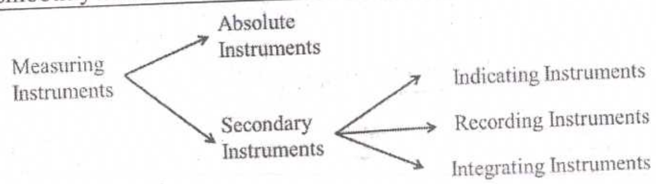
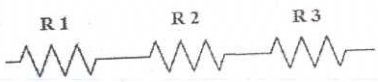
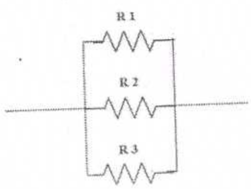
ANSWER KEY &SCHEME OF VALUATION

(Scoring Indicators)

Course Code: 3021

Revision : 2015

Course Title : Electrical & Electronics Engineering

Qst. No	Scoring Indicator	Split up score	Total
I	**Part A**		
1	The time taken by an alternating quantity to complete one cycle and is denoted by T.	2	2
2	Constant voltage Charging , Constant current Charging	1+1	2
3	•Its efficiency is more when compared with the conventional one. •Its size is relatively very smaller. •Voltage Regulation of auto transformer is much better. •Lower cost •Low requirements of excitation current. •Less copper is used in its design and construction. •In conventional transformer the voltage step up or step down value is fixed while in auto transformer, we can vary the output voltage as per out requirements and can smoothly increase or decrease its value as per our requirement.	1+1 (any 2)	2
4		2	2
5	Carbon Composition Resistors, Wire wound Resistors, Thin Film Resistors, Carbon Film Resistors, Metal Film Resistors, Thick Film Resistors, Metal Oxide Resistors, Cermet Oxide Resistors	1+1 (Any 2)	2
II	**PART B**		
1	 Resistor in series, $R_{eq} = R_1 + R_2 + R_3$  Resistor in Parallel, $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	3+3	6

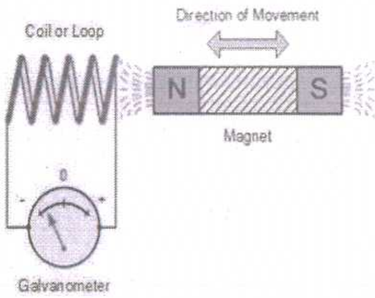
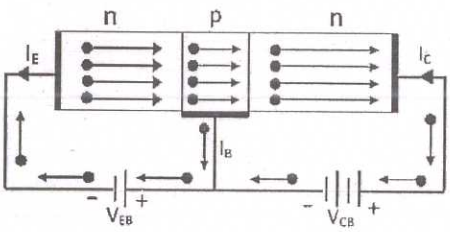
<table>
<tr><td>2</td><td>1st Law- Whenever a conductor cuts the magnetic flux; an emf is induced in the conductor.
2nd Law- The magnitude of the induced emf is equal to the rate of change of flux linkages.


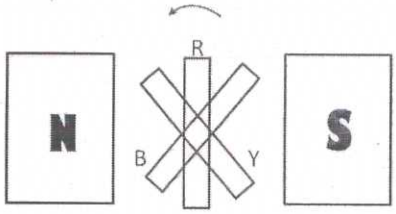
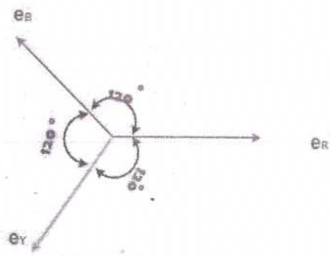
Figure shows the arrangement to study the production of emf from magnetism. A bar magnet is placed close to the coil and connects a galvanometer across the coil. At starting, the magnet is at rest, so there is no deflection in the galvanometer i.e. the needle of the galvanometer is at the centre or zero position. When the magnet is moved towards the coil, the needle of the galvanometer deflects in one direction.
When the magnet is held stationary at that position, the needle of galvanometer returns to zero position. Now when the magnet moves away from the coil, there is some deflection in the needle but opposite direction, and again when the magnet becomes stationary, at that point respect to the coil, the needle of the galvanometer returns to the zero position. Similarly, if the magnet is held stationary and the coil moves away, and towards the magnet, the galvanometer similarly shows deflection. It is also seen that the faster the change in the magnetic field, the greater will be the induced EMF or voltage in the coil.
Induced emf, $e = \frac{changeoffluxlinkage}{time}$
$e = \frac{-Nd\varphi}{dt}$ volt.</td><td>1

1

4</td><td>6</td></tr>
<tr><td>3</td><td>The main functions of starter are to limit heavy starting current in armature circuit during starting.

