

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Turki Alesawi	Student ID number:	
Programme:	HNC Electrical/Electronic Engineering & Instrumentation Engineering		
Module:	Electrical Principles		
Module code:	PCEE4001	Contribution to Overall Module Assessment (%):	100%
Lecturer:	Jason Pointer	Internal Verifier:	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	3.8
Some engagement with essential reading, have listed reference sources. There is a lack of referencing within the assignment.		
2. Knowledge and Understanding Skills	40	30.7
Task 1 achieved 75%. Task 2 achieved 78%, Task 3 achieved 76%. Task 4 achieved 78%. 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	5.4
Task 1 achieved 64%. Task 4 achieved 43%. Good evaluation of the underlying concepts and principles for Task 1 and 4.		
4. Practical Application Skills	30	25.5
Task 1 achieved 85%. 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	7.2
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)		73%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

Task 1 – DC Circuits

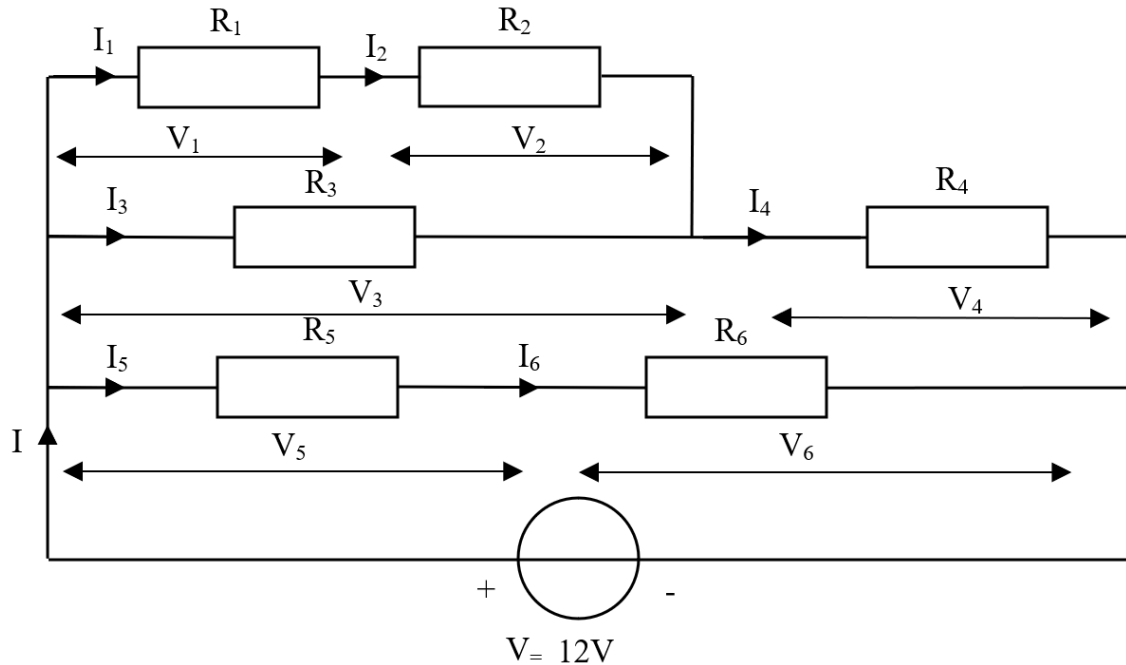


Figure 1 Resistors in Series/Parallel

R_1 (Ω)	R_2 (Ω)	R_3 (Ω)	R_4 (Ω)	R_5 ($k\Omega$)	R_6 (Ω)
680	330	330	560	1	270

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

Should be written in past tense.

$R_T = 488 \Omega$ ✓

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

V_1 (V)	V_2 (V)	V_3 (V)	V_4 (V)	V_5 (V)	V_6 (V)
2.47 ✓	1.18 ✓	3.66 ✓	8.37 ✓	9.44 ✓	2.60 ✓

I (mA)	I_1 (mA)	I_2 (mA)	I_3 (mA)	I_4 (mA)	I_5 (mA)	I_6 (mA)
24.2 ✓	3.6 ✓	3.6 ✓	11.1 ✓	14.8 ✓	9.4 ✓	9.4

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.

