

Military Technological College		Coursework		
		Coursework Portfolio		
Department: Aeronautical, Marine, Systems				
MTCM 3011		Date Set: Click here to enter a date.	Lecturer:	Dr Muhammad Raisuddin Ahmed
Artefact: 1 of 2	Contribution: 30%	Date Due: Click here to enter a date.	Student number:	

Hand in:

Submit your report via the Turnitin link on Moodle before TBA

Objectives:

In this artefact, students will do a technical assignment covering learning outcome 1, 2 , 6 , and 7 as a task 1 and task 2 will carry out a series of laboratory experiments to cover Learning outcome 7.

Task:

Task 1: Technical Assignment

Task 2: Laboratory Experiments

Background:

The students have developed basic understanding of Electrical Engineering Principles for DC circuits and calculations. Students have carried out various laboratory tasks on FESTO Equipment. This Laboratory report is required to be comprehensively comprised of all laboratory tasks coupled with theoretical knowledge covered throughout the course of studies.

Equipment:

FESTO Motor and Generator manual

Procedure:

In the FESTO Laboratory manual

Learning outcomes:

Learning Outcomes (1, 2, 6 & 7)

- 1 Describe the basic structure of the atom and explain the significance of the nucleus, protons, neutrons and electrons in the context of electricity and the movement of electrical charges within

conductor and insulator materials and explain how electrical energy is generated by light, heat, friction, pressure and movement.

- 2 Describe the construction and provide simple explanations of the chemical reaction of various primary and secondary cells and batteries in general use and conduct associated measurements and calculations.
- 6 Explain the characteristics of natural magnets, magnetic and non-magnetic materials and magnetic fields, the phenomenon of electromagnetism, and factors determining electric field strength and direction.

7 Sketch the construction and explain its theory of operation of DC generators and motors.

Reading / References:

The Module teaching notes issued to students by the course team at the start of the Module.

Instructions:

- 1 *Submit your report via the Turnitin link on Moodle before the due date mentioned above.
- 2 **The date you upload to Moodle is considered as the 'Date of Submission' when calculating the late submission.
- 3 Any late submission will result in late submission cap being applied.
- 4 For further information, related to MTC assessments and examinations, please refer to the regulations sections in MTC examinations website.
- 5 This is an individual report and should not exceed 2000 words

Method of feedback to the students

Feedback will be provided to the student through Turnitin only.

Deferred First attempt and second attempt

Deferred First Attempt that requires coursework; students will be allowed an extended submission period, as described in the Examination and Assessment Regulations.

Second Attempt Assessment will be by a 2 hour examination to cover all learning outcomes.

PLAGIARISM

Work in this assignment is covered by the plagiarism regulations of MTC where any work submitted for assessment, should be the product of the individual student effort ONLY and not the work of others - e.g. other students, or external sources such as the internet. Please be aware that any form of plagiarism will be dealt with appropriately according to:

https://moodle.mtc.edu.om/pluginfile.php/40026/mod_resource/content/1/Academic%20Integrity%20and%20Misconduct%20Policy%20-%202007%20Nov%202017.pdf

The Military Technological College regulations require students to keep electronic copies of all assignments, and submit these at any time upon request.

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Task 1: Technical assignment

Students are required to answer the following questions in their own words based on their understanding from the lectures and readings:

1. Explain by means of energy level, why we cannot use Copper, Silicon and Germanium as Insulator?

[6 Marks]

Energy Levels and their effects on insulation and conduction

Different elements exhibit different characteristics when it comes to conduction and insulation of electricity. The energy level of an atom refers to the quantized and discrete energy amounts or values that can be contained within of the specific confines which electrons can occupy in an atom (Haynes, 2014). The energy level can also be defined as the distance that exists between the nucleus and electrons within an atom.

Why Copper Cannot Be Used As an Insulator

Copper (CU) possesses an atomic number of 29. This means that the element copper possesses 29 electrons. Copper possess high conduction properties (Haynes, 2014). This means that the element conducts heat and electricity very well. Therefore, the insulation properties of copper are very poor and the element cannot be used as an insulator.

