# D.C. Generators Module I & II

1. With a neat sketch, explain the different parts of a D.C. Machine.
2. Explain the construction of a DC Machine with a neat diagram.
3. Explain the construction and working principle of a DC Generator.
4. Explain the principle of operation of a DC Generator and explain about mechanical rectifier.
5. Draw a neat sketch of the cross-sectional view of a DC Machine and explain the function and material used for each part.
6. Four terminals of a D.C Shunt machine are available, but they are unmarked. How will you identify the field and armature terminals?
7. Explain why all field coils placed on field poles have the same no. of turns / pole and are always connected in series.
8. Name the main parts of a D.C. Machine and state material used.
9. What does pigtail mean? What is its significance?
10. What is the difference between Lap winding & Wave winding?
11. Give the materials and functions of the following parts of a D.C. Machine:-
    (i) Field Poles (ii) Commutator (iii) Armature
12. Draw the schematic diagrams of various types of D.C. Generators in terms of their field excitation.
13. Define ( i ) self excitation ; (ii) separate excitation.
14. What is separate excitation & self excitation? What do you do if a self excited DC Machine fails to build up e.m.f.?
15. Explain the different methods of excitation of D.C Generators with sketches.
16. What is the meaning of Électrical Angle? How it is different from mechanical angle and explain the relation between this two?
17. Draw the power flow diagram of D.C. Generator and also show the expressions of each step.
18. Derive the e.m.f equation of a D.C. Generator.
19. Briefly describe the Open circuit characteristics of D.C. Generators.
20. Explain the magnetization characteristics of a D.C. Shunt Generator.
21. With reference to the curve for buildup of a self excited generator, explain (i) critical field resistance $R_c$ (ii) field resistance higher than $R_{c;}$ and its effect on build up.
22. Draw and explain the magnetization characteristics of self excited D.C. Shunt generator.
23. Explain the magnetic characteristics of a DC Generator.
24. What does critical field resistance of a D.C Shunt generator mean? Explain how this could be determined.
25. Explain the critical field resistance of D.C. Shunt generator.
26. What do you mean by critical speed? Explain with characteristic curves.
27. Why is the voltage drop due to load in a separately excited generator less than that in shunt generator?
28. State the different types of D.C generators and their applications. Draw their circuit diagrams and write down the voltage equations.
29. Differentiate between cumulatively and differentially compounded D.C Generators.
30. Distinguish between Series and Compound machine.

31. Discuss the process of self-excitation of a D.C machine. What conditions must be fulfilled for self-excitation?
32. What are the conditions needed for building up of voltage in a D.C Shunt generator?
33. Under what conditions a D.C generator fails to build up?
34. Explain the reasons for the failure of a D.C. Shunt Machine to build up voltage. How is it rectified?
35. A Shunt generator, when driven at its normal speed, fails to excite. Discuss briefly the most likely reasons for this, and state how you would proceed to remedy the fault.
36. Describe the conditions to be satisfied to build up voltage of a dc shunt generator.
37. State four specific reasons why a self excited shunt generator will not build up voltage.
38. Describe how a self-excited D.C Shunt generator builds up its terminal voltage as it is run by a prime mover.
39. Distinguish between separately excited D.C generator and self-excited D.C generator.
40. Draw the circuit diagrams of self-excited D.C generators and write their relevant current and voltage equations.
41. Draw the external characteristics of a D.C Series generator. Why does the terminal voltage starts decreasing after a certain value of load current?
42. Draw external characteristics of D.C Shunt and Compound generators and compare.
43. Draw and explain the external characteristics of a Separately excited DC Generator and DC Shunt Generator. Draw its equivalent also.
44. Draw and explain the load characteristics of a D.C Shunt generator.
45. Explain the internal and external characteristics of a D.C. series generator.
46. Draw and explain the internal and external characteristics of a D.C. Shunt generator.
47. Sketch and explain the load characteristics of a differentially-compounded compound generator.
48. Discuss the external characteristics of a DC Compound Generator.
49. Draw and explain terminal characteristics of D.C. Generator
50. Explain the difference between critical field resistance and critical load resistance.
51. Explain the term critical load resistance of a D.C Generator.
52. Explain the various losses occurring at various stages in a D.C. Generator.
53. Derive an expression for the maximum efficiency of a D.C generator.
54. State the maximum efficiency criterion for different types of DC Generators.
55. What are the losses occurring in a D.C generator?
56. Name the losses of a D.C. machine and classify them to constant losses and variable losses.
57. Discuss about the various types of losses in a DC Generator and draw its power flow diagram.
58. What causes heating of armature?
59. Explain the process of connecting two Shunt generators in parallel.
60. Discuss the parallel operation of a D.C. Shunt generator.
61. Explain parallel operation of D.C. Series generators.
62. State the necessity and conditions for parallel operation of D.C Generators.
63. Two shunt generators are operated in parallel. Discuss in detail the manner in which they will share the load.
64. Explain the importance of equalizer connection in parallel operation of compound generators.
65. What are the merits and demerits of two generators operating in parallel?
66. What is armature reaction? What are its effects?
67. Explain armature reaction. Cite methods that are commonly used to compensate the demagnetizing effect of Armature reaction.

68. Explain what armature reaction is. In each case explain how the resultant flux reacts.
69. What is the effect of armature reaction on D.C. machine?
70. What is armature reaction? List out various methods to nullify.
71. With neat sketches, explain the process of armature reaction in D.C. machine.
72. What is meant by armature reaction? How does it affect the performance of a shunt machine?
73. Give two reasons why the resultant flux entering an armature, whose conductors are carrying full load, is less than the no-load flux.
74. Derive an expression for the two components of armature reaction in terms of relevant quantities.
75. Derive an expression for demagnetizing and cross magnetizing ampere turns / pole of a D.C. Machine.
76. What does armature reaction mean in a D.C. generator? What are its effects? Explain how the effect of armature reaction can be neutralized.
77. What are cross magnetizing and demagnetizing armature m.m.f.?
78. Explain the function of compensating windings in a D.C. machine.
79. Define Commutation. Describe the process of commutation in D.C. generators.
80. What is commutation in DC Machine? Explain with neat diagram and also write how to improve commutation.
81. What is commutation? Explain with neat diagram.
82. Explain with a neat diagram the process of commutation in D.C. machines.
83. Explain the function and action of a commutator.
84. Define commutation. Explain the process of commutation in a D.C. Machine and describe the methods to improve it.
85. What are linear commutation, accelerated commutation and retarded commutation?
86. What do you mean by reactance voltage? How is it neutralized in a D.C. machine?
87. Explain the concept of reactance e.m.f. in D.C. machine.
88. What is the significance of 'time of commutation'?
89. Explain different methods of improving commutation in D.C. generator.
90. With neat sketches, explain the action of commutation in D.C. machines.
91. With neat sketches explain inter-poles and their functions.
92. What is the function of inter poles in a D.C. Machine. What should be their polarity with respect to main poles in a D.C. machine?
93. How does an interlope accelerate commutation?
94. What are inter- poles? What the advantages are of inter pole machines?
95. 'The dc machines with inter poles are economical and more compact in size than non- Inter polar dc machines of the same rating'. Comment on this statement.
96. Write short notes on Interpoles.
97. For dc shunt generator operating in parallel, explain why a condition of stable equilibrium exists between these generator for sudden increase or decrease in speed.
98. Define commutation and briefly discuss the various methods of Commutation and methods to improve Commutation.
99. What is the effect of Armature reaction on the external characteristics of DC Generator?

**DCMT - Module I and II**
**KTU Questions**

1. What is armature reaction in DC machines? How it affects the main flux distribution and how can armature reaction be reduced?
2. Define the terms critical resistance and critical speed and bring out their roles in the process of self excitation in dc machines. What are the conditions for voltage build up in a DC shunt generator?
3. Give the constructional features and working principle of a DC generator. Draw the c.s. view of a 4 pole DC generator and label all the parts. Explain the function of each part.
4. Compare lap and wave windings used for DC machine armature.
5. Draw the magnetization characteristic of self excited DC shunt generator and explain.
6. Derive the electro dynamic equation of rotating electrical machines and explain the principle of energy conversion.
7. **Draw the developed diagram** layout of a **lap connected simplex double layer DC armature** with 16 slots and 4 poles. Furnish the winding table and show connections to 4 equalizer rings.
8. Derive the emf equation of a Dc generator from first principles.
9. What is armature reaction in DC machines and explain its effects? Derive expressions for magnetizing and demagnetizing ampere turns per pole.
10. What is the function of an equalizer ring in a lap wound DC machine?
11. With neat diagram explain the construction of DC generator.
12. Define commutation. Explain the process of commutation with neat sketches.
13. What are the effects of armature reaction on the operation of DC machine? What are the remedial measures taken to counter, effects of armature reaction.
14. Point out the necessity of equalizer rings in a lap wound DC machine. Why is it not applicable in wave wound machines?
15. What is armature reaction and how it is eliminated in DC machines.
16. For a 6 pole DC armature with 16 slots having 2 coil sides per slot and single turn coils, calculate the relevant pitches for a **wave winding** and **draw the developed diagram**.
17. Draw the magnetization characteristics of a DC shunt machine. Point out the conditions for voltage build up of a DC shunt generator. Give the significance of the terms critical resistance and critical speed as applicable to DC shunt generator.

18. Derive the emf equation of a DC generator.
19. **Draw the developed view of a double layer lap winding of a 4 pole 12 slot armature. Commutator and brushes need not be drawn.**
20. Draw the developed view of mmf and flux distribution of a loaded 2 pole machine.
21. Name the parts of a DC machine and state the functions of any two parts.
22. Derive the emf equation of a DC generator.
23. **Draw the winding diagram of a DC machine with 4 poles, 12 slots progressive double layer lap winding.**
24. Name the different losses occur in a DC machine. How the magnetic losses are minimized in a DC machine.
25. What is self excitation? What are the conditions for building up of voltage in DC shunt generator?
26. Write any three differences between wave winding and lap winding.

