

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Shaun Harrison	Student ID number:	
Programme:	HNC Electrical/Electronic Engineering, Power Systems Engineering & Instrumentation Engineering		
Module:	Electrical Principles		
Module code:	PCEE4001	Contribution to Overall Module Assessment (%):	100%
Lecturer:	Jason Pointer	Internal Verifier:	Steve Roberts
Assignment Title:	Electrical Principles	Word count (or equivalent):	2000
Submission deadline:	16/01/19	Return date of provisional marks & written feedback:	
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

Module Learning Outcomes (from module syllabus)

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

STUDENT FEEDBACK FORM

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

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	15	9.75
Selection of relevant and credible sources, used a variety of books and websites. Generally sound referencing, with no inaccuracies or inconsistencies.		
2. Knowledge and Understanding Skills	25	18.75
Task 1 achieved 80%. Task 2 achieved 70%. Task 3 achieved 70%. Task 4 achieved 80%. Excellent knowledge and understanding of the basic underlying concepts and principles of the subject.		
3. Cognitive and Intellectual Skills	15	11
Task 1 achieved 75%. Task 4 achieved 70%. Excellent evaluation of the underlying concepts and principles applied to Task 1 and 4, made an excellent effort in discussing the results and linking them to relative concepts.		
4. Practical Application Skills	35	27
Task 1 achieved 80%. Task 4 achieved 75%. An excellent application of practical work for Task 1 and 4, very good use of the test equipment to obtain all of the required results.		
5. Transferable Skills for Life and Professional Practice	10	6.5
Work is accurate, coherent, fluent, well-structured and organised.		

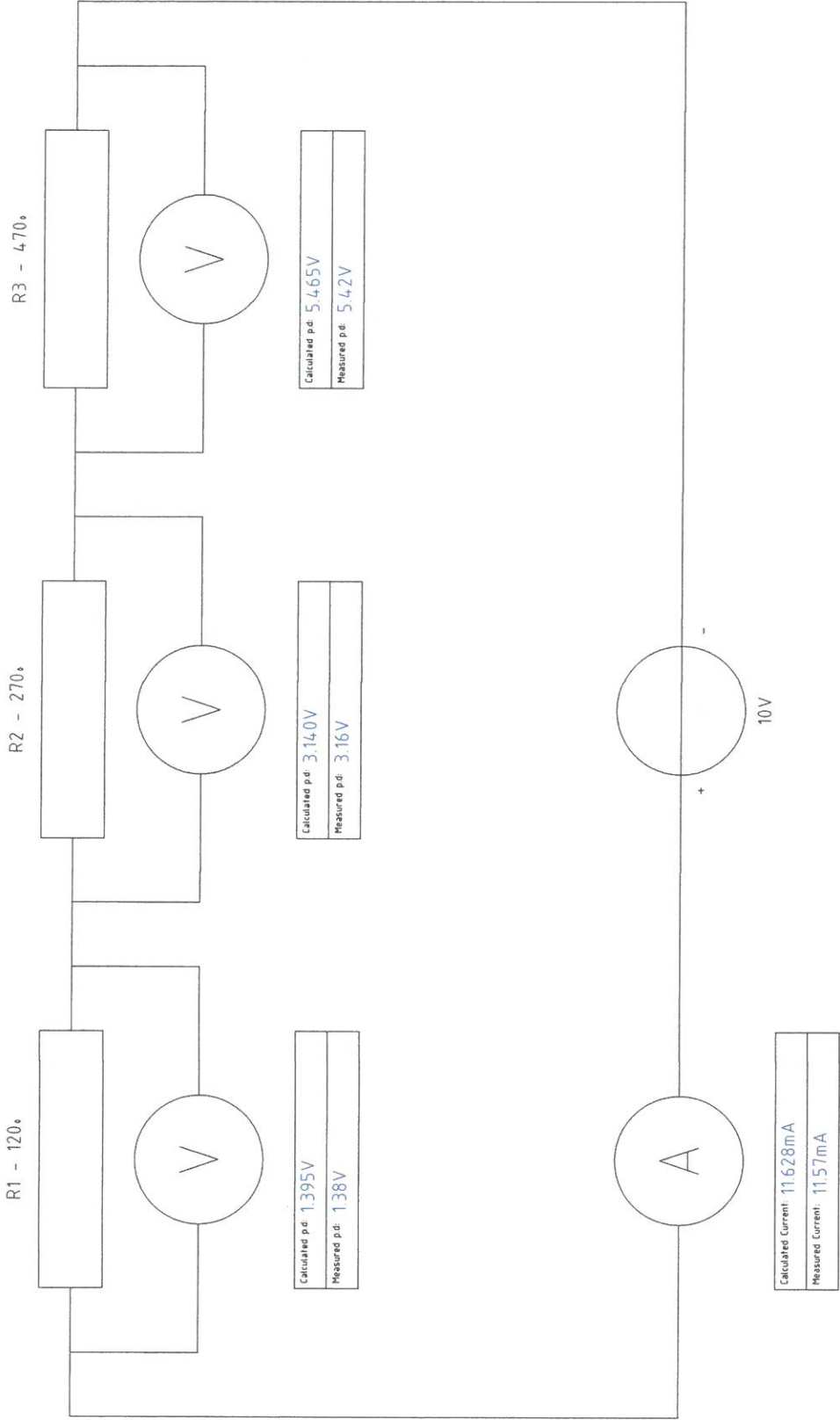
Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)

Late Submission Penalties (tick if appropriate)

