

Assignment1

by Adrian Thomas

FILE	7406_ADRIAN_THOMAS_ASSIGNMENT1_174471_820904220.DOCX (1.4M)		
TIME SUBMITTED	14-MAR-2019 01:52PM (UTC+0000)	WORD COUNT	1820
SUBMISSION ID	102341471	CHARACTER COUNT	13013



Electical Machines

M6X00373 Steve Mosey UWTSD

Adrian Thomas 1708738

Contents

1 Abstract	2
2 Introduction	3
2.1 DC motors: -	3
2.2 Magnetism	5
2.3 Magnetism & Motor's	7
2.4 Specific problem.....	8
2.5 FEM	8
3 Method	9
4 Results	11
4.1 Total flux	11
4.2 Flux leakage.....	12
4.3 Flux cutting rotor coil vs angle	13
The values can then be put into a graph to provide estimates of the flux	13
5 Discussion.....	14
6 Conclusion	15

1 Abstract

The following report is designed too look at magnetic flux being used, created and leaked in a DC motor circuit using FMEE 4.2 simulation software. The aim is to establish flux leakage, an estimate of the total flux being created in the stator circuit & an estimate of the flux cutting the rotor coil as a function of coil angle. In order to complete this a given design is created in the software which then shows the lines of magnetic flux being generated in the circuit, from this measurement can be taken at given points to establish values for the above areas in question.



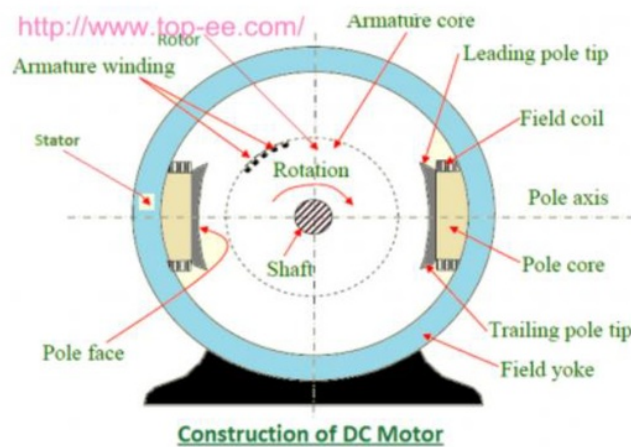
2 Introduction

2.1 DC motors: -

In the basic sense a motor is a machine that takes electrical energy and converts this into mechanical energy. The direction of force is given by Fleming's Left hand rule. To achieve this the motor uses the basic principle of magnetism, by placing a current carrying conductor within a magnetic field it experiences a mechanical force.

3

The construction of a DC motor can be seen below



<https://www.top-ee.com/construction-of-dc-motor>

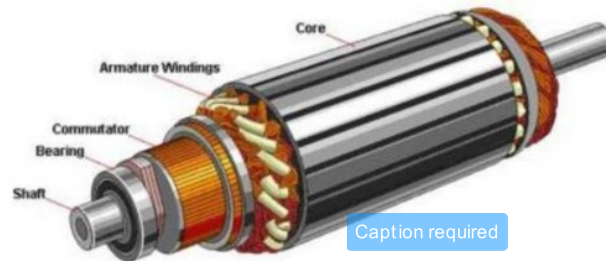
Within the make up of the motor we have the stationary part "Stator" and rotational part "Rotor"

The stator houses the field windings and also the supply, the job of the field windings is to become electro magnetics and provide the flux required for the machine to operate. The field windings are made up of copper coils which are wound over slots in the pole shoes, when current is applied the adjacent poles have the opposite polarity. However in very small motor a permeant magnetic may be used.

Attached to the stator within the yoke are the poles, these comprise of the pole core and pole shoe. The pole core is made up of thin lamination of steel or iron, it is constructed this way to reduce power losses from Eddy currents. The pole shoe is designed to spread flux that is produced over the air gap between the stator and rotor to reduce reluctance losses.

