

1451789

by Joshua Williams

FILE	17594_JOSHUA_WILLIAMS_1451789_175211_2093451397.PDF (1.23M)		
TIME SUBMITTED	13-JAN-2020 12:36PM (UTC+0000)	WORD COUNT	2680
SUBMISSION ID	118151769	CHARACTER COUNT	16078

Course: HNC Electrical and Electronic Engineering

Module: SGEE4000 – Electrical and Electronic Principles

Assignment Title: Investigation into DC Transients

Name: Joshua Williams

University Number: 1451789

Date Submitted: 13/01/2020

Word Count: 1511

Contents

Table of Figures.....	3
Executive Summary.....	3
Task 1	4
Transient behaviour for the charging of a capacitor	4
Calculations.....	4
Practical results for the Charge.....	8
Practical Results Charge.....	10
Table of Results – Task 1	11
Task 2	11
Transient behaviour for the discharging of a capacitor.....	11
Discharge Calculations	11
Practical results for the Discharge:	12
Practical Results for the Discharge Current:	13
Practical Results for the Discharge Voltage	13
Graphical results of the Voltage Discharge:.....	15
Current Discharge	16
Table of Results – Task 2.....	17
Task 3	17
Complex RC Circuit.....	17
Calculations.....	17
The Discharge Conditions	20
The Charge Conditions	21
Task 4	22
Transient behaviour for the Inductive Circuit.....	22
Calculations.....	24
The calculations below are for the 100mA value	24
The calculations below are for the 10mA value	24
Exponential Curve calculations	25
Manual Plot (Current)	28
Conclusions and Recommendations	30
References	30

Table of Figures

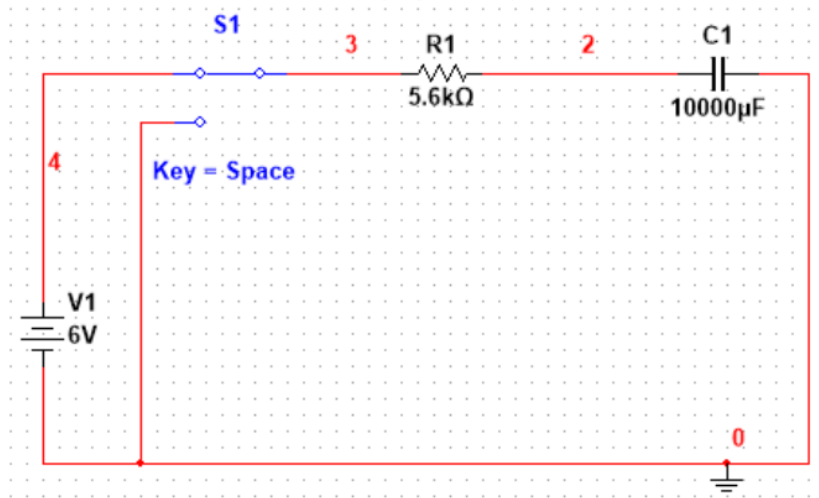
Figure 1 Three random values for the charge.....	6
Figure 2 Three random time values for the discharge.....	7
Figure 3 Charge current	10
Figure 4 Charge voltage	10
Figure 5 Discharge Current	13
Figure 6 Discharge Voltage	13
Figure 7 showing the voltage discharge from the calculated values.....	15
Figure 8 showing the results for the current discharge.....	16
Figure 9 Discharge conditions	20
Figure 10 Charge conditions	21
Figure 11 After the first one second	23
Figure 12 Graph showing the 100mA and 10mA.....	26
Figure 13 Expediential Curve	27
Figure 14 The five-time constants	29

Executive Summary

This report follows investigations into the different methods of testing the R-L and R-C circuits. Each task has the appropriate formulae for carrying out each of the calculations. Each method was then compared and discussed for discrepancies. The investigations were conducted under a few conditions; this is through a direct current voltage source, through intense simulations, practical constructions and each circuit was tested through theoretical calculations and predictions. Each circuit is assigned with a task number with the relevant calculations and simulated graphs these were conducted through the multi-sim package. Throughout the report is a discussion into each investigation and analysis which was conducted for each of the tasks. All theory was mostly researched, one source was used which was the book Electrical and electronic principles and technology. It played a vital part in completing the tasks as the formulae was clear visible. Circuit 2 shows clear use of the theory and this regards to (τ) but all circuits requires a time constant. Once all the tasks were investigated, the report concludes with a summary of what was found in each task and the recommendations for the circuits that were tested and analysed.

Task 1

Transient behaviour for the charging of a capacitor



Calculations

Worked out the time constant through the capacitor value and the resistor value.

$$\text{Time constant} = \tau = C \times R = (10,000 \times 10^{-6}) \times (5.6 \times 10^3) = 56s$$

Calculated the voltage divided by the resistor value this will then give me the value for the max current.

$$\text{Max Current } I_{\max} = \frac{V}{R} = \frac{6}{5.6 \times 10^3} = 1.07mA$$

In the brief three random time values had to be chosen, the voltage and current are then calculated to give:

Voltage across the capacitor after 20, 45, 120 seconds

$$V_c = V_{\max} (1 - e^{-\frac{t}{\tau}})$$

$$\text{20 Seconds} = 6 (1 - e^{-\frac{20}{56}}) = 1.80V$$

$$\text{45 Seconds} = 6 (1 - e^{-\frac{45}{56}}) = 3.31V$$

$$\text{120 Seconds} = 6 (1 - e^{-\frac{120}{56}}) = 5.30V$$

Current flowing after 20, 45, 120 seconds

$$= I_{max} \times e^{-\frac{t}{\tau}}$$

$$= (1.07mA \times 10^{-3}) \times \left(e^{-\frac{20}{56}}\right) = 0.75mA$$

$$= (1.07mA \times 10^{-3}) \times \left(e^{-\frac{45}{56}}\right) = 0.48mA$$

$$= (1.07mA \times 10^{-3}) \times \left(e^{-\frac{120}{56}}\right) = 0.126mA$$

These exponential equations will then be compared to the graphical values that are shown in figure 1. Figure 2 shows the values from the discharge state.

The three random time values:

- 20 Seconds
- 45 Seconds
- 120 Seconds

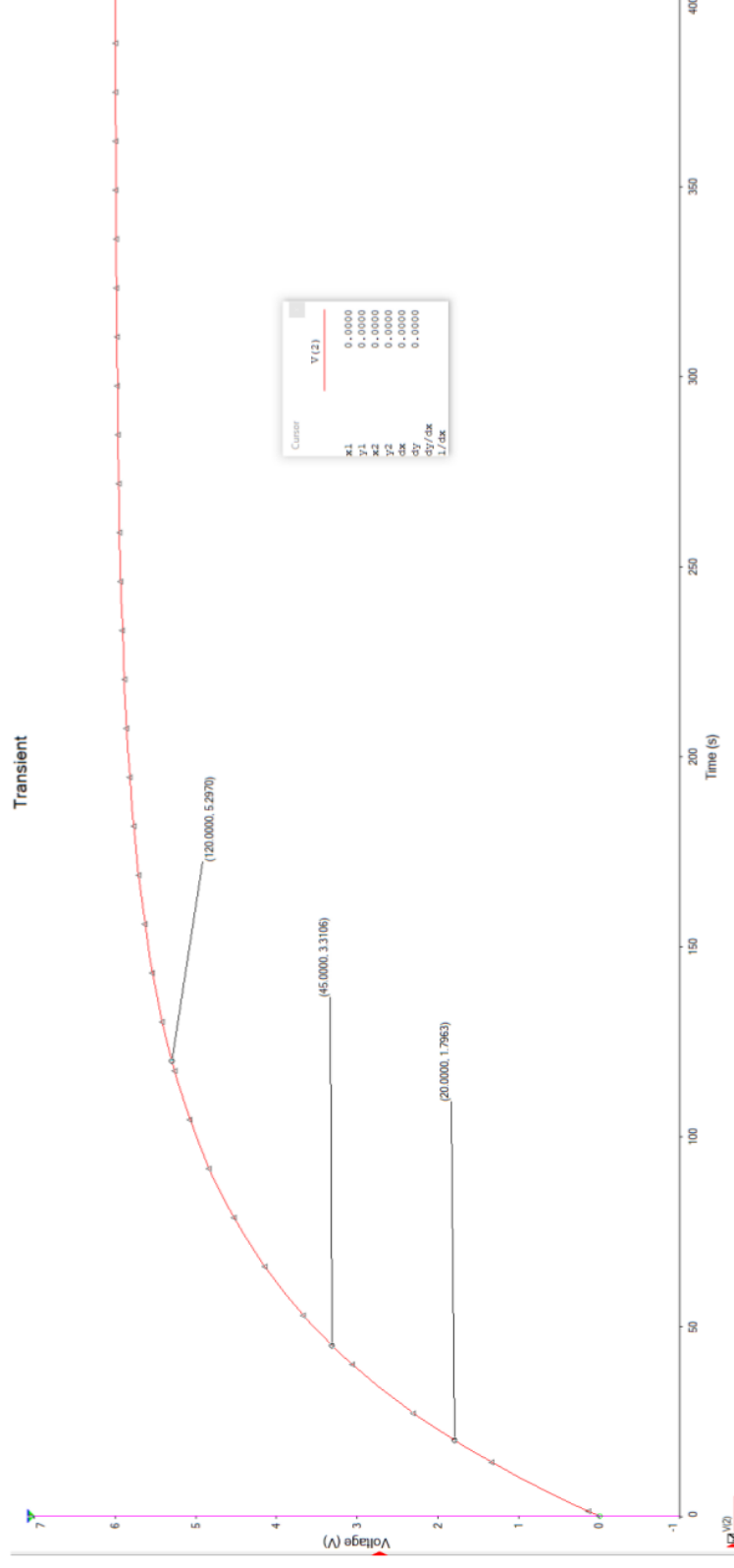


Figure 1 Three random values for the charge

Three separate times for the current were measured on the graph which also shows the charge.

