

## LEVEL 4 ASSESSMENT SPECIFICATION

|                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                      |                  |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|------------------|
| Student name:                   | Jack Collier                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Student ID number:                                   |                  |
| Programme:                      | HNC Electrical/Electronic Engineering & Instrumentation Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                      |                  |
| Module:                         | Electrical Principles                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                      |                  |
| Module code:                    | PCEE4001                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Contribution to Overall Module Assessment (%):       | 100%             |
| Lecturer:                       | Jason Pointer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Internal Verifier:                                   | Lance Rutherford |
| Assignment Title:               | Electrical Principles                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Word count (or equivalent):                          | 2000             |
| Submission deadline:            | 15/01/20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Return date of provisional marks & written feedback: | 29/01/21         |
| Submission method:              | <p>All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.)</p> <p><b>Alternative submission method (if applicable):</b></p> <p><b>Late submission of the assessment will result in a late penalty mark.</b> Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.</p> |                                                      |                  |
| Academic honesty / referencing: | <p>Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.</p>                                                                                                                                                                                                                                                                                              |                                                      |                  |

### Module Learning Outcomes (from module syllabus)

1. Produce routine solutions to typical electrical problems.
2. Relate and apply basic electrical theory to collected data.

# STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

| Generic Assessment Criteria                                                                                                                                                                                                                                                                                          | Marks available | Marks awarded |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------|
| <b>1. Engagement with Literature Skills</b>                                                                                                                                                                                                                                                                          | 15              | 6.5           |
| Engagement with a limited range of mostly relevant and credible sources. Need to work upon your referencing technique, all sources should be listed at the end of the report.                                                                                                                                        |                 |               |
| <b>2. Knowledge and Understanding Skills</b>                                                                                                                                                                                                                                                                         | 25              | 13.3          |
| Task 1 achieved 65%.<br>Task 2 achieved 47%,<br>Task 3 achieved 51%.<br>Task 4 achieved 49%.<br><br>Knowledge of the basic underlying concepts and principles is accurate with a good understanding in most areas. Some of the calculation work was not completed and some of the concepts were not fully explained. |                 |               |
| <b>3. Cognitive and Intellectual Skills</b>                                                                                                                                                                                                                                                                          | 15              | 7.4           |
| Task 1 achieved 49%.<br>Task 4 achieved 50%.<br><br>Good evaluation of the underlying concepts and principles but were a little bit limited in the evaluation of Task 4.                                                                                                                                             |                 |               |
| <b>4. Practical Application Skills</b>                                                                                                                                                                                                                                                                               | 35              | 25.9          |
| Task 1 achieved 70%.<br>Task 4 achieved 78%.<br><br>An excellent application of practical work for Task 1 and 4, very good use of the test equipment to obtain all of the required results.                                                                                                                          |                 |               |
| <b>5. Transferable Skills for Life and Professional Practice</b>                                                                                                                                                                                                                                                     | 10              | 4.5           |
| Mostly ordered presentation and structure in which relevant concepts are reasonably expressed. Work may lack coherence in places. Try to produce all of the work on computer.                                                                                                                                        |                 |               |

**Assessment Mark** (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed. )

**Late Submission Penalties (tick if appropriate)**

Up to 1 week late (40% Max)

Over 1 week late (0%)

**58%**

### Task 1

To complete the activities for this task you will be given a student number which relates to the resistor values for the combinational circuit. Table 1 shows the student numbers and resistor values.

*You should provide an introduction to the task.*

**Table 1** – values for Task 1

| Student Number | R <sub>1</sub> (Ω) | R <sub>2</sub> (Ω) | R <sub>3</sub> (Ω) | R <sub>4</sub> (Ω) | R <sub>5</sub> (Ω) | R <sub>6</sub> (Ω) |
|----------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| 1              | 270                | 560                | 330                | 270                | 330                | 680                |
| 2              | 390                | 470                | 220                | 330                | 180                | 560                |
| 3              | 220                | 470                | 330                | 470                | 220                | 680                |
| 4              | 270                | 680                | 220                | 560                | 330                | 560                |
| 5              | 330                | 560                | 330                | 470                | 180                | 680                |
| 6              | 180                | 680                | 220                | 330                | 270                | 560                |
| 7              | 220                | 560                | 330                | 470                | 220                | 680                |
| 8              | 330                | 470                | 220                | 560                | 180                | 680                |

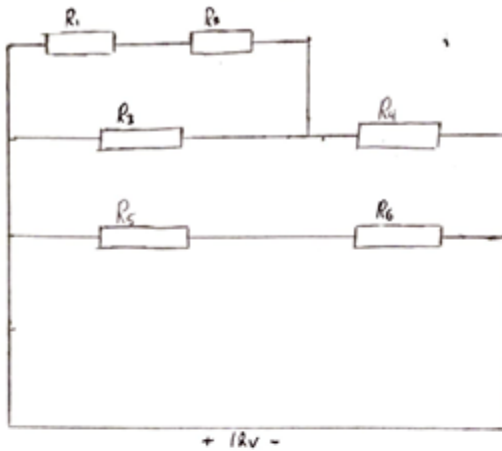
1. Construct the circuit and measure the total resistance ( $R_T$ ) before connecting the power supply.
2. Connect a 12V supply and measure the p.d. value across each resistor, the supply current and the current in each resistor.
3. Calculate the
  - total resistance,  $R_T$
  - supply current,  $I$
  - current in each resistor
  - and the p.d. value across each resistor.

All formulas and workings must be shown.

4. Use Multisim to also produce a set of test results for the voltages and currents.
5. Comment on the practical, calculation and simulation results, discussing any variations when comparing these results and make reference to relative theories such as Kirchhoff's laws.

*You should write in the past tense.*

Task 1



$R1 = 390$   
 $R2 = 470$   
 $R3 = 220$   
 $R4 = 330$   
 $R5 = 180$   
 $R6 = 560$

Next time try to do your calculations using the computer.

