

LEVEL 4 ASSESSMENT SPECIFICATION

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Programme:	HNC Electrical/Electronic Engineering & Instrumentation Engineering		
Module:	Electrical Principles		
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Lecturer:	Jason Pointer	Internal Verifier:	Nigel Richards
Assignment Title:	Electrical Principles	Word count (or equivalent):	2000
Submission deadline:	15/01/25	Return date of provisional marks & written feedback:	29/01/25
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: Work which is submitted up to 1 week late will be capped at 40% for the first attempt and will be awarded a mark of 0% for re-assessment. Late submission penalties may be lifted only if there is an approved extenuating circumstances claim. Work submitted more than 1 week late will be considered as a non-submission and will not be marked. The work may be considered as a submission for reassessment if offered by an Examining Board or if there is an approved extenuating circumstances claim.		
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	10	6.2
Engagement with a wide range of literature sources, including sources retrieved independently. Generally sound referencing, with very few inaccuracies or inconsistencies.		
2. Knowledge and Understanding Skills	40	29.8
Task 1 achieved 77%. Task 2 achieved 72%, Task 3 achieved 75%. Task 4 achieved 74%. Excellent knowledge and understanding of the basic underlying concepts and principles of the subject. Showed excellent understanding the calculated requirements. The research work was very good that showed a clear understanding.		
3. Cognitive and Intellectual Skills	10	6.3
Task 1 achieved 66%. Task 4 achieved 60%. Sound evaluation of the underlying concepts and principles for Task 1 and 4.		
4. Practical Application Skills	30	25.4
Task 1 achieved 84%. Task 4 achieved 85%. 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	7.5
Work is coherent, very fluent and is presented professionally. Excellent layout making the assignment easy to read.		

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)		75%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

TASK DESCRIPTION

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.

Table of Contents

Task 1 – DC Circuits.....	2
Task 2 – Capacitors.....	7
Task 3 – Magnetism.....	10
Task 4 – AC Circuits.....	15
References.....	19
Bibliography	19
Figures	20

Task 1 – DC Circuits

Figure 1 below shows a combinational arrangement of a DC circuit.

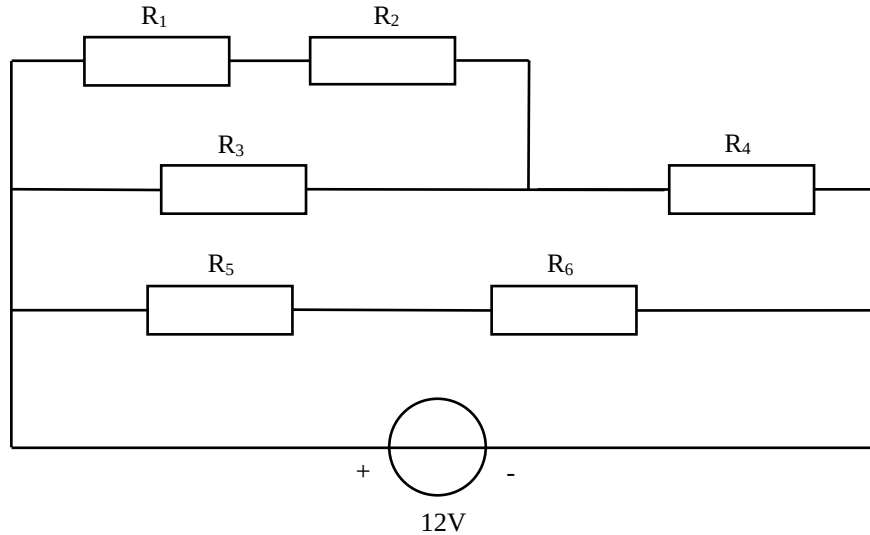


Figure 1 – Resistors in Series/Parallel

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.

Table 1 – values for Task 1

Student Number	R_1 (Ω)	R_2 (Ω)	R_3 (Ω)	R_4 (Ω)	R_5 ($k\Omega$)	R_6 (Ω)
1	680	330	330	560	1	270
2	560	180	220	470	1.2	390
3	680	220	330	470	1.5	220
4	560	330	220	680	1.8	270
5	680	180	330	560	1	330
6	560	270	220	680	1.2	180
7	680	220	330	560	1.5	220
8	680	180	220	470	1.8	330
9	680	180	270	560	1	270
10	560	220	390	680	1.2	330
11	680	330	270	560	1.5	180
12	560	180	390	470	1.8	390

The circuit above was constructed on a bread board, the table below shows the measured results by using a multimeters.

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

$$R_T = 473\Omega$$

2. Connect a 12V supply and measure the p.d. value across each resistor, the supply current and the current in each resistor.

