

LEVEL 4 ASSESSMENT SPECIFICATION

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Programme:	HNC Electrical/Electronic Engineering, Power Systems Engineering & Instrumentation Engineering		
Module:	Electrical Principles		
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Lecturer:	Jason Pointer	Internal Verifier:	Steve Roberts
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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
Selection of relevant and credible sources, used a number of books and websites. Generally sound referencing, with no inaccuracies or inconsistencies but could have included a few more references.		
2. Knowledge and Understanding Skills	25	18
Task 1 achieved 75%. Task 2 achieved 75%. Task 3 achieved 65%. Task 4 achieved 80%. Excellent knowledge and understanding of the basic underlying concepts and principles of the subject.		
3. Cognitive and Intellectual Skills	15	10
Task 1 achieved 70%. Task 4 achieved 65%. Sound evaluation of the underlying concepts and principles applied to Task 1 and 4, made a very good effort in discussing the results.		
4. Practical Application Skills	35	26
Task 1 achieved 75%. Task 4 achieved 75%. 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.		
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)

Up to 1 week late (40% Max)

Over 1 week late (0%)

70%

Electrical Principles

HNC Electrical and Electronic Engineering

James Bacon

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1.1 Overview of the Report

This report investigates electrical principle of resistors and capacitors in a D.C. (Direct Current) E.M.F. (Electromotive Force) in a parallel and series circuit. Magnetism what a permanent magnet and electromagnetism are. An A.C. (Alternating Current) E.M.F. in a series circuit using an inductor and a resistor.

1.2 Resistor in a DC Series and Parallel Circuits

1.2.1 Overview

A resistor is used to create a resistance to the flow of current within the circuit.

1.2.2 Comments on the results from Theoretical and Practical Experiment.

From conducting a theoretical experiment on resistors within a series circuit (See: 2.1.0) and a practical experiment of the same circuit (See: 2.2.0). To see if the voltage gained between the resistors from the experiments correlate to the ones collected with the E.M.F supply voltage. As observed from the voltage calculations on the practical, these are close to the figures shown in theoretical calculations even with slightly lower or higher resistors being used. These voltage calculations within the practical and theoretical circuit confirms Kirchhoff's voltage law. As stated by Bird (2017, p.220) Kirchhoff's voltage law is 'that 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 law is confirmed with the circuit as by add up all voltage in resistors (V_T) as shown in both theoretical (See: 2.1.8) and practical (See: 2.2.9) experiment, it does equal similar value to the E.M.F. voltage of the circuit. The reasons why the values aren't exact can be down to the rounding in calculations as each calculation is given in 2 decimal places. This can make the voltage slightly off to the actual value. Example of this is if you take the total current on practical experiment (2.2.4) as calculated result gives: 0.008688097A which has been rounded to 8.69mA. Due to this it gives knock on an effect onto each voltage calculated as 8.69mA is used and not full calculated result. The calculation is not using exact figure so answer to the voltage in each resistor will be slight lower than the true value. Which explain why they voltage within each resistor when added together are slight off from the E.M.F. supply voltage but this still confirms Kirchhoff's voltage law as if more accurate calculations were used it would mean that voltage of all resistor would equal the E.M.F. supply voltage.

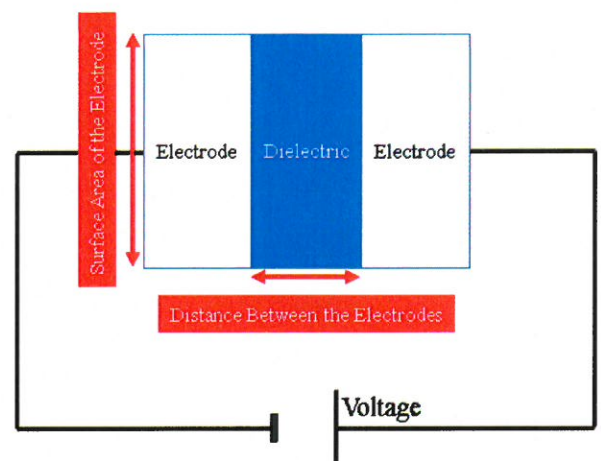
These rounding also appears within the theoretical (See: 2.3.0) and practical (See: 2.4.0) experiment of resistors in parallel. These experiments give a different outcome as the current of the circuit was measured and these confirm Kirchhoff's current law. Also stated, by Bird (2017, p.220) Kirchhoff's current law is 'at any junction in an electric circuit the total current flowing towards that junction is equal to the total current flowing away from then junction'. This law can be confirmed within these experiment as the calculations of the total current of circuit in the practical (2.4.4) does equals the total resistor current (2.4.8) of the same experiment. Another issue other than the rounding which could cause the values to be slightly off than the actual result is that the resistance within the resistor is not exact theoretical values. This is due to the tolerance within the resistor are - + 5% of the stated resistance value as result and will be hard to find a resistor with state values due to the tolerance within the resistors so in order more accurate calculations, resistors with lower tolerance to the stated values need to be used. Even though tolerance it still confirms Kirchhoff's circuit law because if you consider the resistors tolerance within the calculations then it would equal the circuit's current.

1.3 Capacitor in a DC Series and Parallel Circuits

1.3.1 Overview

A Capacitors is an electric device that stores electrical charge. This is achieved by having two conducting plates between each other in parallel which are commonly called Electrode and having insulating material as more commonly known as a Dielectric between them, Which can be seen from the diagram to the right. As each electrode is connected to each side of the E.M.F the

voltage goes into the conducting plate which creates an electric field in the dielectric. Which in turn stores electrical charge within the capacitor. This is agreed by Hiley, Brown & Smith (2012 p.26) 'as materials with sizeable energy gaps between the valence and conduction bands are used to insulate the circuit and to contain the current within the conductors.' A way to improve electorol charge stored in a capacitor is to have a narrower distance between the electrodes as this increase the strength in the electric field so more charge can be stored. Whereas if a wider gap is used means that there is less electrical charge being stored. This is different if there is a higher surface area of the electrode as there are more electric field is present thus meaning that there is more charge can be stored whereas less surface means that there is charge stored.



1.3.2 Different Type of Dielectrics

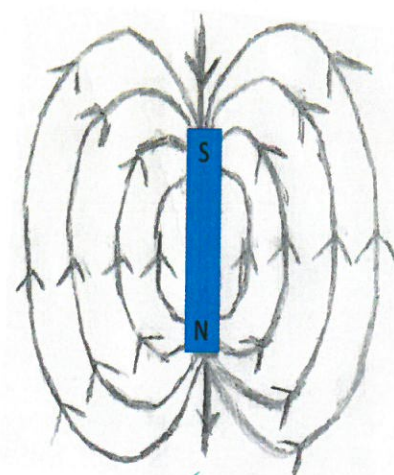
Capacitors Material:	Typical Capacitance Range:	Typical Voltage Ratings:	Typical Tolerance Range:	Features:
Electrolytic	1 μ F – 47mF	2.5V – 300V	20%	An electrolyte capacitor is a capacitor with a liquid containing a high concentration of ions that is soaked into a paper spacer then wrapped in either tantalum or aluminium. These capacitors are typical polarized, so they need be used in a DC Circuit. These found in large amount of domestic appliance and in pc components.
Mica	F1 pF – 1 nF.	100V – 1kV	$\pm 1\%$ - $\pm 20\%$	A Mica capacitor is made by having to mica sheet that are coated in metal sandwiched together these then put in an epoxy to protect them. These are reliable capacitor, but they give very small capacitance values. These values do not change overtime. These are more expensive and due to size are rarely used.

