Signature: Solution Key ~~1986~~ AUD 1

DO NOT OPEN THIS BOOKLET UNTIL INSTRUCTED TO DO SO.

EXAM 1
ELEE 2335
September 27, 1986

INSTRUCTIONS:

1. Sign your name on the upper left of this page.

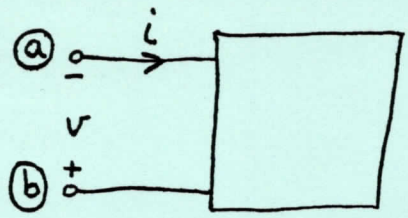
2. All work is to be done in the spaces provided in this booklet. Use the backs if necessary. Indicate clearly where your work and answers may be found. Enclose your final answers in a box. No credit will be given unless the necessary work is shown.

3. Show all of your units explicitly, both in your final answer and in your intermediate steps. Units in exam questions are placed within square brackets.

4. 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. Do not use red ink.

1.	10
2.	10
3.	17
4.	18
5.	15
6.	17
7.	13

1. (10 Points) A complex electric circuit is enclosed in a box, which is shown below. The circuit has two terminals, (a) and (b).



a) Using v and i as they are defined in the above figure, write the expression for the power consumed by the circuit.

6pts

$p = -vi$

b) It is given that v = 100[V], and i = -20[A]. Calculate the value of the power consumed by the circuit.

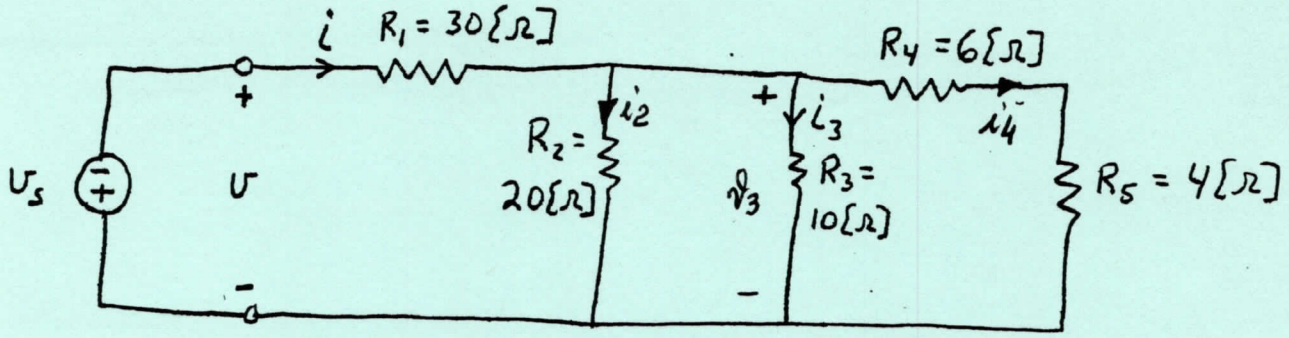
4pts

$p = -100 * (-20) = 2000[W]$

For problems: 1, 2, 3, 5.

- math errors – (-1)
- no units (-3)

2. (10 Points) In the following circuit it is known that $i_3 = 2[A]$. Calculate the values of i and v.



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ohm's law

$$\begin{cases} v_3 = i_3 R_3 = 2 * 10 = 20[V]; \quad i_4 = \dfrac{20}{10} = 2[A] \\ i_2 = \dfrac{20}{20} = 1[A] \qquad i = i_2 + i_3 + i_4 \end{cases}$$

