

# KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA



## BEKP 3553 ELECTROMAGNETICS THEORY 1-2006/2007

No.	Name	Matric No.	Course	Group
1.				
2.				
3.				
4.				

Date:

Instruction:

1. Please read the procedures carefully before doing the circuit connection for every experiment.
2. The lab report must be submitted at the end of each lab session.
3. Please follow the safety measures at all times.

# Content

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**KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA**  
**Faculty of Electrical Engineering**  
**BEKP 3553: Electromagnetics Theory**  
*Lab Module 1*  
**ELECTROSTATICS**

### 1. Objectives

1. Verify the electrization of a body by means of the electrization procedure through wiping.
2. Verify that the discharge potential between two electrodes of opposite sign is a function of the distance.

### 2. Equipments Required

1. Console DL 3155 AL
2. DL 3155 M04
3. Plastic rod and Glass rod

### 3. Introduction

The dielectric strength of the air is of about  $3 \times 10^6$  V/m. If an air layer is subjected to an upper electric field, the air becomes conductor: in practice a spark strikes and a discharge occurs.

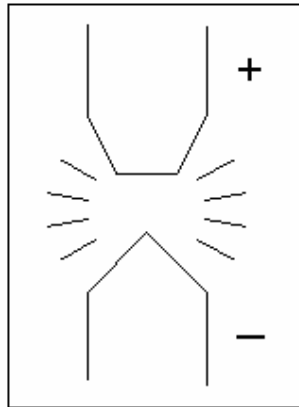


Fig 1.1: Sharp electrodes

The experience is usually led by using the electrodes shown in Fig.1.1.

Since in this case the electrodes are not plane and parallel plates, the electric field is not uniform and it cannot be calculated by the formula  $(U_A - U_B) / d$ , where  $d$  is the distance between the electrodes. As a matter of fact, it is possible to demonstrate that the electric field in proximity of the points can assume very high values; the air in proximity of the point becomes conductor because the dielectric strength value is exceeded.

In practice it is as if the point the other electrode approaches; this determines an increasing of the electric field in the remaining space region.

## 4. Procedure

### 4.1 Experiment A - Superficial electrization of the bodies

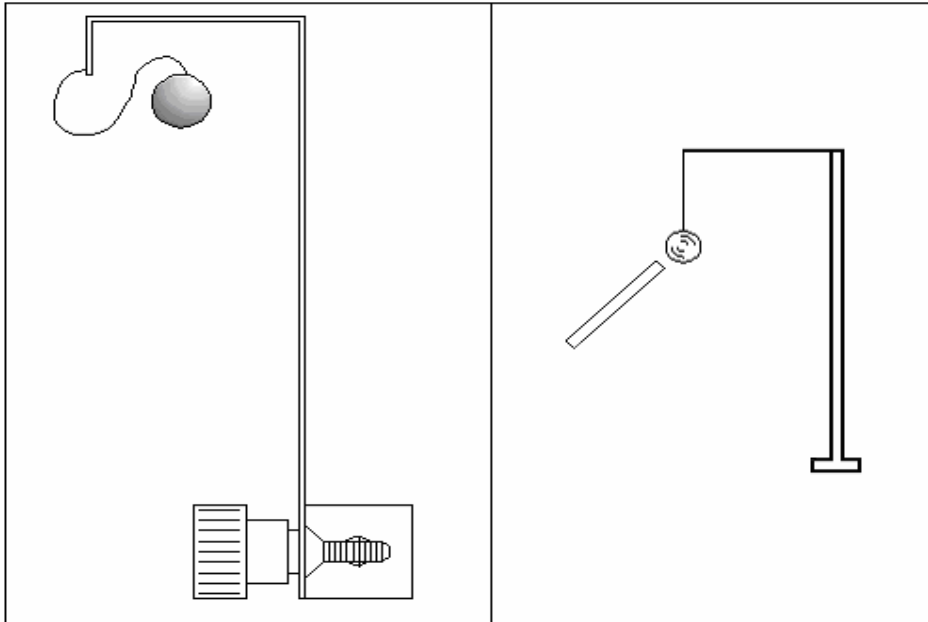


Fig 1.2: The Cork Ball diagram

Fig 1.3: Approaching Rod diagram

1. Insert the Module 4 in the console and refer to the experiment as in Fig.1.2;
2. Wipe energetically one end of the plastic rod with the cloth and approach it to the cork ball as in Fig.1.3, then answer question 1 and 2;
3. Bring the electrized rod to the neutral state again by making slide a hand on it; this is equivalent to ground it;
4. Approach the rod to the cork ball again, then answer question 3;
5. Get a glass rod and step 2, 3 and 4, then answer question 4;
6. Answer question 5 and question 6;
7. Move to experiment B.

