# Electrical Machines Test 3

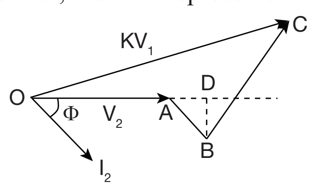
**Number of Questions: 25** **Section Marks: 90**

***Directions for questions 1 to 25:*** Select the correct alternative from the given choices.

1. Hysteresis loss depends on
   (A) $f$ (B) $f^2$
   (C) $f^{1.6}$ (D) $f^{\circ}$

2. A 20KVA, 20000/480V, 60Hz transformer has following results $V_{oc} = 480V$
   $I_{oc} = 1.51A$
   $P_{OC} = 271W$
   $V_{SC} = 1130V$
   $I_{SC} = 1A$
   $P_{SC} = 260W$
   What would be the rating of this transformer, if it is operated at 50Hz?
   (A) 20 KVA, 20000/480V
   (B) 16.67 KVA, 1667/400V
   (C) 24 KVA, 24000/576V
   (D) None of the above

3. In the following phasor diagram $k$ represent turns ratio of the transformer, then $AD$ represents

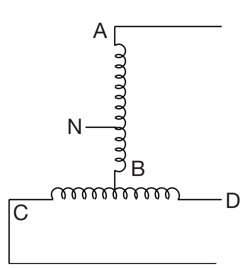



   (A) $I_2 R_{02}.\sin\phi$. (B) $I_2 R_{02}$.
   (C) $I_2 R_{02} \cos\phi$ (D) $I_2 X_{02} \sin\phi$.

4. The total load taken by the $V$-$V$ bank transformers is
   (A) 2/3 of the total load taken by Δ-Δ bank.
   (B) 57.7% of the total load taken by Δ-Δ bank.
   (C) 86.6% of the total load taken by Δ-Δ bank.
   (D) 42.3% of the total load taken by Δ-Δ bank.

5. Three 20 MVA transformers are connected in Δ-Δ fashion, when one of the transformer is removed the total load taken by the remaining transformers is ___________
   (A) 40 MVA (B) 34.64 MVA
   (C) 51.96 MVA (D) 23.08 MVA

6. In the following transformer connection, the voltage between $AB$ terminal is 200V. Then the voltage $AN$ is_______

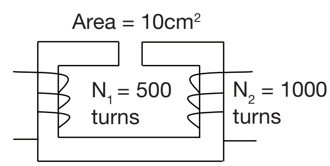



   (A) 100 V (B) 86.6 V
   (C) 133.34 V (D) 66.67 V

7. In no load operation of the transformer, the angle $\phi_o$ (no load angle) is due to
   (A) no load copper losses in the transformer.
   (B) hysteresis loss in the transformer.
   (C) mechanical displacement of core.
   (D) None of the above.

8. A Δ-Δ bank consisting of three 40-KVA, 2000/200V transformers supplies a load of 90 kVA. If one of the transformer is out of service, calculate the percent of rated load carried by each transformer.
   (A) 130% (B) 70%
   (C) 30% (D) 170%

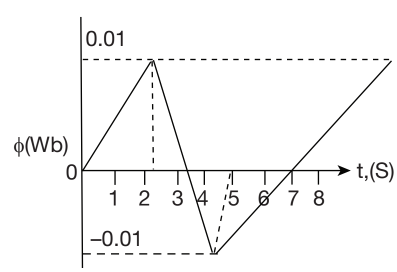
9. A magnetic material of $\mu_r = 200$ carries two coils on its vertical limbs as shown. Their mutual inductance = '$M$'.




   If number of turns of each coil are doubled, what would be the new mutual inductance?
   (A) $M$ (B) $4M$
   (C) $2M$ (D) $M/2$

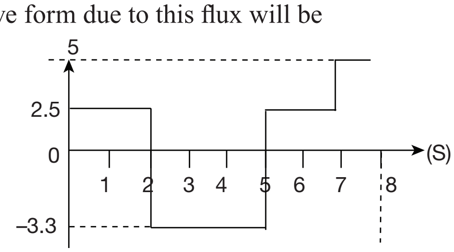
10. A 50 KVA transformer has 800 turns on the primary and 100 turns on the secondary winding. The primary is connected to 5000V, 50 Hz supply calculate the maximum flux in the core
    (A) 225.22 mwb (B) 22.52 mwb
    (C) 2.81 mwb (D) 28.15 mwb

11.

