

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	3.6
No engagement with essential reading, have listed reference sources. There is a lack of referencing within the assignment.		
2. Knowledge and Understanding Skills	40	23.3
Task 1 achieved 68%. Task 2 achieved 55%, Task 3 achieved 62%. Task 4 achieved 48%. Knowledge of the basic underlying concepts and principles is competent with a very good understanding in most areas.		
3. Cognitive and Intellectual Skills	10	4.5
Task 1 achieved 55%. Task 4 achieved 35%. Limited attempt at evaluation of the underlying concepts and principles for Task 1 and 4, tending towards description.		
4. Practical Application Skills	30	24
Task 1 achieved 77%. Task 4 achieved 83%. 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	5
Mostly coherent, organised and accurate work, in a suitable structure and is for the most part clearly expressed.		

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)		60%
	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.

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Task 1 – DC Circuits

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

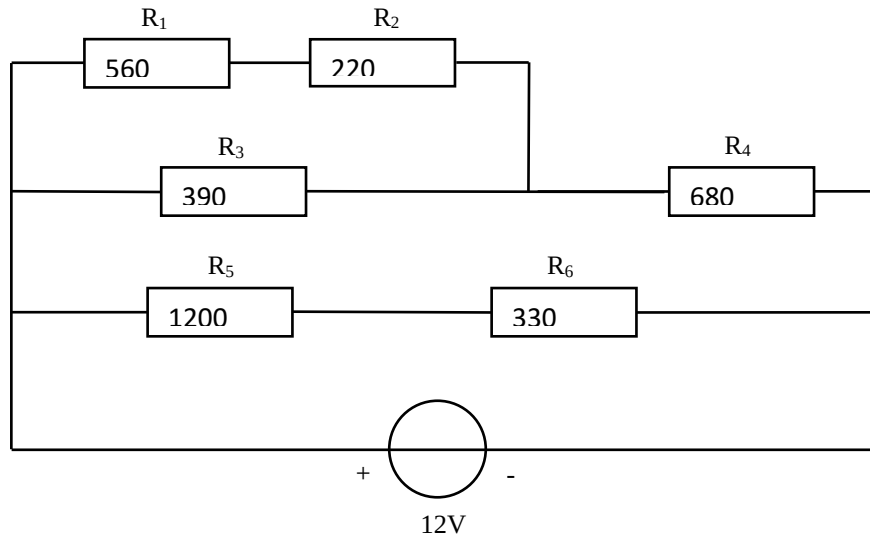


Figure 1 – Resistors in Series/Parallel

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 Ω)	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 following results in the table below were attained using a multimeter.