Find  $R_T$

$$R_{12} = R_1 + R_2 = 390 + 470 = 860 \Omega \checkmark$$

$$R_{123} = \frac{R_{12} \times R_3}{R_{12} + R_3} = \frac{860 \times 220}{860 + 220} = 175.19 \Omega \checkmark$$

$$R_{1234} = 175.19 + 330 = 505.19 \Omega \checkmark$$

$$R_{56} = R_5 + R_6 = 180 + 560 = 740 \Omega \checkmark$$

$$R_T = \frac{R_{1234} \times R_{56}}{R_{1234} + R_{56}} = \frac{505.19 \times 740}{505.19 + 740} = 300.23 \Omega \checkmark$$

$$I_T = \frac{V}{R_T} = \frac{12}{300.23} = 39.97 \text{ mA} \checkmark \text{ finding total current}$$

$$I_5 = I_6 = \frac{V}{R_{56}} = \frac{12}{740} = 16.22 \text{ mA} \checkmark$$

$$V_5 = I_5 \times R_5 = 16.22 \times 180 = 2.92 \text{ V} \checkmark \text{ finding } V_5, V_6$$

$$V_6 = I_6 \times R_6 = 16.22 \times 560 = 9.08 \text{ V} \checkmark$$

$$I_4 = \frac{V}{R_{1234}} = \frac{12}{505.19} = 23.75 \text{ mA} \checkmark$$

$$V_4 = I_4 \times R_4 = 23.75 \times 330 = 7.84 \text{ V} \checkmark \text{ finding } V_4, V_3$$

$$V_3 = V - V_4 = 12 - 7.84 = 4.16 \text{ V} \checkmark$$

$$I_3 = \frac{V_3}{R_3} = \frac{4.16}{220} = 18.91 \text{ mA} \checkmark$$

$$I_1 = I_2 = \frac{V_3}{R_{12}} = \frac{4.16}{860} = 4.84 \text{ mA} \checkmark$$

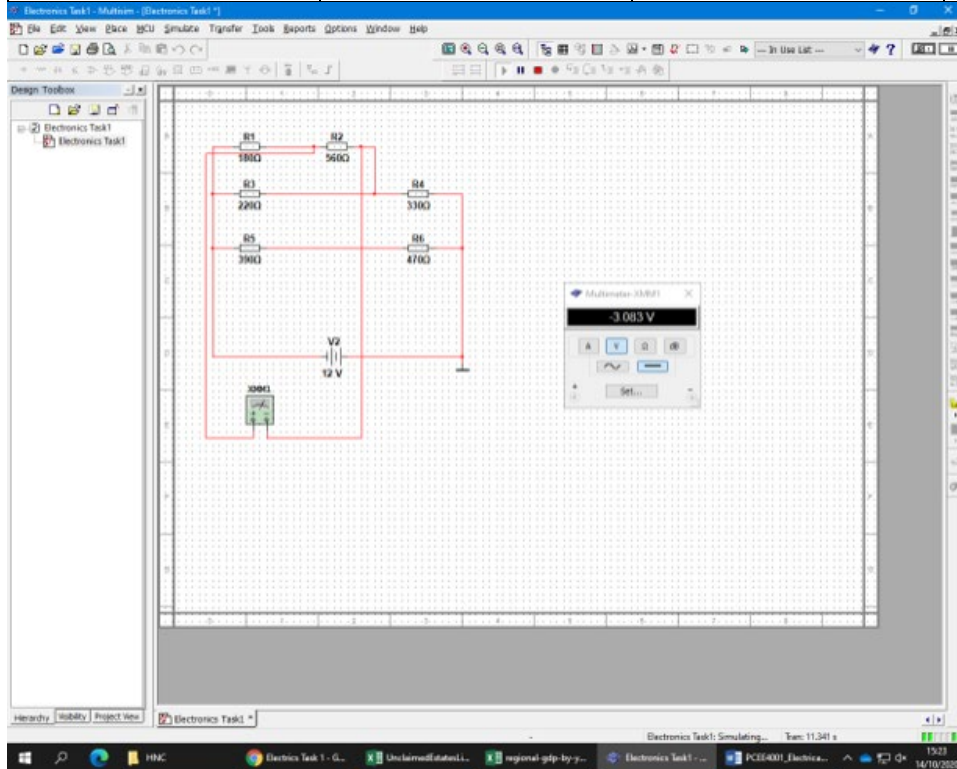
$$V_1 = I_1 \times R_1 = 4.84 \times 390 = 1.89 \text{ V} \checkmark \text{ finding } V_1, V_2$$

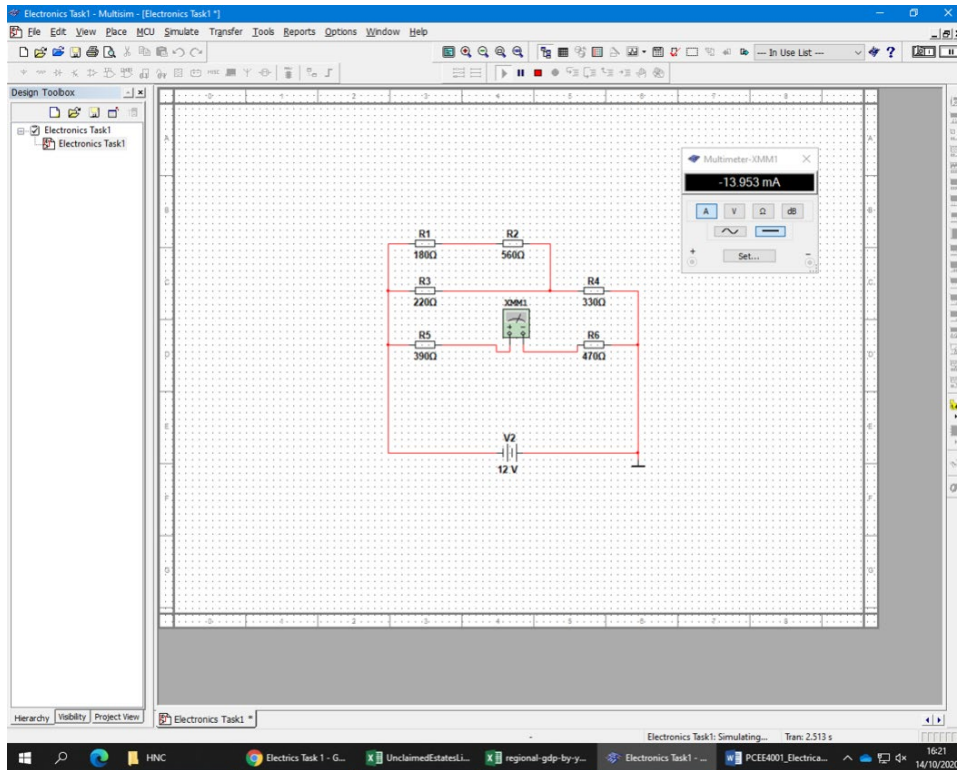
$$V_2 = I_2 \times R_2 = 4.84 \times 470 = 2.27 \text{ V} \checkmark$$

