Signature: Solution Key

Proctor: ________________

Lecture Seat: ____________

DO NOT OPEN THIS BOOKLET UNTIL INSTRUCTED TO DO SO.

EXAM #1
ELEE 2335
SEPTEMBER 21, 1985

INSTRUCTIONS:

1. Fill in the information required on the upper left of this page.

2. All work is to be done in the spaces provided in this booklet. Use the backs if necessary, but indicate clearly where your work and answers may be found. No credit will be given unless necessary work is shown. Show all of your units explicitly. Units in exam questions are placed within square brackets.

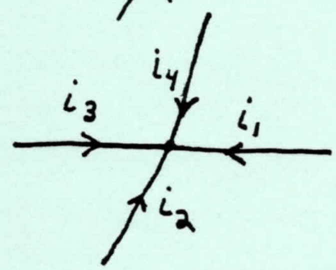
3. If your answers and work are not in ink, there will be no provision for changing your grade once the exam is returned to you.

1.	15
2.	20
3.	20
4.	15
5.	15
6.	15

Part 1. This part is multiple choice. Place a check mark next to the answer that you choose. *3 points per problem, no partial credit.*

a) For the node shown below, $i_1 = 5$ [A], $i_2 = -3$ [A], and $i_3 = 1$ [A] The current i_4 is

( ) 9[A]   ( ) 3[A]   (X) -3[A]   ( ) -9[A]

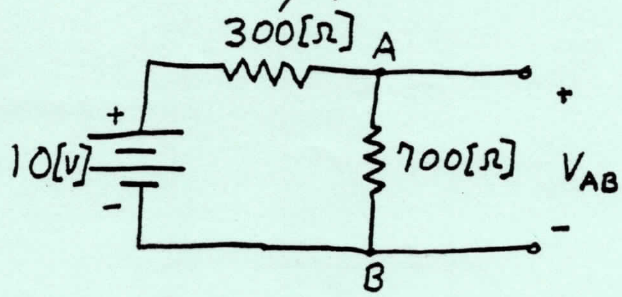


$i_4 + i_1 + i_2 + i_3 = 0$

$i_4 = -5 - 1 + 3 = \boxed{-3[A]}$

b) For the circuit shown the voltage v_{AB} is

( ) 10[V]   (X) 7[V]   ( ) -7[V]   ( ) -10[V]

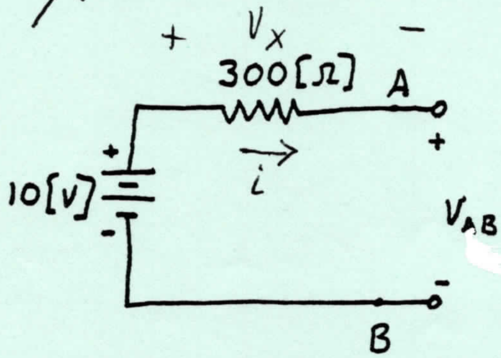


$V_{AB} = 10[V]\left[\frac{700[\Omega]}{300[\Omega]+700[\Omega]}\right]$

$\boxed{V_{AB} = 7[V]}$

c) If the 700[Ω] resistor of problem b) is removed so that the terminals A-B become an open circuit, the voltage v_{AB} will be

(X) 10[V]   ( ) 0[V]   ( ) -10[V]   ( ) undetermined.



$i = 0$

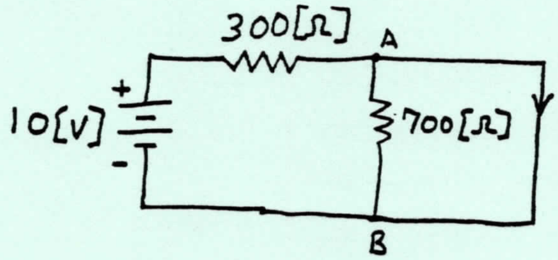
$V_x = 0 = iR$

$V_{AB} = \boxed{10[V]}$

d) If the terminals A-B of the circuit given in b) are shorted together, the current flow i_{AB} will be

