EE281 EXPERIMENT 1

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1 Experimental Work: Theoretical solutions

1.1 Figure 1

Current of the figure 1 is 5A from the formula V$_1 = I_1 * R_1$.

V$_1$ = 5V from the voltage supply
5V = I$_1 * 1k\Omega$
$I_1 = 5mA$

1.2 Figure 2

To apply the formula V = IR, we should find R_{total}. Resistors are connected in series.

R$_{total} = R_1 + R_2$
$R_{total} = 1k\Omega + 10k\Omega = 11k\Omega$
$5V = I_2 * 11k\Omega$
$I_2 = 0.45454545..m\Omega$
$V_2 = I_2 * R_1 \rightarrow V_2 = 0.\overline{45}mA * 1k\Omega = 0.\overline{45}V$
$V_3 = I_2 * R_2 \rightarrow V_3 = 0.\overline{45}mA * 10k\Omega = 4.\overline{54}V$

1.3 Figure 3

Potential difference between both two resistors are equal to 5V from the KVL.
V$_4 = 5V$
$V_5 = 5V$
$I_3 = \frac{5V}{1k\Omega} = 5mA$
$I_4 = \frac{5V}{10k\Omega} = 0.5mA$

1.4 Figure 4

R$_{total} = R_1 + \frac{R_2 * R_2}{R_2 + R_2} = R_1 + \frac{R_2}{2} = 1k\Omega + 5k\Omega = 6k\Omega$
$I_5 = \frac{V_{total}}{R_{total}} = \frac{5V}{6\Omega} = 0.8\overline{3}mA$
$V_6 = I_5 * R_1 \rightarrow V_6 = 0.8\overline{3}mA * 1 = 0.8\overline{3}V$
Current will go through both R$'_2s$ equally since resistances of the resistors are the identical.
I$_6 = I_7 = I_{total}/2 = \frac{0.8\overline{3}}{2} = 0.41\overline{6}$
Voltages of the R$'_2s$ will be the same since their currents and resistances are the same from the formula V = IR
V$_7 = V_8 = I_6 * R_2 \rightarrow 0.41\overline{6}mA * 10k\Omega = 4.1\overline{6}V$

1.5 Figure 5

R$_{total} = R_1 + R_2//(R_2 + R_3) \rightarrow R_{total} = R_1 + \frac{R_2 * (R_2 + R_3)}{2R_2 + R_3}$
$R_{total} = 1k\Omega + \frac{10 * (13.3)k\Omega}{23.3} = 6.708k\Omega$
$I_8 = 25v/6.708k\Omega = 3.73mA \rightarrow V_9 = 3.73mA * 1k\Omega = 3.73V$

$After$R$_1$ our voltage drops to $V_{after} = 25V - 3.73V = 21.27V$. By KVL and because of parallel connection, potential difference is the same between R$_2//(R_2 + R_3)$ which is V_{after}.

$I_9 = \frac{V_{after}}{R_2} = \frac{21.27V}{10k\Omega} = 2.127mA$ $\rightarrow$V$_{after} = V_{11} = 21.27V$ since there are no resistors on that branch other than R$_2$.

$I_{10} = \frac{V_{after}}{R_2 + R_3} = \frac{21.27V}{13.3k\Omega} = 1.59mA$

$V_{10} = I_{10} * R_3 = 1.59mA * 3.3k\Omega = 5.28V$

$V_{12} = I_{10} * R_2 = 1.59mA * 10k\Omega = 15.6V$

1.6 Figure 6

To transfer my solution properly I want to call the diamond's left point "c" and right point "d". I'll assign the letter "A" for the current between the nodes "a" and "c", and assign the letter "B" for the current between the nodes "c" and "d" (direction is to the right), and finally assign the letter "C" for the current between the nodes "a" and "d". In this situtation the $current_{cb}$ will be A-B, and the $current_{db}$ will be C+B by KCL.