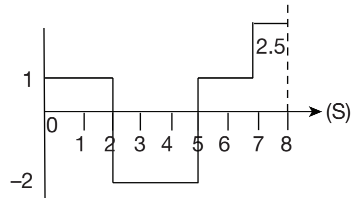



    This flux passes through a coil of 500 turns voltage wave form due to this flux will be

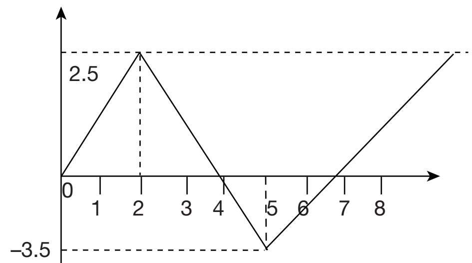
    (A)



(B)




(C)




(D) None of the above

**12.** A 500kVA, 3000/300V, 60Hz transformer the open circuit and short circuit test results are as follows:
*O.C* test: 300V, 5A, 180W
*S.C* test: 115V, 18A, 400W
Calculate the power factor on short circuit
(A) 0.58 lag (B) 0.8 lag
(C) 0.38 lag (D) 0.62 lag

**13.** Calculate the regulation of a transformer in which the ohmic loss is 2% of the output and the reactance drop is 6% of the voltage, when the power factor is 0.7 leading.
(A) 0.02 p.u (B) –0.02 p.u
(C) 0.05 p.u (D) –0.05 p.u

**14.** An auto transformer is used to connect 12.6kV distribution line to a 13.8kV distribution line. It must be capable of handling 2000kVA. The three phases are connection $Y - Y$, neutrals solidly grounded. What should be the turns ratio to accomplish this?
(A) 10 (B) 10.5
(C) 11 (D) 11.5

**15.** A 5000VA 480/120V conventional transformer is used as autotransformer to supply 120V to load from a 600V source. Assuming ideal transformer, what are the maximum primary and secondary currents in this condition?
(A) 10.4A, 52.1A (B) 52.1A, 10.4A
(C) 1.04A, 5.21A (D) 5.21A, 1.04A

**16.** A transformer is connected to 4000V, 50Hz. The core loss is 1000 watts, out of which 600 watts are due to hysteresis and the remaining eddy current losses. Calculate the core loss if the supply voltage and frequency are 4800V and 60 Hz respectively
(A) 720W (B) 1296W
(C) 1200W (D) 1440W

**17.** A short circuit when performed on *h.v* side of a 20 kVA, 5000/500V single phase transformer gave the data, 150V, 8A, 400W. If the *L.V* side is delivering full load current at 0.6 p.f and at 500V. Calculate the voltage applied to on *h.v* side.
(A) 5000V (B) 5500V
(C) 5180V (D) 5320V

**18.** A 40 kVA, 4000/400V single phase transformer, the iron and full load copper losses are 400W and 500W respectively. Calculate the efficiency at half load and 0.8 power factor.
(A) 97.56% (B) 98.48%
(C) 96.10% (D) 96.85%

**19.** *A* 100 kVA, 4000/200V transformer has $R_1$ = 3.85 Ω, $R_2$ = 0.008 Ω. The values of reactance's are $X_1$ = 5.5 Ω and $X_2$ = 0.018Ω. Calculate the total copper loss (Referred to primary) of the transformer.
(A) 2.40 kW (B) 4.40 kW
(C) 2 kW (D) 6.40 kW