Additionally, copper has four energy levels and this translates to a weak force of attraction between the electrons in the outer most level and the nucleus. Therefore the electrons in the outer most level can move freely and thus high conduction and poor insulation properties.

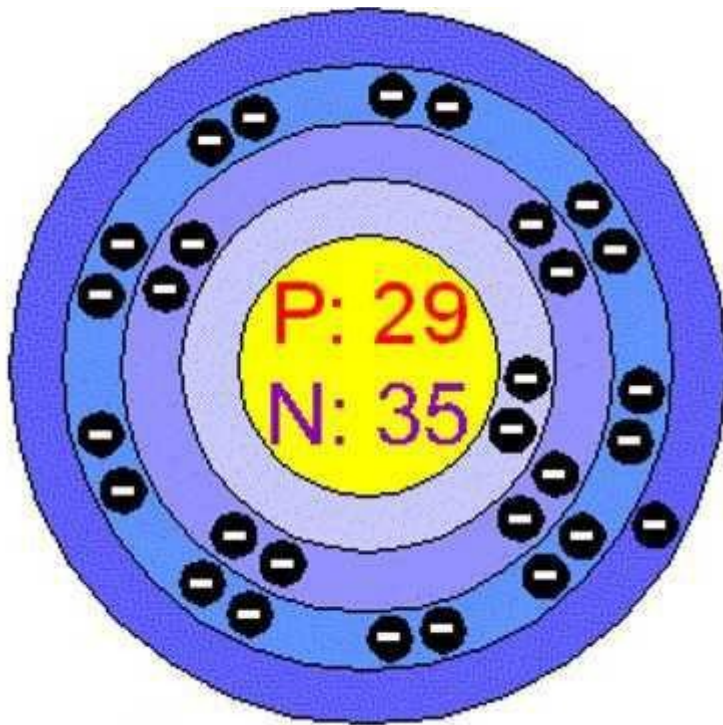


Figure 1: Copper's Structure

Silicon and Insulation:

Silicon has an atomic number 14. According to Shklovskii and Efros (2013), this means that it has three energy levels and the outer most energy level possess 4 electrons. Therefore, it falls between conductors and insulators and thus known as a semiconductor. The insulation properties result from its valence electrons joining together to form a lattice structure that hinders the transfer of heat and electric currents at room temperature.

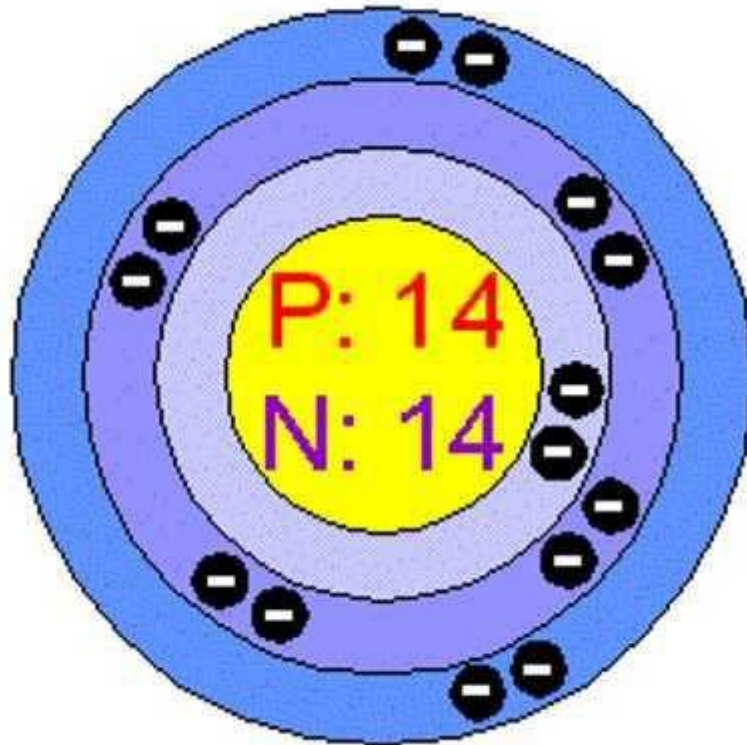




Figure 2: Silicon's Structure

Germanium:

Germanium (Ge) has an atomic number of 32. The elements atoms have four energy levels and its outer most energy level contains 4 valence electrons. Therefore, like silicon, germanium is a semi-conductors (Shklovskii and Efros, 2013). This means that the element can be made into a semiconductor. Germanium has its electronic configuration in the form $3d^{10} 4s^2$

$4p^2$. Therefore, the element cannot solely be used as an insulator solely (Haynes, 2014).

