OFFLINE TEST SERIES

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ESE-2017 : Prelims Exam

UPSC Engineering Services Examination

E & T ENGINEERING

Answer Key & Solutions

Test 17: Part Syllabus Technical
Basic Electrical Engg. + Material Science

1.	(c)	16.	(c)	31.	(c)	46.	(d)	61.	(d)
2.	(c)	17.	(a)	32.	(a)	47.	(b)	62.	(a)
3.	(d)	18.	(c)	33.	(a)	48.	(c)	63.	(c)
4.	(a)	19.	(c)	34.	(d)	49.	(b)	64.	(b)
5.	(b)	20.	(c)	35.	(a)	50.	(a)	65.	(c)
6.	(c)	21.	(d)	36.	(b)	51.	(c)	66.	(a)
7.	(d)	22.	(a)	37.	(d)	52.	(d)	67.	(d)
8.	(c)	23.	(b)	38.	(d)	53.	(c)	68.	(a)
9.	(a)	24.	(d)	39.	(c)	54.	(c)	69.	(a)
10.	(b)	25.	(c)	40.	(d)	55.	(a)	70.	(c)
11.	(c)	26.	(b)	41.	(c)	56.	(b)	71.	(c)
12.	(a)	27.	(c)	42.	(b)	57.	(c)	72.	(c)
13.	(b)	28.	(d)	43.	(c)	58.	(c)	73.	(a)
14.	(d)	29.	(b)	44.	(c)	59.	(d)	74.	(a)
15.	(b)	30.	(d)	45.	(c)	60.	(d)	75.	(b)

DETAILED EXPLANATIONS

1. (c)

$$\text{Initial speed of generator, } N = 1000 \text{ rpm}$$
$$\text{New speed} = N_1$$
$$\text{Generated emf, } E = 200 \text{ V}$$
$$\text{New emf, } E_1 = 250 \text{ V}$$
$$\text{using emf equation, } E = k\phi\omega_m \qquad [\text{as } \phi \text{ is a constant}]$$
$$\frac{E}{E_1} = \frac{\omega}{\omega_1}$$
$$\Rightarrow \quad \frac{200}{250} = \frac{1000}{N_1}$$
$$N_1 = \frac{1000 \times 250}{200} = 1250 \text{ rpm}$$
$$\text{change in speed required} = 1250 - 1000 = 250 \text{ rpm increase}$$

2. (c)

Assuming initial flux be ϕ_1 and initial torque be T_1
similarly for new condition flux ϕ_2 and new torque T_2
The torque relation for dc motor : $T_1 = k\phi_1 I_{a_1} = 200$ N-m
Under new requirement, new torque $T_2 = 150$ N-m
The new flux and assumed current $\phi_2 = 0.5\phi_1,\ I_{a_2} = xI_{a_1}$

$$\frac{T_1}{T_2} = \frac{\phi_1 I_{a_1}}{\phi_2 I_{a_2}}$$
$$\Rightarrow \quad \frac{200}{150} = \frac{\phi_1 I_{a_1}}{(0.5\phi_1)\times(x I_{a_1})}$$
$$\frac{200}{150} = \frac{1}{0.5x}$$
$$\Rightarrow \quad x = \frac{150}{200 \times 0.5} = \frac{150}{100} = 1.5$$

3. (d)

We know motor torque, $\tau = k\phi I_a$

$\therefore$ before saturation, $\tau \propto I_a^2$ ...(until flux becomes constant due to saturation)

and after saturation, $\tau \propto I_a$ ...(flux becomes constant)

5. (b)

Given full load copper loss, $P_{cu} = 3200$ W

Iron loss, $P_i = 3000$ W

At half load rated current becomes half

$$P_{cu} \propto I^2$$

and new $P_{cu} = \left(\frac{I}{2}\right)^2 = \frac{I^2}{4}$

Hence, new copper loss $= \frac{3200}{4} = 800$ W and iron loss is constant.

Copper loss at half load become quarter of full load copper loss when iron loss are fixed loss for a rated frequency.

6. (c)

$$R_{\text{actual}} = R_{pu} \times R_{\text{base}}$$

$$R_{\text{base}} = \frac{(\text{kV})^2}{\text{MVA}}\ \Omega$$

The base value of resistance on HV side $= \frac{16}{8} = 2\ \Omega$

The actual value of resistance of HV side $= 2 \times 0.02 = 0.04\ \Omega$

Similarly $X_{\text{actual}} = X_{\text{pu}} \times X_{\text{base}}$; $X_{\text{base}} = \frac{(\text{kV})^2}{\text{MVA}} = 2\Omega$

The actual value of reactance on HV side $= 2 \times 0.06 = 0.12\ \Omega$

7. (d)

The water meter reading at rated input gives copper loss = 200 W

$$\text{efficiency, } \eta = \frac{\text{kVA}\cos\phi}{\text{kVA}\cos\phi + P_i + P_{cu}}$$

$$= \frac{10}{10 + P_i + \frac{200}{1000}}$$ [at unity power factor cosϕ = 1]

$$0.9 = \frac{10}{10.2 + P_i}$$

$$\Rightarrow \quad 10.2 + P_i = \frac{10}{0.9}$$

$$P_i = \frac{100}{9} - 10.2$$

$$= \frac{100 - 91.8}{9} = \frac{8.2}{9}$$

$$= 91\%$$

8. (c)

Power transferred by both conduction and induction process.