**QUESTION BANK** **D.C Generators Module-I and II**

1. A 500 Volts, 250 kW Long shunt compound generator induces an e.m.f of 480 Volts when running at 1000 r.p.m. on no-load. On full load, the speed of the machine drops to 975 r.p.m, the flux increased by 15% and the terminal voltage rises to 500 Volts. If the series and shunt field resistance are 0.02 ohm and 100 ohm respectively, calculate the armature resistance. Assume a voltage drop of 1Volt per brush.
2. Two shunt generators, each with a no load voltage of 125 V are run in parallel. Their external characteristics can be taken as straight lines over their operating ranges. The first generator is rated at 250 kW and its full load voltage is 119 V. The second generator is rated at 200 kW at 116 V. Calculate the bus-bar voltage when the total load is 3500 A. How is the load divided between the two?
3. Two D.C. Shunt Generators are operated in parallel to supply a load of 1500A. The armature and field resistances of the machines are 0.01 Ω and 0.2 Ω and 25 Ω and 20 Ω respectively. If the induced e.m.f's are 250V and 240V respectively, find (i) terminal voltage (ii) the current output of each generator.
4. A Short shunt Compound generator supplies a load current of 10A at 250V. The generator has the following winding resistances. Shunt field resistance – 130 Ω, Armature resistance – 0.1 Ω, Series field resistance – 0.1 Ω. Find the generated e.m.f. if the brush drop is 1V/ brush.
5. A Short-shunt compound generator supplies a current of 100 A at a voltage of 220 V. The resistance of the shunt field, series field and armature are 50 Ω, 0.025 Ω and 0.05 Ω respectively. The total voltage drop in the brush is 2V and the total iron and friction on losses are 1000 W. Determine (i) Generated voltage (ii) Copper losses (iii) the output of the prime mover driving the generator (iv) Generator efficiency.
6. A 4 pole lap connected D.C. generator has no load generated e.m.f of 500V when driven at 1000 r.p.m. Calculate the flux/pole if the armature has 100 slots with 5 conductors/slot. If each conductor has a resistance of 0.01 ohm, find the resistance of the armature winding.
7. A Shunt generator gave the following results in the OCC test at a speed of 800 r.p.m:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Field current : | 1 | 2 | 3 | 4 | 6 | 8 | 10 |
| EMF : | 90 | 185 | 250 | 290 | 325 | 345 | 360 |

   The field resistance is adjusted to 50 ohm and the terminal voltage is 300 V on load. Armature resistance is 0.1 ohm. Assuming that the flux is reduced by 5% due to armature reaction, calculate the load supplied by the generator.
8. A 60 kW D.C. shunt generator has 1,600 turns/pole in its shunt windings. A shunt field current of 1.25 A is required to generate 125 V at no load and 1.75 A to generate 150 A at full load. Calculate (i) The minimum number of series turns/ pole needed to produce the required no load and full load voltages as a Short shunt compound generator (ii) If the generator is equipped with 3 series turns/pole having a resistance of 0.02 ohm, calculate the diverter resistance required to produce the desired compounding.
9. The OCC of a D.C. machine at 400 r.p.m. is as follows:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Field current in Amps: | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Generated volt : | 110 | 155 | 186 | 212 | 230 | 246 | 260 | 271 |

   Find (i) the voltage to which the machine will build up as self excited shunt generator, if field circuit resistance is 35 ohm (ii) critical field resistance at 700 r.p.m (iii) critical speed if field resistance is 80% of critical resistance 400 r.p.m.

10. The open circuit characteristics of a DC shunt generator at 800 r.p.m. is given below :

If (A) ….0 0.20 0.4 0.65 1.02 1.75 3.15 5

Eo(V)….10 40 80 120 160 200 240 260

Determine (i) The critical field resistance at 800 r.p.m. (ii) If the field resistance is 55 ohm, find the range of the field rheostat to vary the voltage from 200 to 250 V, on open circuit, at a speed of 800 r.p.m

11. Find the number of series turns required per pole on a 50kW Compound generator to give 220V on no-load and 250V on load, the corresponding m.m.f.'s per pole required being 4400AT and 5800AT respectively. Assume that the shunt field alone can give 220V at no-load.
12. A 250 kW, 240V generator is be compounded such that its voltage rises from 220V at no load to 240 at full load . When series field is cut out and shunt field is excited from an external source, then from the load test it is found that, this rise in voltage can be obtained by increasing the exciting current from 7A at no-load to 12A at full- load. Given that shunt turns/pole = 650, series turns/pole = 4 and resistance of series winding, 0.006 ohm. If the machine is connected Long shunt, find the resistance of the series diverter. *Ignore series amp turns at no-load and drop in series winding resistance at full- load.*
13. The armature of a 6-pole D.C. machine has 125 turns and runs at 100 r.p.m. The e.m.f generated on open circuit is 500 V. Find the useful flux per pole when the armature is (i) Lap connected (ii) Wave connected.
14. A D.C. Shunt generator delivers 195A at a terminal voltage of 250V. Its armature resistance is 0.02Ω and shunt field resistance is 50Ω and stray losses are 950W. Find (i) generated e.m.f. (ii) Copper losses (iii) output of the prime mover (iv) mechanical, electrical and commercial efficiencies.
15. The magnetization curve of a D.C. Generator driven at 400 rpm is as follows.

Field current (A): 2 3 4 5 6 7 8 9

Terminal Voltage (V): 110 155 186 212 230 246 260 271

The resistance of the field winding is 34Ω. Find (i) the voltage to which the machine will excite, when running as a shunt generator at 400 rpm. (ii) the additional resistance in the field circuit to reduce the e.m.f. to 220V (iii) the value of the critical field resistance (iv) Critical speed when field circuit resistance is 34 Ω.

## ARMATURE REACTION & COMMUTATION

1. A 4 pole D.C. Generator supplies a current of 143 amperes. It has 492 conductors lap wound. When delivering full load, the brushes are given a lead of $10^0$. Calculate the demagnetizing, ampere turns per pole. The field winding is shunt connected and takes 10 A. Find the number of *extra field turns to neutralize the demagnetization*.
2. A lap-wound, 4-pole D.C. Generator with 480 armature conductors supplies 72 A. The brushes are given an actual lead of $12^0$ mechanical. Calculate the cross magnetizing AT per pole.
3. A 6-pole, 40 kW, 400 V wave connected D.C. Generator has 492 conductors. The brushes are shifted by an angle of 8 mechanical degrees. Calculate the demagnetizing and cross- magnetizing AT per pole.
4. A 4-pole wave wound armature has 880 conductors and delivers 120 A. The brushes have been displaced through 3 angular degrees from the geometrical axis. Calculate (1) Demagnetizing amp-turns/pole (2) Cross-magnetizing amp-turns/pole (3) the additional field current for neutralizing the demagnetization if the field winding has 110 turns / pole.
5. A 4-pole, 50 kW, 250 V wave wound Shunt generator has 400 armature conductors. Brushes are given a lead of 4 commutator segments. Calculate the demagnetization amp-turns/pole if shunt field resistance is 50 ohm. Also calculate extra shunt field turns /pole to neutralize the demagnetization.

6. A 250kW, 400V, 6 pole D.C. Generator has 720 lap wound conductors. It is given a brush lead of 2.5 mechanical degrees from the geometrical neutral. Calculate the cross- magnetizing and de-magnetizing AT per pole. Neglect $I_{sh}$.
7. A 90 kW, 450 V, 4 pole D.C. Shunt generator has a wave wound armature of 640 conductors. If the brushes are given an actual lead of 8 mechanical degrees, determine the demagnetizing and cross-magnetizing AT per pole. The resistance of the shunt field winding is 45 ohm.
8. A 6 pole wave wound D.C. Generator has armature conductors 360, armature current 80A, angle of lead 5 degrees from G.N.A. Calculate (i) the demagnetizing and cross- magnetizing AT per pole. (ii) No: of series turns per pole required for neutralizing the de-magnetization. Take leakage coefficient as 1.2.
9. A 4 pole wave wound D.C. armature has a bore diameter of 0.7m. It has 520 conductors and ratio of pole arc to pole pitch is 0.62. The armature is running at 720 r.p.m. and the flux density in the air gap is 1.1T. Calculate the e.m.f. generated in the armature if the effective length of the armature conductor is 0.2m.
10. A 4 pole lap wound armature running at 1500 r.p.m delivers a current of 150 A and has 64 commutator segment. The brush span 1.2 segments and inductance of each armature coil is 0.04 mH. Calculate the value of reactance voltage, assume linear commutation.
11. A 4-pole, lap wound armature running at 1500 rpm delivers a current of 150A and has 64 commutator segments. The brush spans 1.2 segments and inductance of each armature coil is 0.05 mH. Calculate the value of reactance voltage assuming: (i) linear commutation (ii) Sinusoidal commutation.
12. A long shunt compound generator delvers a load current of 50A at 500V, and has armature, series field and shunt field resistances of 0.05Ω, 0.003Ω and 250Ω respectively. Calculate the generated electromotive force and the armature current. Allow 10 V per brush for contact drop.

