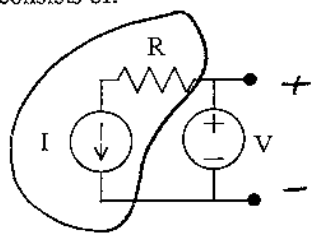
KCL



500mA is shunted

5. A simplified equivalent circuit seen from the terminals marked • consists of:

(a) a current source (only)
(b) a voltage source (only)
(c) a voltage source in series with a resistor
(d) a current source in parallel with a resistor



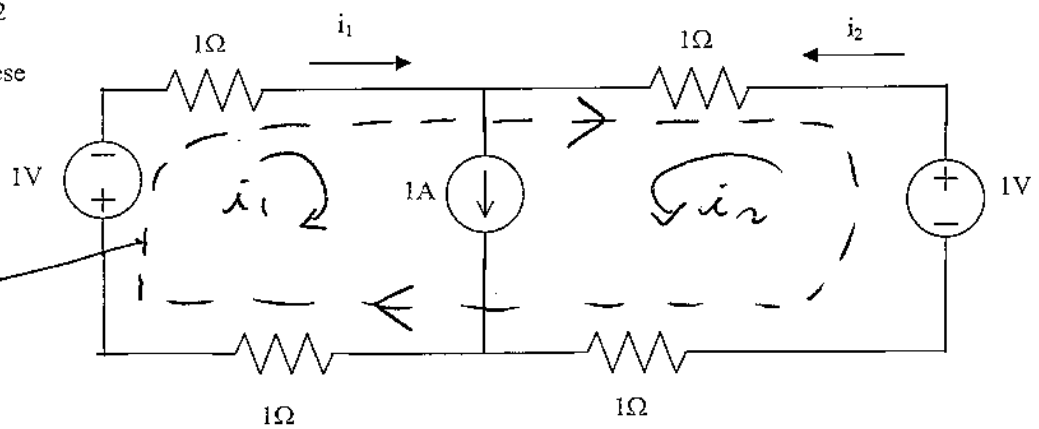
$V_{Th} = V$

$R_{Th} = 0$

I+R are in parallel with V, so are invisible to any load applied at the terminals.

6. A valid supermesh KVL equation for this ckt is given by:

(a) $2i_1 + 2i_2 = 2$
(b) $2i_1 + 2i_2 = -2$
(c) $2i_1 - 2i_2 = -2$
(d) $2i_1 - 2i_2 = 0$
(e) None of these



Supermesh

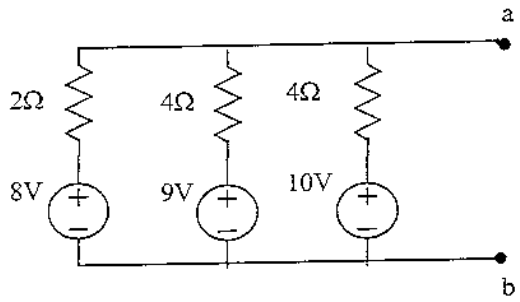
KVL: $1 + (1)i_1 - (1)i_2 + 1 - (1)i_2 + (1)i_1 = 0$

$\therefore \quad 2i_1 - 2i_2 = -2$

Part II **~40 min**

17. Find the parameters of the Thevenin equivalent ckt seen at terminals a-b.

(a) V_{th}= 9V, R_{th} = 1Ω
(b) V_{th}= 9V, R_{th} = 4Ω
(c) V_{th}= 8.75V, R_{th} = 1Ω
(d) V_{th}= 9.25V, R_{th} = 1Ω
(e) None of these



Method 2 Set voltage sources to 0V ie short ckt them

$R_{Th} = 2 // 4 // 4 = 2 // 2 = 1\Omega$

Restore sources and find $V_{Th} = V_{ab}$.