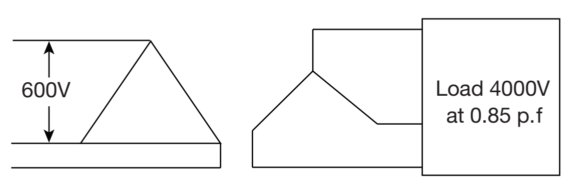
**20.** A 500 KVA transformer has a full load loss of 8kW, the losses being equally divided between iron and copper. During a day, the transformer operates on full load 5 hours, one half load for 6 hours and the output being negligible for the remainder of the day. Calculate the All day efficiency.
(A) 97.04% (B) 96.71%
(C) 96.89% (D) 98.82%

**21.** A 3-phase, delta/star connected 11000/400V, 50Hz transformer takes a line current of 8A. When secondary load of 0.6 lagging p.f connected. Calculate the total power output.
(A) 152.42 kW (B) 50.80 kW
(C) 30.48 kW (D) 29.33 kW

**22.** A single phase transformer has 2000 turns on the primary and 400 turns on the secondary. The no load current is 4A at a p.f of 0.25 lagging. Calculate the primary current when the secondary current is 300A at a power factor of 0.85 lagging.
(A) 62.94∠–34.29° (B) 60∠–31.78°
(C) 64.24∠–75.52° (D) 64∠–107.2°

**23.** A 50 kVA, Single-phase transformer, 4000V to 400 volts has a primary resistance of 1.2 Ω and a secondary resistance of 0.02 Ω. Calculate the full load efficiency at 0.9 p.f, if the iron loss of the transformer is 90% of the full load copper loss.
(A) 97.93% (B) 98.93%
(C) 96.54% (D) 99.82%

**24.** A 3-phase transformer has an equivalent resistance of 2% and an equivalent reactance of 8% as shown in figure, when the transformer delivers 4000V at full load current and 0.85 power factor. Calculate transformation ratio of the transformer.



(A) 0.40 (B) 2.45
(C) 0.70 (D) 1.41

**25.** The results of *OC* and *SC* test on a 2000VA, 230/115V transformer are as follows.

| | |
|---|---|
| $V_{OC}$ = 230V | $V_{SC}$ = 13.2V |
| $I_{OC}$ = 0.45A | $I_{SC}$ = 6A |
| $P_{OC}$ = 30W | $P_{SC}$ = 20.1W |

What is the transformer efficiency at rated conditions 0.8 p.f. lagging?
(A) 95%
(B) 94.3%
(C) 91.7%
(D) 90.4%

## Answer Keys

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** A | **2.** B | **3.** C | **4.** B | **5.** B | **6.** C | **7.** B | **8.** A | **9.** B | **10.** D |
| **11.** A | **12.** C | **13.** B | **14.** B | **15.** A | **16.** B | **17.** C | **18.** D | **19.** B | **20.** A |
| **21.** C | **22.** A | **23.** A | **24.** A | **25.** C | | | | | |

## Hints and Explanations

**1.** $W_h = K_h B^{1.6} f\, V$ watts Choice (A)

**2.** Ratings $\alpha\, f$;
$\therefore$ both apparent power and voltage should be multiplied by 50/60

$$\frac{50}{60}\times 20\text{KVA} = 16.67\text{KVA}$$

$$\frac{50}{60}\times 20000\text{ V} = 16667\text{V};\ \frac{50}{60}\times 480 = 400\text{V}$$

Choice (B)

**3.** Choice (C)

**4.** The $V - V$ bank is taken only 57.7% of the total load taken by $\Delta$ - $\Delta$ bank transformers. Choice (B)

**5.** When one of the transformer is removed from the $\Delta$-$\Delta$ bank, the total load taken by the remaining transformers is 86.6% of their own rating.
One transformer supplies = 0.866 × 20 = 17.32 MVA
Then two transformers supplies total load = 34.64 MVA
Choice (B)

**6.** The diagram given in the question is scott connection therefore the voltage *AN* = 2/3 × voltage of *AB* = 2/3 × 200 = 133.34V Choice (C)

**7.** Choice (B)

**8.** KVA load supplied by each of two transformers

$$= \frac{90}{\sqrt{3}} = 51.96\text{ kVA}$$

$$\text{Percent of rated load} = \frac{\text{kVA load of each transformer}}{\text{kVA rating of each transformer}}$$

$$= \frac{51.96}{40}\times 100 = 130\%$$ Choice (A)