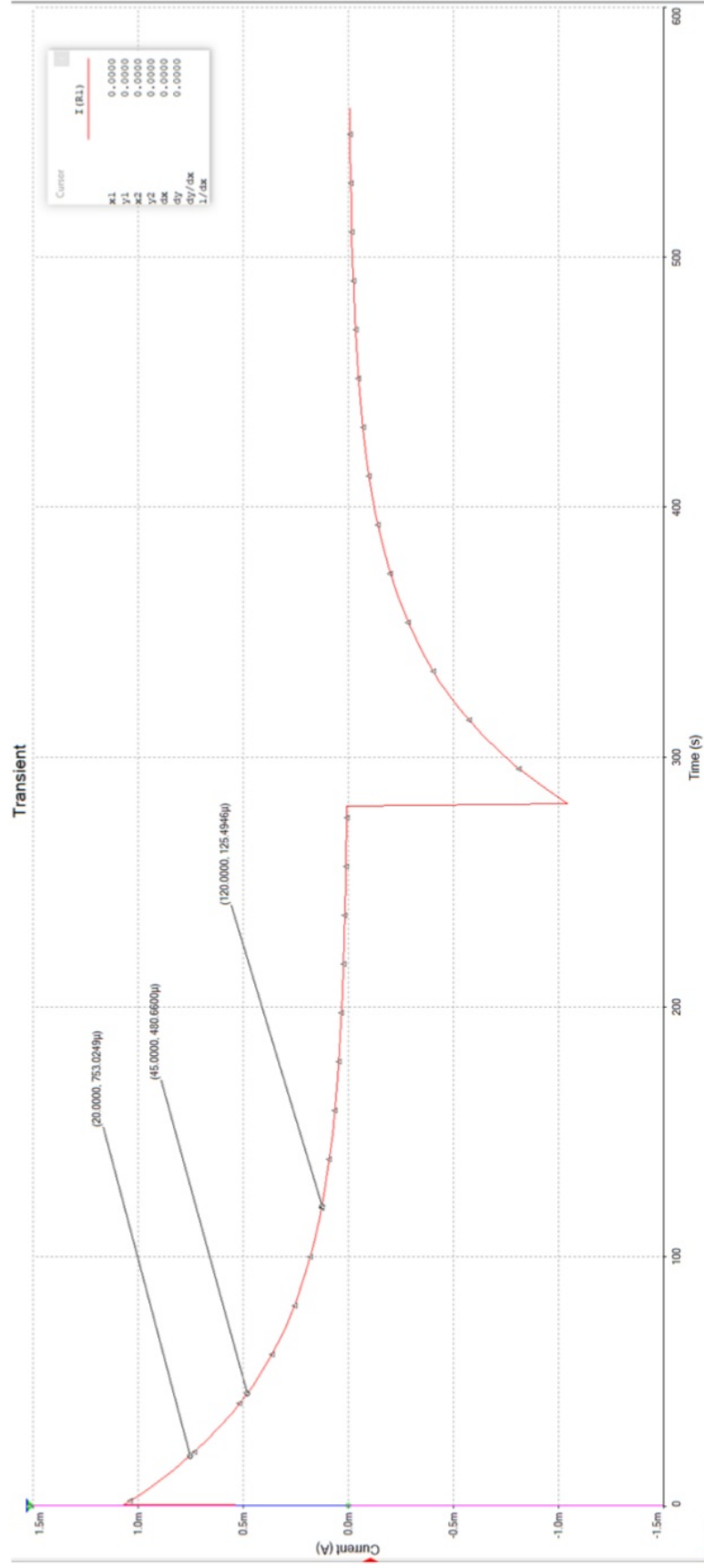
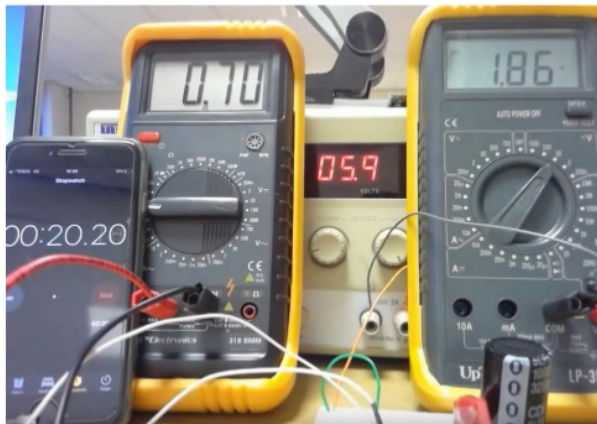
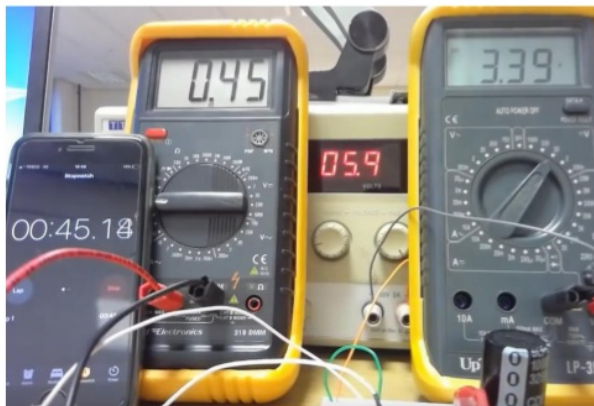


Figure 2 Three random time values for the discharge

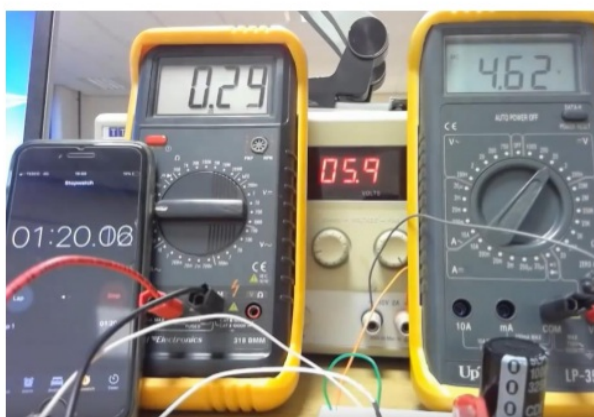
Practical results for the Charge
20 Seconds



45 Seconds



120 Seconds



Practical Results Charge

Charge		
Time	Current	Voltage
0	1.07	0.00
5	0.92	0.54
10	0.84	1.04
15	0.77	1.49
20	0.70	1.86
25	0.64	2.24
30	0.59	2.55
35	0.54	2.87
40	0.49	3.13
45	0.45	3.39
50	0.41	3.61
55	0.38	3.81
60	0.35	4.00
70	0.29	4.34
80	0.29	4.62
90	0.21	4.85
100	0.17	5.05
110	0.15	5.21
120	0.12	5.35
130	0.10	5.47
140	0.09	5.56
150	0.07	5.65
160	0.06	5.72
170	0.05	5.77
180	0.04	5.82
190	0.04	5.86
200	0.03	5.90
210	0.03	5.93
220	0.02	5.95
230	0.02	5.98
240	0.02	5.99
250	0.01	6.01
260	0.01	6.02
270	0.01	6.03
280	0.01	6.04

Practical Results Discharge

Discharging		
Time	Current	Voltage
0	-1.07	6
5	-0.92	5.56
10	-0.83	5.03
15	-0.76	4.62
20	-0.7	4.24
25	-0.64	3.87
30	-0.58	3.53
35	-0.53	3.22
40	-0.49	2.96
45	-0.45	2.72
50	-0.41	2.48
55	-0.38	2.28
60	-0.34	2.08
70	-0.29	1.75
80	-0.24	1.48
90	-0.2	1.24
100	-0.17	1.04
110	-0.14	0.87
120	-0.12	0.74
130	-0.1	0.62
140	-0.08	0.52
150	-0.07	0.44
160	-0.06	0.37
170	-0.05	0.31
180	-0.04	0.26
190	-0.03	0.22
200	-0.03	0.19
210	-0.02	0.16
220	-0.02	0.14
230	-0.02	0.12
240	-0.01	0.1
250	-0.01	0.08
260	-0.01	0.07
270	-0.01	0.06
280	0	0.05

Listed above is the practical results for both charge and discharge. The charge time started when the voltage was at a zero value and the discharge conditions were conducted when the voltage was at 6V.

Practical Results Charge

A line graph for both conditions were conducted on excel, Figure 3 shows the charge current and figure 4 shows the charge voltage. This helps to show the trend of the results.