$$I = I_1 + I_3 + I_5 \quad ✓$$

$$I_1 = I_2 \quad ✓$$

$$V_3 = V_1 + V_2 \quad ✓$$

$$I = I_4 + I_5 \quad ✓$$

$$I_5 = I_6 \quad ✓$$

$$V = V_3 + V_4 \quad ✓$$

$$I_4 = I_1 + I_3 \quad ✓$$

$$V = V_5 + V_6 \quad ✓$$

Total resistance, R_T :

$$R_T = \left(((R_1 + R_2) \parallel R_3) + R_4 \right) \parallel (R_5 + R_6) \quad ✓$$

$$R_{12} = R_1 + R_2 = 680 + 330 = 1010 \, \Omega \quad ✓$$

$$R_{123} = \frac{R_{12} \times R_3}{R_{12} + R_3} = \frac{1010 \times 330}{1010 + 330} = \frac{333300}{1340} = 248.73 \, \Omega$$

$$R_{1234} = R_{123} + R_4 = 248.73 + 560 = 808.73 \, \Omega \quad ✓$$

$$R_{56} = R_5 + R_6 = 1000 + 270 = 1270 \, \Omega \quad ✓$$

$$R_T = \frac{R_{1234} \times R_{56}}{R_{1234} + R_{56}} = \frac{808.73 \times 1270}{808.73 + 1270} = \frac{1027087.1}{2078.73} = \underline{494.09 \, \Omega} \quad ✓$$

Supply current, I :

$$I = \frac{V}{R_T} = \frac{12}{494.09} = 24.29 \times 10^{-3} A = \underline{24.29 \, mA} \quad ✓$$

Current in each resistor and the p.d. value across each resistor:

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

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

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

$$I_4 = I - I_5 = 24.29 - 9.45 = \underline{14.84 \text{ mA}}$$

$$V_4 = I_4 \times R_4 = 14.84 \times 10^{-3} \times 560 = \underline{8.31 \text{ V}}$$

$$V_3 = V - V_4 = 12 - 8.31 = \underline{3.69 \text{ V}}$$

$$I_3 = \frac{V_3}{R_3} = \frac{3.69}{330} = 11.18 \times 10^{-3} A = \underline{11.18 \text{ mA}}$$

$$I_1 = I_2 = I_4 - I_3 = 14.84 - 11.18 = \underline{3.66 \text{ mA}}$$

$$V_1 = I_1 \times R_1 = 3.66 \times 10^{-3} \times 680 = \underline{2.49 \text{ V}}$$

$$V_2 = I_2 \times R_2 = 3.66 \times 10^{-3} \times 330 = \underline{1.20 \text{ V}}$$

Power dissipation in each resistor:

$$P_1 = V_1 \times I_1 = 2.49 \times 3.66 \times 10^{-3} = 9.11 \times 10^{-3} \text{ W} = \underline{9.11 \text{ mW}}$$

$$P_2 = V_2 \times I_2 = 1.20 \times 3.66 \times 10^{-3} = 4.39 \times 10^{-3} \text{ W} = \underline{4.39 \text{ mW}}$$

$$P_3 = V_3 \times I_3 = 3.69 \times 11.18 \times 10^{-3} = 41.25 \times 10^{-3} \text{ W} = \underline{41.25 \text{ mW}}$$

$$P_4 = V_4 \times I_4 = 8.31 \times 14.84 \times 10^{-3} = 123.32 \times 10^{-3} \text{ W} = \underline{123.32 \text{ mW}}$$

$$P_5 = V_5 \times I_5 = 9.45 \times 9.45 \times 10^{-3} = 89.30 \times 10^{-3} \text{ W} = \underline{89.30 \text{ mW}}$$

$$P_6 = V_6 \times I_6 = 2.55 \times 9.45 \times 10^{-3} = 24.1 \times 10^{-3} \text{ W} = \underline{24.1 \text{ mW}}$$

Excellent set of calculations

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.

Measured $R_T = 488 \Omega$

Calculated $R_T = 494.09 \Omega$

	V_1 (V)	V_2 (V)	V_3 (V)	V_4 (V)	V_5 (V)	V_6 (V)
Measured	2.47	1.18	3.66	8.37	9.44	2.60
Calculated	2.49	1.20	3.69	8.31	9.45	2.55

	I(mA)	I ₁ (mA)	I ₂ (mA)	I ₃ (mA)	I ₄ (mA)	I ₅ (mA)	I ₆ (mA)
Measured	24.2	3.6	3.6	11.1	14.8	9.4	9.4
Calculated	24.29	3.66	3.66	11.18	14.84	9.45	9.45

By comparing the measured value of the total resistance with the calculated value, we notice a difference, which is attributed to the tolerance of the resistors used, which can reach up to 5%.