**9.** $M = \sqrt{L_1 L_2}$

$$L_1 = \frac{\mu N_1^2 A_1}{l_1}$$

$$L_2 = \frac{\mu N_2^2 A_2}{l_2}$$

$L\ \alpha\ N^2 \Rightarrow$ Individual inductance become 4 times.
$\therefore$ *M* also becomes 4 times. Choice (B)

**10.** Induced e.m.f $E = 4.44\, \phi f N$
5000 = 4.44 × $\phi$ × 50 × 800
$\phi$ = 0.02815
= 28.15 mwb Choice (D)

**11.** $E = -N\,(d\phi/dt)$

$$0 < t < 2;\ e = 500\times\frac{0.01}{2} = 2.5\text{V}$$

$$2 < t < 5;\ e = 500\times\frac{-0.02}{3} = -3.33\text{V}$$

$$7 < t < 5;\ e = 500\times\frac{0.01}{2} = 2.5\text{V}$$

$$7 < t < 8;\ e = 500\times\frac{0.01}{1} = 5\text{V}$$

This matches graph (*a*) Choice (A)

**12.** Impedance $Z_{01} = \frac{115}{18} = 6.38\Omega$

Resistance $R_{01} = \frac{800}{18^2} = 2.469\Omega$

Power factor on short circuit $= \frac{R_{01}}{Z_{01}}$

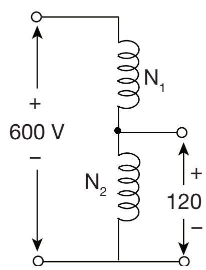
$$= \frac{2.469}{6.38} = 0.38 \text{ lag}$$ Choice (C)

**13.** cos $\phi$ = 0.7 $\Rightarrow \phi$ = 45.57°
sin $\phi$ = sin(45.57) = 0.714
Per unit regulation at 0.7 leading p.f
= 0.02 × 0.7 – 0.06 × 0.714 = – 0.02 Choice (B)

**14.** $$\frac{V_H}{V_L} = \frac{N_1 + N_2}{N_2} = \frac{\sqrt{3}\times 13..8KV}{\sqrt{3}\times 12.6KV}$$

$\Rightarrow$ $12.6N_1 + 12.6N_2 = 13.8N_1$
$12.6N_2 = 1.2N_1$
$N_2/N_1 \approx 10.5$ Choice (B)

**15.**




New KVA rating $= \left(\dfrac{480+120}{480}\right)\times 5000\text{VA} = 6250\text{VA}$

$\therefore$ $I_P = \dfrac{S}{V_P} = \dfrac{6250}{600} = 10.4\text{A}$

$I_S = \dfrac{6250}{120} = 52.1\text{A}$ Choice (A)

**16.** Core loss = hysteresis loss + eddy current loss
Hysteresis loss $W_{h1} = 600\text{W}$
Eddy current loss $W_{e1} = 400\text{W}$
Hysteresis loss $= \dfrac{W_{h1}}{W_{h2}} = \dfrac{Af_1}{Af_2}$

$\Rightarrow$ $\dfrac{600}{W_{h2}} = \dfrac{50}{60}$

$\Rightarrow$ $W_{h2} = \dfrac{600\times 60}{50} = 720\text{ watts}$

Eddy current loss $= \dfrac{W_{e1}}{W_{e2}} = \dfrac{f_1^2}{Bf_2^2}$

$\Rightarrow$ $\dfrac{400}{W_{e2}} = \dfrac{50^2}{60^2}$

$\Rightarrow$ $W_{e2} = \dfrac{400\times 60^2}{50^2} = 576$ watts

Total Iron loss = 1296 watts Choice (B)

**17.** $Z_{01} = \dfrac{150}{3} = 50\ \Omega$

$R_{01} = \dfrac{400}{3^2} = 44.44\ \Omega$

$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2} = \sqrt{50^2 - 44.44^2} = 22.91\ \Omega$

