ELECTRICAL MAINTENANCE STD-XII
INTRODUCTION:

The various electrical quantities such as voltage, current, power energy etc. are to be measured accurately. For measurement purpose following basic meters is used.

- For measuring Current – Ammeter
- For measuring Voltage – Voltmeter
- For measuring power – Watt meter
- For measuring Resistance – Ohmmeter, Megger

In most of the measuring meters following effects of electric current is made use:

1. Magnetic effect of current.
2. Electromagnetic effect
3. Chemical effect
4. Heating effect

For most of the meters following three basic arrangements are essential:

(A) Deflecting system
(B) Controlling system
(C) Damping system.

Let us take some preliminary idea of the above three requirements of the meters in brief.

(A) Deflecting system:
This is the basic system of the meter which requires the following parts

1. A conductor in the form of a coil
2. Some iron parts.
3. Spindle
4. Pointer etc.

When the current passes through the coil, due to the effect of the current iron parts and spindle is subjected to motion due to a force. Due to the movement of the spindle the pointer (indicator) moves on the dial.
(B) **Controlling System:**

This system produces a force which is opposite to the deflecting force. When the deflecting force is equal to the controlling force then at that stage the moving system stops rotating. Following are the types of controlling systems.

![Controlling System Diagram](image1)

Due to deflecting force, the spindle starts rotating but at the same time the spring gets wound itself and produces force in the opposite direction. Or when the spindle starts rotating, at the same time the gravity weights are lifted up and produce the gravitational force to oppose the deflecting force.

(C) **Damping system:**

The third requirement is the damping system explained in A and B when controlling force is equal to the deflecting force at that stage, the moving system should become stable. But this does not happen instantly because of the inertia of the moving parts. The system oscillates momentarily and takes a finite time to become stable. The damping system creates a third force called as damping force which reduces oscillations and brings the system to rest quickly.

- **Following are the main Damping system:**

1. **Air friction Damping:** The deflecting system and controlling systems come in play, at that time air-piston moves in the closed air-chamber and air is pressed which produces a damping force which helps in bringing the system to rest quickly.

![Damping System Diagram](image2)
2. Fluid friction damping:

The rectangular vanes are connected to the spindle and they move in the Chamber of a fluid. When moving, the fluid produces opposition to the vane-moment and thus damping force is produced due to fluid friction which helps to bring he deflecting system quickly to rest.

3. Eddy current damping:

A circular aluminium disc is mounted on the spindle. When the spindle moves, the disc also moves. The disc, while moving cuts the magnetic field of a damping magnet. Due to the cut of flux the e.m.f. is produced in the disc. The e.m.f circulates eddy current in the disc. The effect of these currents is such that it will oppose the motion of the disc and helps in bringing the system to rest quickly.
**MOVING IRON INSTRUMENTS**

**(A) Attraction type:** Magnetic effect of electric current is used in such instruments.

- The coil is wound on the hollow bobbin. When current passes through the coil, magnetic field is produced as shown by the magnetic lines of force in the figure.
- A soft iron piece of a particular shape is pivoted near the coil. Due to magnetic attraction the soft iron piece is attracted towards and inside the coil. Whatever may be the direction of the magnetic field the piece is always attracted.
- Pointer moves when this piece moves. If current is more, field strength will be more and hence force of attraction on the piece is also more. Thus, deflection depends on the strength of current passing through the coil.
- Controlling and balancing weights are also shown. Arrangement of air friction damping is provided. If the instrument is to be used as a Ammeter the coil has comparatively few turns of thick wire so that the ammeter has low resistance to allow to flow maximum current and the instrument is connected in series with the circuit.
- If the instrument is to be used as a voltmeter the coil has high impedance so as to draw as small current as possible since it is connected in parallel with the circuit. As the current through the coil is very small, it has large number of turns of thin wire to produce necessary ampere – turns.
- In such types of instruments the scale on the dial is not uniform but it is uneven. The meter can be used on D.C. and A.C. also. It is not so popular because it is not so strong and acute.
Errors in the instrument:

1. Due to hysteresis
2. Due to Eddy currents.
3. Due to change in resistance due to change in temperature

(B) Repulsion Type:

