GATE 2016 Solved Paper
Electrical Engineering
Set – I

Number of Questions: 65 **Total Marks: 100.0**

Wrong answer for MCQ will result in negative marks, (–1/3) for 1 Mark Questions and (–2/3) for 2 Marks Questions.

General Aptitude

Number of Questions: 10 **Section Marks: 15.0**

Q. 1 to Q. 5 carry 1 mark each and Q. 6 to Q. 10 carry 2 marks each

Question Number: 1 **Question Type: MCQ**

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

Solution: The reference is to a particular person who worked as a security guard.

Hence, the correct option is (B).

Question Number: 2 **Question Type: MCQ**

Nobody knows how the Indian cricket team is going to <u>cope with</u> 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

Solution: To cope with something or someone is to bear with something or someone.

Hence, the correct option is (A).

Question Number: 3 **Question Type: MCQ**

Find the odd one in the following group of words. mock, deride, praise, jeer:

(A) mock (B) deride
(C) praise (D) jeer

Solution: The words mock, deride, and jeer convey the same meaning.

Hence, the correct option is (C).

Question Number: 4 **Question Type: MCQ**

Pick the odd one from the following options.

(A) CADBE (B) JHKIL
(C) XVYWZ (D) ONPMQ

Solution: The arrangement within the group is similar in options (A), (B) and (C), but different in option (D). Hence, option (D) is the odd one.

Hence, the correct option is (D).

Question Number: 5 **Question Type: MCQ**

In a quadratic function, the value of the product of the roots (α, β) is 4. Find the value of $\dfrac{\alpha^n + \beta^n}{\alpha^{-n} + \beta^{-n}}$:

(A) n^4 (B) 4^n
(C) 2^{2n-1} (D) 4^{n-1}

Solution: Let the quadratic equation be $ax^2 + bx + c = 0$. If the roots of quadratic equation are α, β

$$\therefore \quad \alpha + \beta = \frac{b}{a}$$

and $$\alpha\beta = \frac{c}{a}$$

Given $\alpha\beta = 4$

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

$$= (\alpha\beta)^n = 4^n$$

Hence, the correct option is (B).

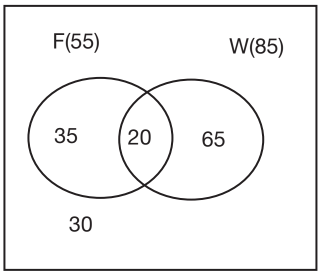
Question Number: 6 **Question Type: MCQ**

Among 150 faculty members in an institute, 55 are connected with each other through Facebook® and 85 are connected through WhatsApp®. Thirty 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

Solution: Consider the Venn diagram given below. Here F is Facebook and W is whatsApp



As 30 faculty members have neither account, 120 have accounts. As 55 have a Facebook account and 85 have a WhatsApp account.

The members who have have either account will be = 55 + 85 − 120, i.e., 20 members have both accounts. The number of faculty members who have only a Facebook account is = 55 − 20, i.e., 35.
Hence, the correct option is (A).

Question Number: 7 **Question Type: MCQ**

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)

Solution: The author is not concluding that the computers are not good. Therefore, statement (i) is not valid. As per author statement (ii) is not valid.

Hence, the correct option is (D).

Question Number: 8 **Question Type: MCQ**

All hills-stations have a lake. Ooty has two lakes.

(i) Ooty is not a hill-station.
(ii) No hill-station can have more than one lake.

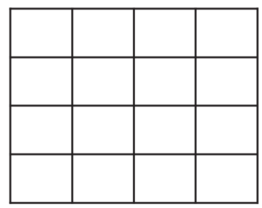
(A) (i) only (B) (ii) only
(C) both (i) and (ii) (D) neither (i) nor (ii)

Solution: Neither statement (i) nor statement (ii) is logically valid.

Hence, the correct option is (D).

Question Number: 9 **Question Type: MCQ**

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



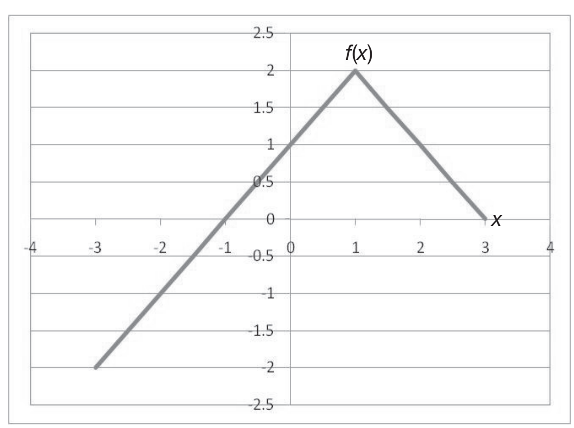
(A) 21 (B) 27
(C) 30 (D) 36

Solution: To select a rectangle from the grid, from the 5 vertical lines we have to select 2 and from the 3 horizontal lines we have to select 2. This number of ways in which this can be done is ${}^5C_2\ {}^3C_2 = 10(3)$ = 30 ways.

Hence, the correct option is (C).

Question Number: 10 **Question Type: MCQ**

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

Solution: V which opens downwards is shown in graph given above. The mod expression has to be preceded by a negative sign [we reject option (B) and (D)] at the vertex of the V, i.e., at $x = 1$, y is 2. We accept option (C) and reject option (A).

Hence, the correct option is (C).

Electrical Engineering

Number of Questions: 55 **Section Marks: 85.0**

Q. 11 to Q. 35 carry 1 mark each and Q. 36 to Q. 65 carry 2 marks each

Question Number: 11 **Question Type: NAT**

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

Solution: Function

$$f(x) = x(x - 1)(x - 2)$$

We known that $f(1) = f(2) = 0$ in [1, 2]

and $f(x) < 0$ for $1 < x < 2$

Therefore, the maximum value of $f(x)$ in interval [1, 2] is 0.

Hence, the correct Answer is (0).

Question Number: 12 **Question Type: NAT**

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

Solution: Consider 3 × 3 matrix A given below:

$$A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

The characteristic equation of A is

$$|A - \lambda| = 0$$

$$\Rightarrow \begin{vmatrix} 1-\lambda & 1 & 1 \\ 1 & 1-\lambda & 1 \\ 1 & 1 & 1-\lambda \end{vmatrix} = 0$$

$$\Rightarrow \quad -\lambda^3 + 3\lambda^2 = 0 \Rightarrow \lambda^2(\lambda - 3) = 0$$

$$\Rightarrow \quad \lambda = 0; \lambda = 0 \text{ and } \lambda = 3$$

∴ The only non zero eigen value of A is 3.

Hence, the correct Answer is (3).

Question Number: 13 **Question Type: MCQ**

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

(A) $\frac{5}{s^2 - 4s + 29}$ (B) $\frac{5}{s^2 + 2}$

(C) $\frac{s-2}{s^2 - 4s + 29}$ (D) $\frac{5}{s + 5}$

Solution: Given

$$f(t) = e^{2t} \sin(5t)\, u(t)$$

We know that

$$L[e^{2t} \sin(5t)] = \frac{5}{(s-2)^2 + 5^2}$$

Let $g(t) = e^{2t} \sin(5t)$

$$\therefore \quad L[g(t)] = L[e^{2t} \sin(5t)]$$

$$= \frac{5}{(s-2)^2 + 5^2} = \bar{g}(s)$$

From the second shifting theorem, we know that

$$L[g(t-a)\, u(t-a)] = \bar{g}(s)e^{-as}$$

Here $a = 0$

$$\therefore \quad L[f(t)] = L[e^{2t} \sin(5t)\, u(t)]$$

$$= L[g(t)\, u(t)]$$

$$= L[g(t-0)\, u(t-0)]$$

$$= \bar{g}(s)e^{-os}$$

$$= \frac{5}{(s-2)^2 + 5^2}$$

$$= \frac{5}{s^2 - 4s + 29}$$

Hence, the correct option is (A).

Question Number: 14 **Question Type: MCQ**

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

(A) $5e^{-1}$ (B) $5e^{-2}$

(C) $7e^{-1}$ (D) $7e^{-2}$

Solution: The differential equation given is

$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + y = 0 \qquad (1)$$

Also $\quad y(0) = 1$ and $y(1) = 3e^{-1} \qquad (2)$

The auxiliary equation for (1) is

$$D^2 + 2D + 1 = 0$$

$\Rightarrow \quad (D+1)^2 = 0$

$\Rightarrow \quad D = -1; -1$

The general solution of Equation (1) is

$$y = (c_1 + c_2 t)e^{-t} \qquad (3)$$

Given $\quad y(0) = 1$

$\Rightarrow \quad y = 1$ at $t = 0$

From Equation (3),

$$1 = (c_1 + c_2 \times 0)\, e^{-0}$$

$\Rightarrow \quad c_1 = 1$

Also given $\quad y(1) = 3e^{-1}$ at $y = 3e^{-1}$ at $t = 1$

From Equation (3),

$$3e^{-1} = (c_1 + c_2 \times 1)\, e^{-1}$$
$$3e^{-1} = (1 + c_2)\, e^{-1}$$
$$3e^{-1} = e^{-1} + c_2 e^{-1}$$
$$c_2 = 2$$

Substituting the values of c_1 and c_2 in Equation (3),

We get

$$y = (1 + 2t)\, e^{-t} \qquad (4)$$
$$y(2) = y_{\text{at } t=2} = (1 + 2 \times 2)\, e^{-2}$$
$$= 5e^{-2}$$

Hence, the correct option is (B).