10. (b)

Given induction motor is 4 pole, 50 Hz, machine

$$\therefore \quad \text{Synchronous speed} = \frac{120f}{p} = \frac{120\times 50}{4} = 1500 \text{ rpm}$$

$$\text{At a speed of 1440 rpm the slip} = \frac{1500-1440}{1500} = \frac{60}{1500} = \frac{2}{50} = 0.04$$

Rotor impedance : $R_r + jX_{ro} = (1 + j4)\ \Omega$

when R_r = rotor resistance ad X_{ro} = rotor reactance at stand still

$$\text{while running rotor impedance} = R_r + jsX_{ro}$$

$$\text{when } s = \text{slip at 1440 rpm} \quad = 1 + j\frac{4}{100}\times 4 = (1 + j0.16)\ \Omega$$

11. (c)

Braking in 3-ϕ induction motor is possible for slip value greater than one.

12. (a)

The power factor of synchronous motor improves by increasing excitation.

13. (b)

Line voltage of star connected synchronous motor = 17320 V

$$\text{Per phase voltage } V = \frac{17320}{\sqrt{3}} = \frac{17320}{1.732} = 10 \text{ kV}$$

Armature resistance $R_a = 2\ \Omega$ and synchronous reactance $X_s = 20\ \Omega$

$$(\text{kVA})_{3\phi} = \frac{\sqrt{3}\, V_L\, I_a}{1000}$$

$$\Rightarrow \quad 5 = \frac{17320\times\sqrt{3}\times I_a}{1000}$$

$$I_a = 166.67 \text{ mA}$$

14. (d)

ASA method gives most accurate voltage regulation value of synchronous generator.

15. (b)

$$\text{Load factor} = \frac{\text{Average demand}}{\text{Maximum demand}}$$

$$\text{Average demand on generating station} = \frac{\text{Total units generated in a year}}{\text{Total hours of year}}$$

$$= \frac{8.76\times 10^6}{24\times 365} = \frac{8.76\times 10^6}{8760} \text{ kWh/h}$$

$$= \frac{8760000}{8760} = 1000 \text{ kW}$$

$$\text{Load factor} = \frac{1000}{5\times 1000} = \frac{1}{5} = 0.2$$

16. (c)

$$\text{Given maximum demand} = 2.5 \text{ MW}$$

$$\text{Total load} = 2000 \text{ kW} + (500 + 200 + 300) \text{ kW} = 3000 \text{ kW} = 3 \text{ MW}$$

$$\text{Diversity factor} = \frac{\text{Sum of maximum demand}}{\text{Maximum demand on power station}}$$

$$= \frac{3 \text{ MW}}{2.5 \text{ MW}} = \frac{30}{25} = \frac{6}{5} = 1.2$$

hence option (c) is correct.

17. (a)

$$\text{Kinetic energy of wind} = \frac{1}{2} mV^2 \quad \text{...}(V = \text{velocity})$$

$$m = \rho V \quad (\rho = \text{density of air, } V = \text{velocity of air through wind mill})$$

Mass of air passing wind mill per second

$$= \rho AV \quad (A = \text{area of cross section} = \pi r^2)$$

$$\text{Wind power available at wind turbine} = \frac{1}{2} mV^2$$

$$= \frac{1}{2} \rho AVV^2 = \frac{1}{2} \rho AV^3$$

$$= \frac{1}{2} \rho \pi r^2 V^3$$

$$\text{power available at wind mill, } P \propto r^2$$

18. (c)

Draft tubes are air tight pipes connecting runner outlet and bottom of tail race to create a negative pressure head.

19. (c)

Given :

Watt hour efficiency of battery = 75%

Ampere hour efficiency of battery = 90%

Average voltage during charging = 100 V

Let average voltage during discharge = x V

$$\text{Using relation } Wh \text{ efficiency} = A-h \text{ efficiency} \times \frac{\text{Average volts on discharge}}{\text{Average volts on charge}}$$

$$0.75 = 0.9 \times \frac{x}{100}$$

$$\frac{75}{90} \times 100 = x$$

$$x = \frac{250}{3} = 83.33 \text{ V}$$

20. (c)
It is convenient to keep field winding on rotor and stator has cooling ducts with coolant passing through which facilitates the better cooling of armature conductors.