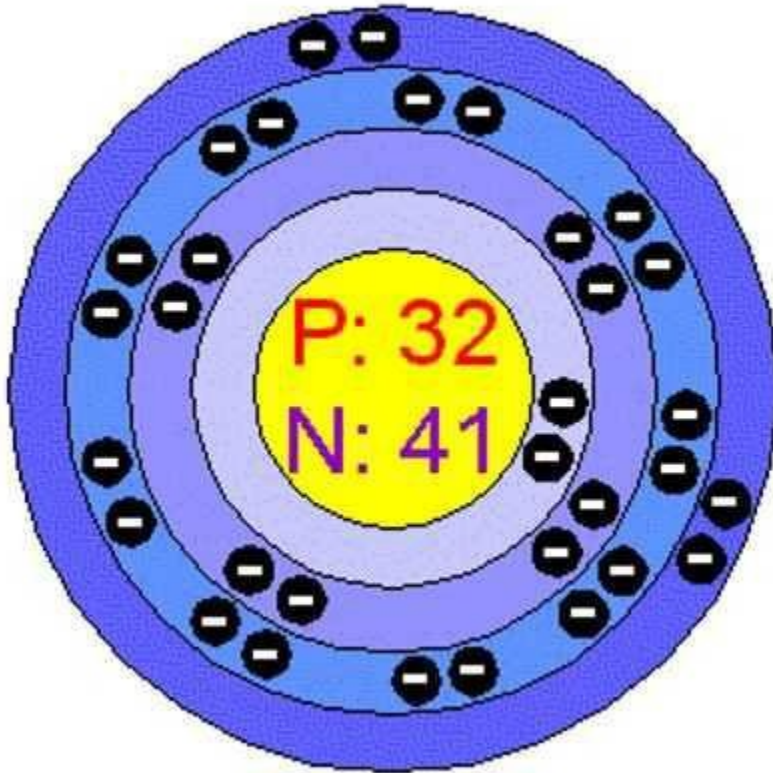


Figure 3: Germanium's Structure

2. Compare at least 6 characteristics for Lead Acid and Nickel Cadmium batteries in terms of advantage for one and disadvantage for the other and vice versa.

[3 Marks]

Advantages of nickel-cadmium batteries over lead acid batteries



Nickel-cadmium battery charges relatively faster when compared to the lead acid battery on average a nickel-cadmium battery charges and discharges in less than 6 hours compared to a similar sized lead-acid battery which can take up to 10 hours to charge (ultimate service associates, 2018). The second advantage is that its cell voltage remains constant event after discharge unlike lead acid batteries which lose cell voltage with discharge. Nickel cadmium offers lower maintenance cost. According to Poullikkas (2103), unlike the lead-acid battery, the nickel-cadmium battery does not require frequent electrolyte change and maintenance.

Advantages lead-acid batteries of over nickel cadmium batteries

Self-discharge rates of lead-acid battery are the lower compared to the nickel-cadmium battery. On average the lead-acid self-discharges by only 3-4% per month (Poullikkas 2013). This is very low compared to the nickel-cadmium battery whose self-discharge rate stands at 20 % per month. Lead-acid batteries initial costs are lower compared to that of nickel-cadmium batteries. Also, the lead-acid batteries are less hazardous than nickel-cadmium batteries whose composition is highly toxic. Lead-acid batteries come in the form of the weight and compatibility of the battery for small and domestic purpose compared to nickel-cadmium. The lead acid batteries are relatively small and portable thus can be used in a wide range of areas.