In case of dc motor $I_a = \frac{V-E_b}{R_a}$ and $E_b = \frac{\emptyset ZNP}{60\ A}$ So during starting, speed (N) is zero. Hence back emf E b is zero. If the armature resistance is very small then armature current will be very large. This excess armature current may damage the winding. To avoid this excessive starting current, the starter is needed in the circuits of the armature. In the starter, additional resistance is connected in series with armature at the time of starting.</td><td>6</td><td>6</td></tr>
<tr><td>4</td><td>• Power transformers are used in transmission network of higher voltages whereas the Distribution Transformers are used in the distribution network of lower voltages.
• The power transformers are available in various ratings of 400 KV, 200 KV, 110 KV, 66 KV, 33 KV in the market and the distribution transformer are available in 11 KV, 6.6 KV, 3.3 KV, 440 V, 230 Volts.
• The power transformer always operates on rated full load as the load fluctuation is very less but the distribution transformer is operated at the load less than full load as the variation in the loads are very high.
• The power transformers are designed for maximum efficiency of 100%, and the efficiency is simply calculated by the ratio of output power to the input power, whereas the distribution transformer the maximum efficiency varies between 50-70% and calculated by All Day Efficiency.
• Power transformers are used in power generating stations and transmission substations, and the distribution transformer is installed at the distribution</td><td>Any 4, 1.5 marks each</td><td>6</td></tr>
</table>

	stationsfrom where the power is distributed for the industrial and domestic purposes. • The size of the power transformer is large as compared to the distribution transformers. • In Power Transformer, the iron and copper losses take place throughout the day but in distribution transformer the iron loss takes place 24 hours i.e., throughout the day, and the copper losses depend on the load cycle.		
5	• These instruments can be used both on A.C and D.C system. • These instruments are robust and free from maintenance • It possesses high starting torque. • It can withstand momentary overloads. • It can give reasonable accuracy in the reading. • In this instrument the scale is non-uniform.	Any 4, 1.5 marks each	
6	The transistor in which one p-type material is placed between two n-type materials is known as NPN transistor. The NPN transistor amplifies the weak signal enter into the base and produces strong amplify signals at the collector end. In NPN transistor, the direction of movement of an electron is from the emitter to collector region due to which the current constitutes in the transistor. Such type of transistor is mostly used in the circuit because their majority charge carriers are electrons which have high mobility as compared to holes. The circuit diagram of the NPN transistor is shown in the figure below. The forward biased is applied across the emitter-base junction, and the reversed biased is applied across the collector-base junction. The forward biased voltage V_{EB} is small as compared to the reverse bias voltage V_{CB}.  The emitter of the NPN transistor is heavily doped. When the forward bias is applied across the emitter, the majority charge carriers move towards the base. This causes the emitter current IE. The electrons enter into the P-type material and combine with the holes. The base of the NPN transistor is lightly doped. Due to which only a few electrons are combined and remaining constitutes the base current I_B. This base current enters into the collector region. The reversed bias potential of the collector region applies the high attractive force on the electrons reaching collector junction. Thus attract or collect the electrons at the collector. The whole of the emitter current is entered into the base. Thus, we can say that the emitter current is the sum of the collector and the base current.	Fig 2+ Exp 4	6
7	• Replacing human operators in tasks that involve hard physical labor. • Replacing human in task done in dangerous environment such as fire space, volcanos, nuclear facilities, underwater etc • Performing tasks that are beyond human capabilities of size, weight, speed, endurance etc. • Automation may involve in economy of enterprises, society or most humanity. When an enterprise invests in automation,technology recovers its investment. • Reduces operation time and work handling time significantly.	Any 4, 1.5 marks each	6

	PART C		
III a	According to Faraday's law of electromagnetic induction, we know that whenever acoil is rotated in a magnetic field, there is a sinusoidal emf induced in that coil. Now, we consider 3 coil C1(R-phase), C2(Y-phase) and C3(B-phase), which are displaced 120^0 from each other on the same axis. This is shown in fig. The coils are rotating in a uniform magnetic field produced by the N and S pols in the counter clockwise direction with constant angularvelocity. According to Faraday's law, emf induced in three coils. The emf induced in these threecoils will have phase difference of 120^0. i.e. if the induced emf of the coil C1 has phase of0^0, then induced emf in the coil C2 lags that of C1 by 120^0 and C3 lags that of C2 by 120^0.  Thus, we canwrite, $e_R = E_m \sin \omega t$ $e_Y = E_m \sin(\omega t - 120°)$ $e_B = E_m \sin(\omega t - 240°)$ The above equation can be represented by their phasor diagram as below  Phasor Diagram of Three Phase EMF	2 3 3	15
B	When the sulphuric acid dissolves, its molecules break up into positive hydrogen ions ($2H^+$) and sulphate negative ions ($SO4^{--}$) and move freely. If the two electrodes are immersed in solutions and connected to DC supply then the hydrogen ions being positively charged and moved towards the electrodes and connected to the negative terminal of the supply. The $SO4^{--}$ ions being negatively charged moved towards the electrodes connected to the positive terminal of the supply main (i.e., anode). Each hydrogen ion takes one electron from the cathode, and each sulphates ions takes the two negative ions from the anodes and react with water and form sulphuric and hydrogen acid. The oxygen, which produced from the above equation react with lead oxide and form lead peroxide (PbO_2.) Thus, during charging the lead cathode remain as lead, but lead anode gets converted into lead peroxide, chocolate in colour.	Fig 2+ Exp5	

