SUMMER – 2018 EXAMINATIONS
Model Answer **Subject Code: 17415 (DMT)**

Important Instructions to examiners:

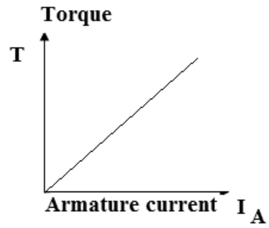
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner should assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner should give credit for any equivalent figure/figures drawn.
5) Credits to be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer (as long as the assumptions are not incorrect).
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept

1	**Attempt any <u>TEN</u> of the following:**	20
1 a)	State Fleming's right hand rule. **Ans:** **Fleming's Right Hand Rule:** Stretch out the first three fingers of your right hand such that they are mutually perpendicular to each other, *align* first finger in direction of magnetic field, thumb in direction of relative motion of conductor with respect to field *then* the middle finger will give the direction of induced EMF.	2 Marks
1 b)	Classify different types of generators. **Ans:** **Different Types of Generators:** 1) Separately excited DC generator 2) Self excited DC generator: (i) DC series generator (ii) DC shunt generator (iii) DC Compound generator: short shunt and long shunt / (cumulative or differential)	2 Marks

1 c) Draw:
(i) Torque Vs. Armature current
(ii) Speed Vs. armature current
Characteristics for DC shunt motor.

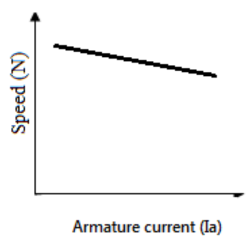
Ans:

(i) Torque Vs. Armature current:



1 Mark each = 2 Marks

(ii) Speed Vs. Armature current:



1 d)	State Fleming's left hand rule. **Ans:** **Fleming's Left Hand Rule:** Stretch out the first three fingers of your left hand such that they are mutually perpendicular to each other, *align* first finger in direction of magnetic field, middle finger in direction of current *then* the thumb will give the direction of force acting on the conductor.	2 Marks

1 e) Which DC motor can be selected for following types of loads
(i) Electric Traction
(ii) Lathe Machine
(iii) Crane
(iv) Printing Machine

Ans:

(i) Electric Traction	D.C. Series motor.	1/2 Mark each = 2 Marks
(ii) Lathe Machine	D.C. Shunt motor.	
(iii) Crane	D.C. Series motor.	
(iv) Printing Machine	D. C. Cumulative compound motor	

1 f) Give classification of DC motors.

Ans:

Classification of DC motors:

(i) DC series motor — 2 Marks
(ii) DC shunt motor
(iii) DC Compound motor : short shunt and long shunt

1 g) Classify types of transformers.

Ans:

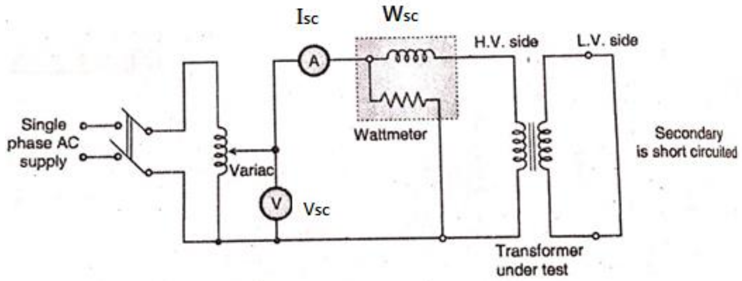
Classification of Transformer Based On:

i) Construction:
Shell type, Core type, Berry type
ii) Change in voltage level: — 2 Marks for any one category
Step-Up, Step-Down,
iii) Number of phases:
Single phase, Three phase
iv) Purpose:
Power T/F, Distribution T/F
v) Use:
Instrument, Protection, Control
vi) Cooling:
Self-cooled, Air-cooled, Forced-air cooled, Oil-cooled, Forced-oil cooled.

1 h) Draw circuit diagram for short circuit test of single phase transformer.

Ans:

Circuit Diagram for Short Circuit Test of Single Phase Transformer:



2 Marks

1 i) Why transformer rating is in kVA?

Ans:

Transformer Rating is in kVA:

The life of insulation of transformer depends upon temperature. Temperature rise results from losses of transformer. The copper loss of transformer depends on the current and the iron loss depends on the voltage. Hence total transformer losses depend on volt-amperes and not on phase angle between voltage and current. The losses are independent of load power factor. To prevent transformer from damage due to temperature rise, it is highly essential to limit the losses. The limiting values are referred as rating. To limit the losses, the operating voltage & current must be maintained within limits. Hence transformer rating is in kVA.

2 Marks

1 j) Write difference between efficiency and all day efficiency of transformer.

Ans:

Difference Between Efficiency and All Day Efficiency of Transformer:

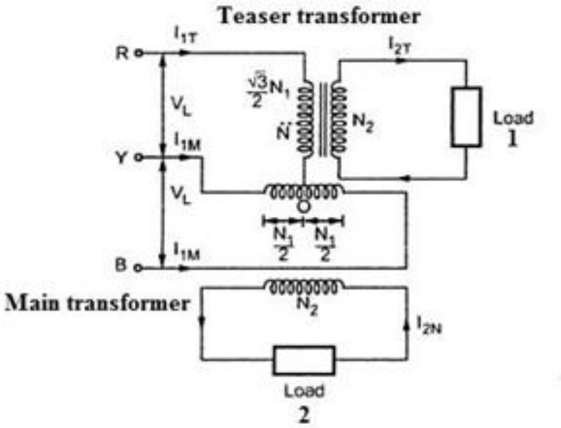
Sr. No.	Efficiency	All Day Efficiency
1.	The efficiency or commercial efficiency of transformer is defined as ratio of output power to input power.	The all-day efficiency of transformer is defined as ratio of output energy to input energy in 24 hours.
2.	$\text{Efficiency} = \dfrac{\text{Output power}}{\text{Input power}}$	All day Efficiency $= \dfrac{\text{kWh Output in 24 hrs}}{\text{kWh Input in 24 hrs}}$
3.	Very much applicable for Power transformers	Very much applicable for Distribution transformers

Any two valid points = 2 Marks

1 k) Draw connection diagram of transformer for Scott connection.

