

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Jaden Chapman	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:	11/01/23	Return date of provisional marks & written feedback:	25/01/23
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)

1. Produce routine solutions to typical electrical problems.
2. Relate and apply basic electrical theory to collected data.

STUDENT FEEDBACK FORM

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	15	6.6
Engagement with a limited range of mostly relevant and credible sources. Generally sound referencing technique but should be using books for direct quotes. Need to use the Harvard system for referencing.		
2. Knowledge and Understanding Skills	30	19.4
Task 1 achieved 68%. Task 2 achieved 68%, Task 3 achieved 52%. Task 4 achieved 70%. Knowledge of the basic underlying concepts and principles is competent with a very good understanding in most areas. Excellent work with the calculations but some of the research work was lacking. Limited explanation on permanent magnets.		
3. Cognitive and Intellectual Skills	10	4.7
Task 1 achieved 52%. Task 4 achieved 42%. Limited attempt at evaluation of the underlying concepts and principles for Task 1 and 4, tending towards description.		
4. Practical Application Skills	35	28.4
Task 1 achieved 82%. Task 4 achieved 80%. 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	5.5
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)

Up to 1 week late (40% Max)

Over 1 week late (0%)

65%

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There is too much information on the contents page.

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.

Task 1 – DC Circuits

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

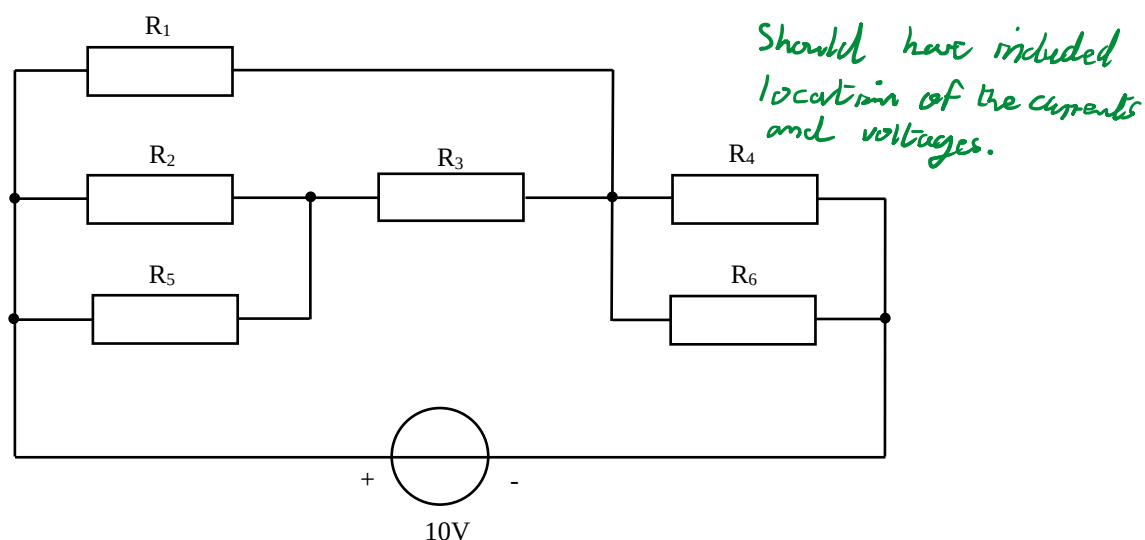


Figure 1 – Resistors in Series/Parallel

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 (kΩ)	R ₂ (Ω)	R ₃ (Ω)	R ₄ (Ω)	R ₅ (Ω)	R ₆ (Ω)
1	5.6	270	330	270	330	680
2	4.7	390	220	330	180	560
3	4.7	220	330	470	220	680
4	6.8	270	220	560	330	560
5	5.6	330	330	470	180	680
6	6.8	180	220	330	270	560
7	5.6	220	330	470	220	680
8	4.7	330	220	560	180	680
9	5.6	390	330	270	150	470
10	6.8	470	220	330	180	560
11	3.9	330	220	560	220	470
12	3.9	270	330	470	180	560

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

$$R_T = 631.1\Omega$$

- Connect a 10V supply and measure the p.d. value across each resistor, the supply current and the current in each resistor.