NVA $\frac{V_{Th}-8}{2} + \frac{V_{Th}-9}{4} + \frac{V_{Th}-10}{4} = 0$

$\therefore 2V_{Th} - 16 + V_{Th} - 9 + V_{Th} - 10 = 0$

$\therefore 4V_{Th} = 35$

$\therefore V_{Th} = 8.75V$

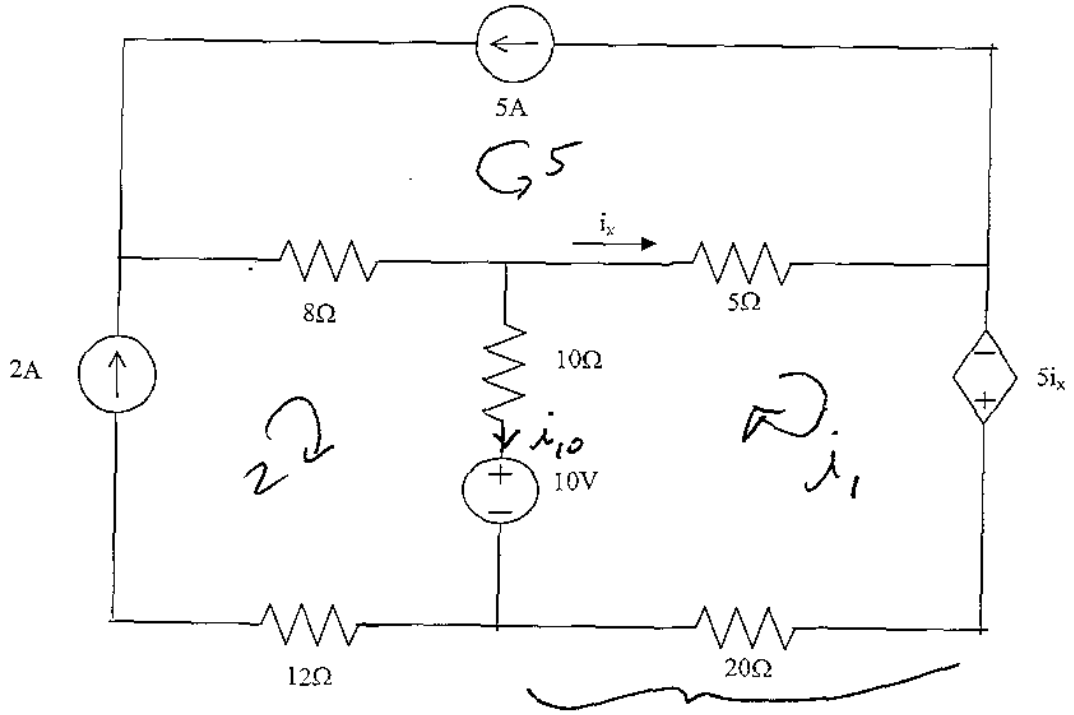
$\therefore$ answer is (E).

8. What is the power consumed by the 10V source? $= 10\, i_{10}$.

$\therefore$ need to find i_{10}.

(a) 25W (b) 8W (c) 5W (d) 10W (e) None of these

Only one unknown mesh current, so use MCA.



KVL

$$-10 + 10(i_1 - 2) + 5(i_1 + 5) - 5i_x + 20i_1 = 0$$

C.E. $\quad i_x = 5 + i_1$

$$\therefore -10 + 10i_1 - 20 + 5i_1 + 25 - 25 - 5i_1 + 20i_1 = 0$$

$$30i_1 = 30$$

$$\therefore i_1 = 1\,A$$

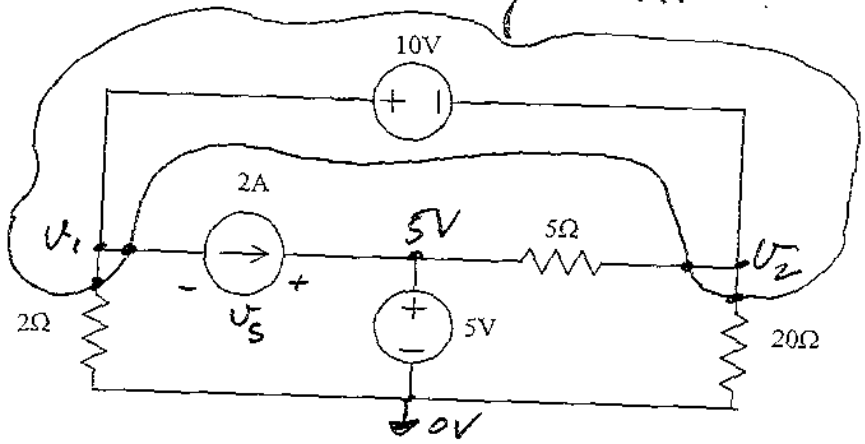
$$\therefore i_{10} = 2 - i_1 = 2 - 1 = 1A$$

$$\therefore p_{10} = 10\, i_{10} = 10W$$

9. Find the power delivered by the 2A current source. $= 2 \times v_9 = 2(5 - v_1)$

(a) 2.4W
(b) 4W
(c) 6W
(d) -8W
(e) None of these

$\therefore$ find v_1 using NVA.