Ans:

Connection Diagram of Transformer for Scott - connection:



Labeled diagram 2 Marks

Unlabeled diagram 1 Mark

1 l) State types of cooling arrangements used in transformer (Any four).

Ans:

Different Types of Cooling System used for 3 phase Transformer:

- Air Natural (AN)
- Air Forced (AF)
- Oil Natural Air Natural (ONAN)
- Oil Natural Air Forced (ONAF)
- Oil Forced Air Natural (OFAN)

½ Mark for each of any four

- Oil Forced Air Forced (OFAF)
- Oil Natural Water Forced (ONWF)
- Oil Forced Water Forced (OFWF)

2 **Attempt any FOUR of the following:** 16

2 a) State principle of operation of DC generator.

Ans:

Principle of Operation of DC Generator:

- Working principle of DC generator is dynamically induced emf or electromagnetic induction. 1 Mark
- According to this principle, if flux is cut by conductor then an emf is induced in the conductor. 1 Mark
- The magnitude of the induced emf is calculated by Faraday's 2^{nd} law of electromagnetic induction and the direction is given by Lenz law OR Fleming's right hand rule. 1 Mark
- In case of DC generator, when armature winding is rotated by the prime mover under the influence of magnetic poles, the flux is cut by armature conductor hence an emf is dynamically induced into armature winding. 1 Mark

2 b) Derive an e.m.f. equation of generator.

Ans:

Derivation of e.m.f. Equation of Generator:

Let P = no of poles,
Ø = average flux per pole (Wb),
Z = total no of armature conductors. 1 Mark
A = number of parallel paths of armature winding,
N = speed of generator in RPM.
E_g = emf of generator

By Faraday's Laws of electromagnetic induction

Induced emf in each conductor $e_c = \frac{d\emptyset}{dt}$

Here, the flux cut by one armature conductor in one revolution = P Ø.

The time for one revolution = (60/N) sec.

Hence e_c = (flux cut in one revolution)/(time for one revolution) volt

$$= \frac{P\,\emptyset}{\frac{60}{N}} = \frac{P\,\emptyset\,N}{60} \quad volt$$ 1 Mark

For Z conductors the total emf will be

$$Ez = Z\frac{P\,\emptyset\,N}{60} \quad volt$$ 1 Mark

Depending on the number of identical parallel paths the conductors get divided into those many paths (depending on the armature winding type as wave and lap winding)

Hence induced emf $E_g = E_Z/A = \frac{\emptyset ZN}{60}\frac{P}{A}$ volts

A= P (lap winding) A= 2 (wave winding) 1 Mark

2 c) "D.C. Series motor cannot operate on no-load."- Justify the statement.

Ans:

D.C. Series Motor Cannot Operate on No - load - Justification:

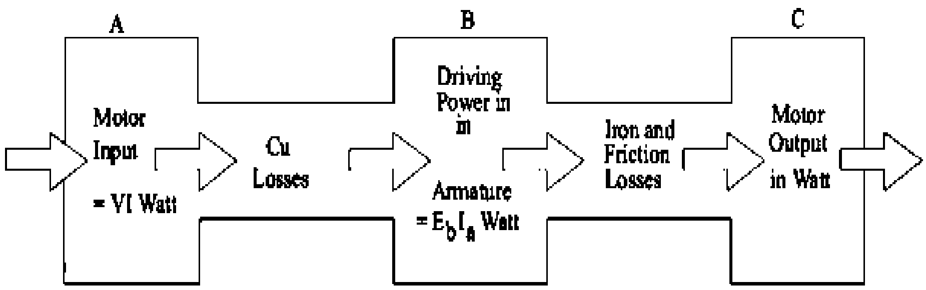
- At no load the field current (which is also the armature current) is very small and hence the useful air-gap field flux. Also the torque is very small. 4 Marks
- As $N \propto \frac{1}{\phi}$ the speed rises excessively high / dangerous values and it is mechanically very harmful for machine.
- At high speeds due to centrifugal forces of the rotating parts they may damage the machine.

Hence DC series motor should never be started on no-load.

2 d) Write power stages of DC motor with flow diagram.

Ans:

Flow Diagram of Power Stages of DC motor:



4 Marks

2 e) State the necessity of starter for D.C. motor. State various types of D.C. motor starter.

Ans:

Necessity of Starter for D.C. Motor:

Armature current, is given by equation $Ia=(V-E_b)/Ra$

i) If the motor is at standstill or rest, back emf E_b is zero (as $E_b=\Phi ZNP/60A$, at start speed N is zero). This causes starting current $Ia=V/Ra$, which is large as armature resistance is usually low. This large starting current may damage armature winding. 2 Marks

ii) Hence to limit the very high starting current, the starter is required.

iii) Once motor picks up the speed, the back emf E_b is induced in armature winding and armature current is limited to safe value. So starter is not required under running condition. 2 Marks

Types of D.C. motor starters:

i) Two point starter

ii)Three point starter

iii) Four point starter

2 f) A 220 V DC shunt motor runs at a speed of 850 rpm and takes a current 20A from mains. Calculate the speed if the torque is doubled. Armature resistance is 0.2Ω

Ans:

Given: DC shunt motor of , V=220 V, N_1= 850 rpm, Ia_1= 20 A, R_a= 0.2Ω

For finding speed N_2, $T_2 = 2T_1$.

