

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	James Watts	Student ID number:	
Programme:	HNC Electrical/Electronic Engineering, Power Systems Engineering & Instrumentation Engineering		
Module:	Electrical Principles		
Module code:	PCEE4001	Contribution to Overall Module Assessment (%):	100%
Lecturer:	Jason Pointer	Internal Verifier:	Steve Roberts
Assignment Title:	Electrical Principles	Word count (or equivalent):	2000
Submission deadline:	16/01/19	Return date of provisional marks & written feedback:	
Submission method:	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.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. 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.		
Academic honesty / referencing:	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.		

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
1. Engagement with Literature Skills	15	9.75
Selection of relevant and credible sources, used a variety of books and websites. Generally sound referencing, with no inaccuracies or inconsistencies.		
2. Knowledge and Understanding Skills	25	16
Task 1 achieved 76%. Task 2 achieved 65%. Task 3 achieved 62%. Task 4 achieved 55%. Competent knowledge of the basic underlying concepts and principles. Exhibits very good understanding but have made some errors in some of the calculation work for Task 4.		
3. Cognitive and Intellectual Skills	15	9.5
Task 1 achieved 72%. Task 4 achieved 55%. Sound evaluation of the underlying concepts and principles but could have consider other factors in the evaluation of Task 4.		
4. Practical Application Skills	35	23.6
Task 1 achieved 75%. Task 4 achieved 60%. A very good application of practical work for Task 1 and 4, very good use of the test equipment to obtain all of the required results.		
5. Transferable Skills for Life and Professional Practice	10	6.5
Work is accurate, coherent, fluent, well-structured and organised.		

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)		66%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		



ELECTRICAL PRINCIPLES

James Watts

Contents

Task 1 – DC Circuits	3
Series Circuit.....	3
Parallel Circuit.....	7
Task 2 – Capacitors	9
Task 3 – Magnetism.....	12
Task 4 – AC Circuits	16
References	19
Bibliography.....	20

Introduction

The aim of this assignment is to develop an understanding of the fundamentals of electrical principles through theoretical and practical applications. The assignment will cover the following areas of Electrical Principles – DC circuits, Capacitors in DC circuits, magnetism and AC circuits. This will be achieved through a range of practical, calculation and research work.

Task 1 – DC Circuits

The circuits below show 2 different arrangement of DC circuits. Figure 1a is a series circuit and figure is 1b is a parallel circuit.

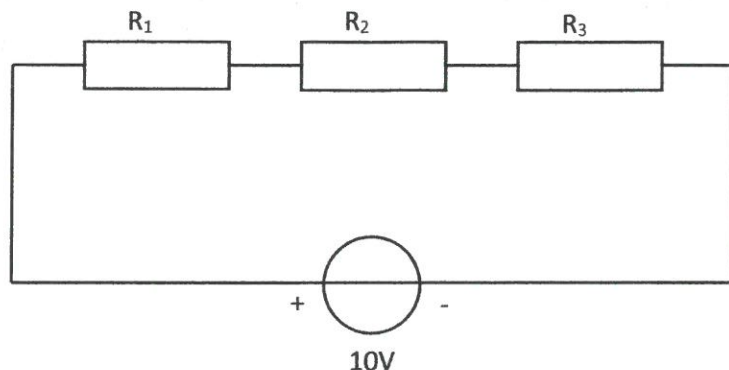


Figure 1a – Resistors in Series

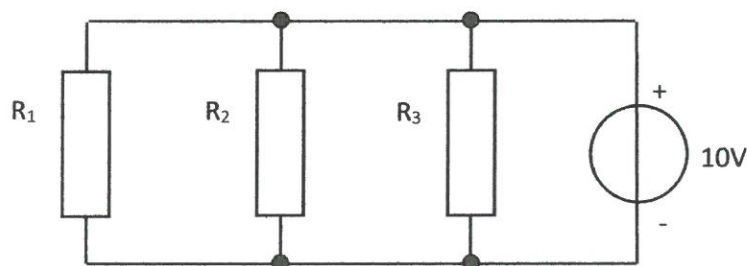


Figure 1b – Resistors in Parallel

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

Table 1 – values for Task 1

Group Number	R_1 (Ω)	R_2 (Ω)	R_3 (Ω)
Series			
4	180	470	680
Parallel			
4	10k	2.7k	5.6k

Series Circuit

1. Construct the circuit and measure the total resistance (R_T) before connecting the power supply.
2. Connect a 10V supply and measure the p.d. value across each resistor and the supply current.

