21.0   ELECTRICITY (448)

As in the previous years, the 2009 KCSE examination in Electricity comprised two papers namely theory and practical papers.

21.1   CANDIDATES' OVERALL PERFORMANCE

The performance of the candidates in Electricity is shown in the table below. The candidates' performance in **2005** and **2008** is also given for comparison.

Table 26: Candidates' Overall Performance in Electricity for the Years, 2009, 2008 and 2005

Year	Paper	Candidature	Max. Score	Mean Score	Standard Deviation
	1		60	36.77	9.76
	2		40	25.43	4.37
2005	Overall	443	100	62.20	12.00
	1		60	26.67	10.78
	2		40	21.83	6.64
2008	Overall	48	100	48.53	15.29
	1		60	35.47	9.65
	2	219	40	24.08	5.66
2009	Overall		100	59.55	13.75

From the table above, the following observations can be made:

21.1.1   The candidature rose remarkably from **48** in **2008** to **219** in **2009**.

21.1.2   There was an improvement in the mean score for both papers resulting in the overall mean score rising from **48.53** in **2008** to **59.55** in **2009**.

21.1.3   The standard deviation however, went down slightly in both papers.

Despite the general improvement in **2009**, poor performance was observed in questions **3, 4, 11, 13** and **15** in **Paper 1** and exercises **1, 2** and **5** in **paper 2** as highlighted below.

21.2   PAPER 1 (448/1)

Question 3
(a)   Name four types of capacitors
(b)   Two capacitors having capacitance of 6 μ and 4 μ are connected
         in series across a 200V dc supply.

         Calculate the:
                 (i)   voltage across each capacitor;
                 (ii)   charge on each capacitor.

This question called for knowledge in capacitors and their manipulations in circuit design. Most of the candidates failed to see the significance of connecting the capacitors in series and take that into consideration when doing the calculations required. However, in part (a) of the question, the candidates were able to list various types of capacitors.

Expected response
(a) Types of Capacitors
   • Air capacitor
   • Paper

- Mica
- Electrolytic
- Tantalum

(b) (i) $V_1 = 200 \times \dfrac{4}{4+6} = 80V$

         $V_2 = 200 - 80 = 120V$

(ii)   Charge is the same on each capacitor

         $Q = CV = 6 \times 10^{-6} \times 80 = 0.00048C$

Question 4
(a)   Name two types of secondary cells.

(b)   Six cells each of emf 1.5V and internal resistance of 1.2Ω are connected
        In parallel to supply a load of 10 Ω. Calculate the current through the load.

The candidates were required to do calculations involving the dry cells in part (b) and in (a) they were expected to name types of secondary cells.

The main weakness displayed by most candidates who attempted this question was failure to include the internal resistance in their calculations. They should have realized that in order to get the total circuit resistance the total internal resistance had to be worked out.

Expected Response
The total emf = 1.5V

Total internal resistance $= \dfrac{r}{R} = \dfrac{1.2}{6} = 0.2 \Omega$

∴Total circuit resistance $= R + r = 10 + 0.2 = 10.2\ \Omega$

Question 11
(a)   With the aid of a labelled diagram, explain the operation of a single
        Phase transformer.

(b)   1 200 KVA, 11000v/240v 5Hz single phase transformer has 600 turns on
        the primary side. Calculate:
           (i)   the primary and secondary currents;
   (ii)   the number of secondary turns.

This question tested the candidates' knowledge on operation of a single phase transformer and the ability to do calculations related to the transformer.

Most of the sketches presented in part (a) did not show distinctly the difference in number of turns between the primary and secondary windings. Correct labelling of the sketch was also lacking in most of the answers presented. The explanation for operation of the transformer should have been systematic and complete.

In part (b) of the question, some candidates could not come up with the required calculations mainly because of poor tuition.

11. **(a)**
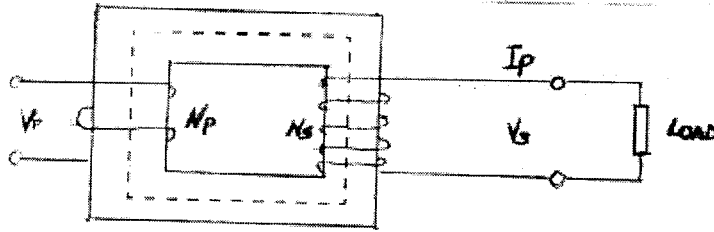
Vs & Vp = primary and secondary voltages.

Np & Ns = primary and secondary windings

The supply voltage will circulate on alternating magnetic flux in the core.

This flux will link with secondary winding to induce emf.

The induced emf will depend on the number of turns in the secondary windings as well as rate of change of magnetic flux.

The winding turns (N) and terminal voltage can be expressed as $\frac{V_p}{V_s}$ $\frac{N_p}{N_s}$

(b) **(i)** 200000 Vplp = Vsls

$$I_p \quad \frac{200000}{11000} = 18.18A$$

(ii) $\frac{V_p}{V_s}$ $\frac{N_p}{N_p}$. Ns = $\frac{N_p \times V_p}{V_p}$ = $\frac{600 \times 240}{11000}$ = 13 turns

Question 13

(a) List **three** metal parts that are exempted from earthing in a domestic installation.

(b) Give **three** reasons why a verification of polarity test is carried out in a completed Domestic installation.