$$\frac{T_1}{T_2} = \frac{I_{a1}}{I_{a2}} \qquad \therefore \quad \frac{T_1}{2T_1} = \frac{20}{I_{a2}}$$ 1 Mark

$$\therefore I_{a2} = 40\ A$$

As $E_{b1} = V - I_{a1}R_a = 220 - (20 \times 0.2) = 216\ V$ 1 Mark

$$E_{b2} = V - I_{a2}R_a = 220 - (40 \times 0.2) = 212\ V$$ 1 Mark

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}}$$

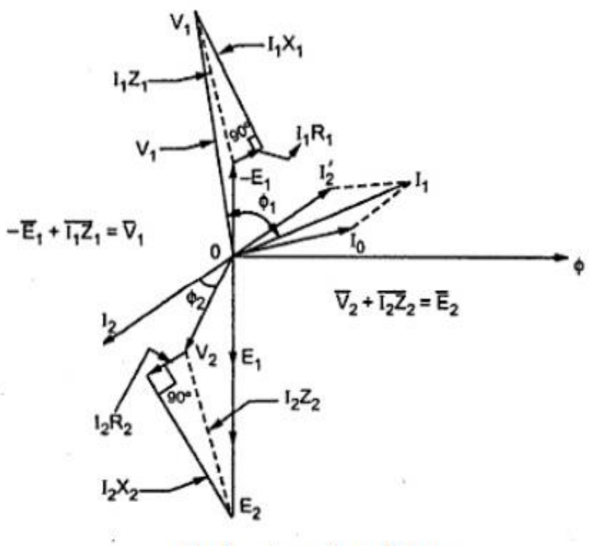
$$\therefore N_2 = \frac{E_{b2}}{E_{b1}} \times N_1 = \frac{212}{216} \times 850 = 834.259\ rpm$$ 1 Mark

3 **Attempt any <u>FOUR</u> of the following**: 16

3 a) Draw practical transformer on load phasor diagram at lagging P.F.

Ans

Phasor Diagram of Practical Transformer for lagging load p.f. :



For Lagging pf condition

Labeled diagram 4 Marks

Partially labeled diagram 3 Marks

Un-labeled diagram 2 Marks

3 b) Estimate the percentage efficiency and regulation of a 100 kVA, 6600V/250V, 50Hz 1ϕ transformer at full load and 0.8 lagging p.f. from following readings;`

O. C. test : 6600 V, 1.5 A, 900 W,

S. C. test : 290 V, 12 A, 860 W.

Ans:

From the SC test:

$$Z_{1T} = \frac{V_{sc}}{I_{sc}} = \frac{290}{12} = 24.166\ \Omega$$

$$R_{1T} = \frac{W_{sc}}{{I_{sc}}^2} = \frac{860}{12^2} = 5.972\ \Omega$$

$$X_{1T} = \sqrt{{Z_{1T}}^2 - {R_{1T}}^2} = \sqrt{24.166^2 - 5.972^2} = 23.416\Omega$$ 1 Mark

To find efficiency:

P_i= 900W $P_{cu} = 860W$ at 12 A load current

$$Efficiency = \frac{F.L.output \times cos\emptyset}{F.L.output \times cos\emptyset + Losses}$$

Full load current on HV side = 100000/6600 = 15.15 A

Full load copper losses = $(15.15/12)^2$[860] = 1.6 x 860 = 1371 W

Total losses = 1371 + 900 = 2271 W.

$$= \frac{100000 \times 0.8}{100000 \times 0.8 + 2271} = \frac{80000}{81760} \times 100$$

=0.9723 OR 97.23% 1 Mark

Regulation

Total approximate voltage drop as referred to primary is

$= I_1(R_{1T}cos\emptyset + X_{1T}sin\emptyset)$

$I_1 = \frac{VA}{V_1} = \frac{100000}{6600} = 15.151$ A

Voltage drop= $15.151[(5.972 \times 0.8) + (23.416 \times 0.6)] = 285.24\ volts$ 1 Mark

$$VoltageRegulation = \frac{Voltagedrop}{NoloadVoltage} = \frac{285.24}{6600}$$

$= 0.0432 \quad or \quad 4.32\%$ 1 Mark

3 c) Compare distribution transformer with power transformer on any four points..

Ans:

Comparision of Distribution Transformer with Power Transformer:

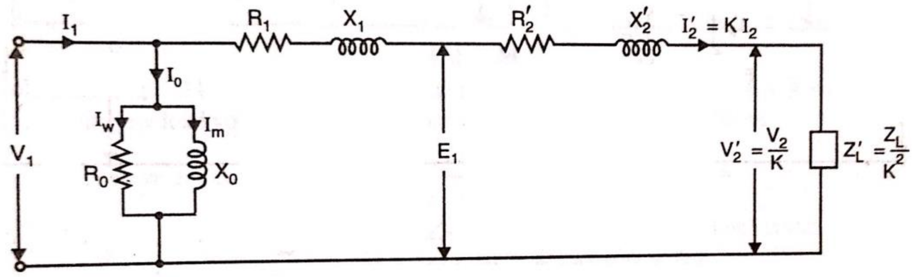
Parameters	**Distribution Transformer**	**Power Transformer**
Typical Voltages	11kV,6.6kV, 3.3kV, 440V, 230V	400kV, 220kV, 110kV,66kV,33kV
Power Rating	Lower (< 1MVA)	Higher (> 1MVA)
Size	Small	Big
Load	50-70% of full load	Full load
Insulation Level	Low	High
Installation	Pole mounted/ Plinth Mounted.	Compulsory Plinth Mounted
Maximum efficiency	Obtained near 50% of full load	Obtained near 100% of full load
Type of efficiency	All day efficiency needs to be defined	Only power efficiency is sufficient

1 Mark each of any four points = 4 Marks

.

3 d) Draw the equivalent circuit of transformer referred to primary. State the meaning of each term.