3,5 pts

Kirchhoff's laws. current

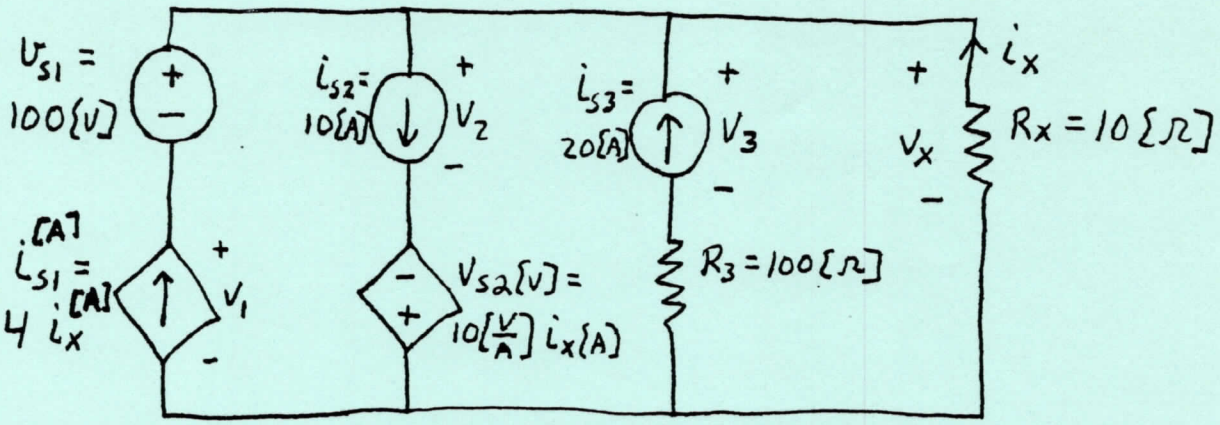
3 pts.

$$\boxed{i = 5[A].}; \qquad \boxed{v = R_{1.5} + 20 = 170[V]}$$

Kirchhoff's voltage laws.

3.5 pts

3. (17 Points) Use the following circuit in both parts, a) and b).



a) Determine the values of i_x and v_x.

Kirchhoff's current law applied on the upper node: (4pts)

$-4i_x + i_{s2} - i_{s3} - i_x = 0$: $5i_x = i_{s2} - i_{s3} = 10 - 20 = -10\,[A]$

$\boxed{i_x = -2\,[A]}$: dependent source : (3pts)

Ohm's law on Rx : $\boxed{v_x = -R_x i_x = -10 \times (-2) = \underline{20\,[V]}}$ (4pts)

3. b) Determine the value for the voltages across the current source terminals, v_1, v_2, and v_3.

Applying the Kirchhoff's voltage law on the closed path that contains that source, and R_x,

(6pts)

source is$_1$:

*) $-v_1 - v_{s1} + v_x = 0$; $\boxed{v_1 = -v_{s1} + v_x = -100 + 20 = \underline{-80[V]}}$

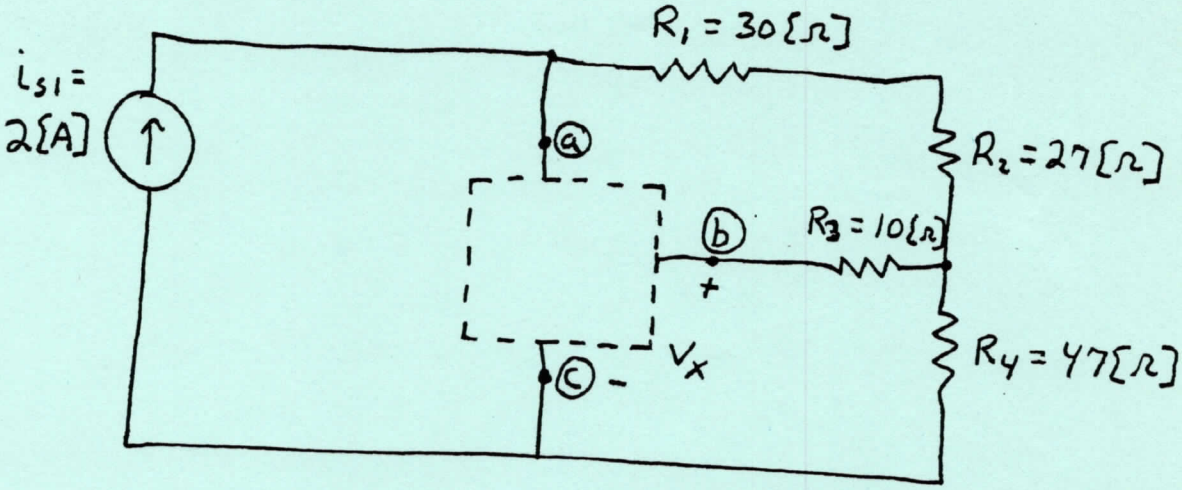
source is$_2$:

*) $v_{s2} - v_2 + v_x = 0$; $\boxed{v_2 = v_{s2} + v_x = 10i_x + 20 = -20 + 20 = \underline{0[V]}}$

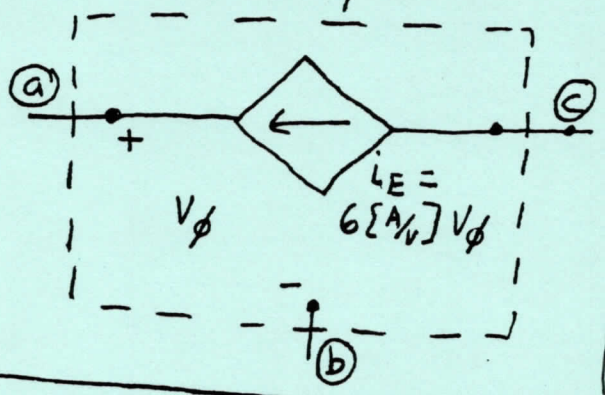
source is$_3$:

*) $20 * 100 - v_3 + v_x = 0$; $\boxed{v_3 = 2000 + 20 = \underline{2020[V]}}$

4. (18 Points) In the circuit shown below, the box represents a circuit component. This component has the equivalent circuit shown below that. Solve for v_x.



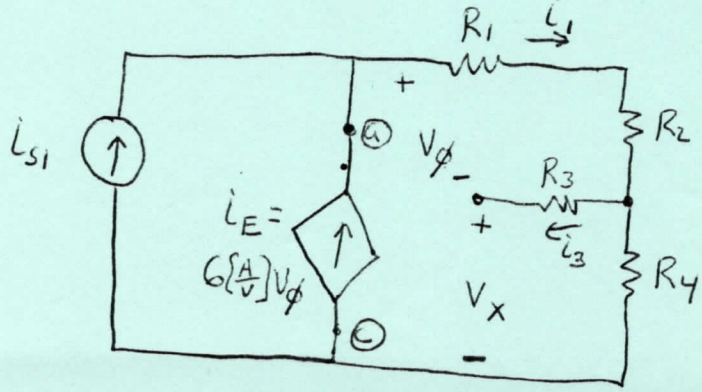
Equiv. ckt. for box component:



Grading Scheme	
+5	correct diagram
+5	KCL
+5	Ohm's Law (V_x)
+3	Correct answer
-3	no units, math error
-5	Wrong sign

Solution:

Redraw Ckt



Partial credit (+3) → Note that $i_3 = 0$, so V_ϕ is across R_1 and R_2, and V_x is across R_4

$$i_1 = i_{s1} + i_E = 2[A] + 6(i_1)(R_1+R_2)$$

$$i_1 = 2[A] + 6(57)\,i_1$$

$$i_1 = \frac{2}{1-6(57)}[A] = -5.865[mA]$$

$$V_x = i_1 R_4 = (-5.865\times10^{-3})(47)[V]$$

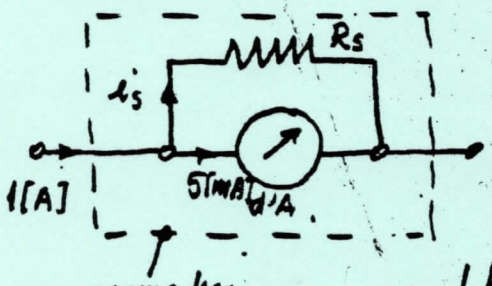
$$\boxed{V_x = -276[mV]}$$

5. (15 Points) Two identical d'Arsonval meters are used, one to create a 1[A] ammeter, and the other to create a 100[V] voltmeter. The d'Arsonval meter rated values are $i_{d'A} = 5[mA]$, and $v_{d'A} = 100[mV]$.