I will use three loops in order to solve this problem. I will use KVL, hence I will write the equations regarding voltages of resistors. (V = IR) First loop will go through the nodes "a", "c", "b" by order. With this loop we can get this equation:

5 - A -3.3(A-B) = 0 $\rightarrow 4.3A + 3.3B = 5$

Second loop will go through the nodes "a", "d", "b" by order. With this loop we can get this equation:

5 - 10C - 10(C + B) = 0 $\rightarrow 20C + 10B = 5$

Third loop will go through the nodes "a", "c", "d", and "a" again by order. With this loop we can get this equation:

A + 10B - 10C = 0 $\rightarrow 10C = A + 10B$

We have three equations:

4.3A + 3.3B = 5

20C + 10B = 5

10C = A + 10B

After solving the algebraic equations we get:

A = 1.23

B = 0.86

C = 0.2

Since $I_{11} = A + CbyKCL, I_{11} = 0.2mA + 1.23mA = 1.43mA$

V = $I_{11} * Rtotal \rightarrow R_{total} = 5V/1.43mA = 3.49k\Omega$

1.7 Color Codes

Resistors	1st Band	2nd Band	3rd Band	Tolerance
22k	Red	Red	Orange	Silver
3.3k	Orange	Orange	Red	Silver
12k	Brown	Red	Orange	Silver
18k	Brown	Gray	Orange	Silver
1M	Brown	Black	Green	Silver

1.8 SMD Resistors

SMD Resistors	Resistor Value	Method
100	10 ohm	Three Digit Resistor
472	4.7 k ohm	Three Digit Resistor
00R1	0.1 ohm	Resistor with Radix Point
0R2	0.2 ohm	Resistor with Radix Point
1002	10 k ohm	Four-Digit Resistor

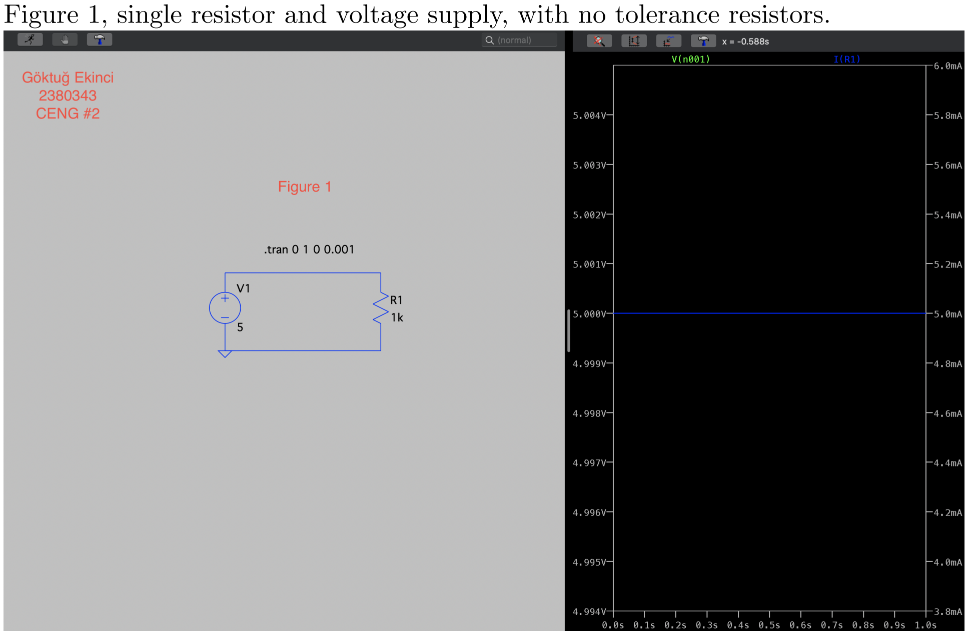
2 Experimental Work: Simulation Solutions

2.1 Figure 1

I set up the circuit with zero tolarence, 1%, 5%, 10% by order as said in the documentation. I set the stop time to 1 second and start time to 0 second, and timestep is 0.001 for all circuits.