Similarly, when comparing the measured voltage and current with the calculated voltage and current, slight differences are observed. These differences can be attributed to variations in resistor values and possibly to human measurement errors. Additionally, several factors may affect the accuracy of the measurements, such as dirty measurement wires, loose connections, and the precision of the measuring devices.

For instance:

The internal resistance of the voltmeter or ammeter can affect the circuit.

The internal resistance of the voltmeter should be very high to minimize current draw.

The internal resistance of the ammeter should be very low to reduce voltage loss

Kirchhoff's* laws state:

(a) **Current Law.** *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.*

Where the law was used to calculate I₁, I₂ and I₄.

(b) **Voltage Law.** *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.*

Where the law was used to calculate V₃.

Task 2 – Capacitors

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 electrical component that stores electrical energy. It consists of two parallel conductive plates separated by an insulating material. When the plates are connected to opposite terminals of an electric potential (voltage), an electric field is generated between the two plates. ✓

The capacitance of a capacitor is determined by the following equation:

$$C = \frac{Q}{V} \quad Q = DA \quad V = Ed$$

$$C = \frac{DA}{Ed} \quad \frac{D}{E} = \epsilon_0 \epsilon_r$$
 ✓

$$C = \frac{\epsilon_0 \epsilon_r A}{d}$$

where $\epsilon_0 = 8.85 \times 10^{-12}$ F/m (constant)
 ϵ_r = relative permittivity
 A = area of one of the plates, in m^2 , and
 d = thickness of dielectric in m

If we want to increase the capacitance of the capacitor, this can be achieved by increasing the plate area, increasing the relative permittivity, or decreasing the thickness of the dielectric. ✓ Good

If we want to decrease the capacitance, this can be done by reversing the above actions.

Types of capacitors

Practical types of capacitors are characterized by the material used for their dielectric

Variable Air Capacitors

These capacitors consist of two sets of metal plates (such as aluminium), one fixed and the other movable around an axis. By moving the plates, the area of the electric field between them changes, which leads to a change in the capacitance of the capacitor. The capacitance values for this type range from 500 picofarads to 1000 picofarads. ✓

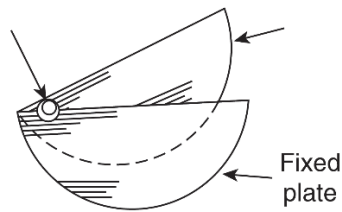


Figure 2

Mica Capacitors

These capacitors are made of thin mica sheets, a good insulator, placed between layers of metal plates. Since mica is expensive, these capacitors are not used for capacitance values greater than 0.2 microfarads.

A modified form of mica capacitors is created by coating a thin layer of silver on both sides to form the plates. This type of capacitor is used in high-frequency circuits with capacitance values up to 1000 picofarads.

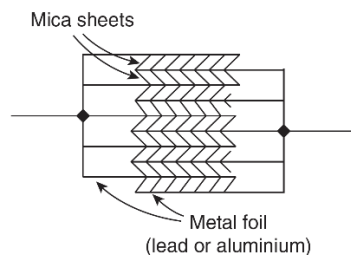


Figure 3

Paper Capacitors

This type of capacitor consists of metal foils with paper placed between them, which are rolled together. The length of the roll determines the required capacitance. The entire assembly is usually impregnated with oil or wax to prevent moisture and then encased in a plastic or aluminium container for protection. The maximum capacitance values for this type range from 500 picofarads to 10 millifarads.

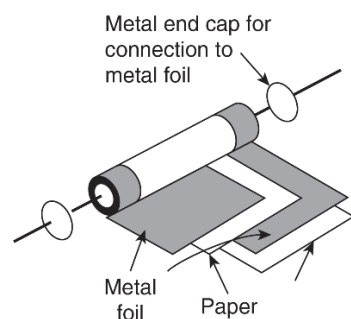


Figure 4

Ceramic Capacitors

Ceramic capacitors use a ceramic material as the dielectric and come in different shapes.

