APPLIED ELECTRICITY 2

1. A SUMMARY OF CANDIDATES' STRENGTHS

(1) Majority of the candidates correctly defined conductors and insulators.

(2) Majority of the candidates correctly drew the frequency modulated wave.

(3) Majority of the candidates drew the truth table for a two-input OR gate.

2. A SUMMARY OF CANDIDATES' WEAKNESSES

(1) Majority of the candidates could not sketch and label the hysteresis loop of a ferromagnetic material.

(2) Some candidates could not calculate power rating of the heater in question 2(b)

(3) Most of the candidates could not define modulation.

(4) Majority of the candidates had difficulty explaining how current flows through the diodes during the positive and negative half cycles of a full wave bridge rectifier circuit.

3. SUGGESTED REMEDIES

(1) Candidates should read more literature on Applied Electricity to improve their level of understanding of the subject.

(2) Adequate practical exercises should be given to students.

(3) Teachers should endeavour to complete the syllabus on time to enable candidates prepare adequately before taking the examinations.

4. DETAILED COMMENTS

QUESTION 1

(a) (i) Sketch and label the hysteresis loop of a ferromagnetic material.

(ii) Indicate on the loop in 1(a) (i), the:

I. residual flux;

II. coercive force.

(b) A capacitor consisting of two parallel plates in air, each of effective area 50 cm^2 and 1 *mm* apart, carries a charge of 1.77 x 10^{-9} *C*. (Take $\varepsilon_r = 1$, $\varepsilon_0 = 8.854$ x 10^{-12} Fm^{-1})

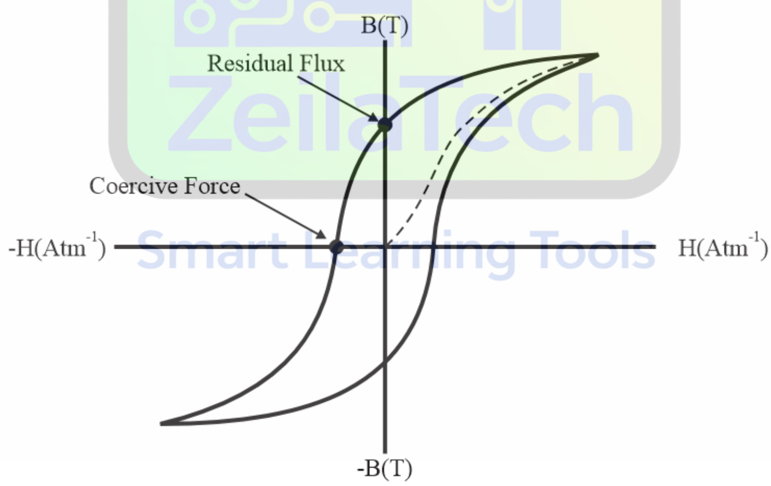
Calculate the:

(i) capacitance of the capacitor;

(ii) potential difference between the plates.

(a) Candidates sketched different shapes for the hysteresis loop of a ferromagnetic material. Some candidates could not identify the residual flux and the coercive force.

Expected response:



(b) Most candidates could not calculate the capacitance of the capacitor and the potential difference between the plates with the information given.

Expected response:

Given that, $\mathcal{E}r = 1$

$\mathcal{E}o = 8.854 \times 10^{-12}$

$A = 50\ cm^2$

$n = 2$

$d = 1\ mm$

$Q = 1.77 \times 10^{-9}\ C$

(i) Capacitance of the capacitor;

$$C = \frac{\mathcal{E}_r \mathcal{E}_0 A}{d}$$

$$C = \frac{1 \times 8.854 \times 10^{-12} \times 50 \times 10^{-4}}{1 \times 10^{-3}}$$

$$C = 442.7 \times 10^{-13} F$$

(ii) Potential difference between the plates;

$$Q = CV$$

$$V = \frac{Q}{C}$$

$$V = \frac{1.77 \times 10^{-9}}{442.7 \times 10^{-13}}$$

$$V = 0.004\ X\ 10^4\ V = 40\ V$$

QUESTION 2

(a) Define the following terms:

(i) Insulator;

(ii) Conductor.

(b) An electric heater consumes 2.7 *MJ* when connected to 230 *V* supply for 30 *mins*. Calculate the:

i. power rating of the heater;

ii. supply current.