Capacitor Guide (2018)

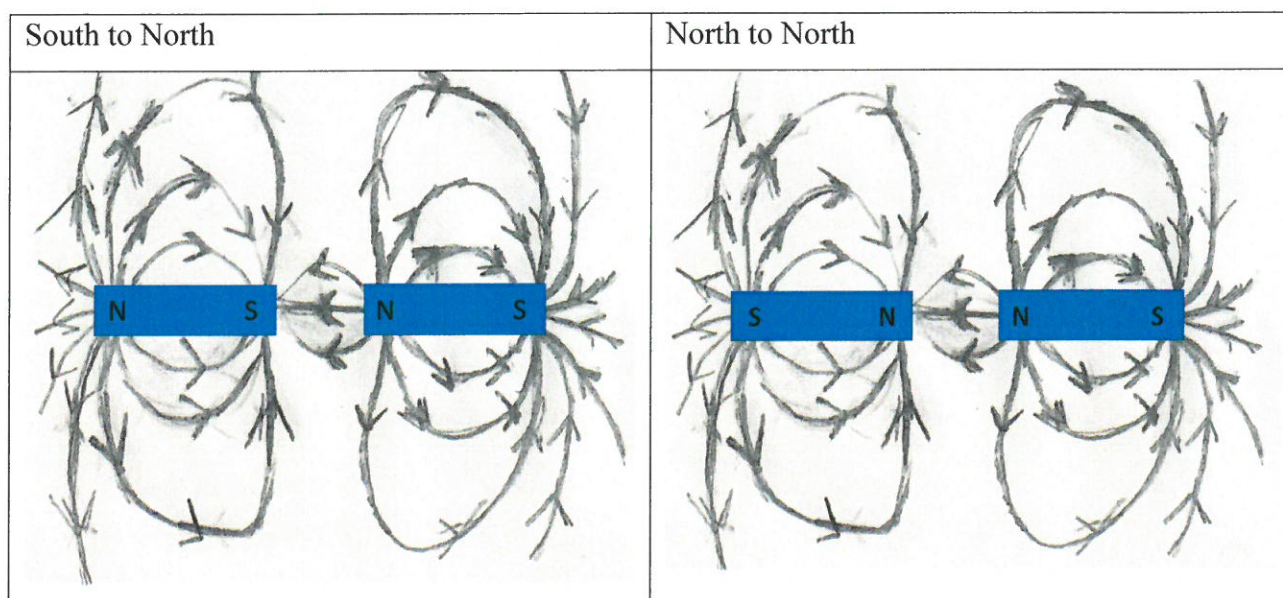
1.4 Magnetism

1.4.1 Permanent Magnets

Magnetism is magnetic field within magnetic material as this more explained by Robertson (2008, p.111-112) as 'Like the electric field, a magnetic field may be considered as being the medium by which forces are transmitted'. This is what is used within a permanent magnet as this magnetic field will either attract or repel to other magnetic objects. The magnetic field that goes around it goes from the north pole to south pole. The contraction of magnetic field is higher at each pole of the magnet. As shown by the diagram on the right. This cannot not be seen by the naked eye, but we can see the effect as when we have two magnets and see what happened when opposite side poles and same side poles are put next to each other.



As shown below:



As you can see from these diagrams the direction of the magnet field of two magnets when placing one poles of each magnet together will result in it either replying or attracting. If the magnetic is going in opposite from each magnet, then they will attract as shown in Diagram South to North. Whereas if the magnet is going in the same direction they will repel as shown in Image North to North.

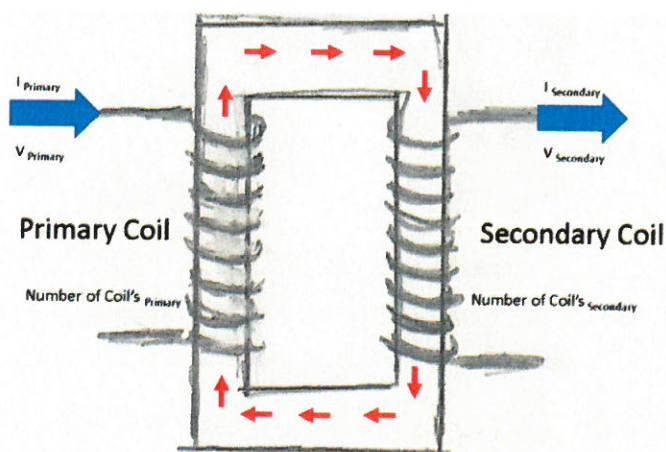
1.4.2 Electromagnets Magnets

Another type of Magnets is Electromagnets. This uses Electromagnetism which is as explained by Robertson (2008, p.113) 'an electric current also produces a magnetic field. The strength of this field is directly proportional to the value of the current'. Unfortunately, a typical current within wire doesn't have high enough strength within the magnetic field to be used as a magnet. The magnetic field can be increase and strengthened by having the wire coil around itself, and the more coils in the wire the higher magnetic field. Another way to increasing magnetic field is have a higher current flowing through the wire as stated above. Having an iron core around the wire will also increase the magnetic field. These then created magnetic field which can be higher or identical to the permeant magnets. This can much more beneficial as the magnetic field can be reserved if the current flowing through goes the alternative way through the wire and can be turned off as once the current is remove from the wire then there is no longer magnetic field present and when it is reintroduced into the wire the magnetic field begin to from.

1.4.3 Examples of where electromagnetism is used.

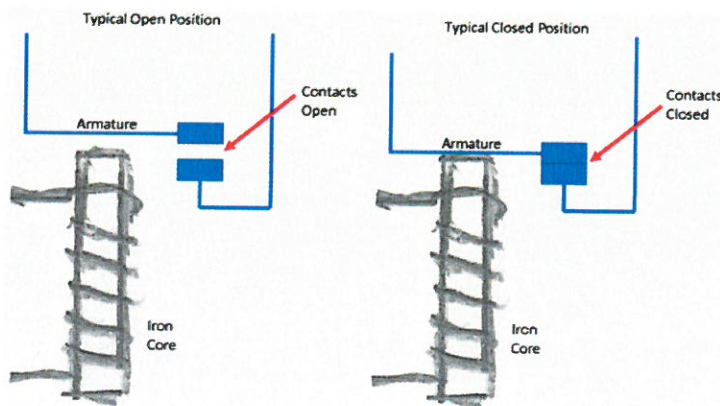
Transformer

A transformer works by having an iron core with two coils connected to it. One being a primary coil and the second coil being a secondary coil. The primary coil has a current going into and as core provide a strong magnetic field this transfers to the secondary coil but there is no electrical connection between the two coils in the core. There is no effect if current remain the same in primary but once the current in primary is changing then an E.M.F begins to be induced into the secondary coil. If there are the more coil in primary to the secondary, then the voltage will be lower when come out of the secondary coil whereas if there are less coil in primary to the secondary then the voltage coming out will be higher in the secondary.



Relays

A relay is a switch that operates two movable contact which give an open and closed position within the relay. This done by having a coil wire within the relay, and above an armature which is next to a movable contact. A relay work by send out a small low powered current into the coil of wire which cause coil to become magnetic. Once it has magnetised it attracts the Armature which cause the switch connection to become closed in an open connection. Once the power to coil is turn off the circuit become open as the armature is no longer attracted to the coil and goes back to its normal state.



1.5 Inductor and Resistor in AC Circuit

1.5.1 Overview

An Inductor is electrical devices that contain iron cores with wires around them inside of it, which creates inductance within a circuit. A resistor is as stated above.

1.5.2 Comment on the thermotical and practical results.

This inductor in this A.C. practical experiment (See: 2.8.0) cause the current to be out of phase with the voltage within the circuit. This is because there is a magnetic field building up in the coil of wire within the inductor when the current is high and collapse due to the current alerts from and to zero this cause the circuit to lag as build-up of current within the inductor creates an E.M.F as the current is still being stored in the inductor. (Bird: 2017, p.236)