Supply current (I) = 25mA ✓

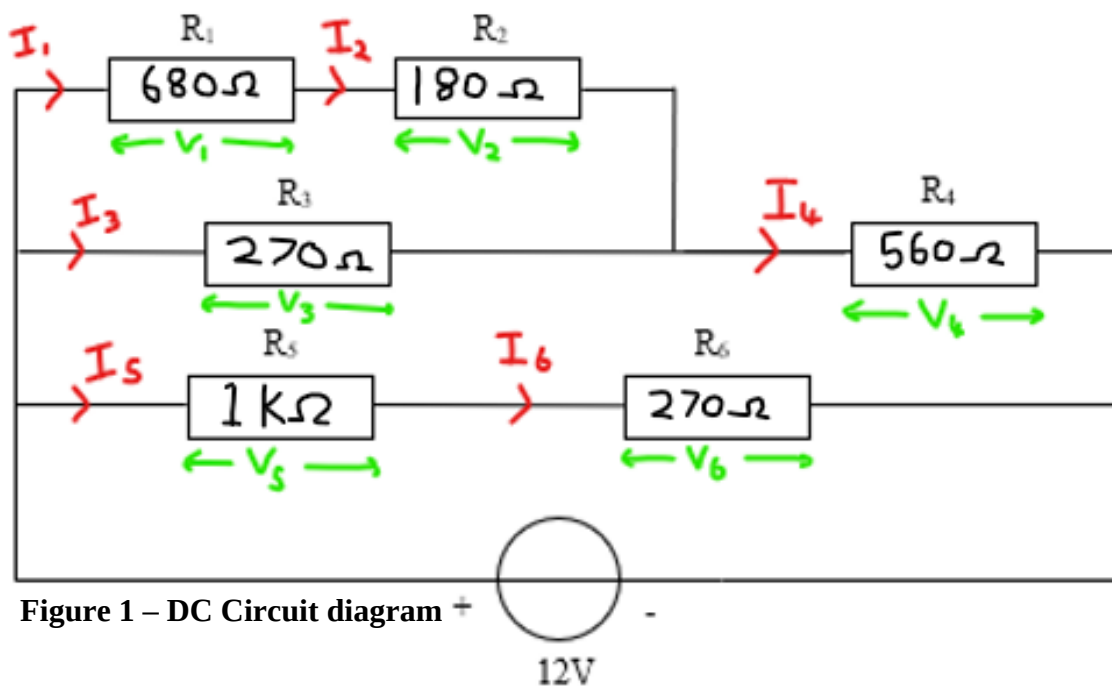
$I_1 = 3.89\text{mA}$, $I_2 = 3.89\text{mA}$, $I_3 = 12.04\text{mA}$, $I_4 = 15.94\text{mA}$, $I_5 = 9.71\text{mA}$, $I_6 = 9.45\text{mA}$ ✓

$V_1 = 2.52\text{V}$, $V_2 = 0.67\text{V}$, $V_3 = 3.21\text{V}$, $V_4 = 8.73\text{V}$, $V_5 = 9.63\text{V}$, $V_6 = 2.54\text{V}$ ✓

3. Calculate the

- total resistance, R_T
- supply current, I
- current in each resistor
- the p.d. value across each resistor
- and power dissipation in each resistor.

All formulas and workings must be shown.



Total resistance

$$R_t = \frac{\left(\left(\frac{R_1 + R_2}{R_3}\right) + R_4\right)}{R_5 + R_6} \quad \checkmark$$

$$R_{12} = 680 + 180 = 860\Omega \quad \checkmark$$

$$R_{123} = \frac{860 \times 270}{860 + 270} = 205.49\Omega \quad \checkmark$$

$$R_{1234} = 205.49 + 560 = 765.49\Omega \quad \checkmark$$

$$R_{56} = 1000 + 270 = 1270\Omega \quad \checkmark$$

$$R_T = \frac{R_{1234} \times R_{56}}{R_{1234} + R_{56}} = \frac{765.49 \times 1270}{765.49 + 1270} = 477.61\Omega \quad \checkmark$$

Supply current

$$I = \frac{V}{R_T} = \frac{12}{477.61} = 0.02513A = 25.13mA$$

Current in each resistor

$$I_5 = I_6 = \frac{V}{R_{56}} = \frac{12}{1270} = 9.45 \times 10^{-3} = 9.45mA$$

$$I_4 = I - I_5 = 25.13 - 9.45 = 15.68mA$$

$$I_3 = \frac{V_3}{R_3} = \frac{3.22}{270} = 0.01193A = 11.93mA$$

$$I_1 = I_2 = I - I_3 - I_5 = 25.13 - 11.93 - 9.45 = 3.75mA$$

The p.d value in each resistor

$$V_5 = I_5 \times R_5 = 9.45 \times 10^{-3} \times 1000 = 9.45V$$

$$V_6 = I_6 \times R_6 = 9.45 \times 10^{-3} \times 270 = 2.55V$$

$$V_4 = I_4 \times R_4 = 15.68 \times 10^{-3} \times 560 = 8.78V$$

$$V_3 = V - V_4 = 12 - 8.78 = 3.22V$$

$$V_1 = I_1 \times R_1 = 3.75 \times 10^{-3} \times 680 = 2.55V$$

$$V_2 = I_2 \times R_2 = 3.75 \times 10^{-3} \times 180 = 0.68V$$

Power dissipation in each resistor

$$Power = P = I \times V$$

$$P_1 = I_1 \times V_1 = 3.75 \times 2.55 = 9.56mW$$

$$P_2 = I_2 \times V_2 = 3.75 \times 0.68 = 2.55mW$$

$$P_3 = I_3 \times V_3 = 11.93 \times 3.22 = 38.41mW$$

$$P_4 = I_4 \times V_4 = 15.68 \times 8.78 = 137.67mW$$

$$P_5 = I_5 \times V_5 = 9.45 \times 9.45 = 89.30mW$$

$$P_6 = I_6 \times V_6 = 9.45 \times 2.55 = 24.10mW$$

Well done.