- Figure shows the coil in which two soft iron pieces are placed. These pieces are in the form of rods or curved surfaces and are parallel to one another. Piece A is fixed to the bobbin and B is movable and mounted on the spindle. This spindle also carries a pointer. This pointer moves over the graduated scale (dial).
- When current passes through the coil the magnetic field is set up. Due to this magnetic field, the rods A and B are magnetized with the same polarities. They repel each other and movable, B moves and hence spindle and pointer get deflected.
- The force of repulsion and therefore the deflection of the pointer is approximately proportional to the square of the current passing though the coil. The scale is therefore uneven.
- They are generally gravity or spring controlled and air friction damping is provided. Such instruments are widely used. They are cheap and robust and can be used on A.C. and D.C. They are comparatively more accurate.
PERMANENT MAGNET MOVING COIL (PMMC) VOLT METERS/ AMMETERS:

CONSTRUCTION:

1. **Permanent Magnet**: It is a U-shaped permanent magnet and has N and S pole which produce the magnetic field in the space. There is a cylindrical round iron core located centrally in this magnetic field.
2. **Moving Coil**: This is very thin and fine coil and supported on the “Aluminium Former”.
3. **Springs**: Thin springs made of phosphor bronze are fixed on the spindle on both sides. The springs of the moving coil are connected to the springs to which supply leads are also connected.
4. **Spindle**: It is thin-round rod which supports former and spring. It is pivoted in the bearings.
5. **Pointer (Indicator)**: It is attached to the spindle.
6. **Dial**: It is graduated over which the pointer moves.

WORKING:

- When the meter is connected to the supply, the current passes through the moving coil. This current carrying coil is located in the magnetic field produced by the permanent magnet. A mechanical force is therefore produced on the coil. It starts rotating in certain direction. The rotational torque depends on the strength of the current passing through the moving coil.
- When the coil moves, the former and spindle move and the springs get wound and produce the necessary controlling torque. When the deflecting torque and controlling torque become equal, at that position the system comes to rest and the pointer shows the reading on the dial.
- The necessary damping effect is produced by the former which is made of aluminium. This former when moves in the magnetic field of the permanent magnet, the eddy currents are produced in the aluminium former and eddy current damping is effected to bring the system quickly to rest.
When this meter is to be constructed as voltmeter, the moving coil is connected in series with a high resistance and when this meter is to be used as an ‘Ammeter’ a low “resistance shunt”.

1. The meter is suitable for D.C. only
2. The scale on the dial is uniform
3. Damping is effective
4. Range of the instrument can be extended
5. Power consumption.

But, as the construction of the meter is very delicate, its life is short. More over it is costly.

**COMPARISON OF MOVING IRON AND MOVING COIL METER:**

<table>
<thead>
<tr>
<th>Moving Iron Type</th>
<th>Moving Coil Type</th>
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<tbody>
<tr>
<td>2. Suitable for both A.C. or d.c.</td>
<td>2. Suitable for D.C. only</td>
</tr>
<tr>
<td>3. Not so accurate</td>
<td>3. Most accurate</td>
</tr>
<tr>
<td>4. Hysteresis and other losses are more</td>
<td>4. Power consumption is more</td>
</tr>
<tr>
<td>5. Scale is not uniform</td>
<td>5. Scale is uniform</td>
</tr>
<tr>
<td>7. Air friction damping</td>
<td>7. Eddy current damping</td>
</tr>
<tr>
<td>8. Life is more</td>
<td>8. Life is less</td>
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</tbody>
</table>

These instruments can be used on AC and DC coil FF is known as fixed coil or pressure coil when current in these coils is passing they will produce their magnetic field and deflecting torque will be produces which is true power circuit.

The current is fed into the moving coil through the springs which also serve as control spring producing controlling torque. He scale is uniform.

**ENERGY METER:**

A.C. Single phase KWH type: Energy meter record the energy in Kilo-Watt Hours consumed during the time duration.
(a) Single Phase A.C. Induction type (KWH) meter:

(i) This is the most commonly used A.C. meter for domestic and industrial installations. They measure electric energy in kWh.

(ii) Principle and construction of such instruments is same as induction type watt meters except that control spring and pointer of watt-meter replaced by braking magnet and register mechanism.

(iii) Braking magnet induces eddy currents in aluminium disc which revolves continuously instead of rotating through a fraction as in watt meters.

