Signature: Solution Key

DO NOT OPEN THIS BOOKLET UNTIL INSTRUCTED TO DO SO.

EXAM 1
ELEE 2335
February 15, 1986

INSTRUCTIONS:

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

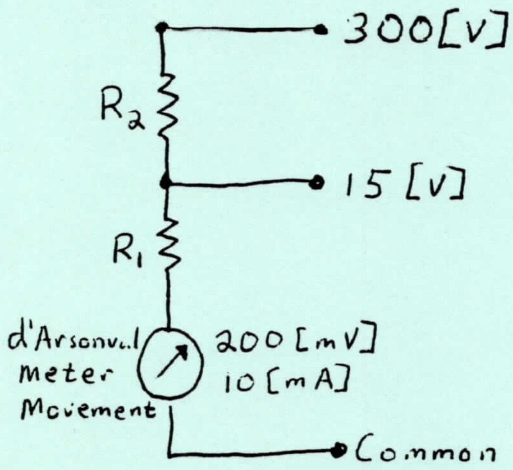
2. All work is to be done in the spaces provided in this booklet. Use the backs if necessary. Indicate clearly where your work and answers may be found. Enclose your final answers in a box. No credit will be given unless the necessary work is shown.

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

1. (20 Points) A multirange voltmeter consisting of a 200[mV], 10[mA] d'Arsonval meter movement and two resistances, R_1 and R_2, is shown in the figure below. The desired voltage ranges are 15[V] and 300[V]. The 15[V] and 300[V] terminals are as shown in the figure.



a) Determine values for R_1 and R_2.

$$R_{d'A} = \frac{v_{d'A}}{i_{d'A}} = \frac{200 \times 10^{-3}}{10 \times 10^{-3}} = 20[\Omega]$$

For; $v_t = 15[V]$; $\quad v_{R_1} = v_t - v_{d'A} = 15 - 0.2 = 14.8[V]$.

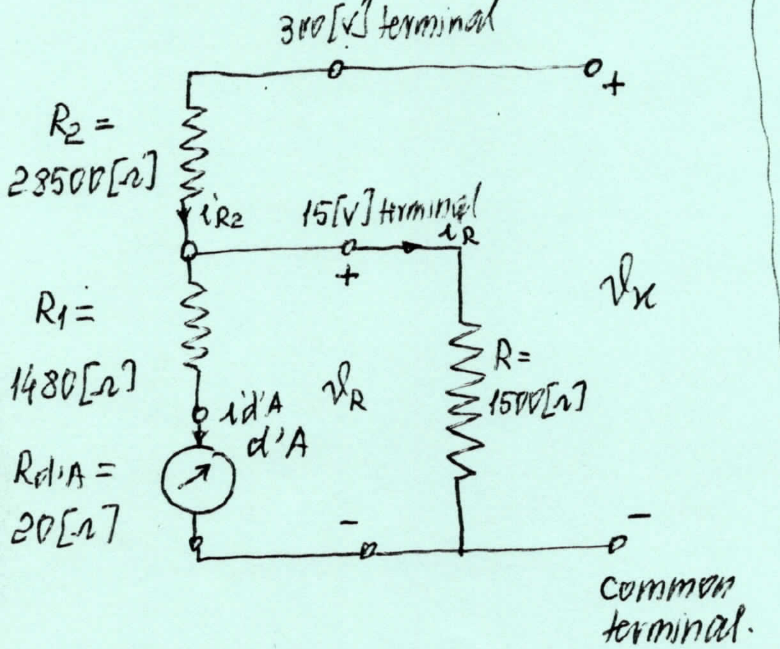
$$R_1 = \frac{v_{R1}}{i_{d'A}} = \frac{14.8}{0.01} = \underline{1480[\Omega]}$$

For; $v_t = 300[V]$, $\quad v_{R_2} = v_t - (v_{d'A} + v_{R1}) = 300 - 15 = 285[V]$

$$R_2 = \frac{v_{R2}}{i_{d'A}} = \frac{285}{0.01} = \underline{28500[\Omega]}$$

1. b) Assume that a 1500[Ω] resistor is connected between the 15[V] terminal and the common terminal. The voltmeter is then connected to an unknown voltage using the common terminal and the 300[V] terminal. The voltmeter reads 250[V]. What is the unknown voltage?

