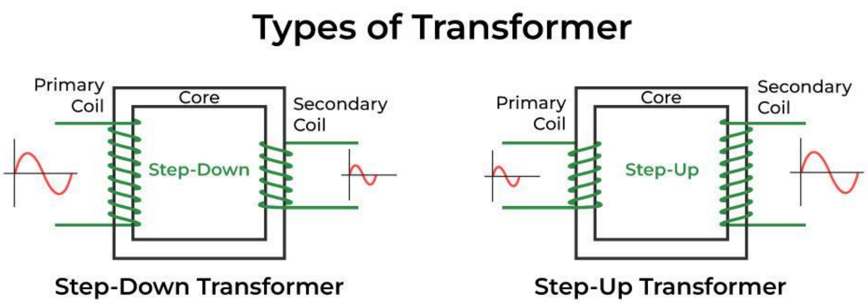
UNIT 3- Model Answer Solution

Department: First Year Dept. **Semester: II** **Academic Year – 2024-25**

Class: FE CSE/ITAIDS/AIML **Div: A/B/C** **Maximum Marks:**

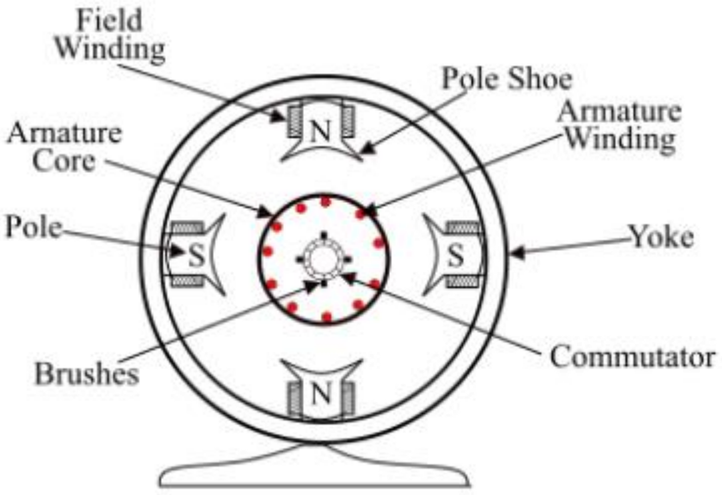
Course: Basic Electrical And Electronics Engineering.(BEE)	**Course faculty: Dr. Manju Pawar**	

Question No.	Question	Marks
Q1	Explain with a neat diagram, working principle of a transformer. **Answer:** A transformer works on the principle of electromagnetic induction, specifically **Faraday's Law of Electromagnetic Induction**, which states that a change in magnetic flux induces an electromotive force (EMF) in a coil. 1 marks **Working Principle:** 1. **Primary Coil:** An alternating current (AC) in the primary coil generates a time-varying magnetic field in the core. 2. **Core:** This magnetic field is confined to the core, which links it to the secondary coil. There are primarily two types of Transformer based on the operating voltage. The following are some of them:  2 marks • **Step-down Transformer:** The primary voltage is converted to a lower voltage across the secondary output using a step-down transformer.	05

	The number of windings on the primary side of a step-down transformer is more than on the secondary side. As a result, the overall secondary-to-primary winding ratio will always be less than one. Step-down transformer are used in electrical systems that distribute electricity over long distances and operate at extremely high voltages to ensure minimum loss and economical solutions. Step-down transformer are used to change high-voltage into low-voltage supply lines. 1 marks • **Step-up Transformer:** The secondary voltage of a step-up transformer is raised from the low primary voltage. Because the primary winding has fewer turns than the secondary winding in this sort of transformer, the ratio of the primary to secondary winding will be greater than one. Step-up transformer are frequently used in electronics stabilizers, inverters, and other devices that convert low voltage to a significantly higher voltage. A step-up transformer is also used in the distribution of electrical power. For applications connected to power distribution, high voltage is necessary. In the grid, a step-up transformer is used to raise the voltage level prior to distribution. 1 marks	
Q.2	Differentiate between a step-up and step-down transformer with examples. **Sol: Any 5 comparative points**-------------------------------------- **5Marks**	05

Aspect	Step-Up Transformer	Step-Down Transformer
Primary Voltage (V_1)	Low voltage on the primary side.	High voltage on the primary side.
Secondary Voltage (V_2)	High voltage on the secondary side.	Low voltage on the secondary side.
Turn Ratio (N_1:N_2)	The number of turns on the secondary coil is greater than that of the primary coil ($N_2 > N_1$).	The number of turns on the secondary coil is fewer than the primary coil ($N_2 < N_1$).
Function	Increases voltage while decreasing current.	Decreases voltage while increasing current.
Power Transmission	Used for transmitting power over long distances because high voltage reduces transmission losses.	Used to reduce voltage for domestic or industrial use where lower voltage is required.
Efficiency	Generally has high efficiency, especially in high-power transmission.	Efficiency depends on load and the quality of the transformer.
Application Examples	1. Power plants to step up voltage for transmission lines. 2. Electrical substations in the transmission grid.	1. Electric appliances (e.g., mobile chargers). 2. Voltage reduction for residential use.
Current Characteristics	Low current on the secondary side.	High current on the secondary side.