Question Number: 15 **Question Type: MCQ**

The value of the integral

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

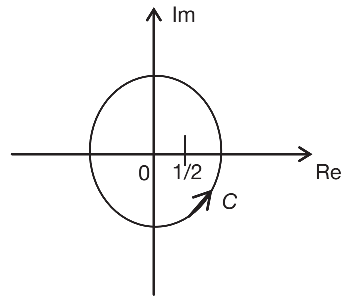
Over the contour $|z| = 1$, taken in the anti-clockwise direction, would be

(A) $\frac{24\pi i}{13}$ (B) $\frac{48\pi i}{13}$

(C) $\frac{24}{13}$ (D) $\frac{12}{13}$

Solution:

Let $\quad I = \oint_C \frac{2z+5}{\left(z - \frac{1}{2}\right)\left(z^2 - 4z + 5\right)}\, dz$



where C is $\quad |z| = 1$

Let $\quad f(z) = \frac{2z+5}{\left(z - \frac{1}{2}\right)\left(z^2 - 4z + 5\right)}$

The singularities of $f(z)$

are $\quad z = \frac{1}{2}; z = 2 \pm i$

of these, only $z = \frac{1}{2}$ lies inside C.

$$\therefore \quad I = \oint_C \frac{2z+5}{\left(z - \frac{1}{2}\right)\left(z^2 - 4z + 5\right)}\, dz$$

$$= \oint_C \frac{(2z+5)\Big/(z^2 - 4z + 5)}{\left(z - \frac{1}{2}\right)}\, dz$$

$2\pi i \cdot g(a)$, where $\; g(z) = \frac{2z+5}{z^2 - 4z + 5}$

and $\quad a = \frac{1}{2}$

(By Cauchy's Integral Formula)

$$= 2\pi i \times \frac{24}{13} = \frac{48\pi i}{13}$$

Hence, the correct option is (B).

Question Number: 16 **Question Type: MCQ**

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 f, respectively are:

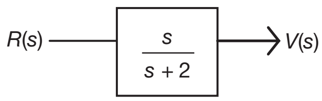
(A) $\frac{1}{\sqrt{2}}, -45°$

(B) $\frac{1}{\sqrt{2}}, +45°$

(C) $\sqrt{2}, -45°$

(D) $\sqrt{2}, +45°$

Solution:



Now we have

$$Y(t) = A\cos(2t + f)$$

and

$$A = \left|\frac{Y(s)}{R(s)}\right| = \left|\frac{s}{s+2}\right|_{\omega=2}$$

$$= \frac{2}{\sqrt{8}} = \frac{1}{\sqrt{2}}$$

and $$\phi = 90 - \tan^{-1}\left(\frac{\omega}{2}\right)\bigg|_{\omega=2} = 45°$$

Hence, the correct option is (B).

Question Number: 17 **Question Type: NAT**

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

Solution: Phase of system = –180°

$$-3\tan^{-1}(W) = -180°$$

$$W = \tan 60$$

$$= \tan 60 = \sqrt{3}$$

Hence, the correct Answer is $(\sqrt{3})$.

Question Number: 18 **Question Type: MCQ**

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

Solution:

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

$$x_1(t) = ax(t)\cos t$$

$$y_1(t) = x_1(t)\cos t$$

$$= ax_1(t)\cos t$$

$$y_1(t) = ay(t) \text{ and } x_3(t) = x_1(t)\cos t$$

$$y_3(t) = [x_1(t)\, x_2(t)]$$

$$= x_1(t)\cos t + x_2(t)\cos t$$

$$y_3(t) = y_1(t) + y_2(t)$$

Thus, the given system is Linear system $y(t) = x(t)\cos t$

$y_1(t)\, x_1(t)\cos t$

$y_2(t)\, x_2(t)\cos t$

$$x_2(t) = x_1(t - t_0)\cos t$$

$$y_2(t) = x_1(t - t_0)\cos t$$

$$y_1(t - t_0) = x_1(t - t_0)\cos(t - t_0)$$

$$y_2(t) = y_1(t - t_0)$$

Thus given system is time-variant system.

Hence, the correct option is (C).

Question Number: 19 **Question Type: MCQ**

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) $\frac{1}{2e^2}$

Solution:

$$\delta\left[a\left(t - \frac{b}{a}\right)\right] = \frac{1}{|a|}\delta(t - b/a)$$

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

$$= \frac{1}{2}\{e^{-t}\}_{t=1} = \frac{1}{2e}$$

Hence, the correct option is (A).

Question Number: 20 **Question Type: MCQ**

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

Solution: Resolution can be calculated using relation

$$R = \frac{\text{Analog output}}{\text{No. of steps}}$$

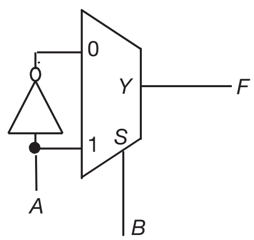
$$0.1°C = \frac{55 - (-40)}{2^n - 1}$$

$$2^n - 1 = \frac{95}{0.1}$$
$$2^n - 1 = 950$$
$$2^n = 951$$
$$n = 10$$

Hence, the correct option is (B).

Question Number: 21 **Question Type: MCQ**

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) $\overline{A \oplus B}$

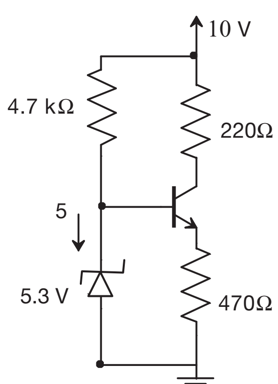
Solution: The Boolean expression for output F in terms of A and B is

$$F = \overline{S} \cdot I_0 + S \cdot I_1$$
$$= \overline{B} \cdot \overline{A} + B \cdot A$$
$$= A \odot B = \overline{A \oplus B}$$

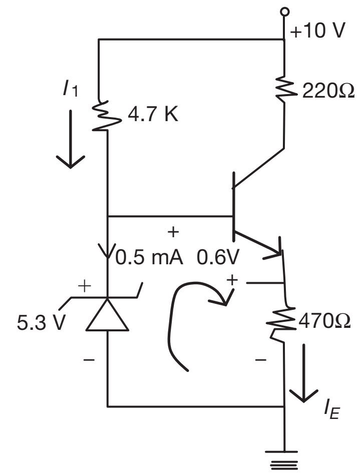
Hence, the correct option is (D).

Question Number: 22 **Question Type: NAT**

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 _________.



Solution: Consider the figure given below:



Zener diode breakdown voltage = 5.3 V

$$I_1 = \frac{10 - 5.3}{4.7K\Omega} = 1\,\text{mA}$$

The base current will be

$$I_B = I_1 - 0.5\text{ mA} = 0.5\text{ mA}$$

Base to emitter voltage drop = 0.6 V, therefore

$$5.3\text{ V} - 0.6 - 470I_E = 0$$
$$470I_E = 4.7\text{ V}$$

The emitter current can be calculates as

$$I_E = \frac{4.7}{470}\text{ A}$$
$$I_E = 10\text{ mA}$$

The current gain can be calculated using the relation

$$I_E = (1 + \beta) \cdot 0.5\text{ mA}$$
$$(1 + \beta) = 20$$
$$\beta = 19$$

Hence, the correct Answer is (18.0 to 20.0).

Question Number: 23 **Question Type: MCQ**

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

(A) increase with r (B) is 0

(C) is 3 (D) decrease with z

Solution: We know that potential Φ and the electric field $\vec{E}$ are functions of r, and z alone and they are independent of time.

Now from Maxwell's equation ∇ for static *e*-fields,

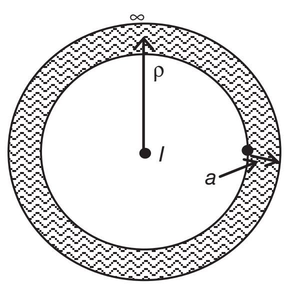
$$\nabla \times \bar{E} = 0$$

Hence, the correct option is (B).

Question Number: 24 **Question Type: NAT**

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 ________.

Solution: Consider the figure given below in which *a* is the radius of toroid.