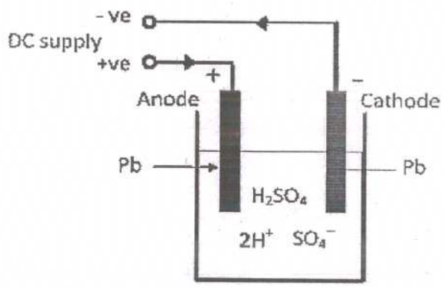
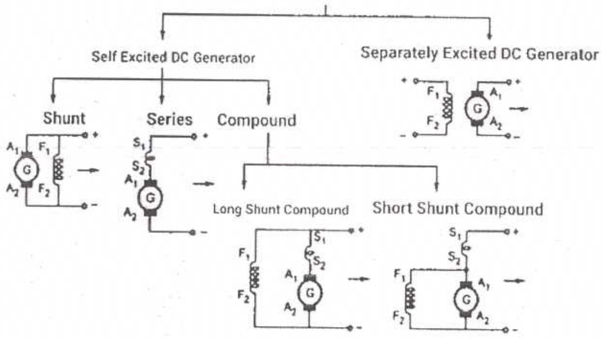
<table>
<tr><td></td><td>If the DC source of supply is disconnected and if the voltmeter connects between the electrodes, it will show the potential difference between them. If wire connects the electrodes, then current will flow from the positive plate to the negative plate through external circuit i.e. the cell is capable of supplying electrical energy.

</td><td></td><td></td></tr>
<tr><td>IV a</td><td>Separately excited Generator are those whose field magnets are energized from an independently external dc source
Self-excited generator is those whose field magnets are energized by the current produced by the generators themselves. Due to residual magnetism there is always present some flux in the poles. When the armature is rotated, some emf and hence some induced current is produced which is partly or fully passed through the field coils thereby strengthening the residual pole flux.
There are three types of Self-excited generator
Shunt wound- The field windings are connected across or in parallel with the armature conductors and have the full voltage of the generator applied across them.
Series wound -The field windings are connected in series with the armature conductors. As they carry full load current, they consist of few turns of thick wire or strips.
Compound wound- It is a combination of a few series and a few shunt windings and can be either short shunt or long shunt. In a compound generator, the shunt field is stronger than the series field. When series field aids the shunt field, generator is said to be commutatively compound. On the other hand if series field opposes the shunt field, the generator is said to be differentially compound.
Types of DC Generators

</td><td>Fig 4
+Exp 4</td><td>15</td></tr>
<tr><td>B</td><td>Suppose due to load impedance the current lags the applied voltage in each phase of the system by an angle ϕ. As we have considered that the system is perfectly balanced, the magnitude of current and voltage of each phase is the same. Let us say, the magnitude of the voltage across the R phase i.e. magnitude of the voltage between neutral point (N) and R phase terminal (R) is V_R.
Similarly, the magnitude of the voltage across Y phase is V_Y and the magnitude of the voltage across B phase is V_B.
In the balanced star system, magnitude of phase voltage in each phase is V_{ph}.
$\therefore V_R = V_Y = V_B = V_{ph}$</td><td>Exp 3+

Fig 2+2</td><td></td></tr>
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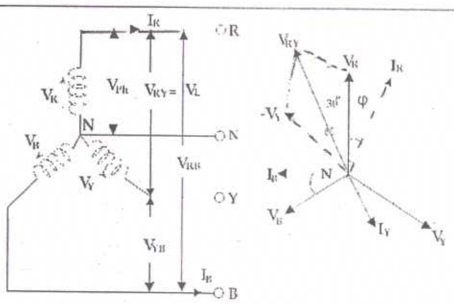


In the star connection, line current is same as phase current. The magnitude of this current is same in all three phases and say it is I_L. $\therefore I_R = I_Y = I_B = I_L$, Where, I_R is line current of R phase, I_Y is line current of Y phase and I_B is line current of B phase. Again, phase current, I_{ph} of each phase is same as line currentI_L in star connected system.

$\therefore I_R = I_Y = I_B = I_L = I_{ph}$.

The voltage across R and Y terminal of the star connected circuit is V_{RY}.

From the diagram, it is found that

$V_{RY} = V_R + (-V_Y)$

The angle between V_R and $-V_Y$ is $180^\circ - 120^\circ = 60^\circ$(electrical).

$$V_L = V_{RY} = \sqrt{V_R^2 + V_Y^2 + 2V_R V_Y \cos 60^\circ}$$

$$= \sqrt{V_{ph}^2 + V_{ph}^2 + 2V_{ph}V_{ph} * \frac{1}{2}}$$

$$= \sqrt{3}V_{ph}$$

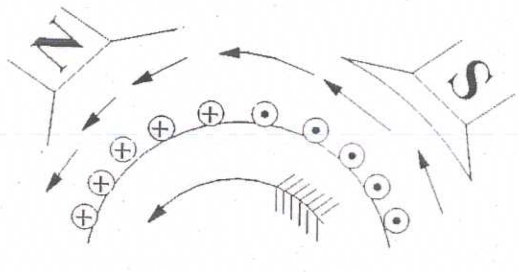
Thus, for the star-connected system line voltage = √3 × phase voltage.