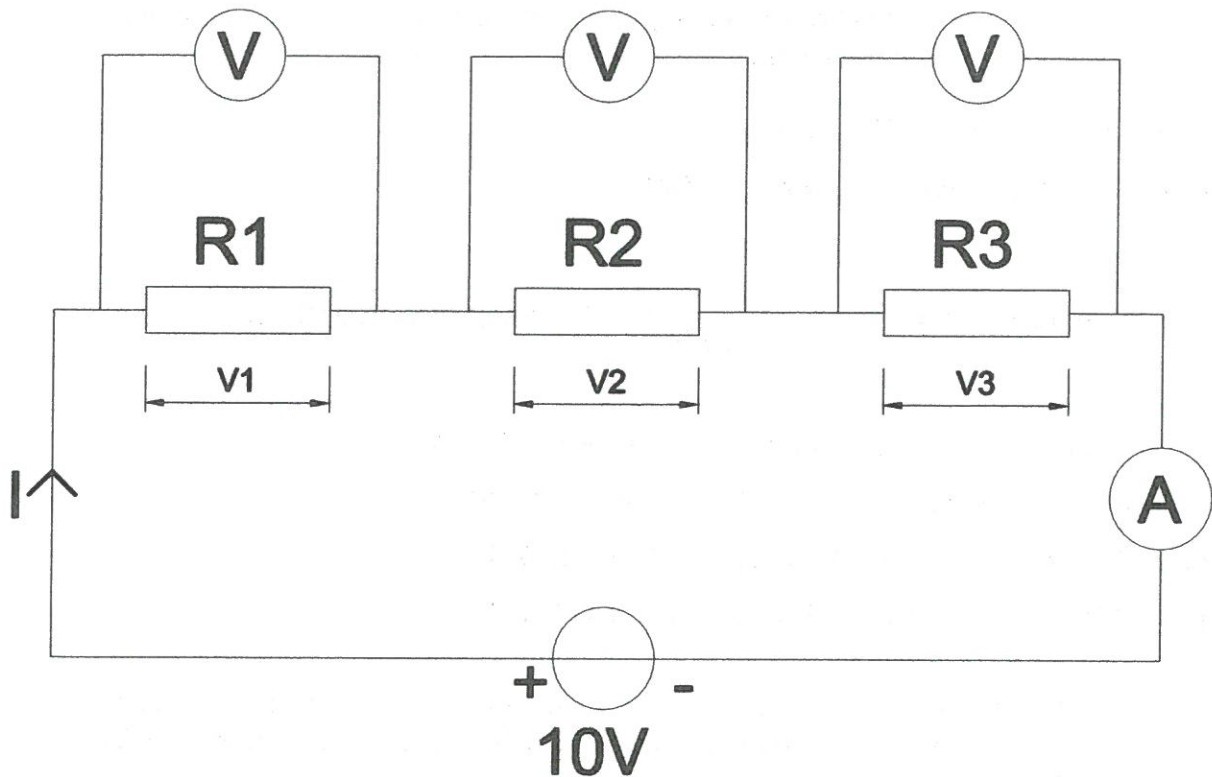


Figure 1 - Measuring Electricity in a Series Circuit

Series Circuit Measurements		
Total Resistance (No Power)	1.318k Ω ✓	
Supply Current	7.50mA ✓	
Potential difference (p.d) across each resistor	R1 (180 Ω)	1.33V ✓
	R2 (470 Ω)	3.48V ✓
	R3 (680 Ω)	5.11V ✓

Table 1 - Series Circuit Measurements

3. Calculate the total resistance, supply current and the p.d. value across each resistor. All formulas and workings must to be shown.

Total Resistance, $R_t = R_1 + R_2 + R_3$

$R_t = 180 + 470 + 680 = 1330\Omega = 1.33k\Omega$

Supply Current = $I = \frac{V}{R_t}$ $I = \frac{10}{1330} = 7.5187 \times 10^{-3} = 7.518mA$

Potential Difference across each resistor – $V = I \times R$

$R_1 (180\Omega) = I \times R_1 = 7.5187 \times 10^{-3} \times 180 = 1.35V$

$R_2 (470\Omega) = I \times R_2 = 7.5187 \times 10^{-3} \times 470 = 3.53V$

$R_3 (680\Omega) = I \times R_3 = 7.5187 \times 10^{-3} \times 680 = 5.11V$

4. Comment on the practical and calculation results, discussing any variations when comparing these results and make reference to relative theories such as Kirchhoff's laws.

The results gathered whilst testing the series circuit varied slightly compared the calculated answer, as shown in table 2. Table 2 shows the difference in total resistance between the measured and calculated value is 12Ω and the other values measured are very similar but only the measurement and calculation of resistor 3 correspond with each other. The difference in practical measurements and calculations can be caused by multiple factors such as the accuracy of test equipment and the materials used to perform the task. The resistors used within the circuit had a tolerance of $\pm 5\%$ as they had a gold tolerance band. For example, a 500Ω resistor could have a value between 475Ω and 525Ω . This would cause the potential difference to vary when carrying out the measurement, whereas with the calculation the resistor value is fixed, therefore no deviation. The power supply unit could have also caused the results to vary due to it not being calibrated, therefore it may not be accurate. An error whilst recording the measurement could be made by the equipment user by rounding incorrectly, causing the results to be different from the actual value.