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

Kirchhoff's laws form the foundation of DC circuit principles. His current law states, "The sum of currents entering and leaving a junction is zero," and the voltage law states, "The sum of the electromotive forces (e.m.f) and potential drops in a closed loop is zero." (Issacphysics, 2021) This can be seen throughout. For example, Kirchhoff's current law is seen where $I_4 + I_6 =$ supply current ($9.45 + 15.68 = 25.13\text{mA}$). Next, Kirchhoff's voltage law can be seen where $V_5 + V_6 =$ supply voltage ($9.45 + 2.55 = 12\text{V}$) as seen in figure 2.

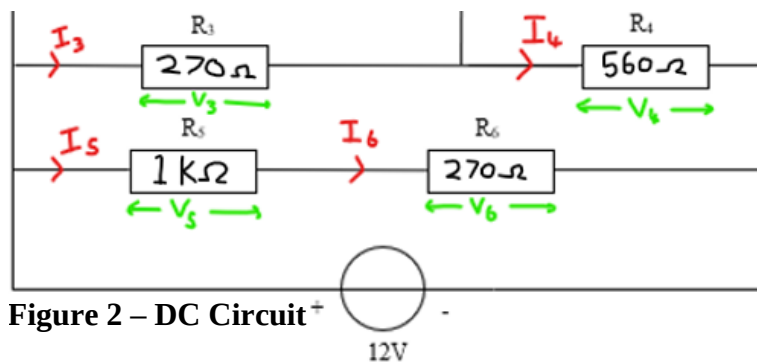


Figure 2 – DC Circuit

When comparing the practical and calculation results, there are slight differences to be seen. For example, the calculated total resistance was 477.61 Ω , whereas the measured resistance was 473 Ω . Another example can be seen in the potential difference across resistor 4 (560 Ω), the calculated value was 8.78V, whereas the measured value was 8.73V. There are several reasons these variations can occur. In theoretical calculations the resistors are assumed to be the exact amount stated and temperature in-dependant. The circuit connections are assumed to be perfect meaning no additional resistance losses occur, and finally, measurement instruments are considered ideal with no internal resistance. This will give exact calculations when working out the values using equations.

However, when this task is completed practically, the theoretical calculations will differ due to several factors. First, resistors are manufactured with tolerances (either +/- 1% or 5%), meaning their actual resistance when measured will have a small deviation from the stated value. For example, R_1 is a 680-ohm resistor with a +/- 5% tolerance, when measured we could see this in a range from 646 ohms to 714 ohms, this will affect the current and voltage distribution in the circuit, leading to variations in the measurements taken.

Another reason we can see slight variations in results is due to the voltage source internal resistance, practical voltage sources (power supplies) have an internal resistance that is not considered in theoretical calculations. The resistance within the power supply causes a voltage drop, reducing the actual voltage powering the circuit. This is an example of Kirchhoff's voltage law where practical results will differ due to imperfect voltage sources. The unaccounted-for

voltage drops will lead to the practical and calculated results being slightly different. (Lenk, R. 1998)

Finally, measurement instruments such as multimeters have many internal components such as resistors and capacitors, these internal components have tolerances which can affect the readings it will display. Multimeters tolerances are usually specified as a percentage of the reading +/- a fixed digit value. For example, "the fluke multimeters have a basic DC accuracy range of 0.5% to 0.025% as stated in the manual" (Fluke, 2024) ✓

Task 2 – Capacitors

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

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.

A capacitor is an electronic component used to store and release electrical energy. There are several primary functions capacitors are used for. First, capacitors can store electrical energy when connected to a power source and release it when required, making them useful for stabilising power supplies. Another practical use of capacitors is found in the start-up of a single stage induction motor, they provide the initial surge of energy required to start the motor up and are not needed once it has reached full running speed. (Horowitz, P. and Hill, W. 2015)

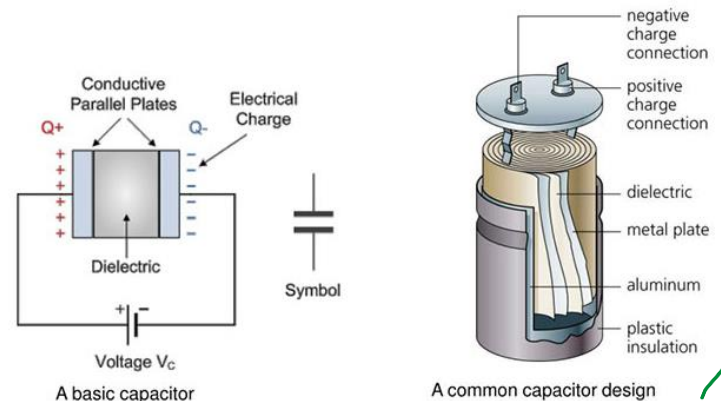


Figure 3 – Capacitor diagram

The construction of a capacitor (Figure 3) is made up of two plates made from materials such as silver, aluminium, or tantalum. These plates can be in the form of sheets, foils, or films. The plates are the source of the electronic field and where the charge is stored. “The conductive metal plates of a capacitor can be either square, circular or rectangular, or they can be of a cylindrical or spherical shape with the general shape, size and construction of a parallel plate capacitor depending on its application and voltage rating.” (Electronics Tutorials, 2023). The two plates are separated by an insulating (non-conducting) material called the dielectric. The dielectric determines the capacitor's ability to store charge; by reducing the electronic field strength between the plates for the same amount of charge, allows more charge to be stored without increasing the voltage, this is determined by the dielectric constant of the material. It is commonly constructed from materials such as ceramic, paper, and plastic film.