### 4.2 Experiment B- Electrostatic machine

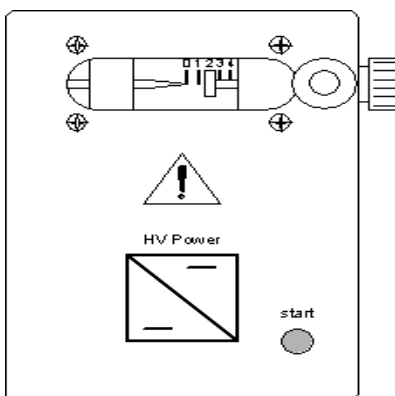


Fig. 1.4: Electrostatic Machine

1. Set the main switch to ON and refer to the experiment as in Fig.1.4;
2. Set the electrode having a shape of cylindrical conductor on the notch indicated with number 2;
3. Push the push-button: a chattering will be heard, then answer question 7;
4. Approach slightly the electrode having a shape of cylindrical conductor to the one of central wire until making strike a spark with a characteristic noise, that makes the interposed air incandescent: this distance is defined explosive distance, answer question 8;
5. Modify the distance between the electrodes in such a way to modify the spark aspect following Table 1.1, if the distance is minimum, the spark trace results continuous, if the distance increases, the spark branches;
6. Answer question 9 and question 10;
7. Set the main switch to OFF and remove module 4 from the console;
8. Do the Analysis part.

## 5. Questions

1. What happen to the cork ball? \_\_\_\_\_
2. In an electrization procedure between two bodies through wiping, the bodies have charge of:
  - A) The same sign
  - B) Opposite sign
3. What happen to the cork ball? \_\_\_\_\_
4. What happen to the cork ball after wiping and after neutralizing?
  
5. Two conductor bodies equipped with electric charge and set one near the other have the following behavior:
  - A) Repel
  - B) Attract
  - C) Exercise between them some electric forces
  - D) Exercise between them some mechanical forces
6. An electrized body with positive charge:
  - A) Has on average more protons than electrons
  - B) Has on average more electrons than protons
  - C) Has the same number of electrons and protons
7. Is there any spark between the two electrodes? \_\_\_\_\_  
Fill Table-1.1 on step No. 1



**MAGNETIC FIELD CREATED BY A RECTILINEAR, CIRCULAR AND SOLENOID CONDUCTOR**

**1. Objectives**

Verify the magnetic field of a rectilinear, circular and solenoid conductor crossed by current.

**2. Equipments Required**

- 4. Console DL 3155 AL
- 5. DL 3155 M05
- 6. Magnet compass or magnaprobe
- 7. Digital Multimeter

**3. Introduction**

The direction of the current following in the circuit that in base to the Ohm's law can be determined with the following rule:

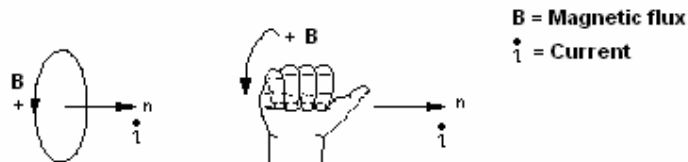


Fig. 2.1: Current and Magnetic flux direction

If the fingers of the right hand are set according to the positive direction of current the thumb shows the perpendicular direction of Magnetic flux.