Let *M* be the flux density, magnetic field $\bar{B}$ of a toroid which is concentric with a conductor (*N* = 1) can be calculated using

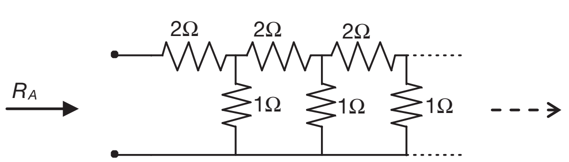
$$B = \frac{\mu NI}{2\pi\rho} \frac{B_{\text{in}}}{B_{\text{out}}}$$

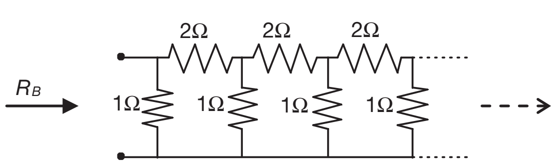
$$= \mu_r = 100$$

Hence, the correct Answer is (100).

Question Number: 25 **Question Type: MCQ**

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) $R_B = R_A/(1 + R_A)$

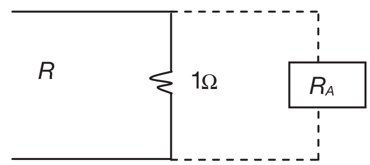
Solution:

$$R_A = \frac{R_A}{1 + R_A} + 2$$

$$R_A^2 - 2R_A - 2 = 0$$

$$R_A = 1 \pm \sqrt{3}$$

$$\therefore \quad R_A = 2.73\Omega$$



From the above figure we conclude that R_A and 1 ohm resistance are in parallel with each other and their equivalent resistance is R_B, therefore

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

Hence, the correct option is (D).

Question Number: 26 **Question Type: MCQ**

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.

Solution: At maximum to square

$$S = \frac{r_2}{X_L}$$

$$T_{\max} a \left(\frac{V}{f}\right)^2 ; T_{\max} = \left(\frac{3}{\omega_s}\right) \frac{v^2}{2x_2}$$

We know that, $\omega_s \alpha f$, $X_2 \alpha f$

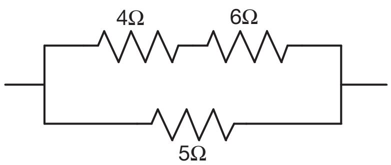
$$\Rightarrow \quad S \alpha \frac{1}{\omega_s}$$

Thus, the slip at the maximum torque has an inverse relation with the synchronous speed.

Hence, the correct option is (C).

Question Number: 27 **Question Type: NAT**

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



Solution: If I is the total current entering into the circuit

$$I_5 = I \times \frac{10}{15} = 2i/3$$

$$I_4 = I_6 = I \times \frac{5}{15} = I/3$$

We know that

$$\left(\frac{2I}{3}\right)^3 \times 5 = 10$$

$$I = 3/\sqrt{2}$$

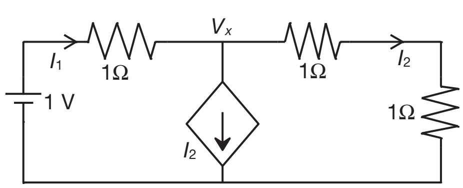
$$\text{Heat generated in } 4\Omega = \left[\frac{\left(3/\sqrt{2}\right)}{3}\right]^2 \times 4$$

$$= \frac{1}{2} \times 4 = 2 \text{ cal/sec}$$

Hence, the correct Answer is (2).

Question Number: 28 **Question Type: NAT**

In the given circuit, the current supplied by the battery, in ampere, is ________.



Solution: From the given figure in problem

$$I_2 = \frac{V_x}{2}$$

and the current supplied by the battery, in ampere can be calculated using relation given below:

$$I_1 = I_2 + I_2 = 2I_2$$

$$= 2\left[\frac{V_x}{2}\right] = V_x$$

$$1 = I_1(1) + V_x$$

$$\Rightarrow \quad 2v = 1$$

$$\Rightarrow \quad V_x = 0.5 \text{ V}$$

$$I_1 = 0.5 \text{ A}$$

Hence, the correct Answer is (0.5 A).

Question Number: 29 **Question Type: MCQ**

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.

Solution: Load buses = Total buses – Gen. buses

$$= 100 - 10$$

$$= 90$$

We know that at every load bus → $|v|$, δ must be calculated and at every gent bus → Q, δ must be calculated, i.e., at all buses, (δ) must be calculated. So, voltage phase angle calculations will not change during iteration, two of the gen. buses changes to load buses.

Total load buses = 92.

Therefore, voltage magnitude calculation will increase by two.

Hence, the correct option is (B).

Question Number: 30 **Question Type: NAT**

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 ________.

Solution: Consider the figure given below:

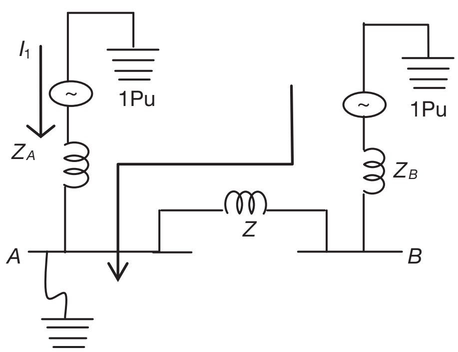


Figure 1

For fault at bus 'A'

$$10 = \frac{1}{z_A} + \frac{1}{z + z_B} \quad (1)$$

Voltage magnitude at bus B is 0.8 Pu, therefore

$$\therefore \quad I_2 = \frac{0.8}{z} = \frac{1}{z + z_B}$$

$$\Rightarrow \quad 0.8(z + z_B) = z$$

$$\Rightarrow \quad z = 4z_B \quad (2)$$

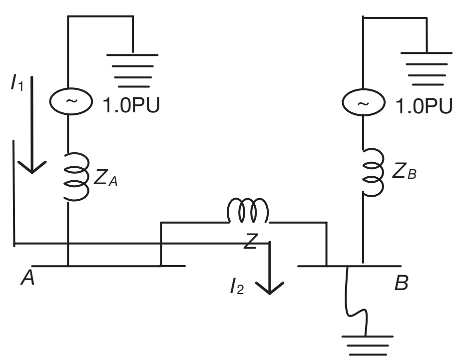


Figure 2

For fault at bus B:

$$8 = I_x + I_y$$

$$8 = \frac{1}{z_B} + \frac{1}{z + z_A} \quad (3)$$

From Equation (2)

$$8 = \frac{1}{z_B} + \frac{1}{4z_B + z_A} \quad (4)$$

$$32z_B^2 + 8z_A z_B = 5z_B + z_A$$

From Equation (1)

$$50z_A z_B + z_A$$

From Equation (3) and (4)

$$z_A = 0.76z_B$$

If bus (A) voltage is V_A

$$8 = \frac{1}{z_B} + \frac{1}{z + z_A}$$

$$= \frac{1}{z_B} + \frac{1}{4z_B + z_A}$$

$$z_B = 0.151$$

$$\Rightarrow \quad z_A = 114, z = 0.604$$

From Figure 2

$$8 = \frac{1}{z_B} + \frac{V_A}{z}$$

$$\Rightarrow \quad 8 = \frac{1}{0.151} + \frac{V_A}{0.604}$$

$$V_A = 0.832 \text{ pu}$$

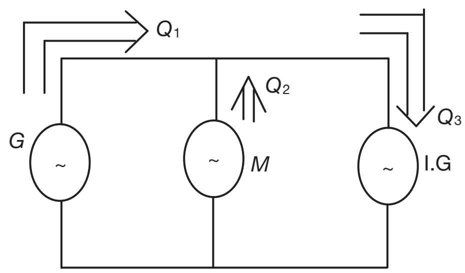
Hence, the correct Answer is (0.832).

Question Number: 31 **Question Type: MCQ**

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.

Solution:

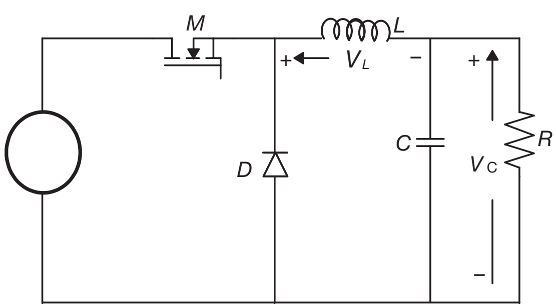


Form the figure we can observe that given synchronous generator operates at lagging *pf*, i.e., an inductive load should be connected so, machine will generate reactive power to lagging load. Synchronous motor is over excited, i.e., it is acting like a Synchronous condenser. Induction generator will absorb reactive power of the development of magnetic field.

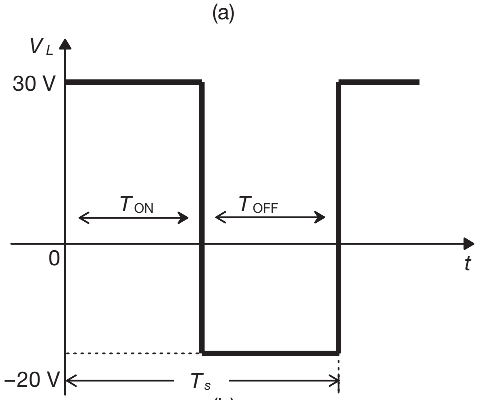
Hence, the correct option is (A).