(c) Draw a line diagram of a national grid system showing typical voltages at each stage

This question on domestic installation required the candidates to explain why verification of polarity test is necessary, state the parts that are exempted from earthing and draw a typical national grid system.

The listing of parts that are exempted from earthing in a domestic installation was very well done. However, most of the candidates failed to give three reasons why verification of polarity test is required in a newly completed domestic installation. The required diagram in part (c) of this question also lacked accuracy and completeness.

(a) **Parts Not Earthed**

Metal clips

Metal caps for lamps

Metal chains for suspending fittings

Catenary wire

(b) **Polarity Test**

Done to establish that

(i) All fuses and switches are connected to live conductors only.

(ii) Socket outlets have the live conductor connected to the terminals marked L Neutral to N and earth to E.

(iii) The centre contact of bayonet and Edison screw lamp holder have their outer contacts connected to earth conductors.

(c)
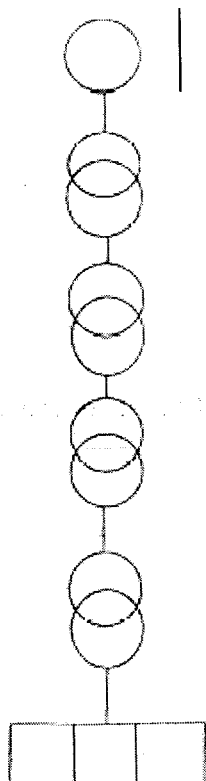
11KV generation

66KV secondary transmission

66KV secondary transmission

33KV h.v. distribution

11KV

415v
240v *utilization*

Question 15

(a)   Draw a labelled circuit diagram of a PNP transistor amplifier in
       Common base configurations.

(b)   Table 1 below shows a bill of materials used to construct a stabilized dc supply.

| No	Description of material	Quantity
1	Double pole switch	1
2	Double wound transformer	1
3	Rectifier diodes	4
4	Electrolytic capacitor	1
5	Carbon resistors	1
6	Zener diode	1
7	Connecting wires	several

       Draw a circuit diagram of the power supply.

A circuit diagram of a PNP transistor was required in part (a) while in part (b) of this question, the candidates were required to come up with a circuit from a given bill of materials.

In part (a), most of the candidates had difficulties in identifying correctly the PNP and giving the correct common configuration. In part (b), majority of the candidates could not draw a complete circuit diagram with all the components included in the circuit. A few candidates also used the wrong symbols for various components.

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Expected Responses

(a)   PNP TRANSISTOR AMPLIFIER
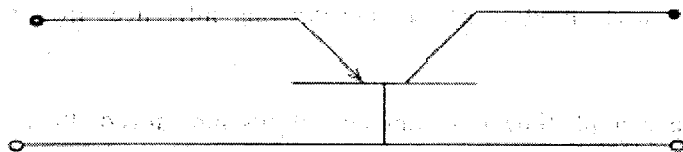
(b)
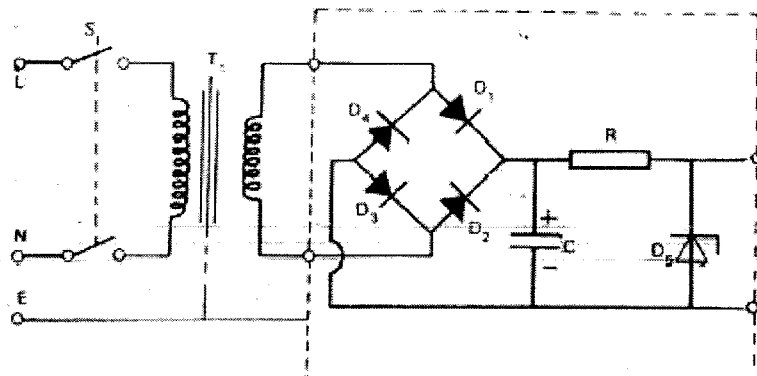
21.3   PAPER 2 (448/2)

Some very good performance in this paper was reported by the chief examiner attributing it to improved tuition. However, relative poor performance was reported particularly in question **1, 2** and **5** where the following skills were tested.

- Connecting various components to complete a circuit
- Measuring current in a circuit with various resistors
- Determining the relationship between total circuit current and the branch current
- Fabricating a sheet metal object from a given drawing.
- Installing a circuit using common house wiring components.

Weaknesses

The following were noted as the main weaknesses displayed by the candidates in this practical paper:
- Inability to fabricate a sheet metal article using basic metalwork tools.
- Failure to connect various components to complete a given circuit and take the necessary measurements.
- Inability to read various measuring instruments accurately.
- Lack of the required speed and accuracy in completing house wiring exercise.

ADVICE TO TEACHERS AND STUDENTS

- Teachers are advised to ensure that the entire syllabus is covered adequately and that the students should be exposed to all the practical activities in the syllabus.

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- Students should take time to read and understand the instructions given in each exercise before they start carrying out the activities.

- Students should be accurate when taking measurements using instruments such as voltmeter onmmeter, micrometer etc. Accuracy is also required when plotting graphs and drawing inferences from the data obtained.

- Teachers should ensure that their students have ample time to manipulate various apparatus on their own.

- Teachers should also ensure that related topics like drawing and metal fabrication are covered adequately.

SECTION A (52 marks)

Answer all the questions in this section.

1   (a)   State **three** conditions required for combustion to take place.