Two electromagnets:
1. Shunt magnet is connected across the supply and carries line current proportional of voltage.
2. Series magnet is excited by line current. Both produce magnetic fluxes. Flux by shunt magnet lags behind by 90°. This is also achieved by adjusting copper shading bands. Both the fluxes produce induced e.m.f in the disc which is 90° behind with their respective fluxes. They produce eddy currents which are in phase with their e.m.f.
3. Thus, the torque is produced and disc begins to rotate continuously.
4. Register mechanism registers the energy which is directly proportional to the revolutions.
**ERRORS:**
1. As the coils are not purely inductive, flux due to shunt magnet does not lag behind V by 90°.
2. Errors in speed can be adjusted when it is tested on non-inductive load by adjusting the position of brake magnet.
3. Friction on bearings: Minimized with shading bands.
4. Criping: i.e. slow but continues rotation when pressure coil is excited, but to know current in current coil, it is avoided by drilling holes on the disc when hole come under the pole rotation stops.
5. Error due to temperature.

**INSTRUMENT TRANSFORMERS:**

The ordinary ammeters and voltmeters are used to measure the low value currents and voltages. They are not capable to be used for measuring high currents and high voltages. Even there is limit to design such meters. So, the same low capacity meters are indirectly used to measure high values of current or voltage with the help of transformers. These transformers which are used in conjunction with the meters are called as instrument transformers.

There are two such types of instrument transformers:
1. Current transformer (C.T.)
2. Potential transformer (P.T)

(A) **Current transformer (C.T.):**

This is used in conjunction with low capacity (5amp) ammeter to measure higher currents on H.V. lines. The primary of the C.T. consists of a few turns or even a single turn to carry the current to be measured and is connected in series with the H.V. current. The secondary winding with large number of turns supplies a reduced current to an ammeter. The readings are marked on the ammeter directly in terms of primary circuit current.
(B) Potential transformer (PT):

(i) These transformers are highly accurate ratio step down transformers and used in conjunction with standard low range voltmeter.
(ii) When secondary voltage is divided by transformation ratio it gives actual voltage on H.V. side.
(iii) Generally they are shell type oil immersed transformers.
(iv) Appropriate earthing & insulation should be provided for safety.

Multimeter:
(i) This meter is basically a P.M.M.C. instrument. A multimeter or a multitester, also known as a VOM (volt-ohm-milliammeter), is an electronic measuring instrument that combines several measurement functions in one unit.
(ii) A typical multimeter can measure voltage, current, and resistance. It comes in both digital as well as analog form. The following is the diagram of digital multimeter.
The Digital Multimeter basically consists of a LCD display, a knob to select various ranges of the three electrical characteristics.
(iii) It has two probes positive and negative indicated with black and red color is shown in figure. The black probe connected to COM JACK and red probe connected by user requirement to measure ohm, volt or amperes.
(iv) A shunt resistance is used for the protection and range extension. The working energy is supplied by a dry cell. It is very handy and useful meter used for multipurpose and hence the name multimeter.
(v) This meter is a must in laboratories, electric workshops, test shops, radio T.V. repair shops and everywhere.
Q.) Why Single Phase induction Motors are not self starting?

- When a 1φ A.C. supply is given to stator of a 1φ motors only alternating flux is produced in stator. It is not of rotating type.
- Hence rotational torque is not produced.
- Alternating magnetic flux cannot move the rotor.
- Therefore the motors are not self starting.

**Broad Classification of single phase motors**

1φ Motors

- 1φ IM
- Repulsion motor
- A.C.Series Motor
- unexcited synchronous motor
- split phase motor
- capacitor motor
- Shaded pole motor
- capacitor start
- Permanent capacitor motor
- Capacitor start capacitor Run motor
1. Split Phase motors (Resistance Start Induction Run Motors)

(a) Constructional Diagram:

(b) Construction:

(i) Stator: It is made up of silicon steel stamping having internal slots for receiving single phase stator winding.

(ii) Stator winding: - It is made up of good quality enameled copper and is split into starting winding and running winding.

(iii) Rotor: It is a round cylindrical part having slots on the periphery for Round Cu bars and is made of silicon steel stamping.

(iv) Rotor conductors: These are round Cu bars embedded in the rotor slots & permanently short circuited (squirrel cage rotor)

(v) Centrifugal Switch: It is connected in series with the starting winding.
(c) **Working:**

(i) When an A.C supply is given to the stator of the motor, the current ($I$) splits into $I_m$ & $I_s$ flowing in the main winding & starting winding.

(ii) The current ($I_m$) lags the applied voltage by a greater angle since more inductive & ($I_s$) lags the applied voltage by a smaller angle since more resistive less inductive.

(iii) The currents $I_m$ and $I_s$ produces its own flux $\phi_m$ & $\phi_s$ having a phase angle difference which interact and r.m.f is set and the rotor start rotating.