( ) 0[A] ( ) -0.01[A] ( ) 0.01[A] (X) 0.033[A]

equivalent circuit



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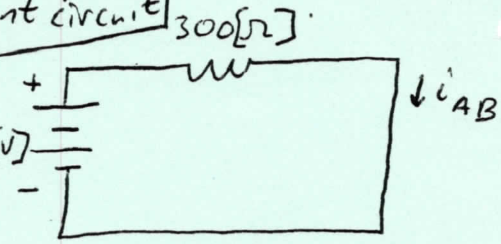


$$i_{AB} = \frac{10[V]}{300[\Omega]} = 0.033[A]$$

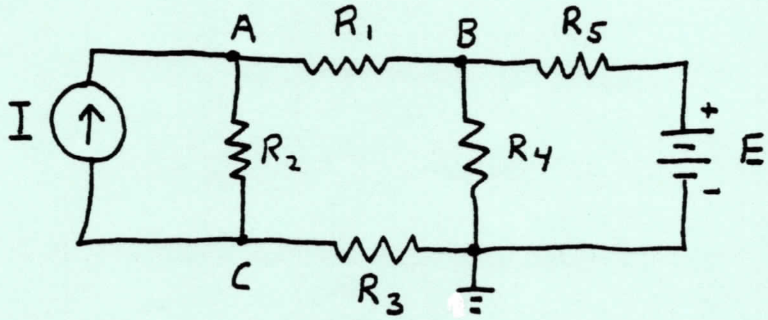
e) v_A, v_B, and v_C are node voltages in the circuit below. The node equation expressing Kirchoff's current law at node B is

( ) $((v_A - v_B)/R_1) + (v_B / R_4) + ((v_B - E) / R_5) = 0$

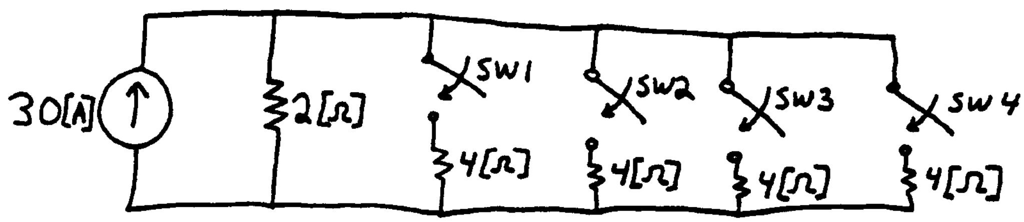
( ) $((v_A - v_B)/R_1) + (v_B / R_4) + ((E - v_B) / R_5) = 0$

(X) $((v_B - v_A)/R_1) + (v_B / R_4) + ((v_B - E) / R_5) = 0$ ← Summing currents, Apply positive polarity to currents leaving node B.

( ) $((v_A - v_B)/R_1) - (v_B / R_4) - ((E - v_B) / R_5) = 0$

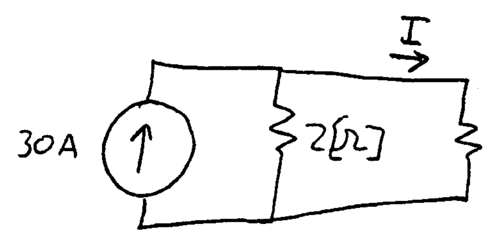


2. Assume than an electric stove has the equivalent circuit shown below. Each of the 4[Ω] resistors represents a heating element on the stove. Each heating element has a switch that can be used to turn it on or off. These are shown as SW1, SW2, SW3, and SW4. Assume that the stove is being used to boil water which is currently at 25° C. If 3 of the switches are in the on position, how much energy is delivered to the water in 15 minutes? Assume that all of the energy in the heating elements is transferred to the water.



Equivalent circuit:

5pt.



$R = 4[\Omega] \,||\, 4[\Omega] \,||\, 4[\Omega] = 1.33[\Omega]$

5pt.

Need Power dissipated by R, heating elements.

Solve for I using current divider rule

-3PT for including 2Ω res.

$$I = 30[A]\left(\frac{2[\Omega]}{2[\Omega]+1.33[\Omega]}\right) = 18[A]$$

5pt

$P = I^2 R = 432$ [watts], positive since energy is dissipated by resistors, delivered to water.

5pt.

$E = Pt = 432$ [watts] 15 [min] = 6480 [watt-min]

-OR-

= 388,800 [watt-sec]

-OR-

= 388,800 [joules]

-OR-

108 [watt-hr]

-3pt for no units
-3pt for wrong sign
-2 pt for math error

3. A d'Arsonval meter has the following rated values: $v_{d'A} = 100[mV]$, $i_{d'A} = 2[mA]$.

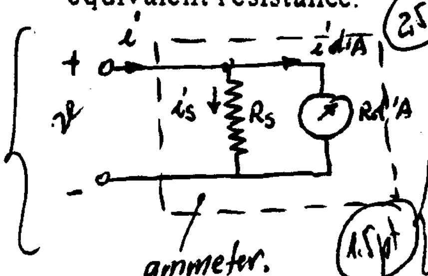
a) Calculate the d'Arsonval meter resistance.