In-Module Coursework Portfolio

Electrical Engineering Principles – MTC Engineering Departments Military Technological College

3. Considering the advantages and disadvantages of each battery, please, discuss which type of battery will be preferred in following application. Your answer should include a justification of your choices:

a. Engine starting

Lead-acid batteries are ideal in starting engines since they can be left on a float charge for long periods with low initial costs compared to nickel-cadmium which cannot withstand long trickle periods. It means that floats that require long replacements can be made possible while using lead-acid batteries. Also, the battery is relatively light and portable and thus very compatible with mobile engines such as those of automotive.

b. For floats, which require long periods before, the battery is replaced.

Lead-acid batteries are ideal in starting engines since they can be left on a float charge for long periods with low initial costs compared to nickel-cadmium which cannot withstand long trickle periods. It means that floats that require long replacements can be made possible while using lead-acid batteries. Also, the battery is relatively light and portable and thus very compatible with mobile engines such as those of automotive.

c. Low temperature application

According to Daniel and Bensenhard (2012), its optimal temperature range stands between -40 to 60 degrees Celsius thus nickel-cadmium battery can operate in temperatures as low as - 40 degrees Celsius.

d. High temperature applications

Basically, nickel-cadmium can withstand extreme temperatures compared to lead-acid batteries (Poullikkas, 2013).

e. Telephone systems

Telephone systems require batteries that can withstand relatively high temperature. Therefore, the most appropriate battery to use is the nickel-cadmium battery. Most telephone systems operate can heat up reaching temperatures above 45 degrees Celsius. This would lead to a malfunction of lead-acid batteries and thus reduce efficiency. Therefore, nickel cadmium batteries are more efficient than lead-acid batteries when it comes to application in telephone systems (Poullikkas, 2013).

Low maintenance requirement For low maintenance situations and applications, the nickel-cadmium battery is the most appropriate battery to use. According to Poullikkas (2013), although their initial cost of acquisition is high, nickel cadmium batteries require less frequent maintenance costs as compared to the lead acid batteries. The low maintenance costs can be attributed to the fact that nickel-cadmium batteries do not require frequent topping up as compared to lead-acid batteries which need electrolyte topping off every few months.

4. Magnetism plays a very important part in the world of Electrical engineering. Given the following materials below:

- a. Alnico
- b. Supermalloy
- c. Gold

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Discuss showing evidence which of these materials are best used as magnets and which are not. You are also required to discuss how magnetism can be created artificially and the means to control field strength and field direction.

[4 Marks]

Alnico and SuperMalloy

Alnico and super Malloy belong to the class of alloy magnets (Heck, 2013). Alnico derives their name from the chemical symbols of their constituent elements which include aluminum, nickel and cobalt while Super Malloy is a magnetic substance made up of molybdenum, iron and nickel as alloys in proportions of 5, 20 and 75 percent respectively. These kinds of magnets are permanent magnets and possess extremely high coercivity and thus known as ferromagnetic.

According to Heck (2013), alloy magnets are manufactured through the sintering or through the use of the casting process. This means the elements are powdered and heated in vacuum their melting point. The alloy undergoes crushing and milling into a fine powder on cooling. The powder is then subjected to a strong magnetic and hydraulic pressuring in order to



align the particles by isostatic compaction. The intensity of the exposure determines the strength of the magnet. Also, magnetic orientation occurs in this stage. For the process of magnetization and magnetic orientation to be effective, temperatures between 900 and 800 degrees Celsius must be observed.

Alnico and supermalloy magnets are very strong offering magnetism up to 300 times the earth's natural magnetic force at the poles. Therefore, considering the aforementioned properties, alnico and supermalloy are a very good option to be used as magnets (Heck, 2013).

Gold:

Gold is only slightly magnetic. The only way gold can be converted into a magnet is through exposure to a strong magnet or through electromagnetism. The manufacture, though not logical due to the cost of gold, can be done by making a coil of insulated conductive wire on a rod of gold and connecting it to a power source. The degree of magnetic strength can be altered by changing the voltage or amount of electric current passing through the insulated conductor (Heck, 2013). Due to its cost, and lack of ferromagnetic properties gold cannot be considered as a good option for making magnets.