(a) This question was answered by most candidates. Majority of the candidates were able to define insulator and conductor correctly.

Expected response:

i. Insulator: An insulator is a material that offers high resistance to the flow of electric current.

ii. Conductor: A conductor is a material that offers low resistance to the flow of electric current.

(b) Very few candidates had difficulties in calculating the power rating of the heater and the supply current.

Expected response:

Given that: Energy consumed = 2.7 *MJ*

Time = 30 *mins*

(i) Power rating of the heater;

$$\text{Power} = \frac{\text{energy}}{\text{time}}$$

$$\text{Power} = \frac{2.7 \times 10^6}{30 \times 60}$$

$$\text{Power} = 1500\ W\ or\ 1.5\ kW$$

(ii) Supply current;

$$Current\ (I) = \frac{Power\ (P)}{Voltage\ (V)}$$

$$I = \frac{1500}{230}$$

$$I = 6.25\ A$$

QUESTION 3

(a) Explain the following terms in relation to an *a.c.* circuit:

i. Power factor;

ii. Series resonant circuit;

(b) A shunt generator delivers 350 *A* with a field and armature resistance of 40 Ω and 0.02 Ω respectively. If the terminal voltage is 220 *V*, calculate the generated *e.m.f.*

(a) The explanation for power factor and series resonant circuit provided by most candidates were inadequate.

Expected response:

(i) Power factor,

It can be defined as the cosine of the angle between current and voltage in the circuit.

$$PF = \cos\theta = \frac{\text{true power}}{\text{apparent power}}$$

OR

Ratio of Resistance (R) to Impedance (Z)

OR

Ratio of true power to apparent power.

(ii) Series resonant circuit.

It is a circuit in which the inductive reactance equals the capacitive reactance

OR

Impedance (Z) = Resistance (R)

OR

Current (I) is maximum

OR

Current (I) is in phase with Voltage (V).

(b) Majority of the candidates who attempted this question were able to calculate the *e.m.f* of the shunt generator.

Expected response:

Generated *e.m.f* of a shunt generator;

Given that:

$I_L = 350\ A$

$V = 220\ V$

$R_f = 40\ \Omega$

$R_a = 0.02\ \Omega$

$$I_f = \frac{220}{40} = 5.5\ A$$

$$Armature\ current, I_a = I_l + I_f$$

$$I_a = 350 + 5.5 = 355.5\ A$$

$$Generated\ e.m.f = V + I_a R_a$$

$$= 220 + (355.5 \times 0.02)$$

$$= 220 + 7.11$$

$$= 227.11\ V$$

QUESTION 4

(a) **Draw a fullwave bridge rectifier circuit.**

(b) **With the aid of the circuit drawn in 4(a), explain how the current flows through the diode during the:**

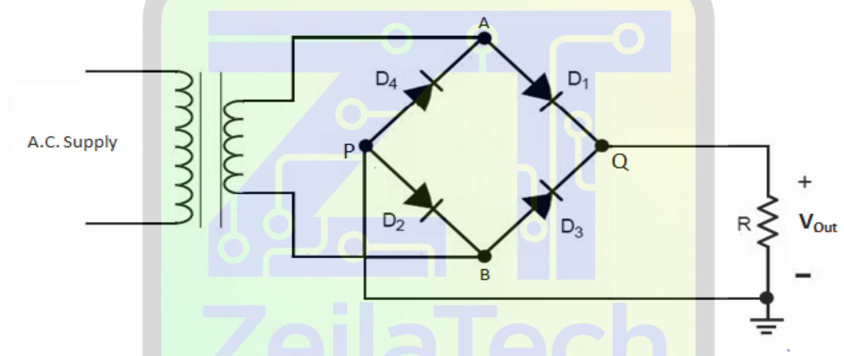
i. **positive half cycle;**

ii. **negative half cycle.**

(a) Candidates had difficulties in drawing the full-wave bridge rectifier circuit. Some could not arrange the diodes well while others also left out the transformer.

Expected response:

Diagram of a full-wave bridge rectifier circuit.



(b) Majority of the candidates explained how the current flows through the diode during the positive and negative half cycles.