2.1.1 (i)

Figure 1, single resistor and voltage supply, with no tolerance resistors.



2.1.2 (ii)

Figure 1 and tolerance is set to 1%

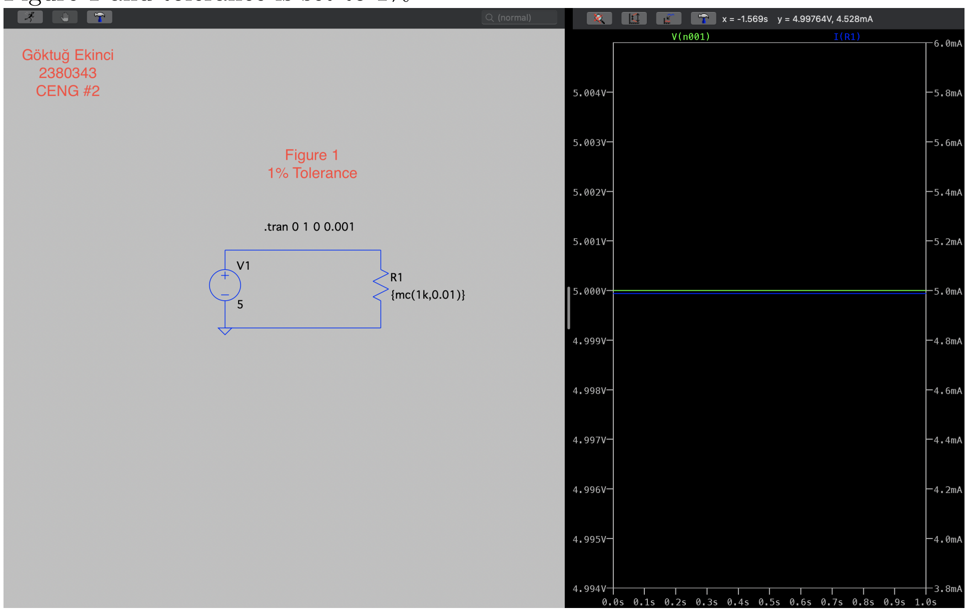