     (b)   Name **three** types of fire extinguishers.   (3 marks)

2   (a)   List **four** types of institutions which offer craft certificate courses in electrical engineering.   (2 marks)

     (b)   Explain the cause of a dry joint on a printed circuit board.   (2 marks)

3   (a)   Name **four** types of capacitors.   (2 marks)

     (b)   Two capacitors having capacitance of $6 \mu F$ and $4 \mu F$ are connected in series across a 200V dc supply.
        Calculate the:

            (i)   voltage across each capacitor;
            (ii)   charge on each capacitor.   (4 marks)

4   (a)   Name two types of secondary cells.   (1 mark)

     (b)   Six cells each of emf 1.5V and internal resistance of 1.2Ω are connected in parallel to supply a load of 10Ω. Calculate the current through the load.   (3 marks)

5   (a)   Determine the resistance of carbon resistor whose colour codes are:

            (i)   green, yellow, brown, gold;
            (ii)   blue, orange, red.   (4 marks)

     (b)   The current through a 0.5H coil of inductance changes 6A to 3A in 0.04 seconds. Calculate the value of e.m.f induced in the coil.   (2 marks)

6   (a)   State **three** characteristics of lines of **magnetic** flux.   (3 marks)

     (b)   State the function of each of the following features of analogue instruments:

            (i)   deflecting;
            (ii)   controlling;
            (iii)   damping.   (3 marks)

7   (a)   Give **three** reasons why copper is commonly used as a conductor material in electrical installations.   (3 marks)

     (b)   State **two** advantages of light gauge pvc conduits over the heavy gauge pvc conduits.   (2 marks)

8   (a)   Compare **two** operational characteristics of silicon diode and Germanium diodes.

                             (2 marks)

    (b)   Sketch a half wave rectifier and its output waveform.   (3 marks)

9   (a)   Sketch a diagram of four pole dc machine and label five main parts.   (5 marks)

    (b)   State **one** possible cause of each of the following symptoms:
                (i)   motor will not reach full speed;
                (ii)   iron box overheats;
                (iii)   fluorescent lamp flickers continuously.   (3 marks)

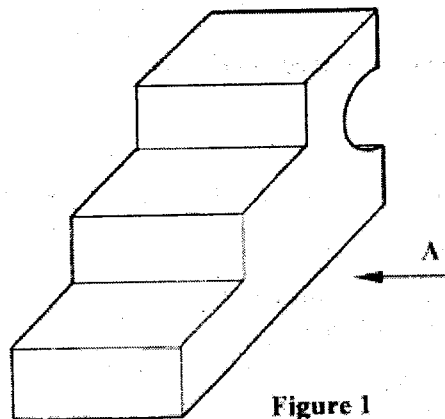10   Figure 1 shows an oblique view of a stepped block.

Figure 1

Sketch in first angle projection the three orthographic views taking the front
elevation in the direction of arrow **A**.   (5 marks)

SECTION B (48 marks)

Answer any **four** questions from this section.

11   (a)   With the aid of a labelled diagram, **explain** the operation of a single phase
            transformer.   (8 marks)

    (b)   A 200 KVA, 11000v/240v 5Hz single phase transformer has 600 turns on the
            primary side. Calculate:
               (i)   the primary and secondary currents;
              (ii)   the number of secondary turns.   (4 marks)

12 (a) Show that the total resistance of two resistors connected in parallel is equal to the product of their resistance divided by the sum of their resistance. (2 marks)

(b) State the meaning of the following terms as applied to alternating current:
- (i) frequency;
- (ii) amplitude;
- (iii) periodic time. (3 marks)

(c) A coil of inductance 30mH and 5Ω resistance is connected across a 240 volt 50 Hz supply. Calculate the:
- (i) circuit current;
- (ii) phase angle;
- (iii) power factor;
- (iv) apparent power;
- (v) active power. (7 marks)

13 (a) List **three** metal parts that are exempted from earthing in a domestic installation. (3 marks)

(b) Give **three** reasons why a verification of polarity test is carried out in a completed domestic installation. (3 marks)

(c) Draw a line diagram of a national grid system showing typical voltages at each stage. (6 marks)

14 With the aid of a diagram, describe the construction and operation of a moving coil instrument. (12 marks)

15 (a) Draw a labelled circuit diagram of a PNP transistor amplifier in common base configurations. (3 marks)

(b) Table 1 below shows a bill of materials used to construct a stabilized dc supply.

No	Description of material	Quantity
1	Double pole switch	1
2	Double wound transformer	1
3	Rectifier diodes	4
4	Electrolytic capacitor	1
5	Carbon resistors	1
6	Zener diode	1
7	Connecting wires	Several

Draw a circuit diagram of the power supply. (9 marks)

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29.11.2   Electricity Paper 2 (449/2)

EXERCISE 1

Using the components, materials and equipment provided, connect the circuit as shown in
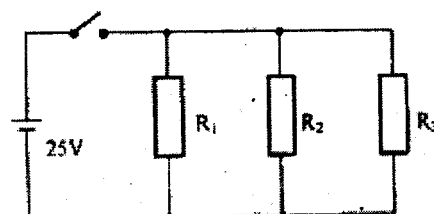figure 1.   (4 marks)

Figure 1

(a)   Measure and record the total circuit current I_T (1 ½ marks)

      I_T ....