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

This should be written in past tense

Current in each resistor -

I1 - 4.32mA ✓

I2 - 4.32mA ✓

I3 - 8.51mA ✓

I4 - 12.85mA ✓

I5 - 8.02mA ✓

I6 - 7.93mA ✓

p.d across each resistor -

V1 - 2.42V ✓

V2 - 0.94V ✓

V3 - 3.36V ✓

V4 - 8.62V ✓

V5 - 9.39V ✓

V6 - 2.58V ✓

Must include all units

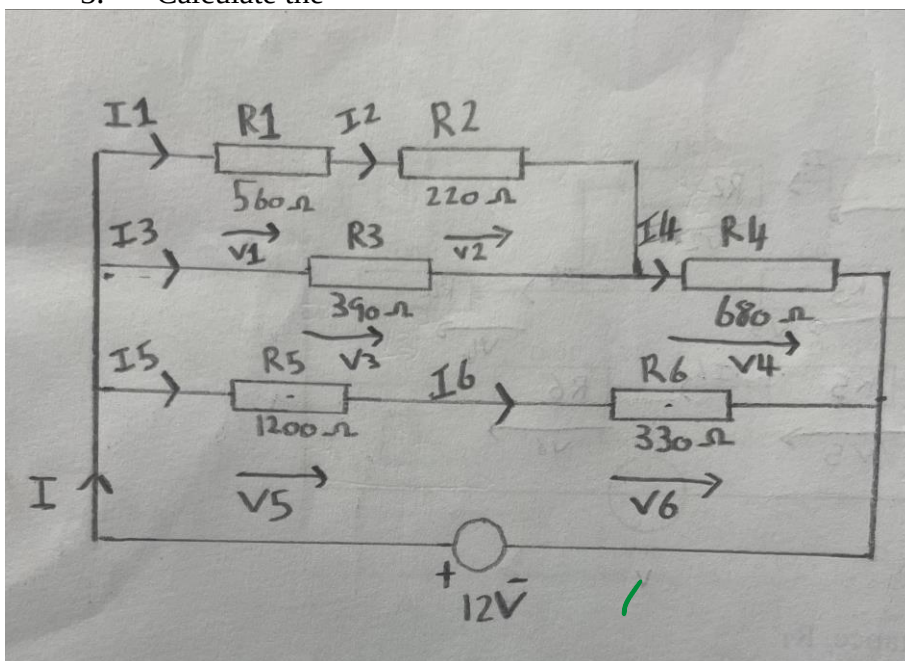
Supply current -

20.8mA ✓

Total resistance -

573Ω ✓

3. Calculate the



- total resistance, R_T

$$R_{1,2} = R_1 + R_2 = 560 + 220 = 780\Omega$$

$$R_{1,2,3} = \frac{R_{1,2} \times R_3}{R_{1,2} + R_3} = \frac{780 \times 390}{780 + 390} = 260\Omega$$

$$R_{1,2,3,4} = 260 + 680 = 940\Omega$$

$$R_{5,6} = 1200 + 330 = 1530\Omega$$

$$R_T = \frac{R_{1,2,3,4} \times R_{5,6}}{R_{1,2,3,4} + R_{5,6}} = \frac{940 \times 1530}{940 + 1530} = 582.27\Omega$$

- supply current, I

$$I = \frac{12}{582.27} = 0.0206A = 20.61 \times 10^{-3} = 20.61mA$$

$$I = \frac{V}{R}$$

- current in each resistor

$$I_5 = I_6 = \frac{V}{R_{5,6}} = \frac{12}{1530} = 7.84mA$$

$$I_4 = I - I_5 = 20.61mA - 7.84mA = 12.77mA$$

$$I_3 = \frac{V_3}{R_3} = \frac{3.32}{390} = 8.51mA$$

$$I_1 = I_2 = I - (I_3 + I_5) = 4.26mA$$

must show workings.

$$I_1 = 4.26mA$$

$$I_2 = 4.26mA$$

$$I_3 = 8.51mA$$

$$I_4 = 12.77mA$$

$$I_5 = 7.84mA$$

$$I_6 = 7.84mA$$

- the p.d. value across each resistor

$$V = IR$$

$$V_5 = I_5 \times R_5 = 7.84 \times 10^{-3} \times 1200 = 9.41V$$

$$V_6 = I_6 \times R_6 = 7.84 \times 10^{-3} \times 330 = 2.59V$$

$$V_4 = I_4 \times R_4 = 12.77 \times 10^{-3} \times 680 = 8.68V$$

$$V_3 = V - V_4 = 12 - 8.68 = 3.32V$$

$$V_1 = I_1 \times R_1 = 4.26 \times 10^{-3} \times 560 = 2.39V$$

$$V_2 = I_2 \times R_2 = 4.26 \times 10^{-3} \times 220 = 0.94V$$

- and power dissipation in each resistor.

$$P = IV$$

$$P_1 = I_1 \times V_1 = 4.26 \times 2.39 = 10.18mW$$

$$P_2 = I_2 \times V_2 = 4.26 \times 0.94 = 4.00mW$$

$$P_3 = I_3 \times V_3 = 8.51 \times 3.32 = 28.25mW$$

$$P_4 = I_4 \times V_4 = 12.77 \times 8.68 = 110.84mW$$

$$P_5 = I_5 \times V_5 = 7.84 \times 9.41 = 73.77mW$$

$$P_6 = I_6 \times V_6 = 7.84 \times 2.59 = 20.31 \text{mW}$$

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.

Do not refer to yourself in a report.

When comparing my results from my practical and calculations I can see the practical was a success as all my results are similar to my projected calculated results. There are of course variations within the results due to external factors such as tolerances on the resistors having a tolerance of $\pm 5\%$ this would therefore cause our practical results to fluctuate slightly. The multimeters we used also had a tolerance

There are other factors to consider.

Kirchhoff's first law, "Kirchhoff's Current Law says that the sum of all currents flowing into a node equals the sum of currents flowing out of the node." In simple terms the amount of current that goes into the circuit must come out, as you can see in our calculations we proved this law, as combining $I_4(12.77\text{mA})$ and $I_5(7.84\text{mA})$ would give us near to our supply current of 20.8mA .