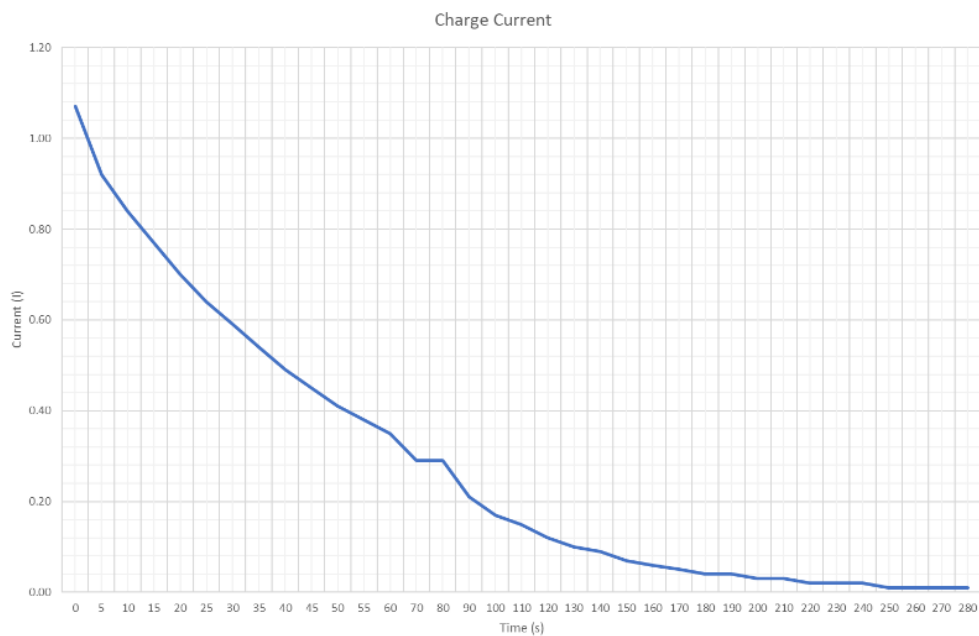


Figure 3 Charge current

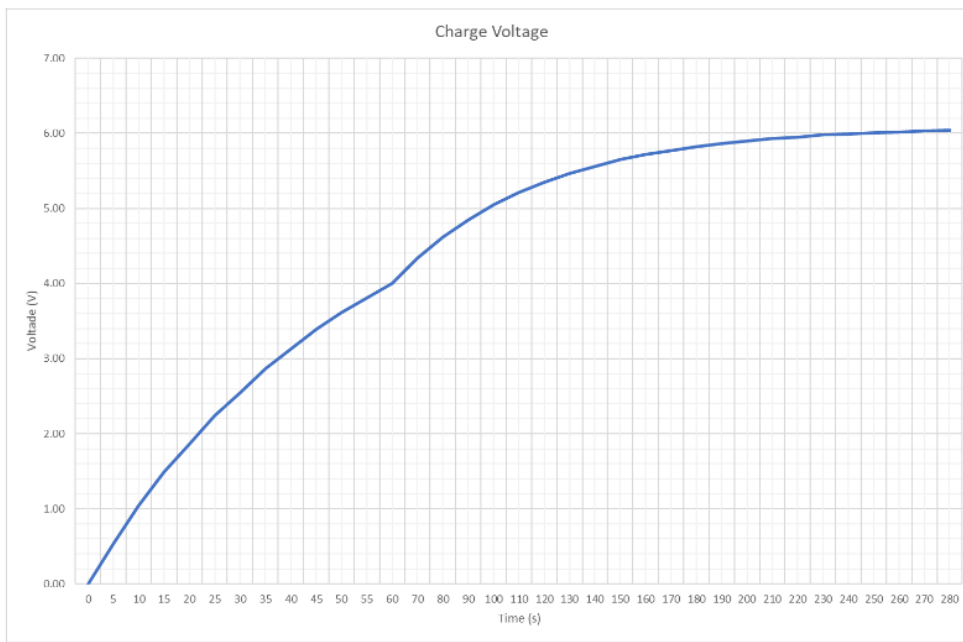


Figure 4 Charge voltage

Table of Results – Task 1

The table below has been devised as it gives an easy understanding of the trend of results calculated through all methods.

Table shows the results across each method in the charge state

Time (Seconds)	Calculated	Multi-Sim	Practical
20	1.80v	1.80v	1.86v
45	3.31v	3.31v	3.39v
120	5.30v	5.30v	4.62v

Table shows the results across the current flow

Time (Seconds)	Calculated	Multi-Sim	Practical
20	0.75v	0.75v	0.70v
45	0.48v	0.48v	0.45v
120	0.13v	0.13v	0.29v

Looking at both tables it is clear to see that the discrepancies are in the practical column and from the results it is the 120 second state that is showing the most obscure results.

Task 2

Transient behaviour for the discharging of a capacitor

Using the same circuit as task 1, the task assigned to perform the discharge state of the circuit.

Discharge Calculations

$$V_{max} \left(e^{\frac{-t}{\tau}} \right)$$

$$20 \text{ Seconds} = 6 \left(e^{\frac{-20}{56}} \right) = 4.2V$$

$$45 \text{ Seconds} = 6 \left(e^{\frac{-45}{56}} \right) = 2.69V$$

$$120 \text{ Seconds} = 6 \left(e^{\frac{-120}{56}} \right) = 0.70V$$

$$-I_{max} \left(e^{\frac{-t}{\tau}} \right)$$

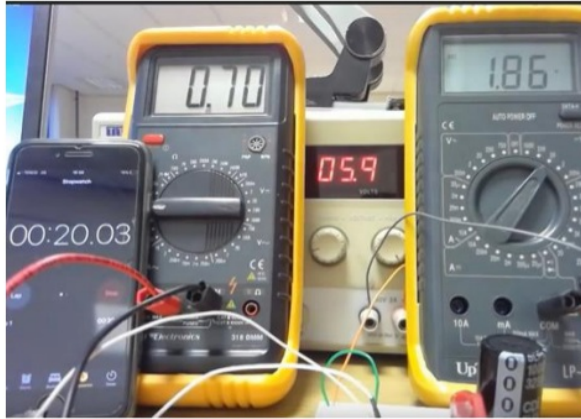
$$20 \text{ Seconds} = -1.07 \times 10^{-3} \times e^{\frac{-20}{56}} = -748.6 \mu A$$

$$45 \text{ Seconds} = -1.07 \times 10^{-3} \times e^{\frac{-45}{56}} = -479.1 \mu A$$

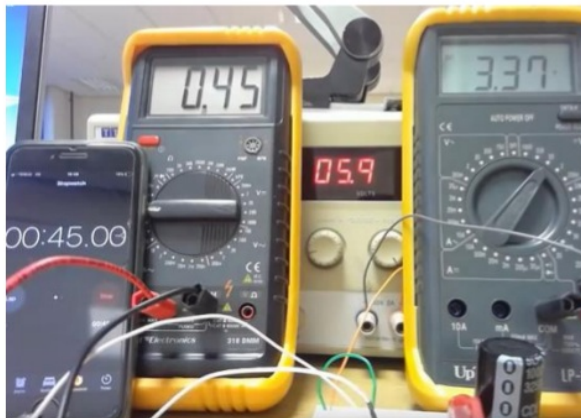
$$120 \text{ Seconds} = -1.07 \times 10^{-3} \times e^{\frac{-120}{56}} = -125.5 \mu A$$

Practical results for the Discharge:

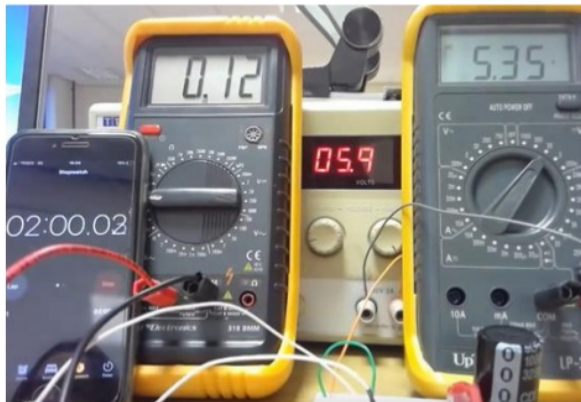
20 Seconds



45 Seconds



120 Seconds



Practical Results for the Discharge Current:

Using excel figure 5 and figure 6 show the graphs for the results from the practical results from the discharge table.