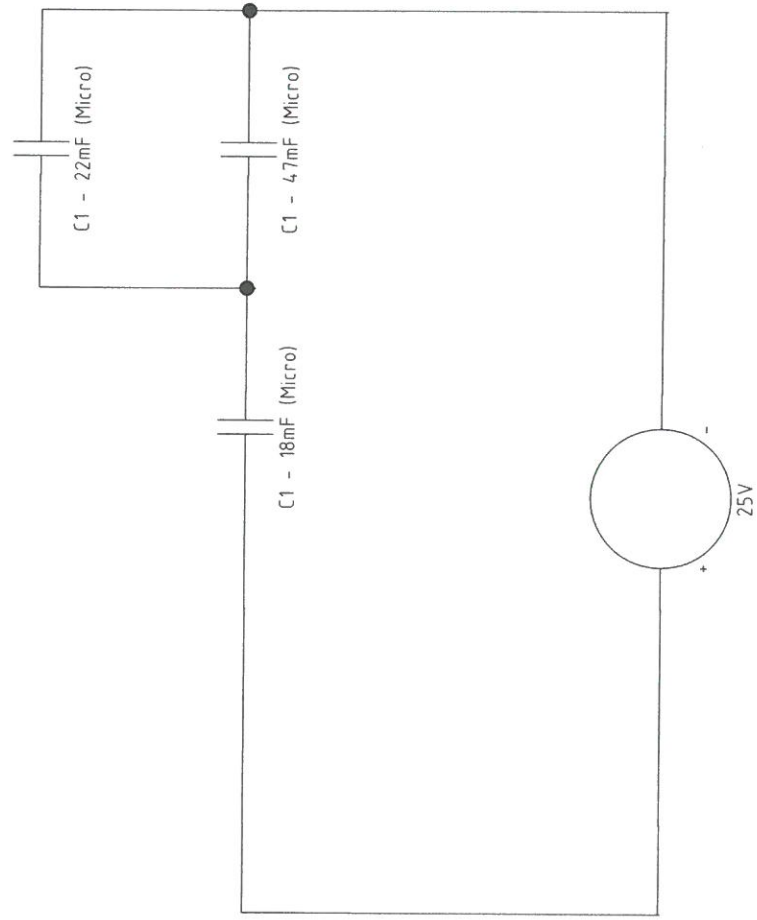
Up to 1 week late (40% Max)
Over 1 week late (0%)

73%

Total Calculated Resistance: 860, | Total measured resistance: 848,



Shaun Harrison 67099@pembrokeshire.ac.uk shaun_harrison@outlook.com	
Title Electrical Circuit Diagram, Task 1 Resistors in Series Electrical Principles	Date 17/10/2018
Description HNC Electrical & Electronic Engineering; Resistors in Series Electrical Principles Assignment, Task 1	Revision Rev 0
Reference HNC Elec Principles-T1-1-SC-00	Scale NTS
Initials S.H.	



Shaun Harrison
67099@pembrokeshire.ac.uk | shaun_harrison@outlook.com

Title		Date
HNC Electrical Principles - Assignment Task 2 Diagram		07/01/2019
Description		Revision
HNC Electrical Principles - Assignment Task 2 Diagram		Rev 0
Reference		Initials
HNC Electrical Principles Assignment Task 2 Diagram		SH

Electrical Principles – Assignment 1

Task 1 – DC Circuits

Series Circuit

Circuit & Measurements

The circuit shown below (figure 1) was constructed, R_t was measured at 848Ω before connecting the power supply. After connecting to a 10V DC Power supply, p.d. across each resistor was measured as:

R1 – 1.38V, R2 – 3.16V R3 – 5.42V

Supply current measured as: 11.57mA

Total Calculated Resistance: 860Ω | Total measured resistance: 848Ω

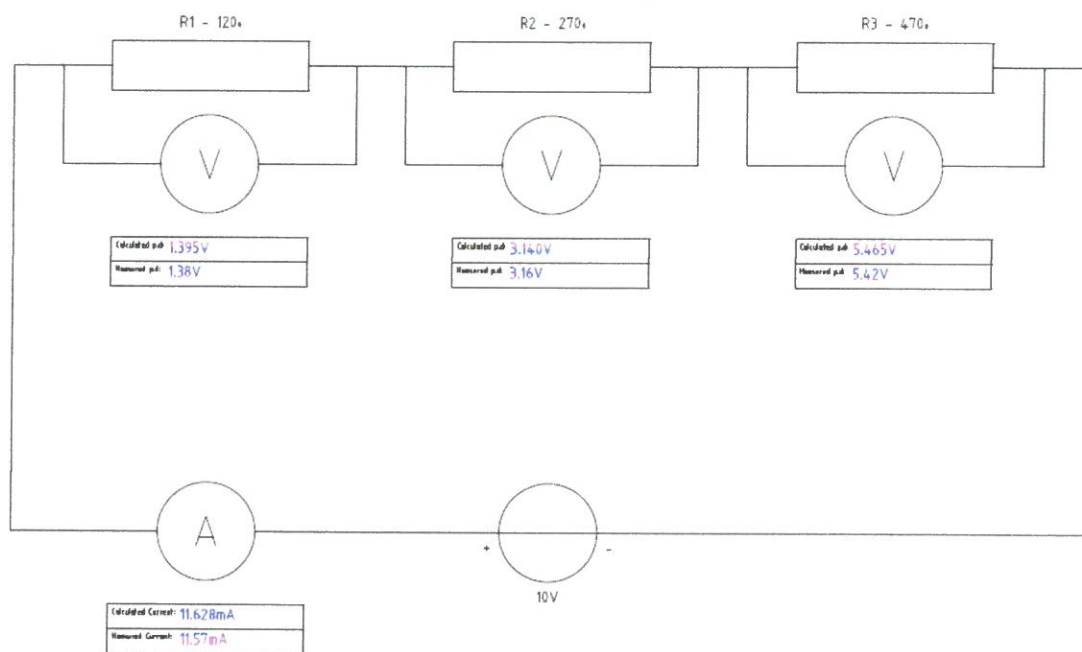


Figure 1: Series Circuit

Calculations

Calculate the total resistance, supply current and the p.d. value across each resistor.