(iv) When the rotor reaches 70 – 80% of the normal speed, the centrifugal switch is operated and the starting winding is disconnected electrically from the circuit. Hence the name (resistance start induction Run motor)

(v) As starting torque is proportional to phase angle between $I_m$ & $I_s$, starting torque is less.

D.O.R: can be changed by interchanging the connection of either starting winding or running winding but not both.

Application: Small machine tools, duplicating machines, oil burners,

2. **Capacitor motors:**

   (a) Capacitor start induction run motors

   (b) Permanent capacitor motors.

   (c) Capacitor start capacitor run motors.

**(a) Capacitor start Induction run motor:**

i) **Constructional diagram**

![Constructional diagram of a capacitor start induction run motor](image-url)
Starting Current = \( I_s = \sin \alpha \)

(ii) Construction:

(a) Stator. It is made up of silicon steel stamping having internal slots for stator winding.

(b) Stator winding: it is made up of good Quality enameled Cu & split as starting winding and running winding.

(c) Rotor: It is round cylindrical part having slots for round copper bars and is made of silicon steel.

(d) Rotor conductors: These are round copper bars embedded in the rotor slots and permanently short circuited (squirrel cage rotor).

(e) Centrifugal switch: It is connected in series with the starting winding.

(iii) Working:

(a) When an AC supply is given to the motor, the current (I) splits into \( I_m \) and \( I_s \) flowing in the main winding and starting winding.

(b) The Current (\( I_m \)) lags by a greater angle since more inductive and Current (\( I_s \)) leads by a smaller angle since more capacitive and less inductive.
(c) The current (I_m) and (I_s) produces its own flux \( \phi_m \) and \( \phi_s \) having a phase angle difference which interacts and rotor starts rotating.

(d) When the rotor reaches 70-80% of the normal speed, the centrifugal switch is operated and starting winding is disconnected electrically from the circuit.

D.O.R Can be changed by making starting winding as running and vice versa.

(iv) Uses:

(i) Refrigerator  
(ii) drilling machine  
(iii) lathe machine  
(iv) pumps  
(v) cooler  
(vi) printing press

(b) Permanent Capacitor motors:

(i) Constructional diagram:
(ii) Construction:

(a) Stator: It is made up of silicon steel stamping having internal slots for stator winding.

(b) Stator winding: It is made up of good quality enameled copper and is split into starting winding and running winding.

(c) Rotor: It is round cylindrical part having slots for round copper bars and is made up of silicon steel stamping.

(d) Rotor conductors: These are round copper bars embedded in the rotor slots and permanently short circuited (Squirrel cage rotor).

(iii) Working:

(a) When an AC supply is given to the motor, the current ($I$) splits into $I_m$ and $I_s$ flowing in the main winding and starting winding.

(b) The Current ($I_m$) lags the applied voltage by a greater angle since more inductive and Current ($I_s$) Leads the voltage by a smaller angle since more capacitive and less inductive.

(c) This creates a phase angle difference between main winding flux and starting winding flux and rotating magnetic flux is set up. Thus rotor starts rotating.

(d) The capacitor remains permanently in the circuit even in the running condition.

D.O.R (Direction of rotation):

It can be changed by making starting winding as running and vice versa.
Uses:

(I) Ceiling fan  (ii) Table fan

(C) Capacitor start Capacitor Run Motor:

(I) Constructional diagram:
(ii) **Construction:**

(a) Stator. It is made up of silicon steel stamping of having internal slots for stator winding.

(b) Stator winding: it is made up of good Quality enameled Cu and is split as starting winding and running winding.

(c) Rotor: It is round cylindrical part having slots for round copper bars and is made of silicon steel.

(d) Rotor conductors: These are round copper bars embedded in the rotor slots and permanently short circuited (squirrel cage rotor).

(e) Centrifugal switch: It is connected in series with the capacitor C1.

(iii) **Working:**

(a) The two capacitors are used Cap1 and Cap2. Cap1 is of higher value but short duty and Cap2 is of lower value but continuous duty.

(b) When the supply is switched ON the current (I) splits into I<sub>m</sub> and I<sub>s</sub> flowing in the main winding and starting winding.

(c) The Current (I<sub>m</sub>) lags by a greater angle since more inductive and Current (I<sub>s</sub>) leads by a smaller angle since more capacitive and less inductive.

(d) This creates a phase angle difference between main winding flux and starting winding flux and rotating magnetic flux is set up. Thus rotor starts rotating.