There are several types of capacitors available, each designed for specific applications. Ceramic capacitors (figure 4) contain ceramic material as the dielectric, they are small, come at a low cost and have high frequency stability. The values of a ceramic capacitor range between 1pF to 100μF. Another type is film capacitors (figure 5) where the dielectric is a thin plastic film, this type tends to be very reliable and has very low losses such as heat compared to other types, these range from 1nF to 10μF. Finally, larger capacitors such as supercapacitors can store anywhere from 1F to several thousand Farads, these are typically used in energy storage facilities



Figure 4



Figure 5

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

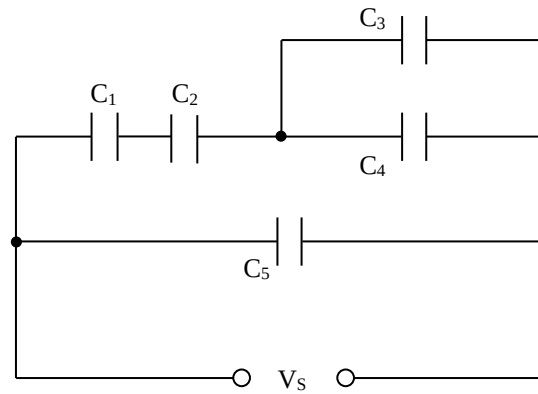


Figure – 2

Using the values stated in Table 2 on the next page, determine:

- a) the equivalent circuit capacitance

$$C_{12} = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{180 \times 220}{180 + 220} = 99\mu F$$

$$C_{34} = C_3 + C_4 = 33 + 10 = 43\mu F$$

$$C_{1234} = \frac{C_{12} \times C_{34}}{C_{12} + C_{34}} = \frac{99 \times 43}{99 + 43} = 29.98\mu F$$

$$C_T = C_{1234} + C_5 = 29.98 + 27 = 56.98\mu F$$

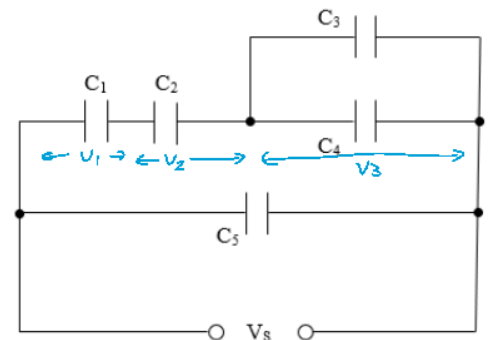


Figure 6

- b) the total charge

$$Q_T = C_T \times V = 56.98 \times 20 = 1139.6\mu C$$

- c) the charge in each capacitor

$$Q_5 = C_5 \times V = 27 \times 20 = 540\mu C$$

$$Q_{1234} = Q_T - Q_5 = 1139.6 - 540 = 599.6\mu C$$

$$Q_1 = Q_2 = Q_{1234} = 599.6\mu C$$

$$V_1 = \frac{Q_1}{C_1} = \frac{599.6}{180} = 3.33V$$

$$V_2 = \frac{Q_2}{C_2} = \frac{599.6}{220} = 2.73V$$

$$V_3 = V_4 = V - (V_1 + V_2) = 20 - (3.33 + 2.73) = 13.94V$$

$$Q_3 = C_3 \times V_3 = 33 \times 13.94 = 460.02 \mu C$$

$$Q_4 = C_4 \times V_4 = 10 \times 13.94 = 139.4 \mu C$$

$$V_5 = V = 20V$$

d) the energy stored in each capacitor

$$W_1 = \frac{1}{2} \times C_1 \times (V_1)^2 = \frac{1}{2} \times 180 \times (3.33)^2 = 998.00 \mu J$$

$$W_2 = \frac{1}{2} \times C_2 \times (V_2)^2 = \frac{1}{2} \times 220 \times (2.73)^2 = 819.82 \mu J$$

$$W_3 = \frac{1}{2} \times C_3 \times (V_3)^2 = \frac{1}{2} \times 33 \times (13.94)^2 = 3206.34 \mu J = 3.206 mJ$$

$$W_4 = \frac{1}{2} \times C_4 \times (V_4)^2 = \frac{1}{2} \times 10 \times (13.94)^2 = 971.62 \mu J$$

$$W_5 = \frac{1}{2} \times C_5 \times (V)^2 = \frac{1}{2} \times 27 \times (20)^2 = 5400 \mu J = 5.4 mJ$$

e) the total energy stored in the circuit.

$$W_T = \frac{1}{2} \times C_T \times V^2 = \frac{1}{2} \times 56.98 \times 20^2 = 11,396 \mu J = 11.40 mJ$$

Table 2 – values for Task 2

Student Number	C ₁ (μF)	C ₂ (μF)	C ₃ (μF)	C ₄ (μF)	C ₅ (μF)	V _S (V)
1	150	470	33	12	15	12
2	150	330	39	15	18	15
3	150	220	43	18	33	20
4	150	220	47	22	27	25
5	220	150	43	27	33	25
6	220	330	39	10	15	25
7	220	470	33	12	18	20
8	220	330	39	15	22	15
9	180	220	33	10	27	20
10	180	270	39	12	33	25
11	180	270	33	6.8	22	18
12	180	150	39	10	27	15

Task 3 – Magnetism

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

Permanent magnets are materials that produce a magnetic field due to the alignment of their atomic structures and the behaviour of their electrons.