(b)   Measure and record the current through each of the following resistors.

      R_1(mA) ....

      R_2(mA) ....

      R_3(mA) ....   (4 ½ marks)

(c)   In the circuit:
    (i)   replace R_3 with R_4 (2 marks)

    (ii)   repeat step (a) above   (1 ½ marks)
        I_T ....

    (iii) repeat step (b) above and record the following:
      R_1(mA) ....

      R_2(mA) ....

      R_3(mA) ....   (4 ½ marks)

(d)   (i)   State the effect on the current when R_3 is replaced with R_4.

                                                                      (1 mark)

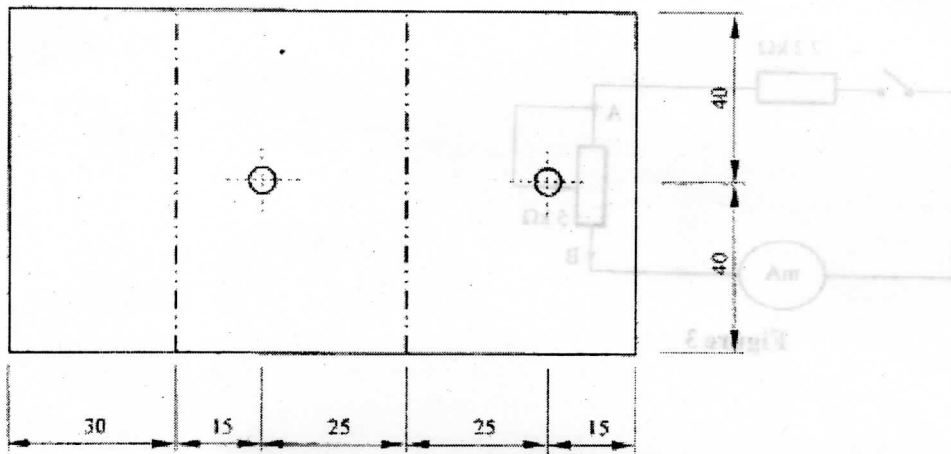   (ii)   State the relationship between total circuit current (I_T) and the branch current.
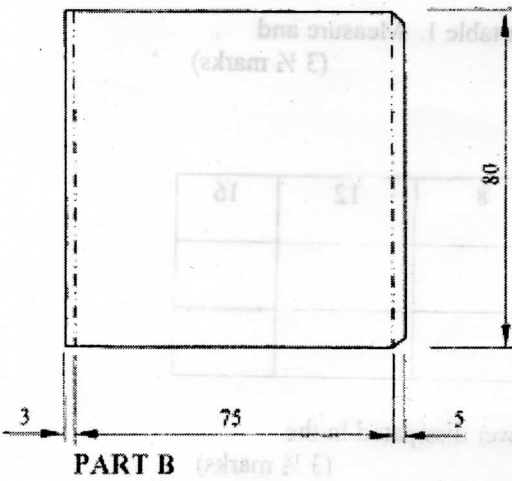   (1 mark)

EXERCISE 2

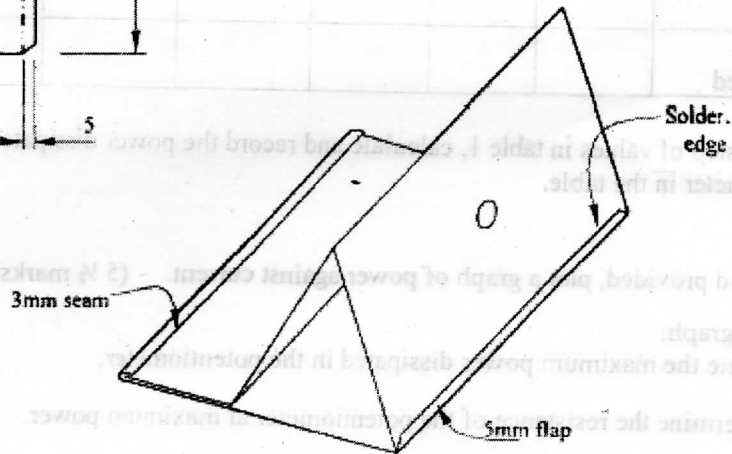Use the tools, equipment and materials provided to make the object shown in figure 2.

(20 marks)

PART A

Dimensions: 30, 15, 25, 25, 15

PART B

Dimensions: 3, 75, 5, 80

Solder. edge

3mm seam

5mm flap

EXERCISE 3

Using the components, materials and equipment provided, connect the circuit as shown in figure 3.
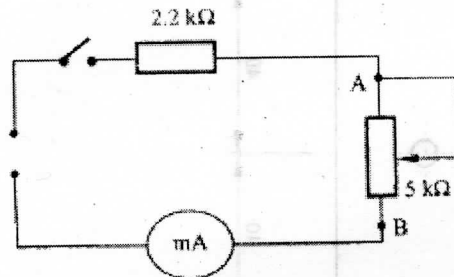
(5 ½ marks)

Figure 3

Perform the following tasks:

(a) Vary the potentiometer to obtain each of the voltages shown in table 1. Measure and record corresponding currents. (3 ½ marks)

Table 1

Voltage (v) across AB	0	2	4	6	8	12	16
Current (mA)							
Power Dissipated							

(b) For each step of values in table 1, calculate and record the power dissipated in the potentiometer in the table. (3 ½ marks)

(c) On the grid provided, plot a graph of power against current. (5 ½ marks)

(d) From the graph:
   (i) state the maximum power dissipated in the potentiometer.

