

Assignment 1 uni number 2321327

by Samuel Shepherd

Submission date: 15-Jan-2024 11:41AM (UTC+0000)

Submission ID: 222038927

File name: 21798_Samuel_Shepherd_Assignment_1_uni_number_2321327_183075_445419920.docx
(1.33M)

Word count: 3316

Character count: 15395

Electrical and Electronic Principles

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University Number: 2321327

Course: HNC Electrical / Electronic Engineering

Module Code: SGEE 4000

Assignment Title: Investigation into DC Transients

Date Submitted: 15/01/2024

Word Count: 2600~ words

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Introduction

This assignment aims to investigate the behaviour of R-L and R-C circuits through different methods (simulated, calculated and practical results) and compare the results given from each method in order to determine if any

differences and discrepancies occur. This will be achieved by using the correct and appropriate formula and using/manipulating it in order to get a set of comparable results. Comparing these results to those obtained from multisim will give us a comparison between practically obtained results and simulated results. Putting these practically obtained results into a graph allows us to compare the voltage, current and transient. The practical side of these tasks will be achieved by re-creating the circuit with physical parts, taking a recording of multimeters reading the voltage and the current and then pausing every 5 seconds to record the voltage and current at the time of the recording.

Task 1

Task 1 gives a resistor value of 5600 ohms and a capacitor value of 10000uF (equivalent to 10000×10^{-6}). These R and C values will give us a good enough value that a set of comparable results for each method is given with a good enough 5τ value that the peaks and declines given by the voltage and current transient graphs are clear enough to easily recreate the graphs in both simulated and practical results.

Practical (Task 1)

The practical results for task 1 were gathered through recreating, the circuit given for task 1, and recording the process of a charging capacitor over the span of 5 minutes, recording its voltage and current, allowing us to go back and pause the video recording every 5 seconds up to a minute, and then every 10 seconds until 5τ is hit. These results allow us to produce 2 graphs, voltage vs time and current vs time.

Time (seconds)	Voltage (V)	Current (A)
0	0	0
5	0.54	0.92
10	1.04	0.84
15	1.49	0.77
20	1.86	0.7
25	2.21	0.64
30	2.55	0.59
35	2.84	0.54
40	3.13	0.49
45	3.39	0.45
50	3.61	0.41
55	3.82	0.38
60	4	0.35
70	4.34	0.29
80	4.62	0.24
90	4.85	0.21
100	5.05	0.17
110	5.21	0.15
120	5.35	0.12
130	5.47	0.1
140	5.56	0.09
150	5.56	0.07
160	5.71	0.06
170	5.77	0.05
180	5.82	0.04
190	5.86	0.04
200	5.9	0.03
210	5.93	0.03
220	5.95	0.02
230	5.98	0.02
240	5.99	0.02
250	6.01	0.01
260	6.02	0.01
270	6.03	0.01
280	6.04	0.01

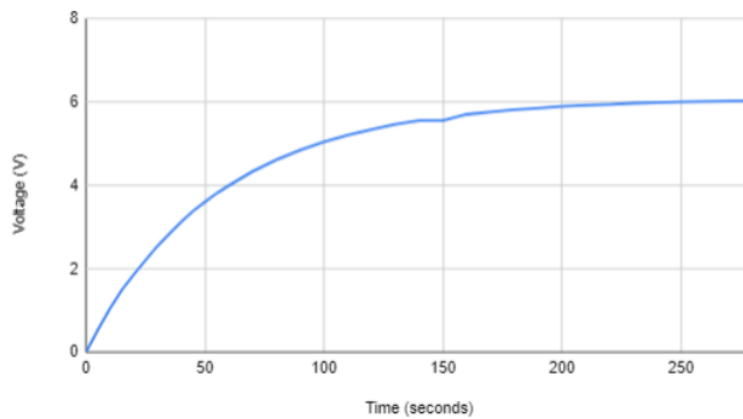
(going up to 280 was due to it being 5τ)

$$\tau = RC = 5000 \times 10000 \times 10^{-6} = 56 \text{ seconds}$$

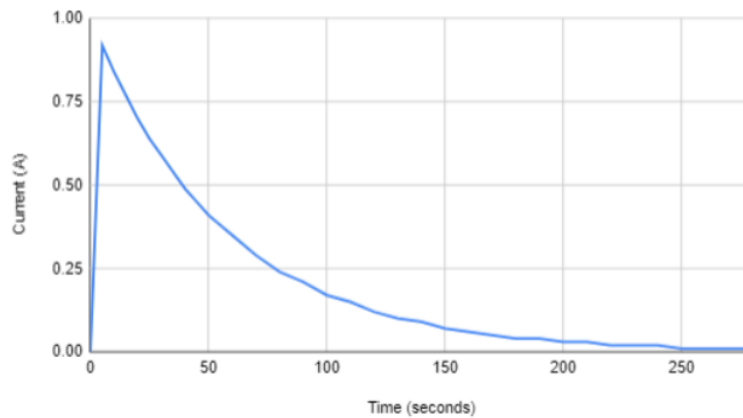
$$5\tau = 5 \times 56 = 280 \text{ seconds.})$$

Using these results in order to create 2 graphs, voltage and current, allows the comparison part of these tasks to be achieved, giving us accurate values, which can be recreated through other methods.

Voltage (V) vs Time (seconds)

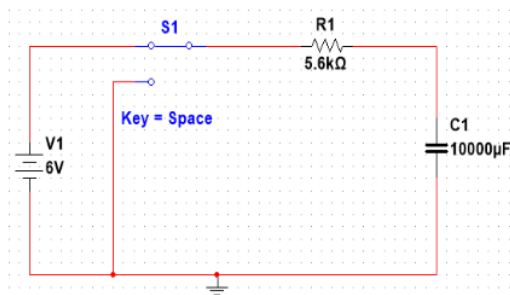


Current (A) vs Time (seconds)



Simulated (Task 1)

The simulated results for this task were achieved by using multisim, allowing the circuit to be recreated and supply similar results to the practically gained values.



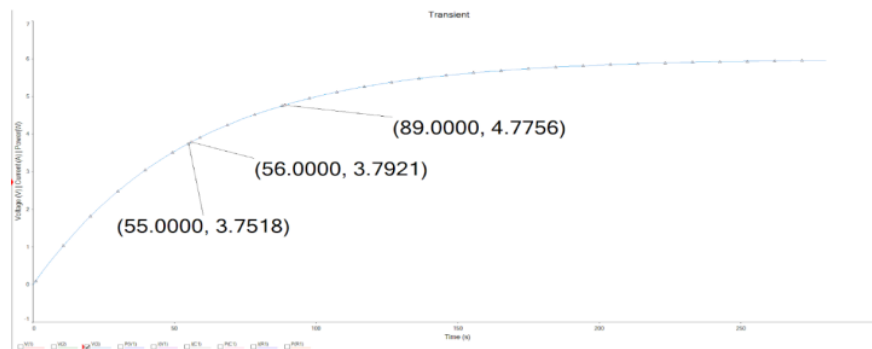
The analysis parameters for task 1 should always have the initial conditions 'set to zero' with the end time being equal to the result of 5, which in this task is 280 seconds.

$$\tau = RC = 5000 \times 10000 \times 10^{-6} = 56 \text{ seconds}$$

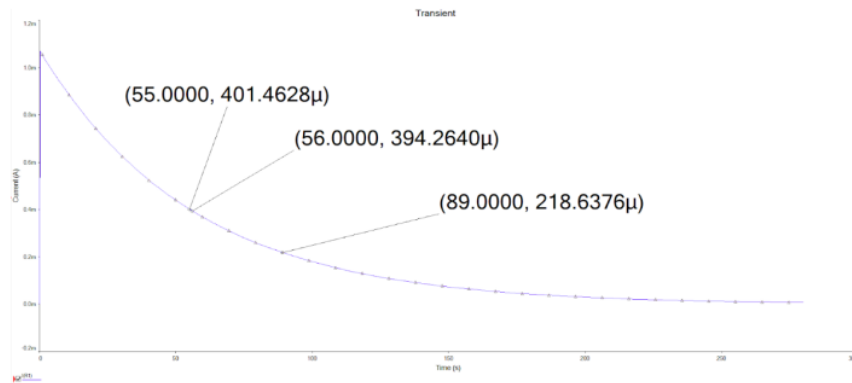
$$5\tau = 5 \times 56 = 280$$

Not setting the initial conditions to 0 will cause the graph output by multisim to be a straight line and contain incomparable results to the other methods.

The supplied transient graphs allow the use of the markers found within the multisim software. Using these and typing in the times, made up in the purpose of gaining results, outputs a highly accurate set of results for the voltage, and right clicking to create a label gives us a set of comparable results to those found in the practical side and theoretical side.



However, unlike the generated voltage transient, the transient created for the current outputs the values in a whole lower unit that was generated using the other results (will give the same results when put into mA). This is possibly due to the software not being able to differentiate the capacitance found within the circuit from the current.



Theoretical (Task 1)

In order to calculate the required for this equation the resistance and capacitance must be multiplied together, this is the reason that the R and C values must be suitable enough for this task.

$$\tau = RC = 5000 \times 10000 \times 10^{-6} = 56 \text{ seconds}$$

In order to generate a stop time for the simulated side of this task we must calculate 5 τ , allowing the transient graphs supplied to hit the maximum and minimum values.

$$5 \tau = 5 \times 56 = 280$$

Calculating the voltage using the exact same time value as the value allows a flat comparable result to be used between all 3 of the methods, and allows the other results to be checked by having a similar value.

$$VC = V(1 - e^{-t/\tau})$$

$$VC = 6(1 - e^{-1}) = 3.79 \text{ V}$$

Doing this again using the 2 other uniquely selected times, 55 and 89 seconds in this case, allows another 2 comparable results to be obtained.

$$55 \text{ Seconds} = 6(1 - e^{-55/56}) = 3.79 \text{ V}$$

$$89 \text{ Seconds} = 6(1 - e^{-89/56}) = 4.78 \text{ V}$$

Using ohm's law, the current was able to be calculated.

$$V/R = 6/5600 = 1.07 \text{ mA}$$

The current has the same situation the voltage where the first set of results is generated using the same time value as the value. Then this step is repeated again for the 2 other results.

$$I_{\max}(e^{-1}) = 1.07 \times 10^{-3} (0.368) = 0.394 \text{ mA} \text{ (0.368 is equal to } e^{-56/56})$$

$$55 \text{ Seconds} = 1.07 \times 10^{-3} (e^{-55/56}) = 0.4 \text{ mA}$$

$$89 \text{ Seconds} = 1.07 \times 10^{-3} (e^{-89/56}) = 0.218 \text{ mA}$$

Table of results (Task 1)