The construction depends on the required capacitance value:

For higher capacitance values, a ceramic tube is used, as shown in the cross-sectional as shown in Figure (5), For smaller capacitance values a cup-shaped construction is used as shown in Figure (6), For the smallest capacitance values, a disk-shaped construction is used as shown in Figure (7). Ceramic capacitors are available in a range from 1 picofarad to 0.1 millifarads.

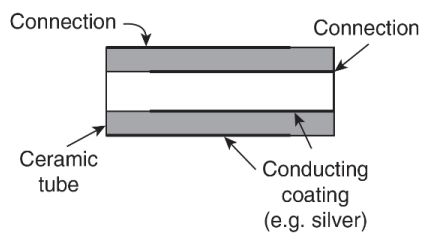


Figure 5

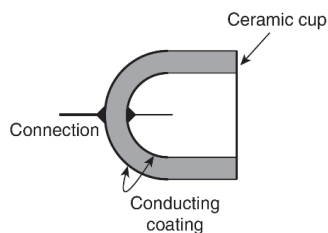


Figure 6

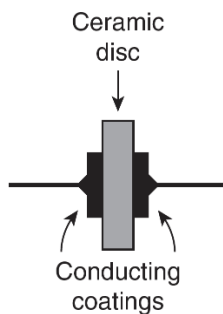


Figure 7

Plastic Capacitors

Some plastics, such as polystyrene and Teflon, can be used as dielectric materials. The construction is similar to paper capacitors, but a plastic film is used instead of paper.

Plastic capacitors perform well under high-temperature conditions, provide precise capacitance values, and have a very long service life with high reliability.

Titanium Oxide Capacitors

These capacitors offer very high capacitance and a small physical size when used at low temperatures. /

Electrolytic Capacitors

The construction of electrolytic capacitors is similar to paper capacitors, but aluminium foils are used for the plates. A thick absorbent material, such as paper soaked in an electrolyte (e.g., ammonium borate), separates the plates. The finished capacitor is usually housed in a sealed aluminium container. /

The operation of electrolytic capacitors depends on the formation of a thin layer of aluminium oxide on the positive plate through an electrolytic process when a suitable direct current (DC) voltage is applied across the plates. This oxide layer acts as the dielectric and is extremely thin, allowing for a much higher capacitance compared to other capacitors of similar size. /

Electrolytic capacitors must always be used with DC and connected with the correct polarity. If connected incorrectly, the oxide layer will be destroyed, and the capacitor will be damaged. /

Electrolytic capacitors are manufactured with operating voltages ranging from 6 volts to 600 volts. However, their accuracy is generally low. Their high capacitance is due to the oxide layer being only a few microns thick. Despite their size advantage, their use is limited to DC applications. /