   (ii) determine the resistance of the potentiometer at maximum power. (2 marks)

EXERCISE 4

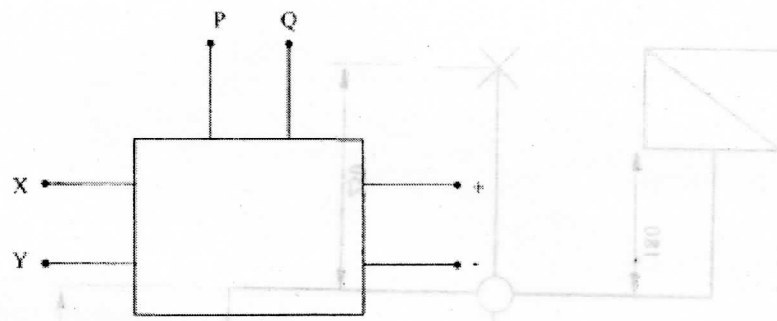Figure 4 shows a block diagram of the prefabricated transistor amplifier circuit provided.

Figure 4

Perform the following tasks:

(a) Connect:

   (i) the microammeter to points PQ to measure base current.

     base current:...

   (ii) the milliammeter to points XY to measure collector current.

     collector current: ....   (2 marks)

(b) Turn the switch to the ON position.

(c) Adjust R_1 to obtain each of the base current values in table 2. Measure and record the corresponding collector current.

Table 2

BASE CURRENT (μA)	COLLECTOCR CURRENT (μA)
10	
20	
30	
40	
50	

(5 marks)

(d) Using the values in table 2, plot the graph of I_C against I_B.   (4½ marks)

(e) From the graph, determine the Beta (β) of the transistor.   (2 marks)

(f) Draw a schematic diagram of the circuit.   (6½ marks)

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EXERCISE 5

Figure 5 shows a layout of a lighting circuit. Using PVC sheathed wiring system, install the circuit such that the lamp is controlled independently by S_1 and S_2.   (20 marks)
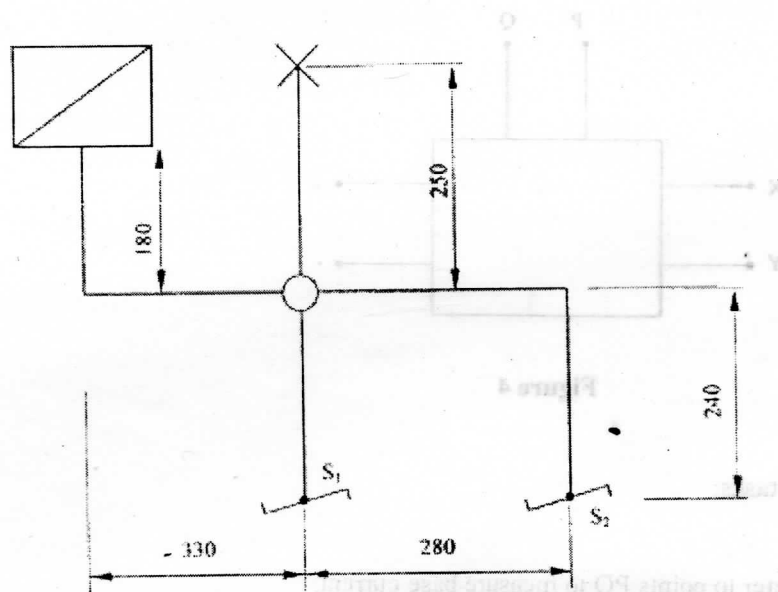

Figure 5

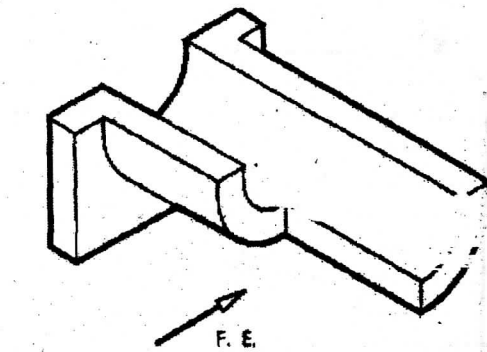**10**   Figure 5 shows an isometric view of a machined block.

Figure 5

(6 marks)

Sketch the orthographic views of the block in first angle orthographic projection.

SECTION B (30 marks)