Voltage

Time	Calculated	Practical	Simulated
55	3.79V	3.82	3.7518V
56	3.79V	3.82	3.7921V
89	4.78V	4.85	4.7756V

Current

Time	Calculated	Practical	Simulated
55	0.4mA	0.38mA	0.4014mA
56	0.394mA	0.38mA	0.3942mA
89	0.218mA	0.21mA	0.2186mA

Task 2

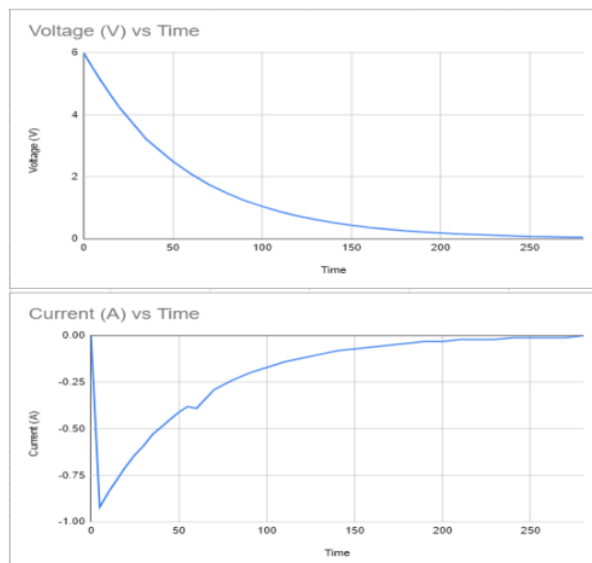
Re-using the circuit used in task 1, figure 1, and recording the discharging state of the circuit, collecting the current and voltage readings using all methods, will give an idea of the transient behaviour found within discharging capacitors. As well as re-using the circuit from figure 1 the 2 unique time values will also be re-used in order to grant an easy comparison between the state of a charging capacitor and discharging capacitor. This task will once again be using practical, simulated and calculated results.

Practical (Task 2)

Once again, using the circuit practically made for task one and changing the switch position from A to B allows the V_{in} to be disconnected from the capacitor. This allows the capacitor to slowly start discharging. Using this method and recording it for 5 minutes allows a set of results to be produced in which using the calculated ($\tau = 56s$, $5\tau = 280s$) allowed a set of results to be produced, in which the values went up in 5s until 60 seconds is hit then jumped up in 10s until 280 seconds. This value would allow both of the parameters to be near/at zero.

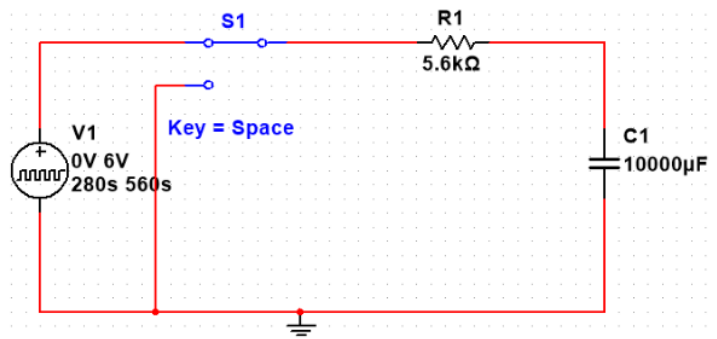
Time	Voltage (V)	Current (A)
0	6	0
5	5.52	-0.92
10	5.07	-0.84
15	4.65	-0.77
20	4.24	-0.7
25	3.9	-0.64
30	3.56	-0.59
35	3.22	-0.53
40	2.98	-0.49
45	2.74	-0.45
50	2.5	-0.41
55	2.3	-0.38
60	2.1	-0.39
70	1.76	-0.29
80	1.48	-0.24
90	1.24	-0.2
100	1.05	-0.17
110	0.88	-0.14
120	0.74	-0.12
130	0.62	-0.1
140	0.52	-0.08
150	0.44	-0.07
160	0.37	-0.06
170	0.31	-0.05
180	0.26	-0.04
190	0.22	-0.03
200	0.19	-0.03
210	0.16	-0.02
220	0.14	-0.02
230	0.12	-0.02
240	0.1	-0.01
250	0.08	-0.01
260	0.07	-0.01
270	0.06	-0.01
280	0.05	0

These results were then plotted into 2 graphs. Hovering over certain points of these graphs allows you to check the voltage/current and certain points.

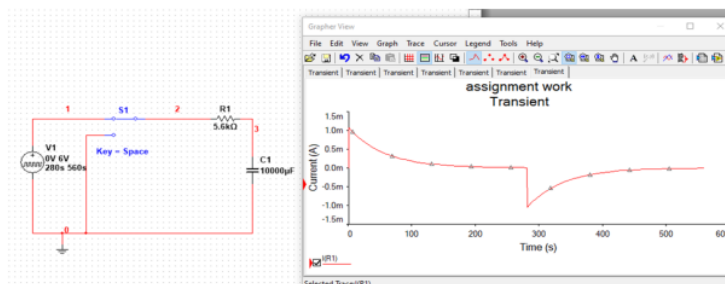


Simulated (Task 2)

Using the same circuit from figure 1, in order to get a simulated discharging circuit, the DC Power source was exchanged for a Pulse Voltage. This allows us to select the end point of the circuit voltage while giving it a time constant. Setting the times to 280 and 560 seconds will allow us to gather results after the circuit has fully hit 0.



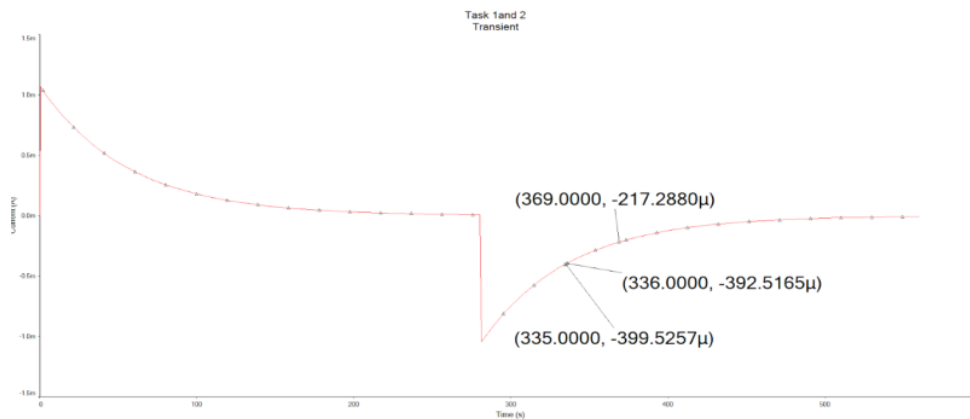
As seen from the transient graph below, the graph line dips down to negative values after 280 seconds. After this point are the results gathered to fulfil task 2 properly.



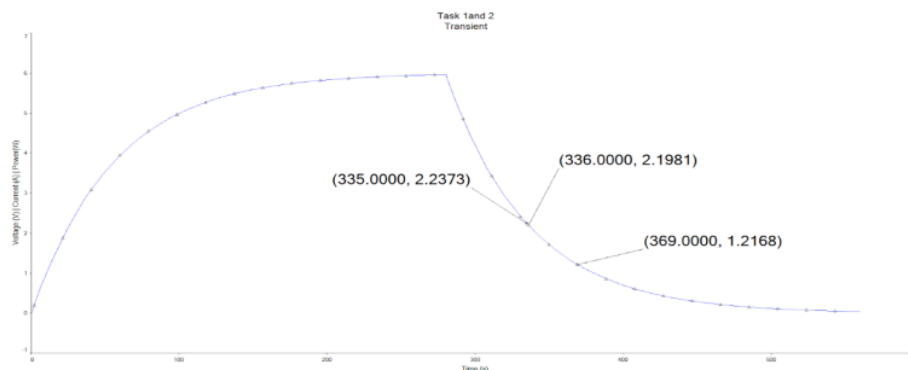
In order to gather these results, after the dip, 280 must be added to all the uniquely chosen times. The unique values chosen for task 2 are the same as those chosen in task 1, so the true values for this task will be 55 into 355, 56 into 356 and 89 into 369. Using the marker feature and setting it to these times (on the x value) will output the required values for comparison.

The transient graph below indicates the current within the discharging capacitor. Using the new unique values calculated for these sets of results should give comparable data. For some reason the current found within this

simulation is using a value lower than mA, however converting it will give the same results, much like it did for task 1.



This 2nd one shows the voltage in a discharging capacitor.



Theoretical (Task 2)

Calculations for this task are also similar to those found within task 1, with the VC equation lacking the '1 -' found within the brackets. These first equation shown below has the T and the set to the same value, 56 seconds ($\tau = RC = 5000 \times 10000 \times 10^{-6} = 56$ seconds), which has them both cancel out and equal 1.

$$VC/56 \text{ Seconds} = 6(e^{-56/56}) = 2.21 \text{ V}$$

The next 2 use the uniquely chosen values, 1 lower than the and one higher than the time constant. Even though 280 is added to these numbers within the simulated method, the theoretical method requires these unique values to be at their normal form in order to get equivalent results

$$55 \text{ Seconds} = 6(e^{-55/56}) = 2.25 \text{ V}$$

$$89 \text{ Seconds} = 6(e^{-89/56}) = 1.22 \text{ V}$$

The I_{max} for this task should be the same found within task 1.

$$I_{\text{max}} = 6/5600 = 1.07 \text{ mA}$$

Unlike the equation found within task 1, I_{max} here is made negative in order to simulate the dropping current found within a discharging capacitor. These results should mirror those found within task 1.

$$I_c = -I_{\text{max}} (e^{-t/\tau})$$

$$56 \text{ Seconds} = -1.07 \times 10^{-3} (e^{-56/56}) = -0.394 \text{ mA}$$

$$55 \text{ Seconds} = -1.07 \times 10^{-3} (e^{-55/56}) = -0.4 \text{ mA}$$

$$89 \text{ Seconds} = -1.07 \times 10^{-3} (e^{-89/56}) = -0.218 \text{ mA}$$

Table of Results (Task 2)

Voltage

Time	Calculated	Practical	Simulated
55	2.25 V	2.3 V	2.2373 V
56	2.21 V	2.3 V	2.1981 V
89	1.22 V	1.24 V	1.2168 V

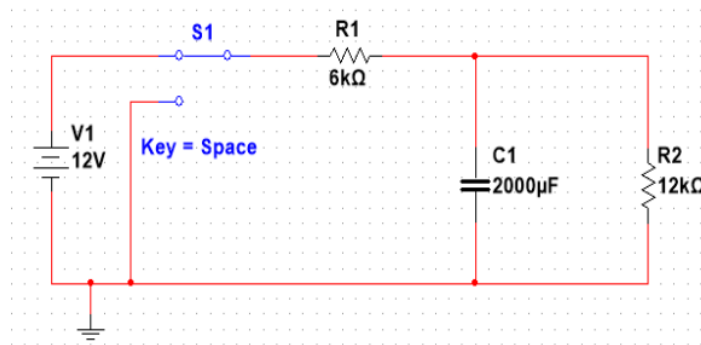
Current

Time	Calculated	Practical	Simulated
55	-0.4 mA	-0.39 mA	-0.3995 mA
56	-0.394 mA	-0.39 mA	-0.3925 mA
89	-0.218 mA	-0.2 mA	-0.2172 mA

Task 3

The figure 2 circuit given for the 3rd task makes the time constant quite difficult to obtain due to multiple time constants existing for the circuit. Because of this we will be required to simplify the circuit meaning new values must be obtained through calculations before the simulated method is able to be produced using multisim.