Kirchhoff's second law, "Kirchhoff's Voltage Law: The sum of voltages around a loop is zero." This once again can be simplified to what voltage goes in must come out, like Kirchhoff's current law. This once again can be proven from our practical tests and calculations because if we add our $V_5(9.41\text{V})$ and $V_6(2.59)$ it gives us our supply voltage of 12V . Therefore proving Kirchhoff's law of what goes in must come out.

where your quotes from?

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.

What is a Capacitor?

A capacitor is a device specially constructed to hold capacitance, to explain it in its most simple form a capacitor is consists of two plates which are separated via a dielectric. The ability of a capacitor is to be charged up and store static electricity and then for it to be released at one time.

Construction

Overall the construction of a capacitor is relatively simple. It is made up of two conductive plates placed close together however never touching, these conductive plates are typically made up of copper or aluminium. The conductive plates of capacitor are separated by a very small distance, the empty void within these plates is then filled with a non conductive material, this is called the dielectric. This non-conductive material can be ceramic, a vacuum, paper, electrolyte and many more. The purpose of the dielectric is to reduce the electric field strength between the plates therefore increasing the capacitors ability to store static electric charge. The thickness of the dielectric will influence the capacitors capacitance and voltage rating. Capacitors can also come in different shapes, they can be flat, folded and rolled. Capacitors can have parallel plates, this is two flat conductive plates with a dielectric in the middle, within a cylindrical capacitor they have rolled foil. This is thin sheets of metal tightly rolled up and separated with a dielectric. Capacitors will be enclosed in protective casing to protect them from environmental factors such as the ingress of dust and moisture. This protective casing is typically made from plastic, ceramic or metal, however the casing material is normally dependant on the application of the capacitor.

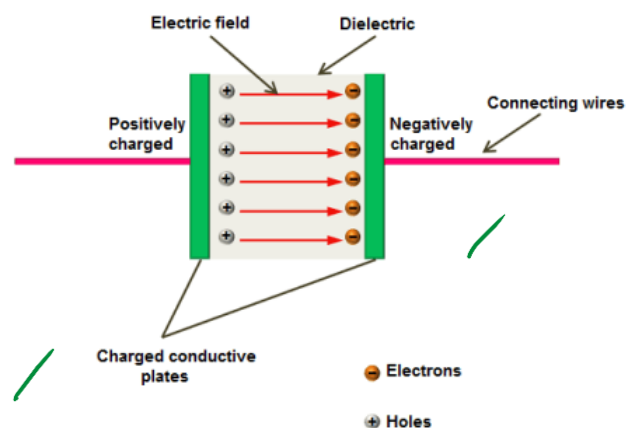


Figure 1

Function

When voltage is applied to the terminals of the capacitor an electric field is created across the dielectric. The electrons will accumulate on one of the conductive plates while the other plate loses electrons. This accumulation and loss of electrons creates a potential difference between the plates and therefore energy is stored within the electric field created. Energy being stored in a capacitor is proportional to its capacitance and the voltage across its plates. When the circuit is closed, a path for current is created, therefore the stored energy in the electric field is released. When discharging electrons flow from the negatively charged conductive plate to the positively charged conductive plate, this equalises the charge difference and releases energy into the circuit. ✓

Different types of capacitors

Variable air capacitors

These capacitors consist of two sets of metal plates, one set is variable and can move the other set is secured in a fixed position. Variable air capacitors are typically found in radio and electronic circuits, or where a variable capacitance is required. Usual maximum value of the variable air capacitors is between 500pF and 1000pF. ✓

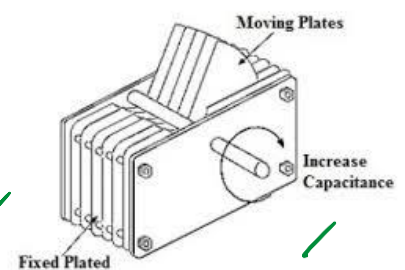


Figure 2

Paper capacitor

Paper capacitors are usually shaped in a cylindrical form, the length of the roll within this cylinder will correspond to the capacitance of the capacitor. A cylindrical capacitor is made up from a thin metal sheet with a paper layer on top tightly rolled and submerged in oil or wax to prevent ingress of external moisture. The roll is then placed in aluminium or plastic case ready for installation onto the circuit board. Paper capacitors can be used in a wide range of different voltages, these voltages can range up to 150 kV, the maximum value of the capacitor also ranges from 500pF to 10μF. However one disadvantage to paper capacitors is its capacitance value can change and fluctuate depending on the temperature of the capacitor. ✓

