Solutions of

of

Electrical Engineering

GATE-2016

Session 6 | Set-1

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Section - I (General Aptitude)

One Mark Questions

Q.1 The man who is now Municipal Commissioner worked as _____.

(a) the security guard at a university

(b) a security guard at the university

(c) a security guard at university

(d) the security guard at the university

Ans. **(b)**

End of Solution

Q.2 Nobody knows how the Indian cricket team is going to cope with the difficult and seamer-friendly wickets in Australia. Choose the option which is closest in meaning to the underlined phrase in the above sentence.

(a) put up with (b) put in with

(c) put down to (d) put up against

Ans. **(a)**

End of Solution

Q.3 Find the odd one in the following group of words.

mock, deride, praise, jeer

(a) mock (b) deride

(c) praise (d) jeer

Ans. **(c)**

End of Solution

Q.4 Pick the odd one from the following options.

(a) CADBE (b) JHKIL

(c) XVYWZ (d) ONPMQ

Ans. **(d)**

$$\underset{-2,\ +3,\ -2,\ 3}{\overbrace{C\ \ A\ \ D\ \ B\ \ E}}$$

same pattern follows in all options A, B, C

only (d) doesn't follow this pattern , Hence odd number out (D).

End of Solution

Q.5 In a quadratic function, the value of the product of the roots (α, β) is 4. Find the value of

$$\frac{\alpha^{n}+\beta^{n}}{\alpha^{-n}+\beta^{-n}}$$

(a) n^4 (b) 4^n
(c) 2^{2n-1} (d) 4^{n-1}

Ans. **(a)**

$$\frac{\alpha^{n}+\beta^{n}}{\alpha^{-n}+\beta^{-n}} = \frac{\alpha^{n}+\beta^{n}}{\frac{1}{\alpha^{n}}+\frac{1}{\beta^{n}}} = \frac{\alpha^{n}+\beta^{n}}{\left(\frac{\beta^{n}+\alpha^{n}}{\alpha^{n}\beta^{n}}\right)} = (\alpha\beta)^{n}$$

given $\alpha \times \beta = 4$

Hence $(\alpha\beta)^{n} = 4^{n}$

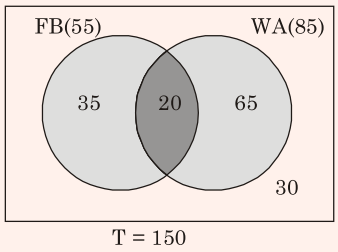
End of Solution

Two Mark Questions

Q.6 Among 150 faculty members in an institute, 55 are connected with each other through Facebook® and 85 are connected through WhatsApp®. 30 faculty members do not have Facebook® or WhatsApp® accounts. The number of faculty members connected only through Facebook® accounts is _____.

(a) 35 (b) 45
(c) 65 (d) 90

Ans. **(a)**



following venn diagram can be drawn as

$$n(A \cup B) = n(A) + n(B) - n(A \cap B)$$
$$120 = 55 + 85 - n(A \cap B)$$
$$n(A \cap B) = 20$$

so only facebook 35(A)

End of Solution

Q.7 Computers were invented for performing only high-end useful computations. However, it is no understatement that they have taken over our world today. The internet, for example, is ubiquitous. Many believe that the internet itself is an unintended consequence of the original invention. With the advent of mobile computing on our phones, a whole new dimension is now enabled. One is left wondering if all these developments are good or, more importantly, required.

Which of the statement(s) below is/are logically valid and can be inferred from the above paragraph?

(i) The author believes that computers are not good for us.

(ii) Mobile computers and the internet are both intended inventions

(a) (i) only (b) (ii) only

(c) both (i) and (ii) (d) neither (i) nor (ii)

Ans. **(d)**

End of Solution

Q.8 All hill-stations have a lake. Ooty has two lakes.
Which of the statement(s) below is/are logically valid and can be inferred from the above sentences?

(i) Ooty is not a hill-station.

(ii) No hill-station can have more than one lake.