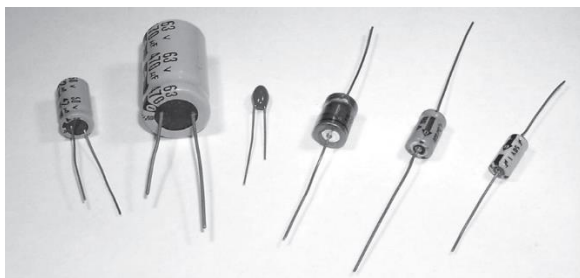


Figure 8

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

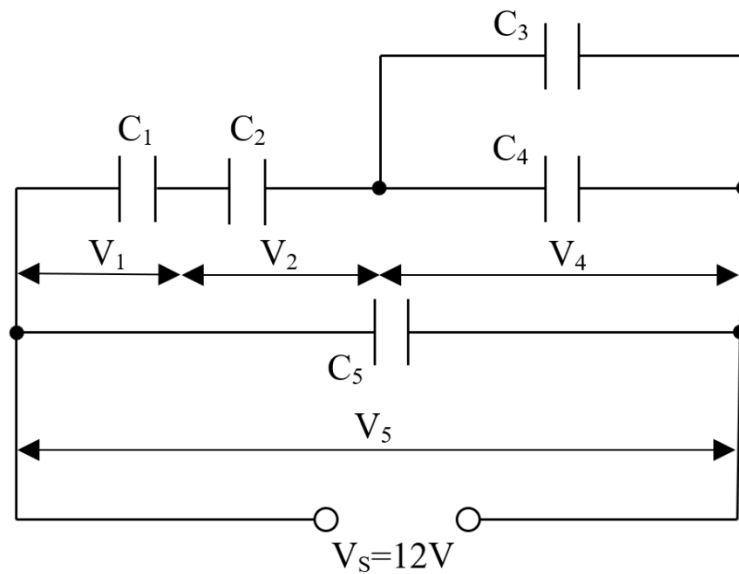


Figure 9

C_1 (μF)	C_2 (μF)	C_3 (μF)	C_4 (μF)	C_5 (μF)	V_S (V)
150	470	33	12	15	12

a) the equivalent circuit capacitance

$$C_{12} = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{150 \times 470}{150 + 470} = \frac{70500}{620} = 113.71 \mu\text{F}$$

$$C_{34} = C_3 + C_4 = 33 + 12 = 45 \mu\text{F}$$

$$C_{1234} = \frac{C_{12} \times C_{34}}{C_{12} + C_{34}} = \frac{113.71 \times 45}{113.71 + 45} = \frac{5116.95}{158.71} = 32.24 \mu\text{F}$$

$$C_T = C_{1234} + C_5 = 32.24 + 15 = \underline{47.24 \mu\text{F}}$$

b) the total charge

$$Q_T = C_T \times V_S = 47.24 \times 12 = \underline{566.88 \mu\text{C}}$$

c) the charge in each capacitor

$$V_5 = V_S = 12 \text{ V}$$

$$Q_5 = C_5 \times V_5 = 15 \times 12 = \underline{180 \mu\text{C}}$$

$$Q_{1234} = Q_T - Q_5 = 566.88 - 180 = 386.88 \mu\text{C}$$

$$Q_1 = Q_2 = Q_{1234} = \underline{386.88 \mu\text{C}}$$

$$V_1 = \frac{Q_1}{C_1} = \frac{386.88}{150} = 2.58 \text{ V}$$

$$V_2 = \frac{Q_2}{C_2} = \frac{386.88}{470} = 0.82 \text{ V}$$

$$V_3 = V_4 = V_S - (V_1 + V_2) = 12 - (2.58 + 0.82) = 8.60 \text{ V}$$

$$Q_3 = C_3 \times V_3 = 33 \times 8.6 = 283.8 \mu\text{C}$$

$$Q_4 = C_4 \times V_4 = 12 \times 8.6 = 103.2 \mu\text{C}$$

d) the energy stored in each capacitor

$$W_1 = \frac{1}{2} C_1 \times V_1^2 = \frac{1}{2} \times 150 \times 2.58^2 = 499.23 \mu\text{J}$$

$$W_2 = \frac{1}{2} C_2 \times V_2^2 = \frac{1}{2} \times 470 \times 0.82^2 = 158.01 \mu\text{J}$$

$$W_3 = \frac{1}{2} C_3 \times V_3^2 = \frac{1}{2} \times 33 \times 8.60^2 = 1220.34 \mu\text{J}$$

$$W_4 = \frac{1}{2} C_4 \times V_4^2 = \frac{1}{2} \times 12 \times 8.60^2 = 443.76 \mu\text{J}$$

$$W_5 = \frac{1}{2} C_5 \times V_5^2 = \frac{1}{2} \times 15 \times 12^2 = 1080 \mu\text{J}$$

e) the total energy stored in the circuit.

$$W_T = \frac{1}{2} C_T \times V_S^2 = \frac{1}{2} \times 47.24 \times 12^2 = 3401.28 \mu\text{J}$$

Excellent calculations.

Task 3 – Magnetism

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

Permanent magnets are materials that produce a constant magnetic field without the need for an external power source. They have a north pole and a south pole, and the magnetic field consists of closed loops that flow from the north pole to the south pole. These loops do not intersect with one another. ✓

When another magnet is brought close, these loops or lines of force are distorted. Like poles repel each other, while opposite poles attract. ✓

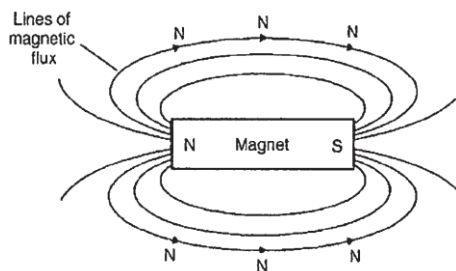


Figure 10

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 150μWb, calculate the flux density.