**4. Procedure**

**4.1 Experiment-A – Magnetic field created by a rectilinear conductor**

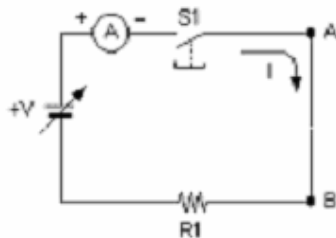


Fig 2.2: Electrical diagram of positive voltage for rectilinear conductor

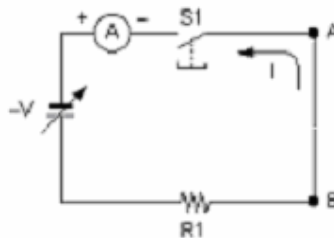


Fig 2.3: Electrical diagram of negative voltage for rectilinear conductor

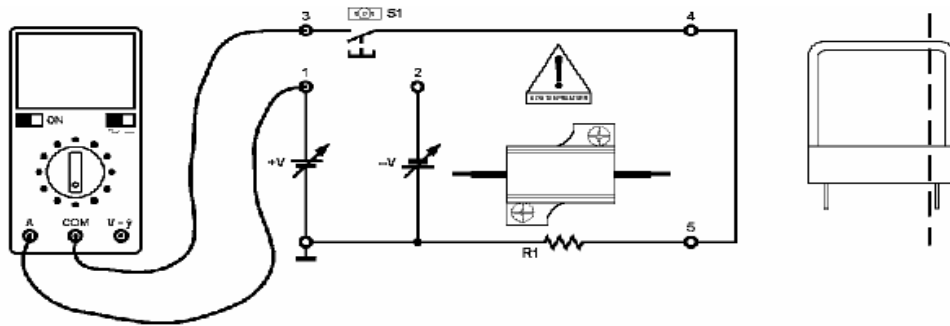


Fig 2.4: Topographical diagram of positive voltage for rectilinear conductor

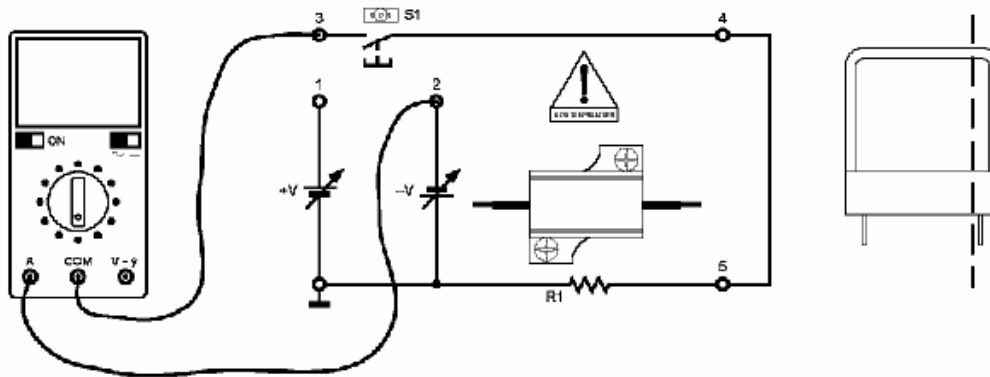


Fig 2.5: Topographical diagram of negative voltage for rectilinear conductor

1. Insert the Module 5 in the console and to set the main switch to ON;
2. Connect a multimeter, set as ammeter, between jack 1 and jack 3 (Fig.2.2 and Fig. 2.4);
3. Keep the push-button S1 pushed for the whole time of the test;
4. Adjust the voltage +V so to read on the ammeter a current intensity equal to 0.35A;
5. Approach a magnetic compass or a magnaprobe to the rectilinear conductor (turn side);
6. Notice the trend of the force lines and answer question 1;
7. Release the push-button S1;
8. Connect the ammeter between jack 2 and jack 3 (Fig.2.3 and Fig. 2.5)
9. Adjust the voltage -V so to read on the ammeter a current intensity equal to -0.35A;
10. Repeat the step 5 and answer question 2;
11. Answer question 3 and question 4;
12. Disconnect all connection, and do Experiment-B.