(e) When the rotor reaches 70-80% of the normal speed, the centrifugal switch is operated and the cap1 is disconnected from the circuit whereas Cap2 remains permanently in the circuit.

(iv) **Uses:**

(I) Room Cooler (II) Refrigerator (III) Compressor

(v) **Specialty:**

(i) p. f. is improved

(ii) Higher efficiency

(iii) Higher torque

(iv) Starts quickly

**D.O.R:**

It can be changed by making starting winding as running and vice versa.
(D) Shaded Pole Motor:
(I) Constructional diagram:

(II) Construction:
(i) Stator: It is made up of silicon steel stamping having salient poles. A slot is cut in the pole and a Cu coil is placed at one corner. Copper coil is known as shading coil. This part of the pole is known as shaded part and the remaining as unshaded part.
(ii) Stator winding [field winding]: It is made up of good quality enameled copper and wound on salient poles.
(iii) Rotor: It is cylindrical part made up of silicon steel stamping having slots for rotor bars.
(iv) Rotor conductors: Made up of round copper bars which are placed in rotor slots and are permanently short circuited (sq. cage)

(iii) Working:

Fig. A

- When the supply is switch “ON” the field current is rapidly increasing along OA (fig.A) in the field winding which produces flux in the poles.
According to transformer action e.m.f. is induced in the shading coil causing heavy current to circulate in it. According to Lenz’s law, an induced electric current flows in a direction such that the current opposes the change that induced it. Hence flux shifts mostly to the unshaded part and the magnetic axis lies along the middle of unshaded part.

**Fig. B**

Consider the moment (Fig. B) when field current is near its peak value (instant AB) & change in exciting [field current] is less. So the induced current in the shading coil is very less. Hence the flux is uniformly distributed over the pole face. So the magnetic axis lies to the center of the whole pole.

**Fig. C**

At one instance (Fig.C) the current in the shading coil decreases very rapidly (instant BC) and hence the M.A shifts towards the shaded pole. It seems as if the M.A is moving from the
unshaded pole to shaded pole and the rotating magnetic field is setup and the rotor starts rotating.

- **D.O.R.** - It is not possible to change the D.O.R. of these motors as the position of the copper rings are fixed.

**Uses:**

(I) Small fans  
(II) Toys  
(III) Hair dryers

**4 Repulsion Motor (Repulsion Start Induction Run Motor)**

(i) **Constructional Diagram:**

![Constructional Diagram](image)

(II) **Construction:**

(i) Stator: It is made up of silicon steel stamping having non-salient poles for stator winding.

(ii) Stator winding: It is made up of good quality enameled copper and is wound on the stator pole.

(iii) Rotor: It is round cylindrical part having slots for copper winding and is made up of silicon steel stampings. It is same as the armature of D.C. motor.

(iv) Rotor winding: These are made up of good quality enameled copper and placed in the rotor slots the ends of which are connected to the carbon brushes.

(v) Commutator: It consists of alternate layers of copper and mica segments.
(vi) Brushes: It is made up of carbon or graphite placed in the holder and ride against commutator. The brushes are shorted by connecting them directly with a cu wire (jumper).

(iii) Working:
- When current is given to the stator winding field is set up. Let an instant the field is such that N pole is at the top and S pole is at the bottom and the MA lies vertical.
- The Brush Axis is neither horizontal nor vertical, but at an intermediate angle $\alpha$.
- The like poles of the stator and rotor repel each other and the rotor starts rotating.
- Since the rotor rotates because of repulsive force it is called Repulsion Motor.
- The speed of this motor can be changed by shifting the position of brushes.
- The D.O.R can be change by shifting the brushes in reversed direction.

Uses:
- (i) Refrigerator
- (ii) mixing machine
- (iii) Floor polishing machine
- (iv) lifts
- (v) compressor.

AC series Motor

Universal Motor is a small version of AC series motor. It works on AC supply as well as DC supply.

(I) Circuit diagram:

(II) Construction:

A.C. series motor is similar in construction as d.c. series motor and has the main parts.

(i) Field pole: It is made up of silicon steel stamping and salient type for field winding.

(ii) Field winding: It is made up of good quality enameled copper and is wound on the field pole.
(iii) Armature: It is round cylindrical part having slots on the periphery for the armature winding.

(iv) Armature winding: It is made up of good quality enameled copper placed in the armature slots the ends of which are connected to the commutator.

(v) Commutator: It consist of alternate layers of copper and mica segments.

(vi) Brushes: There are made up of carbon or graphite.