$$h=200mm \quad l=140mm \quad \Phi=150 \mu Wb$$

$$B = \frac{\Phi}{a} = \frac{150 \times 10^{-6}}{\underbrace{200}_{150} \times 10^{-3} \times 140 \times 10^{-3}} = 5.36 \times 10^{-3} T = \underline{5.36 \times 10^{-3} T} \quad \text{Correct method wrong value.}$$

- 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

$$B=2T \quad \Phi=630mWb$$

$$A = \pi r^2 \quad \checkmark$$

$$B = \frac{\Phi}{A} \Rightarrow A = \frac{\Phi}{B} \quad \checkmark$$

$$\frac{\Phi}{B} = \pi r^2 \Rightarrow r = \sqrt{\frac{\Phi}{\pi B}} \quad \checkmark$$

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

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

When an electric current flows through a wire, a magnetic field is generated in the form of concentric circles around the wire. The direction of the magnetic field can be determined by placing a compass next to the wire. If the direction of the current in the wire is reversed, the direction of the magnetic field will also reverse. The direction of the magnetic field can be determined using the right-hand rule: if the thumb points in the direction of the current, the direction of the other fingers indicates the direction of the magnetic field. ✓

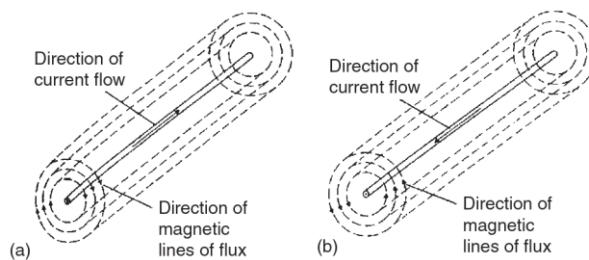


Figure 11

When an electric current flows through a long coil (solenoid), a magnetic field like that of a bar magnet is produced. The direction of the magnetic field can also be determined using the right-hand rule: if the fingers point in the direction of the current flowing through the coil, the thumb will point to the direction of the magnetic field inside the coil or to the coil's north pole. ✓

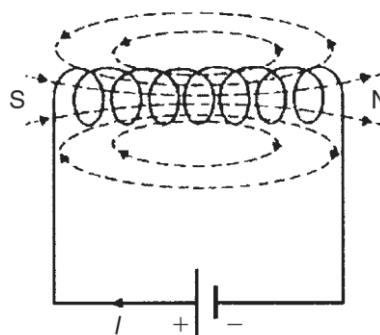


Figure 12

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

An induction motor is a device that converts electrical energy into mechanical motion and operates based on the principle of electromagnetic induction. The induction motor consists of two main parts:

The Stator: A cylindrical iron body with slots on its inner surface. These slots are filled with insulated copper windings.

The Rotor: The rotating part placed inside the stator. It can either be of the wound type or the squirrel cage type.

The magnetic field of the stator interacts with the induced currents in the rotor to generate torque.

How an Induction Motor Works:

The operation of an induction motor relies on Faraday's Law of Electromagnetic Induction and Lenz's Law.

- When an alternating current (AC) is applied to the stator windings, a rotating magnetic field is created around the stator. The speed of this rotating field depends on the frequency of the AC supply and the number of poles in the motor.
- The rotating magnetic field passes through the air gap and cuts through the conductors of the rotor. This induces an electromotive force (EMF) in the rotor conductors according to Faraday's Law. Since the rotor forms a closed electrical circuit, currents are induced in the rotor based on Faraday's Law.
- The induced currents in the rotor create their own magnetic field, which interacts with the rotating magnetic field of the stator. This interaction generates torque, causing the rotor to rotate in the same direction as the rotating magnetic field of the stator.

Energy Loss in Induction Motors

Copper Losses: These occur in the copper windings of the stator due to the electrical resistance of the windings.

Iron Losses:

- Eddy Current Losses: Caused by eddy currents induced in the iron core due to the changing magnetic field. These losses can be minimized by using insulated steel laminations.
- Hysteresis Losses: Caused by repeated magnetization and demagnetization of the core material.

Mechanical Losses: These losses are due to friction between the moving parts of the motor.

By improving insulation, using high-quality materials, and reducing friction, induction motors can be made more efficient.