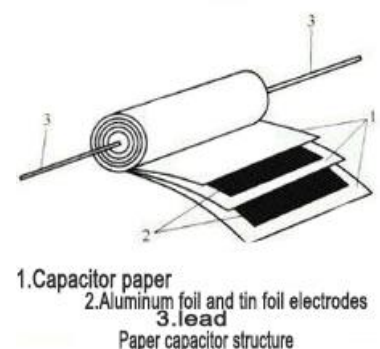


Figure 3

Ceramic capacitors

Ceramic capacitors can be made in several different forms, each form used is dependant on the capacitance and application required. If a high value capacitor is required, it is best to adopt the tube form of capacitor. Whereas if only a small capacitor value is required the cup construction can be used. Ceramic capacitor values can range from 1pF to $0.1\mu\text{F}$, a great benefit of ceramic capacitors is that they can be used in high frequency electronic circuits and can be subject to a wide range of temperatures. ✓

Factors that effect capacitance values

A few simple factors that effect capacitance values can be the plate area and plate separation increasing these will cause the capacitance to rise. Also changing the dielectric material will alter the capacitance values if you changed the material for one with a higher permittivity the capacitance would increase, therefore whilst using material with a lower permittivity the capacitance would decrease. When considering capacitors in a circuit the wiring formation can also have an effect in the overall capacitance, for example if you wire your capacitors in a parallel formation the overall capacitance value would increase combining the value from each capacitor. However, connecting them in series can decrease the total capacitance because the effective plate separation will increase. ✓

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

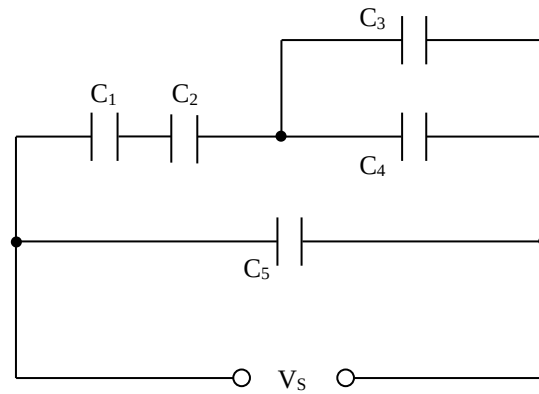
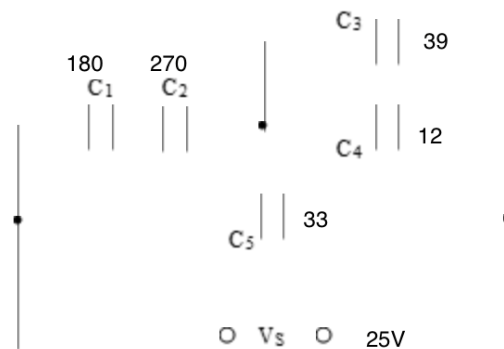


Figure - 2

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

- the equivalent circuit capacitance
- the total charge
- the charge in each capacitor
- the energy stored in each capacitor
- the total energy stored in the circuit.



Next time make sure the diagram is complete.

Figure - 2

A) $C_{1,2} = \frac{C_1 \times C_2}{C_1 + C_2} = \frac{180 \times 270}{180 + 270} = 108 \mu\text{F} \quad (108 \times 10^{-6})$

$$C_{3,4} = C_3 + C_4 = 39 + 12 = 51 \mu\text{F} \quad (51 \times 10^{-6})$$

$$C_{1,2,3,4} = \frac{C_{1,2} \times C_{3,4}}{C_{1,2} + C_{3,4}} = \frac{108 \times 51}{108 + 51} = 34.64 \mu\text{F}$$