Question Number: 32 **Question Type: NAT**

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 indicator voltage V_L during a complete switching interval. Assuming all devices are ideal, the duty cycle of the buck converter is ________.



(a)



(b)

Solution: T_{ON} period:

$$V_L = V_g - V_o = 30 \text{ V} \quad (1)$$

T_{OFF} period:

$$V_L = -V_o = -20 \text{ V} \quad (2)$$

Solving Equations (1) and (2), we get

$$V_g - 20 = 30$$

$$V_g = 30 + 20 = 50 \text{ V}$$

and

$$V_o = DV_g$$

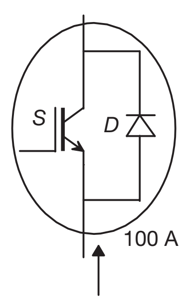
$$20 = D\,(50)$$

$$D = \frac{2}{5} = 0.4$$

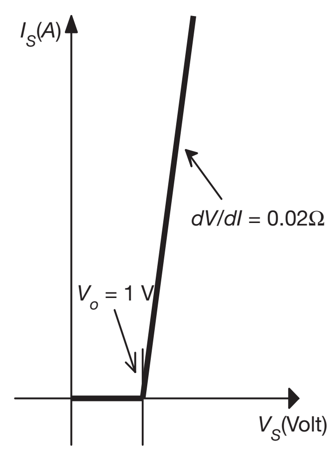
Hence, the correct Answer is (0.4).

Question Number: 33 **Question Type: NAT**

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, *y*. The conduction power loss in the power module (*S*, *D*), in watts, is ________.

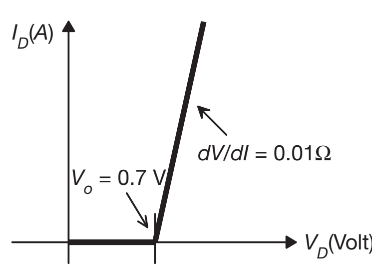


(a)



V-I characteristic of IGBT

(b)



V-I characteristic of diode

(c)

Solution: For diode to be conducting

$$\frac{dv}{dI} = 0.01$$

$$V = 0.01 \times 100 = 1 \text{ V}$$

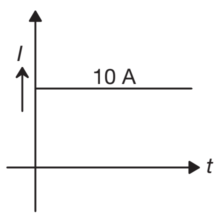
Conduction losses will be

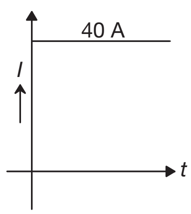
$$= 1 \times 100 + 0.7 \times 100$$
$$= 100 + 70 = 170 \text{ W}$$

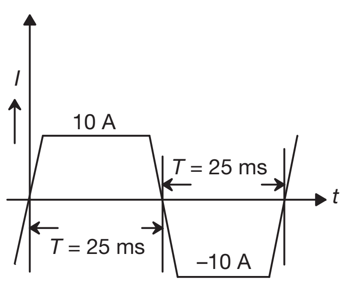
Hence, the correct Answer is (170 W).

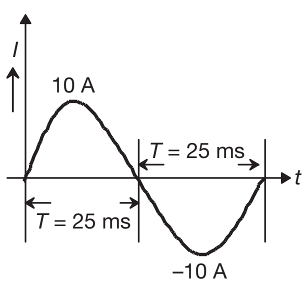
Question Number: 34 **Question Type: MCQ**

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 wave shape of the current in an armature conductor of the motor is given by:

(A)


(B)


(C)


(D)


Solution: Number of poles

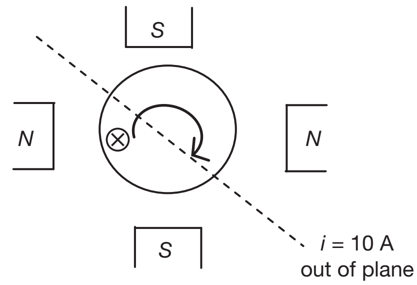
$P = 4, A = 4$

Steady current $I_a = 40$ A

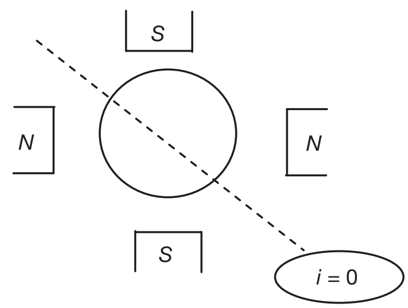
Speed $N = 600$ rpm

Now we have

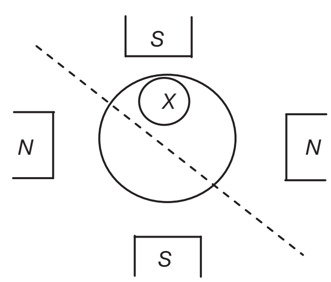
$$i = \frac{I_a}{A} = \frac{40}{4} = 10 \text{ A}$$



Case (i)



Case (ii)



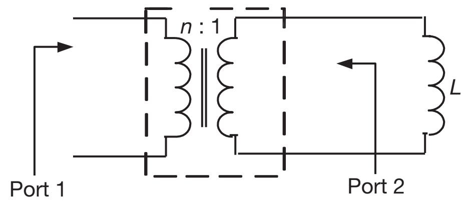
Case (iii)

$$i = 10 \text{ A}$$

Hence, the correct option is (C).

Question Number: 35 **Question Type: MCQ**

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) n/L (D) n^2/L

Solution: If the load element was shifted to primary side, the effective equivalent inductance will be

$L_{prim} = n^2L.$

Hence, the correct option is (B).

Question Number: 36 **Question Type: NAT**

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 ________.

Solution: All 3 pens are same colour = 4 ways.

Two pens are same colour and third pen different colour = 4 × 3 = 12.

All three are of different colour = $4C_3 = 4$.

∴ Total number of ways of selecting three pens from four colours pens = 4 + 12 + 4 = 20.

Favourable cases = 4.

∴ Required probability $= \frac{4}{20} = \frac{1}{5} = 0.2$

Hence, the correct Answer is (0.2).

Question Number: 37 **Question Type: NAT**

Let $S = \sum_{n=0}^{\infty} n\alpha^n$, where $|\alpha| < 1$. The value of α in the range $0 < \alpha < 1$, such that $S = 2\alpha$ is ________.

Solution:

Given $S = \sum_{n=0}^{\infty} n\alpha^n$; where $|\alpha| < 1$

Given $S = 2\alpha$

$\Rightarrow \quad \sum_{n=0}^{\infty} n\alpha^n = 2\alpha$

$\Rightarrow 1 + \alpha + 2\alpha^2 + 3\alpha^3 + ... + \infty = 2\alpha$

$\Rightarrow \quad \frac{\alpha}{(1-\alpha)^2} = 2\alpha$

(∴ $1 + \alpha + 2\alpha^2 + 3\alpha^3 + ... +\infty$ is an *AGP* with $a = 1$; $r = \alpha$ and $d = 1$)

$\Rightarrow \quad \frac{1}{(1-\alpha)^2} = 2$

$\Rightarrow \quad (1-\alpha)^2 = \frac{1}{2}$

$\Rightarrow \quad 1-\alpha = \pm\frac{1}{\sqrt{2}}$

$\Rightarrow \quad 1-\alpha = \frac{1}{\sqrt{2}}, 1-\alpha = \frac{-1}{\sqrt{2}}$

$\Rightarrow \quad \alpha = 1-\frac{1}{\sqrt{2}}, \alpha = 1+\frac{1}{\sqrt{2}}$

$\Rightarrow \quad \alpha = 1.7071; \alpha = 0.2929$

$\Rightarrow \quad \alpha = 0.2929 \quad (\because |\alpha| < 1)$

Hence, the correct Answer is (0.2929).

Question Number: 38 **Question Type: MCQ**

Let the eigenvalues of a 2 × 2 matrix A be 1, −2 with eigenvalues and eigenvectors x_1 and x_2, respectively. Then the eigenvectors of the matrix $A^2 - 3A + 4I$ would respectively be:

(A) 2, 14; x_1, x_2
(B) 2, 14; $x_1 + x_2, x_1 - x_2$
(C) 2, 0; x_1, x_2
(D) 2, 0; $x_1 + x_2, x_1 - x_2$

Solution: Given that A is a 2 × 2 matrix.

And the eigenvalues of A are 1, –2.

Let $\lambda_1 = 1$ and $\lambda_2 = 2$.

The eigenvectors of A are x_1 and x_2 corresponding to the eigenvalues $\lambda_1 = 1$ and $\lambda_2 = 2$, respectively.

∴ The eigenvalues of $A^2 - 3A + 4I$ are

$\lambda_1^2 - 3\lambda_1 + 4$ and $\lambda_2^2 - 3\lambda_2 + 4$

i.e., $1^2 - 3 \times 1 + 4$ and $(-2)^2 - 3(-2) + 4 = 2$ and 14.