Electrons in atoms generate a small magnetic field due to their spinning motion, in normal materials this effect is cancelled out, but in ferromagnetic materials they produced a magnetic field.” Key features of a permanent magnet: it produces its own magnetic field; the magnetic field cannot be turned on and off – it is there all the time” (BBC, 2024)

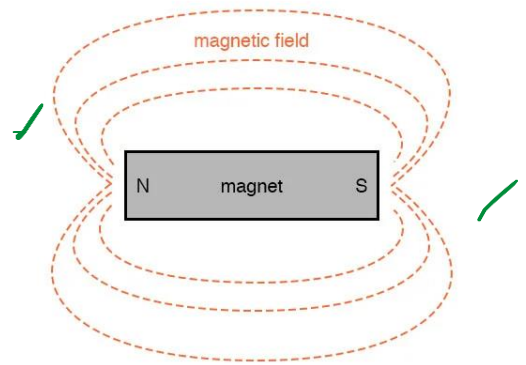


Figure 7

Where magnetic fields are produced by permanent magnets or by current through a conductor such as iron. As seen in Figure 7, the magnetic field of a permanent magnet is represented by magnetic field lines that show the direction and strength of the field. These lines originate from the north pole and terminate at the south pole of the magnet. The density of the lines determines the strength of the field. The closer the lines are to each other, the stronger the field. The field lines then flow back through the magnet to complete the loop, the field is strongest near each of the poles. If two permanent magnets are placed together, opposite poles attract, whereas like poles repel away from each other (figure 8).

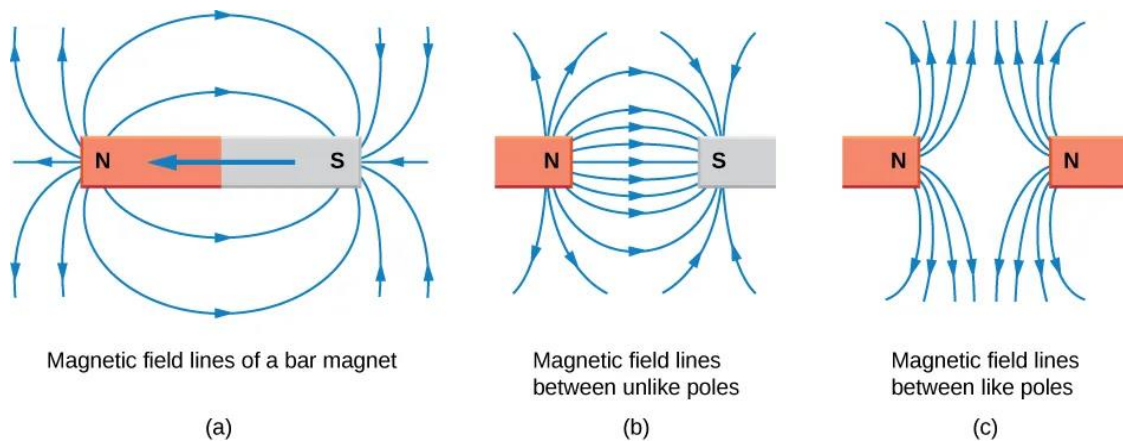


Figure 8

2. Solve the following problems:
 - a) A magnetic pole face has a rectangular section having dimensions 250mm by 140mm. If the total flux emerging from the pole is $150\mu\text{Wb}$, calculate the flux density.

$$\text{Area} = \text{Width} \times \text{Height} = 0.250\text{m} \times 0.140\text{m} = 0.035\text{m}^2$$

$$B = \frac{\Phi}{A} = \frac{150 \times 10^{-6}\text{Wb}}{0.035\text{m}^2} = 4.286 \times 10^{-3} = 4.29\text{mT}$$

- b) The maximum working flux density of a lifting electromagnet is 2T and the effective area of a pole face is circular in cross-section. If the total magnetic flux produced is 630mWb determine the radius of the pole face.

$$B = \frac{\Phi}{A}$$

$$\text{Area of circle} = \pi r^2$$

$$B = \frac{\Phi}{\pi r^2}, r^2 = \frac{\Phi}{B\pi}, r = \sqrt{\frac{\Phi}{B\pi}}$$

$$r = \sqrt{\frac{630 \times 10^{-3}}{2 \times \pi}} = 0.3166 = 0.317m = 317mm$$

3. Explain the principal operation and construction of an electromagnet including the distribution of magnetic fields.

An electromagnet is a device that produces a magnetic field when a current is flowing through it. The construction consists of a core material such as a soft iron, it is used as the core because it enhances the strength of the field (Figure 9). The magnetic properties of the core material are described by a hysteresis loop, which shows the relationship between the magnetic force (H) and the Flux density (B). The soft iron material is used to minimise hysteresis loss due to it having a narrow hysteresis loop, this is important as a narrow hysteresis loop promotes easy switching between magnetisation states, meaning minimal losses. A coil made from insulated copper wire is wound round the core, the number of turns is directly proportional to the strength of the magnetic field. Finally, a DC power supply is used to generate a steady magnetic field, whereas an AC supply is used if you want a varying magnetic field, due to the shape of the AC waveform.