(<https://www.top-ee.com/>, 2019)

<http://www.top-ee.com/>



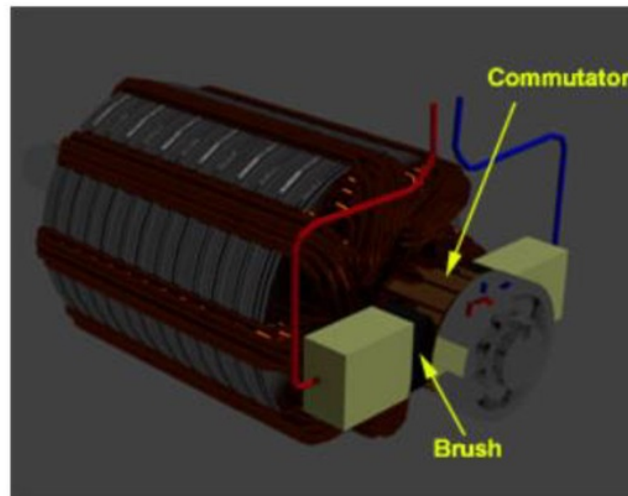
<https://www.top-ee.com/construction-of-dc-motor/>

The rotor consists of a laminated low-hysteresis silicon steel core with slots in which house the copper coils of the armature windings. There are two main ways of constructing these windings

- 1) LAP winding – in this case the number of parallel paths between conductors and poles is equal
- 2) Wave winding – in this case the number of parallel paths is always equal to 2 irrespective of the number of poles

The rotor assembly also houses the commutator which is made up of thin segments of copper insulated from each other by mica. The role of the commutator is to transmit the supply to the armature windings. This transfer is done via carbon brushes.

(<https://www.electrical4u.com/construction-of-dc-motor-yoke-poles-armature-field-winding-commutator-brushes-of-dc-motor/>, 2019)



<https://www.electrical4u.com/construction-of-dc-motor/>

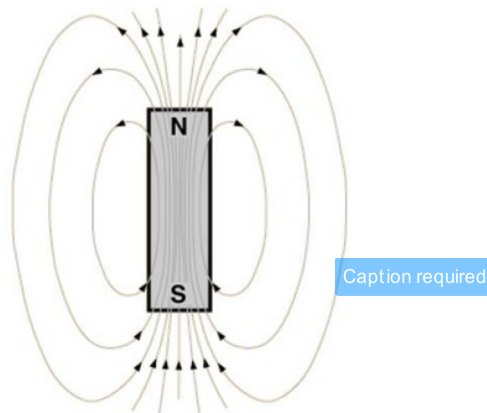
2.2 Magnetism

A magnet is simply an object or material that produces a magnetic field, these can be both permanent or electromagnets. Magnets have the following properties

- the north pole of the magnet points to the geomagnetic north pole (a south magnetic pole) located in Canada above the Arctic Circle.
- north poles repel north poles
- south poles repel south poles
- north poles attract south poles
- south poles attract north poles
- the force of attraction or repulsion varies inversely with the distance squared
- the strength of a magnet varies at different locations on the magnet
- magnets are strongest at their poles
- magnets strongly attract steel, iron, nickel, cobalt, gadolinium
- magnets slightly attract liquid oxygen and other materials
- magnets slightly repel water, carbon and boron