Ans:
Equivalent Circuit Diagram of Transformer Referred to Primary:



2 Marks Equivalent Diagram

V_1 -Primary Input voltage
I_1 - Input Current
I_0 - Exciting current/ No load current
I_m - Magnetizing component of no load current
I_w - Working component of no load current
R_0- Core loss resistance
X_0- magnetizing reactance
R_1 -Primary winding resistance
X_1 - Primary winding reactance
E_1 – Induced emf in Primary winding
R_2' - Secondary winding resistance referred to primary
X_2'- Secondary winding reactance referred to primary
I_2 - Secondary winding current
I_2' – Primary equivalent of secondary current
K- Transformation ratio
V_2 - Secondary terminal voltage
V_2' - Primary equivalent of secondary terminal voltage
Z_L – Load impedance
Z_L' - Primary equivalent of load impedance
(in terminology only passive parameters: resistances and inductive reactance need to be mentioned which are to be awarded marks, voltages, currents are not required).

2 Marks for terminology

3 e) State any two advantages of parallel operation of transformer.
State the two conditions for connecting single phase transformers in parallel.

Ans:
Advantages of Parallel Operation of Transformer:

i) Reliability of the supply system enhances.
ii) Highly varying load demands can be fulfilled.
iii) Loading only the relevant capacity transformer to operate at high efficiency.
iv) Overloading of transformers is avoided and hence the life of transformer increases.
v) Reserved capacity can be reduced.

(Any related advantages should be considered)

Any two Advantages = 2 Marks

Conditions for Connecting Single Phase Transformers in Parallel:

1) Voltage ratings and voltage ratios of the transformers must be same.

	2) Transformer polarity wise connections must be carried out. 3) Percentage / p.u. impedances should be equal for load sharing to occur in proportion to the kVA ratings. 4) X/R ratio of the transformer windings should be equal for load sharing at identical power factor.	Any two conditions = 2 Marks
3 f)	Identify the circuit diagram given in Fig. No. 1. Select proper range of all meters if the transformer is having rating of 440 V/ 220 V, 2kVA	

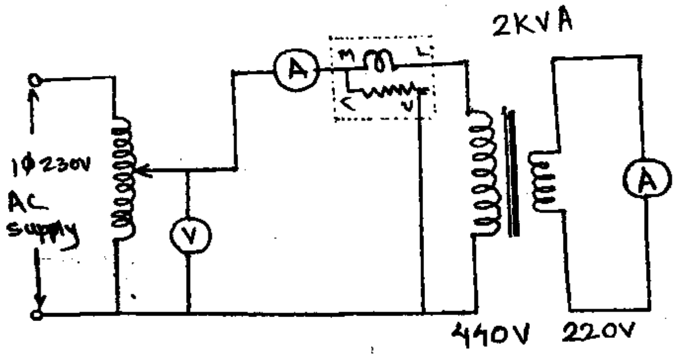


Fig. No. 1

Ans:

Given circuit in Fig. No. 1 is for short circuit test on single phase transformer. — 1 Mark

Here,
Primary full load current = (2000/440) = 4.545 A.
Secondary full load current = (2000/220) = 9.09 A. — 1 Mark
Generally for circulation of full load short circuit current 10% of rated voltage i.e.10% of 220 V = 22V is required.
Hence rating of meters on primary side are;
Ammeter- (0-5 A)
Voltmeter- (0- 30 V) — 1.5 Marks
Wattmeter - 5 Amp / 30, 50, 60 V, 200W.
Rating of meters on secondary side are;
Ammeter - (0-10 A) — 0.5 Mark

4 **Attempt any FOUR of the following**: 16

4 a) A 40 kVA, single phase transformer with a ratio of 2000 / 250 V has a primary resistance of 1.15Ω and a secondary resistance of 0.01555Ω. If the transformer is designed for 75% of full load. Find its efficiency when delivering full load at 0.8 power factor.

Ans:

Given: 40kVA, V_1= 2000 V, V_2= 250 V, R_1= 1.15 Ω, R_2= 0.01555 Ω,
P.F. = 0.8.

$$K = \frac{V_2}{V_1} = \frac{250}{2000} = 0.125$$

As the transformer is designed for 75% of full load, it means that the transformer exhibits maximum efficiency at 75% of full load. — 1Mark

Cu losses at 75% of full load = $(0.75)^2 \times P_{cuFL}$
At maximum efficiency, Cu losses = Iron losses
Hence, $(0.75)^2 \times P_{cuFL} = P_i$
Full load primary current = 40×1000/2000= 20A

Equivalent primary resistance= $R_{01}= R_1+R_2/K^2$

$= 1.15 + 0.01555/(0.125)^2 = 2.145\ \Omega$ 1Mark

Full load Cu losses $P_{cuFL} = I_1^2 \times R_{01} = 20^2 \times 2.145 = 858$ W

As , $(0.75)^2 \times P_{cuFL} = P_i$ 1Mark

$0.5625 \times 858 = P_i$ = Iron losses= 482.625 W

Efficiency when delivering full load at 0.8 power factor:

$$\text{Full load Efficiency} = \frac{\text{output}}{\text{output} + \text{losses}}$$

$$= \frac{40 \times 1000 \times 0.8}{(40 \times 1000 \times 0.8) + (858 + 482.625)}$$ 1Mark

$$= \frac{32000}{33340.625} = 0.9597 \text{ OR } 95.97\%$$

4 b) Fig. No. 2 shows the equivalent circuit of 220/2200 V, single phase transformer as referred to the primary side. Calculate:

(i) Primary current.
(ii) Power factor.
(iii) Secondary terminal voltage.
(iv) Output of transformer.