Good work

|       | Measured     | MultiSim        | Calculated      |
|-------|--------------|-----------------|-----------------|
| $R_T$ | 295 $\Omega$ | 300.07 $\Omega$ | 300.23 $\Omega$ |
| V1    | 2.51V        | 2.27V           | 2.27V           |
| V2    | 2.51V        | 2.27V           | 2.27V           |
| V3    | 4.24V        | 4.15V           | 4.16V           |
| V4    | 7.5V         | 7.83V           | 7.84V           |
| V5    | 2.88V        | 2.92V           | 2.92V           |
| V6    | 9V           | 9.07V           | 9.08V           |

|                |        |           |           |
|----------------|--------|-----------|-----------|
| I <sub>T</sub> | 40mA   | 39.97mA   | 39.97mA   |
| I <sub>1</sub> | 4.86mA | 4.84mA    | 4.84mA    |
| I <sub>2</sub> | 4.8mA  | 4.84mA    | 4.84mA    |
| I <sub>3</sub> | 19.1mA | 18.91mA   | 18.91mA   |
| I <sub>4</sub> | 23.6mA | 23.75mA   | 23.75mA   |
| I <sub>5</sub> | 16mA   | 16.22mA   | 16.22mA   |
| I <sub>6</sub> | 16mA ✓ | 16.22mA ✓ | 16.22mA ✓ |





When we look at the table of results, we can see that there are some similarities in the columns and some differences. First if we compare the calculated results to the Multisim results we can see that they are almost exactly the same, this is because they are both using ideal values of the components so are effectively doing the same calculations. We see slight differences in some of the values and this is due to human error, when carrying out calculations it's important to use all the decimal places and when I carried out my calculations, I only used values up to two decimal places. This causes the values to be slightly out as the Multisim will use all the decimal places. If we then look at the measured values, we will see a bigger difference, this is because we have larger inaccuracies with the measured values since a 390-ohm resistor will not be exactly 390 ohms as it might be 382 ohms. This is due to the quality of the resistor as they all will have a margin of inaccuracy weather that be +/- 5% or more. Due to this factor, we will expect to see that the measured value will be different to the ideal calculated value.

*There are other factors to consider. Also you have not related your results to known theories.*

## Task 2 – Capacitors

Using the values stated in Table 2, determine:

*Again this should be stated in the past tense.*

- a) the equivalent circuit capacitance
- b) the total charge
- c) the charge in each capacitor
- d) the energy stored in each capacitor
- e) the total energy stored in the circuit.

Table 2 – values for Task 2

| Student Number | C <sub>1</sub> (μF) | C <sub>2</sub> (μF) | C <sub>3</sub> (μF) | C <sub>4</sub> (μF) | V <sub>s</sub> (V) |
|----------------|---------------------|---------------------|---------------------|---------------------|--------------------|
| 1              | 12                  | 27                  | 33                  | 4.7                 | 12                 |
| 2              | 15                  | 27                  | 39                  | 3.3                 | 15                 |
| 3              | 18                  | 27                  | 43                  | 2.2                 | 20                 |
| 4              | 22                  | 27                  | 47                  | 2.2                 | 25                 |
| 5              | 27                  | 22                  | 43                  | 1.5                 | 30                 |
| 6              | 10                  | 22                  | 39                  | 3.3                 | 25                 |
| 7              | 12                  | 22                  | 33                  | 4.7                 | 20                 |
| 9              | 15                  | 22                  | 39                  | 3.3                 | 15                 |

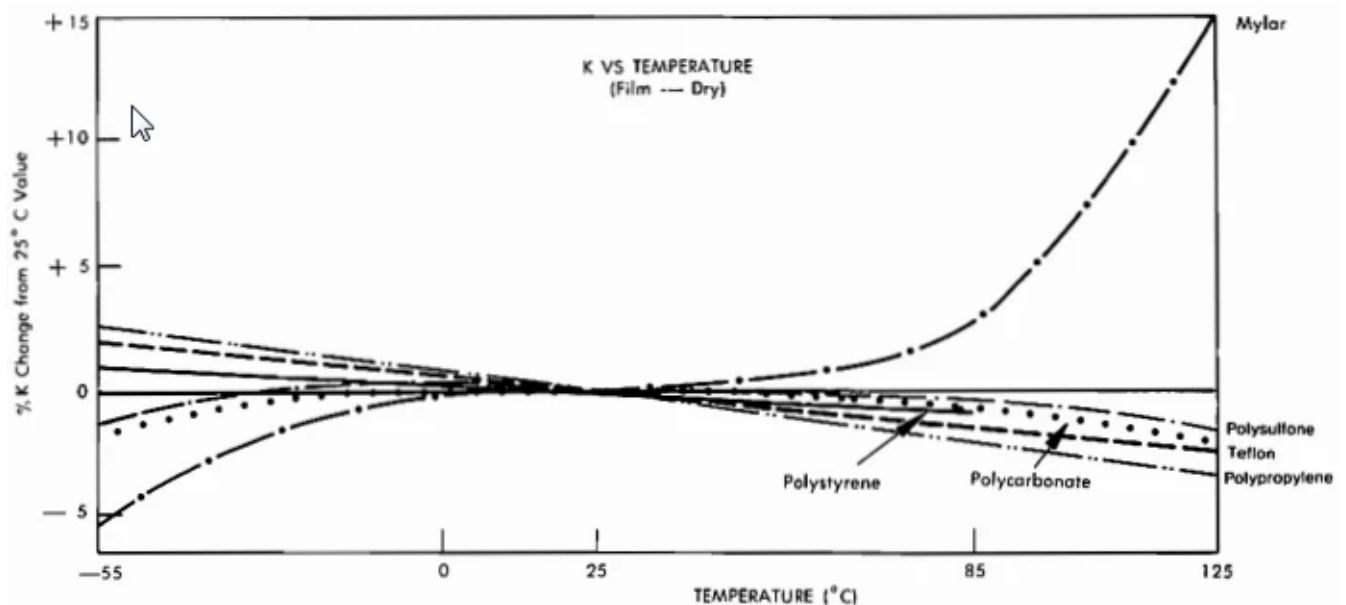
**1.** Explain the construction and function of a capacitor, listing some of the different types that are available and typical values. Include methods that could be used to alter the value of the capacitor.