5. A DC series motor can be driven by either DC or a rectified AC. Therefore its speed is not dependent on the supply frequency. There will be a requirement to control the rotational speed of the motor. This can be controlled by either Armature control or Field control. Using a diagram or diagrams, where required, discuss the differences between the two methods explaining how each method will control the rotational speed of a motor. No reference to power losses required.

6. Regulation of the speed of a DC series motor can occur using different ways. This methods of speed regulation fall with two broad categories which are armature control and field control as illustrated below;

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8. Armature control

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11. This type of control involves changing the voltage in different positions of the DC motor's armature. The speed of rotation of a DC motor shows direct proportionality to the back-

12. electromotive force (E_b). Also, (E_b) equals the voltage (V) supplied, minus the armature current

$$E = V$$

$$I_a$$

- 13.
14. (Ia) multiplied by the resistance of armature (Ra) Therefore, if the resistance of the armature is decreased, the voltage supplied to the armature increases and thus the speed of rotation increases (Gupta and Padhee, 2012).
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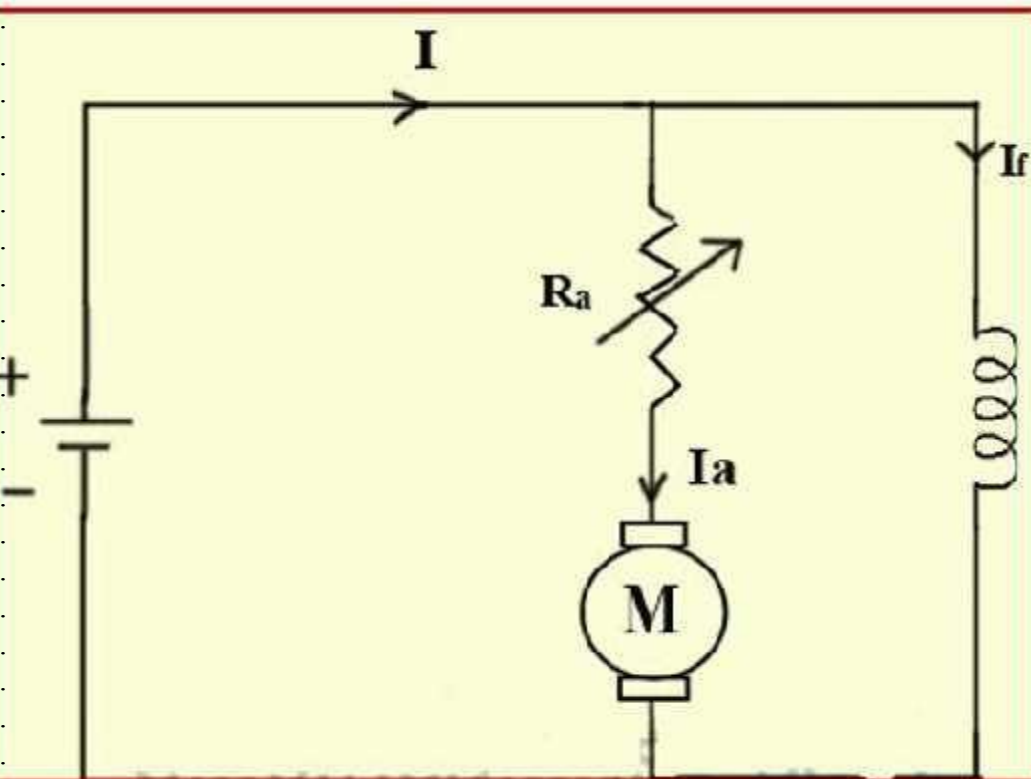
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63. Figure 4: Armature Manipulation

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65. Field control

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68. By passing power/voltage through the diverter, the amount of current passing through series reduces and consequently reducing the flux thus increasing the motor rotation speed (Gupta and Padhee 2012).