Expected response:

(i) Positive half cycle:

During the positive half cycle, the path taken by the current is through Diode D_1, through the load and back to the transformer through Diode D_2. Diodes D_3 and D_4 will not be conducting.

(ii) Negative half cycle:

During the negative half cycle, the path taken by the current is through diodes D_4 through the load and back to the transformer through Diodes D_3. Diodes D_1 and D_2 will not be conducting.

QUESTION 5

(a) Convert the following numerals:

(i) 110001_2 to decimal;
(ii) 25_{10} to binary.

(b) (i) Draw the switching arrangement of the OR logic gate with two inputs.

(ii) Draw the truth table for two-input OR gate.
(iii) Write down the Boolean algebra of the OR gate.

(a) This question was well answered by most candidates.

Expected response:

(i) 110001_2 to decimal.

1 1 0 0 0 1

$= 1(2^5) + 1(2^4) + 0(2^3) + 0(2^2) + 0(2^1) + 1(2^0)$

$= 32 + 16 + 0 + 0 + 0 + 1$

$= 49_{10}$

(ii) 25_{10} to binary.

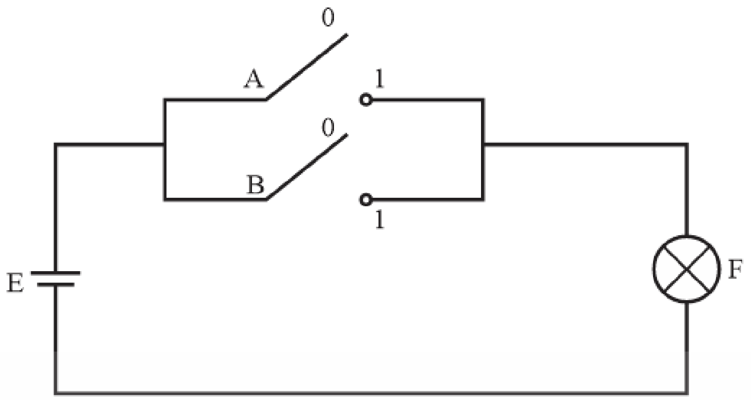
2	25	R
2	12	1
2	6	0
2	3	0
2	1	1
	0	1

$25_{10} = 11001_2$

(b) Candidates who attempted this question answered appropriately except for few who could not draw the switching arrangement for the OR logic gate.

Expected response:

(i) Switching arrangement of the OR logic gate with two inputs;



(ii) Truth table for a two-input OR gate;

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

(iii) Boolean algebra of the OR gate;

A + B = Y

QUESTION 6

(a) Define the following terms:

(i) *Work function* of a metal;

(ii) Surface barrier.

(b) List two methods of electron emission.

(c) Explain each of the methods of electron emission listed in 6(b).

(a) Some candidates could not define work function of a metal and surface barrier appropriately.

Expected response:

(i) *Work function* of a metal

It is the minimum energy required to emit an electron from a metal surface.

(ii) *Surface barrier*

It is a potential barrier that prevents free electrons from leaving the surface of a metal. The barrier is provided by the metal surface.

(b) Majority of the candidates listed and explained two methods of electron emission correctly.

Expected response:

Methods of electron emission

- Thermionic emission
- Field emission
- Photo-electric emission
- Secondary emission

(c) Explanation of methods of electron emission

Thermionic emission:

In this type, the metal is heated to a sufficient temperature to enable the free electron to leave the metal surface. The number of electrons emitted depends upon the temperature.

Field emission:

In this type a strong electric field is applied at the metal surface which liberates the free electrons from the metal. The stronger the electric field (voltage), the greater the electron emission.

Photo-electric emission:

This is the process of emitting electrons from a metal surface through photons (light energy).

Secondary emission:

This is the process of emitting electrons from a metal surface through primary emission (charged particles).

OR

It is a phenomenon in which a number of electrons are emitted when fast-moving electrons, called primary electrons, strike the metal surface.

QUESTION 7

(a) **Define *modulation*.**

(b) **Sketch the following under frequency modulation.**

i. **Modulating signal;**
ii. **Carrier wave;**
iii. **Frequency modulated wave.**

(c) **List two properties of an ideal operational amplifier.**

(a) Most candidates could not define modulation.