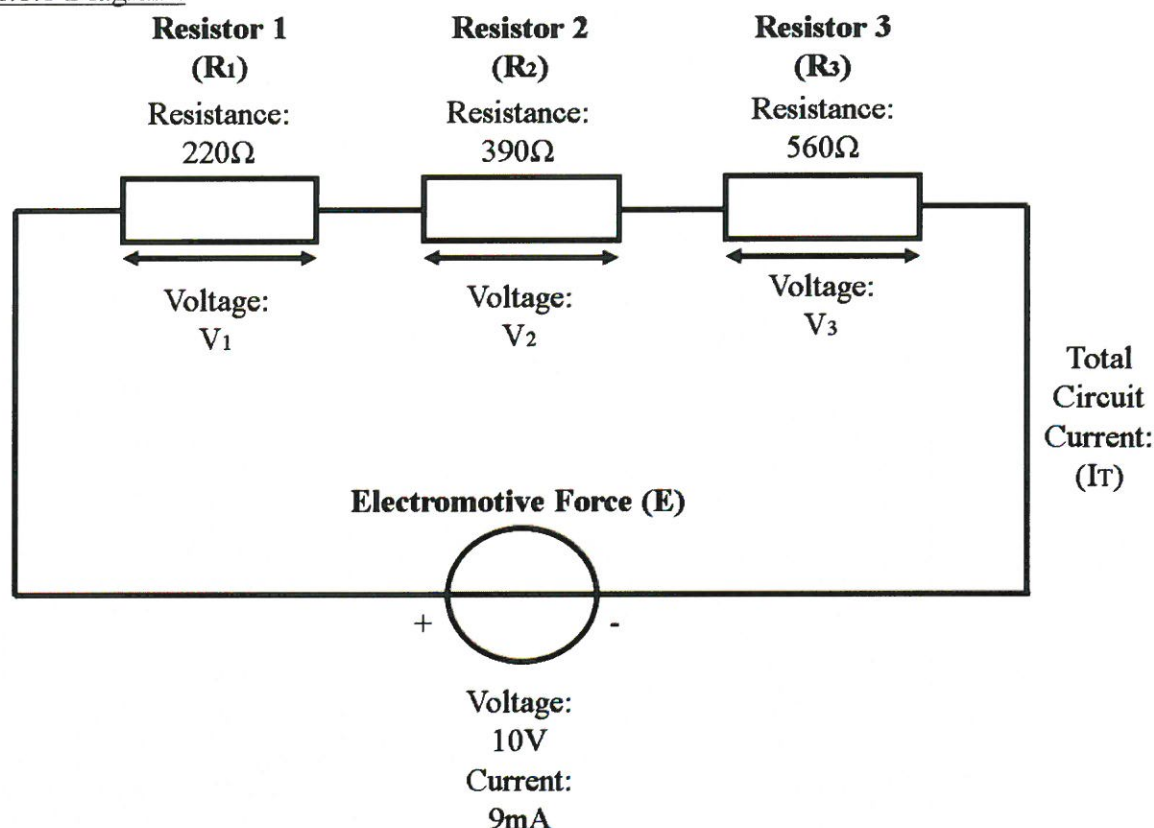
This is what was measured on the oscilloscope, how much out of phase the current is from the voltage within degrees. This table of results give the calculated result using the values gained at the start of the experiment and the result gathered from the Oscilloscope (See: 2.8.2). What can be observed is that they have a slight variation between them. The both result do show when the frequency increase the more out phase the current within the circuit. When comparing the result to ones gained on Oscilloscope you can see that they are not perfect to the ones calculated and this can be down to human error. Even though digital Oscilloscope were used when aligning the two lines to get the time difference between the two channels. It was difficult to get an accurate reading between the two as it was hard to align the lines at the same point on each channel's wave. So, if the lines were slight off this could mean have slightly off correct phase angles which can be seen by the anomaly measurement obtained in frequency 5 on the Table (See: 2.8.2) as it is completely off from the calculated result . The other issue with result could be done to the Oscilloscope not being calibrated meaning it can give less accurate reading even if the line measuring the time difference between the two channels was correct. So, to get better reading the Oscilloscope will need calibrated in order give more accurate and give integrity to our results but the correlation still appears as higher frequency used the more out phase the current is to the voltage. ✓

2.0 Calculations and Diagrams

2.1.0 Theoretical Calculations and Diagram of Resistors in a Series Circuit

This is theoretical circuit of resistors in series which includes a diagram, calculations and final values for the circuit.

2.1.1 Diagram:



2.1.2 Values:

Item	Calculated Values
Voltage of Electromotive Force 1 (E_v)	10V
Current of Electromotive Force (E_i)	9mA
Resistance of Resistor 1 (R_1)	220 Ω
Resistance of Resistor 2 (R_2)	390 Ω
Resistance of Resistor 3 (R_3)	560 Ω
Total Resistance of all resistors (R_T)	1170 Ω
Total Circuit Current (I_T)	8.55mA
Voltage between Resistor 1 (V_1)	1.88V
Voltage between Resistor 2 (V_2)	3.33V
Voltage between Resistor 3 (V_3)	4.79V
Total Voltage of all resistors (V_T)	9.99V

2.1.3 Total Resistance:

$$\begin{aligned}\text{Total Resistance (R}_T\text{)} &= \text{Total Resistance in Resistor 1 (R}_1\text{)} + \text{Total Resistance in Resistor 2 (R}_2\text{)} + \text{Total Resistance in Resistor 3 (R}_3\text{)} \\ \text{Total Resistance (R}_T\text{)} &= 220 + 390 + 560 \\ \text{Total Resistance (R}_T\text{)} &= 1170\Omega\end{aligned}$$

2.1.4 Total Current:

$$\begin{aligned}\text{Total Current (I}_T\text{)} &= \frac{\text{Voltage (E}_V\text{)}}{\text{Total Resistance (R}_T\text{)}} \quad \text{Total Current} = \frac{10}{1170} \\ \text{Total Current (I}_T\text{)} &= 8.55\text{mA}\end{aligned}$$

2.1.5 Total Voltage in Resistors 1:

$$\begin{aligned}\text{Total Voltage in Resistors 1 (V}_1\text{)} &= \text{Total Current (I}_T\text{)} \times \text{Total Resistance in Resistors 1 (R}_1\text{)} \\ \text{Total Voltage in Resistors 1 (V}_1\text{)} &= 0.00855 \times 220 \\ \text{Total Voltage in Resistors 1 (V}_1\text{)} &= 1.88\text{V}\end{aligned}$$

2.1.6 Total Voltage in Resistors 2:

$$\begin{aligned}\text{Total Voltage in Resistors 2 (V}_2\text{)} &= \text{Total Current (I}_T\text{)} \times \text{Total Resistance in Resistors 2 (R}_2\text{)} \\ \text{Total Voltage in Resistors 2 (V}_2\text{)} &= 0.00855 \times 390 \\ \text{Total Voltage in Resistors 2 (V}_2\text{)} &= 3.33\text{V}\end{aligned}$$

2.1.7 Total Voltage in Resistors 3:

$$\begin{aligned}\text{Total Voltage in Resistors 3 (V}_3\text{)} &= \text{Total Current (I}_T\text{)} \times \text{Total Resistance in Resistors 3 (R}_3\text{)} \\ \text{Total Voltage in Resistors 3 (V}_3\text{)} &= 0.00855 \times 560 \\ \text{Total Voltage in Resistors 3 (V}_3\text{)} &= 4.79\text{V}\end{aligned}$$

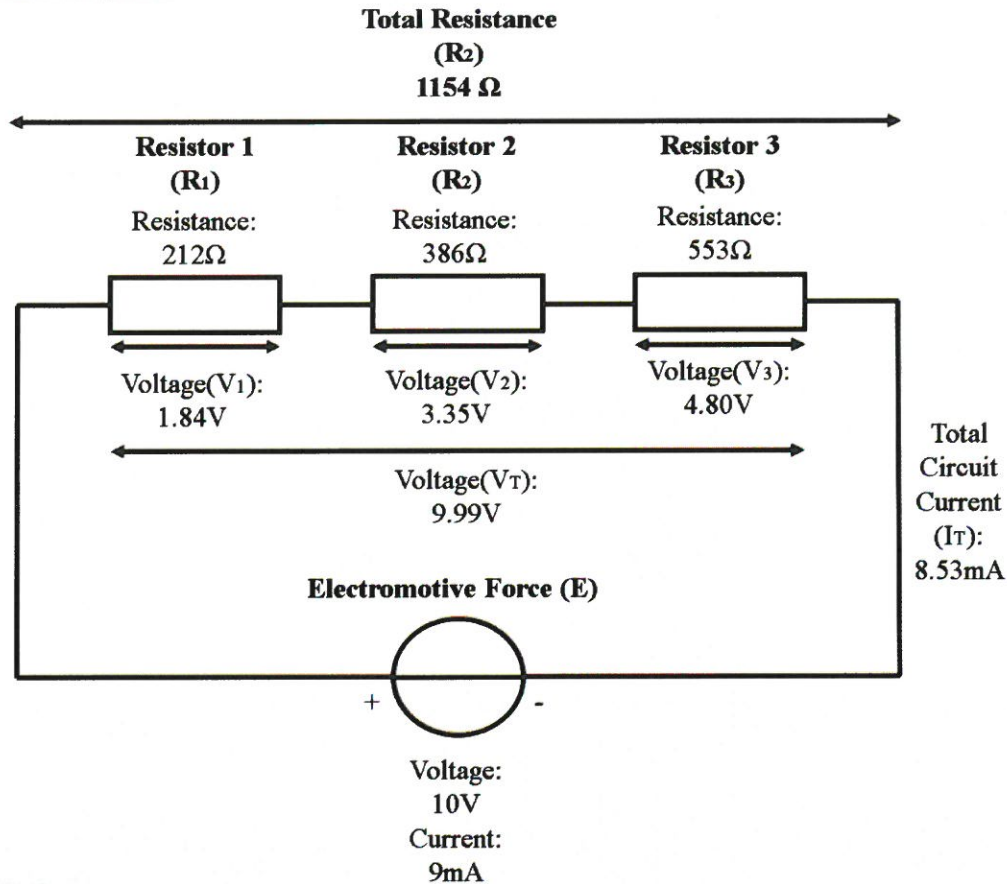
2.1.8 Total Voltage:

$$\begin{aligned}\text{Total Voltage (V}_T\text{)} &= \text{Total Voltage in Resistors 1 (V}_1\text{)} + \text{Total Voltage in Resistors 2 (V}_2\text{)} + \text{Total Voltage in Resistors 3 (V}_3\text{)} \\ \text{Total Voltage (V}_T\text{)} &= 1.88 + 3.33 + 4.79 \\ \text{Total Voltage (V}_T\text{)} &= 9.99\text{V}\end{aligned}$$

2.2.0 Practical Calculations and Diagram of Resistors in a Series Circuit

This is practical circuit of resistor in series which includes diagram, calculations and final values for the circuit.

2.2.1 Diagram:



2.2.2 Total Values:

Item	Multimeter Values	Calculated Values
Voltage of Electromotive Force (E_V)	$10V$	N/A
Current of Electromotive Force (E_I)	$9mA$	N/A
Resistance of Resistor 1(R_1)	212Ω	N/A
Resistance of Resistor 2(R_2)	386Ω	N/A
Resistance of Resistor 3(R_3)	553Ω	N/A
Total Resistance of all resistors(R_T)	1151Ω	N/A
Total Circuit Current(I_T)	$8.53mA$	$8.69mA$
Voltage between Resistor 1 (V_1)	$1.84V$	$1.84V$
Voltage between Resistor 2(V_2)	$3.35V$	$3.35V$
Voltage between Resistor 3 (V_3)	$4.80V$	$4.80V$
Total Voltage of all resistors (V_T)	$9.99V$	$9.99V$

Well done.

2.2.3 Total Resistance:

$$\begin{aligned}\text{Total Resistance (R}_T\text{)} &= \text{Total Resistance in Resistor 1 (R}_1\text{)} + \text{Total Resistance in Resistor 2 (R}_2\text{)} + \text{Total Resistance in Resistor 3 (R}_3\text{)} \\ \text{Total Resistance (R}_T\text{)} &= 212 + 386 + 553 \\ \text{Total Resistance (R}_T\text{)} &= 1151\Omega\end{aligned}$$

2.2.4 Total Current:

$$\begin{aligned}\text{Total Current (I}_T\text{)} &= \frac{\text{Voltage (E}_V\text{)}}{\text{Total Resistance (R}_T\text{)}} \quad \text{Total Current} = \frac{10}{1151} \\ \text{Total Current (I}_T\text{)} &= 8.69\text{mA}\end{aligned}$$

2.2.5 Total Voltage in Resistors 1:

$$\begin{aligned}\text{Total Voltage in Resistors 1 (V}_1\text{)} &= \text{Total Current (I}_T\text{)} \times \text{Total Resistance in Resistors 1 (R}_1\text{)} \\ \text{Total Voltage in Resistors 1 (V}_1\text{)} &= 0.00869 \times 212 \\ \text{Total Voltage in Resistors 1 (V}_1\text{)} &= 1.84\text{V}\end{aligned}$$

2.2.6 Total Voltage in Resistors 2:

$$\begin{aligned}\text{Total Voltage in Resistors 2 (V}_2\text{)} &= \text{Total Current (I}_T\text{)} \times \text{Total Resistance in Resistors 2 (R}_2\text{)} \\ \text{Total Voltage in Resistors 2 (V}_2\text{)} &= 0.00869 \times 386 \\ \text{Total Voltage in Resistors 2 (V}_2\text{)} &= 3.35\text{V}\end{aligned}$$

2.2.7 Total Voltage in Resistor 3:

$$\begin{aligned}\text{Total Voltage in Resistors 3 (V}_3\text{)} &= \text{Total Current (I}_T\text{)} \times \text{Total Resistance in Resistors 3 (R}_3\text{)} \\ \text{Total Voltage in Resistors 3 (V}_3\text{)} &= 0.00869 \times 553 \\ \text{Total Voltage in Resistors 3 (V}_3\text{)} &= 4.80\text{V}\end{aligned}$$

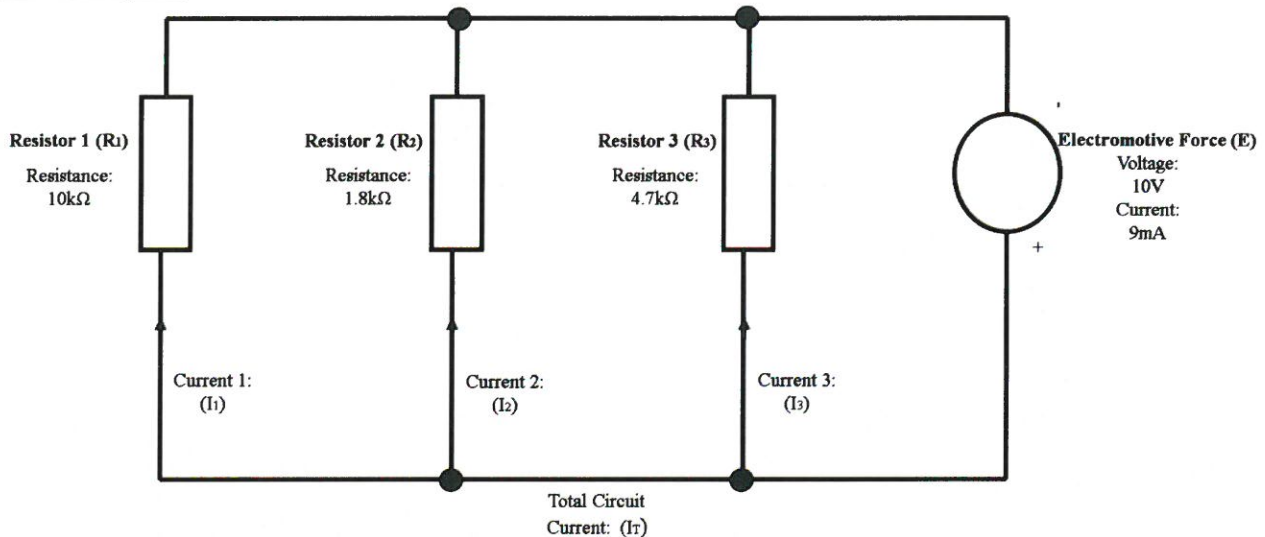
2.2.8 Total Voltage

$$\begin{aligned}\text{Total Voltage (V}_T\text{)} &= \text{Total Voltage in Resistors 1 (V}_1\text{)} + \text{Total Voltage in Resistors 2 (V}_2\text{)} + \text{Total Voltage in Resistors 3 (V}_3\text{)} \\ \text{Total Voltage (V}_T\text{)} &= 1.84 + 3.35 + 4.80 \\ \text{Total Voltage (V}_T\text{)} &= 99.9\text{V}\end{aligned}$$

2.3.0 Theoretical Calculations and Diagram of Resistors in a Parallel Circuit

This is theoretical circuit of resistors in parallel which includes a diagram, calculations and final values for the circuit.