21. (d)
If the load which is added is lagging than the terminal voltage will fall below no load terminal voltage, if the load is leading then the terminal voltage will rise.

23. (b)
Skewing is helpful for noiseless operation of motor hence statement 2 is incorrect.

24. (d)
All statements mentioned above are correct in relation to synchronous generator.

25. (c)
Air gap flux in alternator is due to current in armature as well as dc excitation on field winding also. Hence statement 2 is not correct.

26. (b)
Reflector are placed in inner periphery to reflect the neutrons not radiations. Location of nuclear power plant is near load centre due to negligible transportation cost of fuel.

27. (c)
Sumpner's test or regenerative test is called back to back test or regenerative test, which is performed to know temperature of large rating transformers, whereas polarity test is performed to know correct direction of induced voltage.

31. (c)
Centrifugal switch is used to disconnect starting winding or starting capacitor.

32. (a)
DC generator is oldest electric generator.
3-ϕ synchronous motor can act as a reactive power sink/source.
3-ϕ induction motor is also known as generalized 3-ϕ transformer.

43. (c)
Secondary or molecular bonds are either ion-dipole interaction, dipole-dipole interaction or vanderwalls are weaker than primary bonds (ionic, covalent).

44. (c)
In the case of solids and liquids, internal field $\vec{E}_i$ is not equal to the applied field $\vec{E}$, (for gases $\vec{E}_i = \vec{E}$)

for solids and liquids, $\vec{E}_i = \vec{E} + \left(\frac{\gamma}{\epsilon_0}\right)\vec{P}$.

For cubic symmetry, $\gamma = \frac{1}{3}$

$$\therefore \quad \vec{E}_i = \vec{E} + \frac{\vec{P}}{3\epsilon_0}$$

47. (b)
There is no ferrielectric material and ferroelectric exhibit hysteresis, as like ferromagnetic and ferrimagnetic.

48. (c)
χ_m is negative for diamagnetic material and as long as the electronic structure of the material is independent of temperature, the diamagnetic susceptibility is also essentially independent of temperature.

49. (b)
The Neel temperature plays a similar role in antiferromagnetic materials as does the curie temperature in ferromagnetic materials.

50. (a)
In magnetic materials Alnico having maximum energy product used for making permanent magnet.

51. (c)
Electrets are electrical analogy of electromagnets very similar to permanent magnet materials.

54. (c)
If applied magnetic field is more than critical field transition temperature will be reduced.
Super conductor are used as a Magnetic Switch which can be on & off by application of temperature or Magnetic field.

57. (c)
In ferromagnetic material, all domains are aligned parallel to each other below Curie temperature.

60. (d)
Magnetization, $M = \chi_m H$
where $\chi_m \rightarrow$ magnetic susceptibility
$H \rightarrow$ magnetic field intensity
So, in terms of magnitude, $M \propto H$
According to Curie law,

$$\chi_m = \frac{C}{T}$$

$$\Rightarrow \quad \chi_m \propto \frac{1}{T}$$

So, for constant H, $M \propto \frac{1}{T}$

61. (d)
The dielectric losses in the radio frequency region are usually due to dipole rotation (i.e. oriental polarisation) or to ions (i.e., ionic polarisation) jumping from one equilibrium position to another. But, the losses in the optical region, are associated with the electrons (i.e. electronic polarisabilities).

64. (b)
Both statement are correct but are not related. Efficiency of transformers is high as they don't have any moving part, therefore no friction losses.

65. (c)
Direct online starting draws large value of current from source.

66. (a)
With change in frequency the value of reactance varies hence regulation also change.

$$R = R_{pu}\cos\phi + X_{pu}\sin\phi$$

as $$X_{pu} \propto f \propto \omega L$$

change in frequency, changes regulation.

67. (d)
Assertion is false and reason is true. Due to magnetic locking synchronous motor always runs at synchronous speed.

68. (a)
Without batteries the renewable energy resources and system working on them are mostly infeasible and unpractical by very nature of resources.

69. (a)
Application of an electric field causes relative displacement of these charges, leading to the creation of dipoles and hence polarization.

70. (c)
Hard magnetic materials have a high coercive field.

71. (c)
R is false here because switching action is not only the characteristic of super-conducting materials but also exhibited by conductors and semiconductors.

72. (c)
Diamond lattice structure consists of two interpenetrating FCC lattices, displaced along the body diagonal of the cubic cell by 1/4 the length of the diagonal. Hence, its coordination number is 4 and packing efficiency is very low, i.e. ≈ 34%.

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