Line current = Phase current

V a | Fig 2+ Exp6 | 15

A machine that converts DC electrical power into mechanical power is known as a Direct Current motor. DC motor working is based on the principle that when a current carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force. The direction of this force is given by Fleming's left-hand rule and magnitude is given by;

F = BIL Newtons



All conductors under North-pole carry currents in one direction while all the conductors under South-pole carry currents in the opposite direction. The armature conductors under N-pole carry currents into the plane of the paper (denoted as ⊗ in the figure). And the conductors under S-pole carry currents out of the plane of the paper (denoted as ⊙ in the figure).Since each armature conductor is carrying current and is placed in the magnetic field, a mechanical force acts on it.

On applying Fleming's left-hand rule, it is clear that force on each conductor is tending to rotate the armature in the anticlockwise direction. All these forces add together to produce a driving torque which sets the armature rotates.

When the conductor moves from one side of a brush to the other, the current in that conductor is reversed. At the same time, it comes under the influence of the next pole which is of opposite polarity. Consequently, the direction of the force on the conductor remains the same.

<table>
<tr>
<td></td>
<td>It should be noted that the function of a commutator in the motor is the same as in a generator. By reversing current in each conductor as it passes from one pole to another, it helps to develop a continuous and unidirectional torque.</td>
<td></td>
<td></td>
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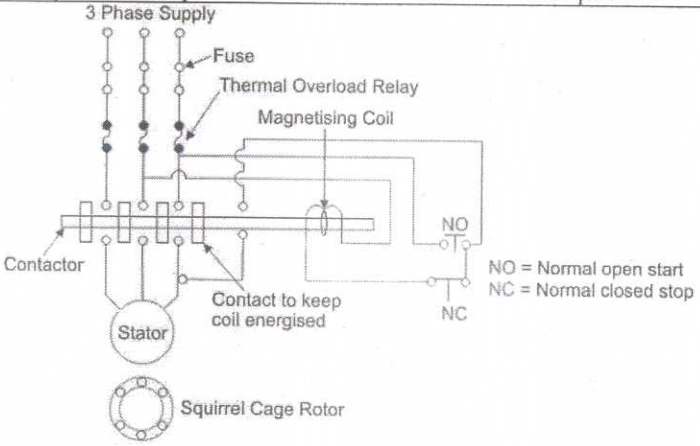
<tr>
<td>B</td>
<td>



Induction motor is started directly, it will draw large amount of current which causes damage to adjoining equipment. Thus, a starter is needed in order to limit the starting current, after the motor has started at reduced starting current and hence reduced voltage; the connections are diverted towards the mains supply.

The wiring diagram for a DOL starter is shown below. A direct online starter consists of two buttons, a GREEN button for starting and a RED for stopping purpose of the motor. The DOL starter comprises of an MCCB or circuit breaker, contactor and an overload relay for protection. These two buttons, i.e. Green and Red or start and stop buttons control the contacts.

To start the motor, we close the contact by pushing Green Button, and the full line voltage appears to the motor. A contactor can be of 3 poles or 4-poles. Below given contactor is of 4-pole type. It contains three NO (normally open) contacts that connect the motor to supply lines, and the fourth contact is "hold on contact" (auxiliary contact) which energizes the contactor coil after the start button is released. If any fault occurs, the auxiliary coil gets de-energized, and hence the starter disconnects the motor from supply mains.

The working principle of a DOL starter begins with the connection to the 3-phase main with the motor. The control circuit is connected to any two phases and energized from them only. When we press the start button, the current flows through contactor coil (magnetizing coil) and control circuit also. The current energises the contactor coil and leads to close the contacts, and hence 3-phase supply becomes available to the motor.

If we press the stop button, the current through the contact becomes discontinued, hence supply to the motor will not be available, and the similar thing will happen when the overload relay operates. Since the supply of motor breaks, the machine will come to rest. The contactor coil (Magnetizing Coil) gets supply even though we release start button because when we release start button, it will get supply from the primary contacts.