2.3.1 Diagram:



2.3.2 Values:

Item	Calculated Values
Voltage of Electromotive Force 1 (E_v)	10V
Current of Electromotive Force (E_i)	9mA
Resistance of Resistor 1 (R_1)	$10k\Omega$
Resistance of Resistor 2 (R_2)	$1.8k\Omega$
Resistance of Resistor 3 (R_3)	$4.7k\Omega$
Total Resistance of all resistors (R_T)	1098.90Ω
Total Circuit Current (I_T)	9.10mA
Current between Resistor 1 (I_1)	1mA
Current between Resistor 2 (I_2)	5.56mA
Current between Resistor 3 (I_3)	2.13mA
Total Current of all resistors (I_R)	8.69mA

2.3.3 Total Resistance:

$$\begin{aligned} \frac{1}{\text{Total Resistance (R}_T\text{)}} &= \frac{1}{\text{Total Resistance in Resistor 1 (R}_1\text{)}} + \frac{1}{\text{Total Resistance in Resistor 2 (R}_2\text{)}} + \frac{1}{\text{Total Resistance in Resistor 3 (R}_3\text{)}} \\ \frac{1}{\text{Total Resistance (R}_T\text{)}} &= \frac{1}{10000} + \frac{1}{1800} + \frac{1}{4700} \\ \frac{1}{\text{Total Resistance (R}_T\text{)}} &= 0.0001 + 0.0006 + 0.00021 \\ \text{Total Resistance (R}_T\text{)} &= \frac{1}{0.00091} \\ \text{Total Resistance (R}_T\text{)} &= 1098.90\Omega \end{aligned}$$

2.3.4 Total Circuit Current:

$$\begin{aligned} \text{Total Circuit Current (I}_T\text{)} &= \frac{\text{Voltage (E}_V\text{)}}{\text{Total Resistance (R}_T\text{)}} \quad \text{Total Current} = \frac{10}{1098.90} \\ \text{Total Circuit Current (I}_T\text{)} &= 9.10\text{mA} \end{aligned}$$

2.3.5 Total Current 1:

$$\begin{aligned} \text{Total Current 1 (I}_1\text{)} &= \frac{\text{Voltage (E}_V\text{)}}{\text{Resistance in the Resistor 1 (R}_1\text{)}} \quad \text{Total Current 1 (I}_1\text{)} = \frac{10}{10000} \\ \text{Total Current 1 (I}_1\text{)} &= 1\text{mA} \end{aligned}$$

2.3.6 Total Current 2:

$$\begin{aligned} \text{Total Current 2 (I}_2\text{)} &= \frac{\text{Voltage (E}_V\text{)}}{\text{Resistance in the Resistor 2 (R}_2\text{)}} \quad \text{Total Current 2 (I}_2\text{)} = \frac{10}{1800} \\ \text{Total Current 2 (I}_2\text{)} &= 5.56\text{mA} \end{aligned}$$

2.3.7 Total Current 3:

$$\begin{aligned} \text{Total Current 3 (I}_3\text{)} &= \frac{\text{Voltage (E}_V\text{)}}{\text{Resistance in the Resistor 3 (R}_3\text{)}} \quad \text{Total Current 3 (I}_3\text{)} = \frac{10}{4700} \\ \text{Total Current 3 (I}_3\text{)} &= 2.13\text{mA} \end{aligned}$$

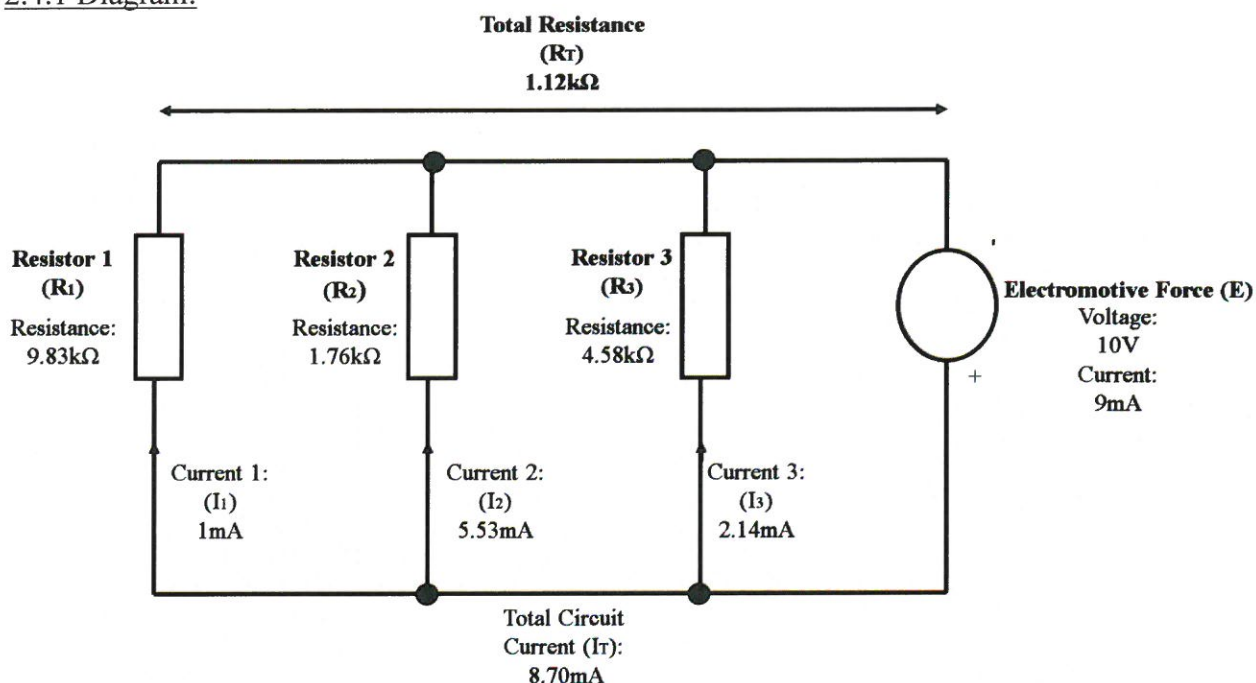
2.3.8 Total Current of all Resistors:

$$\begin{aligned} \text{Total Current of all Resistors (I}_R\text{)} &= \text{Total Current 1 (I}_1\text{)} + \text{Total Current 2 (I}_2\text{)} + \text{Total Current 3 (I}_3\text{)} \\ \text{Total Current of all Resistors (I}_R\text{)} &= 0.001 + 0.00556 + 0.00213 \\ \text{Total Current of all Resistors (I}_R\text{)} &= 8.69\text{mA} \end{aligned}$$

2.4.0 Practical Calculations and Diagram of Resistors in a Parallel Circuit

This is practical circuit of resistor in parallel which includes diagram, calculations and final values for the circuit.

2.4.1 Diagram:



2.4.2 Values:

Item	Multimeter Values	Calculated Values
Voltage of Electromotive Force (E_v)	10V	N/A
Current of Electromotive Force (E_i)	9mA	N/A
Resistance of Resistor 1 (R_1)	9.83k Ω	N/A
Resistance of Resistor 2 (R_2)	1.76k Ω	N/A
Resistance of Resistor 3 (R_3)	4.58k Ω	N/A
Total Resistance of all resistors (R_T)	1.12k Ω	1126.13 Ω
Total Circuit Current (I_T)	8.70mA	8.88mA
Current between Resistor 1 (I_1)	1mA	1.02mA
Current between Resistor 2 (I_2)	5.53mA	5.68mA
Current between Resistor 3 (I_3)	2.14mA	2.18mA
Total Current of all Resistors (I_R)	8.67mA	8.88mA

2.4.3 Total Resistance:

$$\begin{aligned}
 \frac{1}{\text{Total Resistance (R}_T\text{)}} &= \frac{1}{\text{Total Resistance in Resistor 1 (R}_1\text{)}} + \frac{1}{\text{Total Resistance in Resistor 2 (R}_2\text{)}} + \frac{1}{\text{Total Resistance in Resistor 3 (R}_3\text{)}} \\
 \frac{1}{\text{Total Resistance (R}_T\text{)}} &= \frac{1}{9830} + \frac{1}{1760} + \frac{1}{4580} \\
 \frac{1}{\text{Total Resistance (R}_T\text{)}} &= 0.000102 + 0.000568 + 0.000218 \\
 \text{Total Resistance (R}_T\text{)} &= \frac{1}{0.000888} \\
 \text{Total Resistance (R}_T\text{)} &= 1126.13\Omega
 \end{aligned}$$

2.4.4 Total Current:

$$\begin{aligned}
 \text{Total Current (I}_T\text{)} &= \frac{\text{Voltage (E}_v\text{)}}{\text{Total Resistance (R}_T\text{)}} \quad \text{Total Current} = \frac{10}{1126.13} \\
 \text{Total Current (I}_T\text{)} &= 8.88\text{mA}
 \end{aligned}$$