NVA at supernode:

KCL $\quad \frac{v_1}{2} + 2 + \frac{v_2 - 5}{5} + \frac{v_2}{20} = 0$

$\therefore 10v_1 + 40 + 4v_2 - 20 + v_2 = 0$

$\therefore 10v_1 + 5v_2 = -20 \quad (1)$

KVL gnd $\rightarrow v_1 \rightarrow v_2 \rightarrow$ gnd

$-v_1 + 10 + v_2 = 0 \Rightarrow -v_1 + v_2 = -10 \quad (2)$

$\therefore \quad (1) - 5 \times (2) \Rightarrow$

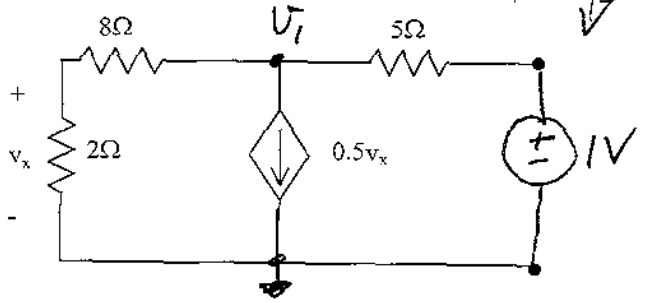
$10v_1 + 5v_2 = -20$
$-5v_1 + 5v_2 = -50$
$15v_1 + 0 = 30 \Rightarrow v_1 = 3V$

$\therefore p_{2A} = 2(5 - v_1) = 2 \times 3 = 6W.$

10. The equivalent resistance seen from the terminals marked • is:

(a) 2 Ω
(b) 3 Ω
(c) 6 Ω
(d) 10 Ω
(e) None of these.

Test source



NVA @ V_1-node:

$$\frac{V_1}{10} + 0.5V_x + \frac{V_1 - 1}{5} = 0$$

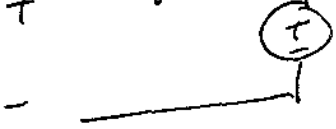
V-Divider:

$$V_x = \left(\frac{2}{2+8}\right) V_1 = 0.2V_1$$

$$\therefore 0.1V_1 + 0.1V_1 + 0.2V_1 = 0.2$$

$$\therefore 0.4V_1 = 0.2 \Rightarrow V_1 = 0.5\,V$$

$$\therefore i_T = \frac{1 - 0.5}{5} = 0.1\,A$$



$$\therefore R_{Th} = \frac{1V}{0.1A} = 10\,\Omega.$$

11. Find the steady-state expression for $v_o(t)$ in this AC ckt when $i_s(t) = 100\cos(10t - 45°)$ mA.

(a) $v_o(t) = 141.4\cos(10t + 53.13°)$ mV

(b) $v_o(t) = 70.71\cos(10t)$ mV

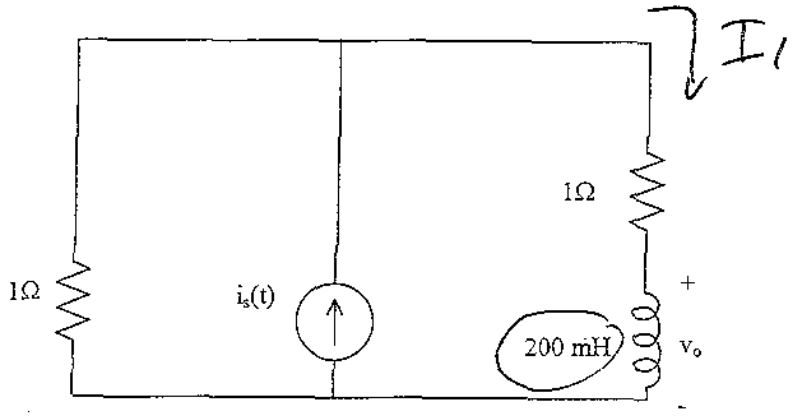
(c) $v_o(t) = 70.71\cos(10t + 53.13°)$ mV

(d) $v_o(t) = 200\cos(10t - 45°)$ mV

(e) None of these.

Phasor current:

$I_s = 100\angle -45°$ mA



Apply current divider to find I_1.