Total Resistance

$$R_t = R_1 + R_2 + R_3 \quad \Rightarrow \quad R_t = 120 + 270 + 470 \quad \Rightarrow \quad R_t = 860\Omega$$

Supply Current

$$I = \frac{V}{R} \quad \Rightarrow \quad I = \frac{10}{860} \quad \Rightarrow \quad I = 11.628mA$$

P.D. across each resistor

$$R1, \quad V = IR \quad \Rightarrow \quad V = 11.628 \times 10^{-3} \times 120 \quad \Rightarrow \quad V = 1.395V$$

R2, $V = IR > V = 11.628 * 10^{-3} * 270 > V = 3.140V$ ✓

R3, $V = IR > V = 11.628 * 10^{-3} * 470 > V = 5.465V$ ✓

Parallel Circuit

Circuit & Measurements

The circuit shown below (Figure 2) was constructed, R_t was measured at $0.93 k\Omega$ before connecting the power supply. After connecting to a 10V DC Power supply, current across each resistor was measured as:

R1 – 0.82mA, ✓ R2 – 6.72mA ✓ R3 – 3.06mA ✓

Supply current measured as: 10.55mA ✓

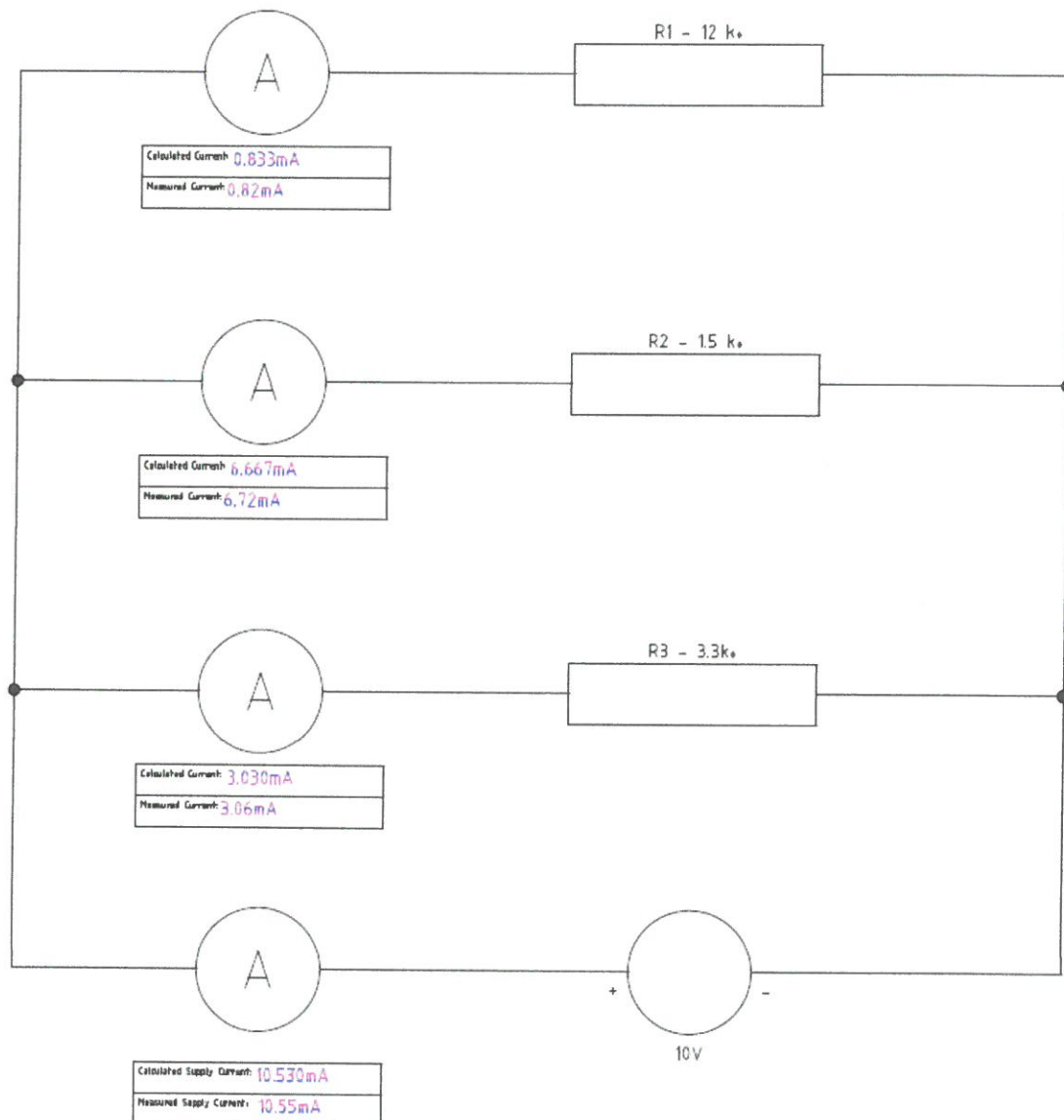


Figure 2 Parallel circuit

Calculations

Calculate the total resistance, supply current and the current through each resistor.

Total Resistance

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} > \frac{1}{R_t} = \frac{1}{12 \times 10^3} + \frac{1}{1.5 \times 10^3} + \frac{1}{3.3 \times 10^3} > \frac{1}{R_t} = 1.053 \times 10^{-3} > R_t = \frac{1}{1.053 \times 10^{-3}} >$$

$$R_t = 949.640 \Omega$$

Supply Current

$$I = \frac{V}{R} > I = \frac{10}{949.640} > I = 10.530 \text{mA}$$

Current through Each Resistor

$$R1, \quad I = \frac{V}{R} > I = \frac{10}{12000} > I = 0.833 \text{mA}$$

$$R2, \quad I = \frac{V}{R} > I = \frac{10}{1500} > I = 6.667 \text{mA}$$

$$R3, \quad I = \frac{V}{R} > I = \frac{10}{3300} > I = 3.030 \text{mA}$$

Comparison of Results

Series Circuit

Parameter	Measured Result	Calculated Result
Total Resistance	848 Ω	860 Ω
Supply Current	11.57mA	11.628mA
p.d R1	1.38V	1.395V
p.d R2	3.16V	3.140V
p.d R3	5.42V	5.465

Parallel Circuit

Parameter	Measured Result	Calculated Result
Total Resistance	0.93 k Ω	0.9496 k Ω
Supply Current	10.55mA	10.531mA
Current R1	0.82mA	0.833mA
Current R2	6.72mA	6.667mA
Current R3	3.06mA	3.030mA