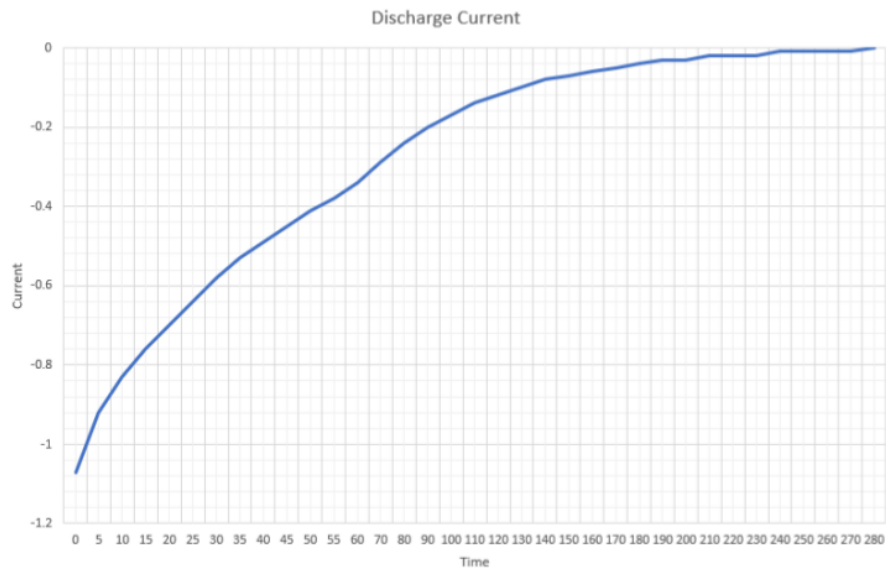


Figure 5 Discharge Current

Practical Results for the Discharge Voltage

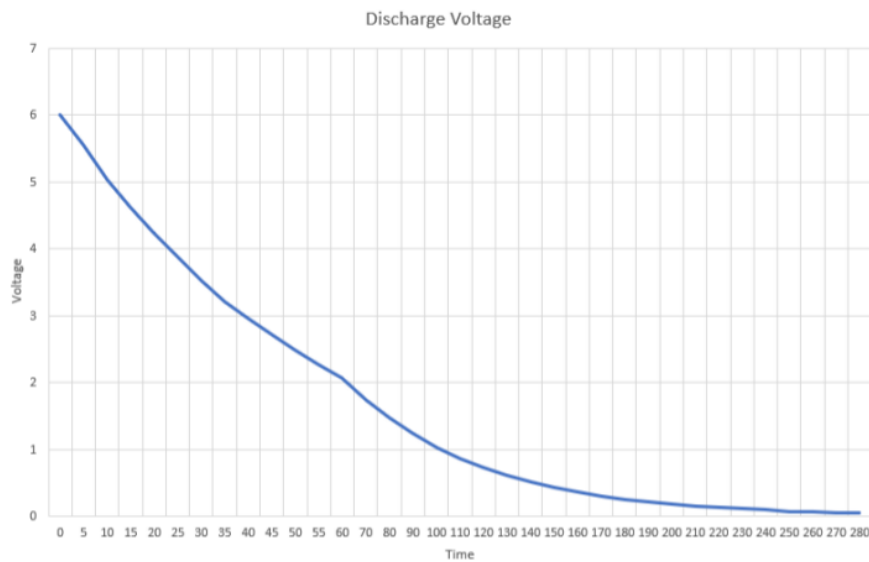
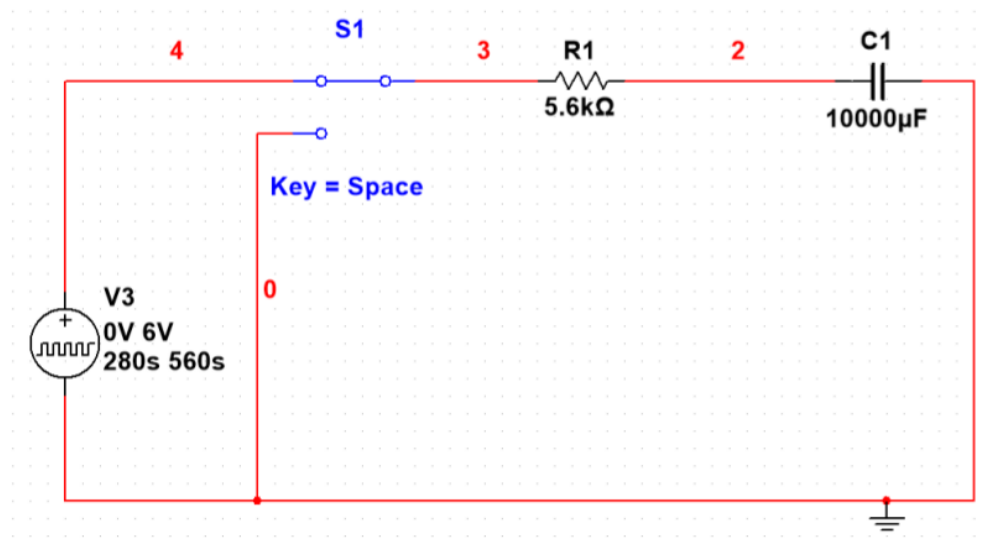


Figure 6 Discharge Voltage

To perform the discharge the circuit had a signal pulse source added into the circuit and remove the power source which was 6v.



Graphical results of the Voltage Discharge:

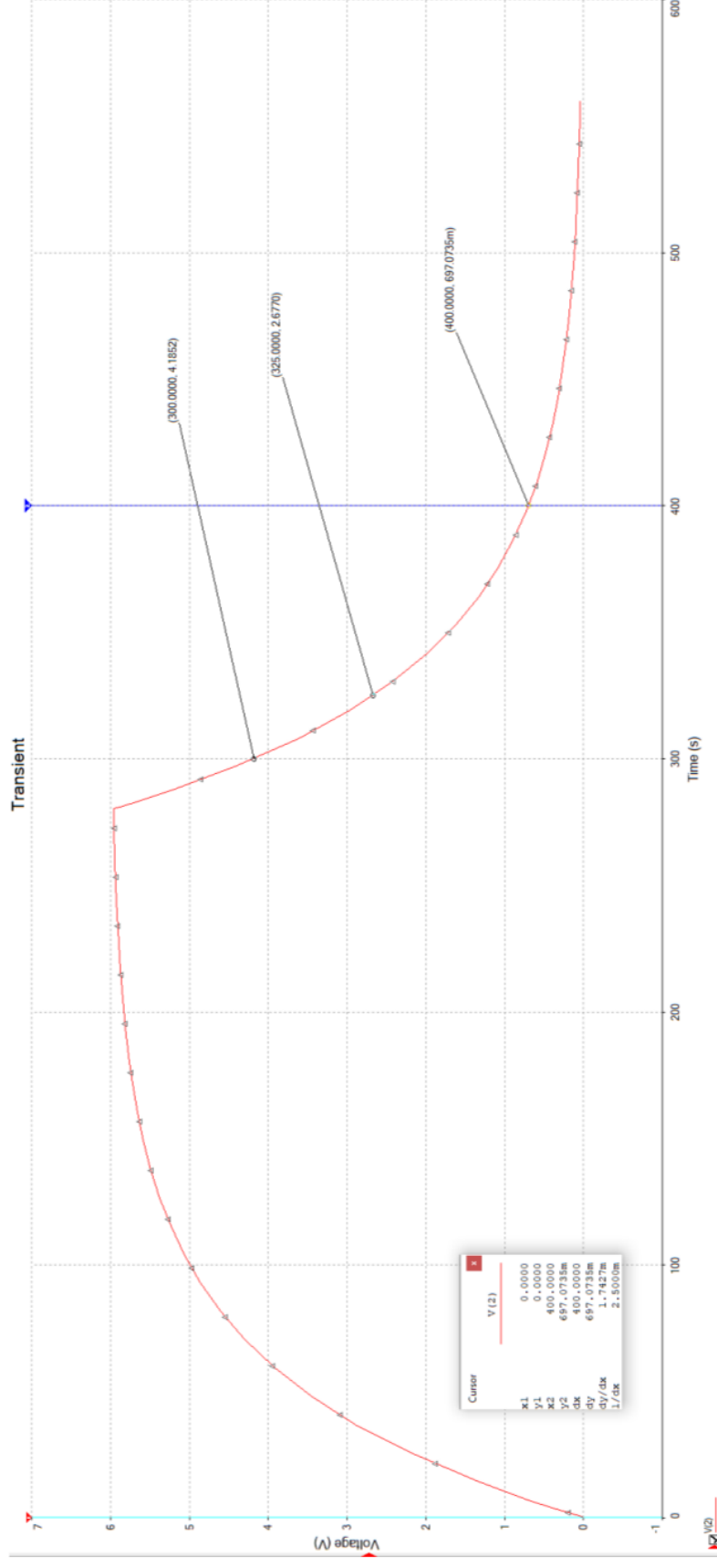


Figure 7 showing the voltage discharge from the calculated values

Current Discharge

From my results figure 8 is showing the graphical results of the Current Discharge:

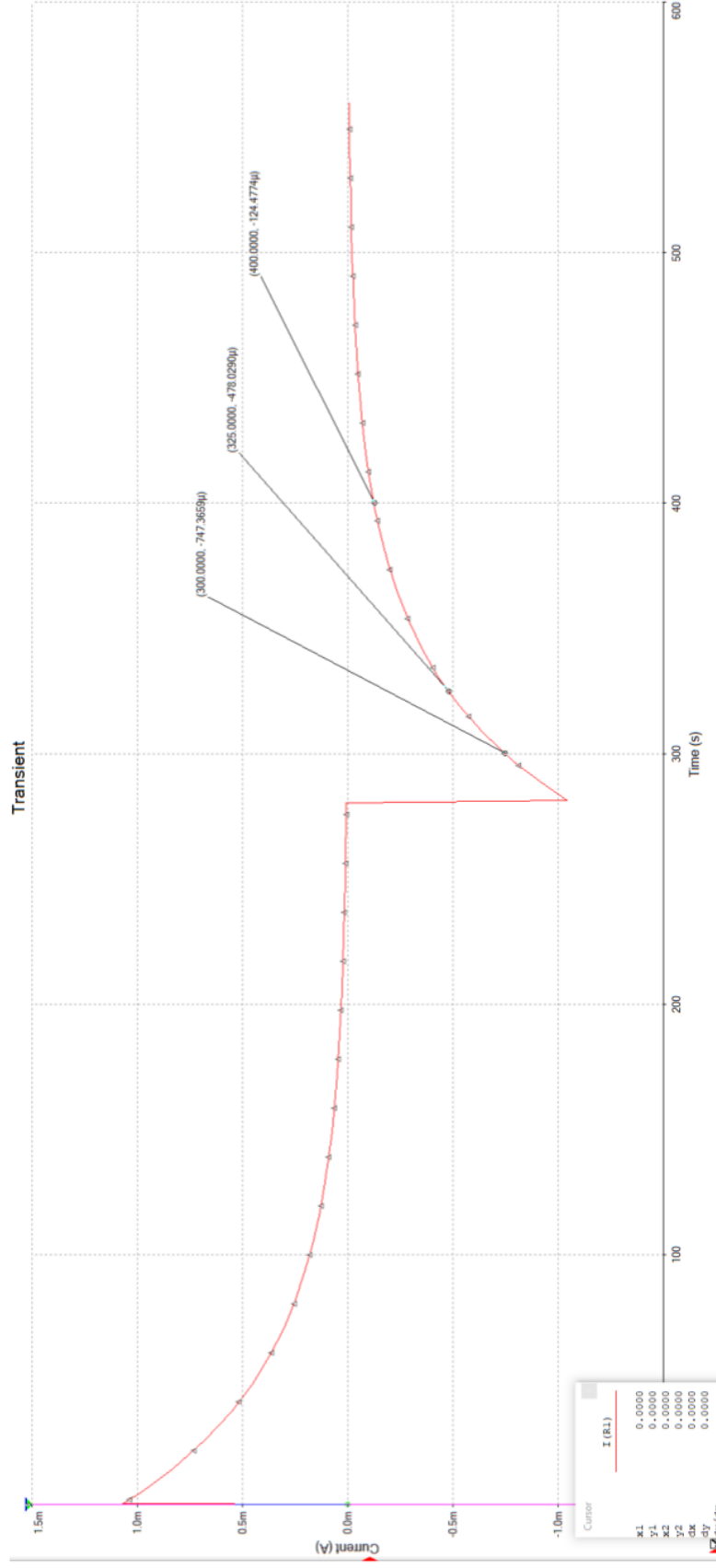


Figure 8 showing the results for the current discharge

Table of Results – Task 2

The table below will give a comparison of the results for the discharge conditions at the charging state across all investigation methods.