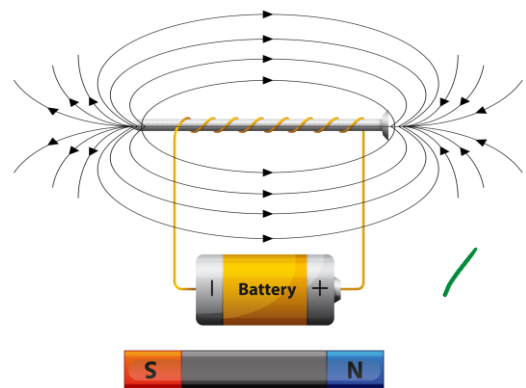


Figure 9

Operation

When a current is passed through the coil, a magnetic field is induced, due to the form of the magnetic field lines, they form a closed loop around the coil and concentrate it within the core material due to its high permeability. The direction of the magnetic field is determined by Faradays 'Right Hand Rule,' "If the fingers of the right-hand curl in the direction of the current in the coil, the thumb points in the direction of the magnetic field (North pole)"

Faradays first and second laws are related to electromagnets when the current of magnetic field changes. His first law states “Whenever a conductor is placed in a varying magnetic field, an electromotive force is induced. If the conductor circuit is closed, a current is induced, which is called induced current.” If there is a change in the current within the coil, the changing magnetic flux induces a voltage in any nearby conductors or within the coil itself. ✓

Faradays second law states “The induced emf in a coil is equal to the rate of change of flux linkage.” The flux linkage is the product of the number of turns in the coil and the flux associated with the coil. Both of his laws give the explanation to changes in the magnetic fields given off by the electromagnet when the current changes. (BYJU'S. 2020) ✓

4. An induction motor is a device that uses some of the principles associated with electromagnetism. Explain the operation and construction of an induction motor, make reference to how to reduce power loss within the motor.

An example of an induction motor is a Cage-motor, it is a type of AC motor that operates on the principles of electromagnetic induction and magnetic fields.

Construction

The first part of the motor is the stator, it consists of a core made of laminated silicon steel to reduce and eddy current losses that may occur, it also has evenly spaced slots that house the stator windings. These windings consist of copper or aluminium insulated wires forming 3 phase windings, which is then connected to a 3-phase power supply. As the name suggests this is the stationary part of the induction motor. The rotor contains aluminium, or copper bars embedded longitudinally within a laminated steel core, these bars are short circuited at each end to form a closed electrical circuit. A small air gap (0.5-2mm) between the stator and rotor ensures magnetic coupling with minimal losses. (See figure 10 for a cage induction motor). ✓

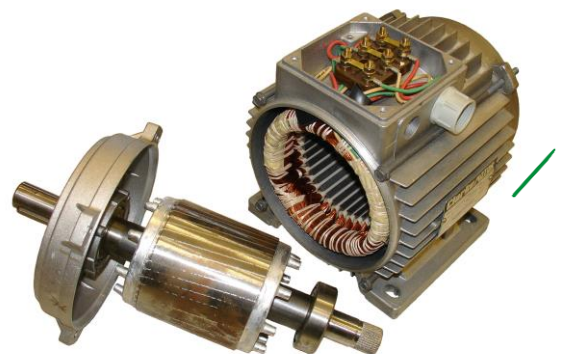


Figure 10

Operation

A 3-phase AC supply energises the stator windings, creating a rotating magnetic field. At this magnetic field sweeps past the stationary rotor bars, the changing magnetic flux induces a voltage and in turn a current, in the bars as per Faradays law. This interaction causes the currents in the rotor to produce a force which turns the rotor in the same direction as the rotating magnetic field.

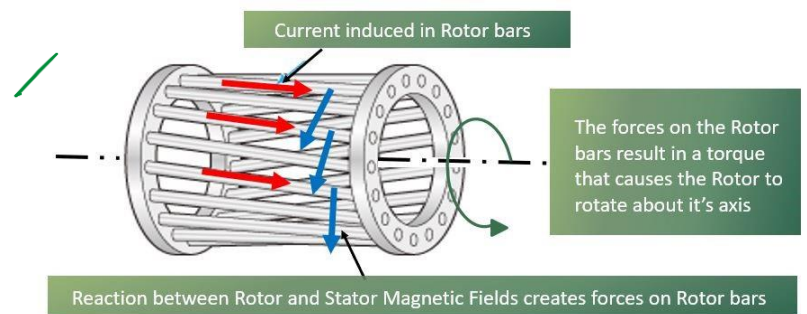


Figure 11

Power losses and reduction methods

First, resistance in the stator windings and rotor bars generate losses through heat, this can be minimised through using high-conductivity materials like copper. Next, Hysteresis losses can occur due to repeated magnetization and de-magnetization of the core, this can be reduced by choosing materials which experience low hysteresis losses such as silicon steel which is commonly used across industrial plants, this is due to its high permeability value of 2000. This can be displayed when looking at the BH curve of silicon steel which is a soft ferromagnetic material compared to a hard ferromagnetic material (figure 12). Finally, mechanical losses such as friction in the bearings can occur, proper lubrication and alignment is key to reduce this from effecting performance, all equipment should be involved in a preventative maintenance plan, meaning the bearings should be replaced periodically.