Variations:

The above tables show that in each circuit, the measured values do not align with the calculated values expected. Assuming the calculations are correct there are many other factors that could lead to discrepancies, including, but not limited to;

- Accuracy of the power supply displayed voltage
- The actual resistance of each resistor – which had an indicated $\pm 5\%$ tolerance
- Accuracy of the multi-meter used
- Losses in the circuit conductors (not considered in design or calculations)

It's likely the variations are not linked to a single possibility listed above but a combination of all of the above. Further calculations on measured parameters give further results that do not align, one example being, for the series circuit, the total calculated voltage using $V = IR$ from the measured total resistance and measured supply current gives:

$$V = IR > V = 11.5710^{-3} * 848 > V = 9.811V$$

However, the total voltage calculated by adding the voltage measured across each resistor is:

$$V_t = V_1 + V_2 + V_3 > V_t = 1.38 + 3.16 + 5.42 > V_t = 9.96V$$

These results lead to questioning the accuracy of the multi-meter, repeating the exercise with a different multi-meter may well lead to different results again.

This results varies marginally from the sum of the three calculated voltages which gives a result of 10.0V. According to Bird (2007) Kirchhoffs voltage law tells us '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'. (p.179) Applying this law to the series circuit in task 1, the total voltage drop must equal the supply voltage, of 10.0V, an exact match with the calculations, but not the measured results.

Similarly, the calculated results of the current in the parallel circuit coincide with expected results using Kirchhoffs current law, where if each branch of the circuit is considered as coming from a single junction, with the supply current flowing to the same junction, the sum of the current from each branch matches the supply current. As with the voltage this is marginally different from measured results.

The difference in the measured total resistance and the calculated total resistance suggests the individual resistors did not exactly match their indicated values.

Calculations of the supply voltage from any of the measured parameters do not give a result of 10V, suggesting the accuracy of the power supply is questionable.

Although not considered in the circuit design, the circuit conductors would have their own resistance, for a circuit of this size, both in terms of capacity (design current) and physical size (overall length) this may well be insignificant, but will still be present. This is considered in the design of larger circuits, such as LV distribution systems, where the voltage drop in the conductor is calculated, to ensure the voltage delivered to electrical equipment is within acceptable parameters.

Task 2 – Capacitors

- 1.) Explain the construction and function of a capacitor, listing some of the different types that are available and typical values.

'A capacitor is an electrical device that is used to store electrical energy. Next to the resistor, the capacitor is the most commonly encountered component in electrical circuits'. Bird (2007, p.55) Bird, (2007), Kuphaldt (2002), Ashby (2012), and Fitzgerald Et Al (2003), all explain the construction and function of a capacitor.

Capacitors are an electrical device constructed with two conducting plates in close proximity to each other, separated by an insulator or dielectric. Apply a DC current across the plates and they will build up equal and opposite charges. Minus some leakage the capacitor can hold this charge once the power source is removed. The capacitor can be quickly discharged, providing large amounts of energy quickly, for items like a camera flash. They are used in car audio systems, power factor correction, timing circuits, medical equipment and many more. Capacitors have capacitance, measured in Farrads, the charge in capacitor can be calculated if the capacitance and voltage the capacitor is charged to are known.

Charge, Q (coulombs) = CV where C is capacitance and V is voltage. Charge can also be calculated as the product of current in amperes and time in seconds, $Q = It$

Most capacitors have a capacitance rating of micro, or nano farrads. Capacitance can be increased in 3 ways, increasing the size of the conducting plates, moving the plates closer together, increasing the insulation value of the dielectric material, or any combination of. The charge in the capacitor can be increased by increasing the voltage, however, if voltage is increased too much it can cause the dielectric to break down and allow the current to flow through the dielectric. This could permanently damage the capacitor.

Types of Capacitors

Capacitors can be made with various dielectric materials.

These include;

Mica Capacitors, Typically made with a lead or aluminium foil, with mica sheets between plates. These have a typically value ranging from pF to nF, although they can be as high as 1 μ F, and can operate at high voltages, typically rated between 100 and 1000V.

Ceramic Capacitors, typical values for ceramic capacitors are 1 nF to 1 μ F, but can be as high as 100 μ F, they are unpolarised so can be used in AC circuits. Glass capacitors are often used where high performance is required, they don't age, have minimal losses, and high temperature tolerance.

Electrolytic Capacitors, typical values are 1 μ F to 47 mF, double layer capacitors can reach hundreds of Farrads. Used in DC circuits and nearly always polarised.

Paper Capacitors, typical values of 500 pF to 10 μ F, these capacitors have a high working voltage.

Film Capacitors, or plastic capacitors, typical values range from 1 nF to 30 μF , these capacitors are not polarised and can be very accurate compared to other types of capacitor.

Variable Air Capacitors, typical values between 500 pF and 1 nF, the dielectric in these capacitors is air, typically interlocking plates can be moved in/out of each other, increasing or decreasing the plate size to give variable capacitance.

2.) For the circuit below (figure 3);