13. A separately excited generator, when running at 1200 r.p.m supplies 200 A at 125V to a circuit of constant resistance. What will be the current when the speed is dropped to 900 r.p.m if the field current is unaltered? Armature resistance is 0.04Ω, total voltage drop at brushes is 2V. Ignore change in armature reaction.
14. A 1500kW, 550V, 16-pole generator runs at 150 r.p.m, what must be the useful flux per pole if there are 2500 conductors lap- connected and full load copper losses are 25kW? Calculate the area of the pole shoe if the gap density has a uniform value of 0.9 $Wb/m^2$ and find the no – load terminal voltage, neglecting armature reaction and change in speed.
15. A 50kW, 120V, long shunt compound generator is supplying a load at its maximum efficiency and at rated voltage. The armature resistance is 50 mΩ, series field resistance is 20 m Ω, shunt field resistance is 40 Ω and Rotational loss is 2kW. What is the maximum efficiency of the generator?
16. A 4 pole, wave wound dc machine running at 1500 rpm has a commutator of 30 cm diameter. If the armature current is 150A, thickness of the brush is 1.25 cm and the self inductance of each armature coil 0.07 mH, calculate the average emf induced in each coil during commutation. Assume linear commutation and neglect mica insulation.
17. Calculate the reactance emf for a 4 pole wave wound machine, having the following particulars. Rpm = 900, No: of commutator segments = 55, Brush width in commutator segments = 1.74. Coefficient of self induction = 153μH, Armature current at full load = 54A. Assume linear commutation and neglect mica thickness.
18. A 24 slot, 2 pole dc machine has 18 turns per coil. The average flux density per pole is 1 T. The effective length of the machine is 20cm and the radius of the armature is 10cm. The magnetic poles are designed to cover 80% of the armature periphery. If the armature angular velocity is 183.2 rad. /sec, determine (a) the induced e.m.f in the armature winding (b) the induced e.m.f per coil (c) the induced e.m.f per turn (d) the induced e.m.f per conductor.

## D.C. Motors Module III

1. What is back e.m.f? How is it related to applied voltage?
2. Derive the expression for back e.m.f.
3. State the importance of 'Back e.m.f' in a D.C motor. How does it make the motor self regulating?
4. How back e.m.f is created in a D.C Shunt motor? Explain its significance.
5. Explain why, the induced e.m.f in a D.C motor is called back e.m.f or counter e.m.f. What will be its value at the time of starting the motor?
6. Explain how the torque is produced in a D.C motor?
7. Explain the construction and working principle of a D.C. Motor.
8. Starting from fundamentals, derive an expression for the torque developed by the armaturewinding.
9. Derive from fundamentals an expression for the torque developed in an electromagnetic machine.
10. State the mechanism of torque generation in a D.C. Motor. Write its expression.
11. Derive an equation for the electromagnetic torque developed in a D.C.Machine
12. Compare D.C. generator and D.C. motor action.
13. Explain the concept of motoring action of a D.C.Machine.
14. Sketch the typical characteristics of a D.C.Series Motor. What are the applications for this motor?
15. Draw and explain the various characteristics of a D.C. Series motor.
16. Compare the characteristics of D.C. Shunt motor and Series motor.
17. Explain the load characteristics of Shunt and Compound motors.
18. What would be the sequence of events if the load on the D.C. Motor is increased?
19. A D.C. Series motor should not be started on no-load. Why?
20. Based on the characteristics, explain the applications of D.C. Series and Shunt motors.
21. On what condition is D.C. Series motor started? On no-load or on-load. Explain.
22. Why a D.C. Series motor should never be run on no-load or it should be belt driven? Explain.
23. Draw the electrical and mechanical characteristics of a D.C. Series motor. What are the practical applications of this motor?
24. In detail explain the electrical, mechanical and other major characteristics of D.C. Series motors. Draw the performance curve of D.C. Series Motor.
25. Draw and explain the performance characteristics of a D.C. Series Motor.
26. Sketch $T_a$ Vs $I_a$, N Vs $I_a$ and N Vs $T_a$ characteristics of a D.C. Shunt motor and D.C. Series motor.
27. With the aid of relevant mechanical characteristics, discuss the various applications of D.C. Shunt, Series and Compound motors.
28. What will happen if D.C. Series motor is run without any load? Explain the reason.
29. A DC machine should never be started at its rated voltage. Why?
30. Draw and explain T Vs $I_a$ characteristics of D.C. Series motor.
31. Draw $T_d$, $P_d$ and N characteristics of a D.C. Series motor as a function of $I_a$. Also draw $T_d$ and $P_d$ of a D.C. Series motor as a function of N.
32. Explain with necessary equations, why a D.C. Series motor should not be started with no load.
33. Draw and explain the electrical and mechanical characteristics of D.C.Shunt motors.

34. Sketch the speed-torque characteristic and explain the relation between them of a D.C Series and Shunt motor.
35. Define percentage speed regulation of a D.C.Motor. Sketch the speed-torque characteristics of D.C.Motor.
36. What does speed regulation mean in a D.C. Motor? Write its expression.
37. How speed of a D.C. Motor is varied?
38. Explain two methods of speed control of D.C. Motor.
39. What are the factors controlling the speed of a D.C. Motor?
40. Explain any one method of speed control of D.C. Series motor.
41. Briefly explain the various methods employed for speed control of a D.C Shunt motor.
42. Briefly explain the various methods employed for speed control of a D.C Series motor.
43. Discuss about various methods employed for speed control of a D.C Shunt motor with diagrams.
44. Explain how the speed of a D.C. Shunt motor can be varied both above and below rated speed.
45. Explain the Series-Parallel method for D.C. Series motor.
46. Discuss the factors controlling the speed of a D.C. Motor. Explain the rheostatic control methods. Discuss the merits and demerits of this method.
47. Why is armature voltage control more effective than field current control in a D.C Motor speed control schemes?
48. Describe any one speed control method for a D.C. Motor.
49. Explain the Ward-Leonard system of speed control of D.C. Motor.
50. With a neat circuit schematic, explain any one method of controlling the speed of D.C. Shunt motor. List advantages and drawbacks of the method.
51. How may the speed of a D.C. Motor be controlled by armature voltage and field current? State the limitations of the two methods.
52. What is a starter? What is the necessity of a starter in a D.C. Motor?
53. What happens if we start a D.C. Motor without starter? Derive the torque equation.
54. What is the need for starters in a D.C. Motor?
55. What is the purpose of a starter in a D.C.Motor?
56. Explain why starters are necessary for starting D.C.Motors.
57. With a neat diagram, explain the working of a 3 point starter. Explain the function of each component.
58. With a neat diagram, explain the working of a 3-point starter used with D.C. Motors.
59. Differentiate between 2 point and 3 point starter.
60. Draw the sketch of a 3 point starter and explain its operation. What is its drawback? How is it overcome in a 4 point starter?
61. With a neat diagram, explain the working of a 4 point starter.
62. Explain the function of ‘No-volt Coil” and ‘Over-load Coil’ in a 3 point starter.
63. How will you change the direction of rotation of a D.C. Motor?
64. What is the effect of an open field connection on the working of a D.C. Shunt motor?
65. What is the effect of an open field circuit on a D.C. Motor? Explain.
66. Derive the condition for maximum efficiency of a D.C. Shunt motor.
67. Which are the losses in a D.C.Motor and how do they vary with load?
68. Name the losses in a D.C. Machine and classify them to 1) Constant losses 2) Variable losses.
69. Which are the various losses occurring in D.C motor? Which are the different types of D.C. Motors?
70. Describe an indirect method for determining the efficiency of a D.C. Machine.
71. List out the tests done on D.C. Machine.

72. Explain the Swinburne’s test on a D.C. Motor. What are its advantages and disadvantages?
73. What are the advantages and disadvantages of Swinburne’s method of testing of D.C. Machines?
74. What is the importance of Swinburne’s test? How do you predetermine the efficiency of a D.C Shunt machine using the above test?
75. How the efficiency of a D.C. Shunt motor can be determined using Swinburne’s test.
76. What are the merits and demerits of Swinburne’s test?
77. Explain Swinburne’s test.
78. Explain Hopkinson’s test.
79. Describe the method of conducting Hopkinson’s test on two similar D.C.Shunt machines. Show also, how the test can be used to compute the efficiency of the machine.
80. Briefly explain the Hopkinson’s test in D.C. Machines.
81. With a neat diagram, explain Hopkinson’s method of testing D.C. Machines.
82. Explain the procedure and calculation for calculating the full load efficiency by Hopkinson’s test.
83. With a neat diagram, explain Hopkinson’s method of testing D.C. Machines.
84. Explain the Hopkinson test on a pair of D.C. Shunt motors.
85. Briefly explain the Retardation test in D.C. Machines.
86. How the rotational losses may be estimated by Retardation test.
87. Briefly describe the three tests conducted on D.C. Machines.
88. Explain why, the armature current often employed as an indication of motor load and speed.
89. What is the effect of armature reaction on the speed regulation of dc motors?
90. Explain why, the D.C Series motor must be started with a mechanical load coupled to its armature?
91. Give reasons why the armature connections are selected for reversal of motor direction rather than the field connections of dc motors.

**KTU QUESTIONS**

1. Why is a starter necessary for a motor? Give the diagram and explain the working of a 3 point starter for a DC Shunt motor including the features of ‘No Volt Release’ and ‘Over load Release’.
2. Draw and explain the electrical and mechanical characteristics of DC Shunt Motors.
3. With neat diagrams, explain the speed control methods in Separately excited DC motors.
4. How back emf is generated in a DC motor? Explain its significance.
5. What is starter? What is the necessity of starter in a DC Motor?
6. Explain with neat sketch how speed control of a DC Motor is done.
7. Compare the electrical and mechanical characteristics of a DC Shunt Motor with those of a DC Series Motor. Based on this, point the application areas of these motors.
8. With a neat sketch, explain the working of a 3 point starter. What is the main drawback? How this is eliminated in 4 point starter?
9. With supporting diagrams, show how the retardation test can be employed to find out the various losses occurring in a DC machine.
10. Why a starter is required to start a DC motor? What is the essential element of a starter?
11. With the help of speed-armature current characteristics, explain why the series motors should not be started without any load.
12. What is the necessity of a starter for motor? With a suitable diagram, explain the working of 3 point starter.
13. With suitable diagram, how Swinburne’s test can be employed to predetermine the efficiency at full load condition when running as a generator.