2.4.5 Total Current 1:

$$\begin{aligned}
 \text{Total Current 1 (I}_1\text{)} &= \frac{\text{Voltage (E}_v\text{)}}{\text{Resistance in the Resistor 1 (R}_1\text{)}} \quad \text{Total Current 1 (I}_1\text{)} = \frac{10}{9830} \\
 \text{Total Current 1 (I}_1\text{)} &= 1.02\text{mA}
 \end{aligned}$$

2.4.6 Total Current 2:

$$\begin{aligned}
 \text{Total Current 2 (I}_2\text{)} &= \frac{\text{Voltage (E}_v\text{)}}{\text{Resistance in the Resistor 2 (R}_2\text{)}} \quad \text{Total Current 2 (I}_2\text{)} = \frac{10}{1760} \\
 \text{Total Current 2 (I}_2\text{)} &= 5.68\text{mA}
 \end{aligned}$$

2.4.7 Total Current 3:

$$\begin{aligned}
 \text{Total Current 3 (I}_3\text{)} &= \frac{\text{Voltage (E}_v\text{)}}{\text{Resistance in the Resistor 3 (R}_3\text{)}} \quad \text{Total Current 3 (I}_3\text{)} = \frac{10}{4580} \\
 \text{Total Current 3 (I}_3\text{)} &= 2.18\text{mA}
 \end{aligned}$$

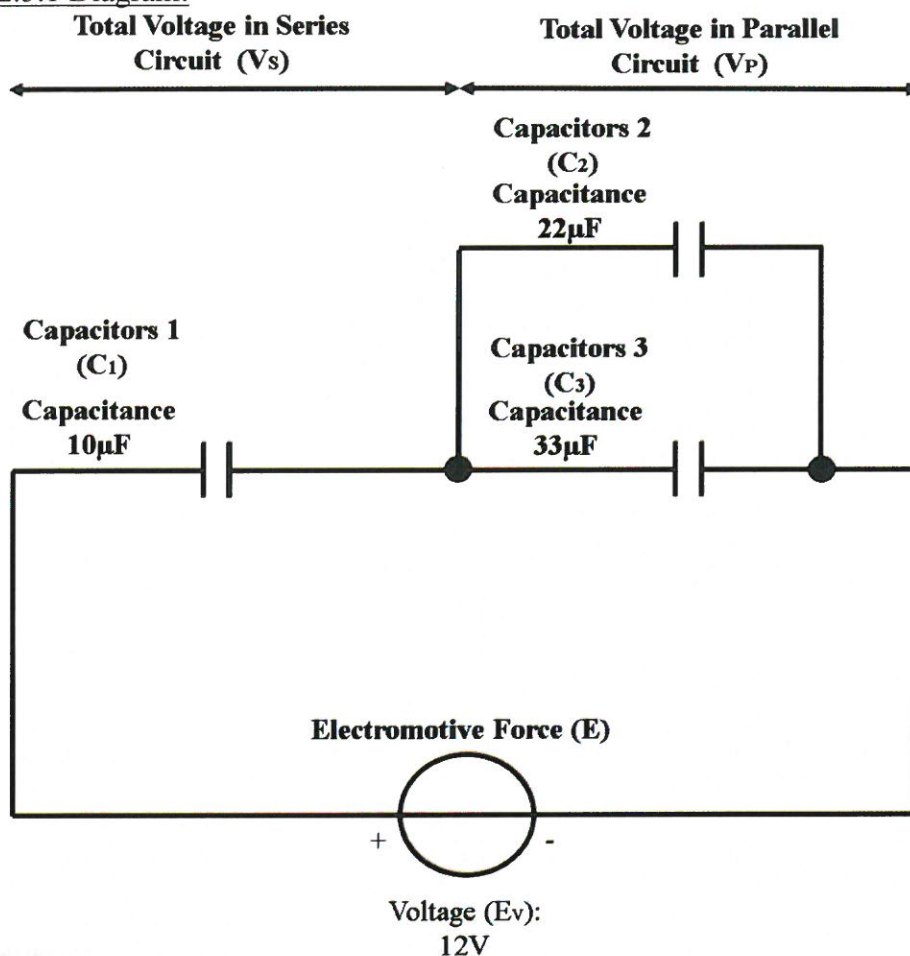
2.4.8 Total Current:

$$\begin{aligned}
 \text{Total Circuit Current (I}_R\text{)} &= \text{Total Current in Resistors 1 (V}_1\text{)} + \text{Total Current in Resistors 2 (V}_2\text{)} + \text{Total Current in Resistors 3 (V}_3\text{)} \\
 \text{Total Circuit Current (I}_R\text{)} &= 0.00102 + 0.00568 + 0.00218 \\
 \text{Total Circuit Current (I}_R\text{)} &= 8.88\text{mA}
 \end{aligned}$$

2.5.0 Theoretical Calculations and Diagram of Capacitors in a Series & Parallel Circuit

This is theoretical circuit of capacitors in series and parallel which includes a diagram, calculations and final values for the circuit.

2.5.1 Diagram:



2.5.2 Values:

Item	Calculated Value
Voltage of Electromotive Force (Ev)	12V
Total Capacitance in Capacitors 1 (C1)	10μF
Total Capacitance in Capacitors 2 (C2)	22μF
Total Capacitance in Capacitors 3 (C3)	33μF
Total Capacitance (Cr)	8.46μF
Total Voltage in Series Circuit (Vs)	10.15V
Total Voltage in Parallel Circuit (Vp)	1.85V
Total Charge (Qt)	101.52μC
Total Charge in Capacitors 1 (Q1)	101.52μC
Total Charge in Capacitors 2 (Q2)	40.7μC
Total Charge in Capacitors 3 (Q3)	61.05μC
Total Energy in Capacitors 1 (W1)	515.11μJ
Total Energy in Capacitors 2 (W2)	37.65μJ
Total Energy in Capacitors 3 (W3)	56.47μJ
Total Energy in the circuit (Wt)	609.12μJ

2.5.3 Capacitance in Parallel Circuit

$$\text{Capacitance Parallel Circuit (Cp)} = \text{Total Capacitance in Capacitors 2 (C2)} + \text{Total Capacitance in Capacitors 3 (C3)}$$

$$\text{Capacitance Parallel Circuit (Cp)} = 0.000022 + 0.000033$$

$$\text{Capacitance Parallel Circuit (Cp)} = 55\mu\text{F}$$

2.5.4 Total Capacitance

$$\text{Total Capacitance (Cr)} = \frac{Cp \times C1}{Cp + C1} \quad \text{Total Capacitance (Cr)} = \frac{0.000055 \times 0.000010}{0.000055 + 0.000010}$$

$$\text{Total Capacitance (Cr)} = 8.46\mu\text{F}$$

2.5.5 Total Charge:

$$\text{Total Charge (Qr)} = \text{Total Capacitance (Cr)} \times \text{Voltage (Ve)}$$

$$\text{Total Charge (Qr)} = 0.00000846 \times 12$$

$$\text{Total Charge (Qr)} = 101.52\mu\text{C}$$

2.5.6 Total Charge in Capacitors 1:

$$\text{Total Charge in Capacitors 1 (Q1)} = \text{Equals Qr due to it being in series with the circuit}$$

$$\text{Total Charge in Capacitors 1 (Q1)} = Qr$$

$$\text{Total Charge in Capacitors 1 (Q1)} = 101.52\mu\text{C}$$

2.5.7 Total Voltage in Series circuit

$$\text{Total Voltage in Series Circuit (Vs)} = \frac{\text{Total Charge in Capacitors 1 (Q1)}}{\text{Total Capacitance in Capacitors 1 (C1)}} \quad \text{Total Voltage in Series Circuit (Vs)} = \frac{0.00010152}{0.000010}$$

$$\text{Total Voltage in Series Circuit (Vs)} = 10.15\text{V}$$

2.5.8 Total Voltage in Parallel circuit

$$\text{Total Voltage in Parallel Circuit (Vp)} = \text{Voltage (Ve)} - \text{Total Voltage in Series Circuit (Vs)}$$