The accuracy of a piece of test equipment is how close the measured value is to the actual value. It's the amount of error in the result of a measurement in respect to the absolute standard. This error of accuracy can be checked by measuring the

applied voltage with a digital multimeter. However, the multimeters available are not calibrated so cannot be considered a reliable source for testing the potential difference. The digital multimeter is placed in parallel with the resistors to measure the potential difference, potentially altering the resistance in the circuit. This is supported by Bird (2007, p.115) stating that 'voltmeters should have as high resistance as possible' as Bird (2007, p.115) says they create a 'loading effect'. This reinforces the concept of multimeters having the potential to affect the circuit measurements.

The series circuit follows the principle of Kirchhoff's voltage law. This is referred to by Bird (2007, p.179) as 'in any closed loop in a network, the algebraic sum of the voltage drops (i.e. products of current and resistance) taken around the loop is equal to the resultant e.m.f. acting in that loop.' This can be simplified as the energy that enters the circuit is equal to what leaves the circuit. This is proved when finding the sum of the voltage values, which is shown in equation 1 and 2. The calculated value is 0.01V away from being equal to the input, whereas the measured value is 0.08V away. The difference for the calculated value is because of only working to two decimal places when carrying out the calculations in task 1, part 3.

Equation 1 – Total Voltage of Calculated Values

$$1.35 + 3.53 + 5.11 = 9.99V$$

Equation 2 - Total Voltage of Measured Values

$$1.33 + 3.48 + 5.11 = 9.92V$$

	Total Resistance	Supply Current	Potential Difference across each resistor		
			R1	R2	R3
Measurement	1.318kΩ	7.50mA	1.33V	3.48V	5.11V
Calculation	1.33kΩ	7.518mA	1.35V	3.53V	5.11V
Difference	12Ω	18μA	0.02V	0.05V	0V

Table 2 - Comparison of Measurement and Calculation Values for Series Circuit

Good work.

Parallel Circuit

- Construct the circuit and measure the total resistance (R_T) before connecting the power supply.

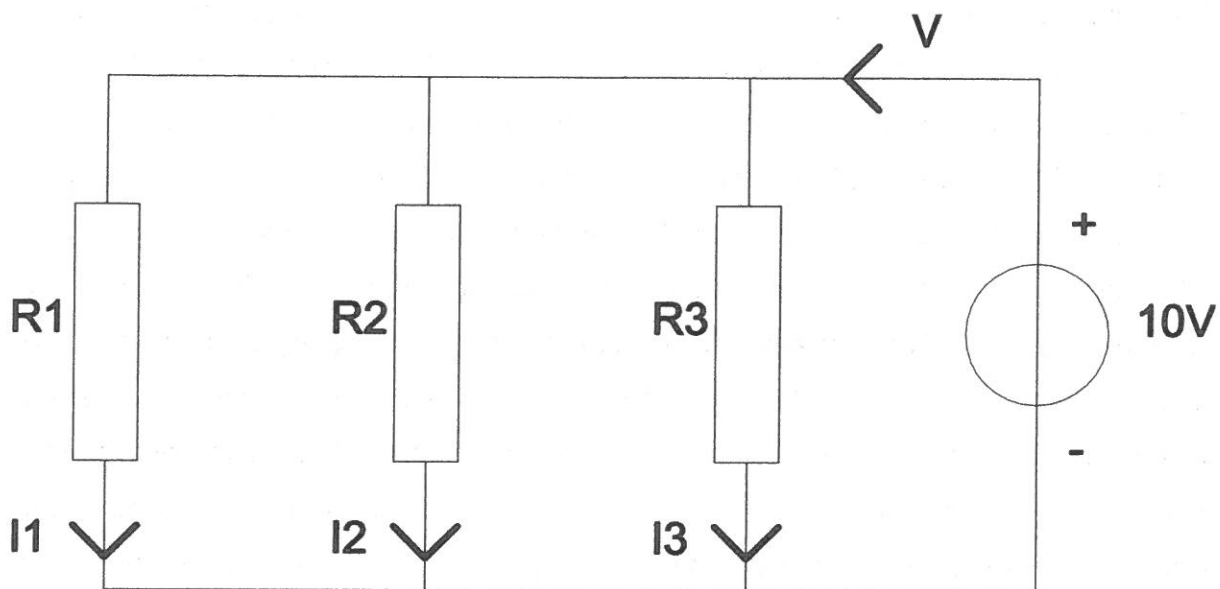


Figure 2 – Parallel Circuit Configuration

- Connect a 10V supply and measure the current through each resistor and the supply current.