11   Figure 6 shows components of a guide pulley and bearing.
Assemble the components with the pulley on the right hand side and draw FULL
SIZE in third angle projection:
(a)   the front elevation;
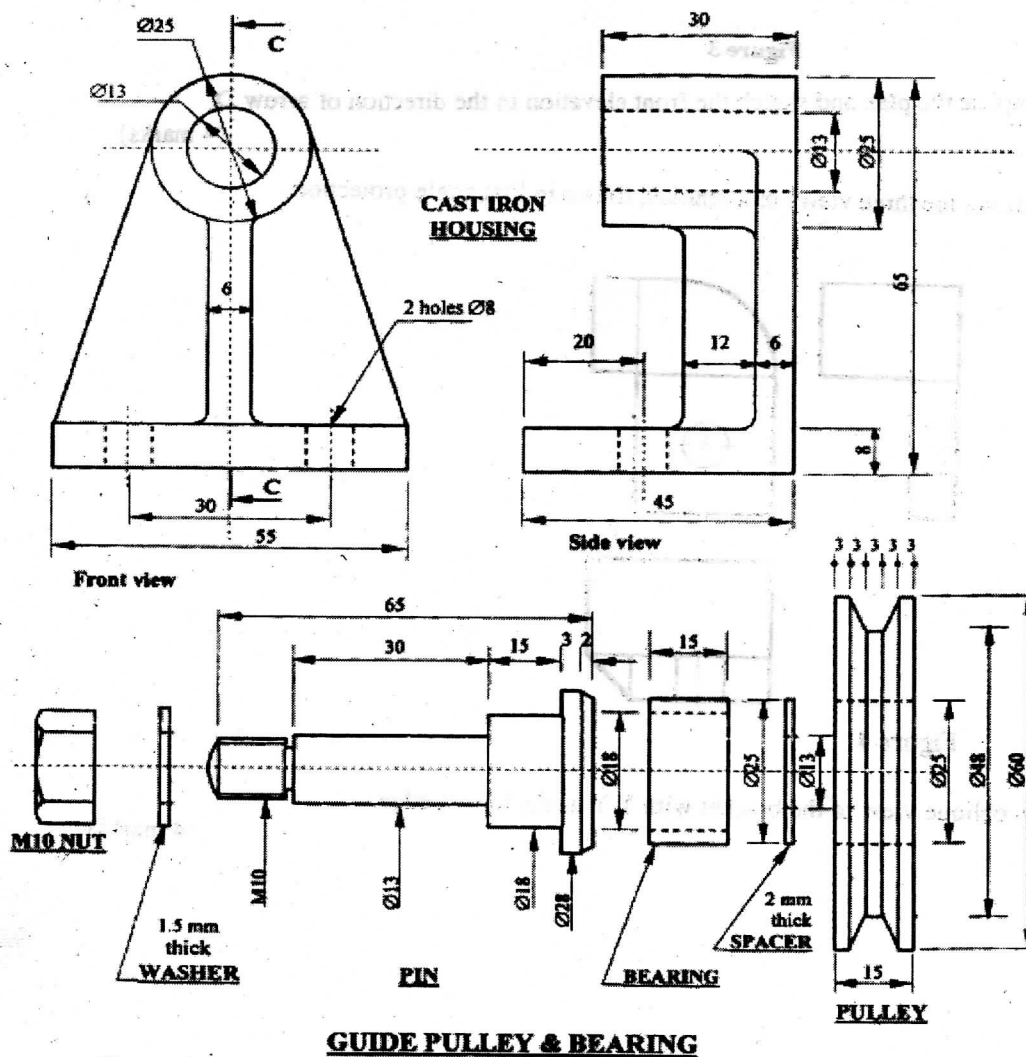(b)   sectional end elevation along the cutting plane C-C.

GUIDE PULLEY & BEARING

Figure 6

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ELECTRICITY (448)

30.18.2   Electricity Paper 1 (448/1)

1. (a)   CONDITIONS FOR COMBUSTION
   Fuel
   Oxygen
   Heat   (3 x ½)

   (b)   TYPES OF EXTINGUISHERS
   Carbon dioxide
   Dry powder
   Water
   Foam   Any (3 x ½)

2. (a)   TYPES OF INSTITUTIONS
   Technical Training Institute
   National Polytechnics
   Institutes of technology
   Youth polytechnics

                                                                   Any (4 x ½)

   (b)   DRY JOINT
   Occurs if solder was not enough when joint was made.   (2 marks)

3. (a)   CAPACITORS
   Air capacitor
   Paper
   Mica
   Electrolytic
   Tantalum   Any (4 x ½)

   (b)   (i) $V_1 = 200 \, x \, \dfrac{4}{4+6} = 80V$

                 $V_2 = 200 - 80 = 120V$

          Charge is the same on each capacitor.
          $Q = CV = 6 \, x \, 10^6 \, x \, 80 = 0.00048C$ (4 x 1)

4.   SECONDARY CELLS
      Lead acid and alkaline.   (2 x ½)

   (b)   Total EMF = 1.5V
          Total Internal resistance $= \dfrac{v}{R} = \dfrac{1.2}{6} = 0.2\Omega$

   Total circuit resistance $= R + r = 10 + 0.2 = 10.2\Omega$ (3 x 1)

5. (a)   RESISTANCE
          (i) $54 \, x \, 10^1 \, \Omega \pm 5\% = 540\Omega \pm 5\%$

          (ii) $63 \, x \, 10^2 \, \Omega \pm 20\% = 6.3K\Omega \pm 20\%$ (2 x 2)

          $\dfrac{\Delta i}{\Delta t} = \dfrac{3-6}{0.04} = 75 \, amps \, per \, sec.$

   (b)   Average emf $= -t\dfrac{di}{dt} = 0.5 \, x - 75 = 37.5V$ (2 x 1)

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6. (a) MAGNETIC INFLUX
        form closed loop.
        do not intersect.
        they are elastic.
        lines of same polarity repel or vice versa.

                                                    Any (3 x 1)

    (b) Deflecting device - moves pointer over the instruments scale to enable quantities
         to be measured.