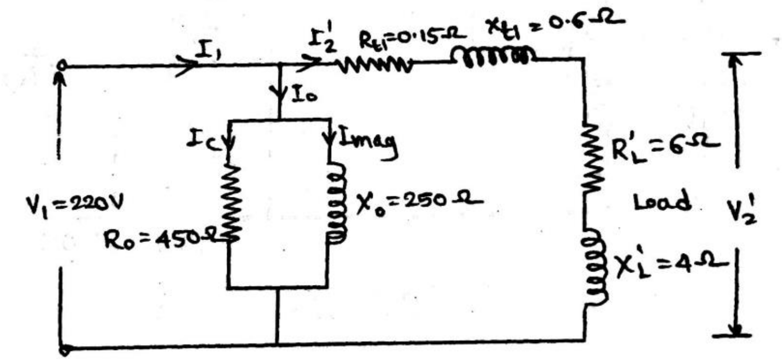


Fig. No. 2

Ans:

Given , R_0=450 Ω, R_{t1}=0.015 Ω, R_L' = 6 Ω

X_0=250 Ω, X_{t1}= 0. 6 Ω, X_L' = 4 Ω,

Transformation ratio K = $\frac{V_2}{V_1} = \frac{2200}{220} = 10$

$$I_C = {}^{V_1}/_{R_0} = \frac{220}{450} = 0.488\text{ A}$$

$$I_m = {}^{V_1}/_{X_0} = \frac{220}{250} = 0.88\text{ A}$$

$$I_0 = \sqrt{0.488^2 + 0.88^2} = 1.006\text{ A}$$

$R_T = R_{t1} + R_L' = 0.15 + 6 = 6.15\ \Omega$

$X_T = X_{t1} + X_L' = 0.6 + 4 = 4.6\ \Omega$

$I_2' = V_1 / \sqrt{(R_T^2 + X_T^2)} = \frac{220}{\sqrt{(6.15^2+4.6^2)}} = \frac{220}{\sqrt{58.98}} = \frac{220}{7.68} = 28.645\ A < 36.75°$

i) Primary current $I_1 = \sqrt{I_0{}^2 + I_2'{}^2} = \sqrt{1.006^2 + 28.645^2} = 28.66$ A — 1 Mark

iii)Terminal Voltage , $V_2' = I_2' \times Z_L'$

$= 28.645\ A < 36.75° \times 7.22 < 33.68°$

= 206.816 V <70.43°

Terminal voltage referred to secondary = k× V_2' — 1 Mark

$= 10 \times 206.816 = 2068.16$ V

ii) Power Factor

Phase angle between $V_2' and\ I_2'$ is $70.43° - 36.75° = 33.68° = \phi$ — 1 Mark

∴ Power Factor = cosϕ = cos 33.68 = 0.832 lag

iv) Output of Transformer — 1 Mark

$= I_2' \times V_2' = 28.645 \times 206.816 = 5924.244$ VA

4 c) Two transformers A of 40 kVA with % Z_A=(3+j4)Ω and B of 25 kVA. Share equally a load of 50kVA. While working in parallel. Find how they will share a load of 40 kVA. Comment your answer.

Ans:

Given: Total load shared, S= 50kVA**,**

Since the transformers share load equally,

Load shared by each transformer $S_A = S_B = 25$kVA

Impedance of transformer A, Z_A=(3+ j4) Ω

Load shared by transformer B

$$S_B = S\frac{Z_A}{Z_A + Z_B}$$

$$25 = 50 \times \frac{(3+j4)}{(3+j4) + Z_B}$$

$$(3+j4) + Z_B = 2\times(3+j4)$$

$$Z_B = 2\times(3+j4) - (3+j4)$$

$$Z_B = (3+j4)\ \Omega$$

2 Marks

NOTE: If we assume, Z_A=(3+ j4)%, it is on the base of its rating i.e 40 kVA. The value of Z_B obtained above is also on the same base i.e 40 kVA.

Load sharing:

$$S_A = S\frac{Z_B}{Z_A + Z_B}$$

$$S_A = 40 \times \frac{(3 + j4)}{(3+j4) + (3 + j4)}$$

$S_A = 20$ kVA and $S_B = 20$ kVA which can be obtained as, — 2 Marks

$$S_B = S\frac{Z_A}{Z_A + Z_B}$$

$$S_B = 40 \times \frac{(3+j4)}{(3+j4) + (3 + j4)}$$

$$S_B = 20\ kVA$$

Comment: Load shared by transformer A is same as that of load shared by transformer B.

4 d) The efficiency of 100 kVA, 1100/440 V, 1ϕ transformer is 87% on half load at 0.8(lag) and 89% on full load at unity power factor. Determine iron and copper losses.

Ans:

$$Full\ load\ effciency, \eta_{FL} = \frac{KVA \times 1000 \times PF}{(KVA \times 1000 \times PF) + P_i + P_{cu}} \times 100$$

$P_i = Iron\ loss\ which\ is\ constant.$
$P_{cu} = Full\ load\ Cu\ loss$

$$\therefore 0.89 = \frac{100 \times 1000}{(100 \times 1000) + P_i + P_{cuFL}} = \frac{100000}{100000 + P_i + P_{cuFL}}$$

$$\therefore P_i + P_{cuFL} = 12359.55W \ldots\ldots\ldots\ldots\ldots..(i)$$ 1 Mark

$$P_{cuHL} = \frac{1}{2}^2 \times P_{cuFL} = \frac{P_{cuFL}}{4}$$

$$Effciency\ at\ Half\ load, \eta_{HL} = \frac{1/2 \times KVA \times 1000 \times PF}{(1/2 \times KVA \times 1000 \times PF) + P_i + P_{cuHL/4}}$$

$$0.87 = \frac{1/2 \times 100 \times 1000 \times 0.8}{(1/2 \times 100 \times 1000 \times 0.8) + P_i + \frac{P_{cuFL}}{4}}$$

$$0.87 = \frac{40000}{(40000) + P_i + \frac{P_{cuFL}}{4}}$$

$$P_i + \frac{P_{cuFL}}{4} = 5977.01W \ldots\ldots\ldots\ldots(ii)$$ 1 Mark

Subtracting (i) from (ii) and solving we get,

Copper losses = $P_{cuFL} = 8510.05\ W$ 1 Mark

Iron losses = $P_i = 3849.49W$ 1 Mark

4 e) List various losses in a transformer and the places at which they occur.