Figure 1 and tolerance is set to 5%

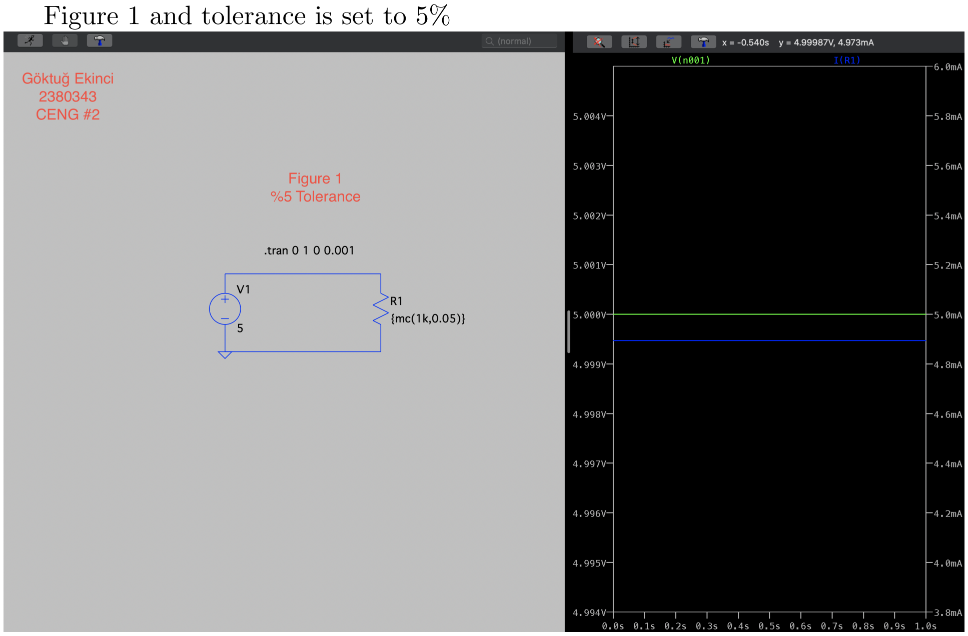
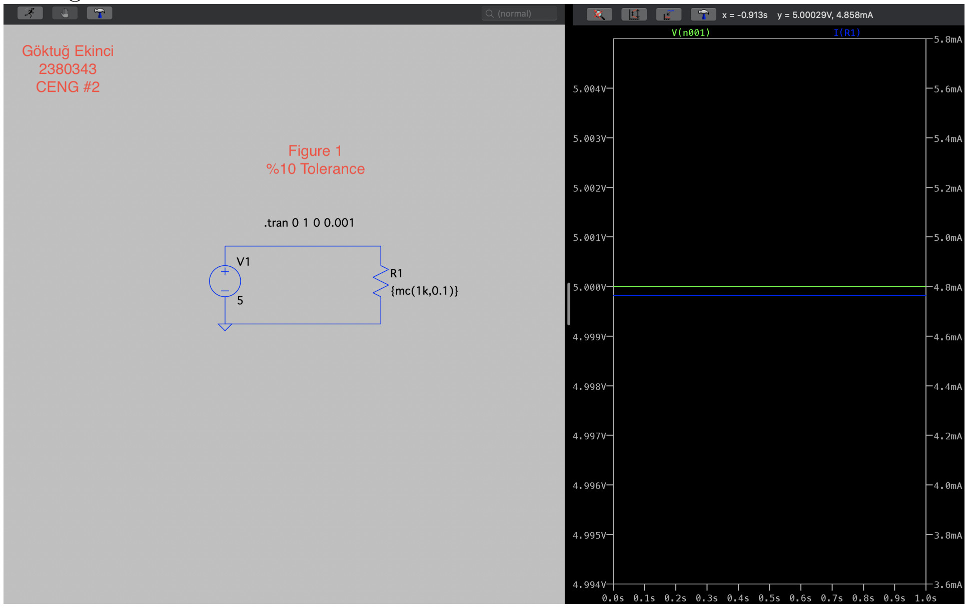
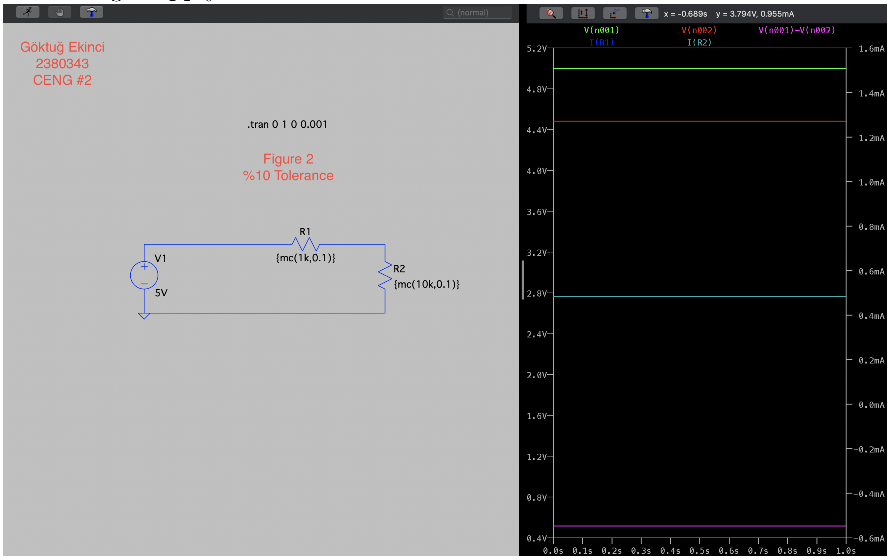