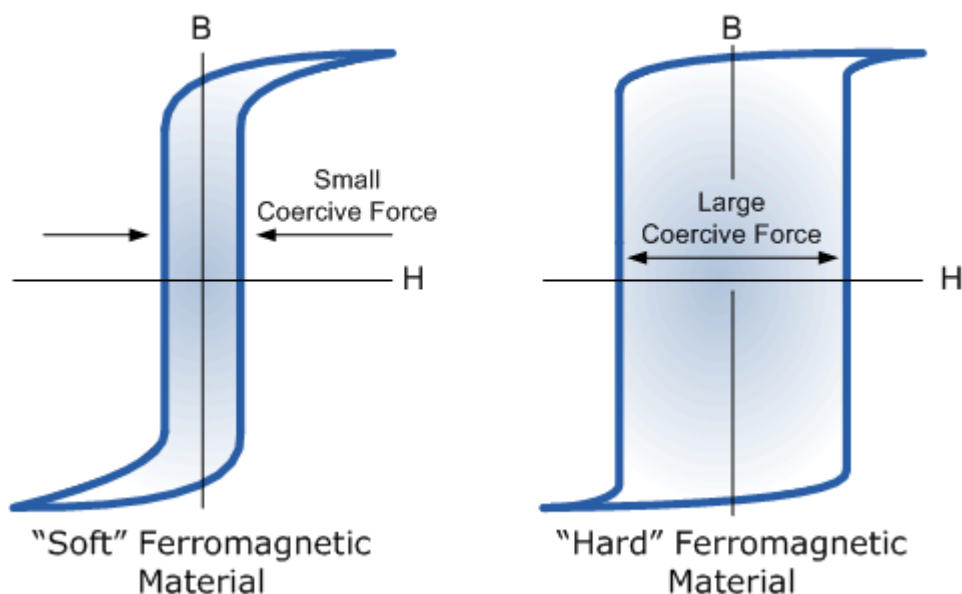


Figure 12

5. Solve the following problems:

- a) A 800 turn coil of inductance 3H carries a current of 1.5A. Calculate the flux linking the coil and the e.m.f. induced in the coil when the current collapses to zero in 25ms.

$$N\Phi = L.I,$$

$$\text{Rearrange For } \Phi = \frac{L.I}{N}$$

$$\Phi = \frac{3 \times 1.5}{800} = \frac{4.5}{800} = 5.625 \text{mWb}$$

$$\text{Induced e.m.f} = -N \times \frac{\Delta\Phi}{\Delta t} = -800 \times \frac{5.625 \times 10^{-3}}{25 \times 10^{-3}} = -180V$$

The negative voltage indicates the direction of the induced e.m.f, which opposes the change in flux.

Magnetic flux linking the coil = 5.625mWb

Induced e.m.f = 180V

- b) A rectangular coil of sides 12cm and 7cm is rotated in a magnetic field of flux density 1.5T, the longer side of the coil actually cutting this flux. The coil is made up of 80 turns and rotates at 1400rev/min. (i) Calculate the maximum generated e.m.f. (ii) If the coil generates 85V, at what speed will the coil rotate?

Given data

- B = 1.5T
- Sides of the coil = 7cm x 12cm = 0.12m x 0.07m
- N = 80
- F = 1400rev/min

Maximum generated e.m.f

$$E = 2NBLV \times \sin\theta$$

$$V = \omega r = \left(\frac{1400}{60} \times 2\pi\right) \times \left(\frac{7 \times 10^{-2}}{2}\right) = 5.13 \frac{m}{s}$$

$$E = 2 \times 80 \times 1.5 \times 12 \times 10^{-2} \times 5.13 \times \sin 90 = 147.7V$$

Rotational speed to generate 85V

When E = 85V

$$V = \frac{E}{2NBL} = \frac{85}{2 \times 80 \times 1.5 \times 12 \times 10^{-2}} = 2.95 \frac{m}{s}$$

$$\omega = \frac{V}{r} = \frac{2.95}{\left(\frac{7 \times 10^{-2}}{2}\right)} = 84.29 \frac{rad}{sec}$$

$$\text{Speed} = \frac{84.29 \times 60}{2\pi} = 804.91 = 805 \frac{rev}{min}$$

Task 4 – AC Circuits

1) AC voltage is represented by the equation:

$$V = V_m \sin(\omega t \pm \phi)$$

Using the values stated in table 3 determine the following:

a) The root mean square voltage of the waveform

$$V_{RMS} = \frac{V_{max}}{\sqrt{2}} = \frac{18}{\sqrt{2}} = 12.73V$$

b) Angular velocity

$$\omega = 2 \times \pi \times F$$

$$\omega = 2 \times \pi \times 40 = 80\pi$$

$$80 \times \pi = 251.33 \frac{rad}{s}$$

c) The output voltage at time, $t = 0s$

$$V_{max} = 18V, \quad f = 40Hz, \quad \theta = 38^\circ, \quad t = 0$$

$$\text{Convert angle into radians} = 38 \times \frac{\pi}{180} = \frac{19}{90}\pi$$