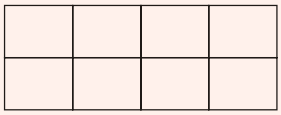
(a) (i) only (b) (ii) only

(c) both (i) and (ii) (d) neither (i) nor (ii)

Ans. **(d)**

End of Solution

Q.9 In a 2 × 4 rectangle grid shown below, each cell is a rectangle. How many rectangles can be observed in the grid?



(a) 21 (b) 27

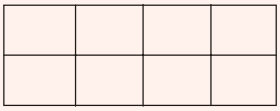
(c) 30 (d) 36

Ans. **(c)**

Number of rectangles will be

$${}^5C_2 \times {}^3C_2$$

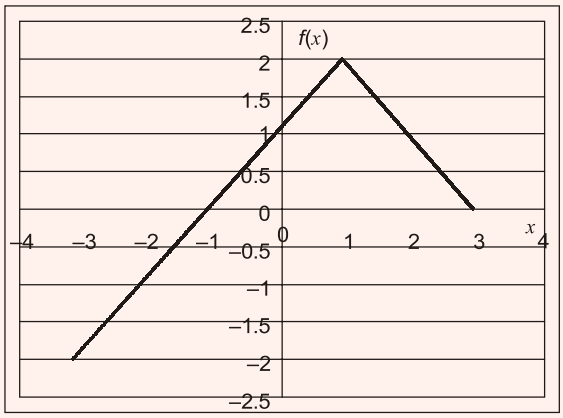
$$10 \times 3 = 30$$



As whenever any two horizontal and any two vertical lines are choosen their intersection will produce a rectangle.

End of Solution

Q.10



Choose the correct expression for $f(x)$ given in the graph.

(a) $f(x) = 1 - |x - 1|$ (b) $f(x) = 1 + |x - 1|$

(c) $f(x) = 2 - |x - 1|$ (d) $f(x) = 2 + |x - 1|$

Ans. **(c)**

End of Solution

Section - II (Electrical Engineering)

One Mark Questions

Q.1 The maximum value attained by the function $f(x) = x(x-1)(x-2)$ in the interval $[1, 2]$ is _____.

Ans. **(0)**

$$f(x) = x^3 - 3x^2 + 2x \qquad [1, 2]$$

$$f'(x) = 3x^2 - 6x + 2$$

$f'(x) = 0$ for stationary point

stationary points are $1 \pm \frac{1}{\sqrt{3}}$

only $1 + \frac{1}{\sqrt{3}}$ lies in $[1, 2]$

$$f(1) = 0$$

$$f(2) = 0$$

$$f\left(1 + \frac{1}{\sqrt{3}}\right) = -\frac{2}{3\sqrt{3}}$$

Maximum value is 0.

End of Solution

Q.2 Consider a 3 × 3 matrix with every element being equal to 1. Its only non-zero eigenvalue is _____.

Ans. **(3)**

$$A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$ Eigen value are 0, 0, 3

End of Solution

Q.3 The Laplace Transform of $f(t) = e^{2t} \sin(5t)\, u(t)$ is

(a) $\dfrac{5}{s^2 - 4s + 29}$ (b) $\dfrac{5}{s^2 + 5}$

(c) $\dfrac{s-2}{s^2 - 4s + 29}$ (d) $\dfrac{5}{s+5}$

Ans. **(a)**

Laplace transform of $\sin 5t\ u(t) \longrightarrow \dfrac{5}{s^2 + 25}$

$$e^{2t} \sin 5t\ u(t) \longrightarrow \frac{5}{(s-2)^2 + 25} = \frac{5}{s^2 - 4s + 29}$$

End of Solution

Q.4 A function $y(t)$, such that $y(0) = 1$ and $y(1) = 3e^{-1}$, is a solution of the differential equation $\dfrac{d^2y}{dt^2} + 2\dfrac{dy}{dt} + y = 0$. Then $y(2)$ is