Parallel Circuit Measurements		
Total Resistance (No Power)	1.527k Ω	
Supply Current	6.47mA	
Current through each resistor	R1 (10k Ω)	0.988mA
	R2 (2.7k Ω)	3.71mA
	R3 (5.6k Ω)	1.77mA

Table 3 - Parallel Circuit Measurements

7. Calculate the total resistance, supply current and the current through each resistor. All formulas and workings must to be shown.

$$\text{Total Resistance, } \frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_t} = \frac{1}{10 \times 10^3} + \frac{1}{2.7 \times 10^3} + \frac{1}{5.6 \times 10^3} = 6.489 \times 10^{-4}$$

$$\frac{1}{R_t} = \frac{1}{6.489 \times 10^{-4}} = 1540.97 \Omega = \mathbf{1.5409k\Omega}$$

$$\text{Supply Current} = I = \frac{V}{R_t} \quad I = \frac{10}{1540.97} = 6.489 \times 10^{-3} = \mathbf{6.489mA}$$

$$\text{Current through each resistor} = I = \frac{V}{R}$$

$$R_1 (10k\Omega) = I_1 = \frac{10}{10 \times 10^3} = 1 \times 10^{-3} = \mathbf{1mA}$$

$$R_2 (2.7k\Omega) = I_2 = \frac{10}{2.7 \times 10^3} = 3.703 \times 10^{-3} = \mathbf{3.703mA}$$

$$R_3 (5.6k\Omega) = I_3 = \frac{10}{5.6 \times 10^3} = 1.785 \times 10^{-3} = \mathbf{1.785mA}$$

8. Comment on the practical and calculation results, discussing any variations when comparing these results and make reference to relative theories such as Kirchhoff's laws.

In a parallel circuit the current is divided down each node in the circuit. This is expressed by Bird (2007, p.44) stating that 'the sum of the currents I_1 , I_2 and I_3 is equal to the total circuit current, I '. This shows that the sum of the individual currents is the input current. Whereas, in a series circuit the voltage varies and the current stays constant. This indicates that the parallel circuit obeys Kirchhoff's Current Law. This is referred to by Bird (2007, p.179) as the 'At any junction in an electric circuit the total current flowing towards that junction is equal to the total current flowing away from the junction'.

The results gathered whilst testing the parallel circuit varied slightly compared the calculated answer which is shown in table 4 below. The differences in results between the calculation and the practical suffer from the same errors that were encountered with the series circuit. However, to measure the current flowing through an individual resistor, the multimeter is placed in series. When measuring current, the multimeter has a low resistance so that the measured value is as close to the actual current flow as possible. If a high resistance was placed in series to measure current, it would

cause a lower current reading to be made, causing the measurement to be further away from the actual current value.

	Total Resistance	Supply Current	Current through each resistor		
			R1	R2	R3
Measurement	1.527k Ω	6.47mA	0.988mA	3.71mA	1.772mA
Calculation	1.5409k Ω	6.489mA	1mA	3.703mA	1.785mA
Difference	13.9 Ω	19 μ A	12 μ A	7 μ A	13 μ A

Table 4 - Comparison of Measurement and Calculation Values for Parallel Circuit

Task 2 – Capacitors

A capacitor is an electronic devices that stores electrical charge and is used in a number electronic applications.

1. Explain the construction and function of a capacitor, listing some of the different types that are available and typical values.

A capacitor is an electrical component that is used to store electric charge and release the electricity shortly after, the capacitance is measured in Farads (F). This is supported by Woodford (2018) who describes the actions of a capacitor as 'Adding electrical energy to a capacitor is called charging; releasing the energy from a capacitor is known as discharging.' This shows that capacitors act similarly to batteries but release their stored energy faster. A capacitor consists of a layers of conductive materials which are separated by an insulator. This is maintained by Woodford (2018) who states that 'conductors (known as plates ...) and there's the insulator in between them (called the dielectric).'

There are many different types of capacitors available, the function and size of a capacitor is dependent on the type of capacitor. A variable air capacitor is made from two aluminium plates separated by air. One of the two plates is able to be rotated, causing the capacitance to vary due to the change in cross-sectional area, as shown in figure 3. Bird (2007, p.67) states that the maximum size of a variable air capacitor is 'between 500 pF and 1000 pF.'

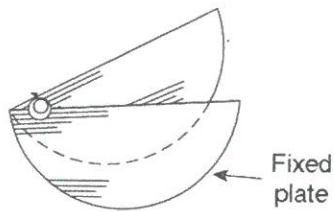


Figure 3 - Variable Air Capacitor, Bird (2007, p.67)

Electrolytic capacitors are created using aluminium foil used for the plates along with an absorbent material that is filled with an electrolyte. The absorbent layer of paper between the plates is a conductor and does not act as a dielectric. It is enclosed within an aluminium container and sealed. The function of the capacitor is determined by the structure of a thin aluminium oxide coating which forms the dielectric. These types of capacitors must be used only on direct current circuit and are polarity sensitive.