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.

$$N=800 \text{ turn} \quad L=3 \text{ H} \quad I=1.5 \text{ A} \quad t=25 \text{ ms}$$

The flux linking the coil

$$L = \frac{N\Phi}{I} \Rightarrow \Phi = \frac{LI}{N} = \frac{3 \times 1.5}{800} = 5.625 \times 10^{-3} \text{ Wb} = 5.625 \text{ mWb}$$

The e.m.f. induced in the coil

$$E = -N \frac{d\Phi}{dt} = -800 \frac{5.625 \times 10^{-3}}{25 \times 10^{-3}} = -180 \text{ V}$$

- 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?

$$h=12\text{cm} \quad l=7\text{cm} \quad B=1.5\text{T} \quad N=80 \text{ turns} \quad \text{speed}=1400\text{rev/min}$$

$$(i) \quad E = 2NBLv \sin \theta$$

$$v = \omega r = \left(\frac{1400}{60} \times 2\pi \right) \times \frac{7 \times 10^{-2}}{2} = 5.13 \text{ m/sec}$$

Max voltage when $\theta=90^\circ$

$$E = 2 \times 80 \times 1.5 \times 12 \times 10^{-2} \times 5.13 \times \sin 90^\circ = \underline{147.74 \text{ V}}$$

(ii) $E=85 \text{ V}$

$$E = 2NBLv \sin \theta$$

$$v = \frac{E}{2NBL \sin \theta} = \frac{85}{2 \times 80 \times 1.5 \times 12 \times 10^{-2} \times \sin 90^\circ} = 2.95 \text{ m/sec}$$

$$\omega = \frac{v}{r} = \frac{2.95}{\frac{7}{2} \times 10^{-2}} = 84.29 \text{ rad/sec}$$

$$\text{speed} = 84.29 \times \frac{60}{2\pi} = \underline{804.9 \text{ rev/min}}$$

Well done.

Task 4 – AC Circuits

1. An AC voltage is represented by the equation:

Maximum Voltage (V)	Frequency (Hz)	Phase Angle (°)
10	40	25

$$V_m = 10V \quad f = 40\text{Hz} \quad \phi = 25^\circ$$

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

$$V = V_m \sin(2\pi f t \pm \phi)$$

$$V = 10 \sin\left(2\pi \times 40 \times t + \frac{25 \times \pi}{180}\right)$$

$$V = 10 \sin\left(80\pi t + \frac{5\pi}{36}\right) \quad \checkmark$$

- a) The root mean square voltage of the waveform

$$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{10}{\sqrt{2}} = \underline{7.07 V} \quad \checkmark$$

- b) Angular velocity

$$\omega = 2\pi f = 2 \times 40 \times \pi = \underline{80\pi \text{ rad/sec}} \quad \checkmark$$

$$\omega = 80\pi \times \frac{180}{\pi} = 14400^\circ/\text{sec} \quad \text{No need to be in } ^\circ/\text{sec.}$$

- c) The output voltage at time, $t = 0\text{s}$

$$V = 10 \sin\left(80\pi \times 0 + \frac{5\pi}{36}\right) \quad \checkmark$$

$$V = 10 \sin\left(\frac{5\pi}{36}\right) = \underline{4.23 V} \quad \checkmark$$

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

$$\sin\left(80\pi t + \frac{5\pi}{36}\right) = 1 \quad \checkmark$$

$$80\pi t + \frac{5\pi}{36} = \frac{\pi}{2} \quad \checkmark$$

$$80\pi t = \frac{\pi}{2} - \frac{5\pi}{36} \quad \checkmark$$

$$80t = \frac{18 - 5}{36} = \frac{13}{36} \quad \checkmark$$

$$t = \frac{13}{36 \times 80} = 4.51 \times 10^{-3} \text{ sec} = \underline{4.51 \text{ ms}} \quad \checkmark$$

2. Below is a RL circuit

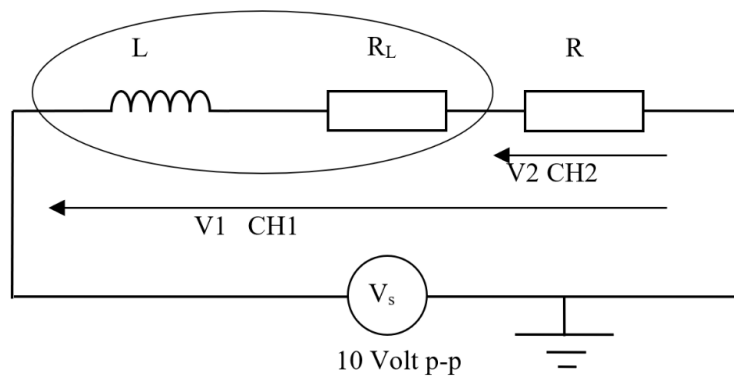


Figure 13

Measure and record the value of each of the component.