a) Draw the ammeter equivalent circuit. Calculate the necessary shunt resistance value to obtain a 1[A] ammeter. Determine the ammeter equivalent resistance.

3pts

The ammeter circuit:



$i_s = 1 - 0.005 = 0.995[A]$.

4.5pts

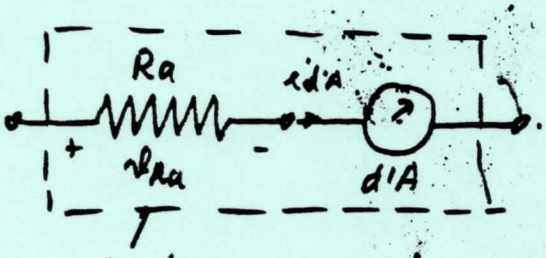
$$R_s = \frac{v_{d'A}}{i_s} = \frac{100*10^{-3}}{0.995} = 0.10050251[\Omega]$$

$$R_A = \frac{v_{d'A}}{1} = 0.1[\Omega]$$

b) Draw the voltmeter equivalent circuit. Calculate the necessary series resistance value to obtain a 100[V] voltmeter. Determine the voltmeter equivalent resistance.

3pts

The voltmeter circuit:



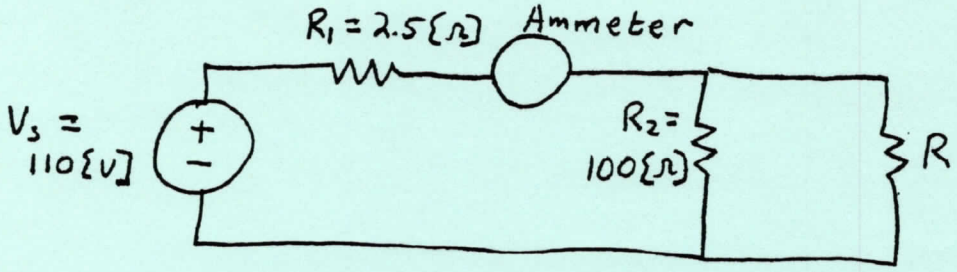
$v_{Ra} = i_{d'A} \cdot R_a = 100 - 0,1 = 99.9[V]$

4.5pts

$$R_a = \frac{99.9}{5*10^{-3}} = 19980[\Omega]$$

$$R_V = \frac{100}{i_{d'A}} = \frac{100}{5*10^{-3}} = 20000[\Omega]$$

6. (17 Points) An ammeter with an internal resistance of 0.5[Ω] is inserted in an electrical network as shown and reads 6.25[A].

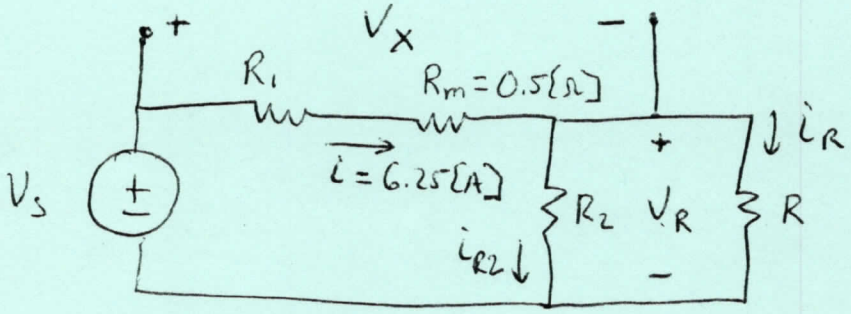


Points deducted.
2pts - math error
3pts - no units
4pts - sign error
5pts - Ohms' Law
Kirchoff Law error

Total = 11 pts

a) What is the value of the resistor R?