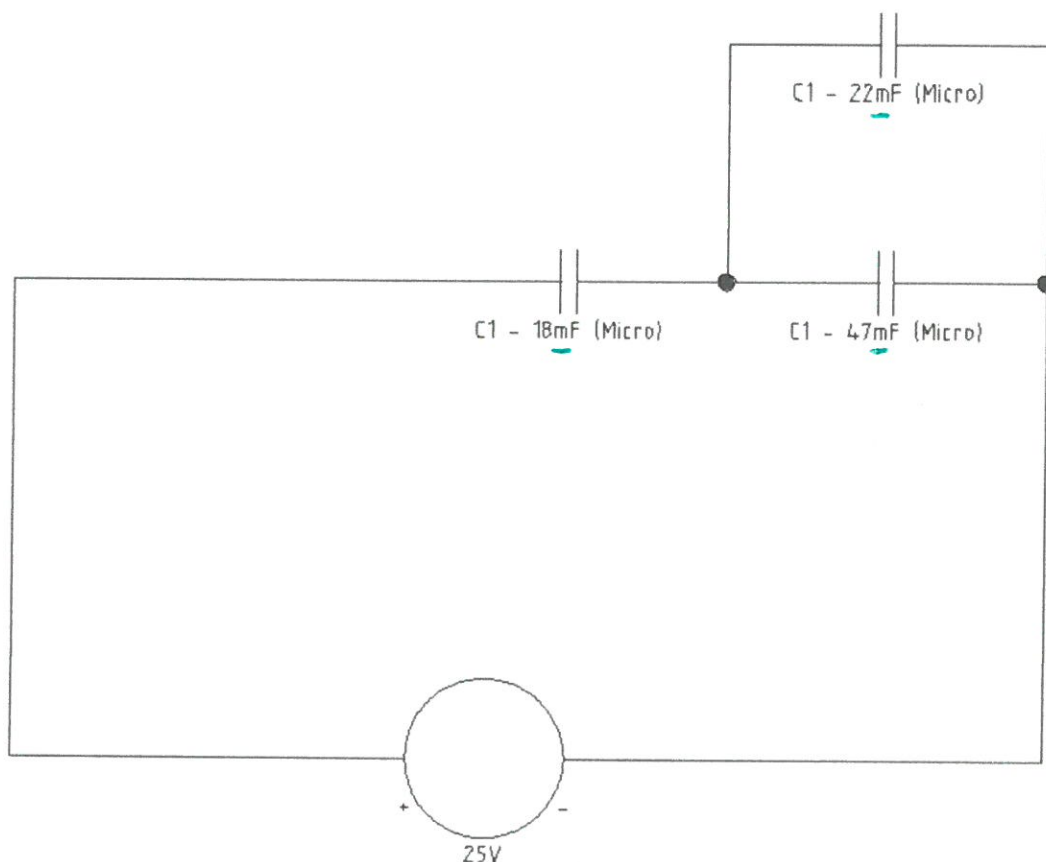


Figure 3 Capacitors in both series and parallel

Determine:

a) the equivalent circuit capacitance

C_2 and C_3 are connected in parallel, therefore: $C_{(2\&3)} = C_2 + C_3$ > $C_{(2\&3)} = 22 * 10^{-6} + 47 * 10^{-6}$ >

$C_{(2\&3)} = 69 * 10^{-6}$ or, $C_{(2\&3)} = 69\mu\text{F}$

C_1 and $C_{(2\&3)}$ are connected in series, therefore: $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_{(2\&3)}}$ or, $C = \frac{C_1 C_{(2\&3)}}{C_1 + C_{(2\&3)}}$ >

$$C = \frac{18 \times 69}{18 + 69} \mu F > C = 14.276 \mu F$$

b) the total charge

$$Q = CV > Q_{(\mu C)} = 14.276 \times 25 > Q = 356.897 \mu C$$

c) the charge in each capacitor

As C_1 and $C_{(2\&3)}$ are connected in series, the charge in C_1 and $C_{(2\&3)}$ are the same and equal to total charge, so charge in C_1 and $C_{(2\&3)}$ is $356.897 \mu C$

$$Q_1 = 356.897 \mu C$$

For $C_{(2\&3)}$, $V_{(2\&3)} = \frac{Q_t}{C_{(2\&3)}}$, and V will be common for both C_2 and C_3 . $V_{(2\&3)} = \frac{356.897 \mu C}{69 \mu F} >$

$$V_{(2\&3)} = 5.172 V$$

$$\text{For } C_1, V_1 = \frac{Q_t}{C_1} > V_1 = \frac{356.897 \mu C}{18 \mu F} > V_1 = 19.828 V$$

Given $Q = CV$, then $Q_2 = C_2 V$, and $Q_3 = C_3 V$

$$Q_2 = 22 \times 5.172 > Q_2 = 113.793 \mu C$$

$$Q_3 = 47 \times 5.172 > Q_3 = 243.103 \mu C$$

d) the energy stored in each capacitor

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

$$\text{For } C_1, C=18\mu F, V=19.828V > W = \frac{1}{2}(18\mu F \times 19.828^2) > W = 3.538mj$$

$$\text{For } C_2, C=22\mu F, V=5.172V > W = \frac{1}{2}(22\mu F \times 5.172^2) > W = 294.245\mu j$$

$$\text{For } C_3, C=47\mu F, V=5.172 > W = \frac{1}{2}(47\mu F \times 5.172^2) > W = 628.615\mu j$$

e) the total energy stored in the circuit.

The total energy in the circuit is equal to the sum of the energy in each capacitor.

$$\text{Total energy} = 3.538mj + 294.245\mu j + 628.615\mu j$$

$$\text{Total energy} = 4.461mj$$

Task 3 –Magnetism

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

Bird (2007) explains 'A permanent magnet is a piece of ferromagnetic material (such as iron, nickel or cobalt) which has properties of attracting other pieces of these materials' (p.72). This attraction is a physical attraction, with enough force to move significant masses of material, or so that significant effort must be exerted to move materials away from the permanent magnet. He further explains that if suspended freely a permanent magnet will position itself in a north and south direction. The area around the magnet, called the magnetic field, is the area in which magnetic force can be detected.