</td>
<td>Fig 4+

Exp 3</td>
<td></td>
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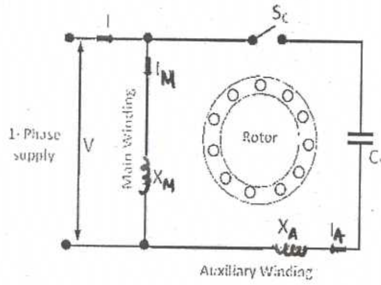
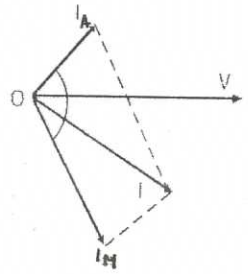
<tr>
<td>VI a</td>
<td>





</td>
<td>Fig (2+2)+

Exp 4</td>
<td>15</td>
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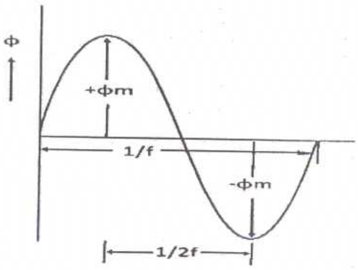
</table>

A Capacitor Start Motors are a single phase Induction Motor that employs a capacitor in the auxiliary winding circuit to produce a greater phase difference between the current in the main and the auxiliary windings. The name capacitor starts itself shows that the motor uses a capacitor for the purpose of the starting.
The capacitor start motor has a cage rotor and has two windings on the stator. They are known as the main winding and the auxiliary or the starting winding. The two windings are placed 90 degrees apart. A capacitor C_S is connected in series with the starting winding. A centrifugal switch S_C is also connected in the circuit.
I_M is the current in the main winding which is lagging the auxiliary current I_A by 90 degrees as shown in the phasor diagram above. Thus, a single phase supply current is split into two phases. The two windings are displaced apart by 90 degrees electrical, and their MMF's are equal in magnitude but 90 degrees apart in time phase.
The motor acts as a balanced two-phase motor. As the motor approaches its rated speed, the auxiliary winding and the starting capacitor is disconnected automatically by the centrifugal switch provided on the shaft of the motor.

B



7

Let
ϕ_m be the maximum value of flux in Weber
f be the supply frequency in Hz
N_1 is the number of turns in the primary winding
N_2 is the number of turns in the secondary winding
As shown in the above figure that the flux changes from $+\phi_m$ to $-\phi_m$ in half a cycle of 1/2f seconds.

By Faraday's Law

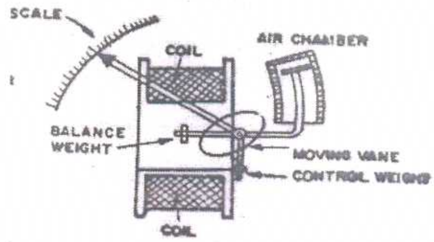
Let E_1 is the emf induced in the primary winding
$E_1 = -N_1 \frac{d\varphi}{dt}$......(1)
Since ϕ is due to AC supply $\phi = \phi_m$ Sinwt

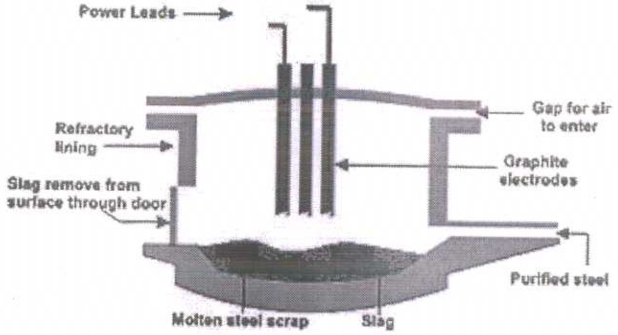
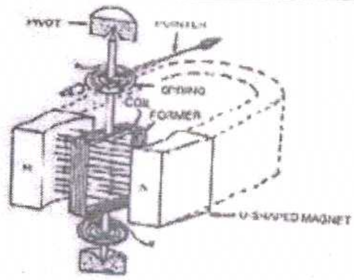
$E_1 = -N_1 \frac{d}{dt}(\varphi_m \sin \omega t)$....(2)

$E_1 = -N_1 \omega(\varphi_m \cos \omega t)$

$E_1 = N_1 \omega \varphi_m \sin(\omega t - \pi/2)$.....(3)

Maximum valve of emf $E_1 max = N_1 \omega \varphi_m$ ....(4)
But $\omega = 2\pi f E_1 max = 2\pi f N_1 \varphi_m$ ....(5)
Root mean square RMS value is $E_1 = \frac{E_1 max}{\sqrt{2}}$....(6)
Putting the value of E_1max in equation (6) we get $E_1 = \sqrt{2}\pi f N_1 \varphi_m$...(7)
Putting the value of $\pi = 3.14$ in the equation (7) we will get the value of E_1 as
$E_1 = 4.44 f N_1 \varphi_m$....(8)
Similarly $E_2 = 4.44 f N_2 \varphi_m$....(9)