(4pt.) $$R_{d'A} = \frac{v_{d'A}}{i_{d'A}} = \frac{100 * 10^{-3}}{2 * 10^{-3}} = 50[\Omega]$$

OK:
-3pt. for no units
-3pt. for assumptions on quantities
-2pt. for math. error.
(valid for problem #6 also.)

b) The d'Arsonval meter is to be used for an ammeter to measure a maximum current of 5[A]. Draw the schematic for the ammeter circuit, and calculate the circuit parameter values, including the ammeter total equivalent resistance.

(4pt)



(2.5pt) $v = v_{d'A} = 100[mV]$; $i_s = i - i_{d'A} = 5 - 0.002 = 4.998[A]$

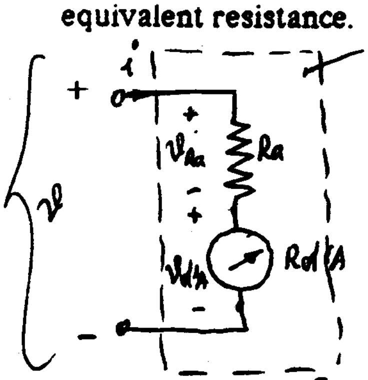
$$R_s = \frac{v}{i_s} = \frac{100 * 10^{-3}}{4.998} = 0.020008[\Omega]$$

(1.5pt) $$R_{eqh\,Amm} = \frac{v}{i} = \frac{100 * 10^{-3}}{5} = 0.02[\Omega]$$

(or: $R_{eqh\,Amm} = \frac{R_{d'A} * R_s}{R_{d'A} + R_s} = \frac{50 * 0.020008}{50.020008} = 0.02[\Omega]$,

c) The same d'Arsonval meter is to be used in a voltmeter to measure a maximum voltage of 300[V]. Draw the schematic for the voltmeter circuit, and calculate the circuit parameter values, including the voltmeter total equivalent resistance.

(4pt.)



(2.5pt) $i = i_{d'A} = 2 * 10^{-3}[A]$; $v_{d'A} = 0.1[V]$.

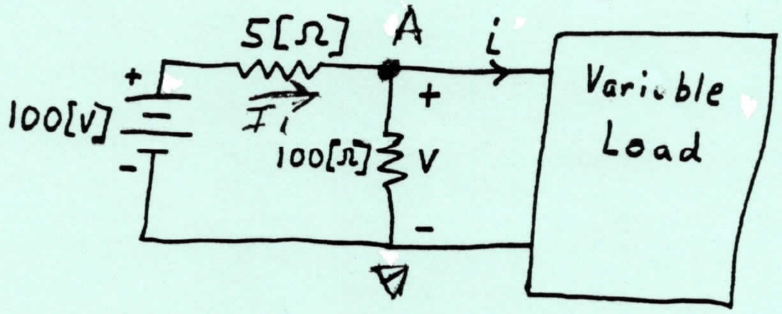
$v_{Ra} = v - v_{d'A} = 300 - 0.1 = 299.9[V]$.

$$R_a = \frac{v_{Ra}}{i} = \frac{299.9}{2 * 10^{-3}} = 149950[\Omega]$$

(1.5pt) $$R_{eqh\,V} = R_a + R_{d'A} = 149950 + 50 = 150{,}000[\Omega]$$

(or; $R_{eqh} = \frac{v}{i} = \frac{300}{2 * 10^{-3}} = 150{,}000[\Omega]$)

5. For the circuit given, determine:



a) The value of v when i = 0.

$$V = \frac{100 \cdot 100}{105} = 95.24\,V$$

≈5

b) The value of v when i = 10[A].