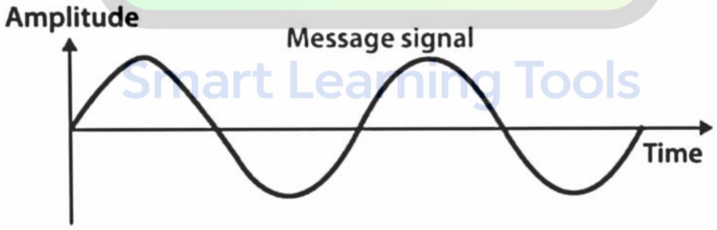
Expected response:

Definition of modulation
It is the process of varying the characteristics of a carrier signal using a low frequency signal.

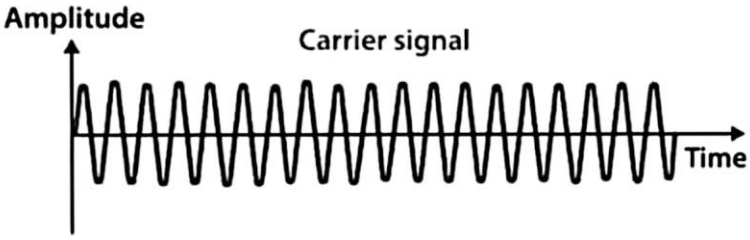
(b) Most candidates were able to sketch the diagrams for modulating signal and carrier wave but could not sketch the frequency modulated wave.

Expected response:

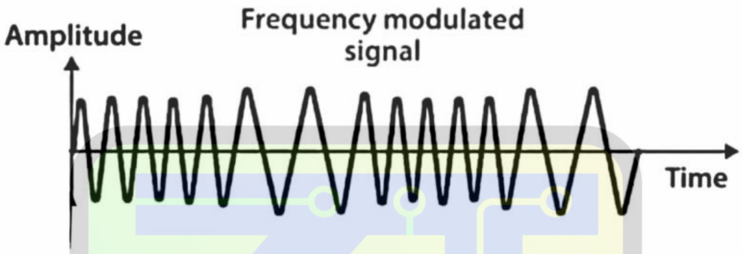
(i) Modulating signal



(ii) Carrier wave



(iii) Frequency modulated wave.



(c) Some candidates could not list two properties of an ideal operational amplifier.

Expected response:

Properties of an ideal operational amplifier

- Uses low power
- No input bias current
- No noise
- No voltage off-set
- Zero output impedance
- Infinite input impedance
- Infinite gain bandwidth
- Infinite voltage compliance

APPLIED ELECTRICITY 3

1. A SUMMARY OF CANDIDATES' STRENGTHS

(1) Candidates connected the circuit diagrams correctly.

(2) Most of the candidates selected suitable scales to plot their graphs.

(3) Majority of the candidates obtained good readings for the experiments conducted.

2. A SUMMARY OF CANDIDATES' WEAKNESSES

(1) Some of the candidates struggled determining the gradient of the graph.

(2) Most of the candidates could not comment on the relevance of the gradient.

3. SUGGESTED REMEDIES

(1) Candidates must be taught how to accurately determine gradients.
(2) Candidates must read widely to appreciate the theory of the experiment.

4. DETAILED COMMENTS

QUESTION 1

AIM: To study the V-I characteristics of an Incandescent lamp.

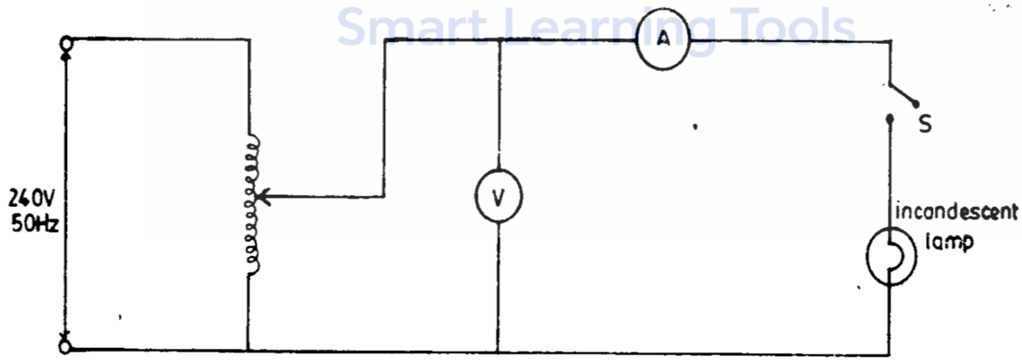


Figure 1

Connect the circuit as shown in Fig. 1.