Time (Seconds)	Calculated	Multi-Sim	Practical
20	4.20v	4.19v	1.86v
45	2.69v	2.70v	3.37v
120	0.70v	0.70v	5.35v

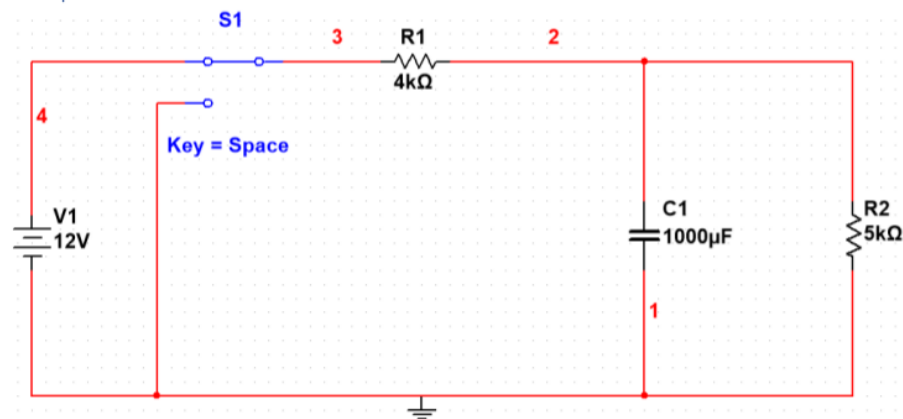
The table below shows the conditions for the discharging on the current state across all investigation methods.

Time (Seconds)	Calculated	Multi-Sim	Practical
20	-0.75v	-0.75v	-0.70v
45	-0.48v	-0.48v	-0.45v
120	-0.126v	-0.124v	-0.12v

From both sets of results, it is clear to see that the practical results have not got the same trend as the calculated and the simulated values.

Task 3

Complex RC Circuit



Calculations

$$\frac{4k \times 5k}{4k + 5k} = \frac{20k}{9k} = 2.22k\Omega$$

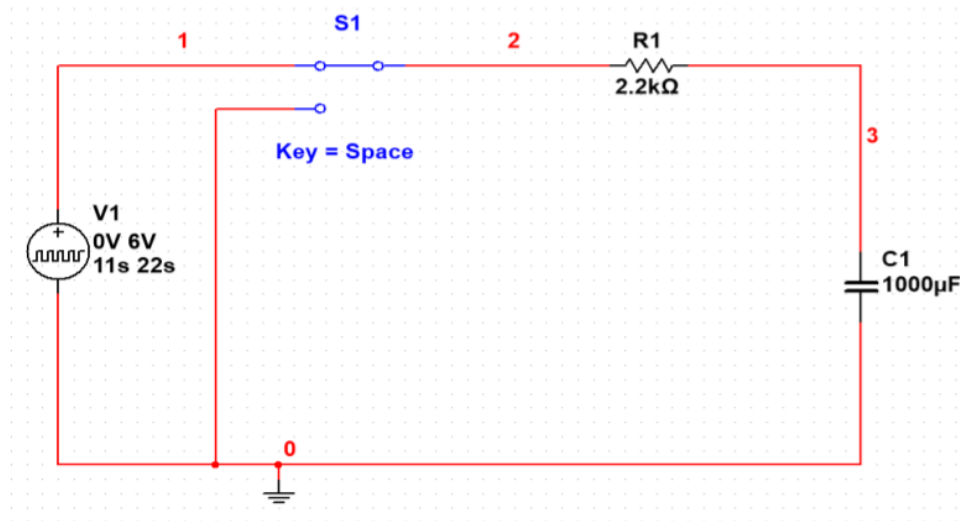
Use a new V_s from a voltage divider that is put into the circuit

$$\frac{5}{5 + 4} \times 12 = 6.67V$$

Time constant =

$$C \times R = \tau = (1,000 \times 10^{-6}) \times (2.2 \times 10^3) = 2.2 \text{ Seconds}$$

Applied these calculations and then worked out all the transient with the simplified circuit that was built on the software multi-sim.



Estimate the time constant when the Vmax is at 63.2%

The value for y2 from figure 5 graphical values work out 63.2% of 5.96.

The 5.96 is the value worked out from the period of time which is 22 seconds and just simply half that value.

$$\frac{63.2}{100} \times 5.96 = 3.767$$

The transient is simulated on multi-sim which each condition is labelled.

Estimate the time constant for the capacitor when the value is 36.82%

$$\frac{36.82}{100} \times 5.96 = 2.19$$

The x1 value is the time constant in the simulation:

Cursor		V (3)
x1	2.1739	
y1	3.7664	
x2	11.0038	
y2	5.9500	
dx	8.8298	
dy	2.1836	
dy/dx	247.2993m	
1/dx	113.2523m	

Initial and final Currents taken from the supply is then calculated:

$$\text{Initial} = i = \frac{V}{R} = \frac{6.67}{2.2 \times 10^3} = 3.03 \text{mA}$$

$$\text{Final Current} = i = I e^{-\frac{t}{\tau}} = (3.03 \times 10^{-3}) \times \left(e^{-\frac{11}{2.2}} \right) = 20.42 \mu\text{A}$$

The Discharge Conditions

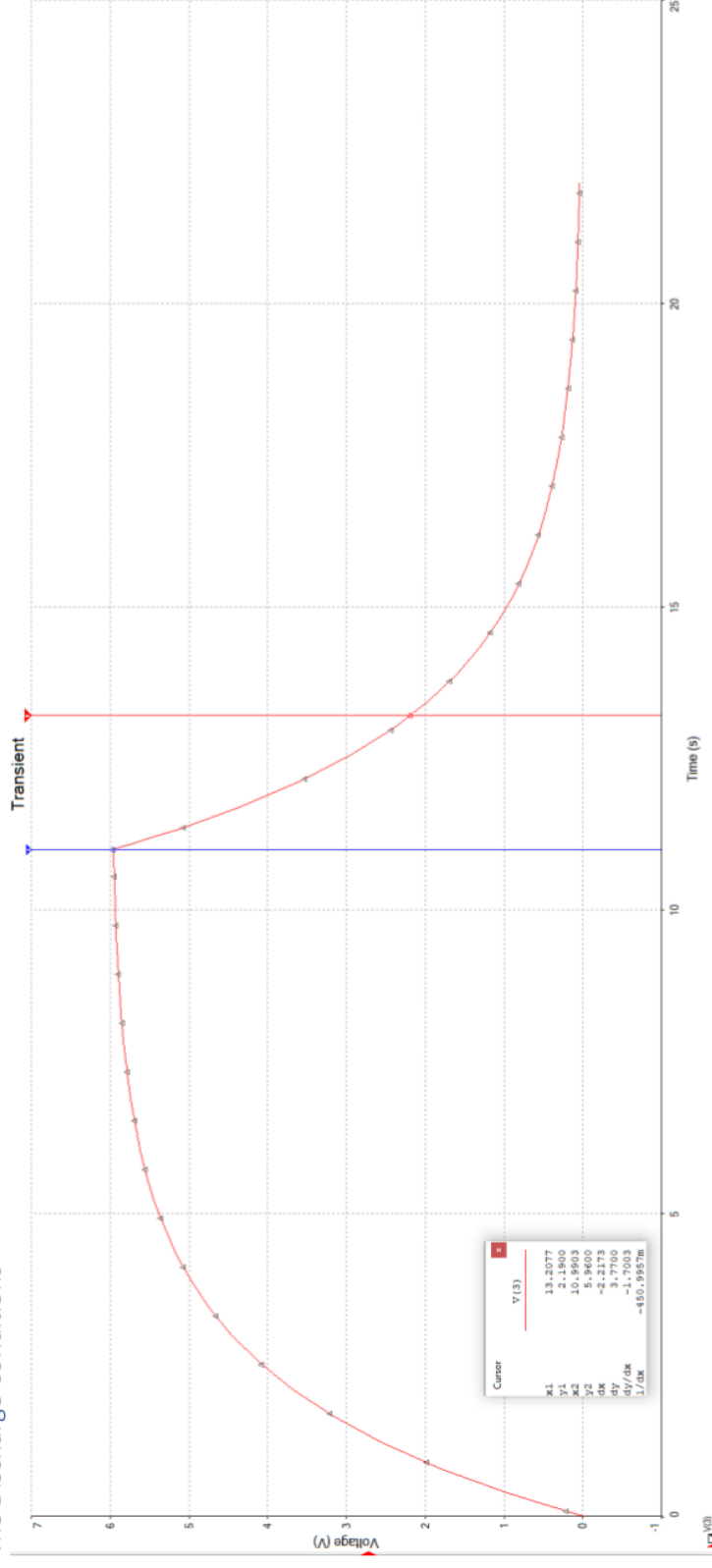


Figure 9 Discharge conditions

Discharge for the time constant when the voltage is set to the calculated value which is 2.19V and once the cursor is set to the value of 2.19, minus the 11 seconds away from the x1 value which is 13.21 and this will leave you with 2.21.