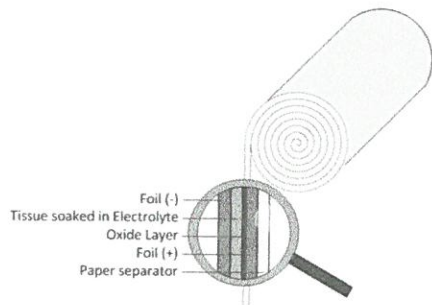


Figure 4 – Electrolytic Capacitor (Capacitorguide)

2. Figure 2 shows a circuit containing three capacitors in series/parallel to a d.c. voltage source.

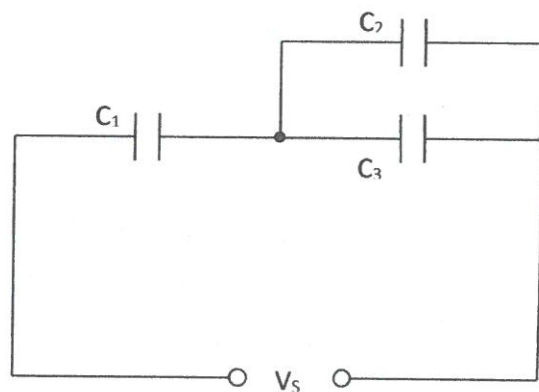


Figure 5

a) The equivalent circuit capacitance

$$C_{23} = C_2 + C_3 = 24 \times 10^{-6} + 27 \times 10^{-6} = 51 \mu\text{F}$$

$$C_t = \frac{12 \times 10^{-6} \times 51 \times 10^{-6}}{12 \times 10^{-6} + 51 \times 10^{-6}} = 9.71 \mu\text{F}$$

b) The total charge

$$Q_t = C_t \times V = 9.71 \times 10^{-6} \times 15 = 145.65 \mu\text{C}$$

c) The charge in each capacitor

Charge for Q_1 is equal to Q_t (in series circuit)

$$Q_1 = Q_t = 145.65 \mu\text{C}$$

$$V_1 = \frac{Q_1}{C_1} = \frac{145.65 \times 10^{-6}}{12 \times 10^{-6}} = 12.14 \text{V}$$

$$V_2 = V_t - V_1 = 15 - 12.14 = 2.86 \text{V}$$

$$\text{Therefore; } Q_2 = C_2 \times V_2 = 24 \times 10^{-6} \times 2.86 = 68.64 \mu\text{C}$$

$$Q_3 = C_3 \times V_2 = 27 \times 10^{-6} \times 2.86 = 77.22 \mu\text{C}$$

d) The energy stored in each capacitor

$$W_1 = 0.5 \times C_1 \times V_1^2 = 0.5 \times 12 \times 10^{-6} \times 12.14^2 = 884.27 \mu\text{J}$$

$$W_2 = 0.5 \times C_2 \times V_2^2 = 0.5 \times 24 \times 10^{-6} \times 2.86^2 = 98.15 \mu\text{J}$$

$$W_3 = 0.5 \times C_3 \times V_2^2 = 0.5 \times 27 \times 10^{-6} \times 2.86^2 = 110.42 \mu\text{J}$$

e) The total energy stored in the circuit.

$$W_t = 0.5 \times C_t \times V^2 = 0.5 \times 9.71 \times 10^{-6} \times 15^2 = 1092.85 \mu\text{J} = 1.09 \text{mJ}$$

Table 5 – Values for Task 2

Student Number	C_1 (μF)	C_2 (μF)	C_3 (μF)	V_s (V)
8	12	24	27	15

Task 3 – Magnetism

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

Permanent magnets are made of ferromagnetic materials such as Iron. Permanent magnets are a piece of metal which have a North and South Pole and the magnetism cannot be deactivated, unlike with electromagnets. Similar poles will repel away from each other before they come into contact and opposite poles will attract each other. Figure 8 shows magnetic field flux lines travelling in an away direction from the North End of the magnet, towards the South End, forming a closed loop and the field lines do not overlap each other. If a magnetic material is brought near to a permanent magnet, the electrons inside of the magnetic material will position its revolutions to correspond with the magnetic field of the permanent magnet, causing the material to be magnetised.

A permanent magnet's strength is greater when the lines of magnetic flux are nearer together. This is reinforced by Bird (2007, p.72) who states 'stronger the field the closer are the lines of magnetic flux and vice versa.' This indicates that a magnetic material is subject to a stronger force the nearer it gets to the magnet.