The magnetic field can be shown by lines of flux, from the north pole of the magnet to the south as shown in figure 4 below (Bird, 2007:p.72):

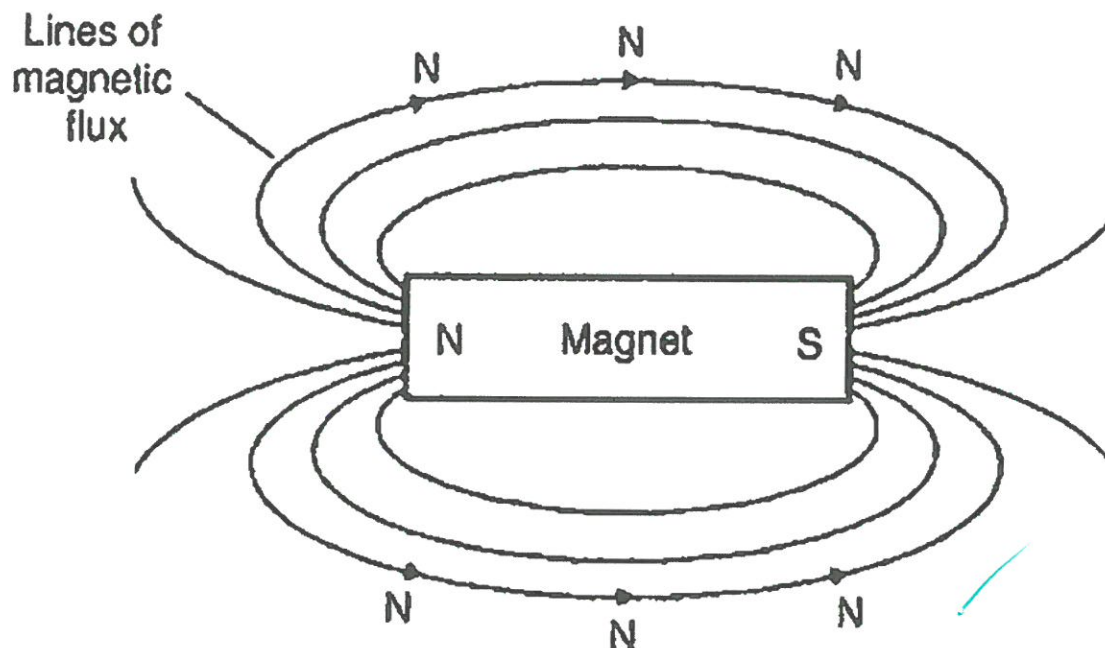


Figure 4 Image from Bird (2007)

The lines of flux act all around the magnet, not just either side as shown in the diagram, and the closer together the lines, the higher the flux density, the stronger the magnetic force is. The lines are considered elastic, as if they are displaced by opposing forces, once the opposing forces are removed, the lines of flux revert to their 'normal' position.

2. Solve the following problems:
 - a) A magnetic pole face has a rectangular section having dimensions 250mm by 120mm. If the total flux emerging from the pole is $120\mu\text{Wb}$, calculate the flux density.

Dimensions, 250mm, or 0.25m by 120mm, or 0.12m, so area is: $0.25 \times 0.12 = 0.03\text{m}^2$

Total flux is $120\mu\text{Wb}$, flux density, B (Tesla) = $\frac{\text{Magnetic Flux, } \phi (\text{Weber})}{\text{Area (m}^2\text{)}}$

In this instance, $\text{flux density} = \frac{120 \times 10^{-6}}{0.03} > \text{flux density} = 0.004 \text{ T or } 4\text{mT}$.

- b) The maximum working flux density of a magnet is 1.5T and the effective area of a pole face is circular in cross-section. If the total magnetic flux produced is 340mWb, determine the radius of the pole face.

$B = 1.5\text{T}$, $\phi = 340 \text{ mWb}$, or 0.34 Wb

$$B = \frac{\phi}{a} > a = \frac{\phi}{B} > a = \frac{.340}{1.5}$$

Area of a circle, $a = \pi r^2 > \frac{.34}{1.5} = \pi r^2 > \frac{.34}{1.5 \times \pi} = r^2 > \sqrt{\frac{.34}{1.5 \times \pi}} = r > r = 0.269\text{m or } 269\text{mm}$

3. Explain the principle operation and construction of an electromagnet including the distribution of magnetic fields. Also discuss two applications where the principles of electromagnetism is used.

Ashby (2012) and Griffiths (1999) explain that a charge, such as an electron moving through a conductor, creates a magnetic field perpendicular to the direction of movement. As with a permanent magnet the magnetic field is not simply 2D in nature, the resulting magnetic field circles the conductor in a clockwise direction (following the flow of the moving charges, or current). Shown in figure 5 below.

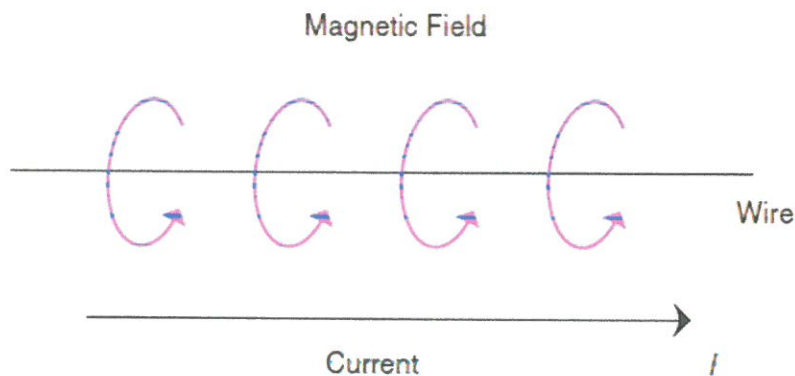


Figure 5 Ashby (2012)

Ashby (2012) states 'the field is identical to the field surrounding a permanent magnet. In fact, if you coil the wire, the magnetic field lines align and reinforce each other, making it even more like a permanent magnet'. (p.55) Shown in figure 6 below.

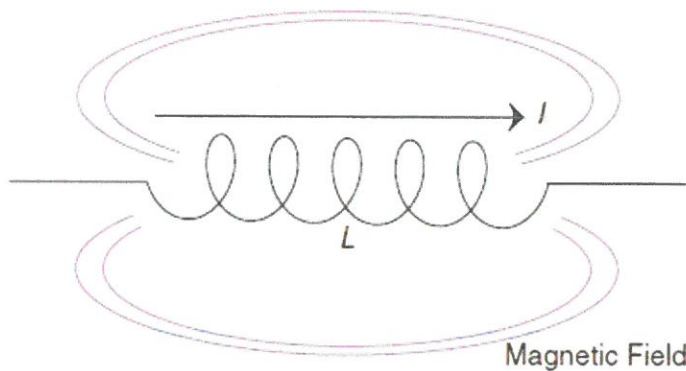


Figure 6 Ashby (2012)

This type of magnet is called an electromagnet, the strength of the magnetic field can be increased by increasing the current in the conductor or coil, for instant changes in field strength as and when required, or increasing the number of coils for permanent changes in field strength. The magnet can also be turned on or off. This means electromagnets can be controlled in a way that permanent magnets cannot, and they are used for many applications.