Q.3	**What are the various losses in a transformer? Explain any one.** 1. **Core Losses (Iron Losses):** Due to hysteresis and eddy currents in the core 2. **Copper Losses:** Due to the resistance of the transformer windings (primary and secondary coils)when current flows through them. 3. **Leakage Flux:** Magnetic flux that does not link both coils. 4. **Stray Losses:** Caused by leakage fields inducing currents in surrounding parts. 3 marks **Example - Core Loss:** Core loss comprises **hysteresis loss** (energy lost due to magnetization and demagnetization of the core material) and **eddy current loss** (induced currents in the core generating heat). These are minimized using laminated cores. 2 marks	05
Q.4	Explain the construction and working principle of a DC motor **Construction of DC Motor** DC motor has such basic components, as a stator (stationary part of the element producing magnetic field) and a rotor part that rotates carrying winding or coil. When a DC voltage is connected to the coil, current flows through it and generates an electromagnetic field. When the magnetic field of this rotor interacts with that produced by the stator, a torque is induced which causes this piece to start spinning. 1 marks	05



2 marks

DC Motor Parts

DC machine has the following main parts:

- Field System or Stator
- Armature
- Commutator
- Brushes

Field Coil or Stator

As the name suggests, the field coil or stator is the non moving or the stationary part of the DC motor around which coil is wounded and produce magnetic field

The stator consists of various parts:

- Yoke
- Pole Core
- Pole Body
- Shoe for the pole
- Field Winding
- End Plates

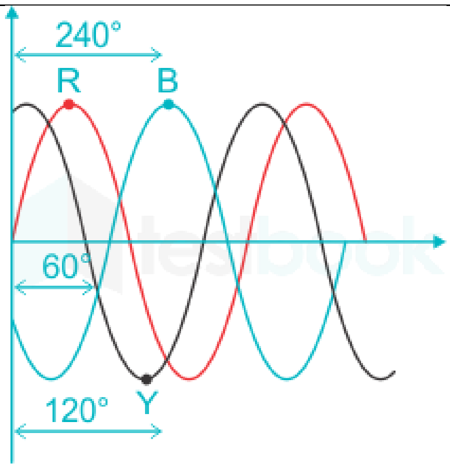
Yoke: The structure of a DC machine works to create the magnetic circuit between the poles.

Pole Core: Pole Core is usually of laminated iron or other magnetic material. Its function is to serve as a passage for the magnetic flux generated by the field winding.

Pole Body: Pole body works with the pole core. When an electric current passes through the field winding, a magnetic flux is established not only in the pole core but also around it. The poles and their bearings are known as the pole body.

Shoe: Shoe is a synonym for one of the brushes inside an electric motor. DC motors have brushes to make contact with the rotating armature, and typically they are sodded.

	Field Winding: Field winding is on the pole core next to the stator. Field winding uses insulated copper wire. An insulated copper coil is wound round the pole core. If this coil on the pole core is excited with direct current, we get magnetic flux. **End Plates:** End plates encapsulate the entire motor. They provide a casing for all of the internal parts--the armature, commutator and brushes as well sometimes also including field windings. 1 marks **Armature** Armature is the rotating part of the motor which generates mechanical energy. Armature core has windings. The armature core is made of 0.3 to 0.5 mm thick high magnetic strength (silicon steel lamination) and a thin layer of varnish is applied on each sheet. **Commutator** Commutators are used in DC appliances such as DC Motors and DC Generators. It periodically reverses the current between the armature and the circuit and produces steady torque **Brushes** Brushes or often called Carbon Brushes are made up of graphite. In DC Motors, brushes supplies current to the winding of the armature. **Working**: 1 marks Current is flowing in the conductor but the magnetic effect of N pole and S pole has been removed. In this situation the conductor will maintain its own magnetic field. The magnetic field lines of force of the conductor will be clockwise according to the cork screw rule. Current is flowing in the conductor and main magnetic field is also present. The magnetic field produced due to the current in the conductor acts along with the main field above the conductor but opposes the main field below the conductor.	
Q.5	**Describe three-phase AC system.** The sequence in which the three phase voltages or currents are labeled is known as the phase sequence. The standard phase sequence used is ABC where phase A is taken as the reference and phases B and C lag A by 120° and 240° respectively. The reverse phase sequence is CBA.	05