Also, we know that, A and a matrix polynomial $f(A)$ will have the same eigenvectors.

$\therefore$ The eigenvalues and the corresponding eigenvectors of $A^2 - 3A + 4I$ are 2, 14, x_1 and x_2.

Hence, the correct option is (A).

Question Number: 39 **Question Type: MCQ**

Let A be a 4 × 3 real matrix with rank 2. Which one of the following statement is TRUE?

(A) Rank of A^TA is less than 2.
(B) Rank of A^TA is equal to 2.
(C) Rank of A^TA is greater than 2.
(D) Rank of A^TA can be any number between 1 and 3.

Solution: Given that A is a 4 × 3 real matrix with rank 2 i.e.,

$$\rho(A) = 2 \quad (1)$$

We know that $\rho(A) = \rho(A^T) = 2$

we have $\rho(A^TA) \le \min.[\rho(A^T), \rho(A)]$ (2)

$[\because \rho(AB) \le \min.[\rho(A), \rho(B)]$

$\therefore \quad \rho(A^TA) \le 2$ (3)

Also, A^TA is a 3 × 3 real symmetric matrix with 2 linearly independent rows/columns

$$\rho(A^TA) \ge 2 \quad (4)$$

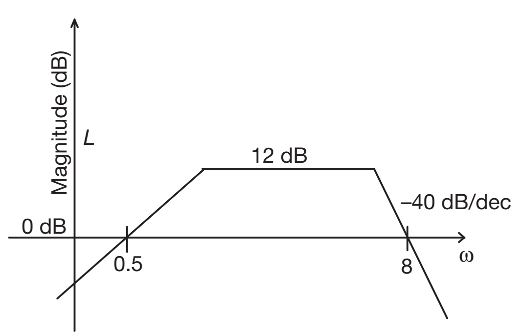
From Equations (3) and (4),

$$\rho(A^TA) = 2$$

Hence, the correct option is (B).

Question Number: 40 **Question Type: MCQ**

Consider the following asymptotic Bode magnitude plot (ω is in rad/s).



Which one of the following transfer functions is best represented by the above Bode magnitude plot?

(A) $\dfrac{2S}{(1+0.5S)(1+0.25S)^2}$

(B) $\dfrac{4(1+0.5S)}{S(1+0.25S)}$

(C) $\dfrac{2S}{(1+2S)(1+4S)}$

(D) $\dfrac{4S}{(1+2S)(1+4S)^2}$

Solution: Using graph given in problem we observe +20 dB/dec slope and 0 dB/dec and –40 dB/dec, which say that there exist '1' zero and '3' poles.

$$G(s)H(s) = \frac{KS}{(1+ST_1)(1+ST_1)^2}$$

$$|1G(s)H(s)| = 20\log k + 20\log \omega|_{\omega=0.5}$$

$$= 0 \text{ dB}$$

$$\Rightarrow \quad k = 2\frac{2S}{(1+ST_1)(1+ST_2)^2}$$

$$= G(s)H(s)$$

0 dB/dec slope occurs at ω_1 which should be greater than 0.5 and –10 dB/dec slope occurs at ω_2, which should be less than 8.

Hence, the correct option is (A).

Question Number: 41 **Question Type: NAT**

Consider the following state-space representation of a linear time-invariant system.

$x(t) = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix} x(t),\ y(t) = c^T x(t),\ c = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $x(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ the value of $y(t)$ for $t = \log_e^2$ is ________.

Solution: We know that

$$Y(s) = C(SI - A)^{-1}B + D$$

$$= \begin{bmatrix} 1 & 1 \end{bmatrix}\left[\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}\right]^{-1}\begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 1 \end{bmatrix}\begin{bmatrix} s-1 & 0 \\ 0 & s-2 \end{bmatrix}^{-1}\begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$Y(s) = \frac{1}{s-1} + \frac{1}{s-2} = e^t + e^{2t}$$

For $t = \log_e^2$,

$$Y(f) = e^{\log_e^2} + e^{2\log_e^2}$$
$$= 2 + 2^2 = 6$$

Hence, the correct Answer is (6).

Question Number: 42 Question Type: MCQ

Loop transfer function of a feedback system is $G(s)\ H(s) = \dfrac{s+3}{s^3(s-3)}$. Take the Nyquist contour in the clockwise direction. Then, the Nyquist plot of $G(s)$ $H(s)$ encircles $-1 + j0$.

(A) once in clockwise direction
(B) twice in clockwise direction
(C) once in anticlockwise direction
(D) twice in anticlockwise direction

Solution: Loop transfer function

$$G(s)\ H(s) = \frac{s+3}{s^3(s-3)}$$

RH criteria,

$$s^3 - 3s^2 + s + 3 = 0$$

s^3	1	1
s^2	–3	3
s^1	2	
s^0	3	

2 sign changes

2 poles lie right half of s – plane

No. of Encirclement $(N) = z - p$

$$= 2 - 1 = 1\ (+\text{ve})$$

Hence, one clockwise encirclement.

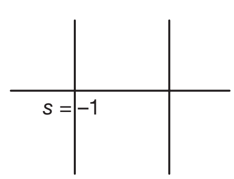
Hence, the correct option is (A).

Question Number: 43 Question Type: NAT

Given the following polynomial equation $S^3 + 5.5S^2 + 8.5S + 3 = 0$, the number of roots of the polynomial, which have real parts strictly less than –1 is ________.

Solution: Given polynomial equation is

$$S^3 + 5.5S^2 + 8.5S + 3 = 0 \qquad (1)$$



Put $(s - 1)$ in place of s in the Equation (1)

$$(s-1)^3 + 5.5\,(s-1)^2 + 8.5\,(s-1) + 3 = 0$$
$$(s-1)^2\ (s + 4.5) + 8.5s - 5.5 = 0$$
$$[s^2 + 1 - 2s]\ [s + 4.5] + 8.5s - 5.5 = 0$$
$$s^3 + 4.5s^2 + s + 4.5 - 2s^2 - 9s + 8.5s - 5.5 = 0$$
$$s^3 + 2.5s^2 + 0.5s - 1 = 0$$

As per RH criteria

s^3	1	0.5
s^2	2.5	–1
s^1	$\dfrac{1.25+1}{2.5}$	
s^0	–1	

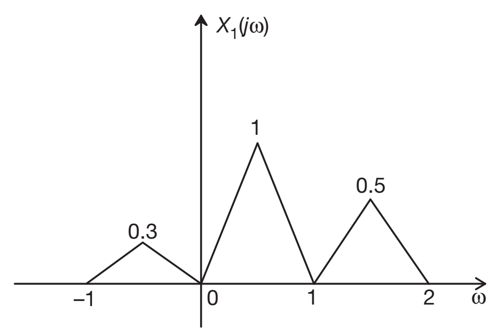
One sign change

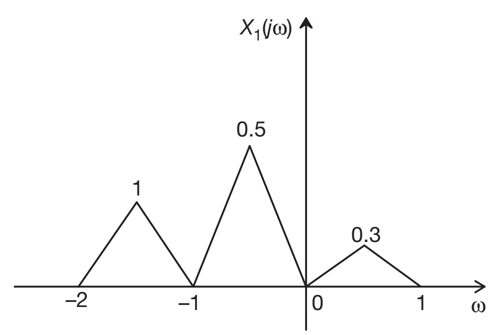
And 2 roots on left of $s = -1$

Hence, the correct Answer is (2).

Question Number: 44 Question Type: MCQ

Suppose $x_1(t)$ and $x_2(t)$ have the Fourier transforms as shown below:





Which one of the following statements is TRUE?

(A) $x_1(t)$ and $x_2(t)$ are complex and $x_1(t)\, x_2(t)$ is also complex with nonzero imaginary part.

(B) $x_1(t)$ and $x_2(t)$ are real and $x_1(t)\, x_2(t)$ is also real.

(C) $x_1(t)$ and $x_2(t)$ are complex but $x_1(t)\, x_2(t)$ is real.

(D) $x_1(t)$ and $x_2(t)$ are imaginary but $x_1(t)\, x_2(t)$ is real.

Solution: Using the figures for fourier transforms in question we get

$$x_1(j\omega) = x_1(-j\omega)$$

Hence, the correct option is (C).

Question Number: 45 **Question Type: MCQ**

The output of a continuous-time, linear time-invariant system is denoted by $T\{x(t)\}$ where $x(t)$ is the input signal. A signal $z(t)$ is called eigen-signal of the system T, when $T\{x(t)\} = xz(t)$, where $x(t)$ is a complex number, in general, and is called an eigenvalue of T. Suppose the impulse response of the system T is real and even. Which of the following statements is TRUE?

(A) cos (t) is an eigen-signal but sin (t) is not.

(B) cos (t) and sin (t) are both eigen-signals but with different eigenvalues.

(C) sin (t) is an eigen-signal but cos (t) is not.