(figure 2 circuit)



Theoretical (Task 3)

Due to the resistors being connected in parallel, the potential divider rule is applied by treating the 12 V as the V_{in} .

$$V = (R_2(R_1+R_2)) V_{in}$$

$$(12 / (6+12))12 = 8 \text{ V}$$

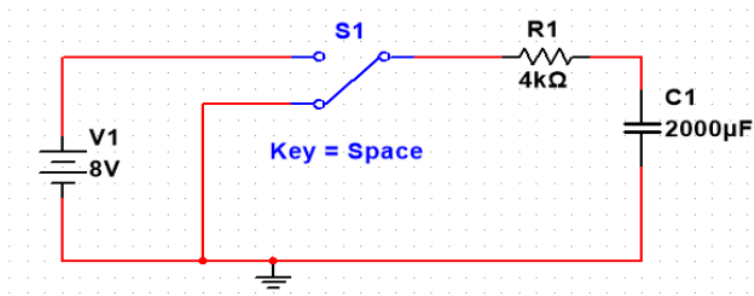
This newfound voltage will be placed in the simplified version of the complex circuit replacing the 12 V.

In order to work out the total resistance of the circuit, the product over sum rule is used. This is due to both resistors being connected in parallel with the 2nd resistor being in parallel with the capacitor.

$$R_T = (R_1 \times R_2) / (R_1 + R_2)$$

$$(6 \times 12) / (6 + 12) = 4k$$

Inserting both of these new calculated values into a new simpler circuit allows the time constant to be more easily produced.



Treating these newly obtained values as if they were the original circuit now allows the current to be more easily deduced using ohm's law.

$$I = V/RT$$

$$8/4000 = 2\text{mA}$$

Times-ing the original capacitance value by the simplified resistor value finally allows the time constant to be properly calculated.

$$= RT \times C$$

$$4000 \times 2000 \times 10^{-3} = 8 \text{ Seconds}$$

$$5\tau = 8 \times 5 = 40 \text{ Seconds}$$

Charging Voltage

Task 3 tosses out all use of unique values which only gives 1 result for every equation.

$$VC = V (1 - e^{-t/\tau})$$

$$8(1 - e^{-8/8}) = 5.057 \text{ V}$$

Charging Current

The charging current equation is taken from task 1.

$$I_{\text{max}} (e^{-t/\tau})$$

$$2 \times 10^{-3} (e^{-8/8}) = 0.736 \text{ mA}$$

Discharging Voltage

$$VC = V (e^{-t/\tau})$$

$$8(e^{-8/8}) = 2.943 \text{ V}$$

Discharging Current

$$- I_{\max} (e^{-t/\tau})$$

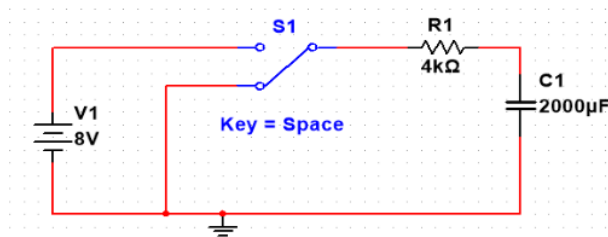
$$- 2 \times 10^{-3} (e^{-8/8}) = - 0.736 \text{ mA}$$

Simulated (Task 3)

The simulated section of this task uses the values calculated in the theoretical section in order to re-create a simplified version of the figure 2 circuit. This means that the supply will be 8 V with the only resistor connected being 4k.

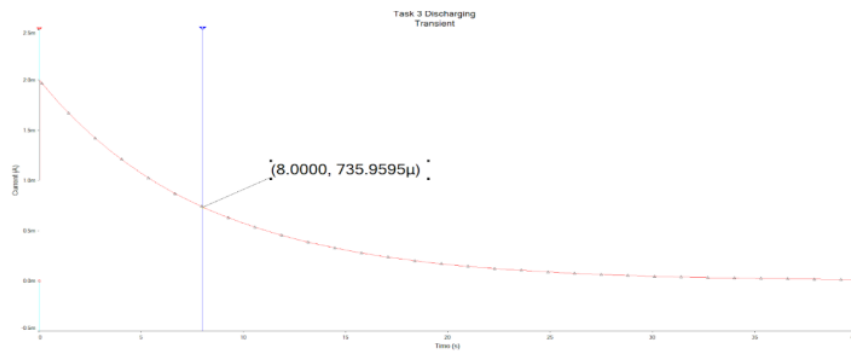
Charging

For the charging results to be obtained the supply must be DC voltages with the transient end time being 40 seconds.



Using this circuit in multisim will allow us to create charging transient graphs.

The transient graph below shows the current within the circuit while it's in its charging state. Once again, the current obtained for this task is in a unit 3 x lower, meaning it has to be converted up, however when converted they equal the exact same value.



discharging

For the discharging side of this task the DC power supply is exchanged with a pulse voltage with the pulse width being set to 8 second and the period set to 40 seconds.

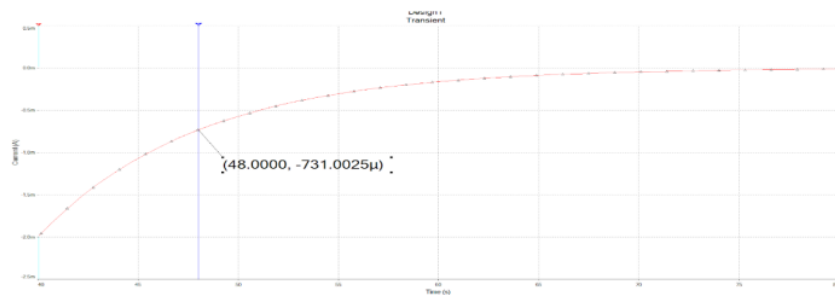
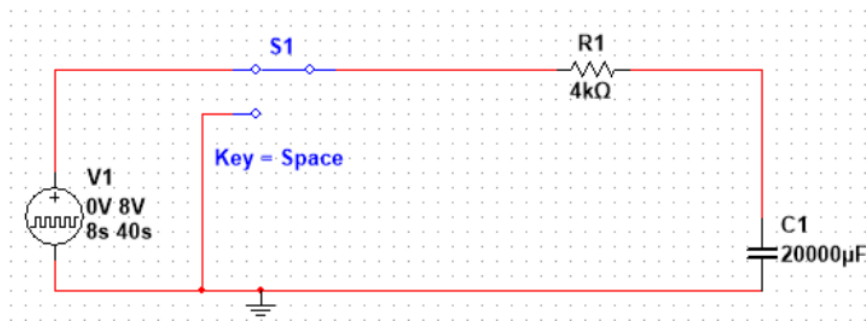


Table of Results (Task 3)

	Simulated	Theoretical
Charging Current	0.735959 mA	0.736 mA

Discharging Current	- 0.731 mA	- 0.736 mA
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Task 4

This task requires multiple operations to be carried out using an inductive circuit. These operations include testing after 1 second of the circuit being completed, using equations to create a comparable graph, finding current before a switch, calculating the time constant and using 2 set values to gain more comparable results.

Theoretical/practical (Task 4)

Using equations in order to recreate a practical set of results, we are able to calculate the current 1 second after a voltage source is connected as if the switch has been turned from B state to A. Below is the current recorded every 0.05 seconds up to 1 total second (Using excel/sheets in order to use the equation feature in order to gauge every time picked. This is due to the time constant being 0.2 seconds, and 5τ being 1 second.

Equation below shows how the time constant was calculated.

$$\tau = L/R$$

$$3/15 = 0.2 \text{ Seconds}$$

$$5\tau$$

$$5\tau = 5 \times 0.2 = 1 \text{ Second}$$

$I_{\max}$ is calculated in order to work out the current within the inductor/capacitor.

$$\text{Work out } I_{\max} = V/R$$

$$12/15 = 0.8 \text{ A}$$

$$I_C = I_{\max} (e^{-t/\tau})$$

$$0.8(e^{-0.2/0.2}) = 0.2943 \text{ mA}$$

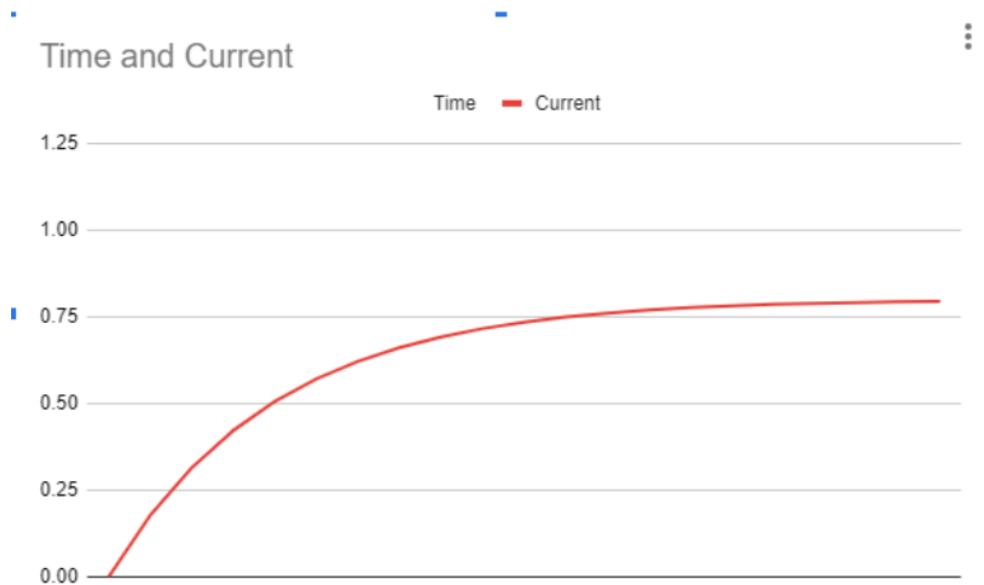
The equation feature used below was completed using these instructions.

$$0.8*(1-EXP(-B87/0.2))$$

B87 is the time found on each row. (e.g. 0.1769 has a B of 0.05.)

