UNIT-III			
DC Machines			
(1 Marks)			

1 **Taxonomy Level: Remember** | **CO: C114.4** | **PI: 2.1.1**

Explain the working principle of a dc generator?

Whenever rotating armature (conductor) placed in a stationary magnetic field, e.m.f will be induced in the armature. This e.m.f is called dynamically induced e.m.f.

2 **Taxonomy Level: Understand** | **CO: C114.4** | **PI: 2.1.1**

Explain the working principle of a dc motor?

Whenever a current carrying armature placed in stationary magnetic field torque will be developed in the armature.

3 **Taxonomy Level: Remember** | **CO:C114.4** | **PI: 2.1.1**

What are different types of armature windings?

Armature windings

There are two types of armature winding connections

1. Lap winding (A=P)

When the armature windings are lap connected then (A=P).

A= Armature parallel paths

P= Number of poles on the stator

2. Wave connection (A=2)

When the armature windings are wave connected then (A=2).

4 **Taxonomy Level: Remember** | **CO: C114.4** | **PI: 2.1.1**

What is the function of Commutator in a dc generator?

Commutator

- It collects the AC emf from the armature and converts into pulsating DC. Therefore it is called as rotating or mechanical rectifier.

5 **Taxonomy Level:Remember** | **CO: C114.4** | **PI: 2.1.1**

write down the induced emf formula for DC Motor?

The Back emf of DC motor is given by,

$$\boxed{E_b = \frac{\phi Z N}{60} \frac{P}{A}}$$

Where,

E_b = Back emf (Volt)

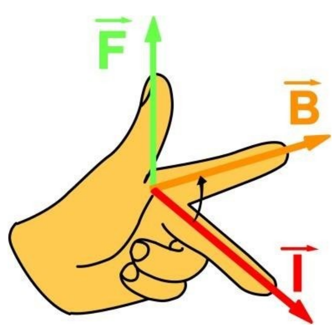
ϕ = Field flux (wb)

Z = Armature conductors

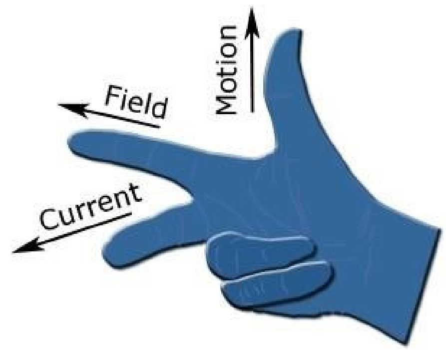
N = Speed of DC motor (rpm)

P = No of field poles

A = Parallel paths

(3 Marks)				
1		**Taxonomy Level: Remember**	**CO: C114.4**	**PI:1.3.1**
		What is statically and dynamically induced emf?		
		STATICALLY INDUCED EMF Whenever a time varying flux linked with a stationary conductor emf will be induced across the conductor. This emf is called statically induced emf. Ex: Transformers **DYNAMICALLY INDUCED EMF** Whenever rotating conductor placed in a stationary magnetic field, emf will be induced in the conductor. This emf is called dynamically induced emf. Ex: DC Generators		
2.		**Taxonomy Level: Remember**	**CO: C114.4**	**PI:2.2.4**
		State Fleming's left-hand rule.		
		Fleming's left-hand rule gives the direction of the force developed by the current carrying conductor when it is placed in a stationary magnetic field. Whenever a current carrying conductor placed in stationary magnetic field torque will be developed in the conductor. As from Fleming's left-hand rule, central finger represents the direction of current, forth finger represents the direction of magnetic field and the thumb gives the direction of developed force. 		
3.		**Taxonomy Level: Understand**	**CO: C114.4**	**PI:2.2.4**
		State Fleming's right-hand rule.		
		Fleming's right-hand rule gives the direction of the current or emf. Whenever a rotating conductor placed in stationary magnetic field emf will be induced across the conductor. As from Fleming's right-hand rule, thumb represents the direction of force, forth finger		

represents the direction of magnetic field and the central finger represents the direction of induced current or emf.