#### 4.2 Experiment-B – Magnetic field created by a circular conductor

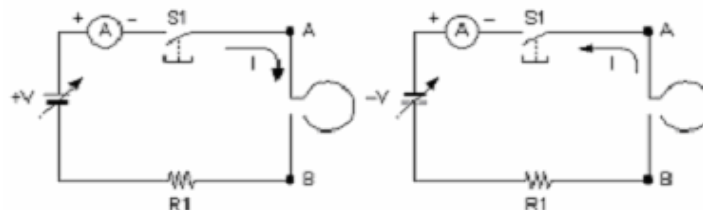


Fig 2.2: Electrical diagram of positive

Fig 2.3: Electrical diagram of negative

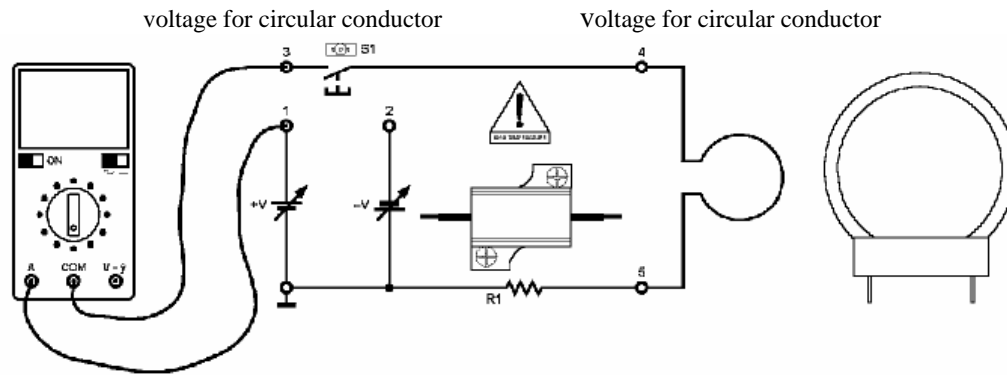


Fig 2.8: Topographical diagram of positive voltage for circular conductor

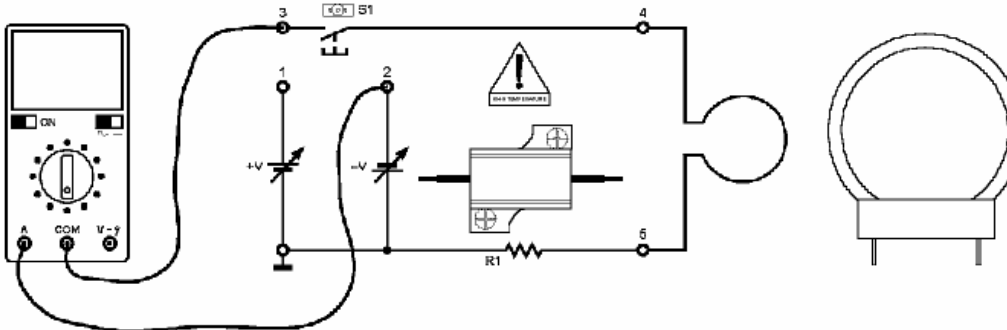


Fig 2.9: Topographical diagram of negative voltage for circular conductor

1. Connect a multimeter, set as ammeter, between jack 1 and jack 3 (Fig.2.6 and Fig.2.8);
2. Keep the push-button S1 pushed for the whole time of the test;
3. Adjust the voltage +V so to read on the ammeter a current intensity equal to 0.35A;
4. Approach a magnetic compass or a magnaprobe to the circular conductor (turn side);
5. Notice the trend of the force lines and answer question 5;
6. Release the push-button S1;
7. Connect the ammeter between jack 2 and jack 3 (Fig.2.7 and Fig.2.9);
8. Adjust the voltage -V so to read on the ammeter a current intensity equal to -0.35A;
9. Repeat the step 4 and answer question 6;
10. Answer question 7;
11. Disconnect all connection, and do Experiment-C.

### 4.3 Experiment C – Magnetic field created by a solenoid conductor

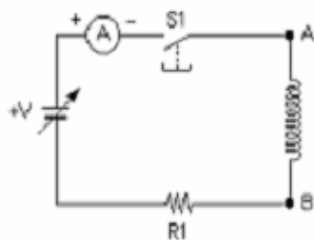


Fig 2.10: Electrical diagram of positive

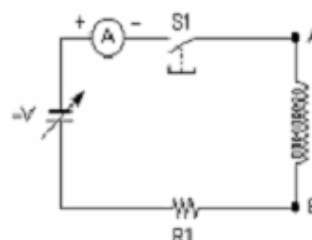


Fig 2.11: Electrical diagram of negative

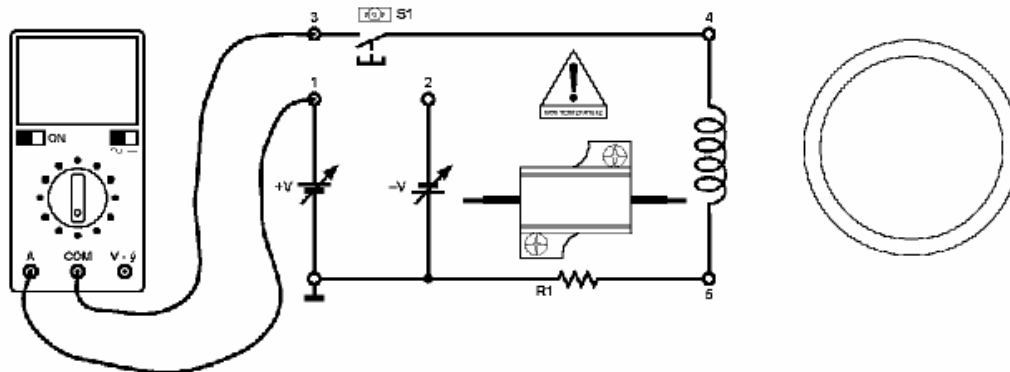


Fig 2.12: Topographical diagram of positive voltage for solenoid conductor

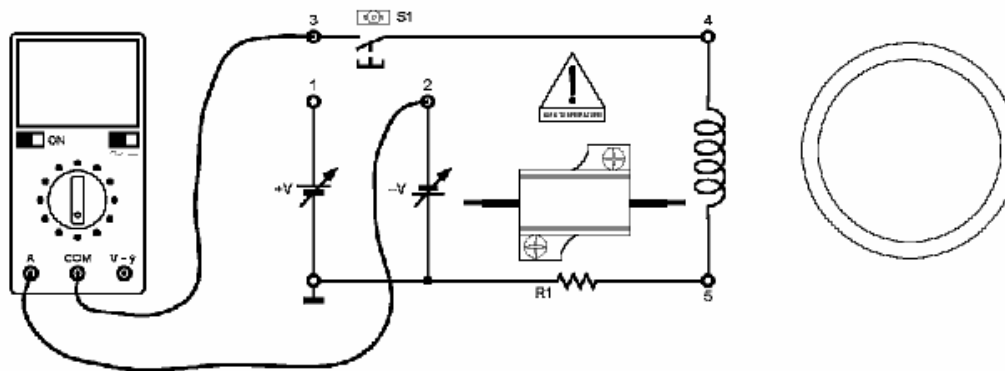
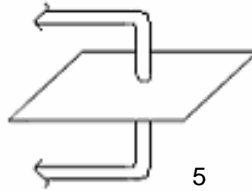