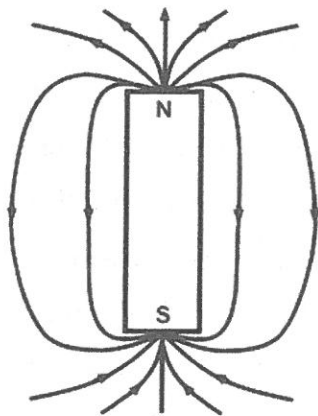


Figure 6 - Magnetic Field of a Permanent Magnet (Unknown, SparkNotes)

2. Solve the following problems:

- a) A magnetic pole face has a rectangular section having dimensions 250mm by 120mm. If the total flux emerging from the pole is $120\mu\text{Wb}$, calculate the flux density.

$$a = 0.25 \times 0.12 = 0.03\text{m}^2 = 0.03 \times 10^{-4}\text{m}^2$$

$$B = \frac{\Phi}{a} = \frac{120 \times 10^{-6}}{0.03 \times 10^{-4}} = 40\text{T} = 4\text{mT}$$

Your value was already in m^2

- b) The maximum working flux density of a magnet is 1.5T and the effective area of a pole face is circular in cross-section. If the total magnetic flux produced is 340mWb , determine the radius of the pole face.

$$a = \frac{\Phi}{B} = \frac{340 \times 10^{-3}}{1.5} = 0.226\text{m}^2$$

$$r = \frac{D}{2} = \frac{0.226}{2} = 0.113\text{m}$$

wrong method

3. Explain the principle operation and construction of an electromagnet including the distribution of magnetic fields. Also discuss two applications where the principles of electromagnetism is used.

Electromagnets are formed from coils of wire with an electric current flowing through it. Electromagnets have a field around the conductor which carries current. The fields are in the form of concentric circles and are positioned along the length of the conductor as shown in figure 9. The direction of rotation of the circles is determined by the current flow direction. If the fields' circles rotate in a clockwise direction, the current flows away from the observer and towards the observer if the rotation is anti-clockwise. This is known by utilising the screw rule, which is supported by figure 10. The direction can be changed by turning the supply around.

The strength of the magnet can be increased by wrapping the coil of wire around a piece of ferromagnetic material. It can also be strengthened by increasing the number of turns in the coil and by increasing the current flow.

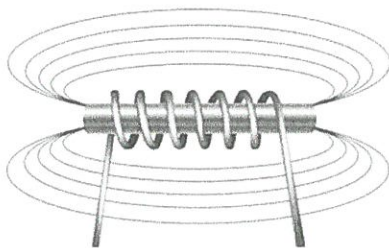


Figure 7 – Electromagnetism (Brain and Looper, Howstuffworks)



Figure 8 - Screw Rule (Bird, p.86)

Electromagnetic induction is based on two key concepts which are: Faradays and Lenz's Laws. Faraday's law states that if there is a change in the magnetic field of a conductor or circuit, it will cause an electromotive force (emf) which will be induced into the coil. The amount of emf that is induced is proportional to the amount of change of magnetic flux. The change of emf can be caused by moving the magnet towards or away from the conductor or circuit or by adjusting the magnetic field strength by applying a greater amount of current. This is reinforced by Bird (2007, p.97) who cites Faraday's Laws by stating 'induced e.m.f. is set up whenever the magnetic field linking that circuit changes. The magnitude of the induced e.m.f. in any circuit is proportional to the rate of change of the magnetic flux linking the circuit.'

Lenz's law which is based on Faraday's law of induction states that when an emf is created by a change in magnetic flux, the polarity of the induced emf produces a current that's magnetic field opposes the change that produces it. This means that when a north pole of a magnet travels towards the coil, the magnetic flux of the coil increases. The magnetic field that is created will oppose the increase in flux through the coil. This law obeys Newton's Third Law because for each action, there is an equal and opposite reaction. This is supported by Unknown (2018, Electrical4u) who explains 'when an emf is generated by a change in magnetic flux according to Faraday's Law, the polarity of the induced emf is such, that it produces an current that's magnetic field opposes the change which produces it.'

A common application of an electromagnet is the squirrel cage induction motor, which is commonly used for powering positive displacement pumps and machining equipment. This type of motor uses a stator which is constructed from coils of electromagnetic conductors. The conductors are paired together to make a North and South Pole which are reversed every half cycle of the sine wave. The greater number of poles, the more torque the motor produces. The stator is in the shape of the ring and inside of the ring is a squirrel-cage rotor made from conductive metal bars connected together. When an electrical current is passed through the stator, a magnetic field is produced surrounding the rotor, inducing a current into the rotor. This in turn produces its own opposing magnetic field, generating torque which turns the rotor. This is supported by Miller and Miller (2014, p.145) who states 'currents set up an opposite-polarity field in the rotor. The attraction between these opposite stator and rotor fields produces the torque'.

A relay is a switch that is capable of turning on and off large loads using a low voltage signal. They use electromagnets which when current flows through the coil, creating a magnetic field. A ferromagnetic material known as the armature is then attracted and is drawn into the coil. Attached to the armature is a switch which then either makes or breaks a contact. They are commonly used in motor control circuits and in automobiles. ✓

Could have included some diagrams.