$$\text{Sub into equation, } V_0 = V_{max} \sin(\theta)$$

$$V_0 = 18 \sin\left(\frac{19}{90}\pi\right) = 11.08V$$

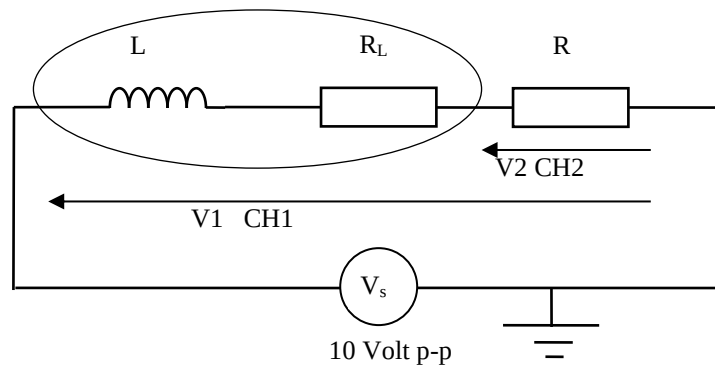
d) The time taken to reach the first peak of maximum voltage.

$$\text{Time taken } (t) = 1000 \times \left(\frac{\left(\frac{1}{2} \times \pi\right) - \left(\frac{38 \times \pi}{180}\right)}{251.33} \right) = 3.61ms$$

Table 3 – values for Task 4

Student Number	Maximum Voltage (V)	Frequency (Hz)	Phase Angle (°)
1	10	40	25
2	12	45	28
3	15	50	33
4	18	55	35
5	20	60	26
6	10	55	28
7	12	50	32
8	15	45	34
9	18	40	38
10	20	44	33
11	12	48	29
12	16	56	25

1. Below is a RL circuit:



$$L = 4.7\text{mH}, R = 33\Omega, R_L = ?\Omega \text{ (measure this value)}$$

Measure and record the value of each of the component.

$$L = 4.52\text{mH}$$

$$R = 32.8\Omega$$

$$R_L = 12.54\Omega$$

2. Produce a table of measurements as shown below:

Frequency (f)	CH1 (V) pk to pk Voltage	CH2 (V) pk to pk Voltage	Time Difference (between peaks) (μS)	Phase Angle ($^\circ$)
1	5.56	3.19	85.50	30.78
2	6.59	2.83	71.93	51.79
3	7.57	2.41	56.60	61.13
4	8.20	2.01	44.81	64.53
5	8.60	1.80	40.09	72.16
6	8.87	1.60	34.20	73.87
7	9.09	1.43	29.48	74.29
8	9.27	1.27	24.76	79.31

E.g., Phase Angle @Frequency = 4kHz

$$\text{Phase Angle} = \frac{f \times \Delta T \times 360}{1000} = \frac{4 \times 44.81 \times 10^{-6} \times 360}{1000} = 64.526 = 64.53^\circ$$

3. Produce a table of calculations as shown below:

Frequency (kHz)	Reactance (Ω)(X_L)	Total Resistance (Ω) (R_T)	Impedance (Ω)(Z)	Current (A) (I)	Phase Angle ($^\circ$)
1	28.40	45.34	53.50	0.1869	32.06
2	56.80	45.34	72.68	0.1376	51.40
3	85.20	45.34	96.51	0.1036	61.98
4	113.60	45.34	122.31	0.0818	68.24
5	142.00	45.34	149.06	0.0671	72.29
6	170.40	45.34	176.33	0.0567	75.10
7	198.80	45.34	203.90	0.0490	77.15
8	227.20	45.34	231.68	0.0432	78.71
9	255.60	45.34	259.59	0.0385	79.94

Show clearly **one full example of your method** for calculating for Reactance, Impedance, Current and Phase Angle for a chosen frequency.

Full workings shown for Frequency @ 3kHz.

$$\begin{aligned}
 X_L &= 2 \times \pi \times 3 \times 4.52 = 85.20\Omega \\
 R_T &= 32.8 + 12.54 = 45.34\Omega \\
 Z &= \sqrt{(45.34)^2 + (85.20)^2} = 96.51\Omega \\
 I &= \frac{V}{Z} = \frac{10}{96.51} = 0.1036A \\
 \text{Phase Angle } (\theta) &= \tan^{-1} \left(\frac{X_L}{R_T} \right) = \tan^{-1} \left(\frac{85.20}{45.34} \right) = 61.98^\circ
 \end{aligned}$$

Must state all formulas

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

When comparing the calculations to the practical values of the phase angle, slight differences can be seen. For example, at 6kHz the calculated phase angle is 75.10° , whereas the measured value in the practical was 73.87° . There are several reasons these variations can occur. Human error can interfere with readings, such as perfectly lining up the cursor bars with the waveforms due to the resolution of the computer screens. To go with this, everyone has a slightly different interpretation of where the reference point should be, even these small differences will influence the phase angle. Another reason human error will affect the results is setting the frequency to the exact value. For example, it was decided to accept a $\pm 1\%$ value (at 1kHz an acceptable range was 0.99-1.01kHz).

Impedance in the coaxial cable will influence the transmission of the waveforms. “Electrical impedance is defined as the measure of opposition that a circuit presents to a current when a voltage is applied, involving both resistance and reactance” (Electrical 4 U. 2024).

Impedance mis-match values in the cable and signal generator (Figure 13) can cause the signal to be partially reflected, causing distortion and phase shifts, leading to variations in the practical results. Resistance in the oscilloscope leads have a small resistance which can



Figure 13

create a voltage drop, leading to the signal being measured slightly differing from the real result, leading to small deviations in practical and calculated results.

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would like to see more text books.

Figures

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