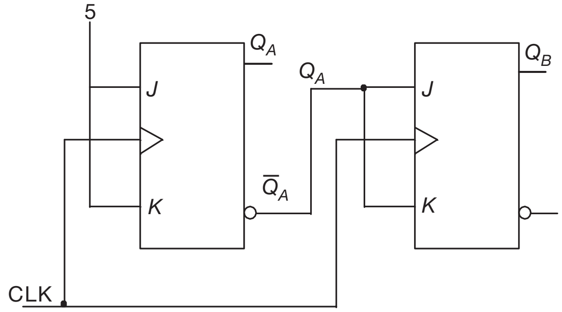
(D) cos (t) and sin (t) are both eigen-signals but with identical eigenvalues.

Solution:

Hence, the correct option is (D).

Question Number: 46 **Question Type: MCQ**

The current state $Q_A Q_B$ of a two JK flip-flop system is 00. Assume that the clock rise-time is much smaller than the delay of the JK flip-flop. The next state of the system is ________.



(A) 00 (B) 01

(C) 11 (D) 10

Solution: Consider the table given below:

CLK	J_A	K_A	J_B	K_B	Q_A	Q_B
–	1	1	–	–	0	0
1	1	1	1	1	1	1

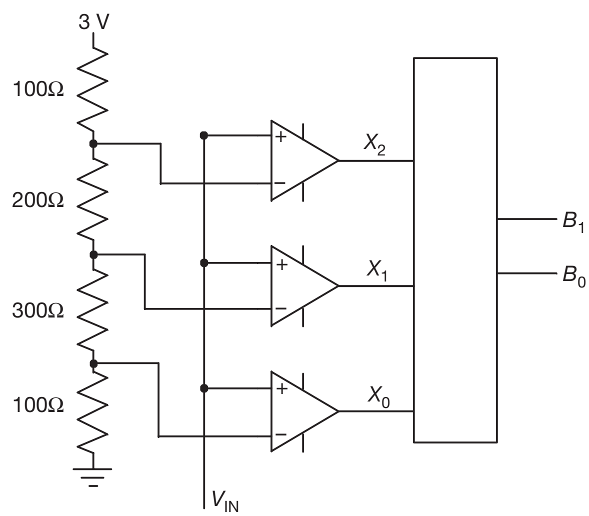
$$00 \rightarrow 11$$

$\therefore$ The next state of the $Q_A Q_B$ is 11.

Hence, the correct option is (C).

Question Number: 47 **Question Type: MCQ**

A 2-bit flash Analog to Digital Converter (ADC) is given below. The input is $0 \le V_{IN} \le 3$ Volts. The expression for the LSB of the output B_0 as a Boolean function of X_2, X_1, and X_0 is:



(A) $X_0[\overline{X_2 \oplus X_1}]$ (B) $\overline{X_0}[\overline{X_2 \oplus X_1}]$

(C) $X_0[X_2 \oplus X_1]$ (D) $\overline{X_0}[X_2 \oplus X_1]$

Solution: Consider the table given below:

X_2	X_1	X_0	B_1	B_0
0	0	0	0	0
0	0	1	0	1
0	1	1	1	0
1	1	1	1	1

$$B_0 = \overline{X_2}\,\overline{X_1}X_0 + X_2X_1X_0$$
$$B_0 = X_0(X_1 \odot X_2)$$
$$B_0 = X_0(\overline{X_2 \oplus X_1})$$

Hence, the correct option is (A).

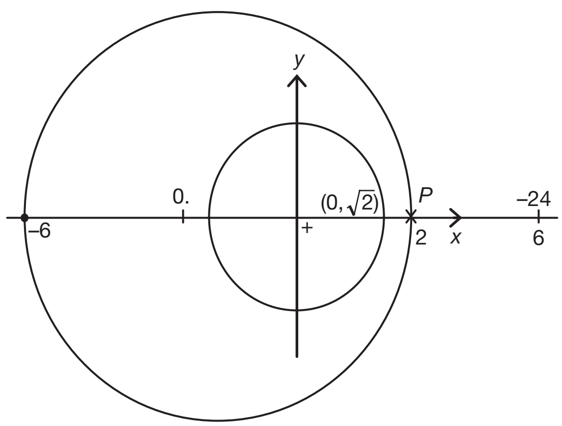
Question Number: 48 **Question Type: MCQ**

Two electric charges z and $-2z$ are placed at (0, 0) and (6, 0) on the x–y plane. The equation of the zero equipotential curve in the x–y plane is ________.

(A) $x = -2$ (B) $y = 2$

(C) $x^2 + y^2 = 2$ (D) $(x + 2)^2 + y^2 = 16$

Solution: $x = -2$ and $y = 2$, represent the planes



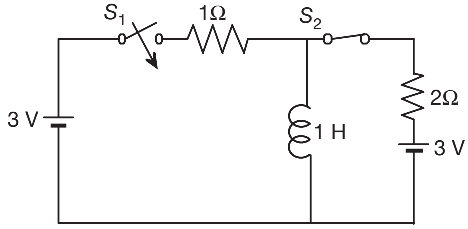
The potential at point P will be,

$$V = \frac{9\times10^9 \times 4}{2} - \frac{2g \times 9\times10^9}{4} = 0$$

Hence, the correct option is (D).

Question Number: 49 **Question Type: NAT**

In the circuit shown, switch S_2 has been closed for a long time. At time $t = 0$ switch S_1 is closed. At $t = 0^+$, the rate of change of current through the inductor, in amperes per second, is ________.



Solution: When time $t < 0$, the current across inductor will be

$$I_L = \frac{3}{2} = 1.5 \text{ A}$$

When time $t > 0$, under steady-state

$$I_{Lf} = \left(\frac{3}{1} + \frac{3}{2}\right) = 4.5 \text{ A}$$

$$I_L = 4.5 + (1.5 - 4.5)e^{-t/\left(3/2\right)}$$

$$I_{L(f)} = 4.5 - 3e^{-2t/3}$$

At $t = 0^+$, the rate of change of current through the inductor, in amperes per second

$$\left.\frac{dI_{L(t)}}{dt}\right|_{t=0} = -3\left(\frac{-2}{3}\right)e^{-2\left(t/3\right)}$$

$$= 2 \text{ A/s}$$

Hence, the correct Answer is (2).

Question Number: 50 **Question Type: NAT**

A three-phase cable is supplying 800 kW and 600 kVAr to an inductive load. It is intended to supply an additional resistive load of 100 kW through the same cable without increasing the heat dissipation in the cable, by providing a three-phase bank of capacitors connected in star across the load. Given the line voltage is 3.3 kV, 50 Hz, the capacitance per phase of the bank, expressed in microfarads, is ________.

Solution: Power

$$P = 800 \text{ kW}$$

Quality factor $Q = 600$ kVAr

Voltage $V_L = 3.3$ kV

For the given load,

$$\tan\theta = \frac{Q}{P} = 0.75$$

$\Rightarrow$ $\cos\phi = 0.8$ lag

Current flowing through cable can be calculated using relation

$$P = \sqrt{3}V_L I_L \cos\phi$$

$$I_L = \frac{800\times10^3}{\sqrt{3}\times3.3\times10^3\times0.8}$$

$$= 174.95 \text{ A}$$

Now, new load of 100 kW is added if the heating in cable should be same as before, the current should not alter $I_L = 174.95$ A.

But power $P = 900$ kW, therefore

$$P = \sqrt{3}V_L I_L \cos\phi = 900 \times 10^3$$

$$\cos\phi = \frac{900 \times 10^3}{\sqrt{3} \times 3.3 \times 10^3 \times 174.95}$$

$$= 0.90$$

The new power factor requirement is 0.9 lag

$\Rightarrow \quad \sin\phi = 0.435$

The new reactive power from supply should be

$$Q_3 = \sqrt{3} \times 3.3 \times 10^3 \times 174.95 \times 0.435$$

$$= 434.98 \text{ kVAr}$$

But load requires 600 kVAr.

So, the capacitor bank must supply

$$Q_C = 600 - 434.98$$

$$= 165 \text{ kVAr}$$

Each phase $\quad = \frac{165}{3} = 55$ kVAr

$$\frac{V_{ph}^2}{X_c} = 55 \text{ kVAr}$$

$\Rightarrow \quad X_c = 65.99$

$\Rightarrow \quad C = 48.23\ \mu$F

Hence, the correct Answer is (48.23).

Question Number: 51 Question Type: MCQ

A 30 MVA, 3-phase, 50 Hz, 13.8 kV, star-connected synchronous generator has positive, negative and zero sequence reactances, 15%, 15% and 5%, respectively. A reactance (X_n) is connected between the neutral of the generator and ground. A double line to ground fault takes place involving phases '*b*' and '*c*', with a fault impedance of *j*0.1 p.u. The value of X_n (in p.u.) that will limit the positive sequence generator current to 4270 A is ________.