Test Results

Voltage (V)	Current (mA)
$V_1 = 6.951$	$I_1 = 1.2$
$V_2 = 2.159$	$I_2 = 7.994$
$V_3 = 4.79$	$I_3 = 14.49$
$V_4 = 3.042$	$I_4 = 11.286$
$V_5 = 2.159$	$I_5 = 6.54$
$V_6 = 3.042$	$I_6 = 4.475$
	$I = 15.8$

- Calculate the following values
 - total resistance, R_T
 - supply current, I
 - current in each resistor
 - the p.d. value across each resistor
 - and the power dissipated in each resistor.

$$V = 10v$$

Calculated Results

Total resistance

$$R_{25} = (R_2 \times R_5) / (R_2 + R_5) = (270 \times 330) / (270 + 330) = 148.5\Omega$$

$$R_{235} = R_{25} + R_3 = 148.5 + 330 = 478.5\Omega$$

$$R_{1235} = (R_1 \times R_{235}) / (R_1 + R_{235}) = (5600 \times 478.5) / (5600 + 478.5) = 440.83\Omega$$

$$R_{46} = (R_4 \times R_6) / (R_4 + R_6) = (270 \times 680) / (270 + 680) = 193.26\Omega$$

$$R_T = R_{1235} + R_{46} = 440.83 + 193.26 = 634.09\Omega$$

Supply current, current in each resistor & p.d. value across each resistor

$$I = V/R_T = 10 / 634.09 = 15.77mA$$

$$V_4 = I \times R_{46} = (15.77 \times 10^{-3}) \times 193.26 = 3.048v$$

$$V_4 = V_6$$

$$I_4 = V_4/R_4 = 3.048 / 270 = 11.288mA$$

$$I_6 = V_4/R_6 = 3.048 / 680 = 4.482mA$$

$$V_1 = V - V_4 = 10 - 3.048 = 6.952v$$

$$I_1 = V_1/R_1 = 6.952 / 5600 = 1.24mA$$

$$I_3 = I - I_1 = 15.77 - 1.24 = 14.53mA$$

$$V_3 = I_3 \times R_3 = (14.53 \times 10^{-3}) \times 330 = 4.795v$$

$$V_2 = V_1 - V_3 = 6.952 - 4.795 = 2.157\text{V}$$

$$V_2 = V_5$$

$$I_2 = V_2 / R_2 = 2.157 / 270 = 7.989\text{mA}$$

$$I_5 = V_2 / R_5 = 2.157 / 330 = 6.536\text{mA}$$

Power dissipated in each resistor

$$P = I \times V$$

$$P_1 = I_1 \times V_1 = (1.24 \times 10^{-3}) \times 6.952 = 8.62\text{mW}$$

$$P_2 = I_2 \times V_2 = (7.989 \times 10^{-3}) \times 2.157 = 17.019\text{mW}$$

$$P_3 = I_3 \times V_3 = (14.53 \times 10^{-3}) \times 4.795 = 69.67\text{mW}$$

$$P_4 = I_4 \times V_4 = (11.288 \times 10^{-3}) \times 3.048 = 34.4\text{mW}$$

$$P_5 = I_5 \times V_2 = (6.536 \times 10^{-3}) \times 2.157 = 14.098\text{mW}$$

$$P_6 = I_6 \times V_4 = (4.482 \times 10^{-3}) \times 3.048 = 13.661\text{mW}$$

$$P_T = 157.468\text{mW}$$

A very good set of calculations, well done.

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

When comparing practical readings and calculated results, it is more than likely that there will be a slight difference. For example, I calculated the total resistance to be 634.09Ω but when taking readings during the practical, the resistance was actually measured to be 631.1Ω . There are a number of reasons as to why values read differently when being compared and I will comment on some of these now:

Due to the multimeter not outputting a set value and instead bouncing around a few different values, this results in us having to decide on an average value. This bouncing of readings may come down to the multimeter probes not being in full contact with the component or the probes themselves housing dirt.

Calibration of equipment is also another reason that values might read differently when comparing the two. Multimeters are only required to be calibrated once a year and this might lead to results being less accurate the longer they are out of calibration.

Multimeters also carry an internal resistance of $10\text{M}\Omega$. This would explain why some resistance readings taken are slightly larger than the calculated values. As well as this internal resistance, components being measured have a tolerance of 5%. This means that a resistor with a value of $5.6\text{k}\Omega$ could measure anywhere between $5.32\text{k}\Omega - 5.88\text{k}\Omega$.

have current

In order to calculate the results, Kirchhoff's current and voltage law can be applied. The law states that 'at a junction in an electrical circuit, the sum of currents flowing into the junction is equal to the sum of currents flowing out of the junction'. (Kirchhoff's Laws, 2022). An example of this law being proven in the circuit is that $I_4 + I_6 = I$. As R_4 and R_6 are in parallel, this means that they must be equal to the whole supply current of the circuit.

*what about voltage law.
there are other factors that
could be consider.*

1. A capacitor is an electronic device that stores electrical charge and is used in a number of electronic applications. Explain the construction of the capacitor, include methods that could be used to alter the value of the capacitor.