$$\text{Total Voltage in Parallel Circuit (Vp)} = 12 - 10.15$$

$$\text{Total Voltage in Parallel Circuit (Vp)} = 1.85\text{V}$$

2.5.9 Total Charge in Capacitors 2:

$$\text{Total Charge in Capacitors 2 (Q2)} = \text{Total Capacitance in Capacitors 2 (C2)} \times \text{Total Voltage in Parallel Circuit (Vp)}$$

$$\text{Total Charge in Capacitors 2 (Q2)} = 0.000022 \times 1.85$$

$$\text{Total Charge in Capacitors 2 (Q2)} = 40.7\mu\text{C}$$

2.5.10 Total Charge in Capacitors 3:

$$\text{Total Charge in Capacitors 3 (Q}_3\text{)} = \text{Total Capacitance in Capacitors 3 (C}_3\text{)} \times \text{Total Voltage in Parallel Circuit (V}_P\text{)}$$

$$\text{Total Charge in Capacitors 3 (Q}_3\text{)} = 0.000033 \times 1.85$$

$$\text{Total Charge in Capacitors 3 (Q}_3\text{)} = 61.05\mu\text{C}$$

2.5.11 Total Energy in Capacitors 1:

$$\text{Total Energy in Capacitors 1 (W}_1\text{)} = \frac{1}{2} \times \text{Total Capacitance in Capacitors 1 (C}_1\text{)} \times \text{Total Voltage in Series Circuit (V}_S\text{)}^2$$

$$\text{Total Energy in Capacitors 1 (W}_1\text{)} = \frac{1}{2} \times 0.000010 \times 10.15^2$$

$$\text{Total Energy in Capacitors 1 (W}_1\text{)} = 515.11\mu\text{J}$$

2.5.12 Total Energy in Capacitors 2:

$$\text{Total Energy in Capacitors 2 (W}_2\text{)} = \frac{1}{2} \times \text{Total Capacitance in Capacitors 2 (C}_2\text{)} \times \text{Total Voltage in Parallel Circuit (V}_P\text{)}^2$$

$$\text{Total Energy in Capacitors 2 (W}_2\text{)} = \frac{1}{2} \times 0.000022 \times 1.85^2$$

$$\text{Total Energy in Capacitors 2 (W}_2\text{)} = 37.65\mu\text{J}$$

2.5.13 Total Energy in Capacitors 3:

$$\text{Total Energy in Capacitors 3 (W}_3\text{)} = \frac{1}{2} \times \text{Total Capacitance in Capacitors 3 (C}_3\text{)} \times \text{Total Voltage in Parallel Circuit (V}_P\text{)}^2$$

$$\text{Total Energy in Capacitors 3 (W}_3\text{)} = \frac{1}{2} \times 0.000033 \times 1.85^2$$

$$\text{Total Energy in Capacitors 3 (W}_3\text{)} = 56.47\mu\text{J}$$

2.5.14 Total Energy in the Circuit:

$$\text{Total Energy in the circuit (W}_T\text{)} = \frac{1}{2} \times \text{Total Capacitance (C}_T\text{)} \times \text{Voltage (V}_E\text{)}^2$$

$$\text{Total Energy in the circuit (W}_T\text{)} = \frac{1}{2} \times 0.00000846 \times 12^2$$

$$\text{Total Energy in the circuit (W}_T\text{)} = 609.12\mu\text{J}$$

good work.

2.6.0 Magnetism Calculations

2.6.1 Question One

A magnetic pole face has a rectangular section having dimensions 250mm by 120mm. If the total flux emerging from the pole is 120μWb, calculate the flux density.

2.6.2 Converting Length and Width into Meters

Conversion into Meters	=	$\frac{\text{Measurement in mm}}{1000}$	Conversion into Meters	=	$\frac{\text{Measurement in mm}}{1000}$
		$\frac{250}{1000}$			$\frac{120}{1000}$
Conversion into Meters	=	0.25m	Conversion into Meters	=	0.12m

2.6.3 Calculating the Area of the rectangular section

$$\begin{aligned}\text{Area (A)} &= \text{Length (L)} \times \text{Width (W)} \\ \text{Area (A)} &= 0.25 \times 0.12 \\ \text{Area (A)} &= 0.03\text{m}^2\end{aligned}$$

2.6.4 Calculating the Flux Density

$$\begin{aligned}\text{Flex Density (B)} &= \frac{\text{Flux } \Phi}{\text{Area (A)}} \\ \text{Flex Density (B)} &= \frac{0.000120}{0.03} \\ \text{Flex Density (B)} &= 4\text{mT}\end{aligned}$$

2.6.5 Question Two

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.

2.6.6 Calculating the Area of the pole face

$$\begin{aligned}\text{Area (A)} &= \frac{\text{Flux } \Phi}{\text{Flex Density (B)}} \\ \text{Area (A)} &= \frac{0.34}{1.5} \\ \text{Area (A)} &= 0.227\text{m}^2\end{aligned}$$

2.6.7 Calculating the Radius of the pole face

$$\begin{aligned}\text{Radius}^2 &= \frac{\text{Area (A)}}{\pi} \\ \text{Radius}^2 &= \frac{0.227}{\pi} \\ \text{Radius}^2 &= 0.0723 \\ \text{Radius} &= \sqrt{0.0723} \\ \text{Radius} &= 0.27\text{m}\end{aligned}$$

2.6.8 Question Three

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.

2.6.9 Converting Radius and Length into Meters:

Conversion into Meters	=	$\frac{\text{Measurement in mm}}{1000}$	Conversion into Meters	=	$\frac{\text{Measurement in mm}}{1000}$
		$\frac{60}{1000}$			$\frac{320}{1000}$
Conversion into Meters	=	0.060m	Conversion into Meters	=	0.32m

2.6.10 Calculating the Area of the pole face:

$$\text{Area (A)} = \pi \times \text{Radius}^2$$

$$\text{Area (A)} = \pi \times 0.06^2$$

$$\text{Area (A)} = 0.011\text{m}^2$$

2.6.11 Calculating the Flux Density:

$$\text{Flex Density (B)} = \frac{\text{Flux } \Phi}{\text{Area (A)}} \quad \text{Flex Density (B)} = \frac{0.0004}{0.011}$$

$$\text{Flex Density (B)} = 36.363\text{mT}$$

2.6.12 Calculating the Force:

$$\text{Force (F)} = \text{Flex Density (B)} \times \text{Current (I)} \times \text{Length (L)}$$

$$\text{Force (F)} = 0.036363 \times 8 \times 0.32$$

$$\text{Force (F)} = 93.089\text{mN}$$

2.6.13 Question Four

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.

2.6.14 Converting Length into Meters

$$\text{Conversion into Meters} = \frac{\text{Measurement in mm}}{1000}$$

$$\text{Conversion into Meters} = \frac{400}{1000}$$

$$\text{Conversion into Meters} = 0.4\text{m}$$

2.6.15 Calculating the Flux Density:

$$\text{Flex Density (B)} = \frac{\text{Current (I)} \times \text{Length (L)}}{\text{Force (F)}} \quad \text{Flex Density (B)} = \frac{25 \times 0.4}{80}$$

$$\text{Flex Density (B)} = 125\text{mT}$$

2.6.16 Calculating the Area of the pole face:

$$\text{Area (A)} = \frac{\text{Flux } \Phi}{\text{Flex Density (B)}} \quad \text{Area (A)} = \frac{0.00127}{0.125}$$

$$\text{Area (A)} = 10.16\text{mm}$$

2.6.17 Calculating the Radius and Diameter of the pole face

$$\text{Radius}^2 = \frac{\text{Area (A)}}{\pi} \quad \text{Radius}^2 = \frac{0.01016}{\pi} \quad \text{Diameter (d)} = 2 \times \text{Radius}$$

$$\text{Radius}^2 = 0.00323$$

$$\text{Diameter (d)} = 2 \times 0.05683$$

$$\text{Radius} = \sqrt{0.00323}$$

$$\text{Diameter (d)} = 113.66\text{mm}$$

$$\text{Radius} = 56.83\text{mm}$$

2.7.0 Theoretical Calculations from using an Oscilloscope

this is calculation finding out values from using an Oscilloscope.