Capacitors are relatively simple components in electronic circuits as main purpose is to hold a small amount of charge and being able to discharge quickly. Capacitors are made of three main components: two conducting plates (positive and negative) <sup>and</sup> the dielectric. The capacitance of the capacitor depends on three factors, first how big the conductor plates are or their total surface area, the material between the two conductor plates which is also called the dielectric and finally how are away the conductor plates are from each other. ✓ Capacitance occurs when one plate is positively charged and the other is negatively charged, this causes a static electric field to be formed between the two plates, it's the strength of this field which determines how much capacitance the capacitor can hold. Therefore, the equation of capacitance is Charge divided by Voltage and capacitance is measured in Farads (F) and is defined as *the capacitance when a p.d. of one volt appears across the plates when charged with one coulomb.* ✓

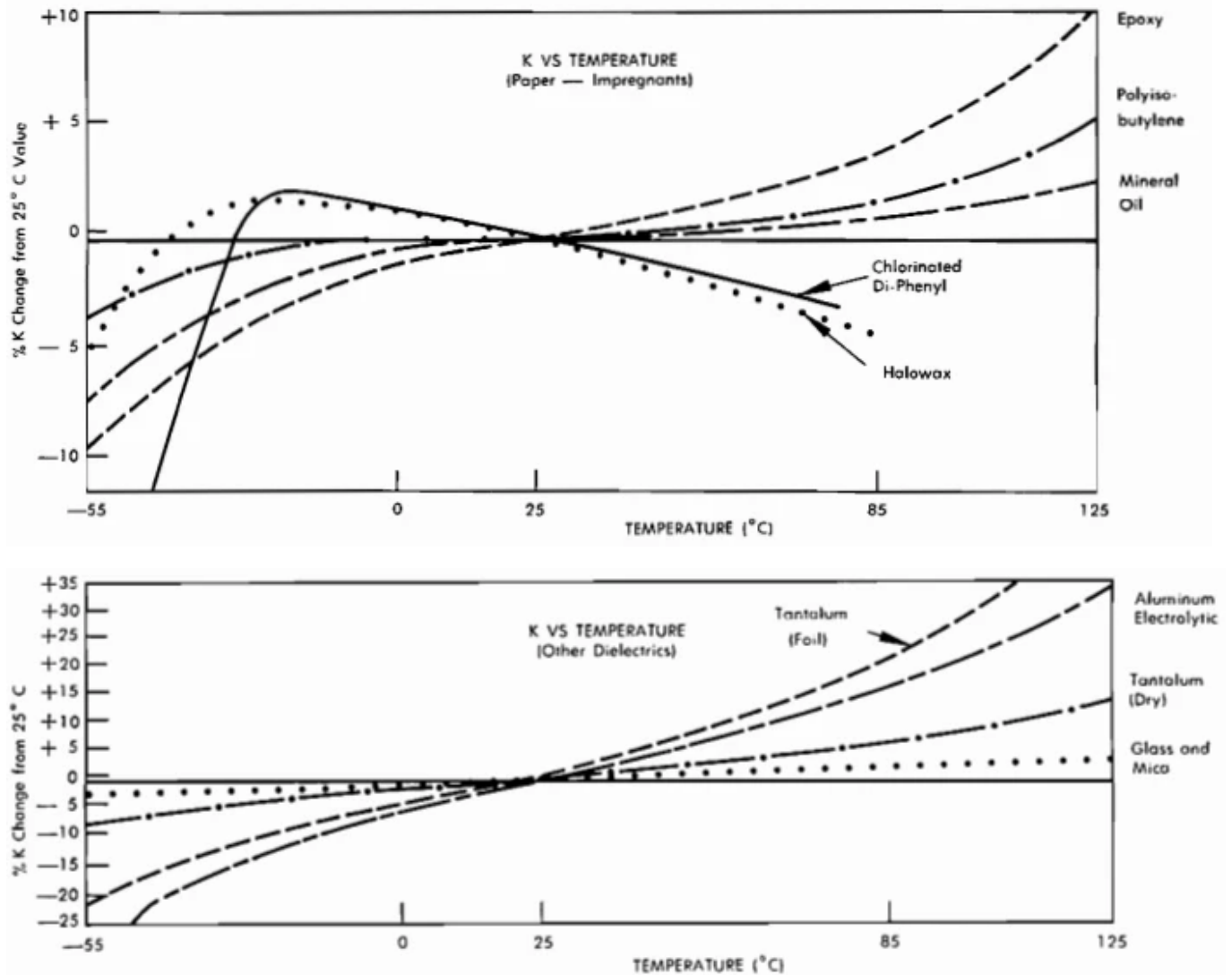
One of the key factors in defining a capacitors capacitance is what material the dielectric is made from whatever it is made from paper, ceramic or film. By having different materials as the dielectric this causes different characteristics of the capacitor to change like its total capacitance or how fast it can discharge. Another factor which effects capacitance is the surface area of the two charge plates, the capacitance is directly proportional to the surface area of the two plates

so the larger the plates the greater the capacitance. The spacing between the plates or the thickness of the dielectric also effect the capacitance of the capacitor as the spacing between the two plates is inversely proportional to the capacitance, this means that the larger the space between the two plates the smaller the capacitance of the capacitor. The last thing which effects capacitance of capacitors is the ambient temperature of the capacitor as this can cause the capacitor to vary in capacitance, when purchasing capacitors, the manufacture will provide a temperature coeffiecnt for the specific capacitor and this can be used to calculate how much the capacitance of the capacitor will vary when experiencing temperatures above or below 25°C. This may not seem important, but capacitors are usually used in circuit boards where the ambient temperature can get well over 25°C which may cause issues in the circuit when the capacitance changes. Below is some graphs of the deviations from the stated value at 25°C of a variety of different capacitors using different dialectics from a website called Electrocube:

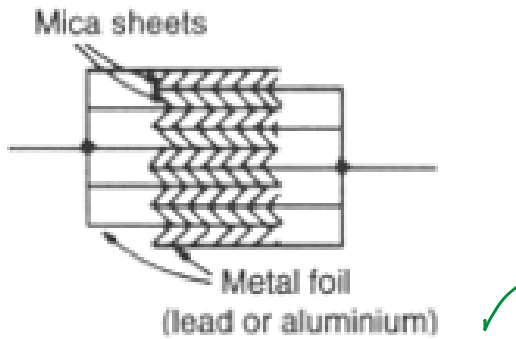
<https://www.electrocube.com/pages/capacitors-capacitance-changes-why-technical-bulletin>.