A capacitor contains two electrically conductive plates which are usually made of aluminium, copper or brass. Although these are placed close to each other, they do not make contact. These plates are capable of holding electric charge as well as allowing electric current to pass through them. ✓

The area between the two plates is filled with a non-conductive material and is known as the dielectric region. When this material is present, electric charge cannot be passed between the two plates. The insulating material does not allow the flow of charge carriers, such as electrons, but what it does allow is the electric force, electric field and electric charged that is produced by the electrons. Therefore, as the electric charge stored within the plates builds up, an electric field is generated between the two plates. (Capacitor Construction & Working, 2015) ✓

There are a few different methods that can be used in order to change the value of a capacitor and one of these methods is to differ the material of the dielectric. The dielectric region is the area between the two plates and is responsible for restricting the flow of electrons between them. There are a variety of different materials that can be utilised due to their insulative properties such as polypropylene, silicone, glass and mica. Materials are rated by their relative permittivity with vacuum being rated as 1.000. Silicones roughly measure between 3.4 and 4.3 whilst mica can measure anywhere between 5.0 and 8.7. ✓

Another method used to alter the value of a capacitor is to increase or decrease the surface area of the plates. If more capacitance is required, the surface area of the plates should be increased in order to hold more charge. By decreasing the surface area, this results in less available space for the plates to hold charge. ✓

The final factor that will alter the capacitance of a capacitor is the spacing between the two plates. By utilising the formula for field force (voltage across the capacitor divided by the distance between the plates), we can see that less spacing results in a greater force. In turn, this results in more charge being collected by the plates. (Direct Current, n.d.) ✓

*Could have included an equation.
Also a diagram to show construction.*

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

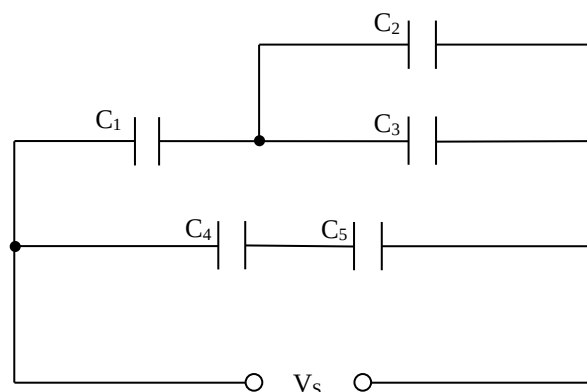


Figure - 2

Using the values stated in Table 2, 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.

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	27	12	33	47	15	12
2	27	15	39	33	18	15
3	27	18	43	22	33	20
4	27	22	47	22	27	25
5	22	27	43	15	33	30
6	22	10	39	33	15	25
7	22	12	33	47	18	20
8	22	15	39	33	22	15
9	18	10	33	22	27	20
10	18	12	39	27	33	25
11	18	15	43	33	47	20
12	18	12	33	22	33	15

$$V = 12$$

a) $C_{23} = C_2 + C_3 = 12 + 33 = 45\mu\text{F}$ ✓
 $C_{123} = (C_1 \times C_{23}) / (C_1 + C_{23}) = (27 \times 45) / (27 + 45) = 1215 / 72 = 16.875\mu\text{F}$ ✓
 $C_{45} = (C_4 \times C_5) / (C_4 + C_5) = (47 \times 15) / (47 + 15) = 705 / 62 = 11.37\mu\text{F}$ ✓
 $C_T = C_{123} + C_{45} = 16.875 + 11.37 = 28.245\mu\text{F}$ ✓

b) $Q_T = C_T \times V = 28.245 \times 12 = 338.94\mu\text{C}$ ✓

c) $Q_4 = Q_5 = C_{45} \times V = 11.37 \times 12 = 136.44\mu\text{C}$ ✓
 $Q_1 = Q_T - Q_{45} = 338.94 - 136.44 = 202.5\mu\text{C}$ ✓
 $Q_1 = C_{123} \times V = 16.875 \times 12 = 202.5\mu\text{C}$ ✓

$V_1 = Q_1 / C_1 = 202.5 / 27 = 7.5\text{v}$ ✓
 $V_2 = V_3 = V - V_1 = 12 - 7.5 = 4.5\text{v}$ ✓

$Q_2 = C_2 \times V_3 = 12 \times 4.5 = 54\mu\text{C}$ ✓
 $Q_3 = C_3 \times V_3 = 33 \times 4.5 = 148.5\mu\text{C}$ ✓

d) $W_1 = \frac{1}{2} C_1 \times V_1^2 = \frac{1}{2} 27 \times 7.5^2 = 759.375\mu\text{J}$ ✓
 $W_2 = \frac{1}{2} C_2 \times V_3^2 = \frac{1}{2} 12 \times 4.5^2 = 121.5\mu\text{J}$ ✓
 $W_3 = \frac{1}{2} C_3 \times V_3^2 = \frac{1}{2} 33 \times 4.5^2 = 334.125\mu\text{J}$ ✓