(a) $5e^{-1}$ (b) $5e^{-2}$

(c) $7e^{-1}$ (d) $7e^{-2}$

Ans. **(b)**

Auxiliary equation

$$m^2 + 2m + 1 = 0$$
$$m = -1, -1$$
$$y = (c_1 + c_2 t)\, e^{-t}$$
$$y(0) = 1$$
$$\Rightarrow \quad c_1 = 1$$
$$y = (1 + c_2 t)e^{-t}$$
$$y(1) = 3e^{-1}$$

$$\Rightarrow \quad (1 + (c_2)e^{-3} = 3e^{-3}$$
$$c_2 = 2$$
$$y = (1 + 2t)e^{-t}$$
$$y(2) = 5e^{-2}$$

End of Solution

Q.5 The value of the integral

$$\int \frac{2z + 5}{\left(z - \frac{1}{2}\right)(z^2 - 4z + 5)} dz$$

over the contour $|z| = 1$, taken in the anti-clockwise direction, would be

(a) $\frac{24\pi i}{13}$ (b) $\frac{48\pi i}{13}$

(c) $\frac{24}{13}$ (d) $\frac{12}{13}$

Ans. (b)

Singlarilies, $Z = \frac{1}{2}, 2 \pm i$

only $Z = \frac{1}{2}$ lies inside C

By residue theorem

$$\int_C = 2\pi i\left(R_{1/2}\right) = \frac{48\pi i}{13}$$

Residue at $\frac{1}{2} = R_{1/2} = \lim_{Z \to 1/2}\left[(Z - 1/2) \cdot \frac{2Z + 5}{(Z - 1/2)(Z^2 + 4Z + 5)}\right] = \frac{24}{13}$

End of Solution

Q.6 The transfer function of a system is $\frac{Y(s)}{R(s)} = \frac{s}{s + 2}$. The steady state output $y(t)$ is $A \cos(2t + \phi)$ for the input $\cos(2t)$. The values of A and ϕ, respectively are?

(a) $\frac{1}{\sqrt{2}}, -45°$ (b) $\frac{1}{\sqrt{2}}, +45°$

(c) $\sqrt{2}, -45°$ (d) $\sqrt{2}, +45°$

Ans. (b)

$$\frac{Y(s)}{R(s)} = \frac{s}{s+2}$$

$$y(t) = A\cos(2t+\phi),\ r(t) = \cos 2t$$

$\because$ $$H(s) = \frac{s}{(s+2)}$$

$$H(j\omega) = \frac{j\omega}{j\omega+2};\ |H(j\omega)| = \frac{\omega}{\sqrt{\omega^2+4}};$$

$$\angle H(j\omega) = 90^\circ - \tan^{-1}\left(\frac{\omega}{2}\right)$$

$\because$ $$\omega = 2 \text{ (given)}$$

$$|H(j\omega)| = \frac{2}{\sqrt{4+4}} = \frac{2}{2\sqrt{2}} = \frac{1}{\sqrt{2}}$$

$$|H(j\omega)| = 90^\circ - \tan^{-1}(1) = 45^\circ$$

$\because$ Hence, $$A = 1 \times |H(j\omega)|_{\omega=2} = 1 \times \frac{1}{\sqrt{2}} = 0.707$$

and $$\phi = +45^\circ$$

End of Solution

Q.7 The phase cross-over frequency of the transfer function $G(S) = \frac{100}{(s+1)^3}$ in rad/s is

(a) $\sqrt{3}$ (b) $\frac{1}{\sqrt{3}}$

(c) 3 (d) $3\sqrt{3}$

Ans. (a)

$$G(s) = \frac{100}{(s+1)^3}$$

$$G(j\omega) = \frac{100}{(1+j\omega)} = \frac{100}{1+(j\omega)^3+3.(j\omega)^2+3j\omega}$$

$$= \frac{100}{(1-3\omega^2)+j(3\omega-\omega^3)} = \frac{100\left[(1-3\omega^2)-j\omega(3-\omega^2)^2\right]}{\left[(1-3\omega^2)+\omega^2(3-\omega^2)^2\right]}$$