Ans:

Various Losses in a Transformer:

Sr. No.	Losses in Transformer	Places at which the losses occur
1	Copper Losses	Windings of transformer
2	Iron Losses or Core Losses i) Eddy Current losses ii) Hysteresis Losses	Core of the transformer

4 Marks

4 f) Derive the condition for obtaining maximum efficiency of transformer.

Ans:

Condition for Obtaining Maximum Efficiency of Transformer:

The efficiency of transformer is given by,

$$\eta = \frac{V_2 I_2 (\cos\phi_2)}{V_2 I_2 (\cos\phi_2) + P_i + I_2^2 R_{02}}$$ 1 Mark

- In above equation P_i is constant and V_2 is practically constant.

At specified value of load p.f. $\cos\phi_2$, the efficiency is maximum when $\frac{d\eta}{dI_2} = 0$

$$\frac{d\eta}{dI_2} = \frac{d}{dI_2}\left[\frac{V_2 I_2 (\cos\phi_2)}{V_2 I_2 (\cos\phi_2) + P_i + I_2^2 R_{02}}\right] = 0$$ 1 Mark

Solving the above equation, we get

$$Pi - I_2^2 R_{02} = 0$$

$$I_2^2 R_{02} = Pi$$

$\therefore$ Condition for Maximum efficiency is,

Copper loss = Iron loss

As V_2 and pf are constant, (let A= V_2 x pf = constant):
dividing numerator and denominator by I_2 we get

$$\eta = [\frac{A}{A + \frac{P_i}{I_2} + I_2 R_{02}}] = [\frac{1}{1 + \frac{P_i}{I_2} + I_2 R_{02}}]$$ 1 Mark

This expression is maximized when the denominator is minimum.
Hence differentiating the denominator with respect to I_2 and equating it to 0

we have $-\frac{P_i}{I_{02}^2} + R_{02} = 0$, (that is $I_{02}^2 R_{02} = P_i$ is the condition)
differentiating once more to determine whether it is max or min at this condition we get $\frac{2P_i}{I_{02}^3}$ which is always positive which means that the denominator is minimum and hence the expression of efficiency is maximum at the condition derived 1 Mark

(copper losses = iron losses)

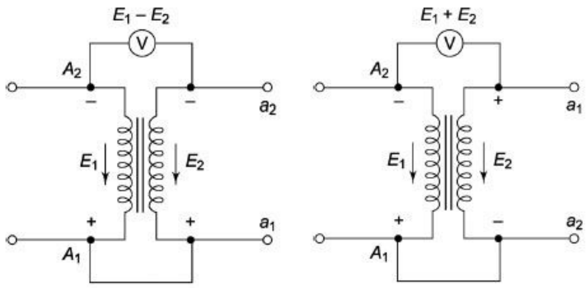
5 **Attempt any <u>FOUR</u> of the following** 16

5 a) Draw polarity test of 1- ϕ transformer.

Ans:

Circuit Diagram of Polarity test of Single Phase Transformer:

4 Marks



Subtractive Polarity Additive Polarity

OR any equivalent diagram

5b) A 500kVA, distribution transformer having copper and iron losses of 5kW and 3kW respectively on full load. The transformer is loaded as shown below

Loading (KW)	Power Factor (lag)	No. of hrs.
400	0.8	08
300	0.75	10
200	0.8	03
No load	-------	03

Ans:

The problem can be solved by using following steps:

Step-I Calculate output energy in KWh

Step-II : Convert the loading from kW to KVA 1Mark

Step-III : Calculate copper losses at different KVA values

Step-IV: Calculate copper losses in 24 hours

Step-V: Calculate iron losses in 24 hours

Step-VI: Calculate All day efficiency

No of Hrs	Load in KW	P.F	Output energy in kWh= $load\ in\ KW \times No.of\ hrs$	Load in KVA= $\frac{Load\ in\ KW}{power\ factor}$	Copper Losses at different kVA= Copper Losses at Full load $\times \left(\frac{Load\ KVA}{RatedKVA}\right)^2$	Total cu Losses in kwh	Total Iron losses
08	400	0.8	3200	$\frac{400}{0.8}$=500	$5\ kw \times \left(\frac{500}{500}\right)^2 =$ 5 kw	5×8 = 40 kWh	$3\times 24 = 72\ kWH$
10	300	0.75	3000	400	3.2 kw	32	
03	200	0.8	600	250	1.25 kw	3.75	
03	No load	---	0	0	0	0	
			Total= 6800 kWH			Total = 75.75 kWH	Total=72 kWH

2 Marks

$$\%Efficiency_{Allday} = \frac{Output\ Energy in\ 24\ hrs}{Output\ Energy\ in\ 24\ Hrs + Lossesin\ 24\ Hrs} \times 100$$ 1 Mark

$$= \frac{6800}{6800 + 75.75 + 72} \times 100 = \frac{6800}{6947.75} \times 100 = 97.87\%$$

$\%\ Efficiency_{Allday} = 97.87\%$ OR 0.9787

5 c) State the advantages of amorphous core type distribution transformer.

Ans:

Advantages of amorphous core type distribution transformer:

1) Increases efficiency of transformer as constant losses are reduced by 75 % compared to conventional transformers.
2) The material has high electrical resistivity hence low core losses.
3) Amorphous material has lower hysteresis losses, hence less energy wasted in magnetizing & demagnetizing the core during each cycle of supply current.
4) Amorphous metal have very thin laminations, which results in lowering the eddy current losses.
5) Reduced magnetizing current.
6) Better overload capacity.
7) High Reliability.
8) Excellent short circuit capacity.
9) Less maintenance cost.

