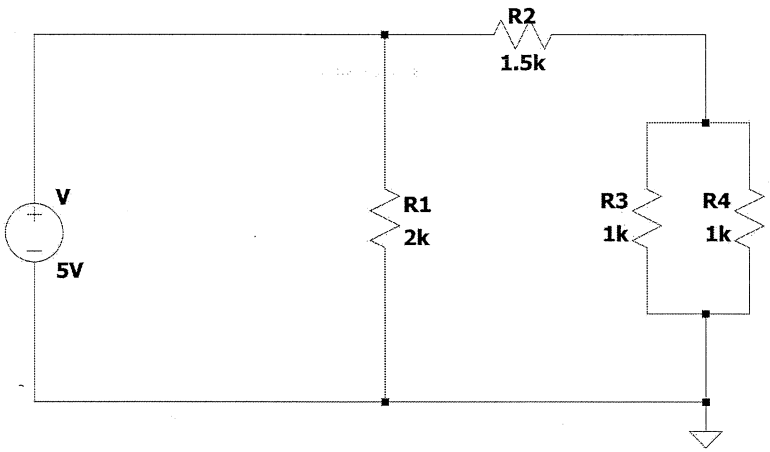
1. Circuit Laws and Resistors (25 points)

Consider the circuit shown below.



5 points each.

Part a) Find the total resistance of R2, R3, R4.

$R_3 \| R_4 = \frac{1K\Omega \cdot 1K\Omega}{1K\Omega + 1K\Omega} = \frac{1}{2} K\Omega$

$R_2 = 1.5K\Omega$

$R_{eq} = 2K\Omega$

Part b) Find the total resistance of the circuit.

$R_1 \| R_{eq} = \frac{2K\Omega \cdot 2K\Omega}{2K\Omega + 2K\Omega} = 1K\Omega.$

Part c) Find the current through R1.

Ohm's law: $V_1 = R_1 I_1$

$$\Rightarrow I_1 = \frac{V_1}{R_1} = \frac{5V}{2k\Omega} = 2.5mA$$

Part d) Find the Voltage across R4

$$I_2 = \frac{V_4}{R_{eq}} = \frac{5V}{2k\Omega} = 2.5mA.$$

$$I_4 = \frac{2.5mA}{2} = 1.25mA$$

$$V_4 = R_4 I_4 = 1.25V$$

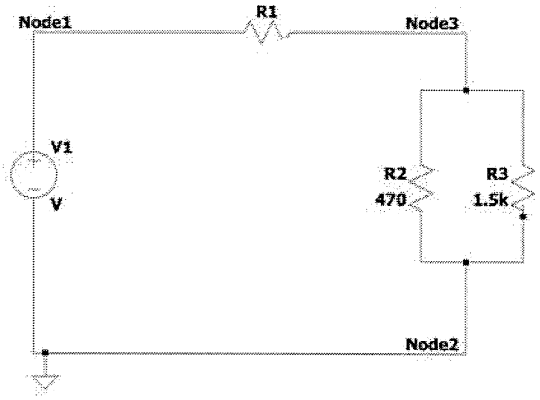
Part e) Find the power absorbed by R3

$$P_3 = V_3 I_3 = V_4 I_4 = 1.25V \cdot 125mA$$
$$\approx 156 mW$$

2. DC source and measurements using M1K board (25 points)

The ADALM1000 (M1K) board is to be used to experimentally source and measure voltages as shown in the circuit diagram below.

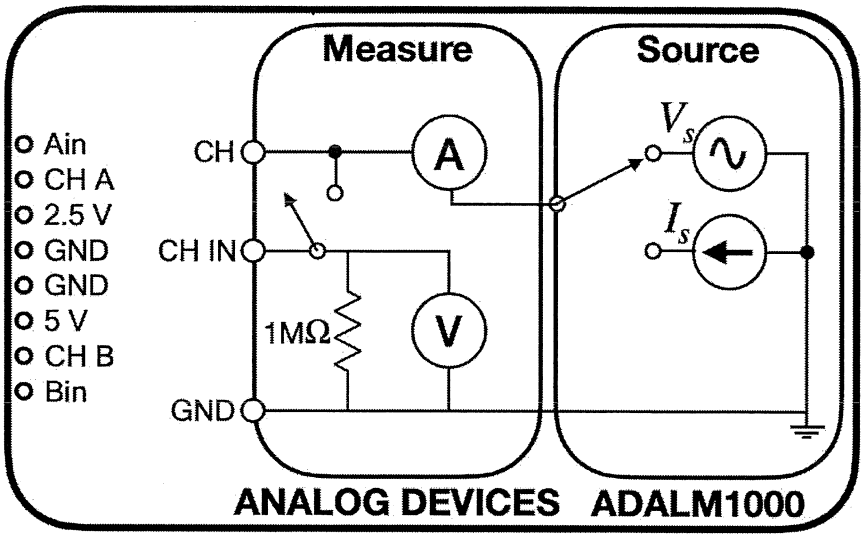
Note: Don't perform any experiments to answer this or any other question on this quiz. Answer questions based on information provided.



a. (7 points) The voltage drop across R1, R2, and R3 is to be measured using the M1K board by making wire connections between the circuit and M1K board pinouts. You would also need to use the M1K board to supply 4V for the voltage source V1.