$V_4 = Q_4 / C_4 = 136.44 / 47 = 2.9\text{v}$ ✓
 $V_5 = Q_5 / C_5 = 136.44 / 15 = 9.096\text{v}$ ✓

$W_4 = \frac{1}{2} C_4 \times V_4^2 = \frac{1}{2} 47 \times 2.9^2 = 197.635\mu\text{J}$ ✓
 $W_5 = \frac{1}{2} C_5 \times V_5^2 = \frac{1}{2} 15 \times 9.096^2 = 620.529\mu\text{J}$ ✓

e) $W_T = \frac{1}{2} C_T \times V^2 = \frac{1}{2} 28.245 \times 12^2 = 2033.712\mu\text{J}$ ✓

Very well done.

Task 3 – Magnetism

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

The principles of a permanent magnet are explained by Faraday's two laws.

'The value of emf induced in a circuit or conductor is directly proportional to the rate of change of magnetic flux linking with it.'

'The polarity of such an emf, induced by an increasing flux, is opposite to that induced by a decreasing flux.'

This is not for permanent magnetics

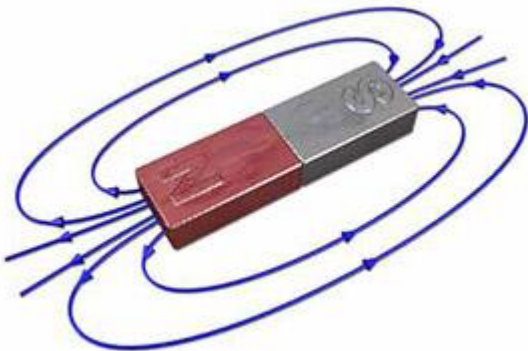
The words 'rate of change' is used in the first of Michael Faraday's laws. This is because change in flux, or change in relationship between the flux and the conductor, is what induces an emf. This law can be simply proven by using a permanent magnet, a coil of wire and a galvanometer.

When moving the magnet into the centre of the coil, the galvo will deflect momentarily. This deflection will only occur whilst the magnet is in motion. A galvanometer is capable of measuring current, but any current flowing must be because of a voltage between terminals. Therefore, an emf has either been induced or created in the coil itself whilst the magnet was in motion.

When the magnet is removed from the coil, the galvo can be seen to deflect again. Although this time the deflection will be in the opposite direction and as long as it has been removed at the same speed as it entered, the magnitude of this deflection will be the same. This confirms the second law.

Also, the quicker the magnet is moved in and out of the coil's centre, the greater the induced emf will be. (Robertson)

The permanent magnet's magnetic field is distributed from north to south poles as can be seen in the diagram below. The lines display where the magnetic field operates. ✓



✓
You have explained Faraday's laws but very little about permanent magnetics.

Figure 1 – Magnetic Field of a Permanent Magnet
(Hannahs, 2022)

2. Solve the following problems:

- a) The maximum working flux density of a lifting electromagnet is 1.6T and the effective area of a pole face is circular in cross-section. If the total magnetic flux produced is 550mWb determine the radius of the pole face.

$$\begin{aligned} 2a) \quad B &= 1.6 \text{ T} \\ \Phi &= 550 \text{ mWb} \end{aligned}$$