Solution:

$$I_{\text{bare}} = \frac{30 \times 10^6}{\sqrt{3} * 13.8 \times 10^3}$$

$$I_{a_1} \text{ (p.u.)} = 4270 \text{ A} = 1255.1 \text{ A}$$

$$I_{a1} \text{ (p.u.)} = \frac{4270 \text{ A}}{1255} = 3.4 \text{ p.u.}$$

w.r.t. $\quad I_{a1} = \dfrac{E_f}{z_1 + \dfrac{z_2(z_0 + 3z_f + 3z_n)}{z_2 + z_0 + 3z_f + 3z_n}}$

$$z_1 + \frac{z_2(z_0 + 3z_f + 3z_n)}{z_2 + z_0 + 3z_f + 3z_n} = \frac{1.0}{3.4}$$

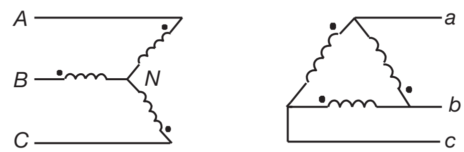
$$0.15 + \frac{(0.15)(0.05 + 0.3 + 3z_n)}{0.15 + 0.05 + 0.3 + 3z_n} = \frac{1}{3.4}$$

$\Rightarrow \quad z_n = 1.08$

Hence, the correct answer is 1.08.

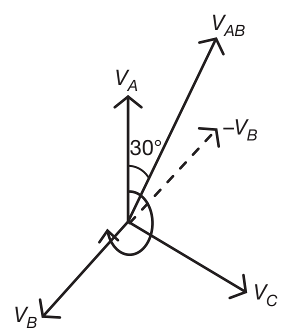
Question Number: 52 Question Type: MCQ

If the star side of the star-delta transformer shown in the figure is excited by a negative sequence voltage, then

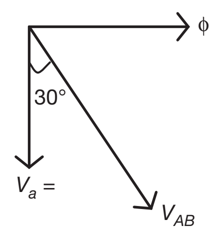


(A) V_{AB} leads V_{ab} by 60°
(B) V_{AB} lags V_{ab} by 60°
(C) V_{AB} leads V_{ab} by 30°
(D) V_{AB} lags V_{ab} by 30°

Solution: Negative sequence on primary:



n secondary side:



V_{AB} lags V_{ab} by 30°.

Hence, the correct option is (D).

Question Number: 53 **Question Type: MCQ**

A single-phase thyristor-bridge rectifier is fed from a 230 V, 50 Hz, single-phase AC mains. If it is delivering a constant DC current of 10 A, at firing angle of 30°, then value of the power factor at AC mains is:

(A) 0.87 (B) 0.9

(C) 0.78 (D) 0.45

Solution: We know that supply power factor

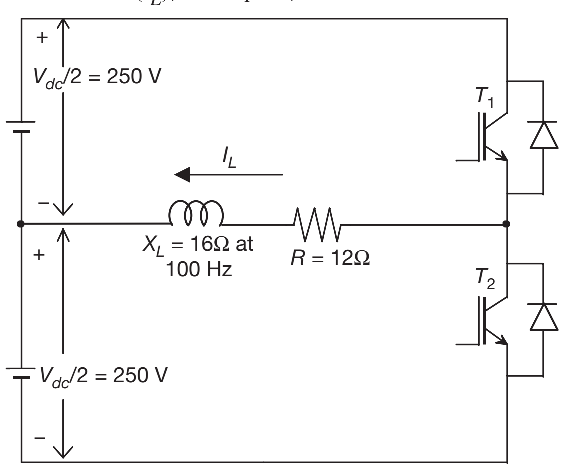
$$= (\text{Distortion factor}) \times (\cos \phi_1)$$

$$= \frac{2\sqrt{2}}{\Pi} \times \cos 30 = 0.7796 \simeq 0.78$$

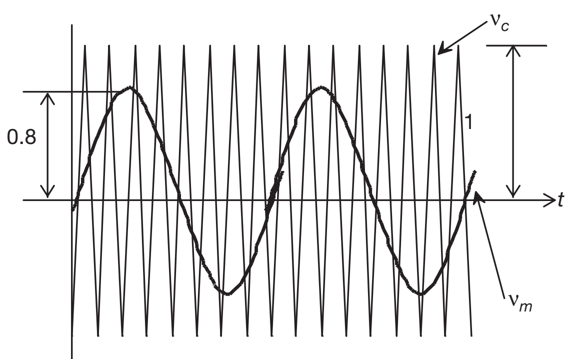
Hence, the correct option is (C).

Question Number: 54 **Question Type: NAT**

The switches T_1 and T_2 in figure (a) are switched in a complementary fashion with sinusoidal pulse width modulation technique. The modulating voltage $v_m(t) = 0.8\sin(200\pi t)$ V and the triangular carrier voltage (v_c) are as shown in figure (b). The carrier frequency is 5 kHz. The peak value of the 100 Hz component of the load current (i_L), in ampere, is ________.



(a)



(b)

Solution:

$$(V_{01})_{\max} = (M.I.)\frac{V_{dc}}{2}$$

$$= 0.8 \times 250 = 200 \text{ V}$$

At fundamental frequency, the reactance will be

$$z = \sqrt{R^2 + X^2} = \sqrt{12^2 + 16^2}$$

$$= 20\Omega$$

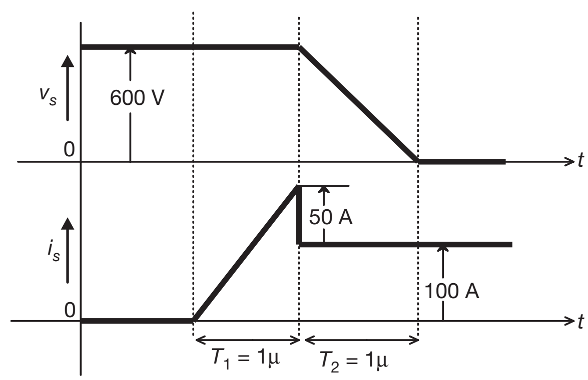
$$(I_{01})_{\max} = \frac{(V_{01})_{\max}}{|z|} = \frac{200}{20}$$

$$= 10 \text{ A}$$

Hence, the correct Answer is (10).

Question Number: 55 **Question Type: NAT**

The voltage (V_s) across and the current (I_s) through a semiconductor switch during a turn-ON transition are shown in figure. The energy sissipated during the turn-ON transition, in mJ is ________.



Solution:

$$E = \int_0^{1\mu \text{ sec}} v_1(t)i_1(t)dt + \int_0^{1\mu \text{ sec}} v_2(t)i_2(t)dt$$

$$+ \int_0^{1\mu \text{ sec}} v_2(t)i_2(t)dt$$

$$E = \frac{600 \times 150}{10^{-6}} \times \frac{10^{-12}}{2} + 600 \times 100 \times 10^{-6}$$

$$- \frac{600 \times 100}{10^{-6}} \times \frac{10^{-12}}{2}$$

$$= 45 + 60 - 30 = 75 \text{ mJ}$$

Hence, the correct Answer is (75).

Question Number: 56 **Question Type: NAT**

A single-phase 400 V, 50 Hz transformer has an iron loss of 5000 W at the rated condition. When operated at 200 V, 25 Hz, the iron loss is 2000 W. When operated at 416 V, 52 Hz, the value of the hysteretic loss divided by the eddy current loss is ________.

Solution:

$$\frac{V_1}{f_1} = \frac{400}{50} = 8$$

$$\frac{v}{f} = \text{constant}$$

$$\frac{V_2}{f_2} = \frac{200}{25} = 8$$

$$W_e \alpha f^2$$

$$W_h \alpha f$$

$$W_i = Af + Bf^2$$

$$5000 = A\,(50) + B\,(50)^2$$

$$2000 = A\,(25) + B\,(25)^2$$

$$4000 = A\,(50) + B2\,(23)^2$$

$$W_n = 60\,(52) + 0.8\,(52)$$

$$1000 = B\,(50)^2 - B2\,(25)^2$$

$$B = \frac{1000}{50^2 - 2(25)^2}$$

$$B = 0.8$$

$$A = 60$$

$$\text{Ratio} = \frac{60(52)}{(0.8)(52)^2} = 1.44$$

Hence, the correct Answer is (1.44).

Question Number: 57 **Question Type: NAT**

A DC shunt generator delivers 45 A at a terminal voltage of 220 V. The armature and the shunt field resistances are 0.01Ω and 44Ω, respectively. The stray losses are 375Ω. The percentage efficiency of the DC generator is ________.

Solution:

$$E_g = 220 + (50)\,(0.01)$$

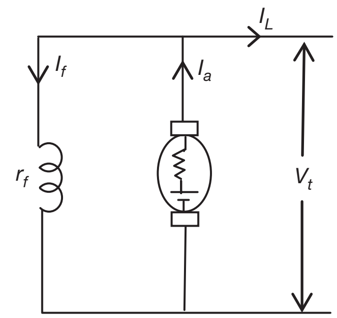
$$E_g \cdot I_a = 220.5 \times 50$$

$$= 220.5$$

$$= 11025 + 375$$

$$P_{\text{in}} = 11025 + 375 = 11400$$

$$\eta = 86.84\%$$



Hence, the correct Answer is (86.84).