$L = 4.53 \text{ mH}$ ✓ $R = 32.8 \Omega$ ✓ $R_L = 12.71 \Omega$ ✓

3. Produce a table of measurements as shown below:

Frequency (f) (kHz)	CH1 (V) pk to pk Voltage	CH2 (V) pk to pk Voltage	Time Difference (μs) (between peaks) (T2-T1)	Phase Angle ($^\circ$)
1	5.701	3.345	92.5	33.30
2	6.923	2.939	72.23	52.01
3	7.828	2.532	56.38	60.89
4	8.507	2.170	46.69	67.23
5	8.869	1.899	38.99	70.18
6	9.231	1.718	34.57	74.67
7	9.503	1.537	30.29	76.33
8	9.593	1.356	27.45	79.06
9	9.729 ✓	1.266 ✓	24.14 ✓	78.21 ✓

4. Produce a table of calculations as shown below:

When $f = 1 \text{ kHz}$ ✓

$$X_L = \omega L = 2\pi f L = 2 \times \pi \times 1 \times 10^3 \times 4.53 \times 10^{-3} = \underline{28.46 \Omega}$$
 ✓

$$R_T = R + R_L = 32.8 + 12.71 = \underline{45.51 \Omega}$$
 ✓

$$Z = \sqrt{R_T^2 + X_L^2} = \sqrt{45.51^2 + 28.46^2} = \underline{53.68 \Omega}$$

$$I = \frac{V_s}{Z} = \frac{10}{53.68} = \underline{0.186 A}$$

$$\phi = \tan^{-1}\left(\frac{X_L}{R_T}\right) \times \frac{180}{\pi} = \tan^{-1}\left(\frac{28.46}{45.51}\right) \times \frac{180}{\pi} = \underline{32.02^\circ}$$

Frequency (kHz)	Reactance X_L (Ω)	Total Resistance R_T (Ω)	Impedance Z (Ω)	Current I (A)	Phase Angle ϕ ($^\circ$)
1	28.46	45.51	53.68	0.186	32.02
2	56.93	45.51	72.88	0.137	51.36
3	85.39	45.51	96.76	0.103	61.94
4	113.85	45.51	122.61	0.082	68.21
5	142.31	45.51	149.41	0.067	72.27
6	170.78	45.51	176.74	0.057	75.08
7	199.24	45.51	204.37	0.049	77.13
8	227.70	45.51	232.21	0.043	78.70
9	256.17	45.51	260.18	0.038	79.93

Excellent work.

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

Frequency (kHz)	1	2	3	4	5	6	7	8	9
Measured Phase Angle ϕ ($^\circ$)	33.3	52.01	60.89	67.23	70.18	74.67	76.33	79.06	78.21
Calculated Phase Angle ϕ ($^\circ$)	32.02	51.36	61.94	68.21	72.27	75.08	77.13	78.7	79.93

By comparing the measured values with the calculated values, differences are observed, which may be attributed to human measurement errors. Additionally, several factors can affect measurement accuracy, such as dirty measurement wires, loose connections, and the precision of the measuring devices. Also adjusting the frequency value on the voltage source was found to be challenging.

Bibliography

- JOHN BIRD. (2017). *Electrical and Electronic Principles and Technology*. New York: Routledge.
- Schneider Electric. (2020). *Induction Motor: Working Principles, Basics & Types Explained*. [Online]. Schneider Electric. Available at: <https://eshop.se.com/in/blog/post/induction-motor-working-principles-basics-types-explained.html> [Accessed 14 January 2025].
- Mango Engineer. (2024). *Losses and Power Stages in Induction Motor*. [Online]. Mango Engineer. Available at: <https://www.mangoengineer.in/2024/03/losses-in-induction-motor.html> [Accessed 14 January 2025].

There is a lack of direct referencing within the assignment