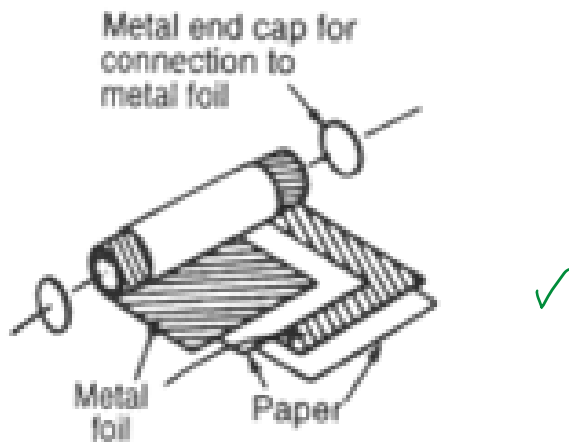
Why include all these graphs?



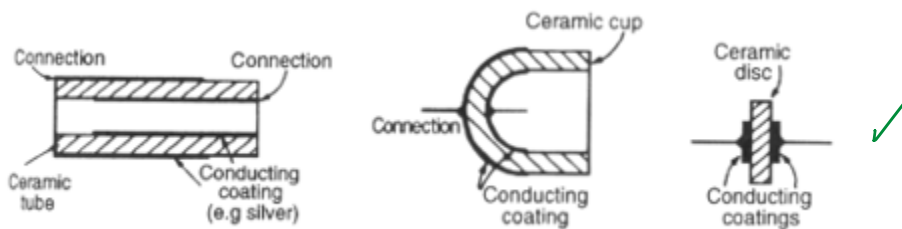
There are multiple types of capacitors which can be used for different applications, for example one of the more popular types of capacitor is the Mica capacitor. These types of capacitors tend to be more expensive than other types as they use silver coated plates for the conductive plates which can obviously get expensive; their capacitance is anything up to 0.2 $\mu$ F as anything above this would require some modification to the capacitor to work reliably. ✓



Another type of capacitors the paper capacitor, the structure of these types of capacitors as in the mica capacitors the conductor plates are placed parallel to the dielectric material where in the paper capacitor, they are rolled together like in the illustration below. This means that the capacitance depends on how many times the material has been rolled. This then placed in an aluminum casting to protect it from moisture. Paper capacitors have working voltages up to around 150kv and its capacitance values can range from 500pF to 10 $\mu$ F. ✓



Ceramic capacitors are the most versatile types of capacitor as they can be made in many ways depending on what is needed. For example, if you needed a higher capacitance value you could make it into a long tube to increase the surface area, if you wanted a smaller value than this you can arrange the dielectric into a cup shape and for even smaller values you can make a small disc for very small values. The values of ceramic capacitors range from 1pF to 0.1 $\mu$ F. ✓



← Do not reference my notes

Jason Pointer (Unknown). *Capacitance and Capacitors*. Pembrokeshire Collage: Unknown. p1-7.

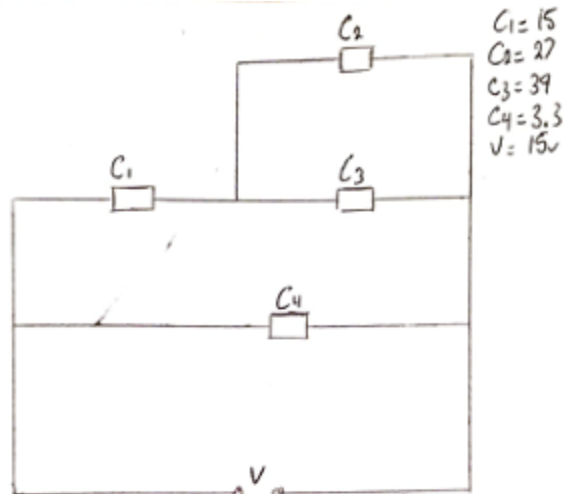
Richard Fiore. (Unknown). *Circuit Designer's Notebook*. Available:  
[https://www.richardsonrfpd.com/docs/rfpd/ATC%20-%20Understanding\\_Temperature\\_Coefficient\\_of\\_Capacitance.pdf](https://www.richardsonrfpd.com/docs/rfpd/ATC%20-%20Understanding_Temperature_Coefficient_of_Capacitance.pdf). Last accessed 29/11/2020.

Unknown. (Unknown). *Capacitors..Capacitance Changes - Why?*. Available:  
<https://www.electrocube.com/pages/capacitors-capacitance-changes-why-technical-bulletin>. Last accessed 29/11/2020.

Stephen L. Herman. (2018). Capacitors. In: Cengage Learning *Delmar's Standard textbook of Electricity Sixth Edition*. London: Cengage Learning. 481-530.

The list of references should be include at the end of the report.

2. Need to state what your doing.



Finding Capacitance

$$C_{23} = C_2 + C_3 = 27 + 39 = 66 \mu\text{f} \checkmark$$

$$C_{123} = \frac{C_1 \times C_{23}}{C_1 + C_{23}} = \frac{15 \times 66}{15 + 66} = 12.22 \mu\text{f} \checkmark$$

$$C_T = C_{123} + C_4 = 12.22 + 3.3 = 15.52 \mu\text{f} \checkmark$$

Finding Charge

$$Q_T = C_T \times V = 15.52 \times 15 = 232.8 \mu\text{C} \checkmark$$

$$Q_4 = C_4 \times V = 3.3 \times 15 = 49.5 \mu\text{C} \checkmark$$

$$Q_{123} = C_{123} \times V = 12.22 \times 15 = 183.3 \mu\text{C} \checkmark$$

$Q_1 = Q_{23}$  as they are in series  $\checkmark$   
 So  $\checkmark$  Must make sure the presentation is neat.