4

<https://www.universetoday.com/82049/how-1>



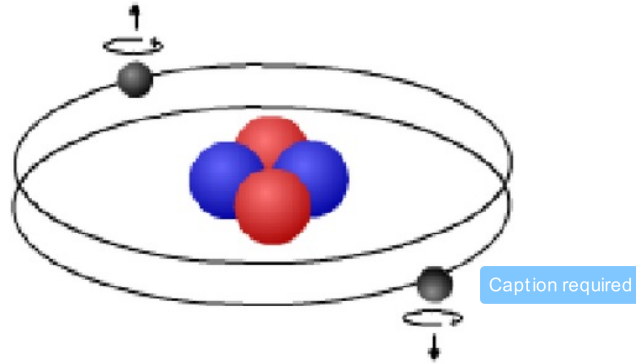
Caption required

5

<https://moodle.uwtsd.ac.uk/pluginfile.php> 1

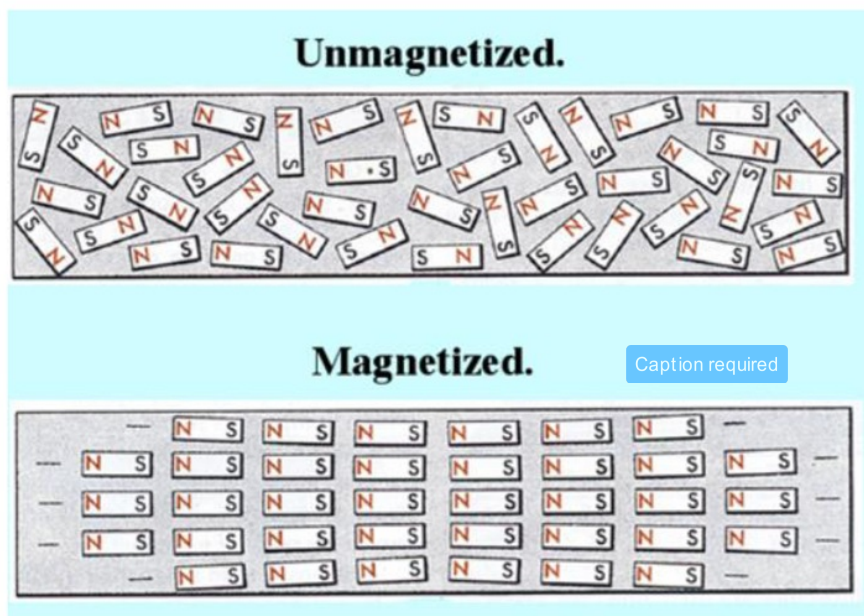
A magnet works by electron flow, when current is passed through a wire a magnetic field is created around it therefore when electrons flow a magnetic field is created. While lots of materials produce a magnetic field ferromagnetic materials are the only ones considered truly magnetic as these are the only ones attracted to a magnetic strongly, all other substances respond weakly to a magnetic field. Ferromagnets tend to have electrons orbiting them and thus create their own magnetic field.

6



<https://moodle.uwtsd.ac.uk/pluginfile.php/2>

Groups of these atoms tend to orientate themselves in a common direction this is known as a magnetic domain, with each domain having its own north and south poles. When a material has domains which are pointing in random direction the magnetic fields of the domain cancel out and thus the material is not magnetic.



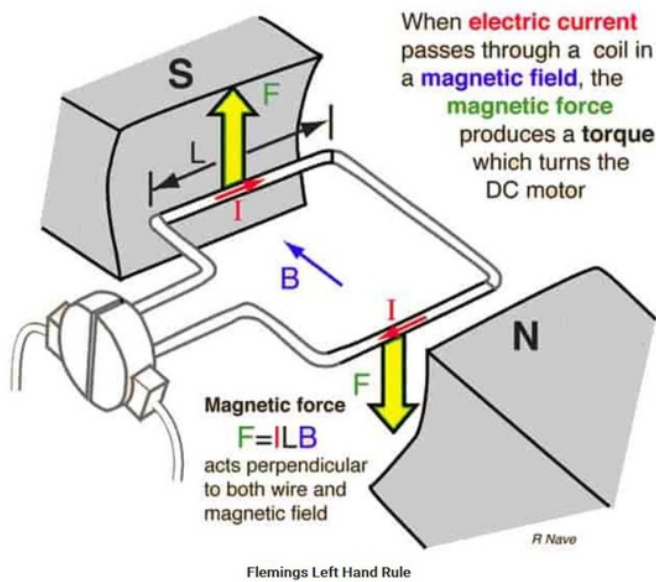
<http://boomeria.org/physicslectures/seco/1>

When a current is passed through this same material the domains begin to align and create a magnetic field, the higher the current the more domains align until saturation point is reached.