4.		**Taxonomy Level: Remember**	**CO: C114.4**	**PI: 2.2.4**
		What is an electrical generator and explain working principle.		
		A Machine which converts mechanical energy into electrical energy is called electrical Generator Working principle base faradays law that is "when ever one conductor cuts the magnetic flux an emf is induced in the condutctor".		
5.		**Taxonomy Level: Understand**	**CO: C114.4**	**PI: 2.2.4**
		List the various losses in a DC machine		
		The various losses in a DC machine are 1. Copper losses 2. Iron losses/ core losses 3. Mechanical losses		

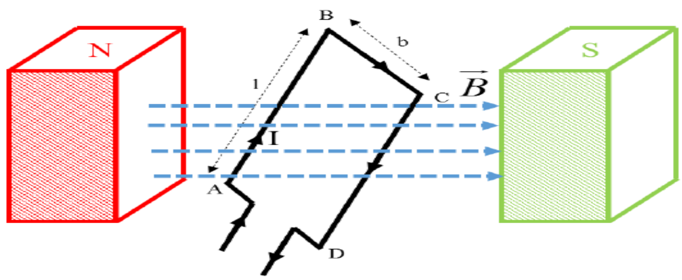
(5 Marks)

1.		**Taxonomy Level: Understand**	**CO: C114.4**	**PI: 2.2.4**
		Write down the working principle of dc motor		

Whenever a current carrying conductor is placed in a stationary magnetic field, a force will be developed in the armature conductor. The direction of this force is determined by Fleming's Left Hand Rule and its magnitude is given by the relation.

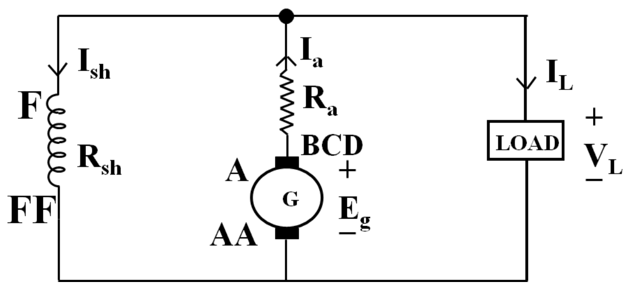
$$F = Bil \quad (Units:- \text{ Newton})$$

Let us consider a single turn coil is placed in the magnetic field. When DC supply is connected to the coil, current flows through it which sets up its own field. By the interaction of the two fields (i.e., field produced by the main poles and the coil), a resultant field is set up. The tendency of this is to come to its original position i.e., in straight line due to which force is exerted on the two coil sides and torque develops which rotates the coil.



2.		**Taxonomy Level: Evaluate**	**CO: C114.4**	**PI: 2.2.3**
		Write down the applications of dc motors		

S.No.	Type of DC Motor	Applications
1	DC Shunt Motor	Constant speed requirement (i) Machine tools (ii) Lathe machine (iii) Fans and blowers (iv) Centrifugal pumps
2	DC Series Motor	Torque requirement is high (i) Electric locomotives/Traction (ii) Cranes (iii) Hoist (iv) Trolley and conveyors
3	Differential DC Compound Motor(or) Short shunt DC Compound Motor	Not practically used Used in Research work
4	Cumulative DC Compound Motor (or) Long shunt DC Compound Motor	Intermittent load (i) Shears (cutters) (ii) Punching machine (iii) Elevators

3.		**Taxonomy Level: Evaluate**	**CO: C114.4**	**PI: 2.2.4**
		A dc shunt generator supplies a load of 55 W at 220 V. The armature and shunt field winding resistances are 0.25 Ohm and 440 Ohm respectively. The voltage drop across each brush is 2 V. Find the armature current and the generated emf.		
		Given data $P = 55\ W$ $V_L = 220$ V $R_a = 0.25\ \Omega$ $R_{sh} = 440\ \Omega$ Voltage across each brush = 2 V $\therefore BCD = 4$ V $I_a = ?$ $E_g = ?$		
		Solution 		

$$\boxed{I_a = I_{sh} + I_L}$$

$$\boxed{I_{sh} = \frac{V_{sh}}{R_{sh}} = \frac{V_L}{R_{sh}} = \frac{220}{440} = 0.5\ A}$$

$$\boxed{I_L = \frac{P_L}{V_L} = \frac{55}{220} = 0.25\ A}$$

$$\boxed{I_a = I_{sh} + I_L = 0.5 + 0.25 = 0.75\ A}$$

$$\boxed{-E_g + BCD + I_a R_a + V_L = 0}$$

$$\boxed{E_g = BCD + I_a R_a + V_L}$$

$$\boxed{E_g = 2 + (0.25 \times 0.25) + 220 = 222.06 V}$$

4.		Taxonomy Level: **Evaluate**	CO: C114.4	PI: 2.2.4
		A 4-pole lap wound dc generator has 200 armature conductors and flux per pole is 0.5 weber. The generator runs at 900 rpm. Find the generated emf.		