The circuit is as follow:



For $i_{d'A} = 10[mA]$, the voltmeter reads 300[V]

If it reads 250[V], means

$$i_{d'A} = 10\,\frac{250}{300} = 8.333\ldots[mA].$$

that is;

$$v_R = i_{d'A}(R_1 + R_{d'A}) =$$

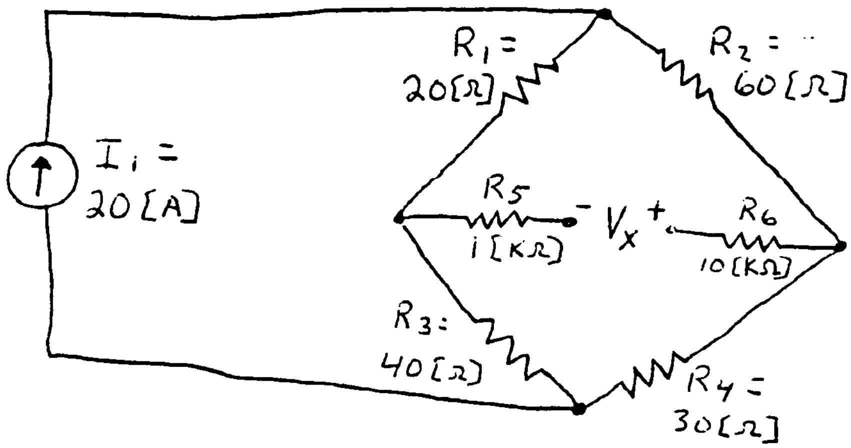
$$= 8.33\ldots * 10^{-3} * (1480 + 20) = 12.5[V].$$

$$i_R = \frac{v_R}{i_R} = \frac{12.5}{1500} = 8.33\ldots * 10^{-3}[A].$$

$$i_{R2} = i_{d'A} + i_R = 2 * 8.33\ldots * 10^{-3} = 16.66\ldots * 10^{-3}[A].$$

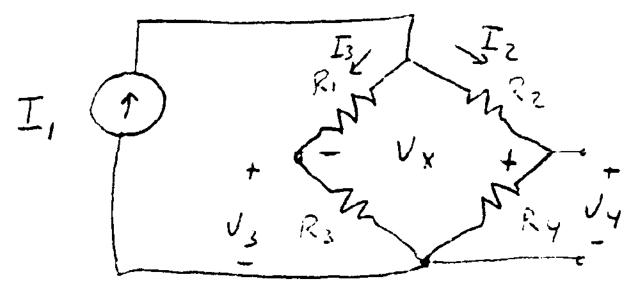
$$v_x = v_R + i_{R2} * R_2 = 12.5 + 16.66\ldots * 10^{-3} * 28500 = \underline{487.5[V]}$$

2. (15 Points) Find the voltage V_x in the circuit below.



Solution.

First, it is clear that the currents in R_5 and R_6 are zero, so the voltage drops across these resistors are zero. Redrawing,



By Current Divider Rule

$$I_2 = \frac{I_1 \ (R_1 + R_3)}{R_1 + R_2 + R_3 + R_4}$$

$$I_3 = I_1 - I_2$$

$$I_2 = \frac{20 [A] \ \ 60 (\Omega)}{60 (\Omega) + 90 (\Omega)} = 8 [A]$$

$$I_3 = (20 - 8) (A) = 12 [A]$$

$$V_3 = I_3 R_3 = 12 [A] \ 40 [\Omega] = 480 [V]$$

$$V_4 = I_2 R_4 = 8 [A] \ 30 [\Omega] = 240 [V]$$

$$V_x = V_4 - V_3 = 240 [V] - 480 [V] = \boxed{-240 [V]}$$

Grading

+4 for each correct equation, leading to solution, Max = 12 pts

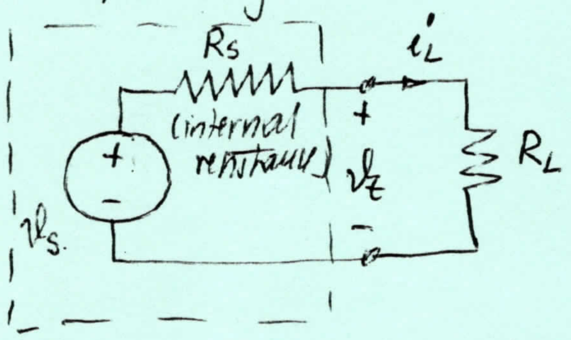
+3 Correct solving method and solution

-2 math error (each)

-3 sign error (each)

3. (15 Points) A certain generator has a terminal voltage of 110[V] when a 5.5[Ω] load is connected to its terminals. The terminal voltage becomes 105[V] when the load is 3.5[Ω]. What is the internal resistance of the generator?