$$B = \Phi/A \rightarrow A = \Phi/B \quad \checkmark$$

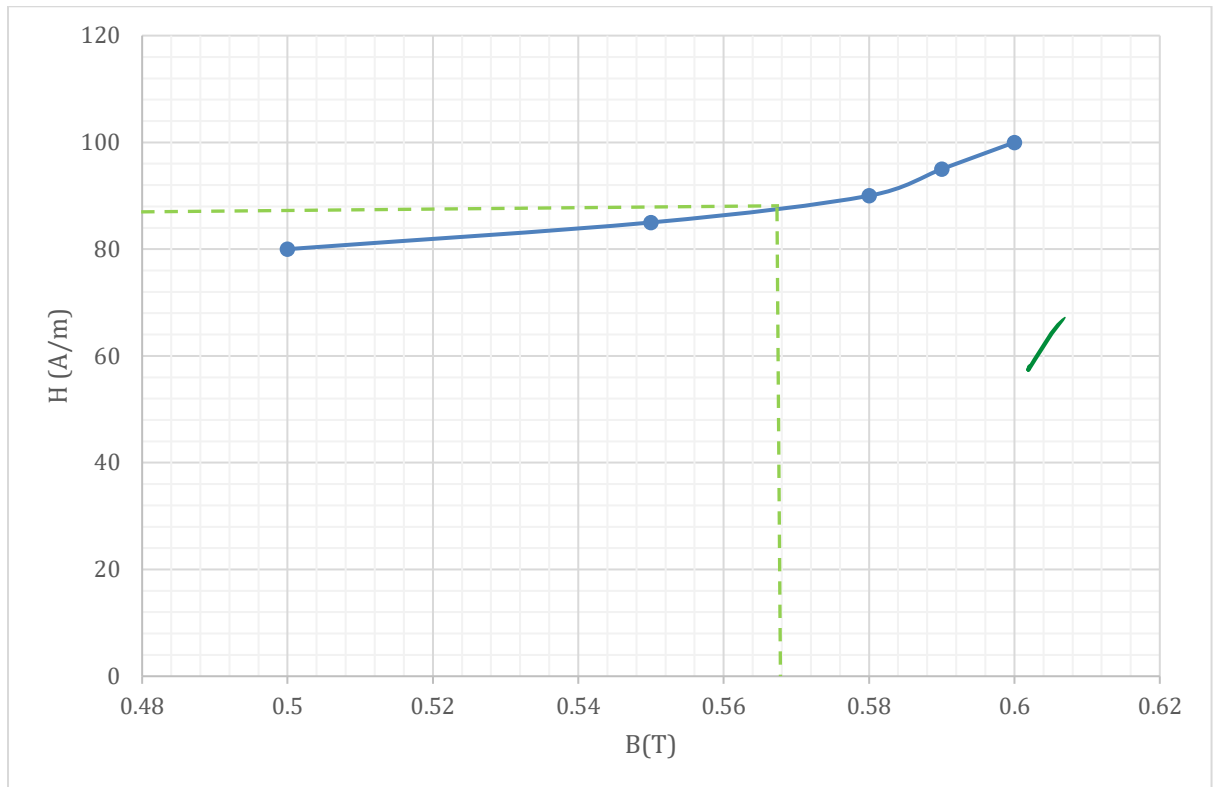
$$\begin{aligned} A &= 0.55/1.6 \quad \checkmark \\ &= 0.3438 \text{ m}^2 \quad \checkmark \end{aligned}$$

$$A = \pi r^2 \rightarrow r^2 = A/\pi \rightarrow r = \sqrt{A/\pi}$$

$$r = \sqrt{0.3438/\pi} = 0.3308 \text{ m} \rightarrow 33.1 \text{ cm} \quad \checkmark$$

- b) An iron toroid having a mean radius of 0.1m and cross-sectional area of 3.49cm^2 is wound with a 1200 turn coil. The coil current results in a flux of 0.2mWb in the toroid. Using the following data, determine (i) the coil current and (ii) the relative permeability of the toroid under these conditions.

H(At/m)	80	85	90	95	100
B(T)	0.5	0.55	0.58	0.59	0.6



$$2bi) \quad A = 3.49\text{cm}^2 = 3.49 \times 10^{-4}\text{m}^2$$

$$B = \Phi/A = (0.2 \times 10^{-3}) / (3.49 \times 10^{-4}) = 0.573\text{T} \quad \checkmark$$

Using the graph, drawing a vertical line from the 'B' value tells us that 'H' must equal 88 A/m ✓

$$H = N \times I / l \quad \checkmark$$

$$l = 2\pi r = 2 \times \pi \times 0.1 = 0.628\text{m} \quad \checkmark$$

$$I = lH/N = 0.628 \times 88 / 1200 = 46.05\text{mA} \quad \checkmark$$

$$2bii) \quad \mu_0 \times \mu_r = B/H \quad \text{where } \mu_0 = 4\pi \times 10^{-7}$$

$$\mu_r = B / (\mu_0 \times H) = 0.573 / (4\pi \times 10^{-7}) \times 88 = 5181.58 \quad \checkmark$$

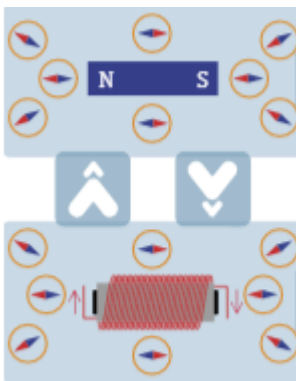
Good calculations

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

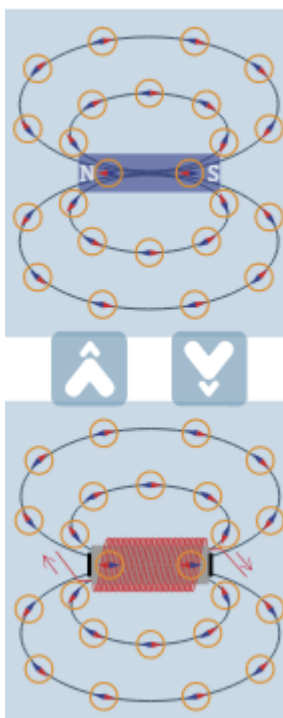
An electromagnet is made up of a ferromagnetic material such as iron which is then tightly wrapped with a coil (usually copper). When a current is sent through the coil, this results in a magnetic field being produced and in this case the iron becoming magnetised. ✓