Given data

$P = 4$

$A = P = 4$

$Z = 200$

$\phi = 0.5\ wb$

$N = 900$ rpm

$E_g = ?$

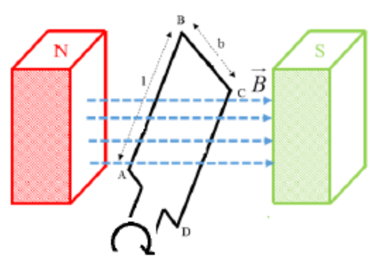
Solution:

$$E_g = \frac{\phi Z N}{60} \frac{P}{A}$$

$$E_g = \frac{0.5 \times 200 \times 900}{60} \left(\frac{4}{4}\right) = 1500\ V$$

5.		Taxonomy Level: **Evaluate**	CO: C114.4	PI: 2.1.1
		Obtain the equation for generating EMF in a DC Generator?		

EMF equation of a DC generator



Consider a DC generator with the following details:

P = Number of poles

ϕ = Magnetic flux/pole (weber)

Z = Total number of armature conductors

A = Number of parallel paths in the armature

N = Speed of the generator (rpm)

According to Faraday's laws of electromagnetic induction principle, The induced emf in the armature, having Z number of conductors, connected in A number of parallel paths,

$$E_g = \frac{Z}{A}\frac{d\phi}{dt}$$

The change in flux in one revolution is given by

$$d\phi = P\phi$$

The time required to complete one revolution is given by

$$dt = \frac{60}{N}$$

$$\boxed{E_g = \frac{\phi Z N}{60} \frac{P}{A}}$$

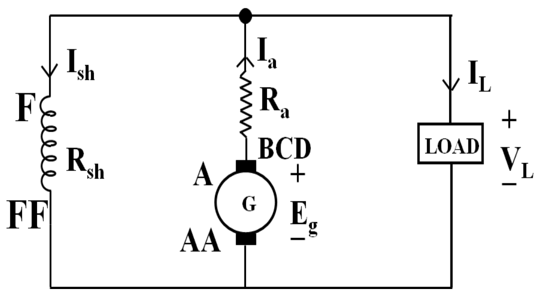
For **Lap winding,** A=P, therefore, $\boxed{E_g = \frac{\phi Z N}{60}}$

For **Wave winding,** A=2, therefore, $\boxed{E_g = \frac{\phi Z N}{60} \frac{P}{2}}$

(10 Marks)

1.	**Taxonomy Level: Evaluate**	**CO: C114.4**	**PI: 2.1.1**
	Classify various DC Generators with neat diagrams and necessary equations		