Fig 2.13: Topographical diagram of negative voltage for solenoid conductor

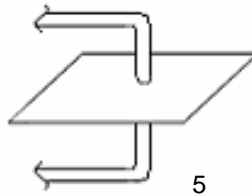
1. Connect a multimeter, set as ammeter, between jack 1 and jack 3 (Fig.2.10 and Fig.2.12);
2. Keep the push-button S1 pushed for the whole time of the test;
3. Adjust the voltage +V so to read on the ammeter a current intensity equal to 0.35A;
4. Approach a magnetic compass or a magnaprobe to the solenoid (turn side);
5. Notice the trend of the force lines and answer question 8;
6. Release the push-button S1;
7. Connect the ammeter between jack 2 and jack 3 (Fig.2.11 and Fig.2.13);
8. Adjust the voltage -V so to read on the ammeter a current intensity equal to -0.35A;
9. Repeat the step 4 and answer question 9;
10. Answer question 10;
11. Disconnect all connection and set the main switch to OFF and release the module 5 from console.

## 5. Question

1. Draw the force lines trend schematically



2. Draw the force lines trend schematically



3. A rectilinear conductor crossed by current generates a magnetic field; the force lines of the field place itself:

- A) In a symmetric way as regards the conductor
- B) In a tangent way as regards the conductor
- C) In a dissymmetric way as regards the conductor

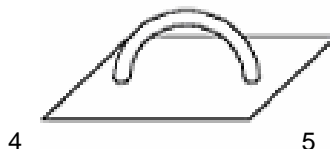
4. The spare area, that feels the effects owed to the presence of a conductor material crossed by electrical current, is defined as:

- A) Electric field
- B) Magnetic field
- C) Magneto-electric field

5. Draw the force lines trend schematically



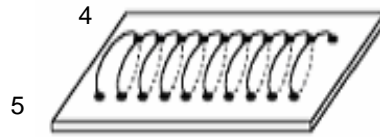
6. Draw the force lines trend schematically



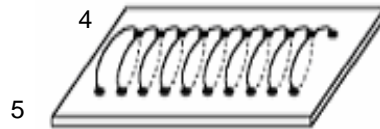
7. In a conductor, bent at shape of circular turn, the force lines place themselves in the surrounding space:

- A) In a dissymmetric way as regards the conductor
- B) In a symmetric way as regards the conductor
- C) In a tangent way as regards the conductor

8. Draw the force lines trend schematically



9. Draw the force lines trend schematically



10. In a solenoid the generated magnetic field is uniform:  
A) Outside  
B) Inside

## 6. Analysis

1. Comment the result that you obtained from Experiment-A.
2. Comment the result that you obtained from Experiment-B.
3. Comment the result that you obtained from Experiment-C.
4. Compare the three results.

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**Faculty of Electrical Engineering**  
**BEKP 3553: Electromagnetics Theory**  
*Lab Module 3*  
**MAGNETIC SWITCH**

**1. Objectives**

1. Measure the distance of Magnetic Switch operation.
2. Verify the operation of a magnetic switch.

**2. Equipments Required**

8. Console DL 3155 AL
9. DL 3155 M05
10. Magnet
11. Digital Multimeter

**3. Introduction**

The reed switch consists of a pair of flexible reeds made of a magnetic material, and sealed in a glass tube filled with inert gas. The reeds are overlapped but separated by a small gap. The contact area of each reed is plated with a noble metal, such as Rhodium or Ruthenium, to provide the switch with stable characteristics and long life.

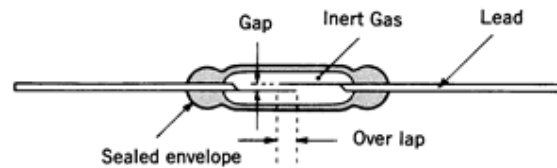


Fig.4.1: The reed Switch diagram

Application of a magnetic field, generated by a permanent magnet or a coil, to the reed switch causes both reeds to be magnetized. This produces an N-pole at the contact area of one reed, and an S-pole at that of the other reed, in a manner shown on the drawing (left). If the magnetic attracting force overcomes the resistive force caused by elasticity of the reed, the reeds come in contact (Pull-In) i.e., the circuit is closed. Once the magnetic field is removed, the reeds are separated again by the effect of elasticity of the reed (Drop-Out) i.e., the circuit is opened.