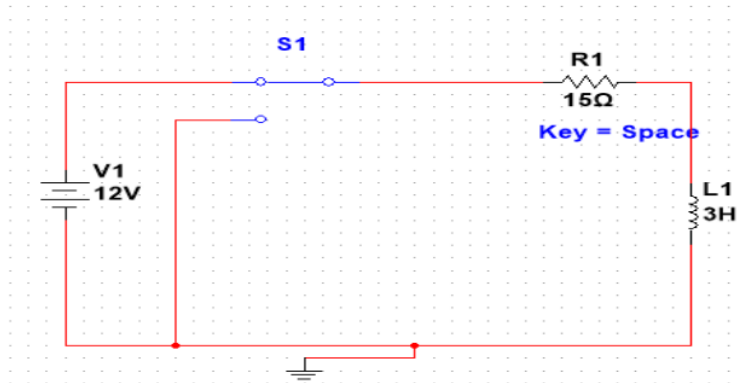
Time	Current
0	0
0.05	0.1769593735
0.1	0.3147754722
0.15	0.4221067578
0.2	0.5056964471
0.25	0.5707961625
0.3	0.6214958719
0.35	0.6609808452
0.4	0.6917317734
0.45	0.7156806204
0.5	0.7343320011
0.55	0.748857711
0.6	0.7601703453
0.65	0.7689806337
0.7	0.7758420933
0.75	0.7811858033
0.8	0.7853474889
0.85	0.7885886129
0.9	0.7911128028
0.95	0.7930786438
1	0.7946096424

The graph found below are these sets of results put into a comparable format after the simulated, multisim side, results are achieved. Using the time constant (0.632) gives the answer of 0.5056 A

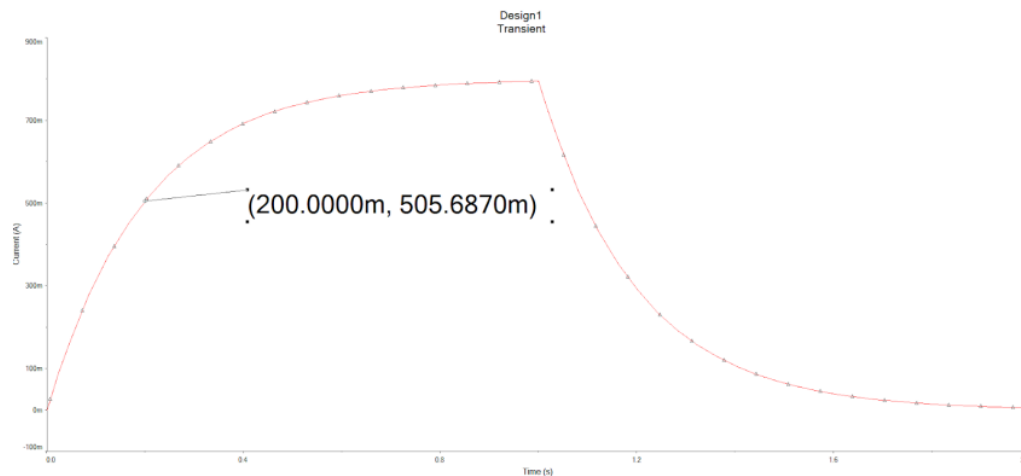


Simulated (Task 4)

The circuit below is listed as figure 3 within the assignment document.

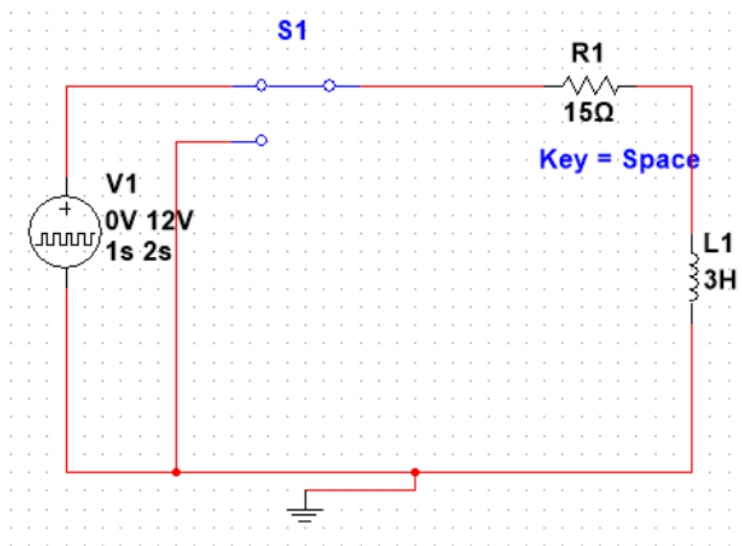


This transient graph has a labelled result from the section where the circuit switch is turned on and the effect it has for the first second.



Changing DC power to voltage pulse allows us to get a falling current voltage between 2 sections.

Set the pulse width to 1 second (due to 5τ) and the period to 2 seconds (double 5τ to get the results needed).



Graph below shows the current flowing 0.2 seconds (1 added due to it being in discharge, $5\tau = 1.$)

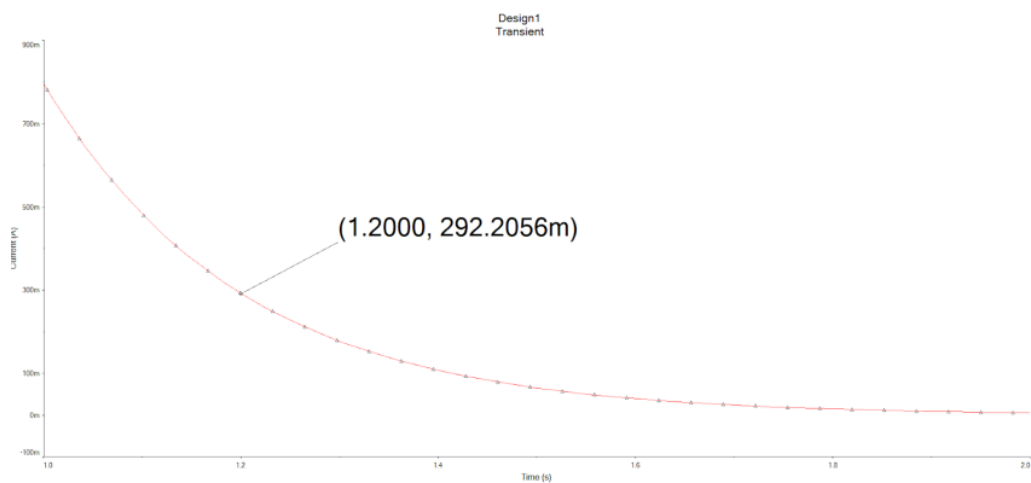


Table of Results (Task 4 part 1 - 2)

1 Second after the switch is turned on.

Time (Seconds)	Simulated	Practical
0.2	0.5056870 mA	0.5056964471 mA

Comparing this version of the transient graph with the one found in the simulation, it is clear that this version, using equations, is more accurate than that of the multisim variant. This is almost entirely due to the decimal place limit found on the multisim section whereas the equation function will go to the 10th decimal place. For example, using the theoretical results, 0.2 seconds on sheets was 0.5056964471 whereas the multisim value was 0.505687.

Theoretical (Task 4 Part 5)

In order to calculate the elapsed time before the current hits the 2 designated points, the equation used throughout the theoretical calculation for current must be manipulated in order to make the output time. Below shows the method taken.

For 100 mA

$$I_C = I_{\max}(e^{-t/\tau})$$

$$0.1 = 0.8(e^{-t/0.2})$$

$$0.1/0.8 = e^{-t/0.2}$$

In order to bring e (exp) over to the other side, it must be changed to an ln.

$$\ln(0.1/0.8) = -t/0.2$$

$$\text{Therefore } t = -0.2 \ln(0.1/0.8)$$

$$0.2 \ln(0.125) = 0.416 \text{ Seconds}$$

This should be the time recorded before it hits 100mA.

The same thing is repeated for 10mA.

For 10 mA

$$0.01 = 0.8(e^{-t/0.2})$$

$$0.01/0.8 = e^{-t/0.2}$$

$$\ln(0.01/0.8) = -t/0.2$$

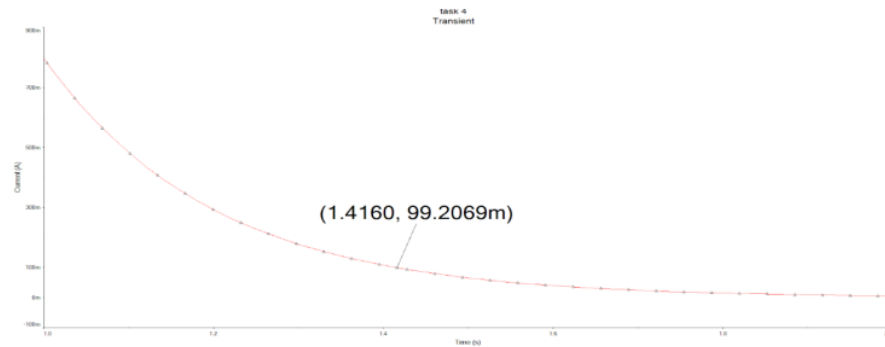
$$T = 0.2 \ln(0.01/0.8) =$$

$$-0.2 \ln(0.125) = 0.879 \text{ Seconds}$$

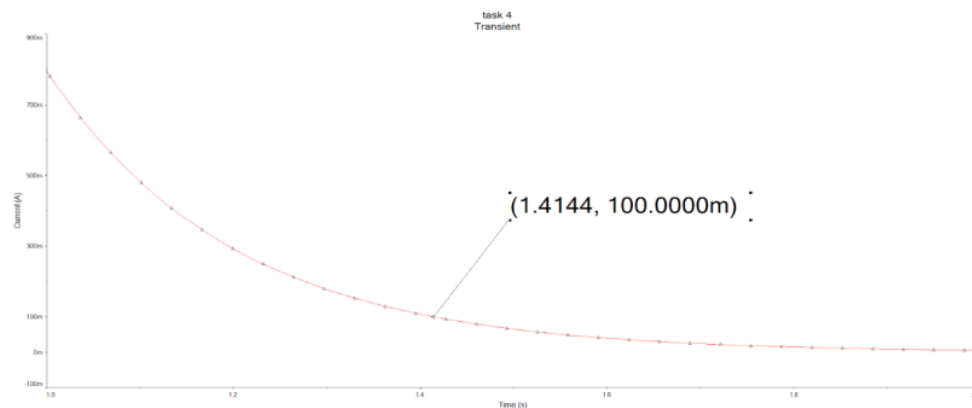
Simulated (Task 4 Part 5)

100mA

Setting the X value to the value output for 100mA, 0.416 (add 1 due to it being in discharge and needing the stop time to be added in order to get those same results), outputs this graph.