DC Shunt Generator

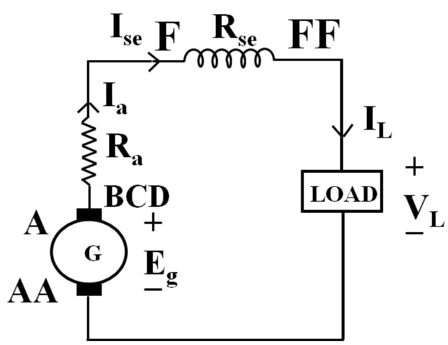


$$\boxed{I_a = I_{sh} + I_L}$$

$$-E_g + BCD + I_a R_a + V_L = 0$$

$$-E_g + BCD + I_a R_a + I_{sh} R_{sh} = 0$$

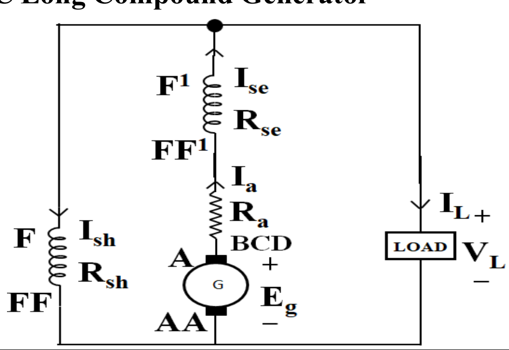
DC Series Generator



$$\boxed{I_a = I_{se} = I_L}$$

$$-E_g + BCD + I_a R_a + I_{se} R_{se} + V_L = 0$$

DC Long Compound Generator

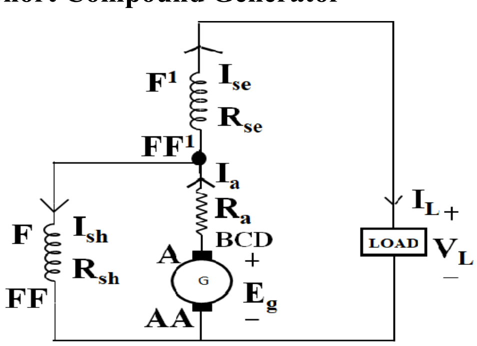


$$\boxed{I_a = I_{se} = I_{sh} + I_L}$$

$$-E_g + BCD + I_a R_a + I_{se} R_{se} + V_L = 0$$

$$-E_g + BCD + I_a R_a + I_{se} R_{se} + I_{sh} R_{sh} = 0$$

DC Short Compound Generator



$$\boxed{I_{se} = I_L}$$

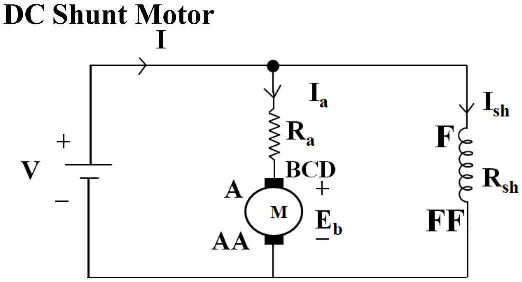
$$\boxed{I_a = I_{sh} + I_{se}}$$

$$-E_g + BCD + I_a R_a + I_{se} R_{se} + V_L = 0$$

$$-E_g + BCD + I_a R_a + I_{sh} R_{sh} = 0$$

2.	Taxonomy Level: Understand	CO: C114.4	PI: 2.1.1
	Classify various DC Motors with neat diagrams and necessary equations		