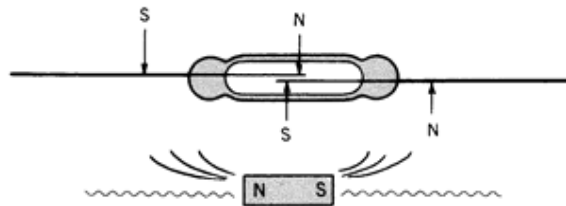


Fig.4.2: The principle diagram

## 4. Procedure

8. Insert the Module 5 in the console and to set the main switch to ON;
9. The system has the electrical diagram as in Fig. 4.3;
10. Connect a multimeter, set as voltmeter, between jack 1 and ground (Fig.4.4);
11. Adjust the input voltage +V so to read on the voltmeter a voltage of 10V;
12. Approach slowly the magnet to the switch S1, so to provoke the contact closing and the consequent switching on of the lamp;
13. Remove slowly the magnet so to provoke the contact opening and the consequent switching off of the lamp;
14. Repeat more times the previous operations, by spotting the minimum closing distance of the switch. Answer question 1;
15. Repeat Step 3 to Step 6 following the values from Table-4.1;
16. Answer question 2 and question 3;
17. Set the main switch OFF and remove module 5 from the console;
18. Do the Analysis part.

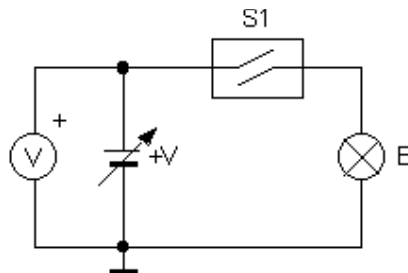


Fig. 4.3: Electrical diagram of Magnetic Switch

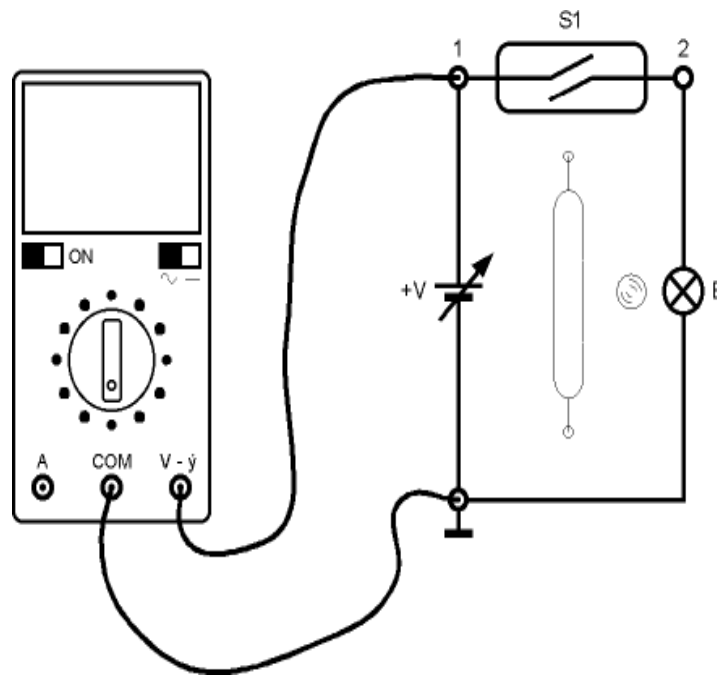


Fig. 4.4: Topographical diagram of Magnetic Switch



3. Represent graphically voltage versus minimum distance.



4. Comment on the graph.

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**Faculty of Electrical Engineering**  
BEKP 3553: Electromagnetics Theory  
*Lab Module 4*  
**ELECTROMAGNET**

### 1. Objectives

1. Verify the operation of an electromagnet.

### 2. Equipments Required

12. Console DL 3155 AL
13. DL 3155 M05
14. Digital Multimeter

### 3. Introduction

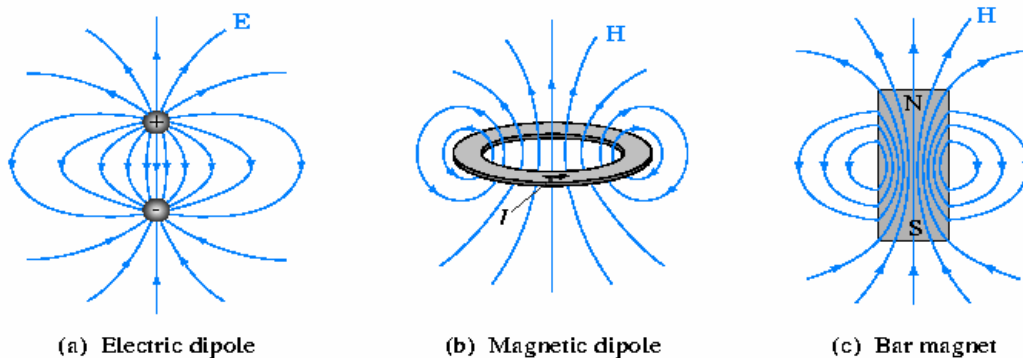


Fig. 5.1: Patterns of (a) the electric field of an electric dipole, (b) the magnetic field of a magnetic dipole, and (c) the magnetic field of a bar magnet. Far away from the sources, the field patterns are similar in all three cases.