$I_1 = \dfrac{20000}{5000} = 4\text{A}$

Voltage drop on primary side $= I_1(R_{01}\cos\Phi + X_{01}\sin\phi)$
$= 4(44.44 \times 0.6 + 22.91 \times 0.8) = 179.96\text{V}$
$\therefore$ Primary voltage has raised to 5180V

Choice (C)

**18.** Copper loss $= 500 \times \dfrac{1}{4} = 125\text{W}$

Iron losses = 400W
Output at Half load and 0.8 power factor
$= 40 \times \dfrac{1}{2} \times 0.8 = 16$ kW

$\%\eta = \dfrac{16}{16+0.12+0.4} \times 100 = 96.85\%$

Choice (D)

**19.** $I_1 = \dfrac{100000}{4000} = 25\text{A}$

$I_2 = \dfrac{100000}{200} = 500\text{A}$

Total copper loss are whether referred to primary (or) secondary
$W_{cut} = 25^2 \times 3.85 + 500^2 \times 0.008$
$= 4406.25$ watts Choice (B)

**20.** Iron loss for 24 hours = 4 × 24 = 96 kWh
Full load copper loss = 4 kW
Full load copper losses for 5 hours = 4 × 5 = 20 kWh
Half load copper losses for 6 hours = 1 × 6 = 6kWh
Total losses = 96 + 20 + 6 = 122 kWh
Total output = 500 × 5 + 250 × 6 = 4000 kWh

$\eta_{all\ day} = \dfrac{4000}{4000+122} \times 100 = 97.04\%$ Choice (A)

**21.** Primary rating $V_1 = 11000$

Secondary rating $V_2 = \dfrac{400}{\sqrt{3}} = 230.94\text{V}$

Primary current $I_1 = \dfrac{8}{\sqrt{3}} = 4.618\text{A}$

Three phase volt – Amp $= 3 \times 11000 \times \dfrac{8}{\sqrt{3}}$

$= 1{,}52{,}420.47$
Volt-amp/phase = 50806.82

Secondary current $I_2 = \dfrac{50806.82}{230.94} = 220\text{A}$

Total output power = 50806.82 × 0.6
= 30.48 kW Choice (C)

**22.** $\cos^{-1}(0.85) = 31.78°$
$I_2 = 300\ \angle -31.78°$
Secondary load current refer to primary
$I_2^1 = 60\angle -31.78°$
$\Phi_0 = \cos^{-1}(0.25) = 75.52°$
$I_1 = I_0 + I_2^1$
$= 4\angle -75.52° + 60\ \angle -31.78°$
$= 52 - 35.472i = 62.94\angle -34.29°$

Choice (A)

**23.** $K = \frac{400}{4000} = 0.1$

$R_{02} = R_2 + K^2 R_1 = 0.02 + \frac{1}{100} \times 1.2 = 0.032\ \Omega$

Full load $I_2 = \frac{50000}{400} = 125A$

Full load copper loss $= I_2^2 R_{02} = 125^2 \times 0.032 = 500W$

Iron loss = 90% of 500 = 450W
Total losses = 450 + 500 = 950W
Full load output = 50 × 0.9 = 45 kW

Full load $\eta = \frac{45000}{45000+950} \times 100$

$= 97.93\%$ Choice (A)

**24.** Percent regulation = 2 × 0.85 + 8 × 0.52 = 5.86%
Induced secondary

e.m.f $= 4000 + \frac{5.86}{100} \times 4000 = 4234.4V$

Secondary phase voltage $= \frac{4234.4}{\sqrt{3}} = 2444.73V$

Transformation ratio $= K = \frac{2444.73}{6000} = 0.40$

Choice (A)

**25.** $P_{out} = V_s I_S \cos\theta = 115V \times 8.7 \times 0.8 = 800W$

$(I_S = \frac{1000VA}{115V} = 8.7A)$

$P^1_{sc} = \left(\frac{8.7}{6}\right)^2 \times 20.1 = 42.26W$

$P_{oc}$ = constant loss

$\eta = \frac{800}{800+42.26+30} = \frac{800}{872.26} = 91.7\%$

Choice (C)