(iii) Working:

(i) If D.C. series motor is connected to AC. supply. It will rotate with unidirectional torque which can be explained as follows.

(ii) For the instantaneous polarity the direction of the current in the series field coil and armature coil is as shown in figure (a). As per the theory, When a current carrying conductor is placed in the magnetic field it experiences a force in certain direction and its direction is given by Flemings Left Hand Rule.

(iii) In the first case, armature starts rotating in anticlockwise direction.

(iv) In the next half cycle of a.c. instantaneous polarities are changed as shown in the figure (b). the direction of field as well as direction of current in the armature is also changed.

(v) By Fleming’s left hand rule, we find that direction of rotation of armature is same that is anticlockwise. Thus we can conclude that to the D.C. series motor even if a.c. supply is given the motor develops at unidirectional torque.

(vi) But for the good performance of a.c. series motor or universal motor some modifications are to be made in the motor.

D.O.R –

It can be changed by reversing the terminals of armature with respect to field coil.

Application:

Speed control of universal motor: (3 Marks)

1. Resistance Method
2. Tapping –field method.
3. Centrifugal mechanism

1. **Resistance Method**: Motor speed is controlled by connecting a variable resistance $R$ in series with the motor.

   ![Resistance Method Diagram]

2. **Tapping –field method**: Field pole is tapped at various points and speed is controlled by varying the field strength.

   ![Tapping Method Diagram]

**Chart of types of motors and its application**

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<tr>
<th>Sr. No.</th>
<th>Purpose</th>
<th>Suitable Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Printing Press</td>
<td>Capacitor Start Motor</td>
</tr>
<tr>
<td>2</td>
<td>Lathe Machine</td>
<td>Capacitor Start Motor</td>
</tr>
<tr>
<td>3</td>
<td>Centrifugal Pump</td>
<td>Capacitor Start Motor</td>
</tr>
<tr>
<td>4</td>
<td>Electric Drill Machine</td>
<td>Universal Motor</td>
</tr>
<tr>
<td>5</td>
<td>Mixer</td>
<td>Universal Motor</td>
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<td>6</td>
<td>Sewing Machine</td>
<td>Universal Motor</td>
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<td></td>
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<tr>
<td>7</td>
<td>Radiogram Tape Recorder</td>
<td>Shaded pole or synchronous motor</td>
</tr>
<tr>
<td>8</td>
<td>Shaving Machine</td>
<td>Shaded pole or synchronous motor</td>
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<tr>
<td>9</td>
<td>Refrigerator</td>
<td>Shaded pole or Capacitor Start / Run Motor</td>
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<tr>
<td>10</td>
<td>Cooler</td>
<td>Capacitor Start Motor</td>
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<tr>
<td>11</td>
<td>Cinema Projector</td>
<td>Universal Motor</td>
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<td>12</td>
<td>Ceiling or Table fan</td>
<td>Permanent Capacitor type Motor</td>
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<td>13</td>
<td>Wall Clocks</td>
<td>Shaded Pole or 1phase Synchronous Motor</td>
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<td>14</td>
<td>Floor Polishing Machine</td>
<td>Repulsion Type Motor</td>
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<td>15</td>
<td>Vacuum Cleaner</td>
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<td>Toy Motor</td>
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<td>17</td>
<td>Tape Recorder</td>
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## Home Assignment-II

<table>
<thead>
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<th>Question No.</th>
<th>Marks</th>
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<td>Q.16</td>
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1. Draw a neat labelled diagram of fluid friction damping
2. Draw a neat labelled diagram of Air friction damping
3. Draw a neat labelled diagram of eddy current damping
4. Explain with neat labelled diagram the construction and working of attraction type moving iron instrument
5. Explain with neat labelled diagram the construction and working of repulsion type moving iron instrument
6. Compare moving iron and moving coil instruments
7. State how PMMC Instrument is constructed as a voltmeter and ammeter
8. Write a note on instrument transformers
9. State the reason why single-phase induction motor is not self-starting
10. Explain with diagram construction and working of Repulsion motor
11. Explain with diagram construction and working of Shaded pole induction motor
12. Explain with phasor diagram split phase induction motor
13. Draw a neat labelled diagram of repulsion start induction run motors
14. Explain with phasor diagram Capacitor start induction run motor motor
15. How to change the DOR of
   1. split phase motors
   2. Universal motors
16. Name any 6 types of single-phase induction motor and explain construction and working of capacitor start capacitor run induction motors.