4. Solve the following problems:

- a) A conductor 320mm long carries a current of 8A and is at right-angles to a magnetic field lying between two circular pole faces each of radius 60mm. If the total flux between the pole faces is 0.4mWb, calculate the magnitude of the force exerted on the conductor.

$$F = BIL$$

$$a = \pi r^2 = \pi \times 0.06^2 = 0.0113\text{m}^2$$

$$B = \frac{\Phi}{a} = \frac{0.4 \times 10^{-3}}{0.0113} = 0.0354\text{T}$$

$$F = BIL = 0.0354 \times 8 \times 0.32 = 0.091\text{N}$$

- b) A 400mm length of conductor carrying a current of 25A is situated at right-angles to a magnetic field between two poles of an electric motor. The poles have a circular cross-section. If the force exerted on the conductor is 80N and the total flux between the pole faces is 1.27mWb, determine the diameter of a pole face.

$$B = \frac{F}{IL} = \frac{80}{25 \times 0.4} = 8\text{T}$$

$$a = \frac{\Phi}{B} = \frac{1.27 \times 10^{-3}}{8} = 158.75 \times 10^{-6}\text{m}^2$$

$$a = \pi r^2 \rightarrow r = \sqrt{\frac{a}{\pi}} = \sqrt{\frac{158.75 \times 10^{-6}}{\pi}} = 7.108 \times 10^{-3}\text{m}$$

$$D = 2r = 7.108 \times 10^{-3} \times 2 = 14.217 \times 10^{-3}\text{m} = 14.217\text{mm}$$

Task 4 – AC Circuits

1. Using the oscilloscope measurements for a sine wave stated in table 3 perform the following calculations
 - a) Peak voltage

Peak Voltage = $\frac{1}{2} \times \text{Peak to Peak Voltage} = \frac{1}{2} \times 6.4 = 3.2V$ ~~X~~ $= \frac{0.5 \times 6.4}{2} = 1.6V$

- b) Frequency

Frequency = $\frac{1}{T} = \frac{1}{20} = 0.05Hz$ ~~x~~ *you have not consider the grid spacing.*

- c) Average voltage

Average voltage = $0.637 \times Vp = 0.637 \times 3.2 = 2.038V$ *correct method*

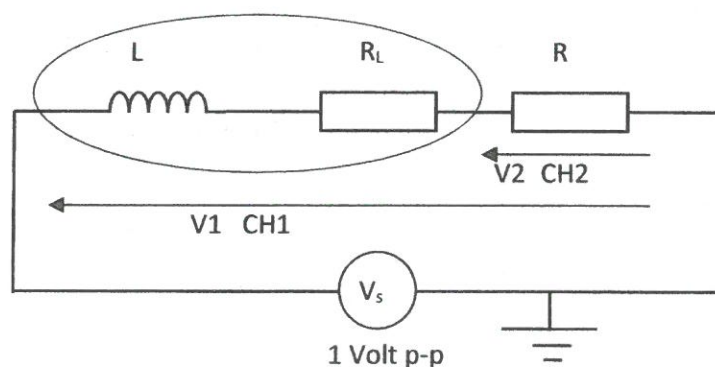
- d) Root mean square (rms) voltage.

$V_{rms} = \frac{Vp}{\sqrt{2}} = \frac{3.2}{\sqrt{2}} = 2.26V$ *correct method*

Table 6- Values for Task 4

Student Number	Oscilloscope Settings		Grid Spacing	
	Volts/Div	Timebase (ms/Div)	Vertical (peak to peak)	Horizontal (1 cycle)
8	0.5	20	6.4	5.2

2. Below is a RL circuit:



$L = 1mH, R = 10\Omega, R_L = ?\Omega$ (measure this value)

3. Measure and record the value of each of the component.

$L = 1mH$

$R = 9.97\Omega$

$R_L = 2.55\Omega$

4. Produce a table of measurements as shown below:

Frequency (f) (kHz)	CH1 (V) <i>pk to pk</i> Voltage	CH2 (V) <i>pk to pk</i> Voltage	Time Difference (between peaks) ($T_2 - T_1$)	Calculated values		
				Time for 1 cycle (T) $= 1/f$	Fraction of cycle ($T_2 - T_1$)/ T	Phase Angle ($^\circ$) (fraction $\times$ 360)
1	221.76	152.46	88	0.001	0.088	31.68
2	277.2	148.5	60	0.0005	0.12	43.2
3	336.6	144.54	46	0.00033	0.138	49.68
4	403.92	142.56	44	0.00025	0.176	63.36
5	467.28	134.64	38	0.0002	0.19	68.4
6	514.8	130	32	0.000167	0.192	69.12
7	570.24	124.74	28	0.000143	0.196	70.56
8	609.84	118.8	26.4	0.000125	0.2112	76.032
9	657.36	112.36	23.2	0.00011	0.2088	75.168