$$V_1 = \frac{Q_1}{C_1} = \frac{183.3}{15} = 12.22V \checkmark$$

$$V_{23} = \frac{Q_{23}}{C_{23}} = \frac{183.3}{66} = 2.78V \checkmark$$

$$Q_2 = C_2 \times V_{23} = 27 \times 2.78 = 75.06 \mu\text{C} \checkmark$$

$$Q_3 = C_3 \times V_{23} = 39 \times 2.78 = 108.42 \mu\text{C} \checkmark$$

Energy in each capacitor

$$W_1 = \frac{1}{2} C_1 V^2 = \frac{1}{2} \times 15 \times 15^2 = 1687.5 \mu\text{J} \checkmark$$

$$W_2 = \frac{1}{2} C_2 V^2 = \frac{1}{2} \times 27 \times 2.78^2 = 3037.5 \mu\text{J} \checkmark$$

$$W_3 = \frac{1}{2} C_3 V^2 = \frac{1}{2} \times 39 \times 2.78^2 = 4387.5 \mu\text{J} \checkmark$$

$$W_4 = \frac{1}{2} C_4 V^2 = \frac{1}{2} \times 3.3 \times 15^2 = 371.25 \mu\text{J} \checkmark$$

Total energy

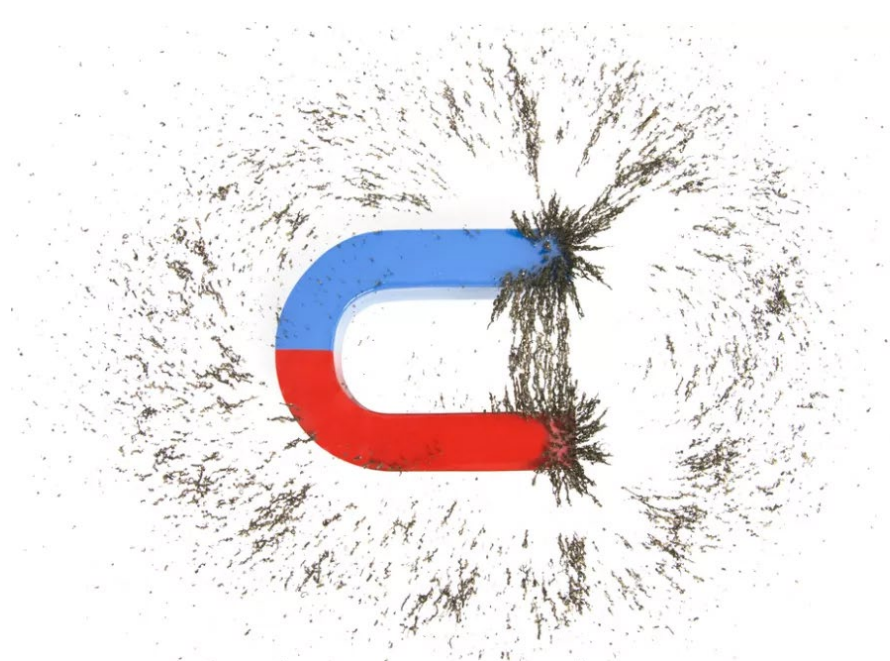
$$W_T = 0.5 \times C_T \times V^2 = 0.5 \times 15.52 \times 15^2 = 1746 \mu\text{J} \checkmark$$

$$= 1075.15$$

### Task 3 – Magnetism

1. Explain the principles of permanent magnets including the distribution of magnetic fields.

Permanent magnets are materials which can generate their own magnetic fields. These magnetic fields have a north and south pole, the north pole is attracted to the south pole and vice versa. If the same poles are placed near each other they will have the opposite effect and repel each other. This phenomenon occurs due to the electrons orbiting the nucleus as the electrons are negatively charged and the nucleus is positively charged, depending on how the structure is made up depends on where the positive and negative charges are and therefore where the north and south pole of the magnet is. Around magnets are magnetic fields, these flow around magnets from the north to the south pole of the magnet which forms a complete loop; this can be visualized using a permanent magnet and fine metal shavings as seen in the image below. ✓



✓  
Could include diagrams showing a clear picture of the fields.

Scott Hannahs. (2020). *Permanent Magnet*. Available: <https://nationalmaglab.org/about/maglab-dictionary/permanent-magnet>. Last accessed 27/12/2020.

Unknown. (2020). *The Basic Principles of Electromagnetism*. Available: <https://electricalapprentice.co.uk/the-basic-principles-of-electromagnetism/>. Last accessed 28/12/2020.

✓

Jim Lucas. (2015). *What is Magnetism?*. Available: <https://www.livescience.com/38059-magnetism.html>. Last accessed 28/12/2020

2. A transformer is a device that uses some of the principles associated with electromagnetism. Explain the operation and construction of transformer, include methods to reduce power loss within the transformer.

A transformer is a type of electrical equipment which is used to change electrical voltage, current and impedance by stepping it up or stepping it down. They are the most efficient types of electrical as they are between 90-99% efficient and they come in many different types like: Isolating transformer, autotransformer, and current transformer. The transformer is made up of two coils and a iron core, the number of windings on each coil depends on if the transformer steps up or down and by how much. The iron core is made up of multiple laminations which can be around 0.3mm thick. When a AC voltage is applied to the primary coil this causes flux to flow though the iron core. This magnetic flux flowing through the core causes the primary and secondary coils to link inducing a voltage in the secondary coil. The voltage which is induced causes eddy currents to flow around the core material, the fact that we have multiple laminations this increases the resistance of the core but also causes it to heat up. To get rid of this heat there are a couple of options, one of the simpler options is to use a fan to blow chilly air around the core to try and disperse the heat. This works well on some of the smaller transformers but on larger ones we completely surround the core in oil which is then run through large radiators which helps to disperse the heat. ✓

*Could included a diagram to show construction.*

Chris Woodford. (2020). *Electricity Transformers*. Available: <https://www.explainthatstuff.com/transformers.html>. Last accessed 21/1/21.

Stephen L. Herman (2016). *Delmar's Standard textbook of Electricity Sixth Edition*. London: Cengage Learning. 95.

3. Solve the following problems:

- a. A magnetic pole face has a rectangular section having dimensions 220mm by 120mm. If the total flux emerging from the pole is 130μWb, calculate the flux density.