Either NODE VOLTAGE SOLUTION

$$\frac{V_A - 100}{5} + \frac{V_A}{100} - 10 = 0$$

$$\therefore V_A = V = \frac{1000}{21} = 47.6V$$

≈10

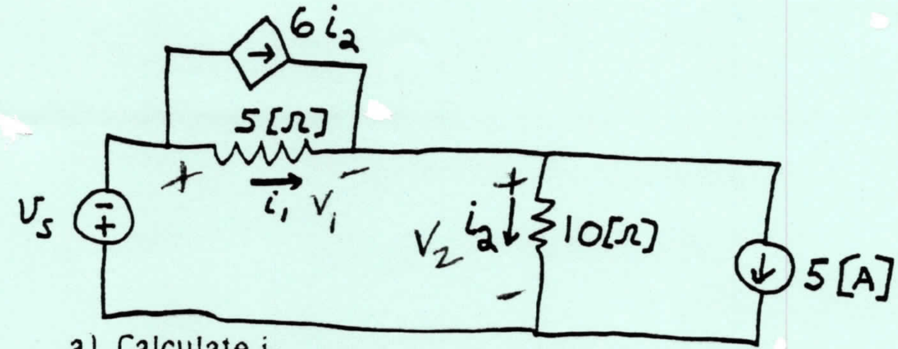
or $V = 100 - 5I_1$; $I = 10 + \frac{V}{100}$

$$V = 100 - 50 - \frac{5V}{100}$$

$$21v = 1000$$

$$V = \frac{1000}{21} = 47.6V$$

4. The current i_2 in the circuit given is 2[A].



a) Calculate i_1.

$i_1 + 6i_2 = i_2 + 5$

$i_1 = -5i_2 + 5 = -10 + 5 = \underline{\underline{-5A}}$

≈5pts

b) Calculate v_S.

$V_S + V_2 + V_1 = 0$; $V_1 = 5 \cdot i_1 = -25$

$V_2 = 10 \cdot i_2 = 20$

$V_S = -V_1 - V_2$

∴ $V_S = +125 - 20 = \underline{\underline{5V}}$

≈5pts

c) Calculate the power absorbed in each element in the network.

$P_{5A} = V_2 \cdot 5 = \underline{100W}$

$P_{10\Omega} = V_2 i_2 = 20 \cdot 2 = \underline{40W}$

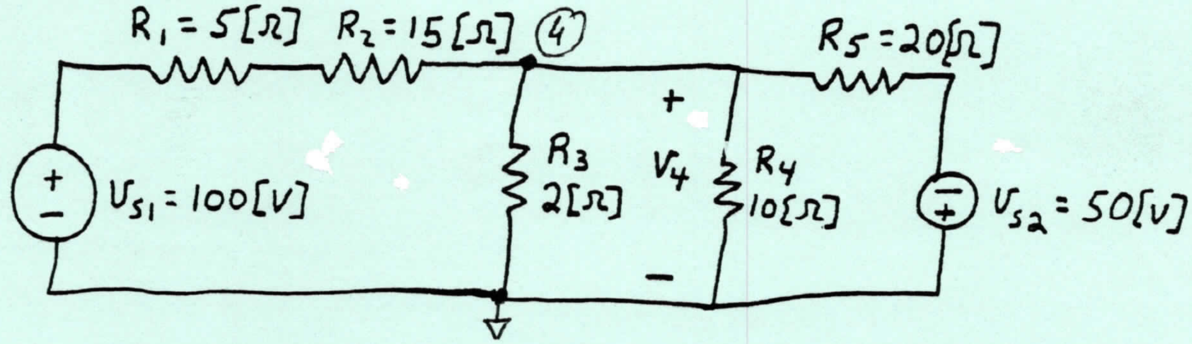
$P_{5\Omega} = V_1 i_1 = (-25)(-5) = \underline{125W}$

$P_{6i_2} = 6i_2 \cdot V_1 = 12 \times (-25) = \underline{\underline{-300W}}$

$P_{VS} = (5 + i_2)V_S = 7 \times 5 = \underline{\underline{35W}}$

≈5pts

6. For the following circuit:



a) How many nodes and essential nodes are there?

$n = 5; \quad n_e = 2$ (3pt)

b) Apply the node voltage method, and determine the value of v_4.

$n_e - 1 = 2 - 1 = 1$;

$$\frac{v_4 - v_{s1}}{R_1 + R_2} + \frac{v_4}{R_3} + \frac{v_4}{R_4} + \frac{v_4 - (-v_{s2})}{R_5} = 0$$ (7pt)

$$v_4\left(\frac{1}{R_1+R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}\right) = \frac{v_{s1}}{R_1+R_2} - \frac{v_{s2}}{R_5}$$

$$v_4\underbrace{\left(\frac{1}{20} + \frac{1}{2} + \frac{1}{10} + \frac{1}{20}\right)}_{0,7} = \underbrace{\frac{100}{20} - \frac{50}{20}}_{2,5}$$

$$v_4 = \frac{2,5}{0,7} = 3,5714286\ [V]$$ (5pt.)