The Charge Conditions

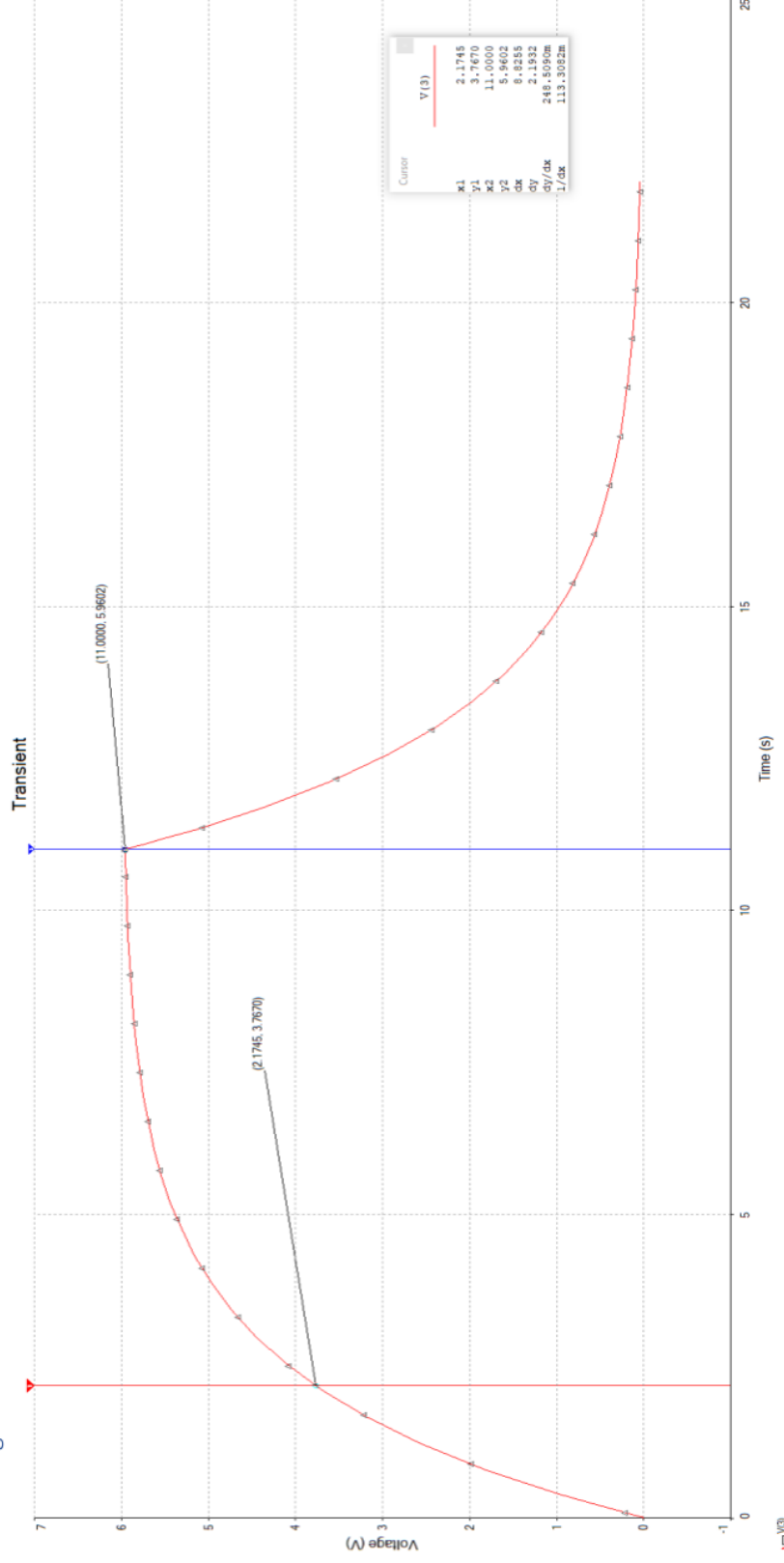
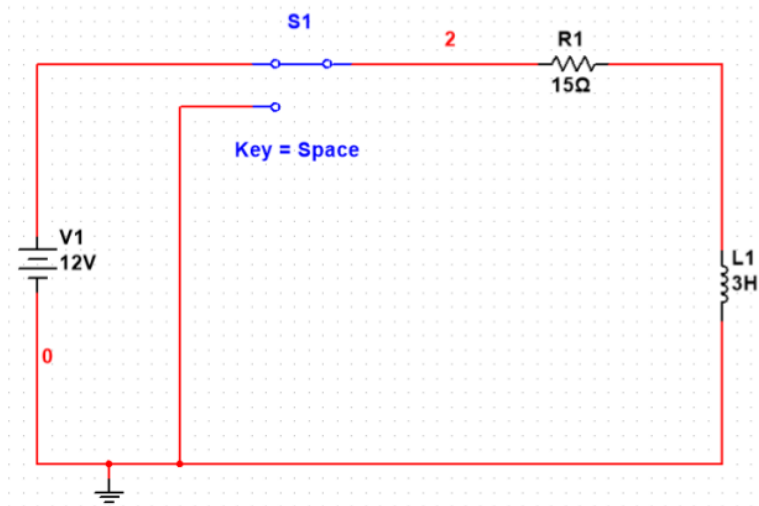


Figure 10 Charge conditions

The cursor is set to 11 seconds and then take the reading of voltage for that time (5.96). Set the second cursor to the time calculated which is 3.767 and take the reading which is 2.1.

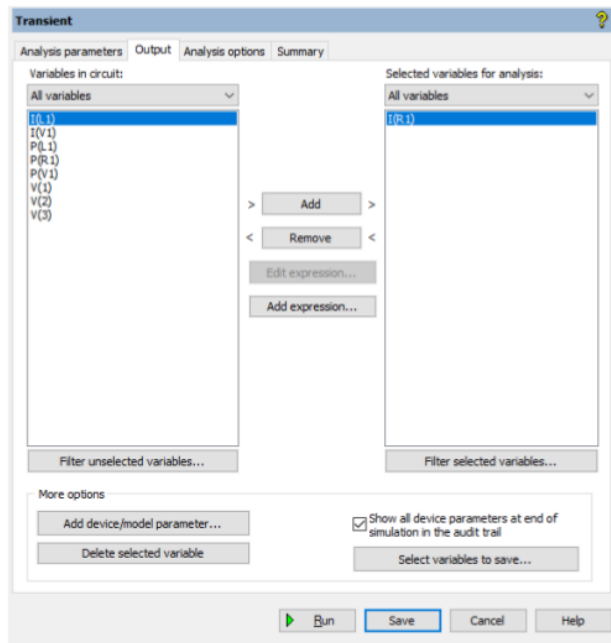
Task 4

Transient behaviour for the Inductive Circuit



Listed below is the simulated current growth for the first one second after the voltage source is applied to the circuit.

These were conducted through a transient graph with these conditions I(R1);



The simulations for the current growth was assigned in the brief and this was simulated after the first one second. This was after the voltage source was applied to the circuit. Figure 11 shows the results.