(Coffey, 2019)

2.3 Magnetism & Motor's

The stator is a magnet all be it permanent or electro, the armature is in simple terms a coil of which when current flow via the commutator creates its own magnetic field, the commutator is split into sections so when power is applied there will be opposite polarity, this ensures that electricity will always flow away on the left side and flow towards on the right side and hence the coil will keep rotating. The more sections or loops in the commutator the smoother the rotational motion



<https://studyelectrical.com/2014/12/work 1>

As can be seen in the depiction above when a current is applied to the armature is generates a magnetic field, this field interacts with the field generated by the stator and hence gives rotation and torque. When the armature is rotating it cuts through the magnetic flux lines, according to Faraday's law of electromagnetic induction and EMF is induced in the armature windings, the direction of this is such that it opposes the armature current, the magnitude of this is directly proportional to the motor speed. When load is low speed will increase and hence back emf will also increase, due to the increased emf armature current will reduce, as torque is proportional to armature current this will also decrease until it become stable for the load

(Daware, 2019)

2.4 Specific problem

The specific problem is to analyse a dc motor stator circuit more specifically how much total magnetic flux is being created in the stator, how much flux is being leaked and finally an estimate of how much flux is cutting the rotor coil as a function of the coil angle. These point can then be used to help understand how the magnetic circuit and the flux interact

To complete this task FEM software will be used specifically FEMM (Finite Element Method Magnetics) 4.2 software

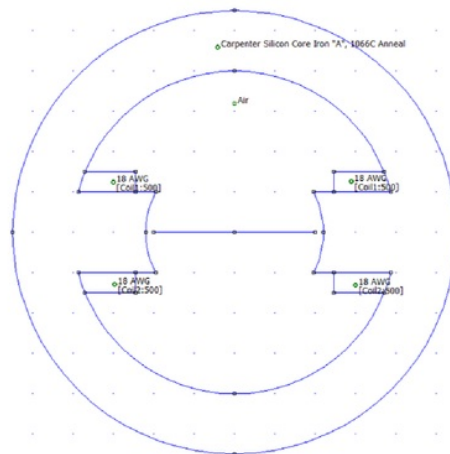
2.5 FEM

This is a numerical method used for solving problems of engineering & maths physics, these problems require the solution to boundary value problems for partial differential equations. The finite element of the problem then results in a system of algebraic equations. It then subdivides a large system into a smaller system with the smaller parts being the finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem.

(Unknown, 2019)

3 Method

Using the FEMM 4.2 software a model was created with the following dimensions



The Stator Dimensions and Parameters are as follows:

NB: When adding labels ensure that a mesh size of 1 is used.

Depth of Circuit: 100mm

Outside Stator Diameter: 110mm

Inside Stator Diameter: 80mm

Pole Face Radius: 22mm

Pole Widths: 20mm

Field Generating Coil Vertical Coordinates: ± 15 mm

Field Generating Coil Horizontal Internal Coordinates: ± 24.5 mm

Rotor Coil Width: 40mm

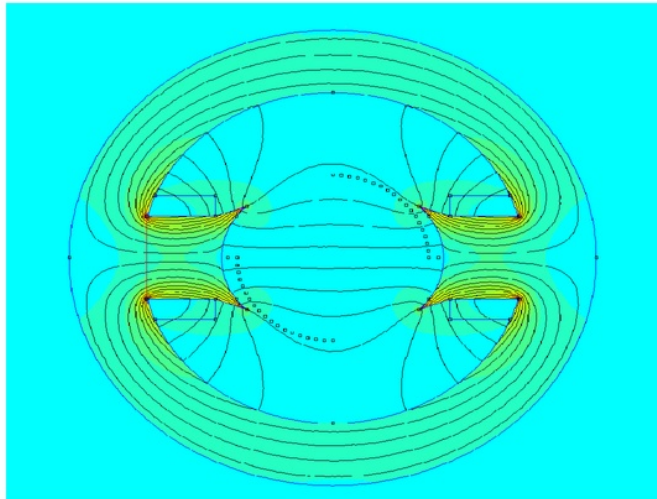
Field Generating Coil Current: ± 1 A (indicates in and out of page)