1 Mark of each of any four points = 4 Marks

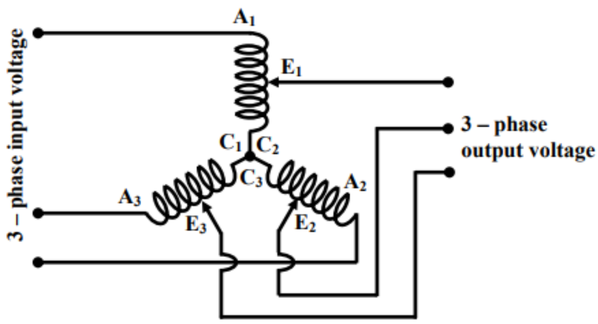
5 d) State with neat sketch the construction of three phase autotransformer.

Ans:

Construction of three phase auto transformer:

- The coils connected in star are placed on electromagnetic cores; each phase of auto-transformer consists of a single continuous winding common to primary and secondary circuit.
- The limbs (electromagnetic cores) are made of laminations (sheet steel with silicon).
- The output terminal connections are gang / simultaneously operated to get identical tapings to all phases and are brought out on the insulated plate. The variable voltage can be obtained with tapings to which the output terminals are connected as required.

Explanation 2 Marks



3 – phase autotransformer

OR Equivalent circuit

Diagram 2 Marks

5 e) What is the aim of conducting phasing out test on three phase transformer?

Draw diagrams for phasing out test.

Ans:- .

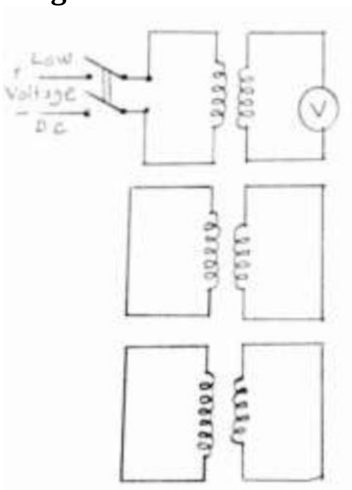
Aim of Conducting Phasing Out Test on Three Phase Transformer:

This test is carried out to identify primary & secondary windings belonging to same phase of poly-phase transformer. 2 Marks for Aim

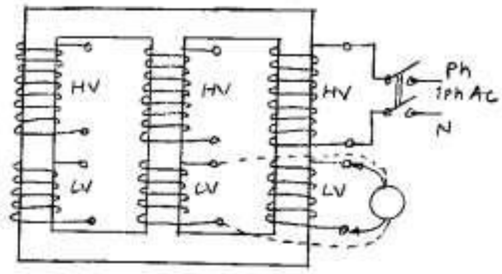
OR

This test is carried out to find out the corresponding HV and LV winding of a phase of poly-phase transformer.

Diagram: 2 Marks for Diagram = 4 Marks



OR



5 f) Write selection criteria of distribution transformer with any four points.

Ans:-

Selection Criteria for distribution transformer:

i) Load requirements that decides kVA Rating
ii) Required Tappings
iii) Vector group.
iv) Winding Impedances
v) Termination Arrangement.
vi) Cooling system
vii) Nature of load
viii) Ambient/ Environment conditions
ix) Voltage ratings
x) Nature of service required
xi) Tariff applicable etc.

½ Mark for each of any eight points

6 **Attempt any FOUR of the following** 16

6 a) Identify the parts shown in the diagram of a transformer in Fig.No.3.

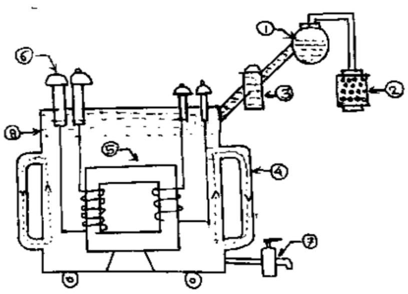


Fig. No. 3

½ Mark for each = 4 Marks

Ans:

Parts Shown in The Diagram of a Transformer:

1-Conservator Tank
2-Breather
3-Buchholz Relay
4-Cooling Tubes
5-Magnetic Core
6-HT Terminal Bushings
7-Drain Valve
8-Transformer Tank

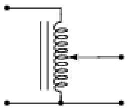
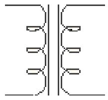
6b) Compare auto transformer with two-winding transformer (Any four point).

Ans:

Comparison of autotransformer with two-winding transformer:

Sr No	**Autotransformer**	**Two winding Transformer**
1	Only one winding, part of the winding is common for primary and secondary.	There are two separate windings for primary and secondary.
2	Movable contact exist	No movable contact between primary and secondary
3	Electrical connection between primary and secondary.	Electrical isolation between primary and secondary windings.
4	Comparatively lower losses.	Comparatively more losses
5	Efficiency is more as compared to two winding transformer.	Efficiency is less as compared to autotransformer.
6	Copper required is less, thus copper is saved.	Copper required is more.
7	Spiral core construction	Core type or shell type core construction
8	Special applications where variable voltage is required.	Most of the general purpose transformers where fixed voltage is required.
9	Cost is less	Cost is more
10	Better voltage regulation	Poor voltage regulation

1 Mark for each of any valid four points = 4 Marks

11	 Symbol of Autotransformer	 Symbol of Two winding transformer

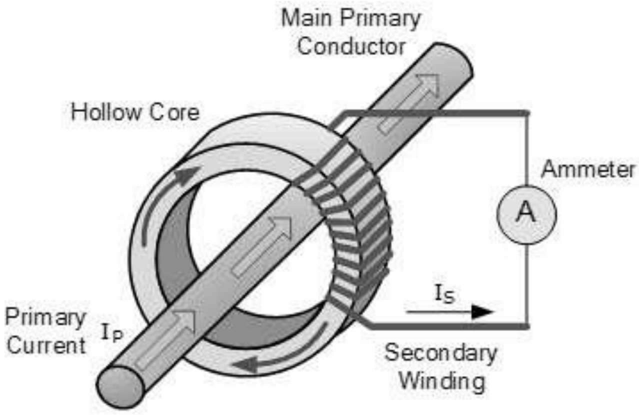
6c) Explain construction and operation of current transformer. Draw a connection diagram for C.T. connection with 1-ϕ load.