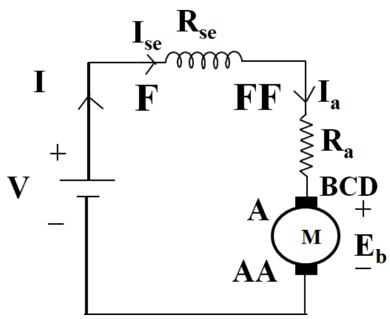
DC Shunt Motor



$$\boxed{I = I_a + I_{sh}}$$

$$\boxed{-V + I_a R_a + BCD + E_b = 0}$$

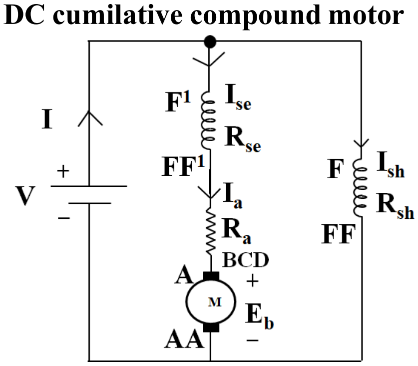
DC Series Motor



$$\boxed{I = I_{se} = I_a}$$

$$\boxed{-V + I_{se} R_{se} + I_a R_a + BCD + E_b = 0}$$

DC cumilative compound motor

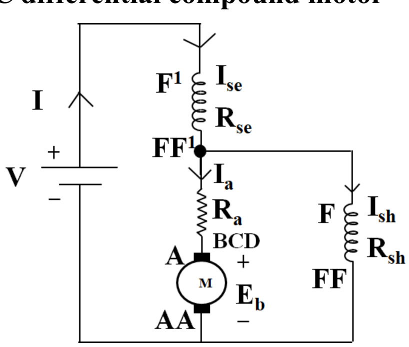


$$\boxed{I = I_a + I_{sh}}$$

$$\boxed{I_a = I_{se}}$$

$$\boxed{-V + I_{se} R_{se} + I_a R_a + BCD + E_b = 0}$$

DC differential compound motor

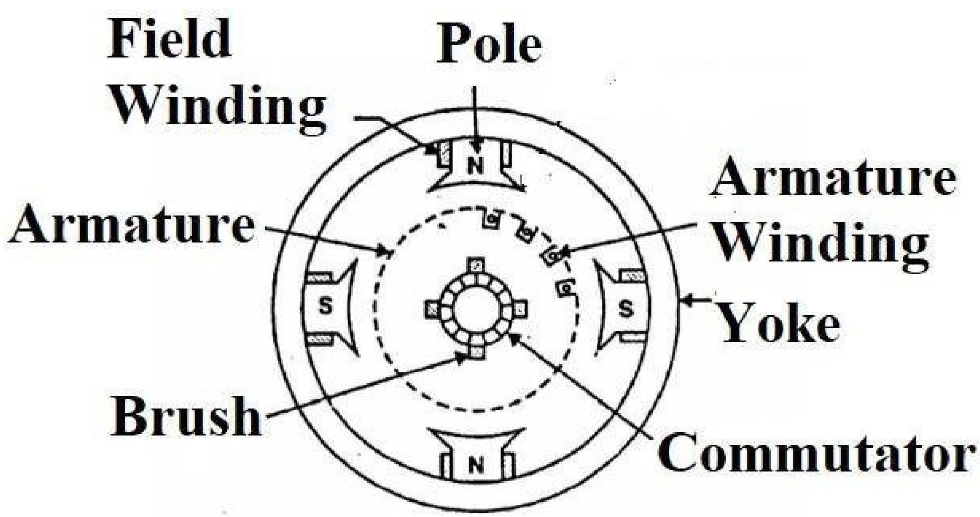


$$\boxed{I = I_{se}}$$

$$\boxed{I = I_a + I_{sh}}$$

$$\boxed{-V + I_{se} R_{se} + I_a R_a + BCD + E_b = 0}$$

3.		**Taxonomy Level: Analyze**	**CO: C114.4**	**PI:2.2.2**
		Briefly explain the constructional details of a dc generator.		



1. **Yoke**

- It is made up of cast iron.
- It carries field poles
- It provides mechanical support for the generator.

2. **Poles**

- Poles are made up of high grade steel.
- Poles are connected to the yoke.
- Poles produce required magnetic flux to generate emf in the generator.
- Poles are generally laminated.
- The tail portion of the poles is called pole shoes. Pole shoes help to distribute the flux more uniformly in the air gap between stator and rotor.

3. **Field Windings**

- Field windings are made up of copper.
- Which carries field current, I_f

4. Armature Drum

- It is made up of steel.
- It is cylindrical structured.
- Laminated type (to reduce eddy current losses).
- It has slots to house the armature winding.
- If the armature has 24 slots and each slot having 4 conductors, then the total number of conductors = 96.

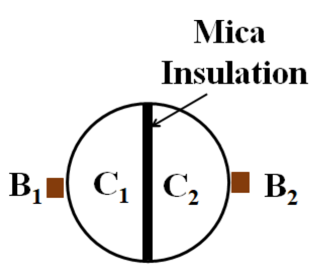
5. Armature Windings

- There are two types of armature winding connections Lap and Wave.
- When the armature windings are Lap connected then (A=P).
- When the armature windings are Wave connected then (A=2).

  Where,
  A= Armature parallel paths
  P= Number of poles on the stator

6. Commutator

- It is made up of copper.
- It is a circular ring shaped conducting element, situated on the shaft.
- It is cut in to two segments C1 and C2, and the two segments are separated by mica insulation. The two segments are connected to two brushes B1 and B2.
- The function of the Commutator: It collects the AC emf from the armature and converts into pulsating DC. Therefore it is called as rotating or mechanical rectifier.



C_1, C_2 = Commutator Segments
B_1, B_2 = Brushes

7. **Brushes**

- Brushes are made up of graphite or carbon
- They are used to collect the current from the Commutator and given to load.
- BCD - Brush contact drop
- If the brush contact drop per brush is 1 volt, the total brush contact drop is 2 volt.

8. **Ball bearings**

- The ball bearings are used to carry the rotor assembly.

9. **Shaft**

- Shaft is the situated on the ball bearings.
- Shaft carries armature and Commutator.
- It is also made up of cast iron or steel.
- Shaft will also helpful to connect two machines.