Electrical Machines Test 4

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

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

1. Hopkinson's Test on D.C machines is
(A) No load test. (B) Full load test.
(C) Break test. (D) None of the above.

2. The compensating winding conductors in D.C machine is (has)
(A) directly proportional to the square of armature conductors.
(B) directly proportional to the armature conductors.
(C) inversely proportional to the armature conductors.
(D) No relation with the armature conductors.

3. Which of the following generator generally not used for power supply cases
(A) d.c. shunt generator.
(B) d.c. series generator.
(C) d.c. compound generator.
(D) Both B and C

4. A d.c booster is connected between a station bus bar and a feeder, the characteristics of the booster is straight line through 0 to 40V at 100A and the feeder has a resistance of 0.6 ohm. When the feeder has a current of 100A, calculate the potential difference between the station bus-bar and far end of the feeder
(A) 60V (B) 40V
(C) 20V (D) 100V

5. In separately excited D.C Generator load saturation curves is drawn between
(A) terminal voltage and field current.
(B) terminal voltage and armature current.
(C) generated voltage and field current.
(D) generated voltage and armature current.

6. The overloading of generator is indicated by
(P) excessive sparking at brushes.
(Q) overheating of the armature and other parts of the generator.
(A) only *P*
(B) only *Q*
(C) both *P* and *Q*
(D) None of the above

7. Match the following

List-I	**List-II**
P. Swinburne's test	1. Below base speed
Q. Field test	2. Above base speed
R. Field control	3. Constant losses
	4. Stray losses in case of d.c series machines
	5. Temperature rise

	P	*Q*	*R*		*P*	*Q*	*R*
(A)	3	5	1	(B)	3	4	2
(C)	4	5	2	(D)	4	5	1

8. A 4-pole D.C machine has an armature resistance of 0.4 Ω and constant losses of the machine 40W. When the machine is working under maximum efficiency, calculate the armature current of the machine.
(A) 100A (B) 2.5A
(C) 10A (D) 16A

9. In which of the following motors 3-point starter is not used
(P) shunt motor. (Q) compound motor.
(R) series motor.
(A) Only *P* (B) Both *P* and *Q*
(C) Both *Q* and *R* (D) *P*, *Q* and *R*

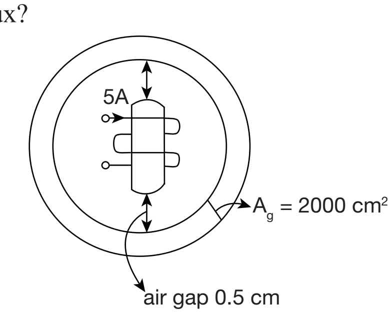
10. In a dc generator, the residual magnetism is of the order of
(A) 2.5% (B) 10%
(C) 15% (D) 25%

11. A d.c. shunt machine develops an a.c emf of 200V at 1000 rpm. Calculate the torque developed for an armature current of 80A
(A) 152.8Nm (B) 16 Nm
(C) 168.8 Nm (D) 136.8 Nm

12. A 250V d.c. shunt motor has an armature resistance of 0.4 Ω and runs at 1000 rpm with an armature current of 80A. If the torque is increased four times then the corresponding speed of the motor is _____.
(A) 560 rpm (B) 440 rpm
(C) 1560 rpm (D) 1440 rpm

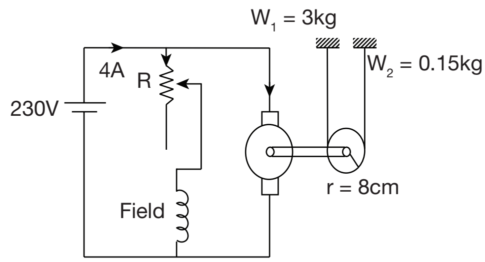
13. Calculate the torque developed in a 8-pole D.C motor having 800 conductors, two paths in parallel, 25 milli-webers of pole flux and the armature current is 100A
(A) 424 N-m (B) 1272 N-m
(C) 636 N-m (D) 2544 N-m

14. For the given magnetic structure, assuming infinite permeability with number of turns 1000, what is the magnetic flux?



(A) 0.1256T (B) 0.2512Wb
(C) 0.2512T (D) 0.1256Wb

15. A brake test is conducted on D.C shunt motor running at a speed of 1500 rpm as shown in the figure. Calculate efficiency of the motor.