VII a	Moving iron instrument works on the principle of magnetism. i.e., A magnet attracts the iron piece or unlike magnetic poles attract each other.  **Construction and working** It consists of a fixed air core coil made by insulated copper wire and an oval shaped soft iron disc fitted on a spindle. The spindle is pivoted between two jeweled bearings near to the coil. A pointer is attached to the spindle, which moves on a pre-calibrated non-uniform scale. The deflecting torque is produced by current passing through the coil (magnetic effect of electric current). The controlling torque is provided by either gravity or spring control method and damping is by air friction method. When the instrument is connected in a circuit, the current passing through the coil will produce a magnetic field and attracts the iron disc inside. Along with the disc, spindle also rotates and causes the pointer to move on the scale. The deflection of the pointer is depends on the magnitude of current passing through the coil. If the current in the coil changes its direction, the polarity of induced magnetic field also changes. In that case also, the coil attracts the iron disc inside the coil by inducing opposite polarity in it. Hence these types of instruments can be used for AC and DC. The attraction force is directly proportional to square of current ($F \alpha I^2$). Therefore, the scale is crowded/cramped at starting and finishing ends. **Applications** The Moving Iron attraction type instrument can be used for AC and DC measurements (Voltmeter and Ammeter)	Fig 4+ Exp 4	15
B	The electric furnace is a large firebrick lined erect vessel. The main parts of electric furnace are the roof, hearth (lower part of a furnace, from where molten metal is collected), electrodes, and side walls. The roof consists of three holes through which the electrodes are inserted. The roof is made up of alumina and magnesite-chromite bricks. The hearth includes metal and slag. The tilting mechanism is used to pour the metal that is molten to the cradle by shifting the furnace. For the electrode removal and furnace charging (topping up scrap metals), roof retraction mechanism is incorporated. The provision for fume extraction is also given around the furnace considering the health of operators. In AC electric furnace, electrodes are three in number. These are round in section. Graphite is used as electrodes because of high electric conductivity. Carbon electrodes are also used. The electrodes positioning system helps to raise and lower the electrodes automatically. The electrodes get highly oxidized when the current density is high. The working of electric furnace includes charging the electrode, melting the metal and refining. The heavy and light scrap in the large basket is preheated with the help of exhaust gas. For speeding up the slag formation, burnt lime and spar are added to it. The charging of furnace takes place by swinging the roof of the furnace. As per requirement, the hot metal charging also takes place. The electrodes are moved down onto the scrap in this period. Then the arc is produced between the electrode and metal. Low voltage is selected for this after the arc is shielded by electrodes, the voltage is increased for speeding up the melting process. In this process, carbon, silicon, and manganese get oxidized. The lower current is required for large arc production. Refining process starts during melting. The removal of sulfur is not essential for single oxidizing slag practice. Only phosphorous removal is required in	Fig 4+ Exp 3	

	this. But in double slag practice, both are to be removed. After the deoxidizing; in double slag practice, the removal of oxidizing slag is performed. Next, with the help of aluminum or ferromanganese or ferrosilicon, it gets deoxidized. When the bathing chemistry and required temperature is reached, the heat will get deoxidized. Then, the molten metal is ready for tapping.  		
VIII a	 This instrument is also called moving coil instrument. It is more accurate, sensitive and has uniform scale. It is most commonly used for DC measurements. **Principle** It works on the principle of electro dynamic effect or principle of DC motor. It states that, whenever a current carrying conductor is placed in a magnetic field, it experiences some mechanical force and moves in a particular direction. **Construction** It consists of a U- shaped permanent magnet. This powerful magnet is made of alnico. Arectangle coil of many turns wound on light aluminium frame is kept inside the pole pieces as shown in the figure. This frame is supported by delicate bearing and to which a light pointer is attached. The aluminium frame provides support for the coil and also acts as damping device by eddy current. When this instrument is connected in a circuit, the current is passed through the coil. As the coil is kept in magnetic field, it experiences a torque and deflected due to electro-dynamic effect. The deflecting torque is proportionalto the quantity of electricity or current which is under measurement. **Controlling Torque** Control of the coil moment is by spring control method, by using two phosphor bronze hair spring-one above and one below. They additionally serves the purpose of passing of current in and out the coil. **Damping torque** Eddy current damping is provided by the Aluminum frame, on which the copper coil was made. When the coil rotates in the magnetic field, the Aluminium frame also moves along with the coil. Hence eddy currents will produce in the frame and there by damping torque is developed. **Applications** This type of instruments are more sensitive, accurate and has uniform scale. They can be used for measurement of DC voltages and currents.	Fig 4+ Exp 4	

b		Fig (2+2)+ Exp 3	15

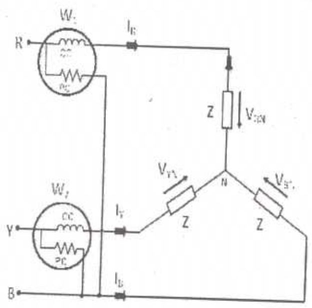


Fig 1

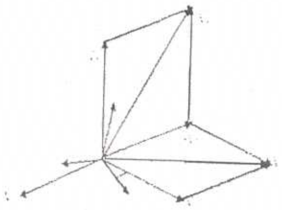


Fig 2

In two wattmeter method, a three phase balanced voltage is to a balanced three phase load where the current in each phase is assumed lagging by an angle of Ø behind the corresponding phase voltage. From the figure 1, it is obvious that current through the Current Coil (CC) of Wattmeter $W_1 = I_R$, current though Current Coil of wattmeter $W_2 = I_B$ whereas the potential difference seen by the Pressure Coil (PC) of wattmeter $W_1 = V_{RB}$ (Line Voltage) and potential difference seen by Pressure Coil of wattmeter $W_2 = V_{BY}$. The phasor diagram of the above circuit is drawn by taking V_R as reference phasor as shown in fig 2.