### 4. Procedure

1. Insert the Module 5 in the console and to set the main switch to ON;
2. The electrical diagram as based on Fig.5.2 and Fig.5.3 for positive and negative voltage;
3. Connect a multimeter, set as ammeter, between jack 1 and jack 3 (Fig.5.4);
4. By keeping the push-button S1 pushed, adjust voltage +V so to read on the ammeter a current intensity equal to 0.05A;
5. Approach the yoke (metal) to the electromagnet core: the electromagnet exerts a magnetic force that attracts the yoke to the core;
6. Release the push-button S1 and to remove the yoke from the electromagnet core;
7. Repeat the previous operations for current values increased, from time to time, of 0.05A until reaching the maximum current value equal to 0.35A;

8. Observe the variations of the magnetic force as a function of the current and to comment the phenomenon;
9. Connect a multimeter, set as ammeter, between jack 2 and 3 (Fig.6.2-b);
10. Repeat all the operations of the previous points;
11. Remove the connections.

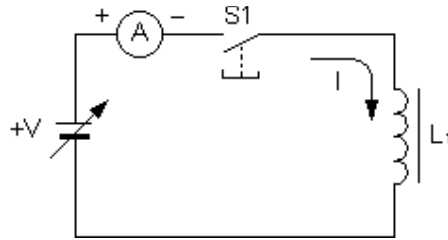


Fig. 5.2: Electrical diagram of positive voltage for electromagnetic

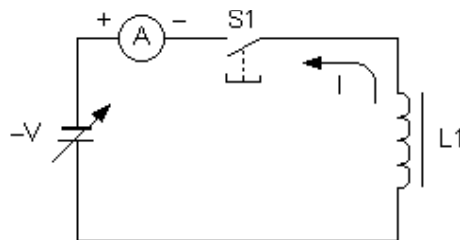


Fig. 5.3: Electrical diagram of negative voltage for electromagnetic

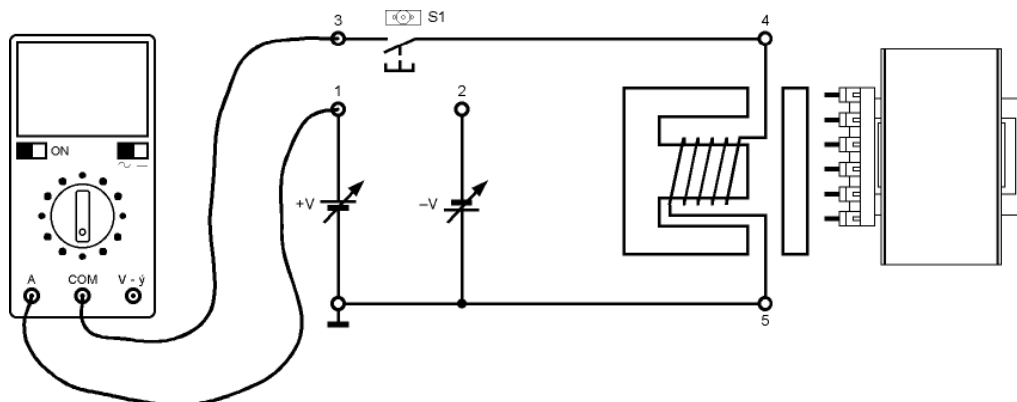


Fig. 5.4: Topographical diagram of positive voltage for electromagnet

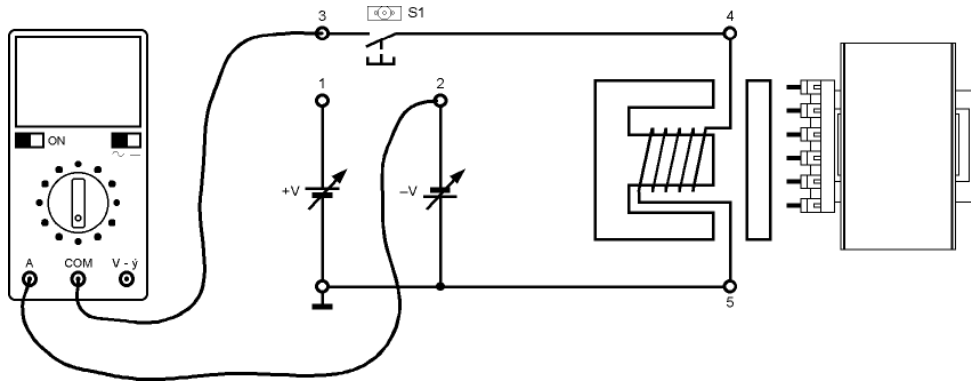


Fig. 5.5: Topographical diagram of negative voltage for rectilinear conductor

Table-5.1: Attraction condition for the yoke (metal)