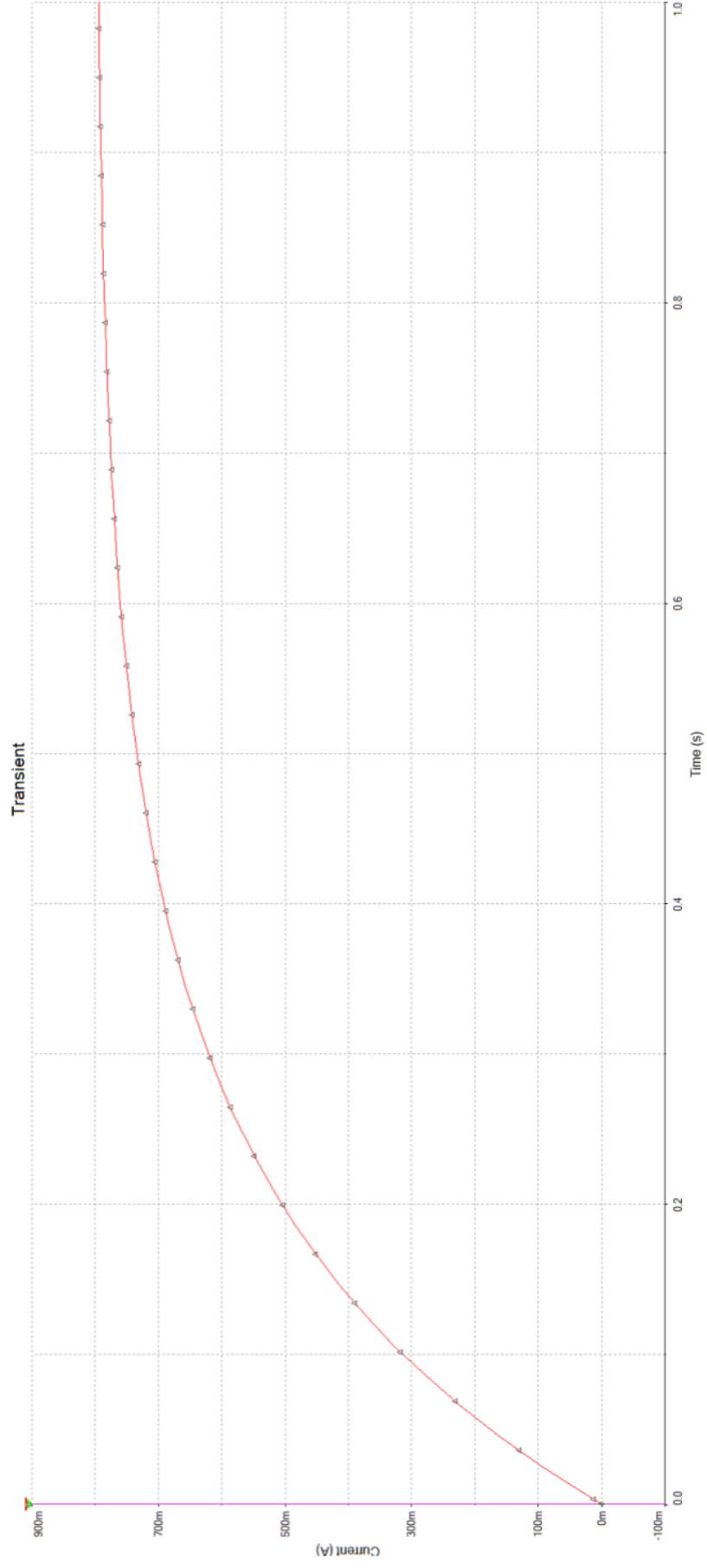


Figure 11 After the first one second

Calculations

The calculations below are for the 100mA value

$$I_{max} = \frac{V}{R} = \frac{12}{15} = 0.8A$$

$$i = I_{max} = e^{\frac{-t}{\tau}}$$

$$100 \times 10^{-3} = 0.8 e^{\frac{-t}{0.2}}$$

$$\frac{100 \times 10^{-3}}{0.8} = e^{\frac{-t}{0.2}}$$

$$0.125 = e^{\frac{-t}{0.2}}$$

$$e^{\frac{-t}{0.2}} = 0.125$$

$$\frac{-t}{0.2} = \ln 0.125$$

$$\frac{-t}{0.2} = -2.0794$$

$$t = (-2.0794) \times (-0.2)$$

$$t = 0.42$$

The calculations below are for the 10mA value

$$\tau = \frac{L}{R} = \frac{3}{15} = 0.2 \text{ seconds}$$

$$10 \times 10^{-3} = 0.8 e^{\frac{-t}{0.2}}$$

$$\frac{10 \times 10^{-3}}{0.8} = e^{\frac{-t}{0.2}}$$

$$0.0125 = e^{\frac{-t}{0.2}}$$

$$e^{\frac{-t}{0.2}} = 0.0125$$

$$\frac{-t}{0.2} = \ln(0.0125)$$

$$\frac{-t}{0.2} = -4.382$$

$$t = (-4.382) \times (-0.2)$$

$$t = 0.88$$

Exponential Curve calculations

For the charge is at 63.2% and the discharge is at the value 36.8%

$$\frac{63.2}{100} \times 0.8 = 0.514$$

$$\frac{36.8}{100} \times 0.8 = 0.3A$$

The calculations below were made for five different time constants which were chosen to be (1 τ , 2 τ , 3 τ , 4 τ and 5 τ) and below they are compared through multi-sim and a manual plot with excel.

$$i = 0.8 \left(1 - e^{\frac{-15-0.2}{3}} \right) = 0.5057$$

$$i = 0.8 \left(1 - e^{\frac{-15-0.4}{3}} \right) = 0.6917$$

$$i = 0.8 \left(1 - e^{\frac{-15-0.6}{3}} \right) = 0.7602$$

$$i = 0.8 \left(1 - e^{\frac{-15-0.8}{3}} \right) = 0.7853$$

$$i = 0.8 \left(1 - e^{\frac{-15-1}{3}} \right) = 0.7946$$

The time lapses before the current flowing has fallen to (100mA) and (10mA). The plots are from the calculations that were made.