$$C_T = C_{1,2,3,4} + C_5 = 34.64 + 33 = 67.64 \mu\text{F}$$

B) $Q = CV$

$$Q_T = C_T \times V = 67.64 \times 25 = 1691 \mu\text{C}$$

C) $Q_5 = C_5 \times V = 33 \times 25 = 825 \mu\text{C}$

$$Q_{1,2,3,4} = Q_T - Q_5 = 1691 - 33 = 1658 \mu\text{C}$$

$$Q_1 = Q_2 = Q_{1,2,3,4} = 1658 \mu\text{C} \text{ - In series}$$

$$V1 = \frac{Q1}{C1} = \frac{1658}{180} = 9.21V \quad \times$$

$$V2 = \frac{Q2}{C2} = \frac{1658}{270} = 6.14V \quad \times$$

$$V3 = V4 = V - (V1 + V2) = 25 - (9.21 + 6.14) = 9.65V \quad \times$$

$$Q3 = C3 \times V3 = 39 \times 9.65 = 376.35\mu C \quad \times$$

$$Q4 = C4 \times V4 = 12 \times 9.65 = 115.8\mu C \quad \times$$

Correct method, wrong value for Q, and Q₂.

D) $W = \frac{1}{2} CV^2$

$$W1 = \frac{1}{2} \times C1 \times V1^2 = 0.5 \times 180 \times 9.21^2 = 7634\mu J \quad \times$$

$$W2 = \frac{1}{2} \times C2 \times V2^2 = 0.5 \times 270 \times 6.14^2 = 5089.45\mu J \quad \times$$

$$W3 = \frac{1}{2} \times C3 \times V3^2 = \frac{1}{2} \times 39 \times 9.65^2 = 1815.89\mu J \quad \times$$

$$W4 = \frac{1}{2} \times C4 \times V4^2 = \frac{1}{2} \times 12 \times 9.65^2 = 558.74\mu J \quad \times$$

$$W5 = \frac{1}{2} \times C5 \times V^2 = \frac{1}{2} \times 33 \times 25^2 = 10312.5\mu J \quad \checkmark$$

E)

$$WT = \frac{1}{2} \times CT \times V^2 = \frac{1}{2} \times 67.64 \times 25^2 = 21137.5\mu J \quad \checkmark$$

Throughout you have shown correct method.

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.

A permanent magnet is a ferromagnetic material which retains a large amount of magnetisation even when current is removed. In times where space is limited, permanent magnets can supply a stronger magnetic field than electromagnets, they require no power source and also do not need a form of cooling. A large benefit of permanent magnets is that they maintain a persistent magnetic field without the need for a personal power source. The way in which a permanent magnet functions within ferromagnetic materials such as iron and nickel is that there are groups of atoms called magnetic domains, these align there rotations of electrons within the same direction and this therefore creates a strong overall magnetic field.

Hysteresis loop

Can be seen in a magnetisation curve this is the process of a material being magnetised and demagnetised is shown in a hysteresis loop. The loop shows how a ferromagnetic material responds to a magnetic field being applied and how much magnetisation will be retained after the applied field is removed. Coercivity also has an effect in the hysteresis loop as the measure of resistance of a material to becoming demagnetised. Permanent magnets often have a high coercivity because they retain magnetisation for far longer after the field is removed.

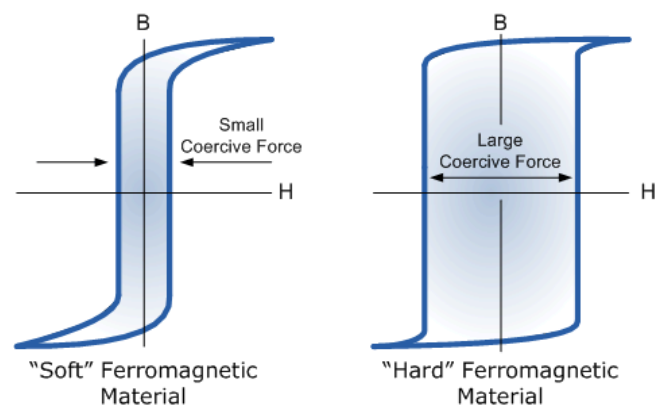


Figure 4

Magnetic Field lines

Lines of force depict the magnetic field around a permanent magnet. The lines emerge and trace externally from the north pole of the magnet to the south pole, they then internally trace back from the south pole of the magnet back to the north. Every permanent magnet has two poles, north and south. The density of the external lines indicates field strength, the closer together the lines are the stronger the magnetic field. These poles are where the magnetic field is strongest. The lines of a magnetic field never cross, each line represents its own unique direction of magnetic force. The field weakens when distance from the magnet increases.