## D.C Motors Module III

1. A 4 pole lap wound Shunt motor has 600 conductors in the armature. The effective resistance of the armature path is 0.05 Ω. The resistance of the shunt field is 25 Ω. Find the speed of the motor when it takes 120A from D.C. mains of 100V supply. Flux per pole is $2 \times 10^{-2}$ Wb.
2. Determine the value of the torque in Nm of a 4 pole motor having 774 conductors, two paths in parallel, flux of 24mWb per pole when total armature current is 50A.
3. A 460V Series motor runs at 500 r.p.m. taking a current of 40A. Calculate the speed and % change in torque, if the load is reduced so that the motor is drawing 30A. Total resistance of armature and field circuit is 0.8 Ω. Assume flux and field current are proportional.
4. A D.C. Shunt motor runs at 9000 r.p.m. from a 400V supply when taking an armature current of 25A. Calculate the speed at which it will run from a 230V supply when taking an armature current of 15A. The resistance of the armature circuit is 0.8 Ω. Assume the flux per pole with 230V to have decreased to 75% of its value at 400V.
5. A belt driven 100kW Shunt generator running at 300 r.p.m. on 250V busbars continues to run as a motor when the belt brakes, then taking 10kW. What will be its speed? Given armature resistance 0.03 Ω, shunt field resistance 50 Ω and brush drop is 1V. Neglect armature reaction.
6. A 200 V , 14.92 kW D.C. Shunt motor when tested by ‘Swinburne’s method’ gave the following results: Running light: the armature current is 6.5 A and field current 2.2 A
   With armature locked: the current was 70A when a pd of 3V was applied to the brushes. Estimate the efficiency of the motor when working under full load conditions.
7. A 200V D.C. Shunt motor has an armature resistance of 0.25 Ω and field resistance of 200 Ω. When running on no-load, it takes 5A. Calculate the hp output and the efficiency of the motor, when loaded to take a line current of 40A.
8. While conducting Hopkinson’s test on a pair of D.C. Shunt machines, following results were obtained. In such a test on 250 V machines, the line current was 50A and the motor current 400 A not including the field currents of 6 and 5 A. The armature resistance of each machine was 0.015 ohm. Calculate the efficiency of each machine.
9. A D.C. Series motor drives a load, the torque of which is proportional to square of the speed. The motor current is 20 A when speed is 500 r.p.m. Calculate the speed and current when the motor field winding is shunted by a resistance of the same value as the field winding. Neglect all motor losses and assume that the magnetic field is unsaturated.
10. A Series motor of resistance 1 ohm between terminals, runs at 900 r.p.m at 220 V, with a current 15 A. Find the speed at which it will run when connected in series with a 4 ohm resistance and taking a current of 10 A at the same supply voltage . Assume linear magnetization curves.
11. A Series motor with an unsaturated magnetic circuit and 0.5 Ω total resistance when running at a certain speed takes 60A at 500V. If the load torque varies as cube of speed, calculate the resistance required to reduce the speed by 25%.
12. The peak current of a D.C. Shunt motor rated at 230V should not exceed 2.5 times the rated value. The rated current of the motor is 12A. Determine the value of starting resistance and the way in which it is divided into 5 sections.
13. A 440 V, 18.65 kW motor has an armature resistance of 1.2 ohm and full load efficiency of 85%. Calculate the number and value of resistance elements of starter for the motor if maximum permissible current is 1.5 times the full load current.

14. A 200 V, D.C. Shunt motor takes full-load current of 12 A. The armature circuit resistance is 0.3 ohm and the field circuit resistance is 100 ohm. Calculate the value of 5 steps in a 6- stud starter for the motor. The maximum starting current is not to exceed 1.5 times the full-load current.
15. A shunt motor develops a total torque of 250Nm at rated load. When it is subjected to a 15% decrease in field flux, the armature current increases by 40%. Calculate the new torque produced as a result of change in field flux.
16. A starter is to be designed for a 10kW, 250V shunt motor. The armature resistance is 0.15 Ω. This motor is to be started with a resistance in the armature circuit so that during starting period the armature current does not exceed 200% of the rated value or fall below the rated value. That is, the machine is to start with 200% of the armature current and as soon as the current falls to the rated value, sufficient series resistance is to be cut out to restore current to 200% (or less in the last step). The process is to be repeated till all the resistance is cut out.
    (i) Calculate the total resistance of the starter.
    (ii) Calculate the resistance to be cut out in each step in the starting operation
17. Hopkinson's test on two machines gave the following results for full load; line voltage 250V, line current excluding field current 50A, motor armature current 380A, field currents 5 and 4.2A. Calculate the efficiency of each machine. The armature resistance of each mahine is 0.02 Ω. State the assumptions made.
18. A retardation test is conducted on a separately excited motor. The induced voltage falls from 400V to 380V. (i) in 65 sec. opening the armature circuit (ii) in 40 sec.on suddenly changing the armature connections from the supply to a resistance taking 10A. Calculate the constant losses of the motor.
19. A 50hp, 500V shunt motor has a full load efficiency of 0.87 and runs at 750 rpm. A series winding is added to raise the speed to 800 rpm. Find the armature current and the efficiency under these conditions. Armature resistance is 0.4 Ω, shunt winding resistance 250 Ω,. Assume that the load and the constant losses remain as constant.
20. A 240V DC Shunt motor takes a current of 3.5A on no-load. The armature circuit resistance is 0.5 Ω and shunt field resistance is 160 Ω. When the motor operates at full load at 2400 rpm, it takes 24A. Determine (i) efficiency at FL (ii) torque developed and useful torque (iii) the no-load speed (iv) percent speed regulation. Sketch the power flow diagram for each operating condition.
21. A 230V DC Shunt motor, takes an armature current of 3.3A at rated voltage and at no-load speed of 1000 rpm. The resistance of the armature circuit and field circuit are respectively 0.3 Ω and 160 Ω. The line current at FL and rated voltage is 40 A. Calculate at FL, speed and developed torque in case the armature reaction weakens the no-load flux by 4%.
22. A DC Shunt machine while running as generator develops a voltage of 250V, at 1000 rpm on no-load. It has armature resistance of 0.5 Ω and field resistance of 250 Ω. When the m/c runs as motor, input to it at no-load is 4A at 250 V. Calculate the speed and $\eta$ of the machine when it runs as a motor taking 40A at 250V. Armature reaction weakens the flux by 4%.

## KTU QUESTIONS

1. A 200 V series motor has a total resistance of 0.5 Ω. It runs at 800 rpm taking an input of 10A. Find the series resistance required to reduce the speed to 600 rpm, the input current being kept constant.
2. A 250 V DC shunt motor has an armature resistance of 0.5 Ω and a field resistance of 250 Ω. The motor draws 21A when driving a constant torque load at 600 rpm. What will be the new speed of the motor if an additional 250 Ω resistance is inserted is inserted in the field circuit?
3. A 6 pole 250 V series motor is wave connected. There are 240 slots and each slot has 4 conductors. Flux per pole is 0.175 mWb when the motor is taking 80A. The field resistance is 0.05 Ω, the armature resistance is 0.1 Ω and the iron and frictional loss is 0.1 kW. Calculate (i) speed (ii) BHP (iii) shaft torque (iv) the pull in Newtons at the rim of the pulley of diameter 25 cm.

4. A 250 V shunt motor has resistances 0.2 Ω and 250 Ω. The motor is driving a constant load torque and running at 1000 rpm drawing 10 A current from the supply. Calculate the new speed and armature current if an external armature resistance of value 10 Ω is inserted in the armature circuit. Also find the stalling current. Neglect armature reaction and saturation.
5. During Swinburne's test a 250V DC machine was drawing 3A from the 250V supply. The resistances are 250 Ω and 0.2 Ω. Find the constant loss of the machine. Also find the efficiency of the machine when it is delivering a 20A at 250V.

**ADDITIONAL QUESTIONS**

1. A 230V D.C. Series motor develops its rated output at 1500 rpm while taking 20A. Armature and series field resistances are 0.3Ω and 0.2Ω respectively. Neglecting saturation, determine the resistance that must be added to obtain rated torque 1) at starting and 2) at 1000 rpm.
2. A 220V D.C Shunt motor has armature of 0.5Ω and field resistance of 220Ω. It takes a line current of 41A, when delivering full load torque. It is desired to raise the speed by 60%, the load torque remaining constant. Find additional resistance to be inserted in the field circuit, assuming linear magnetizing characteristics.
3. A Shunt motor gave the following results of Swinburne's test: Voltage – 600V, Current - 8A, Armature resistance – 0.1 Ω, Field resistance - 300 Ω. Find the efficiency of the machine (i) as generator delivering 100A at 600V (ii) as a motor having a line current of 100A at 600V.
4. A 220V D.C Shunt motor at no-load takes a current of 2.6A. The resistance of the armature and shunt field is 0.8Ω and 200Ω. Estimate the efficiency of the motor when input current is 20A.
5. The results of the Hopkinson's test conducted on a pair of D.C. Shunt machines at full load are as follows. Line Voltage = 200V, Line Current = 50A, Motor Armature current = 195A, Field current = 6A and 5A, Armature resistance = 0.03Ω. Calculate the efficiency of each machine.
6. A 240V D.C. Shunt motor runs at 850 rpm when the armature current is 70A. The armature resistance is 0.1Ω. Calculate the required resistance to be placed in series with the armature to reduce the speed to 650 rpm when the armature current is 50A.
7. A 200V D.C. Series motor takes 40A when running at 700 rpm. Calculate the speed at which motor will run and current taken from the supply if the field is shunted by a resistance equal to the field resistance and load torque is increased by 50%. Armature and field resistances are 0.15Ω and 0.1Ω respectively. Assume flux per pole proportional to field.
8. A Series motor with an unsaturated field and negligible resistance when running at a certain speed on a given load takes 50A at 460V. If the load torque varies as the cube of speed, calculate the resistance required to reduce the speed by 25%.
9. A 250V D.C. Shunt motor has an armature resistance of 0.25Ω. On load, circuit takes an armature current of 50A and runs at 750 rpm. If the flux of the motor is reduced by 10%, without changing the load torque, find the new speed of the motor.
10. A D.C. Shunt machine develops an open circuit voltage of 250V at 1500 rpm. Find the torque developed for an armature current of 20A.
11. A 6 pole D.C. machine has 300 conductors and each conductor is carrying 80A without excessive temperature rise. The flux/pole is 0.015Wb, and the machine is driven at 1800 rpm. Calculate the total current, e.m.f., power developed in the armature and the electromagnetic torque, if the armature conductors are lap connected.
12. A 230V D.C. Shunt motor has an armature resistance of 0.5Ω and field resistance of 115Ω. At no-load the speed is 1200 rpm and armature current is 2.5A. On application of rated load, the speed drops to 1120 rpm. Determine the line current and the power input when the motor delivers rated load.