Angle between the current $I_R$and voltage $V_{RB} = (30° - Ø)$

Angle between current $I_Y$and voltage $V_{YB} = (30° + Ø)$

Therefore, Active power measured by wattmeter $W_1 = V_{RB}I_R \,Cos\,(30° - Ø)$

Similarly, Active power measured by wattmeter $W_2 = V_{YB}I_Y Cos(30° + Ø)$

As the load is balanced, therefore magnitude of line voltage will be same irrespective of phase taken i.e. V_{RY}, V_{YB} and V_{RB} all will have same magnitude. Also for Star / Y connection line current and phase current are equal, say $I_R = I_Y = I_B = I$

Let $V_{RY} = V_{YB} = V_{RB} = V_L$

Therefore,

$W_1 = V_{RB}I_R Cos\,(30° - Ø) = V_L I Cos(30° - Ø)$

In the same manner, $W_2 = V_L I Cos(30° + Ø)$

Hence, total power measured by wattmeters for the balanced three phase load is given as,

$W = W_1 + W_2$

$= V_L I \times Cos(30° - Ø) + V_L I \times Cos(30° + Ø)$

$= V_L I\,[Cos(30° - Ø) + Cos(30° + Ø)]$

$= 2V_L I \times Cos30° CosØ$ $\quad [\cos C + \cos D = 2\cos\frac{C+D}{2} \times \cos\frac{C-D}{2}]$

$= \sqrt{3} V_L I CosØ$

$W_1 - W_2 = V_L I \times Cos(30° - Ø) + V_L I \times Cos(30° + Ø)$

$= V_L I\,[Cos(30° - Ø) + Cos(30° + Ø)]$

$= 2V_L I \times Sin30° SinØ$ $\quad [\cos C + \cos D = 2\sin\frac{C+D}{2} \times \sin\frac{C-D}{2}]$

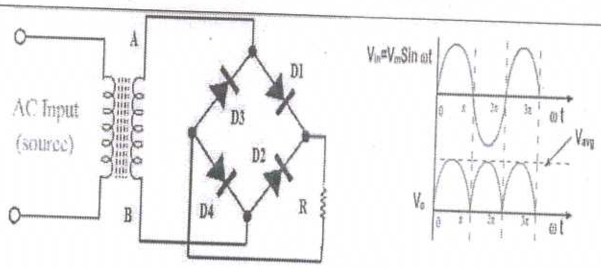
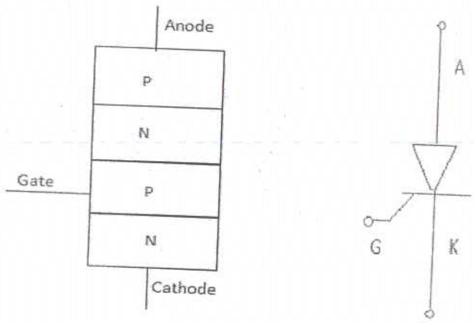
$= V_L I SinØ$

$$\frac{W_1 - W_2}{W_1 + W_2} = \frac{V_L I \sin Ø}{\sqrt{3} V_L \cos Ø}$$

$$\frac{W_1 - W_2}{W_1 + W_2} = \frac{\tan Ø}{\sqrt{3}}$$

$$\tan Ø = \frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2}$$

From the above equation, we can find the value of Ø and hence the power factor Cos Ø of the load.

IX a	 The single – phase full wave bridge rectifier is shown in figure. It is the most widely used rectifier. It also provides currents in both the half cycle of input supply. In the positive half cycle, D1 & D4 are forward biased and D2 & D3 are reverse biased. Current path – A-D1-R-D4-B In the negative half cycle, D2 & D3 are forward biased, and D1 & D4 are reverse biased. Current path – B-D2-R-D3-A The output voltage waveform is shown in fig. 2 and it is same as full wave rectifier but the advantage is that PIV rating of diodes are V m and only single secondary transformer is required. The main disadvantage is that it requires four diodes. When low dc voltage is required then secondary voltage is low and diodes drop (1.4V) becomes significant. For low dc output, 2-pulse center tap rectifier is used because only one diode drop is there.	Fig (3+2)+ Exp 3.	15
B	Thyristor is a four layer three junction pnpn semiconductor switching device. It has 3 terminals these are anode, cathode and gate. SCRs are solid state device, so they are compact, possess high reliability and have low loss.  SCR is made up of silicon, it act as a rectifier; it has very low resistance in the forward direction and high resistance in the reverse direction. It is a unidirectional device. SCR have 3 modes of operation: 1. Reverse blocking mode 2. Forward blocking mode (off state) 3. Forward conduction mode (on state)	Fig 2+ Exp 5	

Reverse Blocking Mode

When cathode of the thyristor is made positive with respect to anode with switch open thyristor is reverse biased. Junctions $J1$ and $J3$ are reverse biased where junction $J2$ is forward biased. The device behaves as if two diodes are connected in series with reverse voltage applied across them.