(a) **Ask the supervisor to check the circuit connection.**

(b) **You are provided with Table 1.**

Table 1

Vs *(V)*	I *(A)*	$R = \frac{V}{I}$ (Ω)
60		
90		
120		
150		
180		
210		
240		

(c) **Set the Variac (Vs) to 60 *V*.**

(d) **Close switch *S*.**

(e) **Read and record in Table 1, the ammeter reading I.**

(f) **Open switch *S*.**

(g) **Repeat steps (*e*) to (*h*) for other values of Variac (V_S) in Table 1.**

(h) **Complete Table 1.**

(i) **Plot the graph of Vs *(V)* on the vertical axis against I *(A)* on the horizontal axis.**

(j) **Determine the slope of the graph.**

(k) **Interpret the slope obtained in *(k)*.**

(l) **Comment on the values of R obtained in Table 1.**

(m) **State the reason for your comment in *(m)*.**

Majority of the candidates connected the circuit diagram correctly and plotted good graphs.

A few of the candidates could not determine the slope of the graph. Most candidates were not able to interpret the slope obtained.

Expected Comments:

(l) the slope is the internal resistance of the lamp.
(m) the values of R are close to each other.
(n) the bulb has a constant internal resistance.

Candidates' performance was generally above average.

QUESTION 2

AIM: To determine the lead angle in an *a.c.* RC circuit

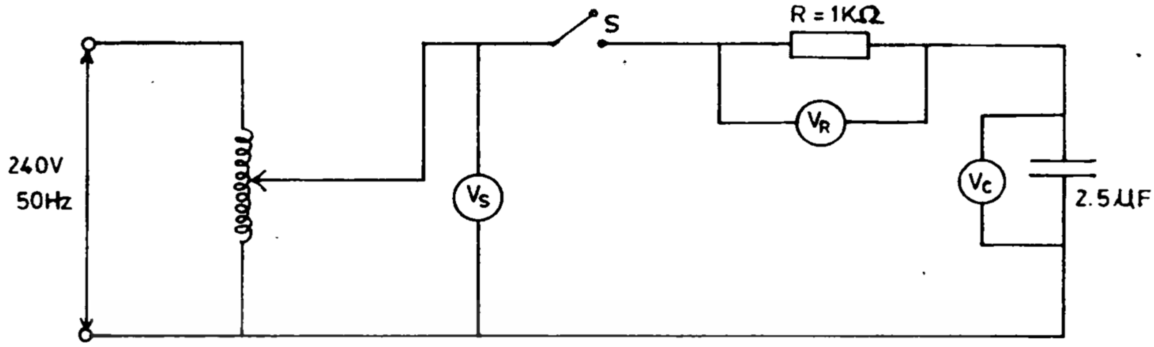


Figure 2

(a) **Connect the circuit as shown in Fig. 2.**

(b) **Ask the supervisor to check the circuit connection.**

(c) **You are provided with Table 2.**

V_S *(V)*	V_R *(V)*	V_C *(V)*
0		
10		
20		
30		
40		
50		

(d) **Set the Variac (V_S) to 0 *V*.**

(e) **Close switch *S*.**

(f) **Read and record in Table 2, the voltmeter reading V_R and V_C.**

(g) **Open switch *S*.**

(h) **Repeat steps (*e*) to (*g*) for other values of Variac (V_S) in Table 2.**

(i) **Plot the graph of V_C *(V)* on the vertical axis against V_R *(V)* on the horizontal axis.**

(j) **Determine the:**

- **(i)** **Slope of the graph;**
- **(ii)** **lead angle using the slope of the graph.**

Majority of the candidates correctly connected the circuit diagram and followed the experimental procedure.

A few of the candidates had challenges in determining the gradient of the graph.

Some of the candidates exhibited poor pencil work. Most candidates determined correctly the lead angle using the slope of the graph.

Expected response

<u>Lead angle</u>

$\tan\theta = Slope$

$\tan\theta = 1.25$

$\theta = \tan^{-1} 1.25$

$\theta = 51.34°$

Candidates' performance was above average.