Actual generator + load equivalent circuit:



actual generator + load

$$i_L = \frac{v_s}{R_s + R_L} \; ; \; v_t = v_s - R_s i_L \text{ or,}$$

$$v_t = v_s \frac{R_L}{R_s + R_L}$$

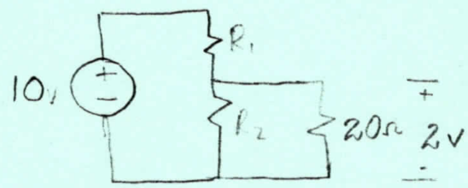
$R_L = 5{,}5\,[\Omega]$, $v_t = 110\,[V]$; $\Rightarrow 110 = v_s \dfrac{5{,}5}{R_s + 5{,}5} \Rightarrow 110 R_s + 605 = 5{,}5\, v_s$ (1)

$R_L = 3{,}5\,[\Omega]$, $v_t = 105\,[V]$; $\Rightarrow 105 = v_s \dfrac{3{,}5}{R_s + 3{,}5} \Rightarrow 105 R_s + 367{,}5 = 3{,}5\, v_s$ (2)

from (1)+(2)

$$\begin{cases} v_s - 20 R_s = 110 \\ v_s - 30 R_s = 105 \end{cases} \Rightarrow 10 R_s = 5 \Rightarrow \boxed{R_s = 0{,}5\,[\Omega]}$$

4. (15 Points) A 100 [Ω] variable resistor potentiometer is to be used as a voltage divider to provide a voltage of 2.0[V] across a 20[Ω] load resistor from a 10[V] DC source. What will be the resistance value of the part of the potentiometer that is in parallel with the 20[Ω] load resistor?



1. $$2 = \frac{10 \times R_2 /\!/ 20}{R_1 + R_2 /\!/ 20} = 10 \times \frac{\frac{20R_2}{R_2+20}}{R_1 + \frac{20R_2}{R_2+20}} = 10 \left[\frac{20R_2}{R_1R_2 + 20R_1 + 20R_2} \right]$$

2. $R_1 + R_2 = 100$; $R_1 = 100 - R_2$

$$2R_1R_2 + 40R_1 + 40R_2 = 200R_2$$

$$2R_2(100 - R_2) + 40(100 - R_2) + 40R_2 = 200R_2$$

$$200R_2 - 2R_2^2 + 4000 - 40R_2 + 40R_2 = 200R_2$$

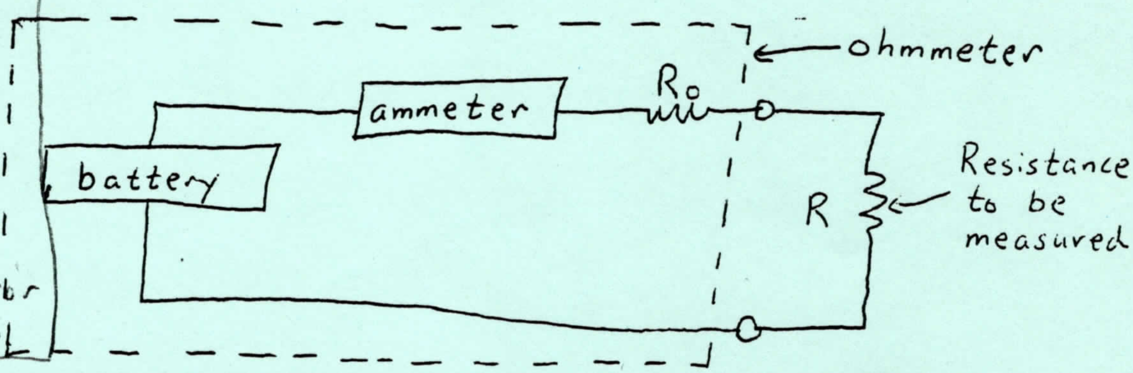
$$R_2^2 = 2000$$

$$R_2 = \sqrt{2000}\ \Omega$$

DIAGRAM - 4
EQ 1 - 5
EQ 2 - 3
SOLUTION - 3

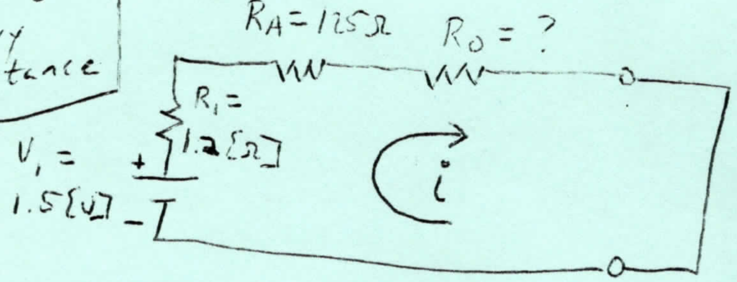
5. (15 Points) An ohmmeter is constructed from a 1.5[V] battery with an internal resistance of 1.2[Ω] in series with an ammeter with an internal resistance of 125[Ω] in series with a resistor R_0 as indicated.