- A small leakage current of the order of few mA only flows. As the thyristor is reverse biased and in blocking mode. It is called as acting in reverse blocking mode of operation.

- Now if the reverse voltage is increased, at a critical breakdown level called reverse breakdown voltage VBR,an avalanche occurs at $J1$ and $J3$ and the reverse

current increases rapidly. As a large current associated with VBR and hence more losses to the SCR.

This results in Thyristor damage as junction temperature may exceed its maximum temperature rise.

Forward Blocking Mode

When anode is positive with respect to cathode, with gate circuit open, thyristor is said to be forward biased.

Thus junction $J1$ and $J3$ are forward biased and $J2$ is reverse biased. As the forward voltage is increases junction $J2$ will have an avalanche breakdown at a voltage called forward breakover voltageVBO. When forward voltage is less thenVBOthyristor offers high impedance. Thus a thyristor acts as an open switch in forward blocking mode.

Forward Conduction Mode

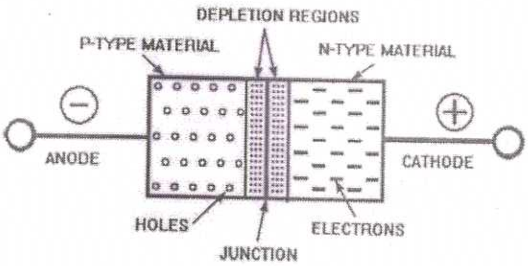
Here thyristor conducts current from anode to cathode with a very small voltage drop across it. So a thyristor can be brought from forward blocking mode to forward conducting mode:

1.By exceeding the forward breakover voltage.

2.By applying a gate pulse between gate and cathode.

During forward conduction mode of operation thyristor is in on state and behave like a close switch. Voltage drop is of the order of 1 to 2mV. This small voltage drop is due to ohmic drop across the four layers of the device.

X a — A P-N junction diode is a piece of silicon that has two terminals. One of the terminals is doped with P-type material and the other with N-type material. The P-N junction is the basic element for semiconductor diodes. A Semiconductor diode facilitates the flow of electrons completely in one direction only – which is the main function of semiconductor diode. It can also be used as a Rectifier. — Fig 3+ Exp 5 — 15



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Zero Biased Condition

In this case, no external voltage is applied to the P-N junction diode; and therefore, the electrons diffuse to the P-side and simultaneously holes diffuse towards the N-side through the junction, and then combine with each other. Due to this an electric field is generated by these charge carriers. Electric field opposes further diffusion of charged carriers so that there is no movement in the middle region. This region is known as depletion width or space charge.

Forward bias condition

The diode is forward biased. The positive terminal of the battery is connected to the anode of a diode and negative terminal to the cathode. When battery is not connected, there is a barrier potential of 0.3 V for Silicon and 0.7 V for Germanium across the across the P-N junction of a diode. Due to majority charge carriers the external applied voltage of forward bias is opposed by the barrier voltage and the diode does not conduct the current. The applied voltage is increased above the barrier potential, it overcome the opposition of barrier potential and diode conducts the current due to majority carriers. This current is known as forward current and flows from anode to cathode through the diode. It is of the order of 20 to 50 mA at about 1V.

Reverse bias Condition

The negative terminal of the battery is connected to the anode of a diode and positive terminal of battery is connected to cathode. Hence, the diode is reverse bias. When diode is reverse biased, majority carriers are blocked and only a small current flows through the diode due to the minority charge carriers. As the reverse voltage is increased from zero, the reverse current very quickly reaches its saturation value which is also called as leakage current or reverses saturation current. It is of the order of nanoamperes (nA) for Silicon and microamperes (μA) for Germanium.

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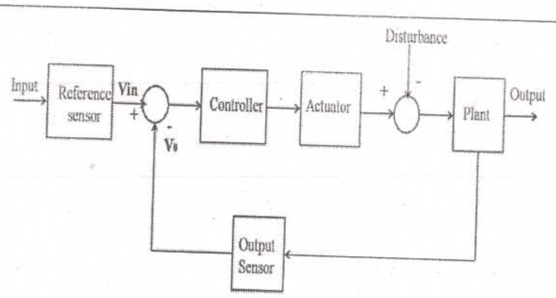

Plastic industrial moulding, Winding binding glue, Automobile assembly, Rotating tube cutter, Optical scanner, Engine set stand, Conveyors, Engraving machine, Surface grinding, Monofilament winder, Labeling machine, Moving position system, Telescopic drive, Capsule filling machine, Flute grinder.

</td><td>Fig 3+

App 4 (any4)</td><td></td></tr>
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