In 1820, a Danish scientist named Hans Christian Oersted first demonstrated the connection between electric current and magnetic fields by placing a wire near a compass and injecting a current through it. The compass needle was seen to deflect whenever there was a current flowing through the wire. (Electromagnets at Work - Physics Narrative, 2023) ✓

Placing a compass above a wire that has a current flowing through it will result in the compass deflecting at a right angle to the wire. The needle of the compass will also deflect in the opposite direction when placed below the wire. If we were to place compasses in different areas around the wire, it would form a continuous loop as seen in the diagram below. (Electromagnet, n.d.)



In terms of distribution, the field around the wire is circular in shape and flows from north to south poles.



Figures 2, 3 & 4 – Magnetic Field of Electromagnets
(Electromagnets at Work - Physics Narrative, 2023)

4. A transformer is a device that uses some of the principles associated with magnetism. Explain the operation and construction of a transformer, include diagrams and equations to show how voltage, current and turn ratios are related. Discuss how transformers are an essential part of the National Grid System.

A transformer works on the principle of Faraday's law of induction by converting electrical energy from one value to another which makes it useful when stepping up or stepping down voltages is required. (Transformer Basics, 2022). The form of induction they operate on is known as mutual induction which can be described as a coil of wire that magnetically induces a voltage into another wire nearby. ✓

A transformer consists of two coils of wire and a laminated core. These coils are referred to as the primary and secondary winding. The primary side is where the power is most commonly received with the secondary side being where power is most commonly delivered from. Although these two coils are not electrically in contact, they are both wrapped around the laminated core. The core is a closed magnetic loop that is most commonly made of iron and although it is not solid, contains individual laminations that are connected to one another in order to reduce the magnetic loss within the core. Electrical power can be transferred from one coil to the other through this core. (A Complete Guide to Transformers, 2018) ✓

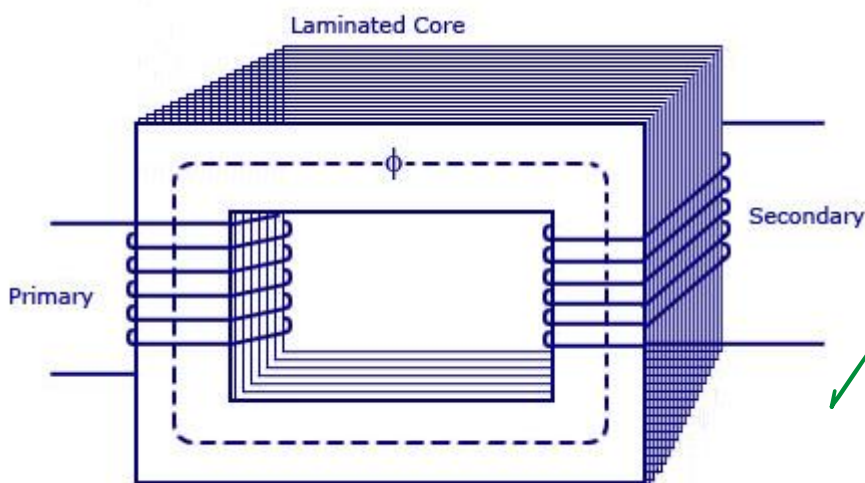


Figure 5 – Working of a Transformer
(A Complete Guide to Transformers, 2018)

By changing the number of turns in the primary coil compared to the secondary coil, we can achieve a difference in voltage. The number of turns in the primary coil divided by the number of turns in the secondary coil is what is known as the turns ratio. This ratio is also directly proportional to the voltage ratio so therefore if the turns ratio was 4:1, an input of 4 volts would equal an output of 1 volt. (Transformer Basics, 2020) ✓

Transformers are used when there is a requirement to step-up or step-down a voltage. An example of when this is necessary is in the National Grid system. This system is responsible for transmitting and distributing electricity to transport networks, factories, schools and homes across the whole of the UK. Transformers are used to 'step-up' or 'step-down' the voltage and current values when between a power station and its destination. Electricity is delivered through the use of transmission lines. ✓

Power transferred will always remain the same and therefore, if voltage is increased, the current will decrease and if current is increased, the voltage will decrease. In the case of the National Grid, voltage is raised from around 25,000 volts to approximately 400,000 volts. Due to the principle that current decreases when voltage increases, this step-up in voltage results in less energy dissipating through the ✓

lines. Before reaching its destination, the voltage is stepped back down to a safe and suitable value. For example, if this electricity was being delivered to a home, it would be stepped down to 230 volts.