Many modern alternators use electromagnets instead of permanent magnets. The emf induced is dependant on the magnetic field strength, using an electromagnet allows for adjusting the magnetic field strength as required to get the desired output voltage under varying load conditions.

Electromagnets are also used in solenoids to operate switches, valves, locking or release mechanisms etc. The ability to turn the magnet on or off allows for a valve to be opened or closed, a switch to be turned on or off etc.

4. Solve the following problems:

- a) A conductor 320mm long carries a current of 8A and is at right-angles to a magnetic field lying between two circular pole faces each of radius 60mm. If the total flux between the pole faces is 0.4mWb, calculate the magnitude of the force exerted on the conductor.

$$F = BIl \quad > \quad I = 8A \quad > \quad l = 320\text{mm, or } 0.32\text{m}$$

$$B = \frac{\phi}{a} \quad > \quad \phi = 0.4 \text{ mWb or } 0.4 \times 10^{-3} \text{ mWb}$$

$$a = \pi r^2 \quad > \quad r = 60\text{mm or } 0.06\text{m} \quad (a \cong 0.011310)$$

$$B = \frac{0.4 \times 10^{-3}}{\pi \times 0.06^2} \quad (B \cong 0.035368)$$

$$F = \frac{0.4 \times 10^{-3}}{\pi \times 0.06^2} \times 8 \times 0.32 \quad > \quad F = 0.091 \text{ N}$$

- b) A 400mm length of conductor carrying a current of 25A is situated at right-angles to a magnetic field between two poles of an electric motor. The

poles have a circular cross-section. If the force exerted on the conductor is 80N and the total flux between the pole faces is 1.27mWb, determine the diameter of a pole face.

$$\phi = 1.27\text{mWb or } 0.00127\text{ Wb} > l = 400\text{mm or } 0.4\text{m} > I = 25\text{A} > F = 80\text{N}$$

$$F = BIl \text{ or } \frac{F}{Il} = B \quad (B = 8\text{T})$$

$$B = \frac{\phi}{a} \text{ or } \frac{F}{Il} = \frac{\phi}{a} > a = \frac{\phi Il}{F} \quad (a \cong 0.000159\text{m}^2)$$

$$a = \pi r^2 \text{ or } \pi r^2 = \frac{\phi Il}{F} > r^2 = \frac{\phi Il}{F\pi} > r = \sqrt{\frac{\phi Il}{F\pi}}$$

$$d = 2r \text{ or } d = 2\sqrt{\frac{\phi Il}{F\pi}} > d = 0.014217\text{m or } 14.217\text{mm}$$

Task 4 – AC Circuits

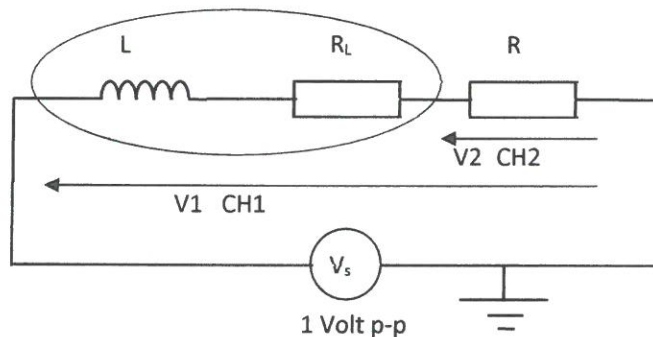
1. Using the oscilloscope measurements for a sine wave stated below perform the following calculations
 - a) Peak voltage
 - b) Frequency
 - c) Average voltage
 - d) Root mean square (rms) voltage.

Oscilloscope Settings		Grid Spacing	
Volts/Div	Timebase (ms/Div)	Vertical (peak to peak)	Horizontal (1 cycle)
5	10	5	4.6

- a) $5\text{V/Div} \times 5\text{ Div} = 25\text{V Peak to Peak}$, $12.5\text{V Peak +ve Voltage}$
- b) $10\text{ms/Div} \times 4.6\text{ Div} = 46\text{ms per cycle}$, $\text{Frequency} = 1/t > 1/46\text{ms} = 21.739\text{ Hz}$
- c) $\text{Average Voltage} = \frac{2V_p}{\pi} > \frac{2 \times 12.5}{\pi} > \frac{25}{\pi} > \text{Average Voltage} = 7.958\text{V}$
- d) $\text{rms voltage} = \frac{V_p}{\sqrt{2}} > \frac{12.5}{\sqrt{2}} > \text{rms voltage} = 8.839\text{V}$

Very well done.

2. Below is a RL circuit:



$$L = 1\text{mH}, R = 10\Omega, R_L = ?\Omega \text{ (measure this value)}$$

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

$$L = 1.007 \text{ mH}$$

$$R = 9.95 \Omega$$

$$R_L = 2.69 \Omega$$

4. Produce a table of measurements as shown below:

Frequency (f) (kHz)	CH1 (V) pk to pk Voltage mV	CH2 (V) pk to pk Voltage mV	Time Difference (between peaks) (T2-T1) μs	Calculated values		
				Time for 1 cycle (T) $= 1/f$ ms	Fraction of cycle (T2- T1)/T	Phase Angle (°) (fraction $\times 360$)
1	222	158	84	0.001000	0.084	30.240
2	282	158	65.6	0.000500	0.131	47.232
3	350	152	52.8	0.000333	0.158	57.024
4	424	148	44.8	0.000250	0.179	64.512
5	484	142	39.2	0.000200	0.196	70.560
6	544	134	31.2	0.000167	0.187	67.392
7	596	130	28	0.000143	0.196	70.560
8	632	122	26.4	0.000125	0.211	76.032
9	672	118	23.2	0.000111	0.209	75.168