For phase crossover frequency ω_{ph}

$$\text{Img}\,[G(j\omega)] = 0;$$

Hence; $$\omega(3-\omega^2) = 0 \quad \text{or, } \omega = 0; \pm\sqrt{3},$$

therefore $$\omega_{ph} = \sqrt{3} \text{ rad/sec}$$

End of Solution

Q.8 Consider a continuous-time system with input $x(t)$ and output $y(t)$ given by

$$y(t) = x(t)\cos(t)$$

This system is

(a) linear and time-invariant
(b) non-linear and time-invariant
(c) linear and time-varying
(d) non-linear and time-varying

Ans. **(c)**

$$y(t) = x(t)\cos(t)$$

To check linearity

$$y_1(t) = x_1(t)\cos(t) \quad [y_1(t) \text{ is output for } x_1(t)]$$
$$y_2(t) = x_2(t)\cos(t) \quad [y_2(t) \text{ is output for } x_2(t)]$$

so the output for $(x_1(t) + x_2(t))$ will be

$$y(t) = [x_1(t) + x_2(t)]\cos(t)$$
$$= y_1(t) + y_2(t)$$

so the system is linear
to check time invariance
The delayed output

$$y(t - t_0) = x(t - t_0)\cos(t - t_0)$$

The output for delayed input

$$y(t, t_0) = x(t - t_0)\cos(t)$$

Since $y(t - t_0) \neq y(t, t_0)$
system is time varying

End of Solution

Q.9 The value of $\int_{-\infty}^{+\infty} e^{-t}\delta(2t-2)dt$, where $\delta(t)$ is the Dirac delta function, is

(a) $\frac{1}{2e}$
(b) $\frac{2}{e}$
(c) $\frac{1}{e^2}$
(d) $\frac{1}{2e^2}$

Ans. **(a)**

To find value of $\int_{-\infty}^{\infty} e^{-t}\delta(2t-2)\,dt$

Since $\delta(2t-2) = \frac{1}{2}\delta(t-1)$

above integral can be written as

$$\int_{-\infty}^{\infty} e^{-t}\frac{1}{2}\delta(t-1)\,dt = \frac{1}{2}e^{-1} = \frac{1}{2e}$$

End of Solution

Q.10 A temperature in the range of –40°C to 55°C is to be measured with a resolution of 0.1°C. The minimum number of *ADC* bits required to get a matching dynamic range of the temperature sensor is

(a) 8 (b) 10

(c) 12 (d) 14

Ans. (b)

Temperature range of –40°C to 55°C

so total range in 95°C

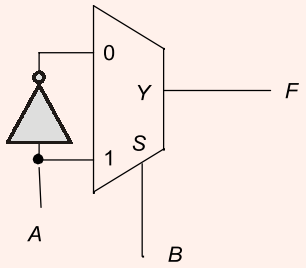
since resolution is 0.1°C

so number of steps will be 950

To have 950 steps we need at least 10 bits

End of Solution

Q.11 Consider the following circuit which uses a 2-to-1 multiplexer as shown in the figure below. The Boolean expression for output F in terms of A and B is?



(a) $A \oplus B$ (b) $\overline{A+B}$

(c) $A + B$ (d) $\overline{A \oplus B}$

Ans. (d)

In the given multiplexer

$$I_0 = \bar{A},\ I_1 = A$$

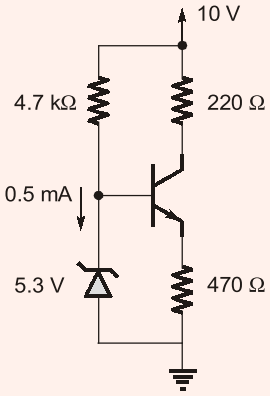
$$\text{Select} = B$$

$$F = \bar{B}I_0 + BI_1$$

$$= \bar{B}\bar{A} + AB = \overline{A \oplus B}$$

End of Solution

Q.12 A transistor circuit is given below. The Zener diode breakdown voltage is 5.3 V as shown. Take base to emitter voltage drop to be 0.6 V. The value of the current gain β is _____.