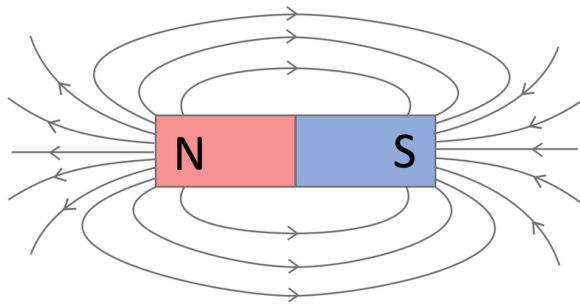


Figure 5

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.

$$\text{Area} = \text{width} \times \text{height} = 0.250\text{m} \times 0.140 = 0.035\text{m}^2 \quad \checkmark$$

$$B = \frac{\phi}{A} = \frac{150 \times 10^{-6} \text{Wb}}{0.035 \text{m}^2} = 4.286 = 4.29\text{T} \quad \checkmark$$

4.29mT

- 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.

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

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

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

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

Electromagnets are created from the flow of electric current through a conductor. When electrons move across a conductor, a magnetic field is generated, therefore creating an electromagnet. Electromagnets can be turned on and off via the isolation of the power source supplying it, the electromagnet is purely dependant on when the coil of wire is conducting current, when isolated from a power source the magnetic field will disappear. The strength of the magnetic field can be increased by adding a ferromagnetic through the centre of the conducting coil of wire.

The principle operation of an electromagnet is that when a voltage is applied to the solenoid, all the atoms align in a particular direction. When these atoms get aligned in a particular direction the magnetic field around the solenoid becomes stronger. The magnetic domains around the within the solenoid become stronger and weaker with the amount of current applied. We can increase the strength of the electromagnet in various ways, one of which like mentioned earlier is inserting a ferromagnetic material such as iron through the core of the conductor. This method increases the permeability in the coil of wire, therefore improving the retentivity of the field. Increasing the number of turns in the windings of the solenoid will increase the magnitude of the magnetic field around the coil. Also increasing the amount of current being carried through the solenoid can increase the strength, however the conducting wire has a resistance and a build up of current through the wire will result in heat being produced therefore each solenoid will have its own safe operating limit.

When the magnetic field is produced around the conductor, the electromagnetic field will be in the form of concentric circles across the length of the solenoid. The direction the field is going is dependant on the direction of the current flow. The magnetic field will be going clockwise around the conductor when the current is flowing away from the observer, and then will flow anti-clockwise when current is flowing toward the observer.

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.

Construction

A typical three phase induction motor is made up of two key parts the rotor and the stator. The rotor is the rotating part of the motor and the stator is stationary.

The stator will be made up from a high quality alloy steel, high quality alloy is key as it will help prevent any eddy current losses when the machine is running. The stator itself has 3 main parts, the outer frame, stator winding and stator core. The outer frame of the machine is mainly to protect the internals of the motor. The stator core has the main function of carrying the alternating magnetic field which produces hysteresis and eddy current losses. It is built out of high quality silicon steel stamping, these stampings are secured to the stator frame. Lastly the windings of the

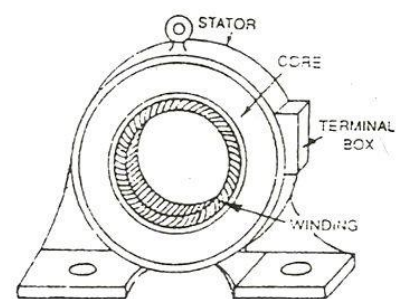


Figure 6

stator, this carries three phase windings. The stator of the motor will be wound for a definite number of poles, this is dependant on the speed of the motor. The more poles the slower the motor will be.

The rotor will be built from the same thin laminations as the stator. The core will be cylindrical and fixed directly onto the shaft of the motor. The lamination of the rotor are slotted on the outside to receive the conductors. A common type of rotor used in many induction motors is the squirrel cage rotor. Each slot contains an insulated bar of copper these act as conductors. At the end of each rotor the conductors are short circuited by a ring of copper. The slots of the rotor are typically not parallel but skewed, this is to help prevent losses and increases the rotors resistance due to an increase in length of the bar.