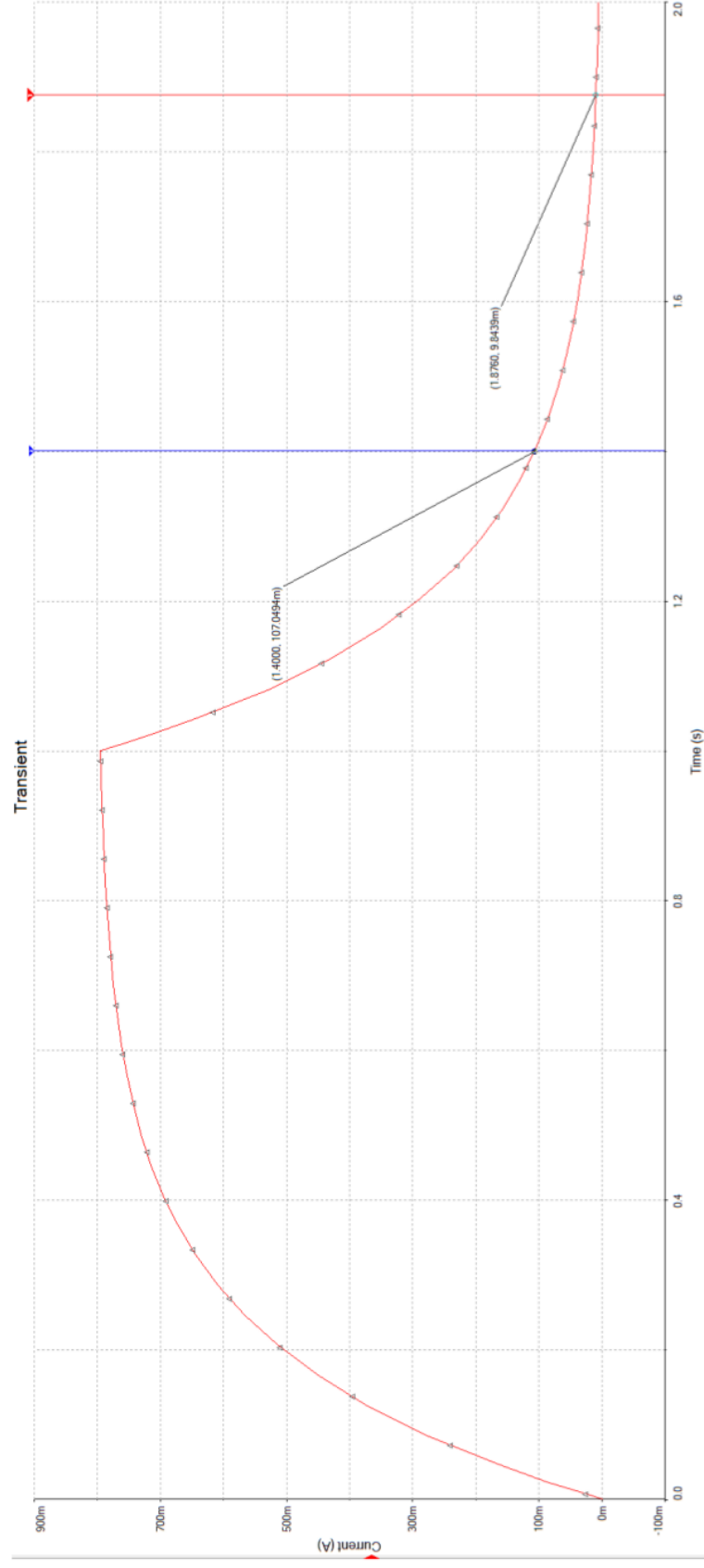


Figure 12 Graph showing the 100mA and 10mA

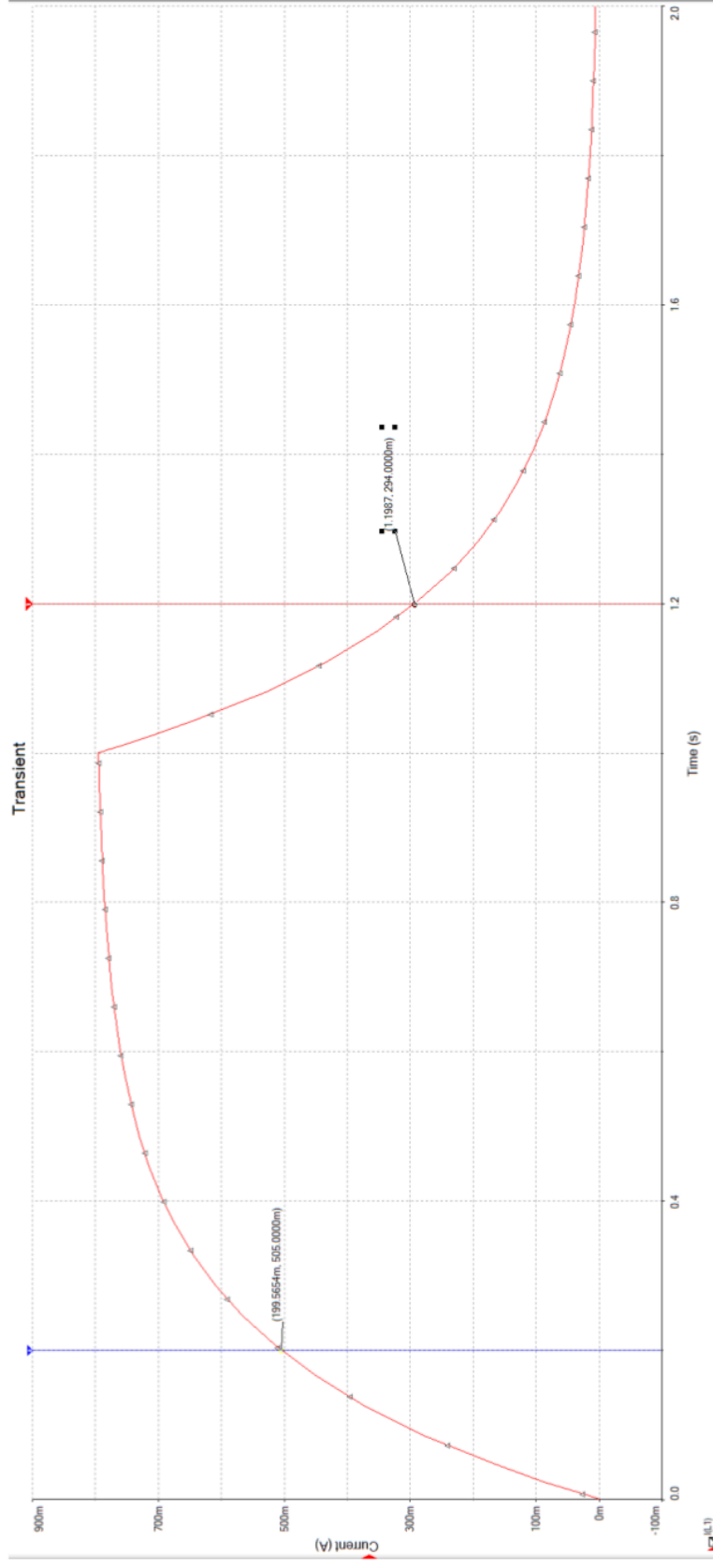
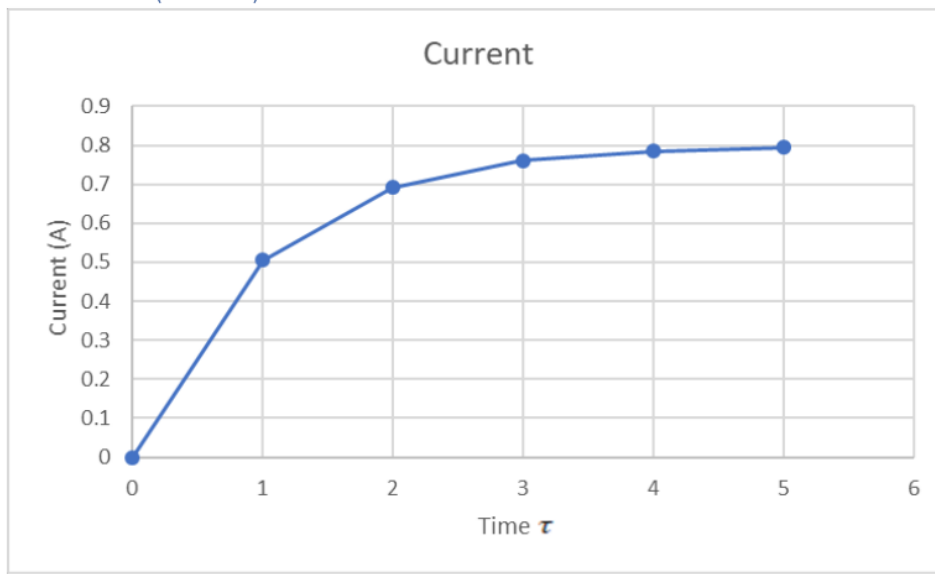


Figure 13 Exponential Curve

Manual Plot (Current)



Using excel a manual graph was made from my time constant and the calculated figures. The graph below will show the simulated values which will also be labelled to compare the figures.

This graph shows the calculated currents for the five calculated relevant time constants and each graph has been annotated.

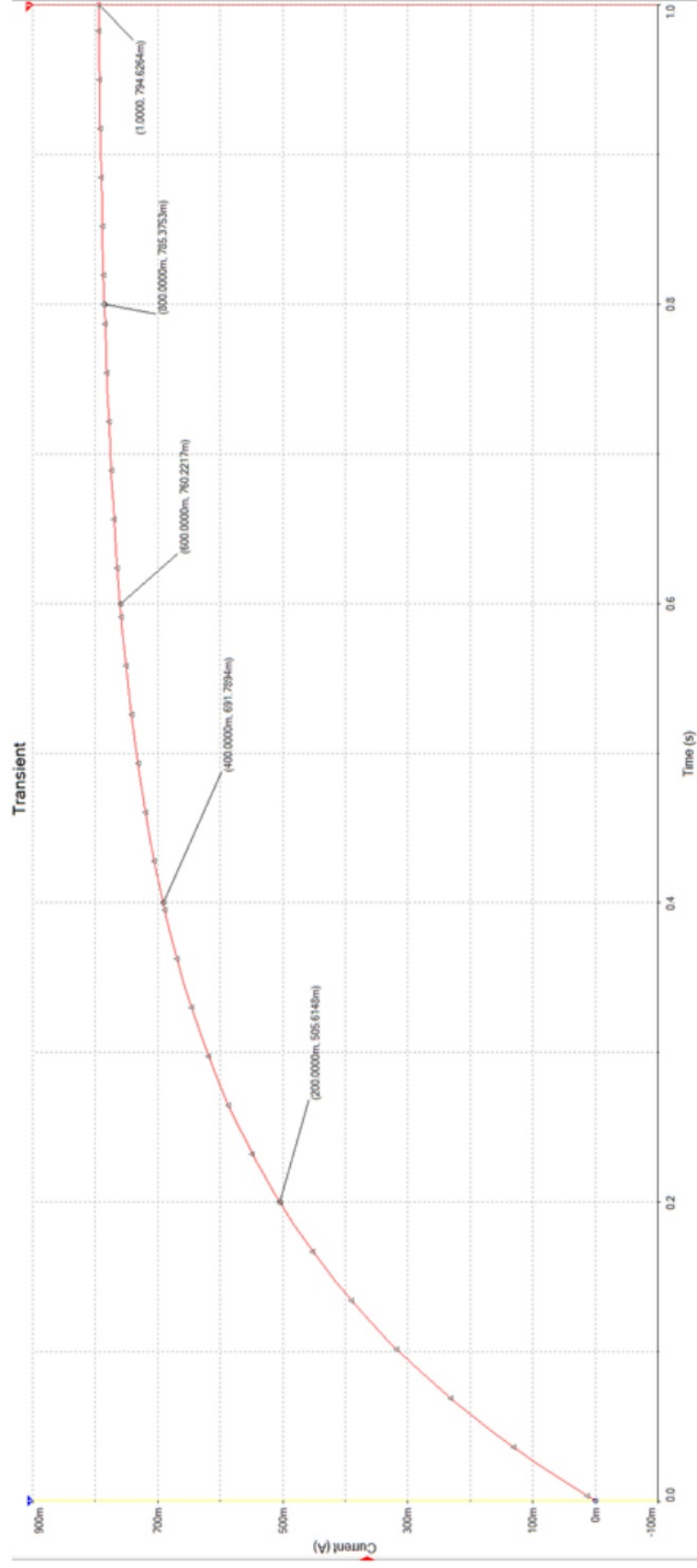


Figure 14 The five-time constants

Conclusions and Recommendations

In conclusion to the investigations it is clear to see from the results conducted there were slight discrepancies in task 1 as the calculated values were almost identical to the simulated values for both the charge and discharge. As for the practical side of the task the values that were assigned for the task started off the same but a slight difference, as the time went on it was getting higher and then decreasing quicker than the simulated value. To conclude the points focused, the discrepancies will come from the operator of the practical task as it will come down to not taking the reading at the right second as you can see from the images it was hard to take a reading at the same second as the ones calculated and simulated. Tolerances were taken into consideration when doing the practical task and the operator didn't allow more than a 0.20 second delay. If more than this, it will certainly affect the results into not being reliable enough to take a proper analysis. Looking through the tables for task 1 and 2, it is clear to see the 120 second state is the one with obvious error. Regarding task 3 it is clear to see from my calculations and the simulated values it is almost identical, the only thing that can explain the difference is the rounding up in the calculations. Analysing task 4 I can see that a consistency with the exponential graph is the same as the calculated values. With the five-time constants calculated, figure 14 is showing the same results as the ones calculated.

References

Bird, J., 2017. *Electrical Circuit Theory and Technology*. 6th ed. Oxon : Routledge .

FINAL GRADE

GENERAL COMMENTS

Instructor

55/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

PAGE 22

PAGE 23

PAGE 24

PAGE 25

PAGE 26

PAGE 27

PAGE 28

PAGE 29

PAGE 30

GRADING FORM: NEW CSG-RUBRIC

**JOSHUA
WILLIAMS**

55

1. ENGAGEMENT WITH LITERATURE



NA

2. KNOWLEDGE AND UNDERSTANDING



2. Basic knowledge, lacks depth, unclear, needs explanations in several areas as marked. 14/25

14

3. COGNITIVE AND INTELLECTUAL



3. Test results are tabulated some errors exist which were not investigated. Conclusion is weak and lacks detail. 16/30

16

4. PRACTICAL APPLICATION



4. Good application of basic methods, although not all your results are clearly explained 14/25

14

5. TRANSFERABLE SKILLS



5. Structure is ok, graphs are good, written communication is vague. Word count too low due to lack of explanation and vital detail. 11/20

11