Ans. **(19)**

$V_B = 5.3\ V$

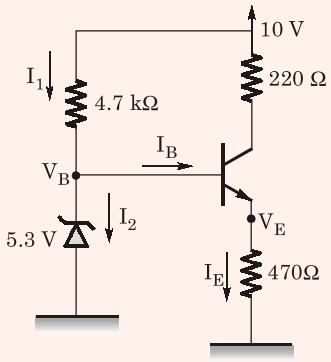
$V_E = V_B - 0.6 = 4.7\ V$

$I_E = \dfrac{V_E}{470\Omega} = 10\ mA$

$I_B = I_1 - I_2 = 0.5\ mA$

$\dfrac{I_E}{I_B} = \beta + 1 = 20$

$\beta = 19$



End of Solution

Q.13 In cylindrical coordinate system, the potential produced by a uniform ring charge is given by $\phi = f(r, z)$, where f is a continuous function of r and z. Let E be the resulting electric field. Then the magnitude of $\nabla \times E$

(a) increases with r.
(b) is 0.
(c) is 3.
(d) decreases with z.

Ans. **(b)**

V is given as static field in time invariant.

Hence $\nabla \times E = 0$

End of Solution

Q.14 A soft-iron toroid is concentric with a long straight conductor carrying a direct current I. If the relative permeability μ_r of soft-iron is 100, the ratio of the magnetic flux densities at two adjacent points located just inside and just outside the toroid, is _____.

Ans. **(100)**

Toroid has field, $B \propto \mu$

As $\mu = 100$ (inside field)

Magnetic field density B at any point at a distance at r is

$$B = \frac{\mu I}{2\pi r}$$

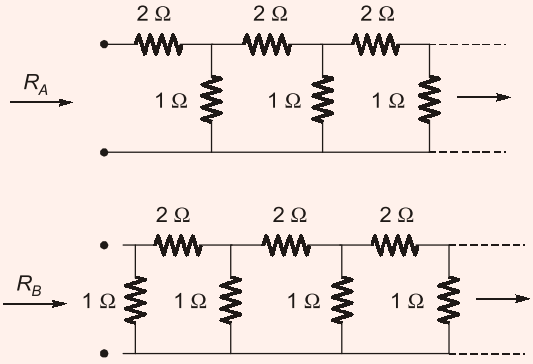
Now, $B_{\text{at } r^-} = \dfrac{\mu_0 \mu_r I}{2\pi r^-}$ (just inside toroid)

and $B_{\text{at } r^+} = \dfrac{\mu_o I}{2\pi r^+}$ (just outside toroid)

$$\frac{B_{at\,r^-}}{B_{at\,r^+}} = \mu_r = 100$$

End of Solution

Q.15 R_A and R_B are the input resistances of circuits as shown below. The circuits extend infinitely in the direction shown. Which one of the following statements is TRUE?



(a) $R_A = R_B$ (b) $R_A = R_B = 0$

(c) $R_A < R_B$ (d) $R_B = R_A/(1 + R_A)$

Ans. **(d)**

If the equivalent resistance of first figure is R_A then from the second figure , we can see that $R_B = R_A \,||\, 1\ \Omega$.

$$R_B = \frac{R_A}{R_A + 1}$$

End of Solution

Q.16 In a constant *V*/*f* induction motor drive, the slip at the maximum torque
(a) is directly proportional to the synchronous speed.
(b) remains constant with respect to the synchronous speed.
(c) has an inverse relation with the synchronous speed.
(d) has no relation with the synchronous speed.

Ans. **(c)**

$$f_0 = \text{nominal frequency}$$

$$\omega_s = \left(\frac{f}{f_0}\right)\omega_{s0} \quad ...(i)$$

$$S_{\max,T} = \left(\frac{f_0}{f}\right)\cdot\left(\frac{R_2}{X_{20}^1}\right) \quad ...(ii)$$

From (i) & (ii)

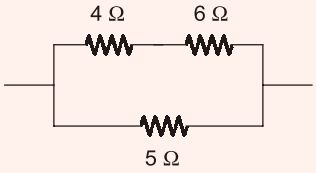
$$S_{\max,T} = \left(\frac{\omega_{s0}}{\omega_s}\right)\cdot\left(\frac{R_2}{X_{20}^1}\right)$$

$$S_{\max,T} = \left(\frac{\omega_{s0}}{\omega_s}\right)\cdot\left(\frac{R_2}{X_{20}^1}\right)$$