13. A 500V D.C. motor takes an armature current of 100A while supplying a load. The resistance of armature circuit is 0.2Ω. The machine has 6 poles and the armature is lap connected with 864 conductors. The flux per pole is 0.05Wb. Calculate the speed and gross torque developed by the motor.
14. A 220V D.C. Shunt motor at no-load takes a current of 2.5A. The resistances of the armature and shunt field are 0.8Ω and 200Ω respectively. Estimate the efficiency of the motor when the input current is 32A.
15. A 500V D.C. Shunt motor runs at 1900 rpm taking an armature current of 150A. The resistance of armature circuit is 0.16Ω. Find the speed of the motor when a resistance is inserted in the field circuit to reduce the field current to 80% and the armature current is 75A.
16. A 6 pole lap connected shunt motor has 500 conductors in the armature. The resistance of the armature path is 0.05 Ω. The resistance of the shunt field is 25Ω. Find the speed of the motor when it takes 120A from D.C. mains of 500V. Flux/pole is 2x $10^{-2}$Wb.
17. A 4 pole 250V D.C. Shunt motor has a lap connected armature with 960 conductors. The Flux/pole is 2x $10^{-2}$Wb. Calculate the torque developed by the armature and the useful torque in Nm when the current taken by the motor is 30A. The resistances of the armature and shunt field are 0.12Ω and 125Ω. The rotational losses are 825W.
18. A 500V D.C. Shunt machine takes 5A when running at light at normal speed as a motor from rated voltage. Calculate power in kW and efficiency when the current taken is 80A as a motor. Calculate also the line current at which efficiency is maximum and the maximum efficiency. Assume armature resistance as 0.5Ω and field resistance as 250Ω.
19. A 220V D.C. Shunt motor takes an armature current of 60A when running at 800 rpm. It has an armature resistance of 0.1Ω. Determine the speed and armature current if the magnetic flux is weakened by 20%. Contact drop per brush = 1V. Total torque remains same.
20. A D.C. Shunt generator delivers 50kW at 250V when running at 400 rpm. The resistances of the armature and shunt field are 0.02Ω and 50Ω. Calculate the speed of the same machine when running as a shunt motor taking 50kW at 250V.
21. Design the starter steps of a 30hp 220V shunt motor starter which takes 113A when running normally at full load. The motor has to start up against full load and starting current shall not exceed one and a half times the normal full load value. Resistance of the armature circuit is 0.2Ω
22. In a 230V, 10kW D.C. Shunt motor, it is required that the starting current shall not exceed twice the rated current. During the starting of the motor, the starting resistance is cut out in steps as soon as the armature current drops to its rated value. The field resistance is 115Ω and the total armature circuit resistance is 0.348Ω. Find (i) the external resistance required at the time of starting (ii) the total no: of steps and their resistance values.
23. A retardation test on a 1400 rpm D.C. Shunt motor gave the following results: (i) with field unexcited the speed dropped from 1425 to 1375 rpm in 80 s. (ii) with the field normally excited, the same speed drop occurred in 25 s. (iii) with an average braking power of 1kW supplied by the armature, the same speed drop occurred in 20 s. Determine the moment of inertia, iron losses and mechanical losses at 1400 rpm.
24. A retardation test is made on a separately excited D.C. Machine as a D.C. Motor. The induced voltage falls from 240V to 225V in 25 seconds, on opening the armature circuit and in 6 seconds on suddenly changing the armature connection from supply to a load resistance taking 10A (average). Find the efficiency of the machine when the machine when running as a motor and taking a current of 25A on a supply of 250V. Armature resistance is 0.4Ω and field resistance is 250Ω.

# QUESTION BANK - Module IV & V

1. What is an ideal transformer?
2. What does transformer mean? List out its major functions.
3. Derive e.m.f. equation of a single phase transformer. Define voltage transformation ratio.
4. What is no-load current in a transformer? Draw the phasor diagram of the transformer at no-load.
5. Draw the general schematic of a single phase transformer. Describe its working principle and deduce the expression for the e.m.f. in secondary winding.
6. Explain with phasor diagram, how the flux in the core remains fairly constant from no-load to Full load. Assume lagging p.f.
7. Explain the principle of operation and constructional features of a core-type single-phase transformer.
8. With neat sketches, explain the principle of operation of a transformer.
9. On what factors do Hysterisis loss and eddy current loss depend? What are the methods to reduce these losses?
10. Explain why the transformer core is laminated?
11. What is the function of the conservator in a transformer?
12. What properties should good transformer oil possess?
13. Explain the principle of operation of a single-phase transformer on no-load and on-load.
14. Draw the complete phasor diagram of a single-phase transformer on load at leading pf. Indicate the various quantities.
15. Derive an expression for the e.m.f. equation of a single-phase transformer.
16. Draw the complete phasor diagram of a single-phase transformer on load at lagging pf. Indicate the various quantities.
17. Which are the various losses occurring in a transformer and how do they vary with load? Explain their dependence on frequency and load.
18. Which are the various losses occurring in a transformer? How they are minimized? How will you determine the losses experimentally?
19. When testing large transformers, the OC test is conducted on the LV side and SC test is conducted oh HV side. Why?
20. Explain the OC and SC tests of transformer with diagrams and also explain significance of each test.
21. Explain which tests have to be carried out to know the characteristics of transformer. Explain each test in detail.
22. Define transformer efficiency and obtain the condition for maximum efficiency.
23. Derive the expression for maximum efficiency and explain when it occurs.
24. Distinguish between voltage regulation and efficiency of a transformer.
25. Deriving necessary equations, explain the term voltage regulation of a transformer.
26. Explain how the regulation and efficiency of a single-phase transformer can be pre-determined?
27. Starting from ideal transformer arrive at the equivalent circuit of a practical transformer, explaining the inclusion of various elements.
28. How short circuit test on a single-phase transformer is performed? What parameters are determined using the test results?
29. How open circuit test on a single-phase transformer is performed? What parameters are determined using the test results?

30. Draw the equivalent circuit of a transformer referred to low voltage side.
31. Draw the equivalent circuit of a transformer referred to high voltage side.
32. Explain the reason for increase of primary current of a single-phase transformer when the secondary load current increases.
33. Why does the open circuit test gives core losses without being involved with copper losses.
34. Draw the complete phasor diagram of a single-phase transformer on load at unity pf. Indicate the various quantities.
35. Draw the circuit diagram for the Sumpner's test and explain the procedure.
36. With a neat diagram, describe the Sumpner's method of testing transformers. How can the regulation be predetermined using this test?
37. Why does the short circuit test gives $I^2R$ losses without being involved with core losses?
38. Explain the procedure for conducting open circuit and short circuit tests in a single-phase transformer. How can the parameters of equivalent circuit be determined from these tests?
39. Explain how you pre-determine the parameters in the equivalent circuit of a transformer.
40. How equivalent resistance and reactance of primary winding referred to secondary winding and vice-versa can be determined?
41. Draw the exact equivalent circuit of a two winding transformer.
42. Draw the approximate equivalent circuit of a two winding transformer and describe the various parameter.
43. From first principle, deduce the equivalent circuit of a transformer.
44. What do you mean by voltage regulation in a transformer? Derive the expression for leading power factor.
45. Explain clearly how the flux in a transformer remains fairly constant from no load to full load.
46. Define voltage regulation of a transformer. Can regulation be negative? If yes, when?
47. For constant values of load voltage and load power factor, obtain the condition for maximum efficiency in a transformer. Hence derive kVA corresponding to maximum efficiency.
48. Briefly explain no load test on a transformer.
49. Briefly explain impedance test on a transformer.
50. Derive an approximate equation for regulation of a transformer working at lagging p.f.
51. State the relation between secondary and primary impedance of a transformer.
52. Is the equivalent copper loss referred to the high voltage side the same as the equivalent copper loss referred to the low voltage side? Explain.
53. Explain various reasons which cause humming noise in a transformer.
54. What are the conditions for paralleling two single phase transformers? Differentiate between the essential and desirable conditions.
55. What are the necessary and sufficient conditions for the parallel operation of transformer and explain.
56. What is the need for connecting the transformers in parallel? Explain how the total load will be shared with example.
57. What is meant by circulating current in parallel operation of two transformers?
58. In detail explain the parallel operation of single phase transformer with diagrams for (i) Ideal case (ii) Equal voltage ratio.
59. Why the transformer rating in kVA? Explain.
60. Write short notes on Tap-changing Transformers.
61. What is meant by 'Tap changing transformers'? What are its applications?
62. Explain the operation of a No-load Tap Changer. What are its disadvantages?
63. Explain the operation of an On-load Tap Changer.
64. Explain the types of tap changing methods of transformers. Also mention its advantages and disadvantages, select which is best method in practice.
65. Describe the constructional details of auto-transformer.