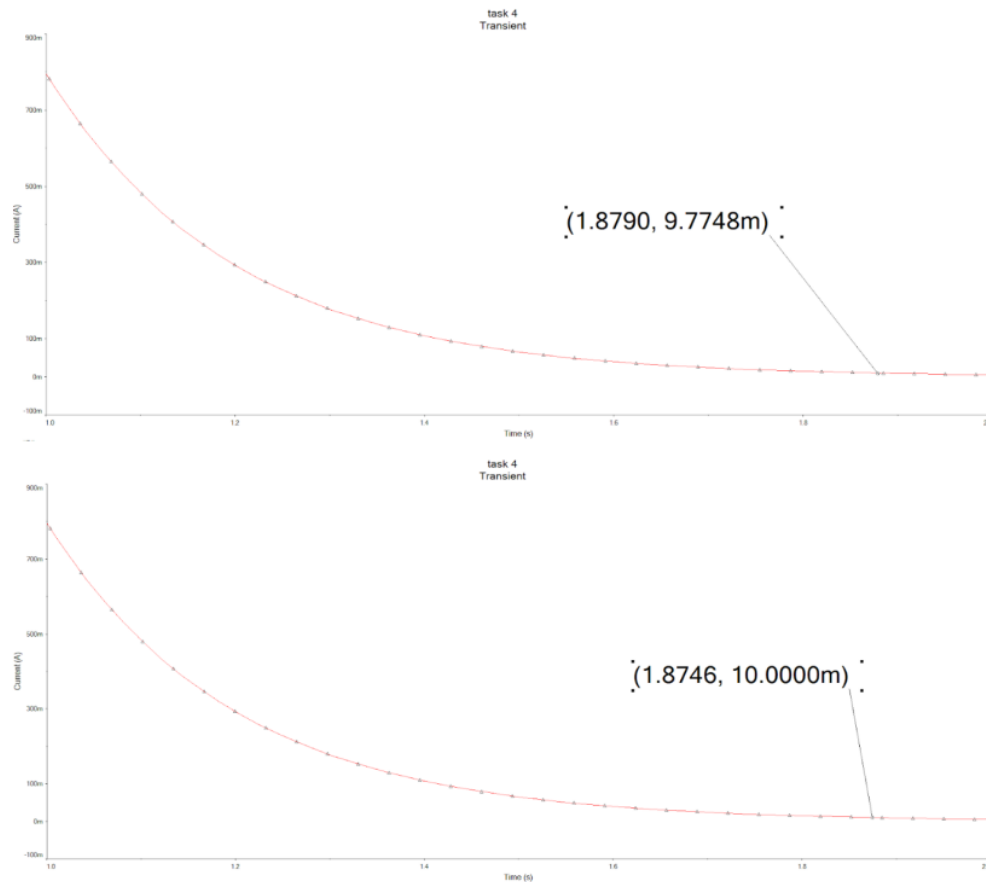


However, by setting the Y value on the multisim graphs to 100 due to the Y scale being current, the outputted results are able to be much more accurate than those gathered with the formulas.



10mA

Repeating this for the 10mA part grants the same view as the 100mA section.



Overall, comparing the simulated results with the theoretical results makes it clear that the simulated versions are able to be much more accurate due to the ability to choose the exact point required through its graph marker feature.

Table of Results (Task 4 Part 5)

Current	Simulated (Seconds)	Theoretical (Seconds)
10mA	0.4144	0.416
100mA	0.8746	0.879

Conclusion

To start off, this conclusion will be comparing all the methods used throughout this assignment while using results gathered from all 4 tasks to provide proof to which one of these types of methods is more accurate and the potential errors picked up.

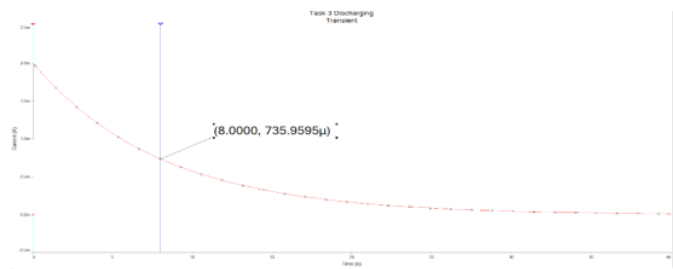
Calculated	Practical	Simulated
3.79V	3.82	3.7518V
3.79V	3.82	3.7921V
4.78V	4.85	4.7756V

Using the 1st tasks set of results we are able to see an easy pattern. The practical side of this task visibly has a higher set of results than the others. This may be due to outside factors affecting the components, such as temperatures, fluctuations and potentially human errors. However, the results aren't too different to cause too many issues, it's just the case that the other 2 methods gained closer results.

The theoretical side of the example pulled (listed as calculated on the results table) has the closest results to the simulated side of things and actually has traceable reasons as to why the numbers are slightly different from that of the practical and simulated sometimes. One part of this is simply because it's not actually using a circuit but using calculations to attempt to simulate/pretend there is a circuit there, which can possibly leave out some situations where the values will differ.

The simulated side of the results easily has the most detailed set of results. This is due to these values being at a higher decimal place than that of the other results. Knowing this, these results can also potentially be argued as the most accurate version of the task. This is due to multisim trying to be as closed as possible to the practical side of circuits without an issue of environmental, procedural or human type errors. However, this is also potentially the most finicky way to do this especially if you haven't attempted the software before. For example, the unit that the original results were output seemingly isn't able to be changed to a preference.

(e.g. other results are put into mA while these results are output as a different lower unit.)



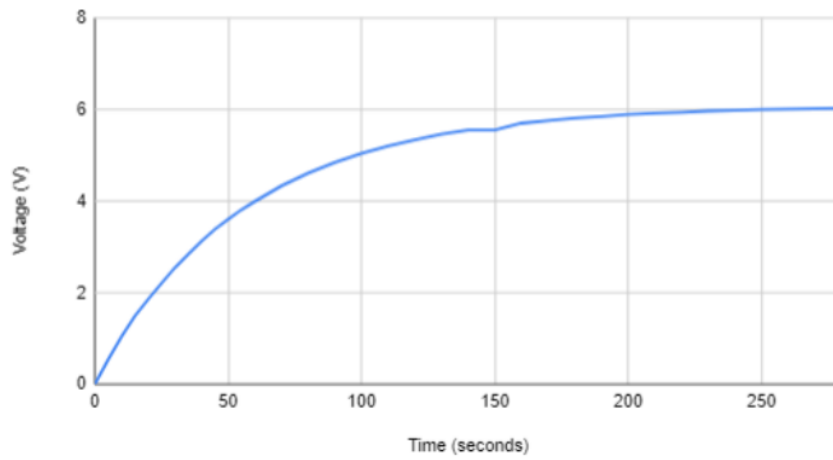
Simulated	Theoretical
0.735959 mA	0.736 mA

Appendix

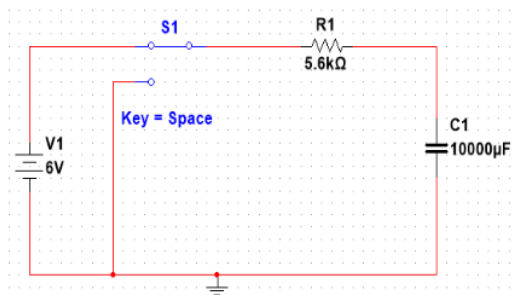
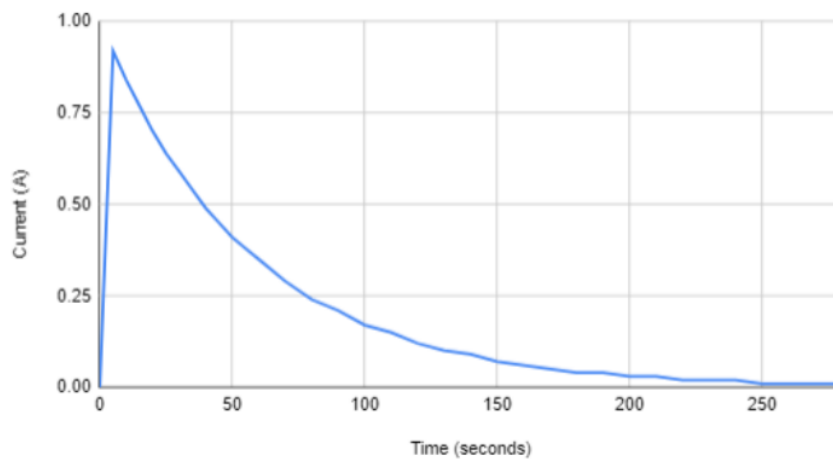
Task 1:

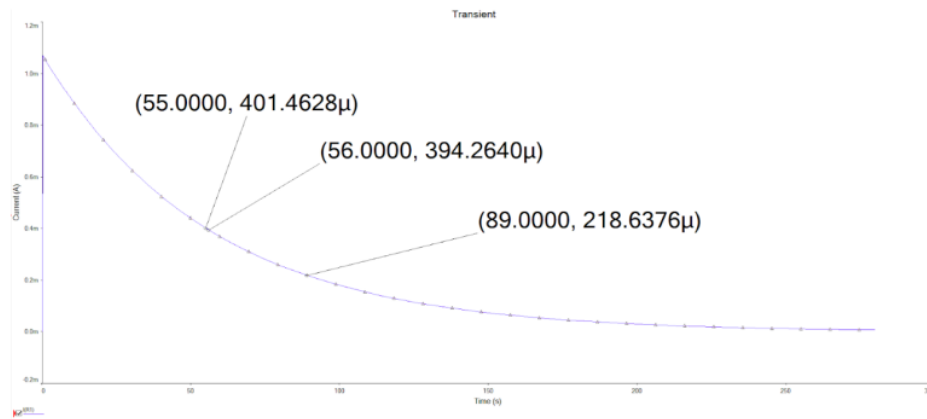
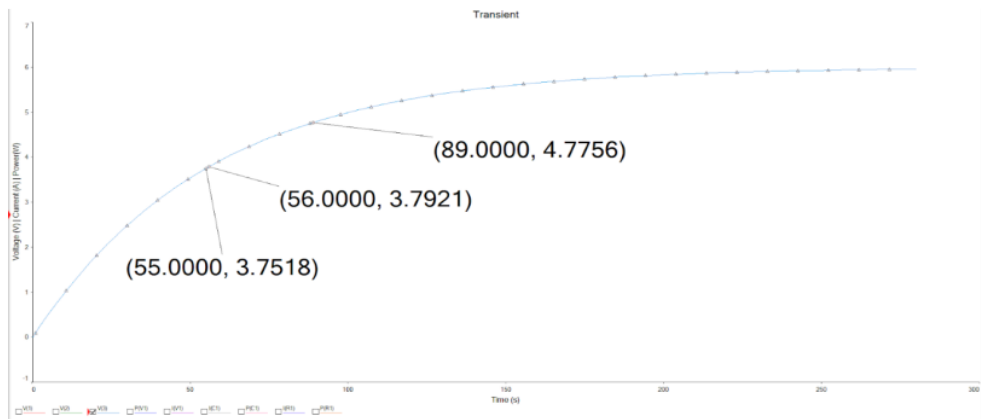
Time (seconds)	Voltage (V)	Current (A)
0	0	0
5	0.54	0.92
10	1.04	0.84
15	1.49	0.77
20	1.86	0.7
25	2.21	0.64
30	2.55	0.59
35	2.84	0.54
40	3.13	0.49
45	3.39	0.45
50	3.61	0.41
55	3.82	0.38
60	4	0.35
70	4.34	0.29
80	4.62	0.24
90	4.85	0.21
100	5.05	0.17
110	5.21	0.15
120	5.35	0.12
130	5.47	0.1
140	5.56	0.09
150	5.56	0.07
160	5.71	0.06
170	5.77	0.05
180	5.82	0.04
190	5.86	0.04
200	5.9	0.03
210	5.93	0.03
220	5.95	0.02
230	5.98	0.02
240	5.99	0.02
250	6.01	0.01
260	6.02	0.01
270	6.03	0.01
280	6.04	0.01

Voltage (V) vs Time (seconds)



Current (A) vs Time (seconds)





Voltage

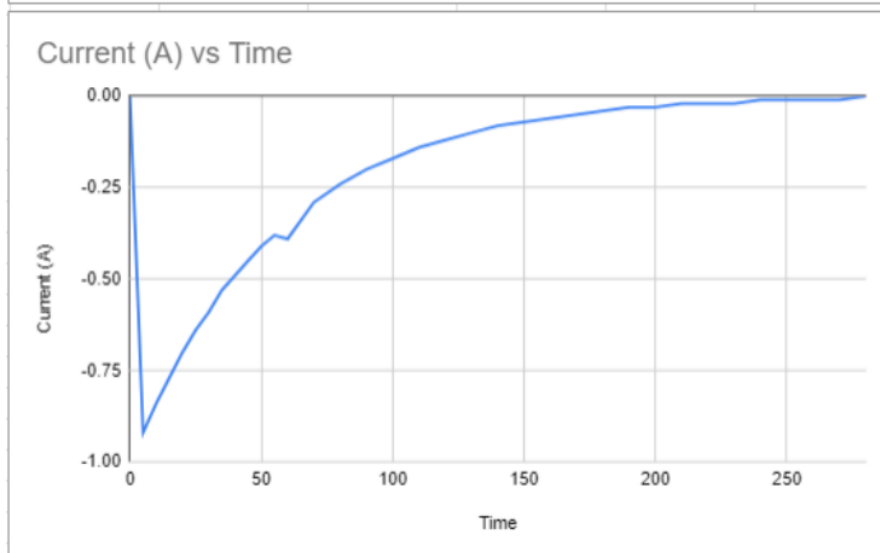
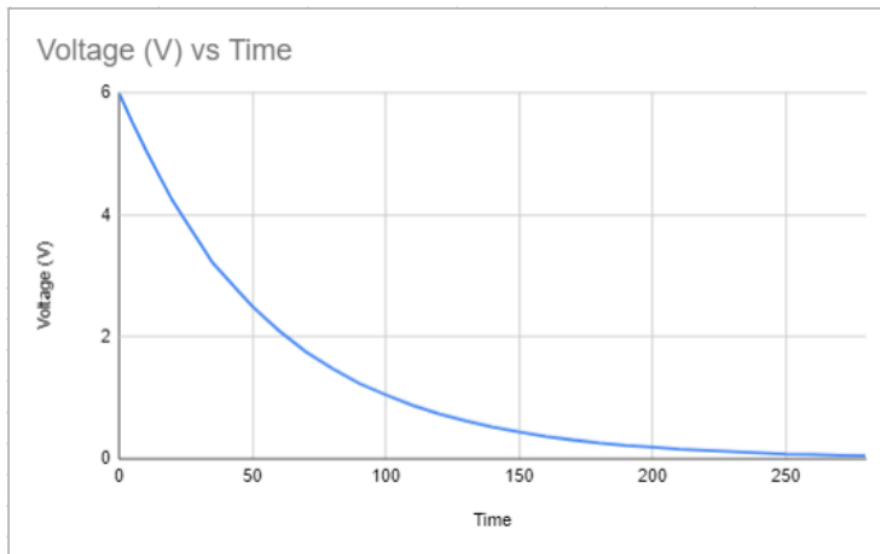
Time	Calculated	Practical	Simulated
55	3.79V	3.82	3.7518V
56	3.79V	3.82	3.7921V
89	4.78V	4.85	4.7756V

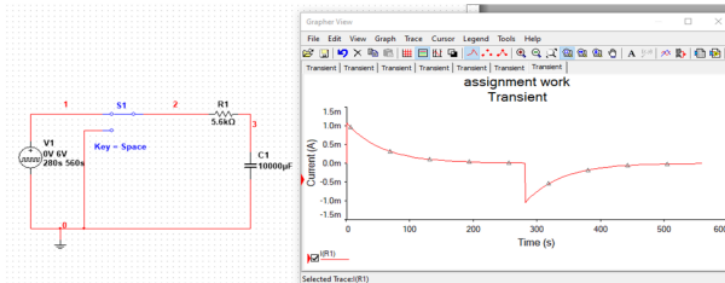
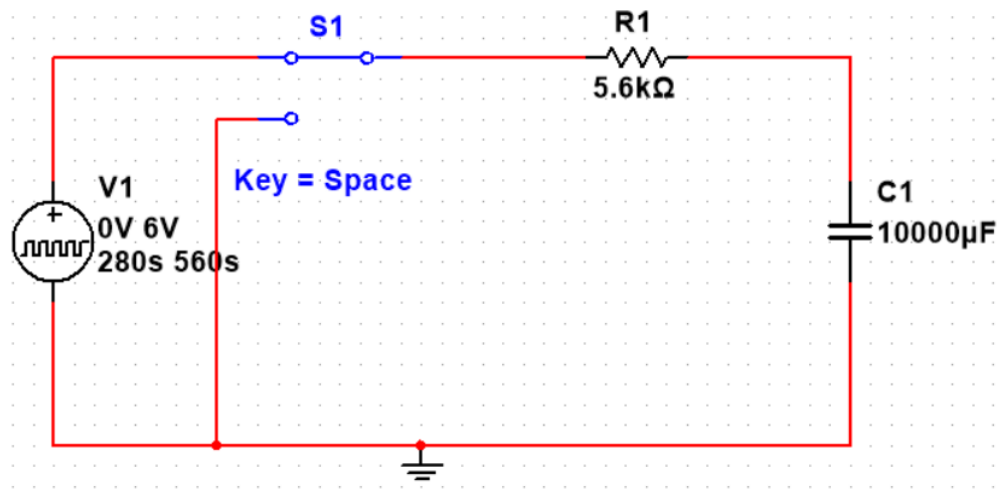
Current

Time	Calculated	Practical	Simulated
55	0.4mA	0.38mA	0.4014mA
56	0.394mA	0.38mA	0.3942mA
89	0.218mA	0.21mA	0.2186mA

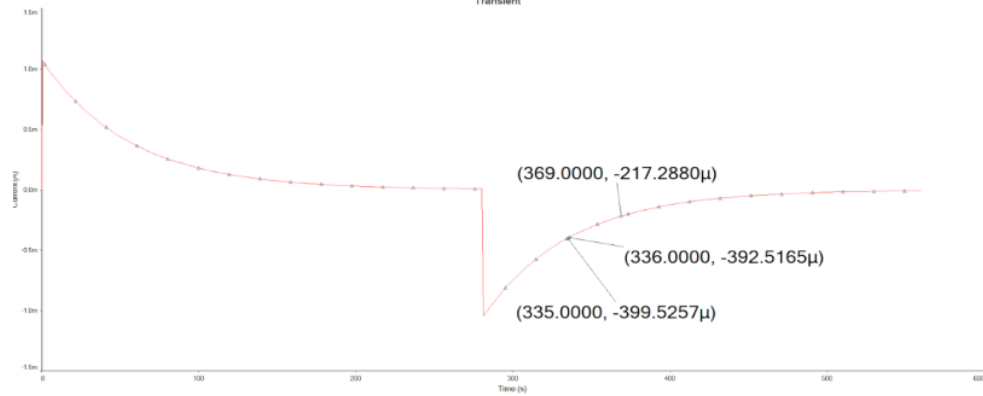
Task 2:

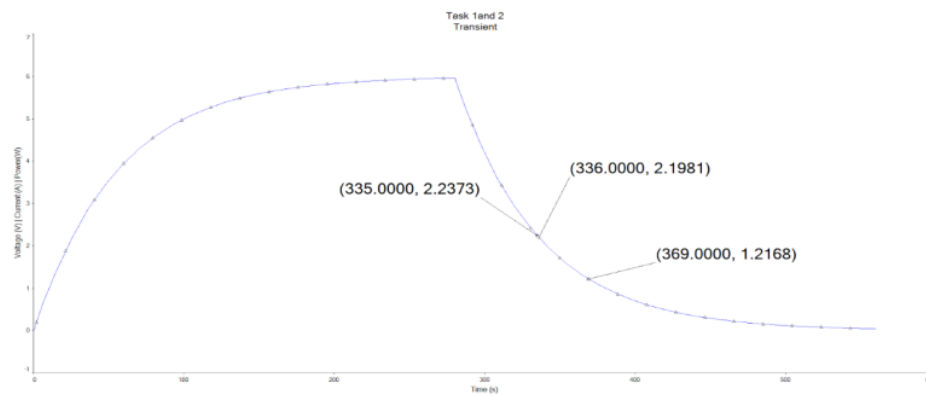
Time	Voltage (V)	Current (A)
0	6	0
5	5.52	-0.92
10	5.07	-0.84
15	4.65	-0.77
20	4.24	-0.7
25	3.9	-0.64
30	3.56	-0.59
35	3.22	-0.53
40	2.98	-0.49
45	2.74	-0.45
50	2.5	-0.41
55	2.3	-0.38
60	2.1	-0.39
70	1.76	-0.29
80	1.48	-0.24
90	1.24	-0.2
100	1.05	-0.17
110	0.88	-0.14
120	0.74	-0.12
130	0.62	-0.1
140	0.52	-0.08
150	0.44	-0.07
160	0.37	-0.06
170	0.31	-0.05
180	0.26	-0.04
190	0.22	-0.03
200	0.19	-0.03
210	0.16	-0.02
220	0.14	-0.02
230	0.12	-0.02
240	0.1	-0.01
250	0.08	-0.01
260	0.07	-0.01
270	0.06	-0.01
280	0.05	0





Task 1 and 2
Transient





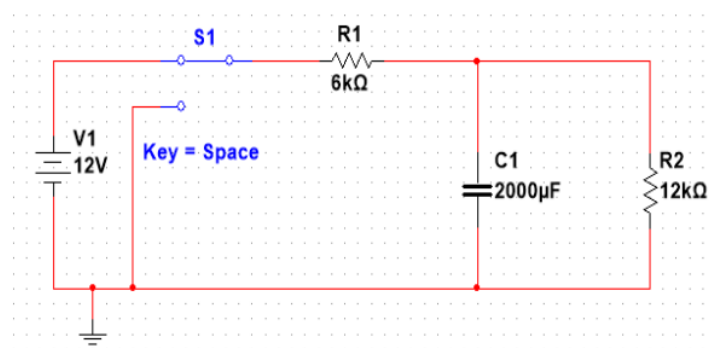
Voltage

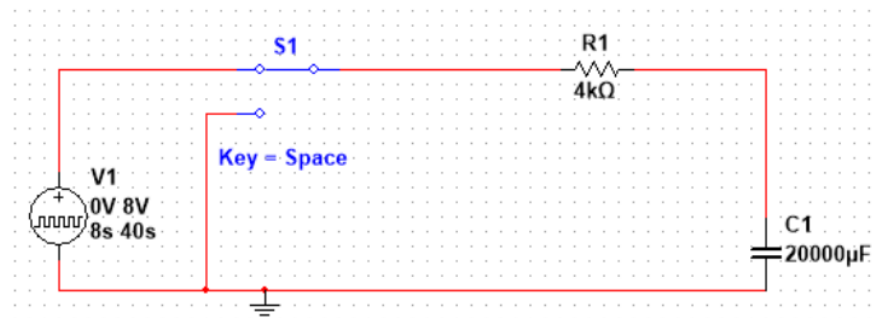
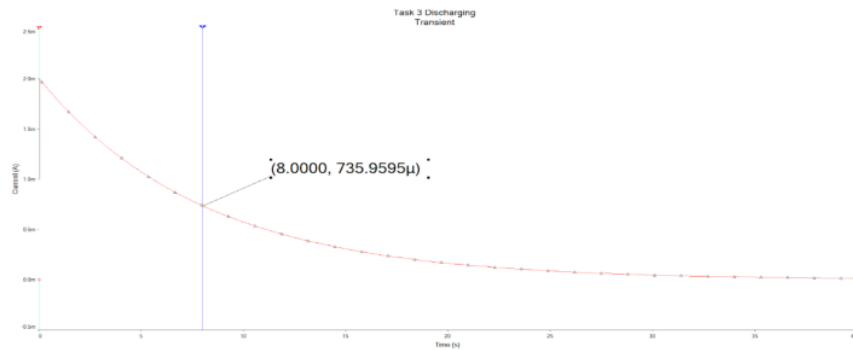
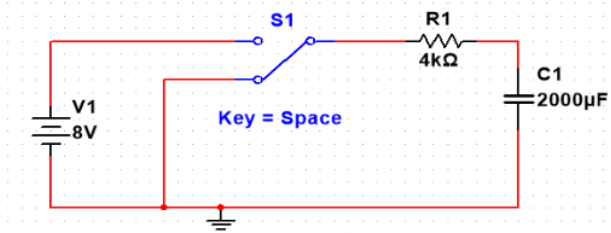
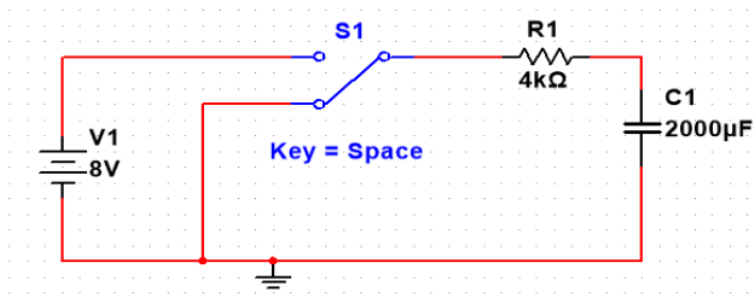
Time	Calculated	Practical	Simulated
55	2.25 V	2.3 V	2.2373 V
56	2.21 V	2.3 V	2.1981 V
89	1.22 V	1.24 V	1.2168 V

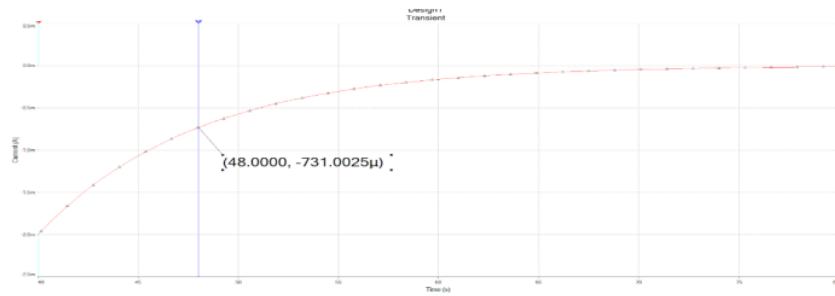
Current

Time	Calculated	Practical	Simulated
55	-0.4 mA	-0.39 mA	-0.3995 mA
56	-0.394 mA	-0.39 mA	-0.3925 mA
89	-0.218 mA	-0.2 mA	-0.2172 mA

Task 3:





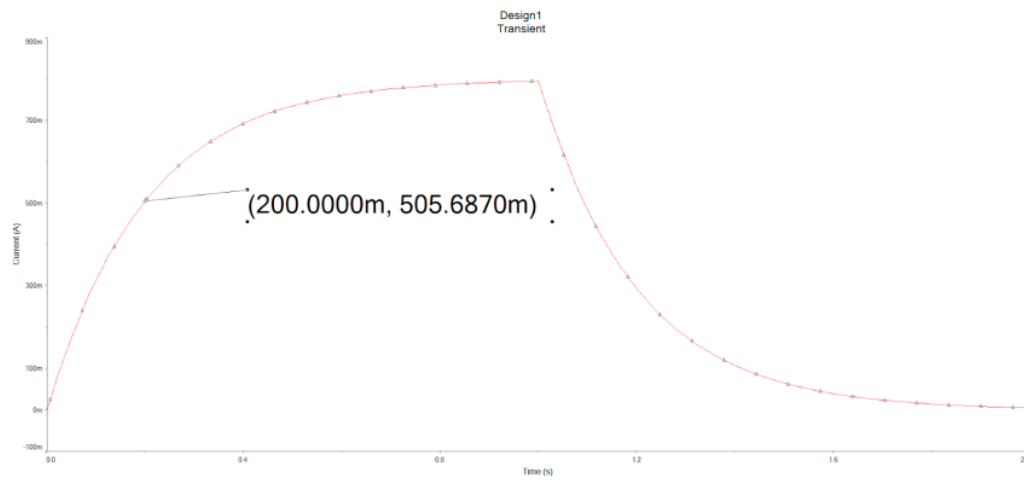
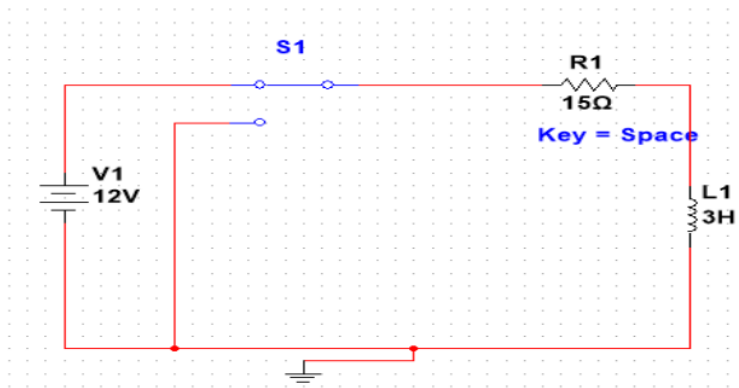
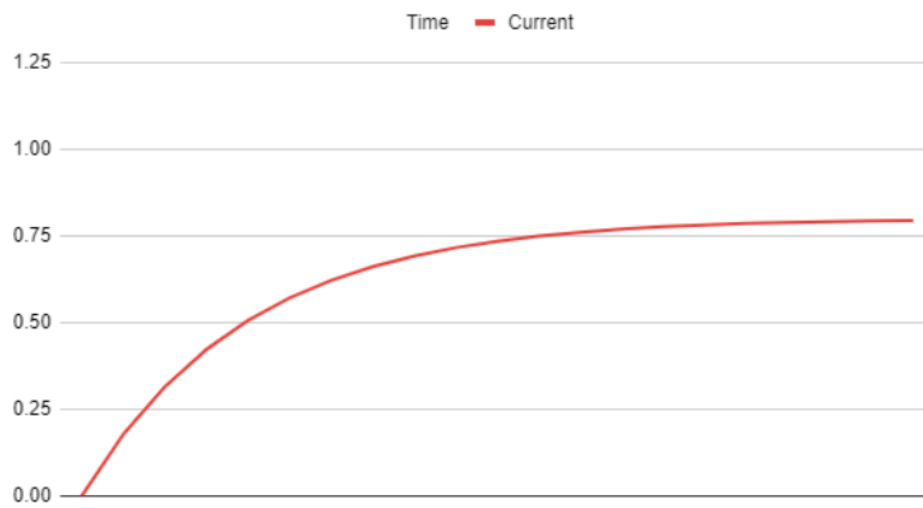