Figure 1 and tolerance is set to 10%



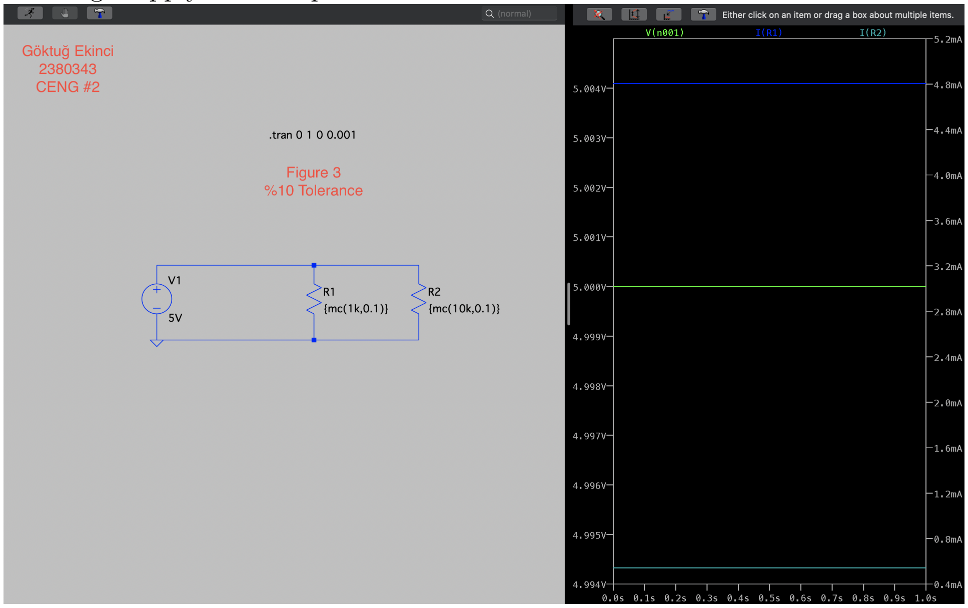
2.2 Figure 2

I used "Add Traces" command to add the plot of voltages of resistors to the graph. I measure the voltage just before the resistors and after the resistors and subtracted them. Tolerances of resistors set to 10%, two resistors in series and one voltage supply.



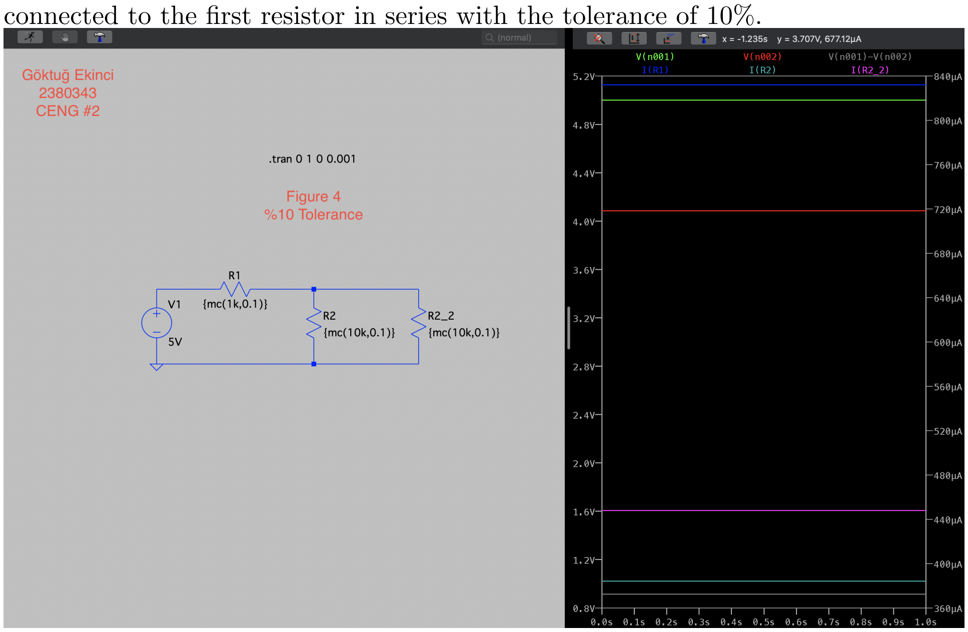
2.3 Figure 3

A voltage supply and two parallel resistors with the tolerance of 10%.