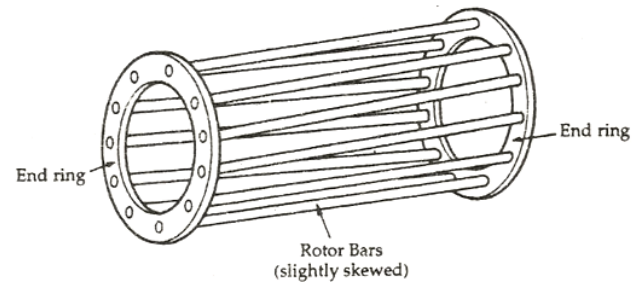


Figure 7

Prevention of losses within the motors

There are a range of losses that can occur in an induction motor from iron losses, eddy current losses and hysteresis losses. Iron losses can be reduced by using thinner laminations within the magnetic structure of the stator, an increase in the length of the magnetic structure can also aid to the reduction. Eddy current losses are avoided by using thin laminations within the stator and all laminations are insulated with a thin layer of oxide. Hysteresis losses can be avoided by using soft magnetic materials as they possess a smaller hysteresis loop as we learned earlier when talking about permanent magnets. A good example of a soft magnetic material which is commonly employed in induction motors is silicon steel sheets.

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.

$$\phi = \frac{L \times I}{N}$$

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

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

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?

Sides of the coil = 0.12m x 0.07m

N = 80

B = 1.5T

F = 1400rev/min = $\frac{1400}{60}$ rev/s = 23.33Hz

Maximum generated e.m.f = N x B x A x w ✓

Maximum generated e.m.f

$$\text{Area} = 0.12 \times 0.07 = 0.0084\text{m}^2 \quad \checkmark$$

$$\text{Angular velocity} = 2\pi f = 2 \times \pi \times 23.33 = 146.6 \text{ Rad/s} \quad \checkmark$$

$$\varepsilon_{\text{max}} \bigcirc = 80 \times 1.5 \times 0.0084 \times 146.6 = 147.7\text{V} \quad \checkmark$$

Rotational speed

$$f = \frac{\varepsilon_{\text{max}}}{N \times B \times A \times 2\pi} \quad \checkmark$$

$$\text{Given } \varepsilon_{\text{max}} \bigcirc = 85\text{V}$$

$$f = \frac{85}{80 \times 1.5 \times 0.0084 \times 2\pi} = 13.42\text{Hz} \quad \checkmark$$

$$f_{\text{rpm}} = f \times 60 = 13.42 \times 60 = 805.2 \text{ rev/min} \quad \checkmark$$

Task 4 – AC Circuits

1. An 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

$$V_{rms} = \frac{V_{max}}{\sqrt{2}} = \frac{20}{\sqrt{2}} = 14.14V \quad /$$

- b) Angular velocity

$$\omega = 2 \times \pi \times 44 = 88\pi \text{ rad/s} \quad /$$

$$88 \times \pi = 276.46 \text{ rad/s} \quad /$$

Must state formula.

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

$$V_{max} = 20, \quad f = 44\text{Hz}, \quad \theta = 33^\circ, \quad t = 0s$$

$$\text{Angle into radians} = 33 \times \frac{\pi}{180} = \frac{11}{60}\pi \quad /$$

$$V_0 = V_{max} \sin(\theta) \quad /$$

$$V_0 = 20 \sin\left(\frac{11}{60}\pi\right) = 0.20V \quad \times$$

You had your calculator in degrees mode.

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

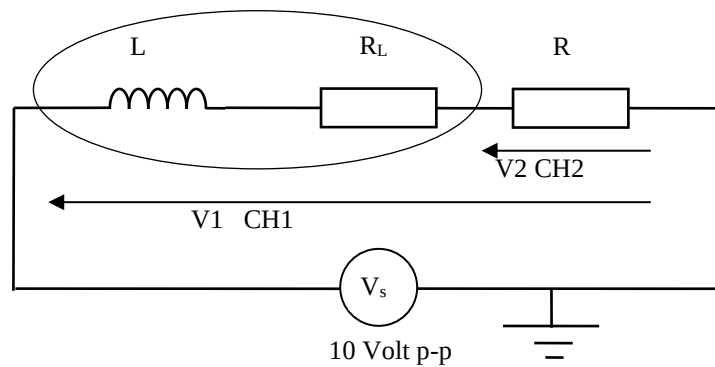
$$\text{First peak of sin wave} = \frac{T}{4}$$

$$T = \frac{1}{f} = \frac{1}{44} = 0.023s = 0.023ms \quad \times$$

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

2. 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.