2.7.1 Measurements

Oscilloscope Settings		Grid Spacing	
Volts/Div	Timebase (ms/Div)	Vertical (peak to peak)	Horizontal (1 cycle)
5	20	6	4

2.7.2 Calculating the Volts Peak to Peak and Time of Single Sine Wave

$$\begin{aligned}
 \text{Voltage Peak to Peak (V)} &= \text{Volts/Div} \times \text{Vertical (peak to peak)} & \text{Periodic Time (T)} &= \text{Timebase (ms/Div)} \times \text{Horizontal (1 cycle)} \\
 \text{Voltage Peak to Peak (V)} &= 5 \times 6 & \text{Periodic Time (T)} &= 20 \times 4 \\
 \text{Voltage Peak to Peak (V)} &= 30\text{V} & \text{Periodic Time (T)} &= 80\text{ms}
 \end{aligned}$$

2.7.3 Peak Voltage

$$\begin{aligned}
 \text{Peak Voltage (V}_P\text{)} &= \frac{\text{Voltage peak to peak (V)}}{2} & \text{Peak Voltage (V}_P\text{)} &= \frac{30}{2} \\
 \text{Peak Voltage (V}_P\text{)} &= 15\text{V}
 \end{aligned}$$

2.7.4 Frequency

$$\begin{aligned}
 \text{Frequency (F)} &= \frac{1}{\text{Periodic Time (T)}} & \text{Frequency} &= \frac{1}{0.08} \\
 \text{Frequency (F)} &= 12.5\text{Hz}
 \end{aligned}$$

2.7.5 Average Voltage

$$\begin{aligned}
 \text{Average Voltage (V}_A\text{)} &= 0.637 \times \text{Peak Voltage (V}_P\text{)} \\
 \text{Average Voltage (V}_A\text{)} &= 0.637 \times 15 \\
 \text{Average Voltage (V}_A\text{)} &= 9.56\text{V}
 \end{aligned}$$

2.7.6 Root Mean Square (rms) Voltage

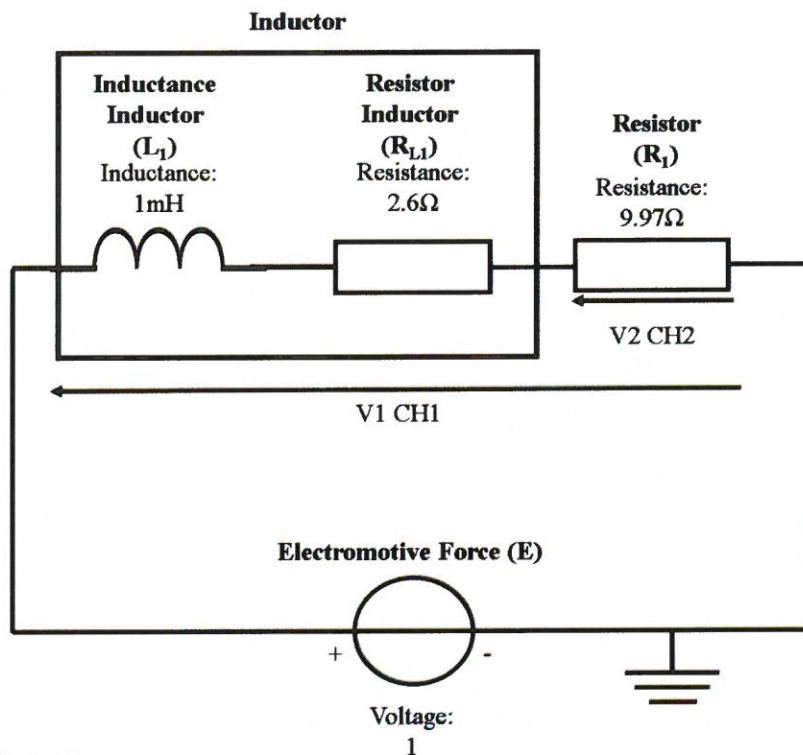
$$\begin{aligned}
 \text{Voltage Root mean square (V}_{\text{RMS}}\text{)} &= \frac{\text{Peak Voltage (V}_P\text{)}}{\sqrt{2}} & \text{Voltage Root mean square (V}_{\text{RMS}}\text{)} &= \frac{15}{\sqrt{2}} \\
 \text{Voltage Root mean square (V}_{\text{RMS}}\text{)} &= 10.61\text{V}
 \end{aligned}$$

good work.

2.8.0 Practical Calculations and Diagram of Inductor and Resistor in a Series Circuit

this is theoretical circuit of an inductor and a resistor in series which includes a diagram, calculations and final values for the circuit.

2.8.1 Diagram:



2.8.2 Values:

Circuit Values											
Voltage (E _v) (V) :		1	Inductance in Inductor (L ₁) (mH) :		1	Resistance in Inductor (R _{L1}) (Ω):		2.6	Resistance in Resistor (R ₁) (Ω) :		9.97
Final Values											
Measurements							Calculations				
Frequency (f) (kHz)	CH1 pk to pk Voltage (mV)	CH2 pk to pk Voltage (mV)	Time Difference (μs)	Calculated Measurements			Calculated Values				
				Time for 1 cycle (T) mT	Fraction of Cycle (m)	Phase Angle (°)	X _L (Ω)	R _T (Ω)	Z (Ω)	Current (mA)	Phase Angle (°)
1	228	164	72	1.00	72	25.92	6.28	12.57	14.05	71.16	26.56
2	284	160	64	0.50	128	46.08	12.57	12.57	17.77	56.26	44.99
3	356	156	44	0.33	132	47.52	18.85	12.57	22.66	44.14	56.30
4	420	148	36	0.25	144	51.84	25.13	12.57	28.10	35.59	63.43
5	484	144	40	0.20	200	72.00	31.42	12.57	33.84	29.55	68.19
6	544	140	30	0.17	180	64.80	37.70	12.57	39.74	25.16	71.56
7	592	136	26	0.14	182	65.52	43.98	12.57	45.74	21.86	74.05
8	640	124	24	0.13	192	69.12	50.27	12.57	51.81	19.30	75.96
9	676	124	24	0.11	216	77.76	56.55	12.57	57.93	17.26	77.47

2.8.3 Time for 1 cycle (T):

$$\text{Time for 1 cycle (T)} = \frac{1}{\text{Frequency (f)}} \quad \text{Time for 1 cycle (T)} = \frac{1}{7000}$$

$$\text{Time for 1 cycle (T)} = 0.14\text{mT}$$

2.8.4 Fraction of Cycle:

$$\text{Fraction of Cycle} = \frac{\text{Time Difference}}{\text{Time for 1 cycle (T)}} \quad \text{Fraction of Cycle} = \frac{0.000026}{0.00014}$$

$$\text{Fraction of Cycle} = 182\text{m}$$

2.8.5 Phase Angle:

$$\text{Phase Angle (}^\circ\text{)} = \text{Fraction of Cycle (m)} \times 360$$

$$\text{Phase Angle (}^\circ\text{)} = 0.182 \times 360$$

$$\text{Phase Angle (}^\circ\text{)} = 65.52^\circ$$

2.8.6 XL:

$$X_L = 2 \times \pi \times \text{Frequency (f)} \times \text{Inductance Inductor (L}_1\text{)}$$

$$X_L = 2 \times \pi \times 7000 \times 0.001$$

$$X_L = 43.98\Omega$$

2.8.7 Total Resistance:

$$\text{Total Resistance } R_T = \text{Resistance in Resistor (R}_1\text{)} + \text{Resistance in Inductor (R}_L\text{)}$$

$$\text{Total Resistance } R_T = 9.97 + 2.6$$

$$\text{Total Resistance } R_T = 12.57\Omega$$

2.8.8 Z

$$Z^2 = R_T^2 + X_L^2$$

$$Z^2 = 12.57^2 + 43.98^2$$

$$Z = \sqrt{2092.2453}$$

$$Z = 45.74\Omega$$

2.8.9 Current

$$\text{Current} = \frac{\text{Voltage (E}_V\text{)}}{Z}$$

$$\text{Current} = \frac{1}{45.74}$$

$$\text{Current} = 21.86\text{mA}$$

2.8.10 Phase Angle

$$\text{Phase Angle} = \frac{X_L}{\text{Total Resistance } R_T} \quad \text{Phase Angle} = \frac{43.98\Omega}{12.57\Omega}$$

$$\text{Phase Angle} = 3.498806683$$

$$\text{Phase Angle} = \tan^{-1} \times 3.498806683$$

$$\text{Phase Angle} = 74.05^\circ$$

3.0 Reference Page and Bibliography

3.1.1 Reference Page

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