In the following table, indicate what wire connections should be made between the M1K board and the circuit. Three nodes have been highlighted in the circuit diagram for you to use them as reference points in the table below. **There are more rows in the table than you may need. Leave blank if unused.**

Node on circuit diagram	Pinout of M1K board
Node1	CHA
Node1	A In
Node1	
Node2	GND
Node2	
Node2	
Node3	B In
Node3	
Node3	



b. (10 points) After making the connections based on your table for 3.1, explain in a few sentences how you would determine the voltage drop across R1, R2, and R3 while supplying 4V for the voltage source. You would need to specify the software tool you would use, and where/which channel voltage you would be looking at for the voltage across each of the three components. Also specify any special settings you would choose for the channels.

- Voltage drop across R_2 and R_3 is measured by channel B.
- voltage drop across R_1 is the difference between $V_{Ain} - V_{Bin}$.

c. (8 points) Assume that the following voltages at nodes were measured node1: 4V, node2: 0.0 V, node3: 0.5V. Determine the current flowing through R1? Express your answer in milli-amps. Determine the value of the resistance R1

$$V_{R_1} = 4V - 0.5V = 3.5V$$

$$R_2 \| R_3 = \frac{470\,\Omega \times 1.5\,k\Omega}{1.5k\Omega + 470\Omega} = 357.86\Omega$$

$$I = \frac{0.5V}{R_2 \| R_3} = 1.4mA \quad \Rightarrow R_1 = \frac{3.5V}{1.4mA} = 2.5k\Omega$$

3. **Voltage Dividers and Measurement Error (25 points)**

The circuit shown below was built in the lab and voltage VR2 was measured using a voltmeter with internal resistance 1MΩ.

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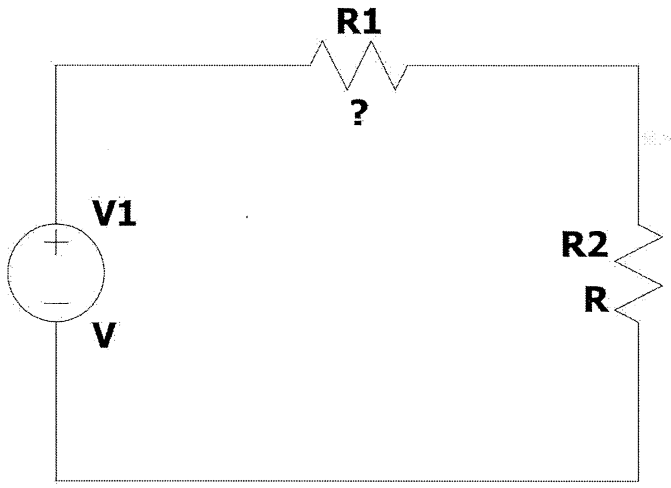
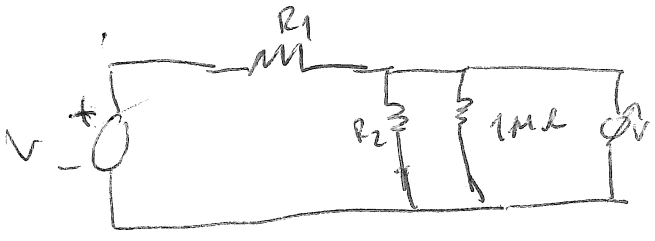


Part a) (10 points) For different values of resistances we measure the following voltages:

R2	VR2
100 Ω	3.401 V
1 kΩ	4.775 V
10 kΩ	4.996 V
100 kΩ	4.997 V
1 MΩ	4.999 V

Determine the voltage of V1.



As $R_2 \uparrow$

$R_2 \| 1M\Omega \to \infty$

$I_{R1} \Longrightarrow 0$

$V_{R1} = 0$

$V_{R2} = V \to 5V$

Part b) (10 points) Draw an equivalent circuit that includes the resistance of the voltmeter. Compute the effective resistance of R2 and the resistance of the voltmeter for R2= 100 Ω.

$$R_{eq} = \frac{100\Omega \cdot 1M\Omega}{100\Omega + 1M\Omega} = 99.99\Omega$$

Part c) (5 points) Using the circuit from part b, the value computed of the equivalent resistance and using the voltage divider expression, compute the value of R1.