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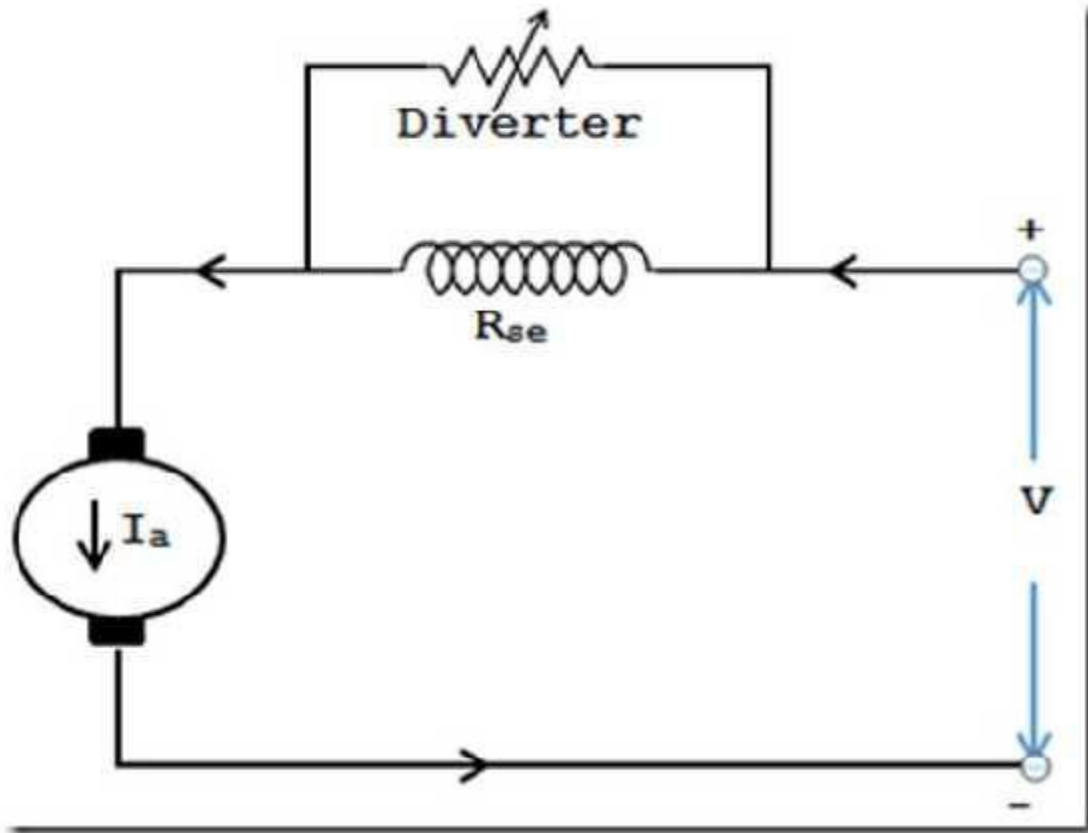


Figure 5: Field Control Flow v = voltage I_a = armature current

116. Rse= armature resistance

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118. Task 2: Laboratory Experiments

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120. Based on the experiments had carried out, students are required to write a separate report on the following Experiments:

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123. Experiment 1: The Direct Current Motor

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126. Introduction

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129. There are two classifications of motors, they are either DC or AC in regards to the type of power used. DC motors are important in the engineering field as they speed-control capabilities unlike AC motors. Speed, rotation direction and torque can be manipulated to help meet specific applications.

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131. Requirements for the experiment:

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135. Material	136. Quantity
137.	138.
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140. DC power Supply	151. 1
141.	152.
142.	153.
143. Wooden Base	154. 1
144.	155.
145.	156.
146. Magnets	157. 2
147.	158.
148.	159.
149. Insulated Copper Wire	160. 1 (0.5m)
150.	161.



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168. Sandpaper 171.	169. 170. 172.173.
174. 300g Mass 177.	175. 176. 178.179.
180. Wires and Connectors 183.	181. 182. (1m) 184.185.
186. Wire Stands 189.	187. 188. 190.191.
192. Wooden stick 195.	193. 194. 196.197.
198. Brushes 201.	199. 200. (Halfs) 202.203.