2 marks

Fig- Three-phase Waveform

- **In a three-phase system, the order in which the voltages attain their maximum positive value is called Phase Sequence.**

- There are three voltages or EMFs in the three-phase system with the same magnitude, but the frequency is displaced by an angle of 120° electrically.
- Consider the R, Y, and B the three phases of the supply system.
- Taking an example, if the phases of any coil are named as R, Y, B then the Positive phase sequence will be RYB, YBR, BRY also called clockwise sequence and similarly, the Negative phase sequence will be RBY, BYR, and YRB respectively, and known as an anti-clockwise sequence.

- For a three-phase system, there are only two possible phase sequences RYB and RBY corresponding to the two possible directions of alternator rotation.

Balanced System **1 marks**

A three phase system is said to be balanced if the magnitudes of the three line voltages are equal and the phase displacement between any two line voltages is exactly 120°. In a balanced system, the currents and voltages are constant in magnitude and the loads on each phase are identical.

In a balanced three-phase system, the voltages and currents across each phase are identical in magnitude and phase angle. This balance ensures efficient power distribution and minimizes voltage fluctuations and power losses.

Unbalanced System

Any deviation from the ideal balanced conditions results in an unbalanced three-phase system. The common causes of unbalance are unequal line

	impedances, improper loading of the phases, and faulty equipment. This leads to non-sinusoidal currents, excessive neutral currents, overheating of conductors, and reduced performance of equipment. **Balanced Three-Phase Connections** **2 marks** Three phase circuits can be connected in various configurations with different implications on voltages and currents. The commonly used connections are: **There are four possible connections between a three-phase source and a three-phase load as shown below:** ○ **YY connection:** Both source and load are wye (star or wye) connected. Line and phase voltages are the same. No neutral current flows. ○ **YΔ connection:** Source is wye and load is delta connected. Line voltages are higher than phase voltages by √3 times for the load. ○ **ΔY connection:** Source is delta and load is wye connected. Reverse of Y-Δ connection. ○ **ΔΔ connection:** Both source and load are delta-connected. Phase currents are higher than line currents by √3 times. Neutral wire is not required. Possibility of circulating currents through delta loop if voltages are unbalanced.	
Q.6	**What is a single-phase system? Give examples.** A **single-phase AC system** is a type of electrical power distribution system that uses a single alternating current (AC) waveform to deliver electricity. It is the most common type of power system used in residential and small commercial applications, where the power requirements are relatively low. s 1. **Single Waveform**: ○ The system operates with one AC voltage waveform, alternating periodically between positive and negative cycles. 2. **Power Delivery**: ○ Power is delivered through two wires: a **live (hot)** wire and a **neutral** wire. ○ The current flows between these wires to power electrical devices. 3. **Voltage**: ○ Typically operates at 120V or 240V, depending on the region and application. **Examples of Applications:** **3 marks** 1. **Residential Use**: 2. **Small Commercial Use**:	05

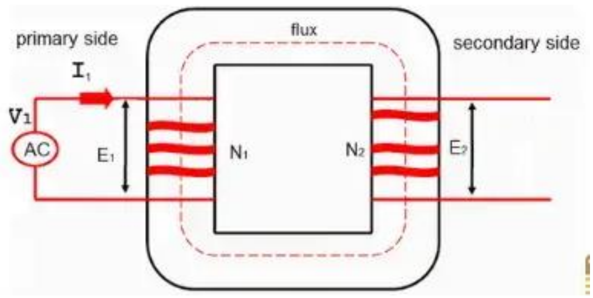
	3. **Rural Areas**: 4. **Portable Equipment**: 2 marks	
Q.7	**List applications of AC motor?** **Sol: Any 10 points-------------------------------------- 5Marks** 1. Industrial Applications • Machinery • Cranes and Hoists: Industrial Robots: • Textile Mills • Steel and Paper Mills 2. Residential Applications • Fans and Blowers • Refrigerators and Air Conditioners: • Washing Machines • Vacuum Cleaners: 3. Commercial Applications 4. Automotive Applications 5. Agricultural Applications 6. Aerospace and Marine Applications 7. Small Appliances and Tools 8. Renewable Energy Systems	
Q.8	**The primary winding of a transformer has 500 turns, and the secondary winding has 250 turns. If the input voltage is 230 V, find the output voltage**	