Convert length and width into meters

$$L = 220\text{mm} = 0.22\text{m}$$

$$W = 120\text{mm} = 0.12\text{m}$$

Finding the surface area of the rectangular section

$$A = L \times W = 0.22 \times 0.12 = 0.0264\text{m}^2$$

$$\Theta = 130\mu\text{Wb}$$

Finding the flux density

$$B = \Theta / A = (130 \times 10^{-6}) / 0.0264 = 4.92 \times 10^{-3}\text{T}$$

- b. The maximum working flux density of a lifting electromagnet is 1.9T and the effective area of a pole face is circular in cross-section. If the total magnetic flux produced is 611mWb determine the radius of the pole face.

$$B = 1.9\text{T}$$

$$\Theta = 611\text{mWb}$$

Finding the surface area by rearranging  $B = \Theta / A$  for A

$$A = \Theta / B = (611 \times 10^{-3}) / 1.9 = 0.321\text{m}^2$$

Using the equation to find the surface area of a circle to find the radius by rearranging it for r (radius)

$$A = \pi r^2$$

$$r = \sqrt{0.321 / \pi} = 0.32\text{m}$$

1. [Explain the principle operation and construction of an electromagnet including the distribution of magnetic fields.

*"Whenever electric current flows through a conductor, a magnetic field is formed around the conductor."* This is one of the basic rules of physics which allows electromagnets to operate and means that electromagnets will only operate when there is a current flowing through them. Electromagnets function on the principle that when current flows through them they produce a magnetic field around them, this magnetic field can be made stronger by changing the shape of the conductor by winding it into a coil. This effect stacks as a coil with 10 turns will produce ten

times stronger magnetic field than a coil with only one turn. This happens as the lines of magnetic flux are close enough together, so they overlap, and this causes them to add to each other making a stronger magnetic field. ✓

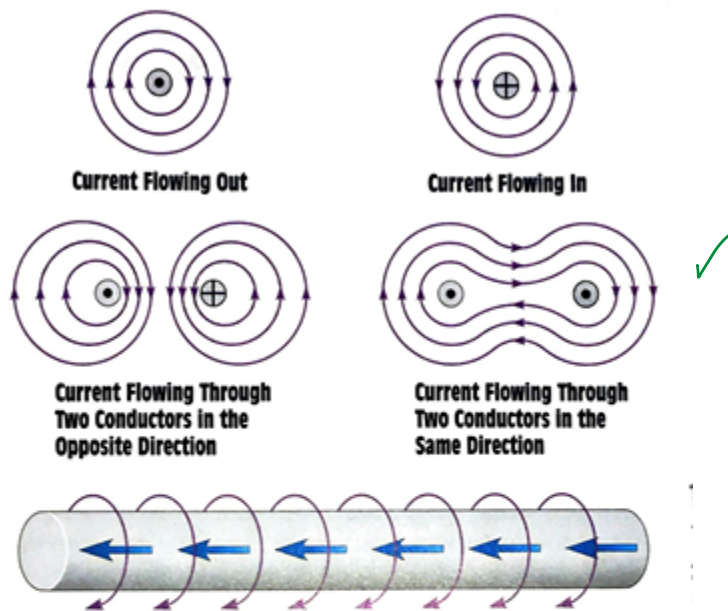


**FIGURE 4-13** Current flowing through a conductor produces a magnetic field around the conductor.

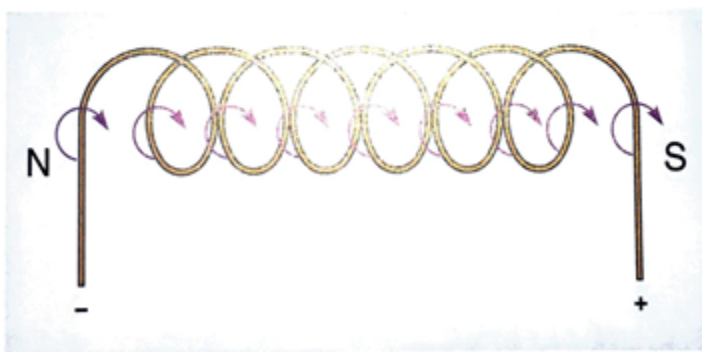


**FIGURE 4-14** Winding the wire into a coil increases the strength of the magnetic field.

Stephen L. Herman (2016). *Delmar's Standard textbook of Electricity Sixth Edition*. London: Cengage Learning. 95.

There is also another factor which effects the strength of an electromagnet, this is the amount of current flowing through the conductor, the more current which flows through the conductor the stronger the magnetic field. By increasing the current or the number of coils is the two ways to increase the field strength of an electromagnet and can be represented by amper-turns. ✓ Although the current and coils are the important factors when determining the strength of an

electromagnet the core material is also another important factor, it's important that if you are aiming to have a stronger electromagnet you will need to use a more magnetic core material. The ability of the core material to increase the magneticity of the magnet is called permeability, if the core material increases the flux generated by the magnet by a factor of 3 it will have a permeability value of 3. By having a larger permeability this causes the flux lines to be concentrated in a smaller surface area. A transformer is a device that uses some of the principles associated with electromagnetism. Explain the operation and construction of transformer, include methods to reduce power loss within the transformer. ✓

Stephen L. Herman (2016). *Delmar's Standard textbook of Electricity Sixth Edition*. London: Cengage Learning. 95.

2. Solve the following problems:

- a) A 700 turn coil of inductance 2.5H carries a current of 1.6A. Calculate the flux linking the coil and the e.m.f. induced in the coil when the current collapses to zero in 20ms.

$$N=700$$

$$L= 2.5 \text{ H}$$

$$Dt= 20\text{ms}$$

$$I= 1.6\text{A}$$

The coils inductance is  $L = N \Phi / I$  ✓

$$\Phi = IL/N = 1.6 \times 2.5 / 700 = 5.71 \times 10^{-2} \text{ Wb} \quad \checkmark \quad \text{Not completed.}$$

- b) A rectangular coil of sides 10cm and 6cm is rotated in a magnetic field of flux density 1.2T, the longer side of the coil actually cutting this flux. The coil is made up of 70 turns and rotates at 1200rev/min. (i) Calculate the maximum generated e.m.f. (ii) If the coil generates 80V, at what speed will the coil rotate?