$$V_{R2} = V\frac{R_{eq}}{R_1 + R_{eq}} = 3.401\,V$$

$$\Rightarrow R_{eq}(5V - 3.401V) = R_1\, 3.401\,V$$

$$\Rightarrow R_1 = \frac{5 - 3.401}{3.401} \cdot R_{eq}$$

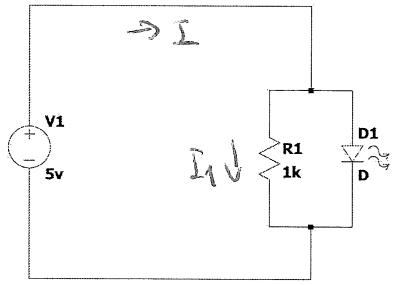
$$= 47\Omega$$

Short Answer questions (25 points)

Multiple Choice and Fill blank questions. Select the correct answer or write in your answer in the blank field provided in the specific format mentioned in the question.

Fill Blank 1: The DC source is supplying 35mW. Determine the current through the led. Express it in **milli-amperes**.

For example, if your answer is 1milli-ampere, then enter 1 in the field provided for answer.



$I = 7mA$

$I_1 = \frac{5V}{1k\Omega} = 5mA$

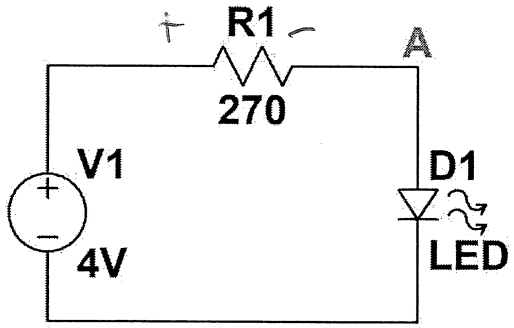
$I_{Led} = 7mA - 5mA$

$= 2mA.$

Answer :_____

Fill Blank 2: Find the power absorbed by the LED in the circuit shown below. You are given that the voltage at point A is 1.3V. Round your answer to the nearest **integer** and express it in **milli-amps**. watts

For example, if your answer is 5 milli-watts, then enter 5 in the field provided for answer.



$V_{R1} = 4V - 1.3V$

$= 2.7V$

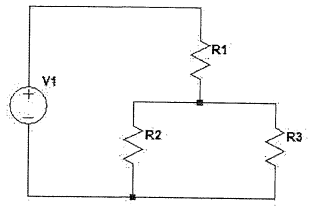
$I = \frac{2.7V}{270\Omega} = 10mA$

$P_{Led} = 10mA \times 1.3V$

$= 13mW$

Answer :_____

Multiple Choice 1: In the circuit shown below, If R2 is larger than R3 (R2 > R3), is the power dissipated in R2

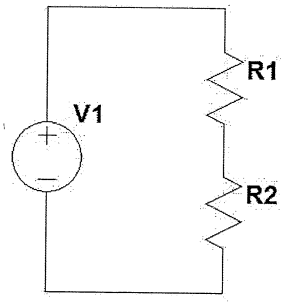


(Choice A) Greater than the power dissipated in R3

(Choice B) Less than the power dissipated in R3

$P = V^2/R$ $R_2 > R_3 \Rightarrow \boxed{P_{R3} > P_{R2}}$

Multiple Choice 2: For the voltage divider circuit shown below



If R1 is larger than R2 (R1 > R2), the relationship between PR1 (power dissipated in R1) and PR2 (power dissipated in R2) will be

(Choice A) PR2 > PR1

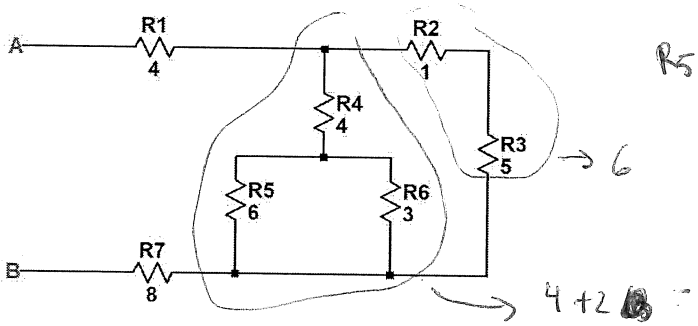
(Choice B) PR2 < PR1

$P = RI^2$

$R_1 > R_2 \Rightarrow \boxed{P_1 > P_2}$

Fill Blank 3: What is the equivalent resistance between points A and B shown in the circuit diagram below. Express your answer as an integer in ohms.

For example, if your answer is 10 ohms, then enter 10 in the field provided for answer.



$R_5 \| R_6 = \frac{6 \cdot 3}{9} = 2\,\Omega$

$\rightarrow 6$

$\rightarrow 4 + 2\,\Omega$

Answer : _____

$6 \| (4+2\,\Omega) = 3\,\Omega$

$R_{tot} = 4 + 8 + 3 = 15\,\Omega$