Ans:

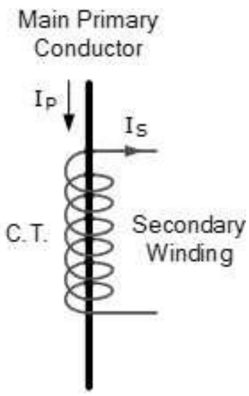
Construction and Operation of current transformer:

Construction-

- Construction of CT is as shown in above figure.
- C.T. has bar type conductor, which behaves as primary winding.
- The primary of C.T. carries large current Ip which is to be measured, so the bar is of large cross sectional area. 1 Mark
- The secondary of C.T.is made up of large number of turns. It is wound on core. The secondary winding is a low current winding. Hence it's cross sectional area is small.
- An ammeter of small range is connected across the secondary as shown in figure given below



Construction



Circuit Symbol

1 Mark

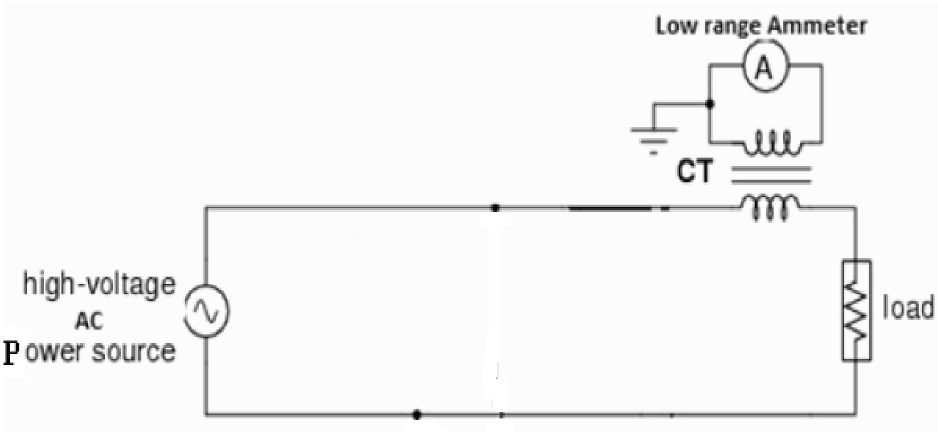
Operation of C.T.;

- C.T. is basically a step-up transformer. Hence the secondary is high voltage low current winding. 1 Mark
- The secondary current is given by;
  $Is = Ip \times \frac{N1}{N2}$ $\quad N2 \gg N1$
- The current Is is measured by the ammeter. So knowing turns ratio it is possible to measure Ip.
- The primary current is given by;

$$Ip = Is \times \frac{N2}{N1}$$

Connection diagram for C.T. connection with single phase load:

1 Mark

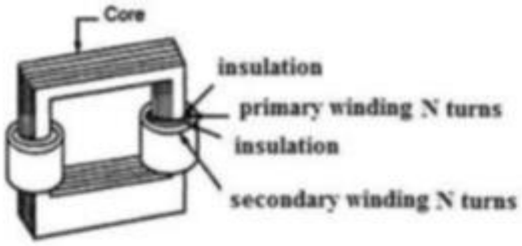


6 d) Explain construction and working of isolation transformer.

Ans:

Construction and Working of Isolation Transformer:

Construction:



1 Mark

i) Isolation transformers are specially designed transformers for providing electrical isolation between primary & secondary windings.

ii) The transformer has primary and secondary windings placed on the common core limbs which have equal number of turns so that the voltage fed to the primary is available at the secondary without any change in its magnitude. 1 Mark

iii) These are built with special insulation between primary and secondary.

Working:

When supply is given to primary it causes primary current to flow in primary winding and inducing ac fluxes in core. The secondary winding is wound on common magnetic core, hence these ac fluxes are linked with it. Now secondary emf is induced according mutual induction action and secondary current flows through load if connected. 2 Marks

6 e) Compare single phase welding transformer with two winding transformer on the basis of construction, winding size.

Ans:

Comparison between Single Phase Welding Transformer with Two winding Transformer:

Parameter	Single phase welding transformer	Single phase two winding transformer

2 Marks

Construction	• Several taps on secondary side to adjust/control the current to reasonable values. • Very highly reactive windings. • Separate reactors are used purposely. • The transformer is normally large in comparison to other step down transformers as the windings are of a much larger gauge.	• Taps are not always needed but provided if required. • Less reactive in comparison. • No reactors used purposely • Comparatively smaller sizes.	each point = 4 Marks
Winding sizes	• Very thin large number of turns of primary conductors. • Secondary conductors very thick due to very high currents (step down).	• Winding sizes depend on the type of the transformers. • Not as thick depends on current rating and type of transformer.	

6 f) List special features (any four) of isolation transformer with any four applications.

Ans:

Special Features of Isolation Transformer:

i) Number of primary turns are equal to number of secondary turns.

ii) Disconnect the load equipment from supply:
Sometimes it is essential to disconnect the load equipment such as the cathode ray oscilloscope (CRO) from the supply ground. 2 Marks

iii) Sensitive and costly equipment need to be disconnected from supply to protect from noisy ground connection.

iv) Reduction of voltage spikes:
Voltage spikes are short duration high amplitudes pulses which get superimposed on the ac supply. These are dangerous to delicate equipment. Isolation transformer reduces the amplitude of spike .

Applications of isolation transformer:

i) Disconnect the load equipment from supply ground: 2 Marks
ii) Reduction of voltage spikes
iii) It acts as a decoupling device.
iv) Protects loads from harmonic distortion.