I)

$$E = 2 \times N \times B \times L \times V \times \sin(\Theta)$$

$$N= 70$$

$$B= 1.2\text{T}$$

$$L= 10\text{cm} = 0.10\text{m}$$

$$V= 1200\text{rev/min}$$

Convert Rpm to m/s

$$(1200 \times 2\pi / 60) \times (0.06 / 2) = 3.76\text{m/s} \quad \checkmark$$

For Maximum EMF  $\Theta = 90$

$$E = 2 \times 70 \times 1.2 \times 0.10 \times 3.76 \times \sin(90) = 63.17 \text{ v}$$

II)

$$E = 80 \text{ v}$$

$$80 = 2 \times 70 \times 1.2 \times 0.10 \times v$$

$$V = 80 / 16.8$$

$$V = 4.76$$

Now, we convert back to RPM

$$(v \times 60 / 2\pi) \times (2 / 0.06) = 1515.16 \text{ RPM}$$

#### Task 4 – AC Circuits

1. Using the oscilloscope measurements for a sine wave stated in table 3 perform the following calculations
  - a. Peak voltage
  - b. Frequency
  - c. Average voltage
  - d. Root mean square (rms) voltage.

*You have not done this*

Table 3 – values for Task 4

| Student Number | Oscilloscope Settings |                   | Grid Spacing            |                      |
|----------------|-----------------------|-------------------|-------------------------|----------------------|
|                | Volts/Div             | Timebase (ms/Div) | Vertical (peak to peak) | Horizontal (1 cycle) |
| 1              | 5                     | 20                | 6.8                     | 4                    |
| 2              | 2                     | 20                | 7.2                     | 4.4                  |
| 3              | 2                     | 10                | 7.8                     | 4.4                  |
| 4              | 5                     | 10                | 5.4                     | 4.6                  |
| 5              | 5                     | 5                 | 4.8                     | 4.8                  |
| 6              | 2                     | 5                 | 6.6                     | 4                    |
| 7              | 2                     | 20                | 5.2                     | 5.2                  |

Show clearly **one full example of your method** for calculating for  $X_L (\Omega)$ ,  $Z (\Omega)$ , Current (A) and Phase Angle ( $^\circ$ ) for a chosen frequency.

2. Comment on the practical and calculation results, discussing any variations when comparing these results. *Need to state the measure values of the components.*

| Frequency (f) | CH1 (V)          | CH2 (V)          | Time                       | Calculated values    |                   |                  |
|---------------|------------------|------------------|----------------------------|----------------------|-------------------|------------------|
| (kHz)         | pk to pk Voltage | pk to pk Voltage | Difference (between peaks) |                      |                   |                  |
|               |                  |                  | (T2-T1)                    |                      |                   |                  |
|               |                  |                  | (Micro Seconds)            | Time for 1 cycle (T) | Fraction of cycle | Phase            |
|               |                  |                  |                            | $=1/f$               | $(T2-T1)/T$       | Angle (°)        |
|               |                  |                  |                            |                      |                   | (fraction x 360) |
| 1             | 1                | 0.66             | 38.1                       | 1                    | 0.0381            | 13.716           |
| 2             | 1                | 0.79             | 38.1                       | 0.5                  | 0.0762            | 27.432           |
| 3             | 1                | 0.84             | 34.9                       | 0.33333333           | 0.1047            | 37.692           |
| 4             | 1                | 0.89             | 31.9                       | 0.25                 | 0.1276            | 45.936           |
| 5             | 1                | 0.92             | 28.9                       | 0.2                  | 0.1445            | 52.02            |
| 6             | 1                | 0.95             | 27                         | 0.16666667           | 0.162             | 58.32            |
| 7             | 1                | 0.96             | 24.9                       | 0.142857143          | 0.1743            | 62.748           |
| 8             | 1                | 0.98             | 23.1                       | 0.125                | 0.1848            | 66.528           |
| 9             | 1                | 0.97             | 20.5                       | 0.11111111           | 0.1845            | 66.42            |

*Do not need so many decimal places.*

| Frequency (f - kHz) | $X_L (\Omega)$ | $R_T$       | $Z (\Omega)$ | Current (A) | Phase Angle (°) |
|---------------------|----------------|-------------|--------------|-------------|-----------------|
|                     | $(2\pi fL)$    | $(R + R_L)$ |              |             |                 |
| 1                   | 6.302034863    | 20.61       | 21.55197771  | 0.046399454 | 17.00235297     |
| 2                   | 12.60406973    | 20.61       | 24.15853211  | 0.041393243 | 31.44791995     |
| 3                   | 18.90610459    | 20.61       | 27.96806913  | 0.03575506  | 42.53099197     |
| 4                   | 25.20813945    | 20.61       | 32.56105641  | 0.030711534 | 50.73080541     |
| 5                   | 31.51017432    | 20.61       | 37.65186829  | 0.026559107 | 56.81232615     |
| 6                   | 37.81220918    | 20.61       | 43.06431542  | 0.023221082 | 61.40687526     |
| 7                   | 44.11424404    | 20.61       | 48.69125822  | 0.020537567 | 64.95820498     |
| 8                   | 50.4162789     | 20.61       | 54.46625817  | 0.018359991 | 67.76542633     |
| 9                   | 56.71831377    | 20.61       | 60.34682441  | 0.01657088  | 70.03013612     |

When Frequency is 1

*Must include all units.*

$F = 1 \text{ kHz}$

$L = 1.003 \text{ mH}$

$R_t = 20.61 \text{ Ohms}$  ← *How did you find this?*

$X_L = 2\pi fL$

$$X_L = 2\pi f L = 6.30 \text{ Ohms}$$

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{20.61^2 + 6.30^2}$$

$$Z = 21.55 \text{ Ohms}$$

$$A = 1/Z$$

$$A = 1/21.55$$

$$A = 46.40 \text{ mA}$$

$$\phi = \tan^{-1}(X_L/R)$$

$$\phi = \tan^{-1}(6.30/20.61)$$

$$\phi = 17.00 \text{ Degrees}$$

When looking back at my results in the two tables above a few conclusions can be drawn. When we look at the calculated results and the recorded results there are some variances in the values, one example of this is in the phase angle of the AC wave form. When the frequency is one, we can see that there is a difference of around 3 degrees between the recorded value and measured value. This can be down to several variables as the calculated value is the value which you would measure if every component in the circuit had exactly the value that they stated they had. For example, the actual value of the resistors we used could be up to 510% out from their actual values, this is also the same for the inductor we used as the value of this is unlikely to be what is stated on the side of this. For this reason, we would expect to have values which are different from what we had when carrying out our calculations. To try and get our results as close as possible to the measured values we could use a calibrated multimeter to measure the actual values of the components that we were using and then use these values in our calculations, but this also relies on the measuring equipment giving us the correct values. ✓

*Are there other factors to consider.*