(Mains Electricity, 2022)

5. Solve the following problems:

- a) An iron ring of cross-sectional area 8.4cm^2 and mean diameter 25cm , contains an air gap 3mm wide. It is required to produce a flux of 1.4mWb in the air gap. Calculate the mmf required, given that the relative permeability of the iron is 1200 under these operating conditions.

Task 3 - Magnetism

$$\begin{aligned} 5a) \quad A &= 8.4\text{cm}^2 \rightarrow 8.4 \times 10^{-4}\text{m}^2 \\ d &= 25\text{cm} \rightarrow 0.25\text{m} \\ \text{Air gap} &= 3\text{mm} \rightarrow 0.003\text{m} \rightarrow 3 \times 10^{-3}\text{m} \end{aligned}$$

For iron

$$\begin{aligned} S_i &= l_{\text{iron}} / \mu_0 \mu_r \times A \quad / \quad l_{\text{iron}} = \pi d \\ &= 0.25 \times \pi / (4\pi \times 10^{-7}) \times 1200 \times 8.4 \times 10^{-4} \\ &= 0.62 \times 10^6 \text{ A/Wb} \end{aligned}$$

for air

$$\begin{aligned} S_a &= l_{\text{air}} / \mu_0 \mu_r A \quad \text{where } l_{\text{air}} = \text{air gap} \\ &= 3 \times 10^{-3} / (4\pi \times 10^{-7}) \times 1 \times 8.4 \times 10^{-4} \\ &= 2.842 \times 10^6 \text{ A/Wb} \end{aligned}$$

$$\begin{aligned} S &= S_i + S_a = 0.62 \times 10^6 + 2.841 \times 10^6 \\ &= 3.461 \times 10^6 \text{ A/Wb} \\ &= \text{mmf} / \phi \end{aligned}$$

$$\begin{aligned} \text{mmf} &= S \phi \\ &= 3.461 \times 10^6 \times 1.4 \times 10^{-3} \\ &= 4845.4 \text{ At} \end{aligned}$$

- b) A rectangular coil of sides 10cm and 6cm is rotated in a magnetic field of flux density 1.2T, the longer side of the coil actually cutting this flux. The coil is made up of 80 turns and rotates at 1200rev/min. (i) Calculate the maximum generated e.m.f. (ii) If the coil generates 100V, at what speed will the coil rotate?

Task 3 - Magnetism

5b) emf, $\mathcal{E} = 2 B l v N$ where $v = \omega r$

$$\omega r = \pi r / 60 \times 2\pi \times 6 \times 10^{-2} / 2$$

$$v = 3.77 \text{ m/s}$$

bi) $\mathcal{E} = 2 \times 1.2 \times 10 \times 10^{-2} \times 3.77 \times 80$
 $= 72.384 \text{ V}$

bii) when $\mathcal{E} = 100 \text{ V}$

$$v = \mathcal{E} / 2 B l N$$
$$= 100 / (2 \times 1.2 \times 10 \times 10^{-2} \times 80)$$
$$= 5.208 \text{ m/s}$$

$$\omega = v / r = 5.208 / (6 \times 10^{-2} / 2)$$
$$= 173.6 \text{ rad/s}$$

$$\text{Speed} = \omega \times 60 / 2\pi = 173.6 \times 60 / 2\pi$$
$$= 1657.76 \text{ RPM}$$

Well done.

Task 4 – AC Circuits

1. Using the oscilloscope measurements for a sine wave stated in table 3 perform the following calculations
 - a) Peak voltage
 - b) Frequency
 - c) Average voltage
 - d) Root mean square (rms) voltage.