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208. The mass will be used to make round turns for the coil which should not be less than ten to help obtain a good magnetic vector. The stick will be used to hold onto the already made coil which should be symmetric. The sandpaper will be used in removing the enamel insulation on the copper wire only on the parts making contact with the wire stands. Place the magnets onto the wooden block and connect to the DC power supply. Make sure that the voltage applied is about 12V but can be adjusted later. The connector will be used to link the power source to the

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210. Experiment Results

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213. When current flows through the commutator, the armature rotates in a clockwise manner. When the armature has made a 90 degrees turn, the current would have reversed its direction since the commutator will be contacting the opposite brush.



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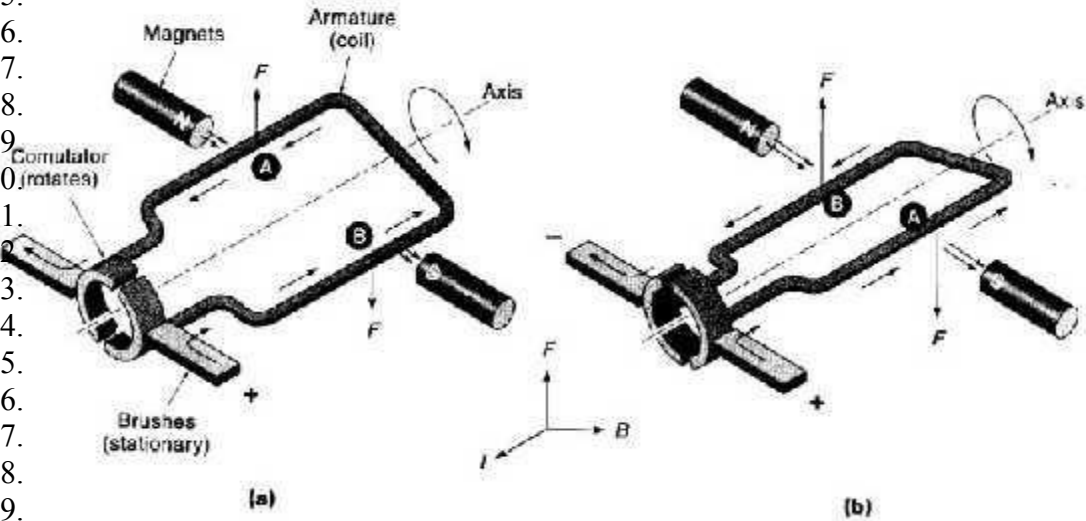
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264. *Figure 8: DC Motor in Action*

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267. The commutators will help in maintaining the direction of rotation of the armature by changing the current flow on contacting the opposite sides of the brushes. To reverse the armature direction, the polarity of voltage received in the commutator will have to be changed (Obaidullah, Raza and Hammoud, 2013). This will be possible due to the fact that the force in the coil will have been reversed. Having the magnets as close as possible to the armature meant that rotations ran longer.

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269. **Discussion**



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275. Any metal can be used as the conductor in the coil such as aluminum or iron. The more loops the on the armature created a stronger magnetic field and rotation counts increased while maintaining a constant flow of current in the coil. To have improvements on this simple DC motor, creating stability would be recommended by nailing the wire carrying current from the battery to the brushes onto a wooden block.

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277. **Conclusion**

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280. The experience was refreshing in having to practically see how motors react to current and magnets. All that was taught and read in books was proven and indeed thrilling to see function as expected. Such a small experiment of DC motors can be used as a model for the creation of large scale and commercial with only a few improvements.

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282. Experiment 2: The DC Separately Excited Shunt Generator

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284. **Introduction**

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287. A DC shunt generator is one that has its field winding connected in a parallel manner with an external circuit. We shall examine how DC shunt generators respond to voltage and current when in a serial circuit. The main goal is to find out whether these generators are able to produce voltage that can be used in other applications.



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293. Experiment Results

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297. Material 299.	298. Quantity 300.
301. Tachometer 303.	302. 1 304.
305. Connecting wires 307.	306. 2 308.
309. DC generator 311.	310. 1 312.
313. Load Resistance 315.	314. 1 316.
317. DMM 319.	318. 1 320.