Field Generating Coils Number of Turns: 500

11

Once the model was complete a mesh was then drawn which draws a triangular mesh of the problem, the mesh spacing can be altered to suit the problem however a small number of nodes generated will result in an inaccurate model with too many nodes resulting in a excessive simulation time. Next the model was analysed by “turning the Crank” in the software and viewing results with Glasses symbol

(Meeker, 2019)

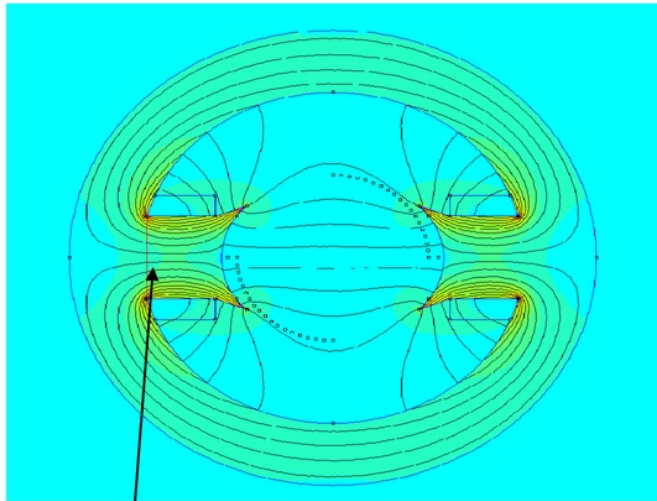


This allows the lines of magnetic flux generated by the circuit to be viewed, points are then placed around the rotor diameter to allow points to measure values from, the following can be calculated

- 1- Total magnetic flux in the stator
- 2- Flux leakage
- 3- Flux cutting the rotor as a function of angle

4 Results

4.1 Total flux



By inserting a line across the pole body the total flux can be calculated via the software, in the case of the this problem the total flux produced was

6.48E-05 Weber's  12

4.2 Flux leakage

The flux leakage is calculated by $\frac{\text{Total flux} - \text{Useful flux}}{\text{Total Flux}}$

Flux leakage is defined as the flux that does not follow the intended path of the magnetic circuit

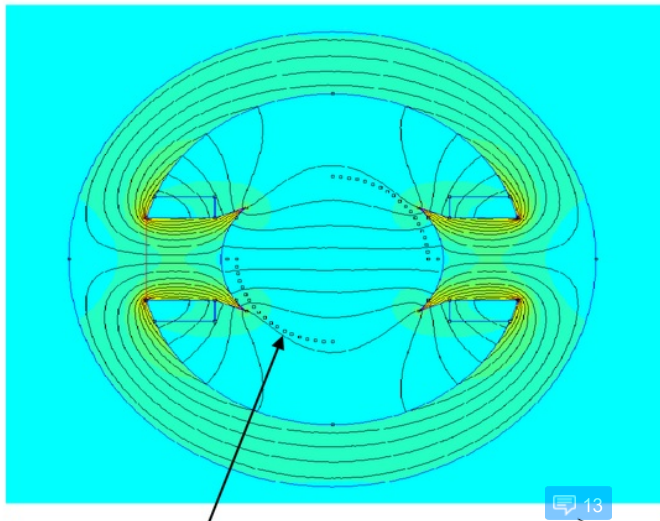
Useful flux is defined as flux which passes through the air gap and is utilised in the magnetic circuit

Fringing can be seen on the above simulation model this is where the flux lines bulge out around the rotor, because of this air gap the effective air gap area increases and the flux density of the air gap decreases

(Unknown, <https://circuitglobe.com/what-is-leakage-flux-and-fringing.html>, 2019)