Grading
+2 diagram
+2 equ.
+1 soln or equiv.
−1 matherror
−2 no units



−3 for neglecting Ammeter or battery resistance

a) What value should the resistor R_0 have if the ammeter is to register a full scale reading of 10[mA] when the measured resistance R is 0[Ω] (a short circuit)?



$i = 10[mA]$

$V_1 = iR_1 + iR_A + iR_0$

$\frac{1.5[V]}{10[mA]} = [1.2[\Omega] + 125[\Omega] + R_0]$

$150[\Omega] - 1.2[\Omega] - 125[\Omega] = \boxed{R_0 = 23.8[\Omega]}$

b) With the value for R_0 that you found in part a), what measured resistances R will make the ammeter read one-half, and one-quarter of its full scale reading?

For $\frac{1}{2}$ reading

$R_T = R_1 + R_A + R_0$

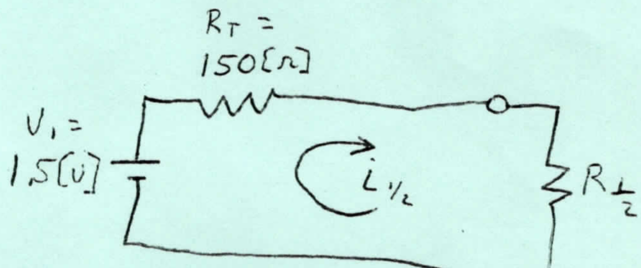
$V_1 = i_{\frac{1}{2}} R_T + i_{\frac{1}{2}} R_{\frac{1}{2}}$

$i_{\frac{1}{2}} = 5[mA]$

$1.5[V] = 5[mA]\left(150[\Omega] + R_{\frac{1}{2}}\right)$

$300[\Omega] = 150[\Omega] + R_{\frac{1}{2}}$

$\boxed{150[\Omega] = R_{\frac{1}{2}}}$



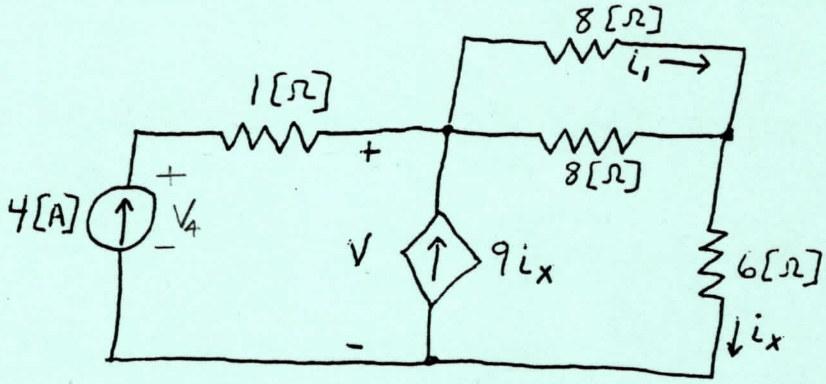
For $\frac{1}{4}$ reading, similar equ.

$i_{\frac{1}{4}} = 2.5[mA]$

$\frac{1.5[V]}{2.5[mA]} = 150[\Omega] + R_{\frac{1}{4}}$

$\boxed{R_{\frac{1}{4}} = 600[\Omega] - 150[\Omega] = 450[\Omega]}$

6. (20 Points) Use the circuit below to find the values requested.



a) Determine the value of i_1.

$i_x = 2i_1$

$i_x = 9i_x + 4$; $-8i_x = 4$

5 PTS

$i_x = -\frac{1}{2}A$

$i_1 = -\frac{1}{4}A = -.25A$

b) Determine the value of V.

$V = 8i_1 + 6i_x = -\frac{8}{4} - \frac{6}{2} = -5V$

5 PTS

c) Determine the power absorbed by each of the two current sources.

$V_4 - 4 \times 1 = V$

10 PTS

$V_4 = V + 4 = -5 + 4 = -1$ VOLT

$P_{V_4} = -4V_4 = 4$ WATTS

$P_{9i_x} = -9i_x V = +4.5 \times -5 = -22.5$ WATTS