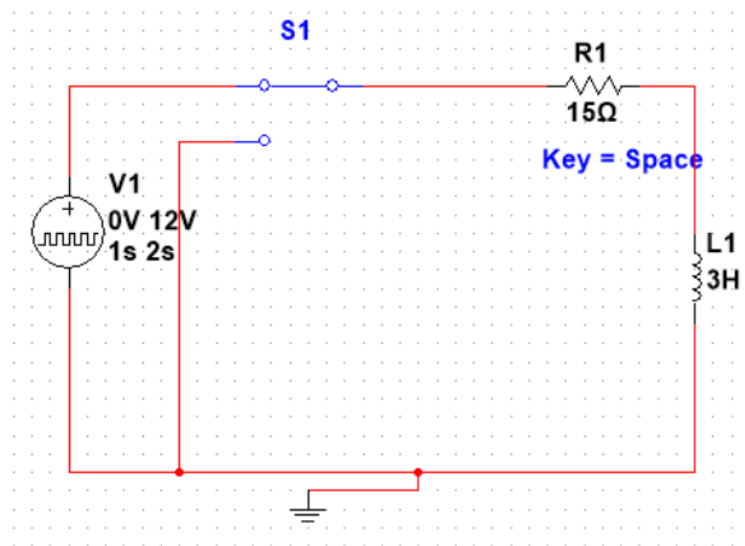
	Simulated	Theoretical
Charging Current	0.735959 mA	0.736 mA
Discharging Current	- 0.731 mA	- 0.736 mA

Task 4:

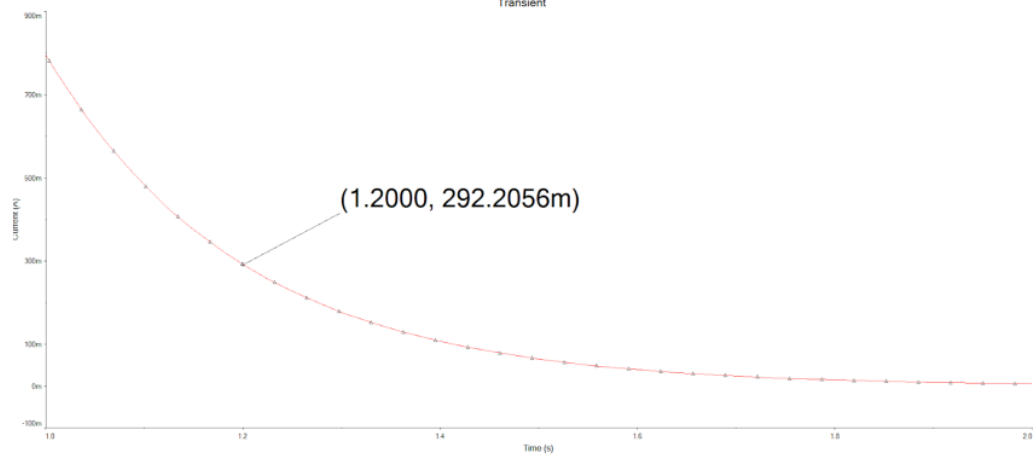
Time	Current
0	0
0.05	0.1769593735
0.1	0.3147754722
0.15	0.4221067578
0.2	0.5056964471
0.25	0.5707961625
0.3	0.6214958719
0.35	0.6609808452
0.4	0.6917317734
0.45	0.7156806204
0.5	0.7343320011
0.55	0.748857711
0.6	0.7601703453
0.65	0.7689806337
0.7	0.7758420933
0.75	0.7811858033
0.8	0.7853474889
0.85	0.7885886129
0.9	0.7911128028
0.95	0.7930786438
1	0.7946096424

Time and Current

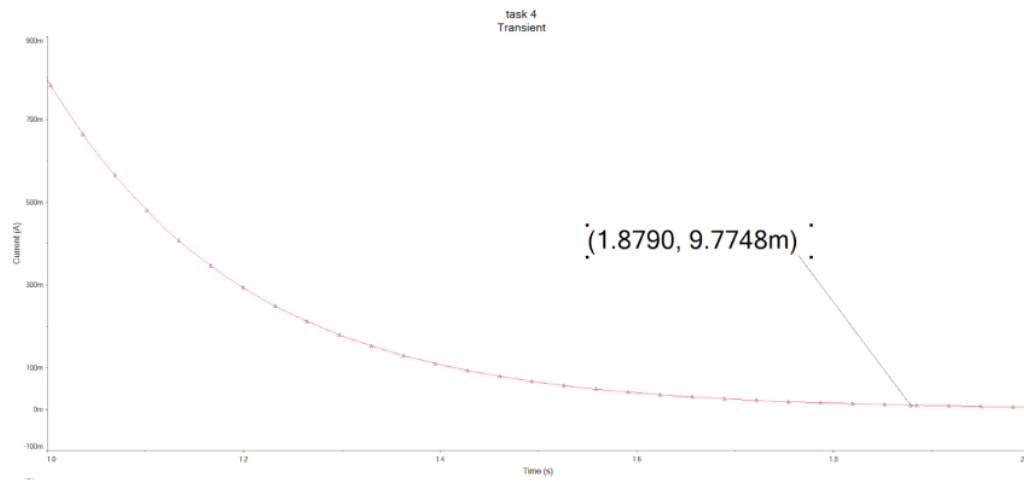
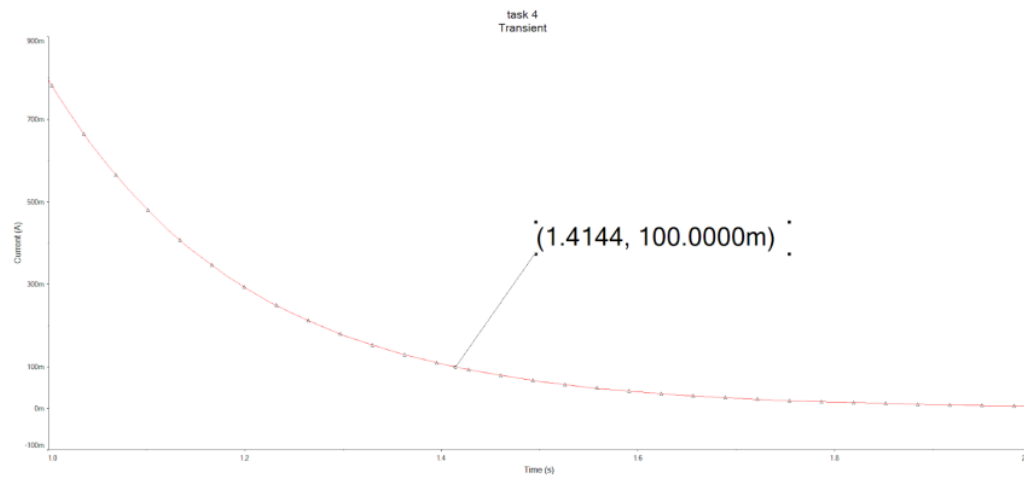
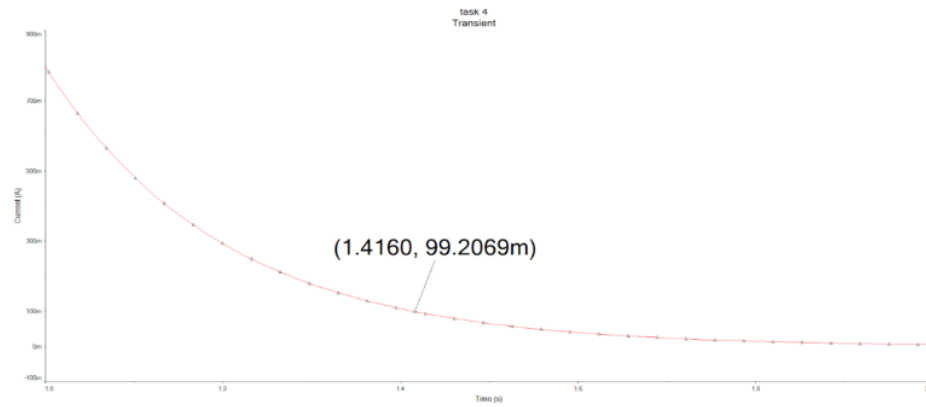


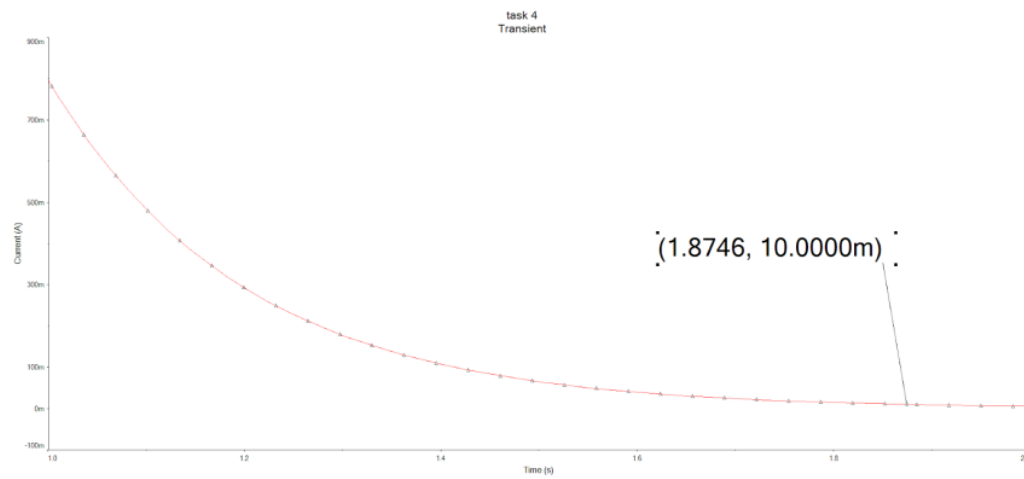


Design1
Transient



Time (Seconds)	Simulated	Practical
0.2	0.5056870 mA	0.5056964471 mA





Current	Simulated (Seconds)	Theoretical (Seconds)
10mA	0.4144	0.416
100mA	0.8746	0.879