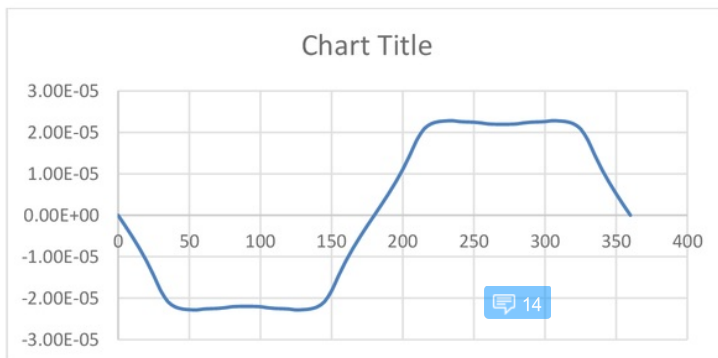
Useful Flux	2.28E-05	Webers	
Total Flux	6.48E-05	Webers	
Flux Used	3.52E-01	or	35.20%
Flux leakage	64.80%		

4.3 Flux cutting rotor coil vs angle



In order to calculate the above measurement, points were put around the rotor diameter top form 90 degree, a line was then inserted between two points i.e. from $10^\circ +$ to $10^\circ -$. These values can then be made replicated to form the other half of the waveform and give 180° sample and finally make the values opposite polarity to give the further 180° .

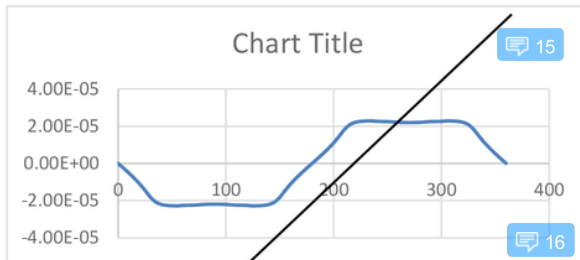
The values can then be put into a graph to provide estimates of the flux



Angle	X	Y	Phi (Wb)
0	20.00	0.00	3.16E-09
5	19.92	1.74	-2.56E-06
10	19.70	3.47	-5.19E-06
15	19.32	5.18	-8.00E-06
20	18.79	6.84	-1.11E-05
25	18.13	8.45	-1.45E-05
30	17.32	10.00	-1.82E-05
35	16.38	11.47	-2.08E-05
40	15.32	12.86	-2.21E-05
45	14.14	14.14	-2.26E-05
50	12.86	15.32	-2.28E-05
55	11.47	16.38	-2.28E-05
60	10.00	17.32	-2.26E-05
65	8.45	18.13	-2.25E-05
70	6.84	18.79	-2.25E-05
75	5.18	19.32	-2.23E-05
80	3.47	19.70	-2.21E-05
85	1.74	19.92	-2.20E-05
90	0.00	20.00	-2.20E-05

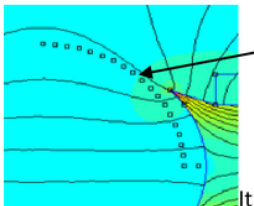
5 Discussion

From the results seen above it can be seen that maximum flux levels are achieved around 54°



The maximum level is achieved here since

this is where the rotor is most effected by the lines of flux



It can be seen on this segment of the simulation, 54 °is where our points are closest to the lines of flux. This is also supported by our table above where max flux occurs approx. 50 & 55° sample points.

It can also be noted how much flux is leaked, in this case 64.80%

6 Conclusion

From this assignment and simulation, a greater understanding of how the armature and field winding magnetic fields interact was achieved. It was also seen how much flux is useful and therefore how much was actually leaked and not used as intended.

Greater appreciations of how a DC motor is constructed and how the various components interact within it to create mechanical force.

The author has also got a much clearer grasp on how magnets are created, their different types and how they are used in interactions.