66. What are the advantages, disadvantages and applications of auto-transformers?
67. Write major differences between 2 winding transformer and auto transformer. Explain how efficiency will be in auto transformer.
68. Discuss in detail the operation of an auto-transformer and derive the expression for the savings of copper when compared to a two-winding transformer.
69. Prove that in auto transformer saving of copper will increase as ‘k’ approaches unity.
70. List the disadvantages of autotransformers over the conventional type.
71. In an autotransformer, how the current flows in different parts of its windings? Derive an expression for the saving of the copper in an autotransformer as compared to an equivalent two winding transformer.
72. Show that, in the case of an autotransformer:
    Inductively transferred power / Total power = high voltage – low voltage / high voltage.
73. Describe a distribution transformer. Explain the significance of all day efficiency in transformer.
74. Explain the ‘All day Efficiency’ of Distribution transformers.
75. Which of the two powers is responsible for the increase in kVA using an Auto transformer over a conventional isolation transformer? Explain.
76. Discuss the operation of Auto transformers and Copper savings associated with it. List out its advantages.
77. Which are the losses in a transformer? How they affect its all-day efficiency?
78. Define all day efficiency.
79. Discuss the different methods of cooling of transformer. Why it is more difficult to cool a transformer than any other electrical rotating machines? Why is cooling necessary?
80. Briefly explain cooling arrangement of transformer.
81. Draw the phasor diagram of a transformer on no load. Show the two components of the no load current and write their names.
82. What is meant by negative voltage regulation? For what type of load you may get negative voltage regulation?
83. Why transformers are rated in kVA not in kW?
84. Develop the equivalent circuit of a transformer.
85. What are the necessary and desirable conditions for successful parallel operation of two single phase transformers?
86. Why the rating of transformer in kVA?
87. List out the necessary & desirable conditions for parallel operation of two Single phase transformers.
88. Define all day efficiency. How this efficiency of a transformer varies with load?
89. Differentiate between core type and shell type transformers.
90. Explain the working of a transformer on no-load and load condition.
91. Derive the condition for maximum efficiency of transformer. How the efficiency of a transformer depends on load?

## KTU QUESTION BANK - Module IV & V

1. What is the principle of operation of a transformer? Show how the flux is balanced when the transformer is supplying load.
2. With supporting phasor diagrams, derive the expression for secondary side voltage regulation of a transformer for lagging and leading power factor loads.
3. What are the necessary and desirable conditions to be satisfied for parallel operation of two single phase transformers?
4. Derive the condition for maximum efficiency for a transformer.
5. Distinguish between two winding transformer and auto transformer. Derive the expression for the savings of copper in an auto transformer.
6. Derive the condition for zero voltage regulation and maximum voltage regulation for a transformer.
7. Distinguish between core and shell type transformer.
8. What is an auto transformer? Derive an expression for the savings of copper in an auto transformer as compared to an equivalent two winding transformer.
9. Draw the phasor diagram of a single phase transformer supplying to an inductive load.
10. What are the different cooling methods used in transformer?
11. Explain the working of Off-load tap changing transformer with the help of neat diagram.
12. Draw and explain the detailed phasor diagram of a practical transformer supplying lagging pf load.
13. Define all day efficiency of a transformer. What steps are taken to improve the all day efficiency of a distribution transformer?

14. List out the necessary and desirable conditions to be satisfied for parallel operation of two single phase transformers.
15. Enumerate the losses in a loaded transformer. Derive the condition for maximum efficiency in a transformer.
16. With a neat diagram, describe the Sumpner's method of testing transformers. How can the voltage regulation be predetermined using this test?
17. Derive the expression for the savings in copper effected by using an auto transformer instead of a two winding transformer.
18. What is the principle of operation of a transformer? Derive the e.m.f. equation of a single phase transformer.
19. Explain Sumpner's method of testing transformers. What are its advantages over OC and SC tests?
20. Explain the operation of an autotransformer. How saving of copper is achieved in an autotransformer as compared to an ordinary 2 winding transformer. What are the advantages of autotransformer over conventional 2 winding transformer?
21. Why the rating of transformer in kVA?
22. List out the necessary and desirable conditions for parallel operation of two single phase transformers.
23. Define all day efficiency. How this efficiency of a transformer varies with load?
24. Derive the condition for maximum efficiency of transformer. How the efficiency of a transformer depends on load?
25. Differentiate between core type and shell type transformers.
26. Explain the working of a transformer on no-load and load condition.
27. Draw the phasor diagram of a transformer on no load. Show the two components of the no load current and write their names.
28. What is meant by negative voltage regulation? For what type of load you may get negative voltage regulation?
29. Why the rating of transformer in kVA not in kW?
30. Develop the equivalent circuit of a transformer.

1. The maximum flux density in the core of a 250/3000V, 50 Hz single phase transformer is 1.5T. If the e.m.f per turn is 8V, determine (i) Primary & Secondary turns (ii) c.s.a. of the core.

2. A 100 kVA, 3300/400 V, 50 Hz, 1 phase transformer has 110 turns on secondary. Calculate the approximate values of the primary and secondary Full Load currents, the maximum value of flux in the core and the no. of primary turns.

3. The e.m.f. per turn of a 1 phase, 2310/220 V, 50 Hz transformer is approximately 13 Volts. Calculate a) the no. of primary and secondary turns b) the net c.s.a of the core, for a max. flux density of 1.4 T.

4. A 3.3kV/240V, 1 phase transformer draws a no-load current of 0.7A and absorbs 650W on no-load. Find the magnetizing current and iron loss current.

5. A single-phase transformer with a ratio of 6.6kV/415V takes a no-load current is 0.75A at a power factor of 0.22 lag. If the secondary supplies a current of 120A at 0.8pf lag, calculate the total current taken by the primary.

6. A single-phase transformer with a ratio of 440/110V takes a no-load current is 5A at a p.f. of 0.2 lag. If the second. supplies a current of 120A at 0.8pf lag, calculate the total current taken by the primary.

7. A 100kVA, 1 phase, 1100/220V, 60 Hz transformer has a HV winding resistance of 0.1ohm and a leakage reactance of 0.3 ohm. The LV winding resistance is 0.004 ohm and leakage reactance of 0.012 ohm. Determine (a) Equivalent winding resistance, leakage reactance and impedance referred to hv and lv side (b) equivalent resistance and leakage reactance drops in % and p.u. of the rated voltage expressed in terms of hv and lv quantities.

8. Following data were obtained on a 20kVA, 50 Hz, 2000/200V transformer. Draw the approximate equivalent circuit referred to LV and HV side.
   OC Test: 200V 4A 120W (LV Side) SC Test: 60V 10A 300W (HV Side)

9. A 20 kVA, 2500/250V, 50Hz single-phase transformer gave the following test results:
   OC Test: 250V 1.4A 105W (LV Side)
   SC Test: 104V 8A 320W (HV Side)
   Draw the approximate equivalent circuit referred to LV and HV side.

10. A 4 kVA 200/400V, 50Hz transformer give the following test results:
    OC Test: (LV) - 200V, 0.7A, 70W
    SC Test: (HV) - 15V, 10A, 85W
    (i) Draw the equivalent circuit referred to HV and LV Side.
    (ii) Find the full-load efficiency at u.p.f. (iii) Regulation at FL for 0.8pf lagging and leading.

11. A 5 kVA 1000/200V, 50Hz single-phase transformer gave the following test results:
    OC Test: 200V 1.2A 90W (LV Side)
    SC Test: 50V 5A 110W (HV Side)
    Draw the approximate equivalent circuit referred to HV side.

12. A 33 kVA transformer has a FL copper loss of 800W and iron loss of 350W. If the p.f. of the load is 0.82 lagging, calculate the FL efficiency, load kVA corresponding to maximum efficiency, maximum efficiency.

13. The efficiency of a 440 kVA, single phase transformer is 98.11% when delivering Full load at 0.8 p.f. and 99.09% at Half full load and unity p.f. Calculate (i) the iron loss (ii) Full load Copper loss.

14. A 40 kVA, single phase transformer has iron loss of 800W and copper loss of 1140W, when supplying its FL. Calculate the efficiency at FL 0.8 p.f. lag and HFL u.p.f.

15. A 5 kVA 250/500V, 50Hz single-phase transformer gave the following test results.

    OC Test: 250V 0.75A 60W (LV Side)

    SC Test: 9V **6A** 21.6W (HV Side)

    Calculate (i) the magnetizing and iron loss component at normal voltage and frequency. (ii) efficiency at full-load, unity pf, and (iii) the corresponding terminal voltage on full load at a pf of 0.8 lagging.

16. A 60 kVA, single-phase transformer has an efficiency of 92% at both full load and half-load at upf. Determine the efficiency at 75% full-load and 0.9 pf lag.

17. A 10 kVA, 50Hz, 400 / 200V single phase transformer has a maximum efficiency of 96% at 75% of FL at u.p.f. Calculate the efficiency at FL 0.8 pf lagging.

18. A single phase transformer has a regulation of 10% when delivering FL at upf and 15% when delivering the same load at 0.8pf lag. What would be the regulation if the transformer is delivering half load at 0.8 pf lead.

19. A single phase 100 kVA, 2000 / 200V, 50 Hz transformer has an impedance drop of 10 % and resistance drop of 5%. Calculate the (i) regulation at FL, 0.8 p.f. lag (ii) value of p.f. at which regulation is zero.

20. The percentage resistance and reactance of a transformer are 2.5% and 4% respectively. Find the approximate voltage regulation at full load (i) u.p.f. (ii) 0.8 p.f. lag (iii) 0.8 p.f. lead.

21. A transformer has a copper loss of 1.5% and reactance of 3.5% when tested on FL. Calculate its FL regulation at 0.8 pf lead.

22. In a back-to-back test, the wattmeter $W_1$ read 4 kW while wattmeter $W_2$ read 6kW. Find the FL efficiency at u.p.f. of each transformer. The transformers are rated 200 kVA.