         Controlling device - allows the pointer to stop so that the scale can be read. Also
         allows pointer to return to zero.

         Damping device - prevents the pointer form oscillating to enhance steady value reading.
                                                    Any (3 x 1).

7. (b) LIGHT GAUGE PVC CONDUIT
         -   Saves time during installation.
         -   no burrs left in conduit after cutting.
         -   simplifies routing conduit round corners.
         -   Nail holes close up to avoid entry of moisture.
         -   Less costly.   Any (2 x 1)

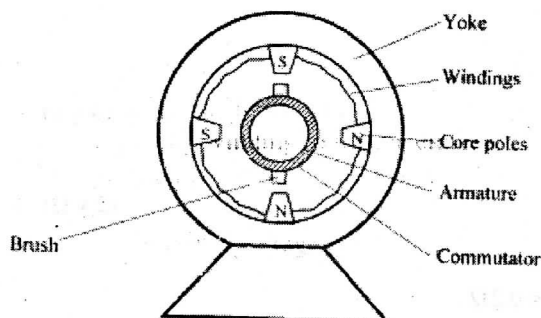8. (a) Forward voltage is roughly double that of germanium diodes.
         Can withstand higher reverse voltage.
         Can operate at temperatures upto 150^0 -200^0 compared to 75^0 - 90^0c.
                                                    Any (2 x 1)

    (b)

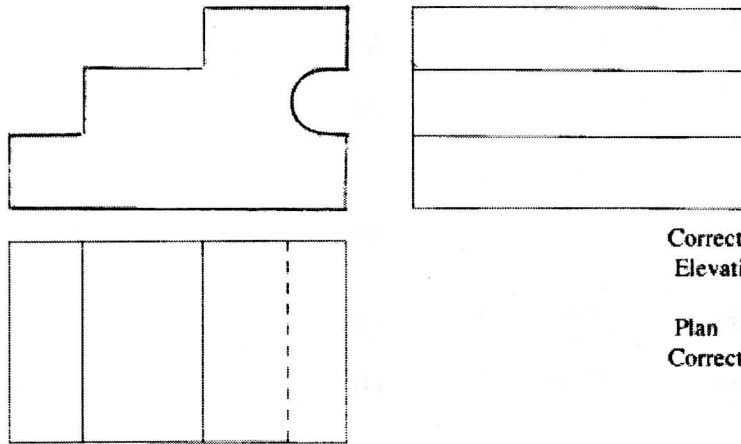   (2 marks)
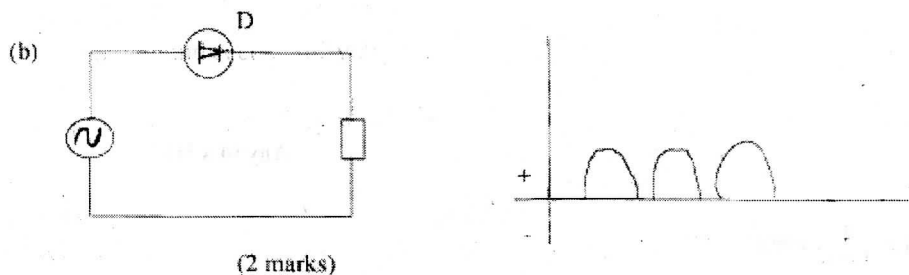
9. (a)

         Sketching 5 parts x ½ = 2½

         Labeling any 5 parts x ½ = 2½

    (b) (i)   overload or low supply
         (ii)   faulty thermostart
         (iii) faulty or loose starter or
         (iv)   low voltage or aged lamp
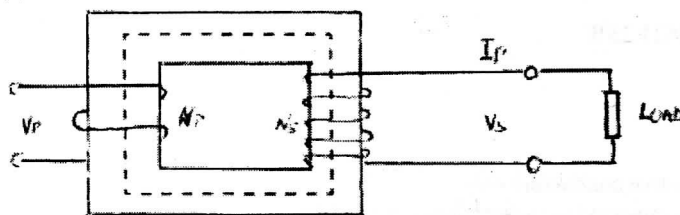
                                                    (3 x 1)

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10.

Correct projection	I	
Elevations : FE	I	
EE	I½	
Plan	I	
Correct proportion	½	
Total	5	

11. (a)

Vs & Vp = primary and secondary voltages.

Np & Ns = primary and secondary windings.

Sketch:
Primary side (1)
Secondary side (1)
Core (1)
Flow of magnet influx (1)

The supply voltage will circulate on alternating magnetic flux in the core.
This flux will link with secondary winding to induce emf.
The induced emf will depend on the number of turns in the secondary windings as well as rate of change of magnetic flux.
The windings turns (N) and terminal voltage can be expressed as   (4 x 1)

$$\frac{Vp}{Vs} = \frac{Np}{Ns}$$

11. (b) (i) $200000 = VpIp = VsIs$

$$Ip = \frac{200000}{11000} = 18.18A$$ (2½ marks)

(ii) $\frac{Vp}{Vs} = \frac{Np}{Ns}$. $Ns = \frac{Np \times Vp}{Vp} = \frac{600 \times 240}{11000} = 13\ turns$ (1½ marks)

12. (a)   Let resistors be R_1 and R_2

Total resistance $\frac{1}{R_T} = \frac{1}{R_1} + \frac{2}{R_2} \Longrightarrow \frac{1}{R_T} = \frac{R_1 + R_2}{R_1 R_2}$ then $R_T = \frac{R_1 + R_2}{R_1 R_2}$ (2 marks)