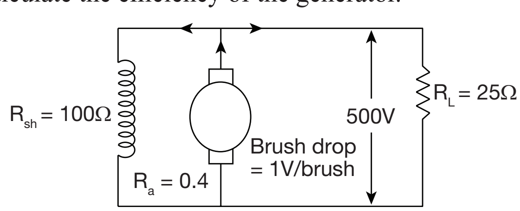
(A) 38.17% (B) 61.29%
(C) 55.64% (D) 84.25%

16. A 4-pole lap wound d.c generator has 300 coils of single turn each, Resistance of each turn is 0.04 Ω. The armature is 40 cm long and 30 cm diameter. Airgap flux density of 0.8*T* is uniform over pole shoe. The mechanical angle of each pole is 30°. For an armature current of 50A, calculate the terminal voltage of machine at a speed of 1500 rpm.
(A) 412.5V (B) 375V
(C) 373V (D) 337.5V

17. A d.c series motor having a resistance of 2 Ω drives a fan for which the torque varies as the square of the speed at 300V, the set run at 500 rpm and takes 30A. The speed is to be raised to 800 rpm by increasing the voltage, when the field is unsaturated. Calculate the terminal voltage of the machine.
(A) 614.4V (B) 710.4V
(C) 240.0V (D) 204.4V

18. The hysteresis and eddy current losses in a d.c. machine running at 1500 rpm are 500W and 200W respectively. Calculate the total iron loss of the machine at half rated speed of the machine.
(A) 250W (B) 700W
(C) 300W (D) 254W

19. A 6-pole d.c generator circuit as shown in the figure. Calculate the efficiency of the generator.

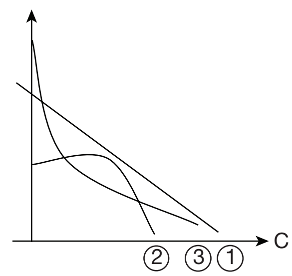


(A) 79.68% (B) 80.85%
(C) 78.12% (D) 79.02%

20. The essential condition for the stable operation of two dc generators in parallel is that they should have the same
(A) kW rating.
(B) No load and full load speeds.
(C) Drooping voltage characteristics.
(D) Voltage regulations at full load.

21. A 200V shunt motor has armature and field resistance of 0.2 and 200Ω respectively. The motor drives a torque load, $T_L \propto n^2$. It runs at 1000 rpm, drawing 10A from supply. If an external resistance of 5Ω is given to armature circuit, what would be the new speed of rotation? (Neglect armature reaction & saturation)
(A) 900 rpm (B) 856 rpm
(C) 841 rpm (D) Data insufficient

22. Given the various torque - speed curves of dc motors 1, 2, 3 may be (respectively)



(A) Permanent magnet, series, compound
(B) Compound, series, permanent magnet
(C) Series, compound, permanent magnet
(D) Permanent magnet, compound, series

23. Plugging in an motor implies
(A) rapidly stopping the motor by using mechanical brakes.
(B) rapidly stopping the motor by reversing armature field.
(C) rapidly accelerating the motor by using mechanical means.
(D) rapidly accelerating the motor by reversing armature field.

Common data questions for 24 and 25:

24. A separately excited DC motor is rotated at 1000 rpm, no load test results are as follows

I_F (Amperes)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
V_T (Volts)	0	30	60	85	102	115	124	130	134

V_F = 24V and field resistance is adjustable
R_A = 0.2Ω, V_T = 130V
The motor drives a load at 1200 rpm.
If R_F = 60Ω, what is the armature voltage?
(A) 102V (B) 122.4V
(C) 115V (D) 100V

25. If the above motor supplies mechanical load of 4kW at 1450 rpm and rotational losses are 160W, what is the efficiency? (Approximately)
(A) 96% (B) 91%
(C) 93% (D) 94%

Answer Keys

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

Hints and Explanations

1. Regenerative (or) Hopkinson's test is a full load test conducted on two similar d.c shunt machines.
Choice (B)

2. Compensating winding Turns $AT_C = \frac{\text{Pole arc}}{\text{Pole pitch}} \times \frac{I_a Z}{2ap}$
$AT_C \,\alpha\, Z$ Choice (B)