23. The maximum efficiency of a 500 kVA, 3300/500V, 50 Hz single phase transformer is 97% and occurs at $3/4^{th}$ FL upf. If the impedance is 10%, calculate the % voltage regulation at FL, 0.8 pf lag.

24. The primary and secondary winding resistances of a 30 kVA, 6600/250V, single phase transformer are 8 ohms and 0.015 ohms respectively. The equivalent leakage reactance as referred to primary is 30 ohms. Find the % voltage regulation at (i) FL 0.8 pf lag and (ii) FL upf.

    A 33 kVA, 2200/220 V single phase transformer has $R_1 = 2.4\ \Omega$, $X_1 = 6\ \Omega$, $R_2 = 0.03\ \Omega$ and $X_2 = 0.07\Omega$. Find the equivalent resistance and reactance with respective secondary.

## ALL DAY EFFICIENCY

1. A 50 kVA transformer has Full load copper loss of 750W and core loss of 600W. Determine the all-day efficiency, when the load during the day is as follows:
   (i) 6 hrs. – 5kW at a p.f. of 0.6 lead (ii) 12hrs. – 40 kW at a p.f. of 0.8 lag
   (ii) 6 hrs. – 30 kW at a p.f. of 0.85 lag.

2. A 100kVA lighting Transformer has a FL loss of 3 kW, the losses being equally distributed between iron and copper. During a day, the transformer operates on FL for 3 hrs, HL for 4 hrs, the output being negligible for remainder of the day. Calculate the all day efficiency.

3. Two transformers A and B each rated for 40kVA have core losses of 500W and 250W respectively and 500W and 750W respectively. Compare the all day efficiency of the two transformers, if they are used to supply a lighting load with output varying as follows:
   O/P – FL for 4 hrs, HL for 8 hrs, NL for remaining 12 hrs. Justify your answer.

4. A 200kVA, three phase transformer is in circuit continuously. For 8 hrs in a day, the load is 160 kW at 0.8 p.f., for 6 hrs the load is 80 kW at u.p.f. and for the remaining period of 24 hrs, it runs at no load. FL Copper loss is 3.02 kW and iron loss is 1.6 kW. Find all day efficiency.

5. A 5kVA single phase transformer has a core loss of 40W and a FL copper loss of 100W. The daily variation of load on the transformer is as follows:
   (iii)7am to 1pm – 3kW at 0.6 pf (ii) 1pm to 6pm – 2kW at 0.8pf (iii) 6pm to 1am – 6kW at 0.9pf
   (iii)1am to 7am – NL. Find all day efficiency.

## AUTO TRANSFORMER

1. A 20kVA, 2000/200V, two winding transformer is to be used as an autotransformer, with constant source voltage of 2000V. At full load of unity power factor, calculate the power output, power transformed and power conducted. If the efficiency of the two winding transformers at 0.7p.f. is 97% find the efficiency of the autotransformer.

2. A step up autotransformer is used to supply 3kV from a 2.4kV supply line. If the secondary load is 50A, neglecting losses and magnetizing current, calculate: (i) Current in each part of the transformer (ii) current drawn from the 2.4kV supply line. (iii) the kVA rating of the autotransformer (iv) the kVA rating of the comparable conventional two winding transformer necessary to accomplish the same transformation.

3. A load of 6 kW is supplied by an autotransformer at 120 V and u.pf. If the primary voltage is 240 V, determine (i) Transformation ratio (ii) Secondary current (iii) primary current (iv) Number of secondary turns if the total number of turns is 280 (v) Power transformed (vi) Power conducted directly from supply mains to load.

4. A 20kVA, 2300/230V, 2 winding transformer is to be used as an auto transformer. Calculate the power output, power transformed and power conducted at FL, upf with constant supply voltage of 2300V.

5. A 11.5kV/2300V transformer is rated 100kVA as a two winding transformer. If the two windings are connected in series to form an auto transformer, what will be the (i) Voltage ratio (ii) Power inductively transferred (iii) Power conductively transferred. Also calculate the savings in conductor material.

## PARALLEL OPERATION

1. Two 100kW, 1 phase transformers are connected in parallel both on primary and secondary. One transformer has an ohmic drop of 0.5% at FL and an inductive drop of 8% at FL current. The other has an ohmic drop of 0.75% and an inductive drop of 2%. Show, how will they share a load of 180 kW at 0.9 pf.

2. Two 1 phase transformers are connected in parallel both on primary and secondary. They have resistances of 0.2 Ω and 0.1 Ω & reactances of 0.35 Ω and 0.6 Ω respectively referred to secondary. The no-load secondary voltage of each transformer is 550 V. Determine (i) o/p current of each transformer (ii) the ratio of kW O/Ps if the second load is 200A at 0.8pf lagging.

3. A 500 kVA transformer with 1.5% resistive & 5% reactive drops is connected in parallel with 1000 kVA transformer with 1% resistive & 4% reactive drops. The secondary voltage of each transformer is 400V on load. Determine how they share a load of 500 kVA at a p.f. of 0.8 lagging.

4. Two transformers A and B are connected in parallel to a load of (3+j2) Ω. Their impedance referred to secondary side are $Z_A$ = (0.15+j0.5) Ω and $Z_B$ = (0.1+j0.6) Ω respectively. Their no-load terminal voltages are $E_A$ = 207V and $E_B$ = 205V. Find the power output and power factor of each transformer.

5. Two transformers of the same rating connected in parallel supplies a load of 450 kW at 0.9 pf lag. The % impedance of the two transformers are (1+4j) and (1.5+5j). Determine the load in kVA supplied by each transformer and its p.f.

6. Two 1 phase transformers of 200 kVA having equal turns ratio are connected in parallel. One transformer has an equivalent impedance of (0.005+j0.08) p.u. and the other (0.0075+j0.4) p.u., their rated voltages being equal. How will the following loads be shared? (i) 360 kW, 0.9 pf lag (ii) 400 kW, upf.

## KTU - TUTORIALS

1. A transformer on no-load has a core loss of 50W, draws a current of 2A (rms) and has an induced e.m.f. 0f 230V (rms). Determine the no-load p.f., core loss current and magnetizing current. Also calculate the no-load circuit parameters of transformer. Neglect winding resistance and leakage flux.
2. A 4kVA, 400/200V single phase transformer has a resistance of 0.02 p.u. and reactance of 0.06 p.u. What is the value of its resistance and reactance referred to h.v. side?
3. Reading from OC & SC test on a 8kVA, 400/200V, 50 Hz transformer are

   **OC Test:** 200V, 2A, 80W; (LV side) **SC Test:** 10V, 20A, 120W; (HV side).

   Compute the equivalent circuit of the transformer as referred to HV side.
4. The efficiency of 100kVA, 110/220V, 50 Hz single phase transformer is 98.5% at half full load and 0.8 p.f. lead and 98.8% at FL upf, find (a) Iron loss (b) FL copper loss (c) maximum efficiency at upf.
5. The following test results were obtained on a 20kVA, 2200/220V, 50 Hz single phase transformer

   **OC Test (LV side):** 220V, 1.1A, 125W **SC Test (HV side):** 52.7V, **8.4A**, 287W

The transformer is loaded at u.p.f. on secondary side with a voltage of 220V. Determine the maximum efficiency and the load at which it occurs.

6. The efficiency of a 200kVA, single phase transformer is 98.75% when delivering FL at 0.8 pf and 99% of 80%FL at 0.9 pf. Calculate (i) the iron loss and (ii) FL copper loss
7. A 200/2000V transformer is fed from a 200V supply. The total winding resistance and leakage reactance as referred to LV side is 0.15 Ω and 0.6 Ω respectively. The resistance representing core loss is 450 Ω and magnetizing reactance is 250 Ω. A load impedance (600+400j) Ω is connected across the secondary terminals. Calculate (i) input current (ii) secondary terminal voltage and (iii) primary p.f..
8. A 220kVA single phase transformer is in circuit continuously. For 4 hours in a day, the load is 60kW at 0.8 p.f.. For 6 hours, the load is 80kW at unity pf and for the remaining period of 24 hours, it runs at no-load. FL copper losses are 3.02kW & iron losses are 1.6kW. Find all day η.
9. A load of 6kW is supplied by an autotransformer at 120V and upf. If the primary voltage is 240V, determine (i) transformation ratio (ii) secondary current (iii) primary current (iv) no. of secondary turns if the total no. of turns is 280 (v) power transformed and (vi) power conducted directly from supply mains to load.
10. Two standard tests were conducted on a 10kVA, 1000/200V transformer. Current in one test was 2A. Voltage in one test was 15V. Power factors were 0.8 and 0.2. Find the efficiency at 90% full load and 0.8 power factor.
11. A 1000/800V, 8kVA autotransformer supplies rated current to a load on low voltage side. Draw a schematic diagram and mark input current, output current and current in the section of the winding common to high voltage and low voltage sides.
12. A 10 kVA, 1500/150 V, single phase transformer has following parameters:
    $HV\ side$: $r1$=4.2 $\Omega$ $x1$=5.1 $\Omega$ $LV\ si\quad e$: $r2$=0.05 $\Omega$ $x2$=0.062 $\Omega$. Find the per unit values of equivalent resistance and inductive reactance.
13. A 600W single phase transformer working at unity power factor has an efficiency of 95 percent at both half full load and full load. Determine the efficiency at 70 percent of full load.

## ADDITIONAL QUESTIONS

1. A 230 / 460 V transformer has a primary resistance 0.2 Ω and reactance of 0.5Ω and the corresponding values for the secondary are 0.75 Ω and 1.8 Ω respectively. Find the secondary terminal voltage when supplying 10A at 0.8pf lagging.