(b)   Frequency - the number of cycles per second.
Amplitude - the peak or maximum value measured.
Periodic time - time taken to complete a cycle.   (3 x 1)   (3 marks)

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(c) (i) $X_l = 2\pi fl = 2 \times 3.14 \times 50 \times 0.03 = 9.42\Omega$ (1)

Impendance $Z = \sqrt{5^2 + (9.42)^2} = 10.66\Omega$ (1)

Current $I = \dfrac{V}{Z} = \dfrac{240}{10.66} = 22.5A$ (1)

(ii) $\tan X = \dfrac{Xl}{R} = \dfrac{9.42}{5} = 1.884 = 62.04^{\circ}$ (1)

(iii) Power factor $= Cos\phi = Cos\, 62.04 = 0.4688$ (1)

(iv) Apparent power $= VI = 240 \times 22.5 = 5400W$ (1)

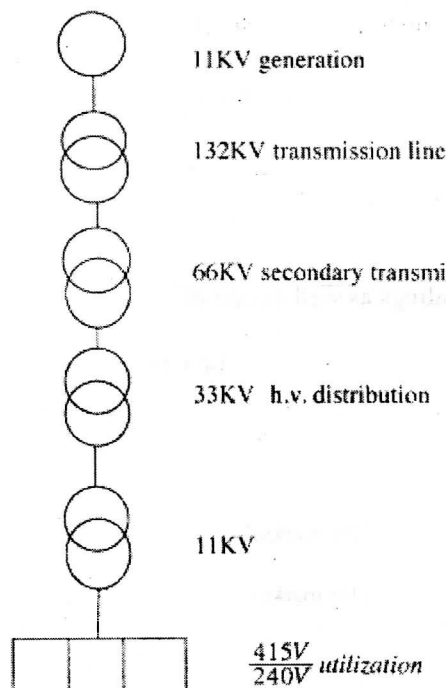(v) Active power $= VI \cos\phi = 5400 \times 0.4688 = 2531.52W$ (1)
or alternatively
or $P = I^2 R = 22.5 \times 5^2 = 2531.25W$
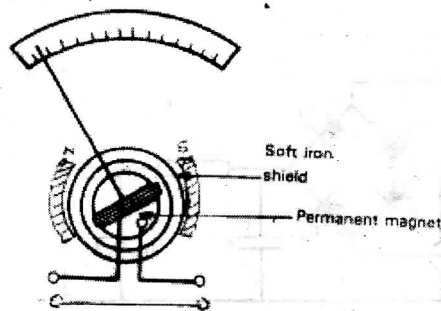
(b) POLARITY TEST
Done to establish that
(i)   All fuses and switches are connected to live conductors only.
(ii) Socket outlets have the live conductor connected to the terminals marked L,
      Neutral to N and earth to E.
(iii) The centre contact of bayonet and Edison screw lamp holder have their outer
      contacts connected to earth conductors.   (3 x 1)

(c)

11KV generation

132KV transmission line

66KV secondary transmission

33KV h.v. distribution

11KV

$\dfrac{415V}{240V}$ utilization

6 x 1

550

14.

(6 x ½)

The moving coil instrument consist of a coil made of copper wire wound in rectangular frame and situated in a magnetic field. (2 x 1)

The pointer is mounted on bobbin (1)

The frame is attached to highly polished pivot which rests on jewels and rotates with minimum friction. (1)

The controlling device has two hair springs wound in the opposite direction. (1)

OPERATION

When the current flows in the coil, it becomes an electromagnetic producing its own magnetic field.
The coil field interacts with the permanent magnetic field to producing a turning force.

The magnitude of the turning force is determined by the current through the coil.

Damping is achieved by eddy current and involve an aluminium device for damping.
(4 x 1)

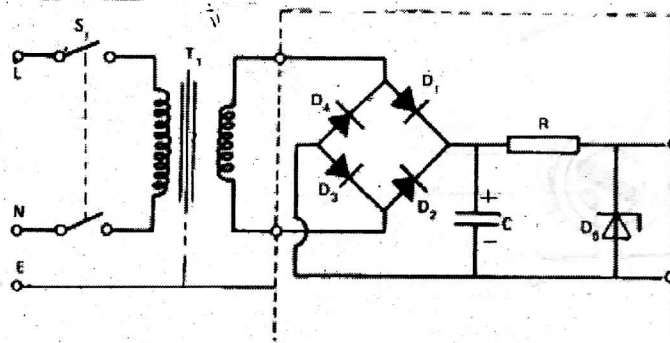15. (a) PNP TRANSISTOR AMPLIFIER
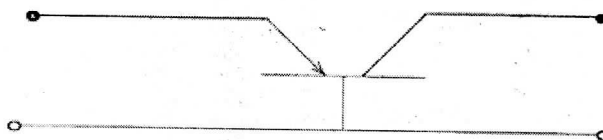
Correct identification of PNP (1)
Common base configuration (1)
Labelling input and output (1)

551

(b)

Correct circuit connection:
-Switch to transformer primary
-Transformer secondary to bridge
-Bridge to capacitor
-Capacitor to resistor
-Resistor to Zener

(5 x 1)

Correct polarity (1)
Correct bridge (3)

Total 9 marks