	• Formula: $\frac{V_1}{V_2} = \frac{N_1}{N_2}$. • $\frac{230}{V_2} = \frac{500}{250}$. • $V_2 = \frac{230 \times 250}{500} = 115\ \mathrm{V}$. 2marks---step 1 2marks---step 1 1marks---step 3	
Q9	**A transformer primary winding is powered by 120 V ,If the turn ratio is 10 what is the secondary voltage equal to.** V2\V1=N2\N1 ---------------------2marks V2\120=10------------------2marks V2=1200V--------------------------- 1marks	05
Q10	**Differentiate between shunt, series, and compound DC motors** **Sol: Any 5 comparative points------------------------------------- 5Marks**	05

Parameter	Shunt DC Motor	Series DC Motor	Compound DC Motor
Connection of Windings	The field winding is connected in parallel (shunt) with the armature.	The field winding is connected in series with the armature.	Has both series and shunt field windings, combining their characteristics.
Torque-Speed Characteristic	Nearly constant speed regardless of load.	High starting torque but speed decreases significantly with load.	Moderate speed and torque characteristics, depending on the connection.
Starting Torque	Low starting torque.	Very high starting torque.	Intermediate starting torque, higher than shunt but lower than series.
Speed Regulation	Good speed regulation under varying loads.	Poor speed regulation; speed varies with load.	Better speed regulation than series, but slightly worse than shunt.
Applications	Suitable for applications requiring constant speed, e.g., fans, blowers, lathes, and machine tools.	Used in applications requiring high torque, e.g., cranes, hoists, and elevators.	Ideal for applications needing both high torque and moderate speed, e.g., rolling mills and presses.
Efficiency	More efficient for constant-load operations.	Less efficient due to high current in the series winding.	Efficiency varies depending on the proportion of series and shunt windings.
Load Handling	Cannot handle heavy loads due to limited starting torque.	Well-suited for heavy-load applications.	Handles moderate to heavy loads effectively.
Overload Behavior	Cannot sustain excessive loads; speed increases dangerously with no load.	Can handle overloads temporarily; speed decreases with high loads.	Balances the behavior of shunt and series motors under varying loads.

Q.11 **Draw and explain Step-down transformer** 05

if the voltage is decreased, it is called a **Step-Down Transformer**. We can say that, it converts high-voltage power to low-voltage power and also reduces the AC voltage or AC source. 1 marks



2 marks

A Step Down Transformer consists of these parts :

- **Core**
- **Winding**

1. Core

They are made up of high permeable material and carry the flux. It gives the path to the magnetic flux to flow easily in a smooth way with minimum losses. In the transformers , thin metallic sheets are used because the core produces eddy current which decreases the efficiency so **ferromagnetic material are used - iron .**

2. Winding

The Step Down Transformer is winded with wires which are called coils .This aids in the current passage to the transformer, the secondary winding wire is thin with many turns on the other hand primary winding wire is thick with fewer turns. Copper is used in the winding of the Step Down Transformer.

Step Down Transformer Working Principle 2marks

Since in the Step Down Transformer , output voltage is decreased which will increase the output current to maintain the balance. The primary winding is connected to AC source, when the voltage is supplied an alternating current flows through the primary coil. As the source is AC, there will be a change in magnetic flux when this changing flux passes through the secondary winding, an emf is induced in the secondary coil according to **law of induction**. The emf induced is directly proportional to the number of coils in the secondary coil.

The ratio of number of the turns in the Secondary Coil Compared to the primary coil determines the **Voltage Transformation ratio.** Since the number of the coil in Secondary has fewer turn than the primary coil in the step down transformer, the voltage induced in the secondary will be less than the Primary coil.

Q.12	**Compare AC and DC Motors** **Sol: Any 5 comparative points--------------------------------------- 5Marks**	5M

Feature	AC Motor	DC Motor
Power Source	Alternating Current (AC).	Direct Current (DC).
Construction	Simpler construction due to absence of commutator and brushes.	Complex construction with commutator and brushes in traditional DC motors.
Efficiency	Higher efficiency at higher speeds and constant operation.	High efficiency in low-speed and variable-speed applications.
Speed Control	More difficult; requires external equipment like VFDs (Variable Frequency Drives).	Easier and more precise using resistors or controllers.
Starting Torque	Lower starting torque compared to DC motors.	High starting torque, especially in series DC motors.
Maintenance	Low maintenance due to absence of brushes and commutators.	Requires regular maintenance for brushes and commutator (in traditional designs).
Size and Weight	Smaller and lighter for the same power output.	Larger and heavier for the same power output.
Applications	Suitable for industrial applications like fans, pumps, compressors, and conveyors.	Suitable for applications like cranes, lifts, electric vehicles, and small appliances.
Cost	Lower initial cost for high-power applications.	Higher initial cost for high-power applications.
Load Characteristics	Performs well under constant loads.	Performs well under varying loads.

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