Question Number: 58 **Question Type: NAT**

A three-phase, 50 Hz salient-pole synchronous motor has a per-phase direct-axis reactance (X_d) of 0.8 pu and a per-phase quadrature-axis reactance (X_q) of 0.6 pu. Resistance of the machine is negligible. It is drawing full-load current at 0.8 pf (leading). When the terminal voltage is 1 pu, per-phase induced voltage, in pu, is ________.

Solution:

$$\tan\psi = \frac{V\sin\varnothing + I_a X_a}{V\cos\varnothing}$$

$$\psi = 56.3°$$

$$\psi = \varnothing + \delta$$

$$\delta = 56.3 - 36.86 = 19.7°$$

$$E = V\cos\delta + I_d X_d$$

$$I_d = I_a \sin\varnothing = 0.831$$

$$E = (1)\cdot\cos(19.7) + (0.831)\,(0.8)$$

$$= 1.606 \text{ V}$$

Hence, the correct Answer is (1.606).

Question Number: 59 **Question Type: MCQ**

A single-phase, 22 kVA, 2200 V/220 V, 50 Hz, distribution transformer is to be connected as an auto-transformer to get an output voltage of 2420 V. Its maximum kVA rating as an auto-transformer is ________.

(A) 22 (B) 24.2
(C) 242 (D) 2420

Solution:

$$I_1 = \frac{22 \times 1000}{2200} = 10 \text{ A}$$

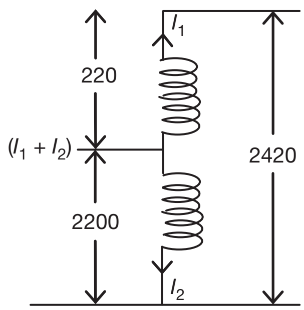
$$I_2 = \frac{22 \times 10000}{220} = 100 \text{ A}$$

An auto transformer will give maximum VA rating if it is operated with a voltage ratio near to unity.

Two connections are possible:

(1) 2200/2420 V (2) 220/2420 V

But connection (1) is suitable for maximum VA rating



$$\text{VA rating} = (2420)\,(I_2) = (2420)\,(100)$$
$$= 242 \text{ kVA}$$

Hence, the correct option is (C).

Question Number: 60 Question Type: MCQ

A single-phase full-bridge voltage source inverter (VSI) is fed from a 300 V battery. A pulse of 120° duration is used to trigger the appropriate devices in each half-cycle. The rms value of the fundamental component of the output voltage, in volts, is:

(A) 234 (B) 245
(C) 300 (D) 331

Solution: Fundamental output voltage,

$$v_{01} = \frac{4V_{dc}}{n\pi} \sin nd \times \sin \frac{n\pi}{2} \times \sin n\omega t$$

$$(v_{01})_{rms} = \frac{2\sqrt{2}V_{dc}}{\pi} \times \sin d$$

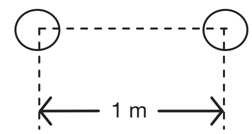
$$= \frac{2\sqrt{2} \times 300}{\pi} \times \sin 60 = 234 \text{ V}$$

Hence, the correct option is (A).

Question Number: 61 Question Type: NAT

A single-phase transmission line has two conductors each of 10 mm radius. These are fixed at a center-to-center distance of 1 m in a horizontal plane. This is now converted to a three-phase transmission line by introducing a third conductor of the same radius. This conductor is fixed at an equal distance D from the two single-phase conductors. The three-phase line is fully transposed. The positive sequence inductance per phase of the three-phase system is to be 5% more than that of the inductance per conductor of the single-phase system. The distance D, in meters, is ________.

Solution: When a 1–ph system is available:



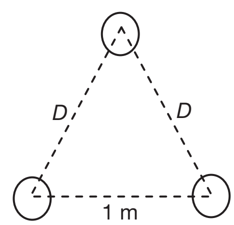
$$L_{1-ph} = 2 \times 10^{-7} \ln\left(\frac{D}{D_3}\right) \text{H/m}$$

$$D \to 1 \text{ mt}$$
$$D_s \to 0.7788r$$

$$L_{1-ph} = 2 \times 10^{-7} \ln\left(\frac{1}{0.7788 \times 10 \times 10^{-3}}\right) \text{H/m}$$

$$= 2 \times 10^{-7} \times 4.85 \text{ H/m}$$

Now a 3–ph system:



$$(1.05)\left(\cancel{2} \times \cancel{10}^{-7} \times 4.85\right)$$
$$= \cancel{2} \times \cancel{10}^{-7} \ln\left(\frac{\sqrt[3]{D_{12} \cdot D_{13} \cdot D_{23}}}{0.7788r}\right) \text{hfont}$$

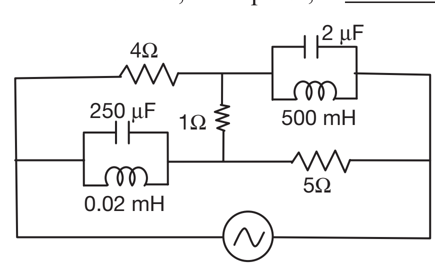
$$(1.05)\,(4.85)$$
$$= \frac{\sqrt[3]{D_{12} \cdot D_{13} \cdot D_{23}}}{0.7788r}$$

$$D = 1.42 \text{ m}$$

Hence, the correct Answer is (1.42).

Question Number: 62 Question Type: NAT

In the circuit shown below, the supply voltage is 10 sin (1000t) volts. The peak value of the steady-state current through the 1Ω resistor, in amperes, is ________.



Solution: For steady-state, for inductive and capacitive element branches impedance becomes infinity, therefore they act as open circuit

$$I = \frac{10\sin(1000t)}{4+1+5}$$

$$I = 1 \sin(1000t)$$

$$I_p = 1 \text{ Amp}$$

Hence, the correct Answer is (1).

Question Number: 63 **Question Type: NAT**

A dc voltage with ripple is given by $v(t) = [100 + 10 \sin \omega(t) - 5 \sin \{3\omega(t)\}]$ volts. Measurements of this voltage $v(t)$, made by moving-coil and moving-iron voltmeters, show readings of V_1 and V_2, respectively. The value of $V_1 - V_2$, in volts, is ________.

Solution:

Moving coil, $V_1 = 100$ V

Moving iron, $V_2 = \sqrt{100^2 + \frac{10^2}{2} + \frac{5^2}{2}}$

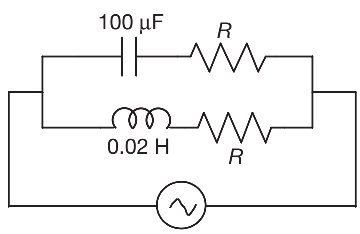
$$= 100.312 \text{ V}$$

$$V_2 - V_1 = 0.312 \text{ V}$$

Hence, the correct Answer is (0.312).

Question Number: 64 **Question Type: NAT**

The circuit below is excited by a sinusoidal source. The value of R, in Ω, for which the admittance of the circuit becomes a pure conductance at all frequencies is ________.



Solution: The impedance will be

$$z = \frac{R^2 + \frac{L}{C} + j\left(\omega RL - \frac{R}{\omega C}\right)}{2R + j\left(\omega L - \frac{1}{\omega C}\right)} y$$

$$= \frac{1}{2} = \frac{2R}{R^2 + \frac{L}{C}}$$

The resistance will be

$$\frac{1}{R} = \frac{2R}{R^2 + 200}$$

$$2R^2 = R^2 + 200$$

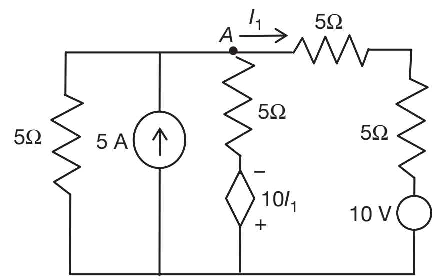
$$R^2 - 200$$

$$R = 14.14\Omega$$

Hence, the correct Answer is (14.14).

Question Number: 65 **Question Type: NAT**

In the circuit shown below, the node voltage V_A is ________V.



Solution: Applying KVL at node A, we get

$$\frac{V_A}{5} - 5 + \frac{V_A + 10I_1}{5} + \frac{V_A - 10}{10}$$

$$= 0$$

$$I_1 = \frac{V_A - 10}{10}$$

$$\frac{V_A}{5} - 5 + \frac{V_A}{5} + \frac{V_A - 10}{5} + \frac{V_A - 10}{10}$$

$$= 0$$

$$V_A = \left[\frac{1}{5} + \frac{1}{5} + \frac{1}{5} + \frac{1}{10}\right]$$

$$= 5 + 2 + 1$$

$$V_A = \frac{8}{\frac{3}{5} + \frac{1}{10}} = \frac{8}{\frac{6}{10} + \frac{1}{10}}$$

$$= \frac{80}{7} \text{ volts}$$

$$= 11.428 \text{ volts}$$

Hence, the correct Answer is (11.428).