$j\omega L = j \cdot 10 \cdot 0.2 = j2\Omega$

$$I_1 = \left(\frac{1}{1+1+j2}\right) \cdot 100\angle -45° \text{ mA}$$

$$= \frac{100\angle -45° \text{ mA}}{2+j2} = \frac{100\angle -45°}{2\sqrt{2}\angle 45°} \text{ mA}$$

$$= \frac{50}{\sqrt{2}}\angle -90° \text{ mA} = \frac{50}{\sqrt{2}} \times -j \text{ mA}$$

$$\therefore V_o = (j\omega L) I_1 = (j2) \times \left(\frac{50}{\sqrt{2}}\right) \times (-j) \text{ mV}$$

$$= \frac{100}{\sqrt{2}}(-j^2) \text{ mV} = \frac{100}{\sqrt{2}} \text{ mV} = 70.7 \text{ mV}$$

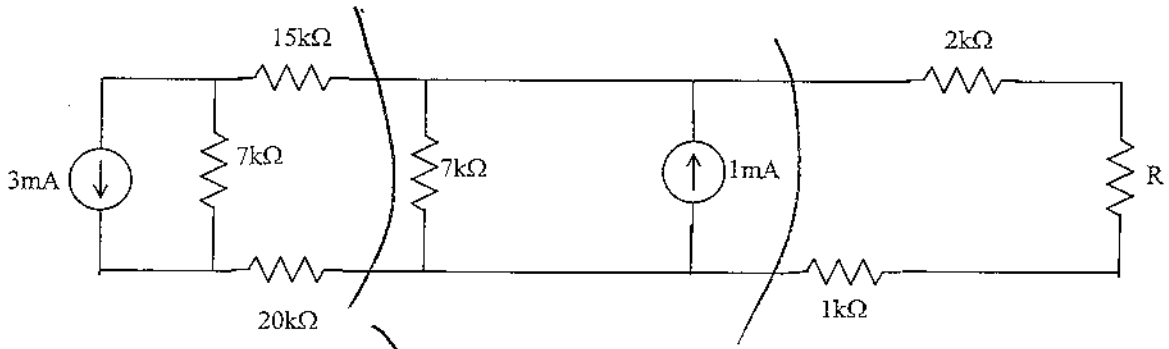
$$= 70.71\angle 0° \text{ mV}$$

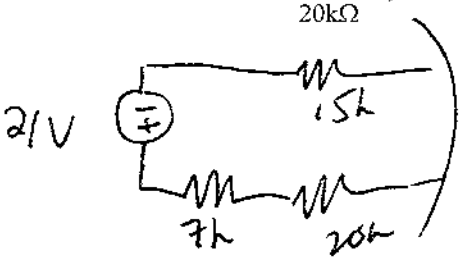
$$\therefore v_o(t) = 70.71\cos(10t) \text{ mV}$$

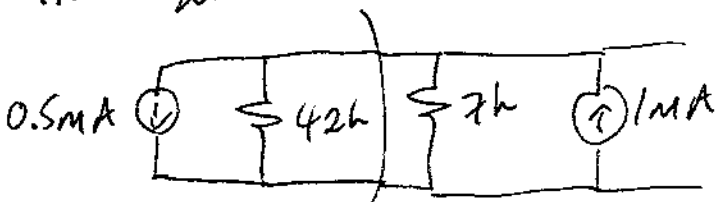
Need to find: V_{Th} R_{Th} R or i_N R_N R

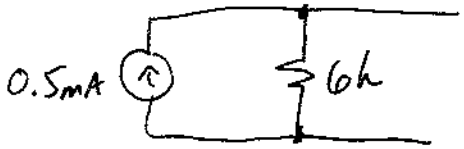
12. What is the maximum power that can be delivered to R, given that R can have any value?

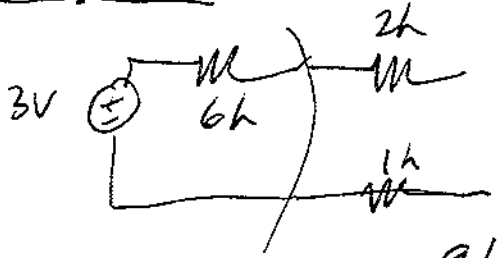
(a) 250μW (b) 300μW (c) 220 μW (d) 100μW (e) None of these











$\therefore p_{max} = \frac{V_{Th}^2}{4R_{Th}}$

$= \frac{3^2}{4 \times 9k} = 0.25mW$