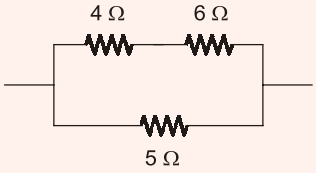
$$S_{\max,T} \propto \frac{1}{\omega_s}$$

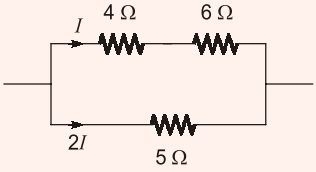
End of Solution

Q.17 In the portion of a circuit shown, if the heat generated in 5 Ω resistance is 10 calories per second, then heat generated by the 4 Ω resistance, in calories per second, is _____.



Ans. **(2)**





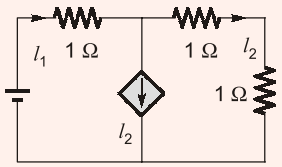
and $(2I)^2 \times 5 = 10$

$$\Rightarrow \qquad I^2 = \frac{10}{5\times 4} = \frac{2.5}{5} = 0.5$$

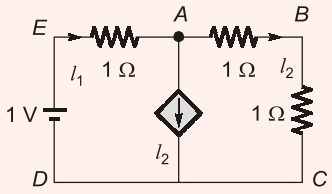
So, $\qquad I^2 \times 4 = 0.5 \times 4 = 2$ cal/sec.

End of Solution

Q.18 In the given circuit, the current supplied by the battery, in ampere, is _____.



Ans. **(0.5)**



Applying KCL at node A,

$$-I_1 + I_2 + I_2 = 0$$
$$2I_2 = I_1 \quad ...(i)$$

and applying KVL in loop ABCD,

$$1 - I_1 - I_2 - I_2 = 0$$
$$I_1 + 2I_2 = 1 \quad ...(ii)$$

From (i) and (ii)

$$\Rightarrow \qquad 2I_2 + 2I_2 = 1$$
$$\Rightarrow \qquad 4I_2 = 1$$
$$\Rightarrow \qquad I_2 = \frac{1}{4}\text{ A}$$

and $\qquad I_1 = 2\times\frac{1}{4} = \frac{1}{2}\text{ A}$

End of Solution

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Q.19 In a 100 bus power system, there are 10 generators. In a particular iteration of Newton Raphson load flow technique (in polar coordinates), two of the *PV* buses are converted to *PQ* type. In this iteration,

(a) the number of unknown voltage angles increases by two and the number of unknown voltage magnitudes increases by two.

(b) the number of unknown voltage angles remains unchanged and the number of unknown voltage magnitudes increases by two.

(c) the number of unknown voltage angles increases by two and the number of unknown voltage magnitudes decreases by two.

(d) the number of unknown voltage angles remains unchanged and the number of unknown voltage magnitudes decreases by two.

Ans. **(a)**

For load bus both $|v|$ and δ are unspecified, so both should be calcualted. So option (A) is correct.

End of Solution

Q.20 The magnitude of three-phase fault currents at buses *A* and *B* of a power system are 10 pu and 8 pu, respectively. Neglect all resistances in the system and consider the pre-fault system to be unloaded. The pre-fault voltage at all buses in the system is 1.0 pu. The voltage magnitude at bus *B* during a three-phase fault at bus *A* is 0.8 pu. The voltage magnitude at bus *A* during a three-phase fault at bus *B*, in pu, is _____?

Ans. **(0.75)**

Voltage at bus B after 3-phase fault at A = 0.8 p.u.

$$V_B = V_{(prefault)} - Z_{12} \times I_{f(B)}$$
$$0.8 = 1.0 - Z_{12} \times 8$$
$$Z_{12} = 0.025 \text{ p.u.}$$
$$V_A = 1.0 - (0.025 \times 10)$$
$$V_A = 0.75 \text{ p.u.}$$

Q.21 Consider a system consisting of a synchronous generator working at a lagging power factor, a synchronous motor working at an overexcited condition and a directly grid-connected induction generator. Consider capacitive *VAr* to be a source and inductive *VAr* to be a sink of reactive power. Which one of the following statements is TRUE?