Table 3 – values for Task 4

Student Number	Oscilloscope Settings		Grid Spacing	
	Volts/Div	Timebase (ms/Div)	Vertical (peak to peak)	Horizontal (1 cycle)
1	5	10	6.8	4
2	2	10	7.2	4.4
3	2	20	7.8	4.4
4	5	20	5.4	4.6
5	5	5	4.8	4.8
6	2	5	6.6	4
7	2	10	5.2	5.2
8	0.5	20	7.8	4
9	0.5	20	7.2	4.2
10	2	5	5.5	4.4
11	0.5	10	5.6	4.6
12	0.5	5	6.2	4.2

$$V_{pp} = 5 \times 6.8 = 34\text{v}$$

$$T = 10 \times 4 = 40\text{ms}$$

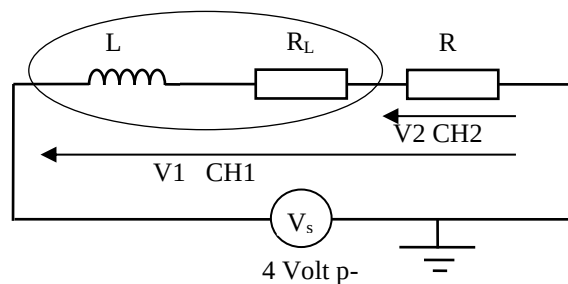
$$\text{a) } V_p = 34/2 = 17\text{v}$$

$$\text{b) } F = 1/T = 1/40 \times 10^{-3} = 25\text{Hz}$$

$$\text{c) } V_{av} = 0.637 \times V_p = 0.637 \times 17 = 10.829\text{v}$$

$$\text{d) } V_{rms} = V_p / \sqrt{2} = 17 / \sqrt{2} = 12.02\text{v}$$

2. Below is a RL circuit:



$L = 2.2\text{mH}$, $R = 27\Omega$, $R_L = 4\Omega$ (measure this value)

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

$$L = 2.23 \quad R = 27.4 \quad R_L = 4.4$$

4. Produce a table of measurements:

Frequency (f) (kHz)	CH1 (V) <i>pk to pk</i> Voltage	CH2 (V) <i>pk to pk</i> Voltage	Time Difference (between peaks) (μs)	Phase Angle ($^\circ$)
1	1.66	1.36	66	23.76
2	1.98	1.3	60	43.2
3	2.3	1.32	50	54
4	2.6	1.14	44	63.36
5	2.86	1.04	36	64.8
6	3.06	0.96	32	69.12
7	3.2	0.9	28	70.56
8	3.32	0.84	27	77.76
9	3.44	0.78	24.4	79.056

5. Produce a table of calculations:

Frequency (f - kHz)	X_L (Ω)	R_T	Z (Ω)	Current (A)	Phase Angle ($^\circ$)
1	14.01	31.8	34.75	0.115	23.78
2	28.02	31.8	42.39	0.094	41.39
3	42.03	31.8	52.71	0.076	52.89
4	56.05	31.8	64.44	0.062	60.43
5	70.06	31.8	76.94	0.052	65.59
6	84.07	31.8	89.88	0.045	69.28
7	98.08	31.8	103.11	0.039	72.04
8	112.09	31.8	116.52	0.034	74.16
9	126.10	31.8	130.05	0.031	75.85

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

For a frequency of 4

$$\begin{aligned}X_L &= 2\pi \times F \times L \\&= 2\pi \times 4 \times (2.23 \times 10^{-3}) \\&= 56.05 \Omega \\Z &= \sqrt{R_T^2 + X_L^2} \\&= \sqrt{31.8^2 + 56.05^2} \\&= 64.44 \Omega \\A &= F/Z \\&= 4/64.44 \\&= 0.062 \text{ A} \\ \phi &= \tan^{-1} (X_L/R_T) \\&= \tan^{-1} (56.05/31.8) \\&= 60.43^\circ\end{aligned}$$

Have not shown
the calculation of R_T .

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

When comparing practical readings and calculated results, it is more than likely that there will be a slight difference. For example, the inductor used in the circuit is 2.2mH but when taking readings during the practical, this was actually measured to be 2.23mH. There are a number of reasons as to why values read differently when being compared and I will comment on some of these now:

Due to the multimeter not outputting a set value and instead bouncing around a few different values, this results in us having to decide on an average value. This bouncing of readings may come down to the multimeter probes not being in full contact with the component or the probes themselves housing dirt. This might be the reason there is a difference of 0.4Ω between the resistor found in the RL circuit compared to the practical.

Calibration of equipment is also another reason that values might read differently when comparing the two. The longer the equipment goes without being calibrated, the more likely it is that results will be inaccurate.

Multimeters also carry an internal resistance of $10\text{M}\Omega$. This would explain why some resistance readings taken are slightly larger than the calculated values. As well as this internal resistance, components being measured have a tolerance of 5%. This means that a resistor with a value of 27Ω could measure anywhere between $25.65 - 28.35 \Omega$.

When using the oscilloscope, the user is responsible for choosing where the measurements are taken from. This could result in a discrepancy with calculations later on that include this figure. Although we used different methods to find the phase angle, the phase angle value should still read the same. As can be seen in the two tables, this value reads around the same on both but never exact. ✓

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