2. A 10 kVA, 50Hz, 4800 / 240V transformer is tested by the open circuit and short circuit tests. The test data are as follows:
   Open circuit: 240V, 1.5A, 160W on low voltage side.
   Short circuit: 180V, 2.083A, 180W on high voltage side.
   Calculate:
   i. Equivalent resistance and reactance referred to LV and HV sides.
   ii. Voltage regulation of step-down transformer at unity p.f., Full load.

3. A 50 kVA, 2200 / 110V transformer when tested gave the following results:
   OC test measurements on LV side: 400W, 10A, 110V
   SC test measurements on HV side: 800W, 20A, 90V
   Draw the equivalent circuit referred to LV & HV sides and also draw the phasor diagram for lagging p.f. load.

4. A 20 kVA 2000 / 200V, Single- phase transformer has the following parameters:
   HV Winding: $R_1 = 3\ \Omega$, $X_1 = 5.3\ \Omega$.
   LV Winding: $R_2 = 0.05\Omega$, $X_2 = 0.05\Omega$.
   i. Find the % voltage regulation at FL (i) 0.8 p.f lag (ii) u.p.f (iii) 0.707 p.f lead.
   ii. Calculate the secondary terminal voltage at (i) 0.8 p.f. lag (ii) u.p.f. (iii) 0.707 p.f lead when delivering FL current with primary voltage held fixed at a 2 kV.

5. A 40kVA transformer with a ratio of 2000/250V has a primary resistance of 1.15Ω and a secondary resistance of 0.0155Ω. Calculate:
   a. The equivalent resistance referred to primary.
   b. The equivalent resistance referred to secondary.
   c. Copper loss at 75% load current.
   d. Voltage drop at 90% load current.

6. In a 25kVA, 1000/400V single-phase transformer, the iron and copper losses at full load are 300W and 400W respectively. Calculate the load (in kVA) for maximum efficiency.

7. A 25kVA transformer has 500 turns on the primary and 50 turns on the secondary winding. The primary is connected to 3000V, 50Hz supply. Find the full load primary and secondary currents, the secondary e.m.f. and the maximum flux in the core. Neglect leakage drops and no-load primary current.

8. A single-phase transformer has 1000 turns on the primary and 250 turns on secondary. The no-load current is 3A at a power factor of 0.2 lag. Calculate the primary current and its power factor when the secondary current is 160A at 0.8 lag.

9. A 5kVA 200/400V single-phase transformer gave the following test results. Secondary winding short-circuited and 8V applied to primary, which circuits full load current in the secondary winding and takes 80Watts. Calculate the secondary voltage at full load 0.8pf lag. Also calculate the voltage regulation in percentage.

10. A 40kVA transformer has core loss of 450W and full load copper loss of 850W. Find its efficiency at 3/4$^{th}$ full load 0.8pf lag.

11. A single- phase transformer has primary voltage of 230V. No load primary current is 5A. No-load pf is 0.25. No: of primary turns is 200, frequency is 50Hz. Calculate
    i. maximum value of flux in the core
    ii. core losses
    iii. magnetizing current

12. Two transformers A and B are connected in parallel to a load of (3+j2) Ω. Their impedance referred to secondary side are $Z_A$ = (0.15+j0.5) Ω and $Z_B$ = (0.1+j0.6) Ω respectively. Their no-load terminal voltages are $E_A$ = 207V and $E_B$ = 205V. Find the power output and power factor of each transformer.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

***EE 205 D. C. Machines & Transformers***

# Module VI

**Additional Questions**

1. Briefly explain the various methods of inter-connection of single-phase transformers for a three-phase supply.
2. Draw the Scott connection of the transformer and mark the terminal and turns ratio.
3. Explain with the help of relevant diagrams, the Scott connection of single-phase transformers.
4. Write short notes on
   a) Scott connection.
   b) 3 phase core type transformers.
   c) Role of Tertiary Windings in three phase transformers.
5. Draw circuit diagrams showing delta and star connection of phase to transform three phase current at one voltage to three phase current at another voltage.
6. Explain the Scott connection method to obtain two phase supply from three phase supply.
7. What is the name of the connection that converts 3 phase to 2 phase? Explain with neat diagram and also derive how it is converted into 2 phase.
8. What are the merits and demerits of an YY 3-phase transformer?
9. What are the functions of tertiary windings in transformers?
10. Briefly explain the different connections of three phase transformers.
11. Give three purposes for the use of tertiary windings in power transmission and distribution transformers.
12. Explain in details what tertiary winding is and write its applications.
13. Write short notes on parallel operation on a 3 phase transformer.
14. Explain the process of 3 phase to 2 phase conversion in 3 phase transformer.
15. Discuss various types of 3 phase transformer connections with diagrams.

**KTU Questions**

1. Which are the different connections of three phase transformers?
2. Enumerate the purposes which dictate the use of tertiary winding in a three winding transformer.
3. Draw the diagram for a V V connection of transformers and explain the voltage and current relations of line and phase values. Derive the capacity ratio as a function of Δ- Δ capacity.
4. Explain with neat diagram and phasors, how a 2 phase supply can be obtained from a 3 phase supply.
5. Explain the vector groupings Yy0, Dd0, Yd1, Dy1, Yd11 and Dy11 in tree phase transformers.
6. What is a purpose of tertiary winding on transformer?
7. In detail explain Scott connection in three phase transformer.
8. What are the advantages and disadvantages of Δ- Δ connection?
9. What is meant by vector grouping? What is Yd1 vector grouping?

10. Can a Yd transformer be operated in parallel with Dy transformer? What additional condition has to be satisfied?
11. In Scott connection, prove that the 3 phase currents will be balanced if the two phase currents are balanced. Assume u.p.f. loads.
12. Prove three phase currents will be balanced for a balanced u.p.f. load on 2 phase side in a Scott transformer.
13. Explain the purposes of tertiary winding in a three winding transformer.
14. Why Y-Δ 3 phase transformer is used to step down the voltage in transmission systems?
15. With a neat circuit diagram, explain how a 2 phase supply can be obtained from a three phase supply.

## Module VI (Tutorials)

1. A 3 phase step down transformer is connected to 6.6kV supply mains and takes 80A. Calculate its secondary line voltage, line current and output kVA for the following connections if the ratio of turns per phase is 16. **(i) Y – Δ (ii) Y – Y (iii) Δ – Δ (iv) Δ – Y**.
2. A bank of three single phase transformers is connected to 11,000V supply and takes 15A. If the ratio of turns/phase is 10, calculate the secondary line voltage and current, primary and secondary phase currents and output for the following connections. **(i) Y - Δ (ii) Δ - Y**.
3. A 3 phase transformer has 500 primary turns and 50 secondary turns. If the supply voltage is 2.4 kV, find the secondary line voltage on no-load when the windings are connected **(a) Y - Δ (b) Δ - Y**.
4. A 120 kVA, 6000/400 V, **Y/Y**, 3 phase, 50 Hz transformer has an iron loss of 1600 W. The maximum efficiency occurs at ¾ full load. Find the efficiencies of the transformer at (i) Full load and 0.8 p.f. (ii) Half load, unity power factor and (iii) the maximum efficiency at u.p.f.
5. A 3 phase transformer, ratio 33/6.6 kV, **Δ/Y**, 2MVA has a primary resistance of 8 Ω per phase and a secondary resistance of 0.08 Ω per phase. The percentage impedance is 7%. Calculate the secondary voltage with rated primary voltage and hence the regulation for full load 0.75 p.f. lagging.
6. A 5000kVA, 3-phasetransformer 6.6/33kV, **Δ/Y**, has a no-load loss of 15 kW and full-load loss of 50 kW. The impedance drop at full-load is 7%. Calculate the primary voltage when a load of 3200 kW at 0.8 p.f. lagging is delivered at 33 kV.
7. A 2000 kVA, 6600/400 V, three phase transformers is ***delta-connected on HV side*** and ***LV side is star connected***. Determine its percentage resistance and percentage reactance drops, percentage efficiency and percentage regulation at full load 0.8 p.f. leading. Given the following data :

   **SC test: 400 V, 175 A, 17 kW (HV side)**

   **OC test: 400 V, 150 A, 15 kW (LV side)**
8. A balanced 3-phase load of 150 kVA at 1000V, 0.866 lagging power factor is supplied from 2000 V, 3-phase mains through single-phase ideal transformer connected **(i) delta-delta (ii) V-V**. Find the current in the winding of each transformer and the power factor at which they operate in each case. Explain your answer with circuit and phasor diagrams.
9. A **Scott** connected transformer is fed from a 6600 V, 3-phase network and supplies two single-phase furnaces at 100 V. Calculate the line currents on the 3 phase side when the furnace take 400kW and 700 kW respectively at 0.8 pf lagging .
10. Two 220 V, single phase electrical furnace take loads of 350 kW and 500 kW respectively at a power factor of 0.8 lagging. The main supply is 11 kV, 3 phase, 50 Hz. Calculate currents in the 3-phase lines which energizes a **Scott** connected transformer combination.
11. Two single phase furnaces A & B are supplied at 100V by means of a **Scott** connection transformer combination from a 3 phase 6600V system. The voltage of furnace A is leading. Calculate the line currents on the three phase side, when the furnace A takes 400kW at 0.707 lagging and furnace B takes 800kW at upf.
12. Two 110V, single phase furnaces take loads of 500kW and 800kW respectively at a p.f. of 0.71 lagging are supplied from 6600V, 3 phase mains through a **Scott** connected transformer combination. Calculate the currents in the 3 lines, neg. transformer losses. Draw the phasor diagram.
13. A 2 phase, 4 wire, 250 V system is supplied to a plant which has a 3 phase motor load of 30 kVA. Two **Scott** connected transformers supply the 250 V motors. Calculate (a) Voltage ratings (b) kVA rating of each transformer. Draw the connection diagram.
14. Find the line current on HV and LV sides of a 500 kVA, 11 kV/400V, Δ/Y transformer.