(a) Synchronous motor and synchronous generator are sources and induction generator is a sink of reactive power.

(b) Synchronous motor and induction generator are sources and synchronous generator is a sink of reactive power.

(c) Synchronous motor is a source and induction generator and synchronous generator are sinks of reactive power.

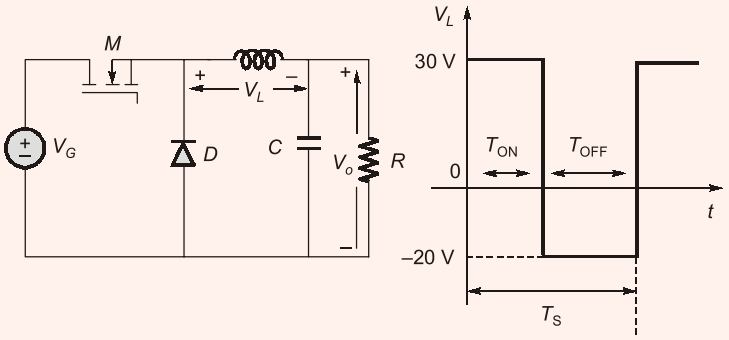
(d) All are sources of reactive power.

Ans. **(a)**

Synchronous generator working at a lagging power factor, will supply active power and lagging reactive power, so this is source.
Synchronous motor working at an overexcited condition i.e. leading p.f. operation so it will take active power and leading reactive power in other words taking active power and supplying lagging reactive power.
Indection generator generates active power but as there is no dc excitation in rotor so it takes lagging reactive power.

End of Solution

Q.22 A buck converter, as shown in Figure (a) below, is working in steady state. The output voltage and the inductor current can be assumed to be ripple free. Figure (b) shows the inductor voltage V_L during a complete switching interval. Assuming all devices are ideal, the duty cycle of the buck converter is _____.

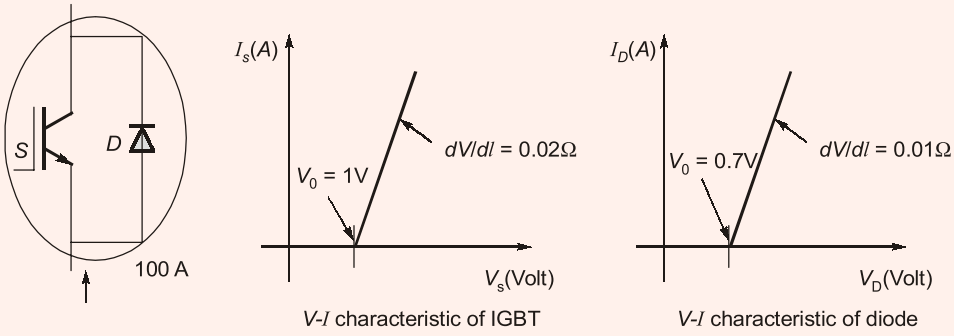


Ans. **(0.4)**

Average voltage across inductor is zero.

$$V_{L(Avg)} = 0$$
$$30\ (T_{on}) - 20\ (T_{off}) = 0$$
$$30\ (\alpha T) = 20\ (1 - \alpha)T$$
$$30\alpha + 2\alpha = 20$$
$$50\alpha = 20$$
$$\alpha = \frac{2}{5} = 0.4$$

Q.23 A steady dc current of 100 A is flowing through a power module (S, D) as shown in Figure (a). The V-I characteristics of the IGBT (S) and the diode (D) are shown in Figures (b) and (c), respectively. The conduction power loss in the power module (S, D), in watts, is _____.