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325. Connect all materials as shown in the diagram below:



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367. Figure 9: Circuit diagram for DC Shunt Generator

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369. The current (I_f) is additional which comes about due to the resistance of the generator (R_f). When R_f is replaced by the field resistance which is in series (R_s) which is parallel to both the load and source then we are going to have different currents being generated, (I_a , I_f and I_L). When load resistance was added on the shunt generator, there was a decrease in both current and full load voltage. However, there was an increase in the power generated by the circuit meaning that it can be harnessed for other purposes. All current from the external circuit will flow through the armature winding because it is connected in a serial manner with the load (Saini et al., 2014).

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371. A decrease in field strength will be a result of the reduction in the amount current flowing through the coil.

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373. A rheostat can be used in controlling output voltage by being introduced in a serial arrangement with the field winding. The load on the circuit can be reduced to a point

where the voltage output reaches a point in which there can be no more increase. Current flow in the winding will also increase but there would be no change in the terminal output (George et al., 2017). This limit is called field saturation. A rheostat will control field saturation by regulating the amount of load required to reach just the maximum possible voltage output. The rheostat ensures that as the resistance increases the amount of current flow in the circuit is reduced as well as the voltage generated. As the load is increased the output voltage reduces and vice versa.

374.

375. When using DC shunt generator magnetic the strength is attained from the numerous turns of small wires in the field coils. Basically, magnetic strength in this generator comes mostly from the huge number of turns in the coils and not necessarily dependent on the current strength through the circuit. The amount of output voltage was higher than the initial input voltage meaning that there was efficiency in conversion by the generator.

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377. Discussion

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380. There are four resistances that make DC shunt generators complete, without them then we wouldn't have the existence of these generators. They include: armature (R_a), Load (R_L), shunt-

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382. field (R_f) and series field resistances (R_s). Both R_L and R_s are connected in parallel while the R_a is in series. Any increase in load while using shunt generators will lead to a decrease in the output voltage (Saini et al., 2014). These kind of generators can produce fluctuating output voltage if the load in the current is altered therefore making it not ideal for applications that desire a constant output of voltage.

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384. Conclusion

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387. Shunt generators use a higher voltage as compared to DC series generators. As the load in the circuit is increased, the current in I_a and I_L also increase. However, the current in (I_f) decreases since the system makes the most out of the source current when the load is increased. This leads to the releazion of the equation ($I_a = I_L + I_f$).

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397. References

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400. Daniel, C., & Besenhard, J. O. (Eds.). (2012). Handbook of battery materials. John Wiley & Sons.

401. Gupta, R., Lamba, R., & Padhee, S. (2012). Thyristor based speed control techniques of DC motor: A comparative analysis. Simulation, 3, 7.

402. Haynes, W. M. (2014). CRC handbook of chemistry and physics. CRC press.

403. Heck, C. (2013). Magnetic materials and their applications. Elsevier.

404. Poullikkas, A. (2013). A comparative overview of large-scale battery systems for electricity storage. Renewable and Sustainable energy reviews, 27, 778-788.

405. Shklovskii, B. I., & Efros, A. L. (2013). Electronic properties of doped semiconductors (Vol.

406. 45). Springer Science & Business Media.

[407.](#) Ultimate service associates. (2018). NiCd versus Lead Acid Starter Batteries for Generator Systems.

408. Shivalli, S. (2016). Lightning Phenomenon, Effects and Protection of Structures from Lightning.

409. *Journal of Electrical and Electronics Engineering, Vol. 11, Issue 3, Version 1. Pp. 44-50.*

410. Obaidullah, M., Raza, A. and Hammoud, A. (2013). Lab Report 3: DC Motors and Generators.

411. *Abu Dhabi University. Pp. 1-14.*

412. Carroll, L. (2013) Bell Circuit, *Electrical Course Notes - Unit 2.2.4*. Pp. 1-14.
413. George, J., Cherian, R., Renju, M. and Thomas, R. (2017). Automatic on Load Voltage Regulation of DC Shunt Generator, *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, Vol. 6, Issue 4. Pp. 2-5
414. Saini, T., Kumar, S. and Khanna, S. (2014). Excitation of D.C. Generator, *International Journal of Innovative Research in Technology*, Vol, 1 Issue 7. Pp. 191-19.

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