3. *D.C* series generators are not used for power supply because of their rising characteristics.
Choice (B)

4. Voltage drop = 100 × 0.6 = 60V
Booster voltage for 100*A* current is given as 40V
Net voltage drop = 60 – 40 = 20V
Choice (C)

5. Choice (A)

6. Choice (C)

7. Swinburne's test is no load test, the test is conducted to find constant losses and field control method is used to control the speed of the motor above base speed only.
Choice (B)

8. Copper losses = Constant losses $I_a^2 R_a = 40$
$I_a = \sqrt{\frac{40}{0.4}}$ = 10A Choice (C)

9. Choice (C)

10. Choice (A)

11. Mechanical power developed in the arm = $E_b I_a$
= 200 × 80 = 16000 watts
$T_a = 9.55 \times \frac{E_b I_a}{N}$
$= \frac{9.55 \times 200 \times 80}{1000} = \frac{9.55 \times 16000}{1000}$ = 152.8 N-m
Choice (A)

12. $T \,\alpha\, I_a$
$\Rightarrow \frac{T_{a2}}{T_{a1}} = \frac{I_{a2}}{I_{a1}} \Rightarrow 4 = \frac{I_{a2}}{80} \Rightarrow I_{a2} = 320\text{A}$
$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \Rightarrow \frac{N_2}{1000} = \frac{250 - 320 \times 0.4}{250 - 80 \times 0.4}$
N_2 = 559.63 r.p.m
$\Rightarrow N_2$ = 560 rpm
Choice (A)

13. $T = \frac{0.159 \varphi Z I_a P}{A}$
$T = \frac{0.159 \times (25 \times 10^{-3}) \times 800 \times 100 \times 8}{2}$
= 1272 N-m Choice (B)

14. $\phi = \frac{N\,\text{I}\,\mu_0 A_g}{\ell} = \frac{1000 \times 5 \times 4\pi \times 10^{-7} \times 2000 \times 10^{-4}}{2 \times 0.5 \times 10^{-2}}$
$= \frac{5000 \times 4\pi \times 10^{-7} \times 0.2}{10^{-2}}$ = 0.1256 Wb Choice (D)

15. Net Force on Pulley = $(W_1 - W_2) \times 9.81$
= 2.85 × 9.81 = 27.95 N
Power output = Torque × ω
$= 27.95 \times \frac{8}{100} \times \frac{2\pi \times 1500}{60}$ = 351.23 watts
% efficiency $= \frac{\text{Power output}}{\text{Power input}} \times 100$
$= \frac{351.23}{230 \times 4} \times 100$ = 38.17% Choice (A)

16. electrical angle = $\frac{4}{2} \times 30 = 60°$
Flux per pole $= \frac{2\pi \times 0.15 \times 0.4}{4} \times \frac{60}{180} \times 0.8 = 0.025$ wb
Total armature conductors *Z* = 300 × 2 = 600
Generated e.m.f at no load $E_g = \frac{\varphi Z N}{60} \times \frac{P}{A}$
$= \frac{0.025 \times 600 \times 1500}{60} \times \frac{4}{4}$ = 375 V
Number of armature turns per path = $\frac{300}{4}$ = 75
Resistance of one path = 75 × 0.04 = 3 Ω
Resistance of armature circuit = $\frac{3}{4}$ = 0.75 Ω
Terminal voltage $V_t = E_g - I_a R_a$
= 375 – 50 × 0.75
= 337.5 V Choice (D)

17. Torque $\propto I_a^2 \propto N^2$
$\Rightarrow I_a \,\alpha\, N$

$\Rightarrow$ $I_{a1} \propto N_1$

$$\therefore \frac{I_{a2}}{I_{a1}} = \frac{N_2}{N_1} = \frac{800}{500} \Rightarrow I_{a2} = \frac{800}{500} \times 30 = 48\text{A}$$

$E_{b1} = 300 - 30 \times 2 = 240$ V

$E_{b2} = V - 48 \times 2$

$$\frac{\varphi_1}{\varphi_2} = \frac{30}{48} = \frac{5}{8} = \frac{N_2}{N_1} = \frac{E_{b_2}}{E_{b_1}} \times \frac{\varphi_1}{\varphi_2}$$

$$= \frac{800}{500} = \frac{V - 48 \times 2}{240} \times \frac{5}{8}$$

$\Rightarrow$ $614.4 = V - 48 \times 2$

$\Rightarrow$ $V = 710.4$V Choice (B)