(a) (b) (c)

Ans. (170)

$$I_D = \frac{1}{0.01} V_D$$

$$V_D = 0.01\ I_D + 0.7 = 1.7\ V \qquad (y = mx + c)$$

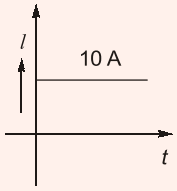
$$I_D = \frac{V_D}{0.01} - \frac{0.7}{0.01}$$

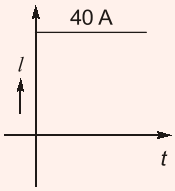
$$P = V_D\ I_D = 1.7\left(\frac{1.7}{0.01} - \frac{0.7}{0.01}\right)$$

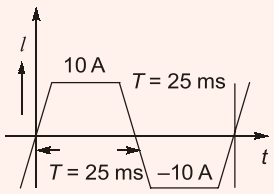
$$P = 170\ W$$

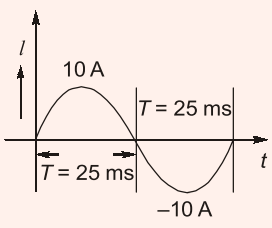
End of Solution

Q.24 A 4-pole, lap-connected, separately excited dc motor is drawing a steady current of 40 A while running at 600 rpm. A good approximation for the waveshape of the current in an armature conductor of the motor is given by

(a)


(b)


(c)


(d)


Ans. **(c)**

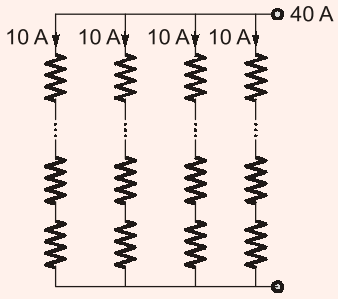
4 pole, lap - connected, separately excited dc motor, $N = 600$ rpm

$$I_{\text{total}} = 40 \text{ A}$$

Parallel path = 4 = no. of poles

Current in each parallel path = $\frac{40}{4}$ 10 A

Current in armature conductor = 10 A



$$\text{Speed} = 600 \text{ rpm}$$

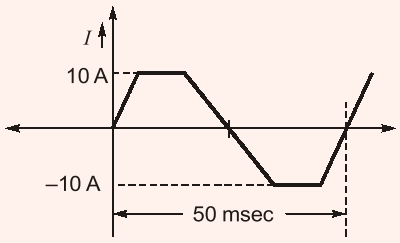
$$N = \frac{120 \times f}{4} = 600$$

$$f = \frac{600 \times 4}{120} = 20 \text{ Hz}$$

Time period, $T = \frac{1}{f} = \frac{1}{20}$

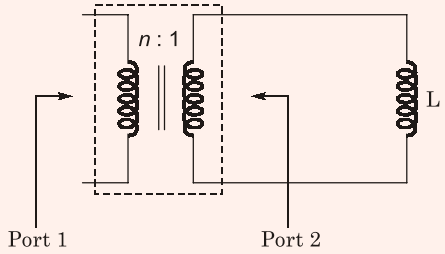
$= 50$ msec

So,



End of Solution

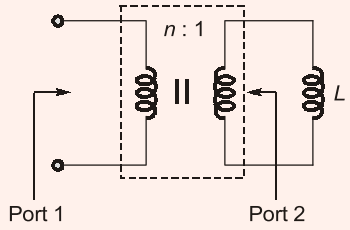
Q.25 If an ideal transformer has an inductive load element at port 2 as shown in the figure below, the equivalent inductance at port 1 is



(a) nL (b) n^2L

(c) $\frac{n}{L}$ (d) $\frac{n^2}{L}$

Ans. **(b)**



At port 1 i.e. high voltage side
impedance will be high and current will be low, So n^2L.

End of Solution

Two Marks Questions

Q.26 Candidates were asked to come to an interview with 3 pens each. Black, blue, green and red were the permitted pen colours that the candidate could bring. The probability that a candidate comes with all 3 pens having the same colour is _____.

Ans. **(0.0625)**

$$\text{Total} = \underset{4}{\square_1}\ \underset{4}{\square_2}\ \underset{4 = 64}{\square_3}$$

$f_{av} = 4$ [3 pens having same color]

prob [3 pens having same color]

$$= \frac{4}{64} = \frac{1}{16} = 0.0625$$

End of Solution