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

$$R = 32.8 \Omega \checkmark$$

$$R_L = 12.64 \Omega \checkmark$$

Must include all units

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 (between peaks) (T2-T1)	Phase Angle (°)
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	71.31
9	9.36 ✓	1.13 ✓	23.01 ✓	74.55 ✓

4. Produce a table of calculations as shown below:

mH

Ω

Ω

4.52

R= 32.8

RI= 12.54

Frequency (kHz)	Reactance (Ω)	Total Resistance (Ω)	Impedance (Ω)	Current (A)	Phase Angle (°)
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.

$$X_L = 2 \times \pi \times 3 \times 4.52 = 85.20\Omega \quad \checkmark$$

$$R_t = 32.8 + 12.54 = 45.34\Omega \quad \checkmark$$

$$Z = \sqrt{(45.34)^2 + (85.20)^2} = 96.51\Omega \quad \checkmark$$

must state
all formulas

$$I = \frac{V}{Z} = \frac{10}{96.51} = 0.1036A$$

$$\text{Phase angle } (\theta) = \tan^{-1} \left(\frac{X_L}{R_T} \right) = \tan^{-1} \left(\frac{85.20}{45.34} \right) = 61.98^\circ$$

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

From comparing my calculations to my practical results I can see small differentiations when looking at phase angle. For example at 4KHz I calculated the phase angle to be 68.24° when in fact the measured value when carrying out the practical was 64.53°. This could be down to multiple reasons. One of which could be an impedance in the co-axial cable being used can influence the waveform being transmitted. Signal generator and cable impedance mismatch values could cause the signal to be partially distorted and also cause phase shifts, therefore causing a change in my practical results. The oscilloscope leads we used also have a measured resistance which can lead to a voltage drop. This voltage drop can effect the signal meaning it will be measures slightly different to the true result, this therefore leads to small changes in our practical results from our calculated results.

Human error is also a cause for deviations in our results for example each person doing the practical would have had slightly different interpretations of the reference point therefore effecting the phase angle. Also lining up the cursor bars to the waveforms proved difficult due to the limited resolution on the monitors.

Bibliography

<https://www.khanacademy.org/science/ap-physics-2/x0e2f5a2c:ap-2-circuits/x0e2f5a2c:ap-2-circuits-with-resistors/a/ee-kirchhoffs-laws#:~:text=Kirchhoff's%20Current%20Law%20says%20that,flowing%20out%20of%20the%20node.>

<https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/passive-components/capacitors/capacitorconstructionandworking.html>

<https://www.allaboutcircuits.com/textbook/direct-current/chpt-13/factors-affecting-capacitance/>

[Principles of Magnetostatics](#) , pp. 211 - 228

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https://www.flippedaroundphysics.com/uploads/4/5/0/0/45000279/7.1_permanent_magnets_and_fields.pdf

<https://www.embibe.com/exams/electromagnet/>

<https://circuitglobe.com/construction-of-induction-motor.html>

References

<https://www.khanacademy.org/science/ap-physics-2/x0e2f5a2c:ap-2-circuits/x0e2f5a2c:ap-2-circuits-with-resistors/a/ee-kirchhoffs-laws#:~:text=Kirchhoff's%20Current%20Law%20says%20that,flowing%20out%20of%20the%20node.>

“Kirchhoff's Current Law says that the sum of all currents flowing into a node equals the sum of currents flowing out of the node.” -
Khana academy. (2016). *Kirschoffs laws*. [Online]. Khana acadamy.
Available at: <https://www.khanacademy.org/science/ap-physics-2/x0e2f5a2c:ap-2-circuits/x0e2f5a2c:ap-2-circuits-wi> [Accessed 17 January 2025].

“Kirchhoff's Voltage Law: *The sum of voltages around a loop is zero.*” –
Khana academy. (2016). *Kirschoffs laws*. [Online]. Khana acadamy.
Available at: <https://www.khanacademy.org/science/ap-physics-2/x0e2f5a2c:ap-2-circuits/x0e2f5a2c:ap-2-circuits-wi> [Accessed 17 January 2025].

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