References

Coffey, J. (2019, 03 09). Retrieved from <https://www.universetoday.com/https://www.universetoday.com/82049/how-do-magnets-work/>

Daware, K. (2019, 03 09). Retrieved from <https://www.electricaleasy.com/https://www.electricaleasy.com/2014/01/basic-working-of-dc-motor.html>

<https://www.top-ee.com/>. (2019, 03). Retrieved from <https://www.top-ee.com/https://www.top-ee.com/construction-of-dc-motor/>

Meeker, D. (2019, 03). Retrieved from <https://edoc.site/https://edoc.site/femm-42-magnetostatic-tutorial-pdf-free.html>

<https://www.electrical4u.com/construction-of-dc-motor-yoke-poles-armature-field-winding-commutator-brushes-of-dc-motor/>. (2019, 03 08). Retrieved from <https://www.electrical4u.com/construction-of-dc-motor-yoke-poles-armature-field-winding-commutator-brushes-of-dc-motor/https://www.electrical4u.com/construction-of-dc-motor-yoke-poles-armature-field-winding-commutator-brushes-of-dc-motor/>

Unknown. (2019, 03). Retrieved from https://en.wikipedia.org/https://en.wikipedia.org/wiki/Finite_element_method

Unknown. (2019, 03). Retrieved from <https://circuitglobe.com/what-is-leakage-flux-and-fringing.htmlhttps://circuitglobe.com/what-is-leakage-flux-and-fringing.html>

Assignment1

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

67/100

PAGE 1

PAGE 2

PAGE 3



Comment 1

You should not use abbreviations or contractions in formal academic writing. You should have used the word "and" instead of &



Comment 2

Your abstract is good and reads well, but you should include a statement of your results.

PAGE 4



Comment 3

Missing full stop

PAGE 5



Caption required

Caption?

PAGE 6



Comment 4

This should have been paraphrased and inserted as text - not as an image.



Caption required

Caption?



Comment 5

An electromagnet works by...



Comment 6

Not sure this is true.

PAGE 7

QM

Caption required

Caption?

QM

Caption required

Caption?



Comment 7

When the material is placed in a magnetic field the domains begin to align. The stronger the magnetic field the more domains align until all the domains are aligned and saturation is reached.

Magnetic saturation has nothing to do with passing current through something, unless that something is a coil of wire around a ferromagnetic former.

PAGE 8



Comment 8

it



Comment 9

Your references should be using the IEEE standard which the school requests you use, not Harvard.



Comment 10

A very detailed introduction covering the basics of magnetism and motors.

PAGE 9

PAGE 10



Comment 11

Should have been inserted as text not as an image.



Comment 12

Webbers



Comment 13

were



Comment 14

Chart title?

Axis Labels?

Scale Units?



Comment 15

What is this arrow for?



Comment 16

See comments on previous graph



Comment 17

Your referencing should be done using the IEEE standard. More information can be found on the university library web page. <https://www.uwtsd.ac.uk/media/uwtsd-website/content-assets/documents/library-and-learning-resources/IEEE-eng.PDF>



Comment 18

GRADING FORM: SMU GENERIC_SMOSEY

ADRIAN THOMAS

66.51

ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



Although you have cited a range of sources, they have been mostly from websites. You should look to cite more material from more reputable sources such as academic peer reviewed journals, text books, published research etc. You should also use the school referencing style, IEEE, more information on this can be found on the university library website.

<https://www.uwtsd.ac.uk/media/uwtsd-website/content-assets/documents/library-and-learning-resources/IEEE-eng.PDF>

4.5

KNOWLEDGE & UNDERSTANDING

Knowledge of the basic underlying concepts and principles of a subject.



Excellent knowledge and understanding of the main concepts and key theories.

22.2

COGNITIVE & INTELLECTUAL

Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.



Thoroughly logical work, supported by evaluated evidence. High quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Good conclusions

21.9

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



A very good application of a range of methods, tools and techniques. Very good consideration of the context of the application. Evidence of some innovation and creativity.

12.8

TRANSFERABLE SKILLS

Communicate the results of their study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.



Can communicate effectively in a suitable format, but may have minor errors. Mostly coherent work and is in a suitable structure.

5.11