Redraw Ckt.



$$V_x = i(R_1 + R_m) = 6.25[A](3[\Omega]) = 18.75[V]$$

$$V_s - V_x = V_R = 110[V] - 18.75[V] = 91.25[V]$$

$$i_{R_2} = \frac{91.25[V]}{100[\Omega]} = 912.5[mA]$$

$$i_R = i - i_{R2} = (6.25 - .9125)[A] = 5.3375[A]$$

$$R = \frac{V_R}{i_R} = \frac{91.25[V]}{5.3375[A]} = \boxed{17.096[\Omega]}$$

6. b) Suppose that the resistance was calculated without considering the ammeter internal resistance. If this new resistance is called R_E, and the true resistance is called R_T, then we can use the following formula for the percent error.

$$\%_0.error = \frac{R_E - R_T}{R_T} \times 100$$

Find the percent error in this case.

Assume $R_m = 0$

$$V_x = i R_1 = 6.25[A]\,2.5[\Omega] = 15.625[V]$$

$$V_S - V_x = V_R = 110[V] - 15.625[V] = 94.375[V]$$

$$i_{R_2} = \frac{94.375[V]}{100[\Omega]} = 943.75[mA]$$

$$i_R = (i - i_{R_2}) = (6.25 - .94375)[A] = 5.306$$

(+3) $$R = \frac{V_R}{i_R} = \frac{94.375[V]}{5.30625[A]} = 17.786[\Omega]$$

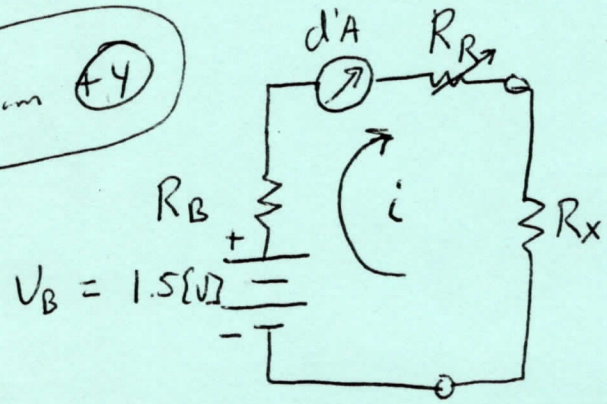
$$\%_0\ error = \frac{17.786 - 17.096}{17.096} \times 100$$

(+3) $$= 4.03\ \%_0$$

Total = 6pt

7. (13 Points) An ohmmeter is to be designed with a 1.5[V] battery, and a d'Arsonval meter movement rated at 2[mA], 200[mV]. The battery internal resistance is 10[Ω] when the battery is fresh, but increases to 100[Ω] as the battery runs down. What resistance range must the regulating resistor cover to make it possible to calibrate the ohmmeter for these cases?

Diagram (+4)



d'A rated at 200[mV] 2 [mA]

$r_{d'A} = 100[\Omega]$

R_R is adjusted to yield full scale reading when $R_x = 0$

$$V_B = i(R_B + R_{d'A} + R_R) \quad (+3)$$

$$1.5[V] = 2[mA]\,(R_B + 100[\Omega] + R_R)$$

for $R_B = 10[\Omega]$

$$750[\Omega] = (10[\Omega] + 100[\Omega] + R_{R_1})$$

$$640[\Omega] = R_{R_1} \quad (+2)$$

for $R_B = 100[\Omega]$

$$750[\Omega] = (100[\Omega] + 100[\Omega] + R_{R_2})$$

$$550[\Omega] = R_{R_2} \quad (+2)$$

So R_R must range from

$$\boxed{550[\Omega] < R_R < 640[\Omega]} \quad (+2)$$