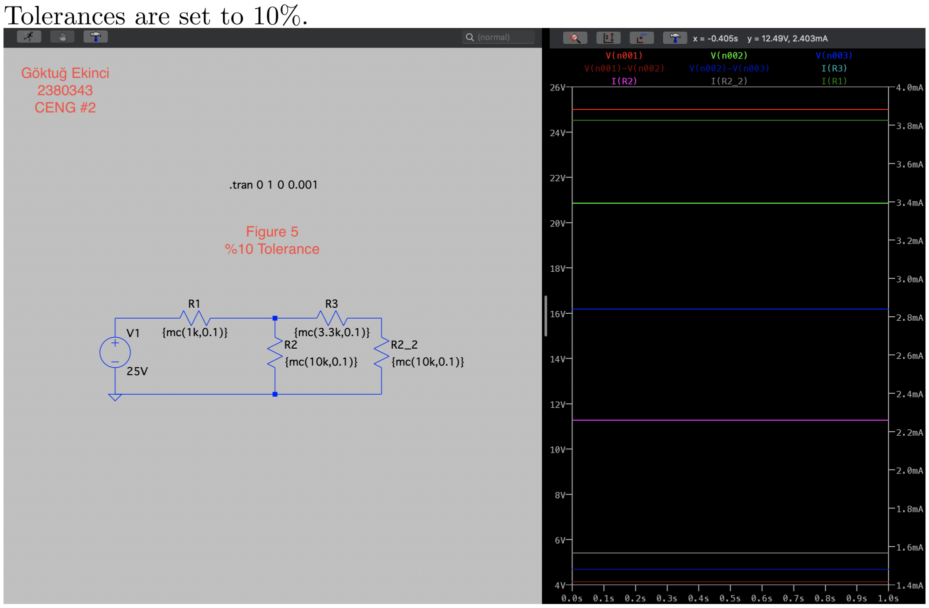
2.4 Figure 4

A voltage supply with 3 resistors which two are connected in parallel and they're connected to the first resistor in series with the tolerance of 10%.



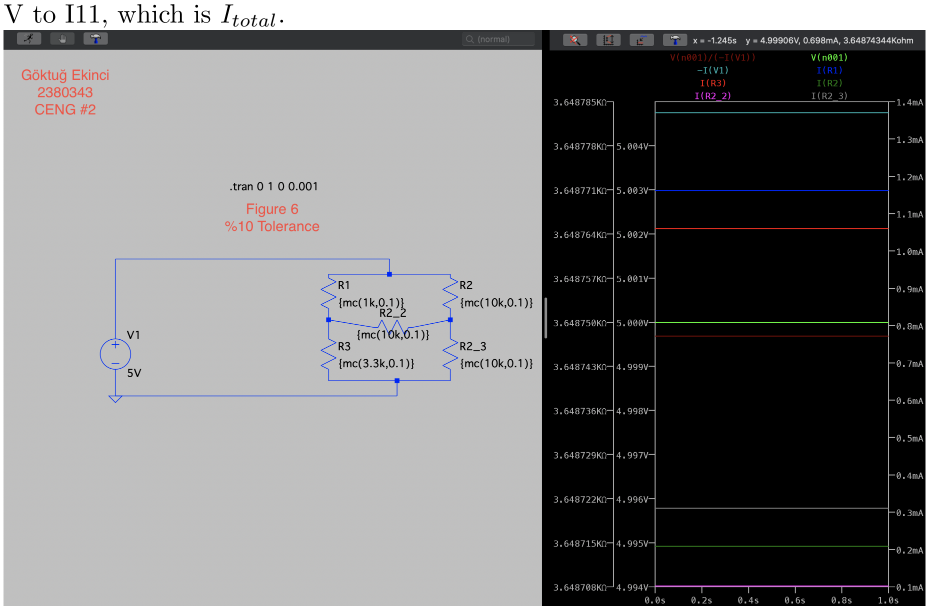
2.5 Figure 5

A voltage supply with 4 resistors their connections is like: $R1{+}((R3{+}R2_2)//R2)$. Tolerances are set to 10%.