5. Produce a table of calculations as shown below:

Frequency (f - kHz)	$X_L (\Omega)$ ($2\pi fL$)	$R_T (R+R_L)$	$Z (\Omega)$	Current (mA)	Phase Angle ($^\circ$)
1	6.283	12.52	14.008	71.387	26.650
2	12.566	12.52	17.739	56.374	45.106
3	18.850	12.52	22.629	44.192	56.408
4	25.133	12.52	28.079	35.614	63.520
5	31.416	12.52	33.819	29.569	68.272
6	37.699	12.52	39.724	25.174	71.629
7	43.982	12.52	45.730	21.868	74.110
8	50.265	12.52	51.801	19.305	76.014
9	56.549	12.52	57.918	17.266	77.516

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

Example shown for 3kHz of frequency.

$$X_L = 2\pi FL = 2 \times \pi \times 3 \times 10^3 \times 0.001 = 18.85\Omega$$

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{12.52^2 + 18.85^2} = 22.629\Omega$$

$$\text{Current} = I = \frac{V}{Z} = \frac{1}{22.629} = 44.192 \times 10^{-3} = 44.192\text{mA}$$

$$\text{Phase Angle} = \theta = \tan^{-1} \left(\frac{V_L}{V_R} \right)$$

$$V_R = I \times R$$

$$V_L = I \times X_L$$

$$\theta = \tan^{-1} \left(\frac{V_L}{V_R} \right) = \tan^{-1} \left(\frac{18.85}{9.97} \right) = 56.408^\circ$$

6. Comment on the practical and calculation results, discussing any variations when comparing these results.

The phase angle results from the calculation method predominantly differs from the practical measuring method. An example of this can be shown when the frequency is at 1 kHz, where the calculated value is 26.65° and the measured value is 31.68° . This is a large difference of 5.03° . The difference of values between calculations and measurements is likely to be caused by human error when using the oscilloscope. This is because if the oscilloscope is not correctly configured it is possible to obtain inaccurate results. For the oscilloscope to be correctly configured, the horizontal time base and vertical volts/ division need to show a complete view of the sine wave so that it can be measured accurately. To measure the peak to peak voltage, the cursors are manually moved into position between two peaks of the sine wave. This method is vulnerable to parallax error as it is difficult to position each cursor at the peak of the waveform. The variation in results could also be caused by the test equipment used being out of calibration, leading to inaccurate measurements.

References

Bird, J (2007). *Electrical and Electronic Principles and Technology*. 3rd Edition. Oxford: Elsevier Ltd.

Brain, M and Looper, L. (No date). Howstuffworks. [Online]. [13 January 2019]. Available from: <https://science.howstuffworks.com/electromagnet3.htm>

Miller, R and Miller, M.R. (2014). *Industrial Electricity and Motor Controls*. 2nd Edition. London: McGraw-Hill Education.

Unknown, (2018). Electrical4u. [Online]. [13 January 2019]. Available from: <https://www.electrical4u.com/lenz-law-of-electromagnetic-induction/>

Unknown. (No date). Capacitor Guide. [Online]. [13 January 2019]. Available from: <http://www.capacitorguide.com/electrolytic-capacitor/>

Unknown, (No date). SparkNotes. [Online]. [13 January 2019]. Available from: <https://www.sparknotes.com/physics/magneticforcesandfields/sourcesofmagneticfields/section1/>

Woodford, C. (2018). Explain that Stuff. [Online]. [12 January 2019]. Available from: <https://www.explainthatstuff.com/capacitors.html>

Bibliography

Bird, J (2007). *Electrical and Electronic Principles and Technology*. 3rd Edition.
Oxford: Elsevier Ltd

Brain, M and Looper, L. (No date). Howstuffworks. [Online]. [13 January 2019]. Available from: <https://science.howstuffworks.com/electromagnet3.htm>

Miller, R and Miller, M.R. (2014). *Industrial Electricity and Motor Controls*. 2nd Edition.
London: McGraw-Hill Education

Unknown. (No date). BBC Bitesize. [Online]. [13 January 2019]. Available from:
<https://www.bbc.com/bitesize/guides/z3g8d2p/revision/5>

Unknown. (No date). Capacitor Guide. [Online]. [13 January 2019]. Available from:
<http://www.capacitorguide.com/electrolytic-capacitor/>

Unknown, (2018). Electrical4u. [Online]. [13 January 2019]. Available from:
<https://www.electrical4u.com/lenz-law-of-electromagnetic-induction/>

Unknown. (2019). Mccdaq. [Online]. [10 January 2019]. Available from:
<http://kb.mccdaq.com/KnowledgebaseArticle50043>

Unknown, (No date). SparkNotes. [Online]. [13 January 2019]. Available from:
<https://www.sparknotes.com/physics/magneticforcesandfields/sourcesofmagneticfields/section1/>

Woodford, C. (2018). Explain that Stuff. [Online]. [12 January 2019]. Available from:
<https://www.explainthatstuff.com/capacitors.html>.