Step	Current (A)	Positive voltage attraction Condition	Negative voltage attraction Condition
1	0.05		
2	0.15		
3	0.25		
4	0.35		

## 5. Question

1. If an electromagnet is deenergized: does it exerts any force?
2. If the current flowing in the coil of an electromagnet is inverted, its magnetic force will be: \_\_\_\_\_
3. If the yoke (metal) is made from plastic, what condition will be happened?

## 6. Analysis

1. What is the difference between positive voltage attraction condition and negative attraction condition? Why?

2. Based on your observe of the variations of the magnetic force as a function of the current from Table-5.1, give your comments.

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BEKP 3553: Electromagnetics Theory  
*Lab Module 5*  
**STUDY OF VOLTAGE STANDING WAVE RATIO (VSWR)**

### 1. Objective

To study the voltage standing wave ratio (VSWR).

### 2. Equipments Required

1. TechLab transmission line trainer
2. Oscilloscope
3. Digital Multimeter

### 3. Introduction

A transmission line that is terminated in its characteristic impedance has an standing wave ratio (SWR) of 1:1 and is called a non-resonant or flat transmission line. It is non-resonant because it presents constant load impedance to the generator regardless of the operating frequency.

On the other hand, a transmission line with an SWR greater than 1:1 presents a variable load impedance that is dependent upon the operating frequency. Therefore, a line with an SWR greater than 1:1 is called a resonant transmission line.

### 4. Procedure

1. Connect sine input from the function generator to the transmission line and adjust the frequency to be 1KHz by selecting the frequency multiplier to  $\times 100$  and adjust the frequency control to mid range.

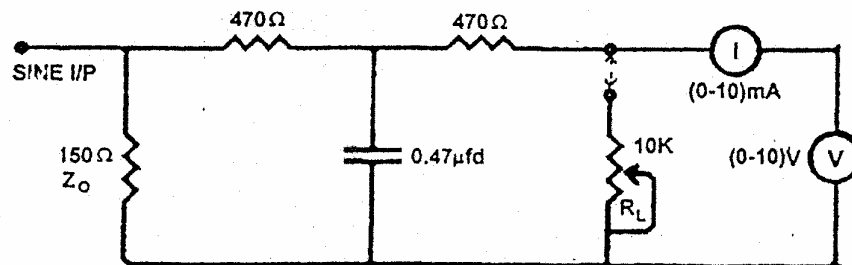


Figure 1: Electrical circuit diagram of the transmission line

2. Adjust the amplitude control in maximum position.
3. Using multimeter, adjust the 10K trimpot to 100Ω.
4. Patch the circuit as shown in wiring diagram of Figure 2.

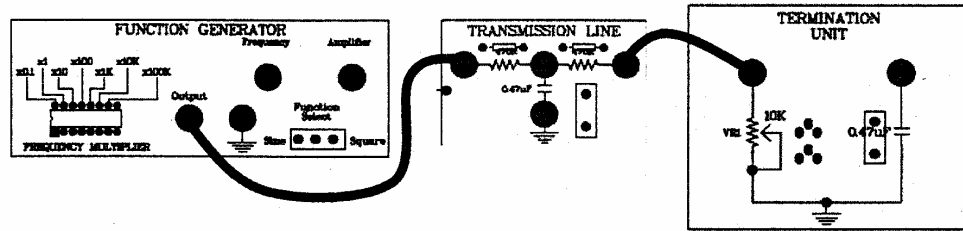


Figure 2: Wiring diagram of the transmission line trainer

- Connect voltmeter across  $R_L$  and record the readings as in the Table 1, where  $R_L$  is the load resistance.

Table 1: SWR based on load impedance

No.	$R_L$	$V_o(V)$	$I$	Power = $V_o^2/R$	$Z_o=V_o/I$	SWR= $Z_o/R_L$
1	100					
2	300					
3	500					
4	1k					
5	2k					
6	7k					
7	10k					

- Similarly for different value of  $R_L$  record the current and voltage in the table and calculate the value of SWR.

## 5. Question

- What is the most commonly used graphical technique for engineer to design the impedance-matching circuits?
- Why it is important to have SWR=1.

## 6. Analysis

1. Represent graphically the SWR as a function of the load impedance.

2. Discuss the SWR value you obtained and comment on the graph.

~~~~~The End~~~~~

*Congratulations, you have completed all of the experiments of BEKP 3553-Electromagnetics Theory*