18. $W_i = W_n + W_e = AN + BN^2$

$$\therefore W_n = 500\text{W} \Rightarrow A \times \frac{1500}{60} = 500$$

$\Rightarrow$ $A = 20$

$$\therefore W_e = 200 \text{ W} \Rightarrow B \times \frac{1500 \times 1500}{60 \times 60} = 200$$

$\Rightarrow$ $B = 0.32$

$$\text{New iron loss } W_i = \frac{20 \times 750}{60} + \frac{0.32 \times 750^2}{60^2}$$

$= 250 + 50 = 300$ W Choice (C)

19. Terminal voltage $= 20 \times 25 = 500$V

$$I_{sh} = \frac{500}{100} = 5\text{A}$$

$I_a = 20 + 5 = 25$A

$I_a R_a = 25 \times 0.4 = 10$V

Brush drop = 2V

Generated voltage = 500 + 2 + 10 = 512 V

$$\eta = \frac{\text{Power output}}{\text{Power generated}} = \frac{500 \times 20}{512 \times 25} \times 100$$

$= 78.125\%$ Choice (C)

20. Choice (C)

21. Initially $I_{f1} = 1A$; $I_{a1} = 9$A

$T_{e1} = K_1 \times 1 \times 9 = T_{L1}$

$E_{b1} = K_2 \times 1 \times 1000 = V - I_{a1} V_a = 200 - 9 \times 0.2$

$= 198.2$V

Let new steady state armature current $= I_{a2}$;

Speed $= n_2$

$\therefore$ $T_{e2} = K_1 \times 1 \times I_{a2} = T_{L2}$

$E_{b2} = K_2 \times 1 \times n2 = V - I_{a1}(r_a + R_{ext})$

$\Rightarrow$ $K_2 n_2 = 200 - I_{a2}\,(5.2)$

$$\frac{T_{e2}}{T_{e1}} = \frac{T_{L2}}{T_{L1}} = \frac{K_2 \times 1 \times I_{a2}}{K_2 \times 1 \times 9}$$

$$\Rightarrow \frac{n_2^2}{1000^2} = \frac{I_{a2}}{9} \qquad \text{———(1)}$$

$$\text{Similarly } E_{b2}/E_{b1} = \frac{K_1 \times 1 \times n_2}{K_1 \times 1 \times 1000}$$

$$= \frac{200 - I_{a2} \times 5.2}{198.2}$$

$$\Rightarrow \frac{n_2}{1000} = \frac{200 - I_{a2} \times 5.2}{198.2} \qquad \text{———(2)}$$

Substituting (2) in (1)

$$\left(\frac{200 - 5.2 I_{a2}}{198.2}\right)^2 = \frac{I_{a2}}{9}$$

$\Rightarrow$ $I_{a2} \approx 6.36$A

$$\therefore \frac{n_2}{1000} = \sqrt{\frac{6.36}{9}} \approx 841\text{rpm}$$ Choice (C)

22. Choice (D)

23. Choice (B)

24. $E_A = K \phi W$

$V_F = I_F R_F \Rightarrow 24 = I_F \times 60$

$\Rightarrow$ $I_F = 0.4$A

From the table, at 1000rpm, $I_F = 0.4$A gives

$V_T = 102$V

$$\text{at 1200rpm, } E^1 = E_{1000} \times \frac{1200}{1000} = 122.4\text{V}$$

Choice (B)

25. $I_A^2 R_A - V_T I_A + P = 0$

$\Rightarrow$ $I^2_A\,(0.2) - V_T I_A + 4160 = 0$

$I_A = 33.75$A

$E_A = V_T - I_A R_A = 123.25$A (at 1450rpm)

E_A^1 at 1000rpm $= 85V \Rightarrow I_F = 0.3$A

Copper losses $= I^2_A R_A + I_F^2 R_F$

Total loses $= I_A^2 R_A + I^2_F R_F + P_{\text{rotational}} = 395$W

$$\eta = \frac{4000}{4395} \approx 91\%$$ Choice (B)