2.6 Figure 6

The wheatstone bridge simulation circuit with 10% toleranced resistors.I used "Add Traces" method again to add the plotting of R_{total}. I divide the value of V to I11, which is I_{total}.



2.7 Simulation vs Calculated Results

	Voltages				Currents	
	Simulation	Calculated			Simulation	Calculated
V1	5V	5V		I1	4.6	5mA
V2	0.517V	0.46V		I2	0.484mA	0.45mA
V3	4.48V	4.55V		I3	4.81mA	5mA
V4	5V	5V		I4	0.541mA	0.5mA
V5	5V	5V		I5	0.832mA	0.84mA
V6	0.914V	0.84V		I6	0.384mA	0.417mA
V7	4.08V	4.17V		I7	0.448mA	0.417mA
V8	4.08V	4.17V		I8	3.83mA	3.73mA
V9	4.14V	3.73V		I9	2.26mA	2.13mA
V10	4.68V	5.28V		I10	1.57mA	1.59mA
V11	20.9V	21.27V				
V12	16.2V	15.9V				

2.8 Comments

Simulation results were really close to my calculated results. Simulated results are changing nearly in the range of 10% of calculated results since we adjust the tolerance of 10%. Simulations tolerance logic is completely random. Resistances can change randomly from run to run. It was a delightful experience to use LTspice. I had a chance to compare the theoretical and practical solutions of the circuits

3 Online Laboratory Part

3.1 Measurements

Measured values in the online laboratory part was really close to my simulation measurements. They were not equal due to the real life conditions and tolerances in simulations. There are some examples of mine and measured values;

	Simulation	Online Experiment		Simulation	Online Experiment
V_1	5V	4.97V	I_1	4.6mA	5mA
V_2	0.517V	0.452V	I_2	0.484mA	-
V_3	4.48V	4.51V	I_3	4.81mA	-
			I_{11}	1.39mA	1.38mA
$R_{equivalent}$	3.64kΩ	3.56kΩ			

3.2 Question 1

How many measurement terminals of multimeter are used when measuring resistance, current and voltage? What is the importance of the polarity of the measurement terminals?

3.2.1 Answer

Two terminals are used to measure these features, which are red and black ports. Furthermore, signs are important for current and voltage since we do calculations with the directions of the voltages and currents but their absolute values are not changed.

3.3 Question 2

How to connect the ammeter and voltmeter to the measured element? Parallel or series and how?

3.3.1 Answer

Ammeter must be connected in series since it should measure the ampere that goes in that line, and also it has no resistance so if it connected in parallel it would cause a short circuit. Voltmeter must be connected in parallel since it must measure the voltage difference between two points, and also its resistance can be accepted as infinity so if it connected in series it would cause a open circuit.

3.4 Question 3

If I used 1 Ohm instead of 1k Ohm in figure 1 circuit, what happens on the physical circuit?

3.4.1 Answer

There is a power limit of resistors which is 250 m Watts in our case. If we used a 1 ohm instead of 1 k ohm, resistor would burn since we exceed the limit of power with 5 Watts.

3.5 Question 4

How tolerances distort measurements for circuits containing resistors only? How the situation changes for serial and parallel connections.

3.5.1 Answer

If we use 10% tolerance that means the value of the resistance can change by 10%. These changes result with the change of current in both series and parallel connected circuits, and this leads to change of voltages of resistors in series connected circuits. LTspice apply these tolerances completely random as I observed. There is no pattern of tolerance.