5. Produce a table of calculations as shown below:

Frequency (f - kHz)	$X_L (W)$ ($2\pi fL$)	R_T ($R + R_L$)	$Z (W)$	Current (A)	Phase Angle (°)	Check with b) above
1	6.327	12.64	14.135	0.070746	26.59	13.7%
2	12.654	12.64	17.886	0.055910	45.03	4.9%
3	18.982	12.64	22.805	0.043850	56.34	1.2%
4	25.309	12.64	28.290	0.035349	63.46	1.7%
5	31.636	12.64	34.068	0.029353	68.22	3.4%
6	37.963	12.64	40.012	0.024993	71.58	-5.9%
7	44.290	12.64	46.059	0.021712	74.07	-4.7%
8	50.617	12.64	52.172	0.019167	75.98	0.1%
9	56.945	12.64	58.330	0.017144	77.48	-3.0%

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 1 kHz, 1000 Hz, $L = 1.007$ mH

$$X_L = 2\pi fL > X_L = 2\pi \times (1 \times 10^3) \times (1.007 \times 10^{-3}) > X_L = 6.327\Omega$$

Inductor Measured Resistance = 2.69Ω

Resistor Measured Resistance = 9.95Ω

$$R_t = R + R_L > R_t = 12.64\Omega$$

$$Z^2 = R_t^2 + X_L^2 > Z = \sqrt{R_t^2 + X_L^2} > Z = \sqrt{12.64^2 + 6.327^2} > Z = 14.135\Omega$$

$$V = 1V, I = \frac{V}{Z} > I = \frac{1}{14.135} > I = 70.746 \times 10^{-3}A > I = 70.746mA$$

$$\text{Phase Angle} = \tan^{-1}\left(\frac{X_L}{R_t}\right) > \text{Phase Angle} = \tan^{-1}\left(\frac{6.327}{12.64}\right) > \text{Phase Angle} = 26.59^\circ$$

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

As with results from Task 1 discrepancies between calculated results and measured results are going to be for a variety of reasons. The results where an exact comparison can be made are the results for the phase angle. The measured results vary from -4.7% to + 13.7% of the calculated value for each frequency. Excluding results for 1 kHz this reduces to $\pm 5\%$.

Some of these reasons will include;

- Equipment not perfectly calibrated;
 - The power supply *← No power supply, function generator.*
 - The oscilloscope
 - The multi-meter used to measure inductance & resistance
- Human error;
 - Frequency of power supply not exactly set
 - Error in positioning cursors for measuring time difference between peaks
- Component tolerances
- Unmeasured circuit resistance

Equipment not perfectly calibrated

Small variations in the calibration of the equipment used could quickly add up. If the power supply frequency was not as displayed then results recorded at 1 kHz may well have been for a supply of 1.04 kHz, or 0.95 kHz, a marginal difference to a known

parameter may have increased, or decreased inductive reactance. If the inductor was measured as having inductance of 1.007 mH, but the multi-meter was not perfectly calibrated and this was actually 1.012 mH, or 0.999 mH, there could again be increased, or decreased inductive reactance. The same meter measuring resistance may have resulted in total resistance or impedance calculations differing from actual values.

If the oscilloscope calibration wasn't perfect there could be a variation in displayed values to actual values. This could be on just one waveform, or both wave forms in opposite directions.

Human Error

This is where slight variation in actual values and recorded values is almost certain. Although steps were taken to ensure the most accurate possible results when measuring the time difference between peaks it was still a manual measurement. Peak to Peak voltages were measured by the oscilloscope. To measure the time difference between peaks as accurately as possible, the waves were made as large as possible whilst fitting the two downward wave forms on the screen. Cursors were placed where the waveforms crossed the axis, to ensure measurements were at like for like points in each wave. The oscilloscope provided a measurement for the time difference between the cursors. Measurements looked accurate to the eye, but minor variations almost certainly exist here.

Component tolerances

Component tolerances will likely have a negligible effect on the results of this experiment, as values were measured rather than using stated values. This means any variation in the actual component value compared with the stated component value has been taken into account already.

Unmeasured Circuit Resistance

Like the series circuit there will be an amount of resistance within the circuit conductors. This again will be negligible, but our calculations do not account for any resistance in the conductors whatsoever.

Kuphaldt (2002) States, 'It can be said that conductors have low resistance and insulators have very high resistance'. (p.23) Although low, conductors do not have zero resistance.

Result Variations

Given the number of variables, and number of potential areas for differing values, the measured results overall are a close comparison to the expected calculated values. It is

likely the variations come from numerous small variations adding to give, with the exception of the results at 1 kHz, variations of $\pm 5\%$ from 2 kHz to 9 kHz are fairly consistent, and suggest both the calculations and practical experiment where completed correctly.

References

Bird, J. (2007) *Electrical and Electronic Principles and Technology*, 3rd Edition, Oxford, Elsevier

Ashby, D. (2012) *Electrical Engineering 101*, 3rd Edition, Oxford, Elsevier

Griffths, D. (1999) *Introduction to Electrodynamics*, 3rd Edition, New Jersey, Prentice Hall

Kuphaldt, T. R. (2002) *Lessons in electric circuits*, 5th Edition, Design Science License

Bibliography

Fitzgerald, A. E. Kingsley, C. and Umans, S. (2003) *Electric Machinery*, 6th Edition, New York, McGraw-Hill

Bird, J. (2007) *Electrical and Electronic Principles and Technology*, 3rd Edition, Oxford, Elsevier

Ashby, D. (2012) *Electrical Engineering 101*, 3rd Edition, Oxford, Elsevier

Griffths, D. (1999) *Introduction to Electrodynamics*, 3rd Edition, New Jersey, Prentice Hall

Kuphaldt, T. R. (2002) *Lessons in electric circuits*, 5th Edition, Design Science License

<https://study.com/academy/lesson/the-lorentz-force-law.html> - 10/01/19

<https://uk.farnell.com/capacitor-types-and-performance> - 15/01/19