GATE 2018 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 three roots of the equation $f(x) = 0$ are $x = \{-2, 0, 3\}$. What are the three values of x for which $f(x - 3) = 0$?

(A) –5, –3, 0 (B) –2, 0, 3
(C) 0, 6, 8 (D) 1, 3, 6

Solution: $f(x) = 0$ for $x = -2$, 0 and 3.

$\therefore \quad f(x - 3) = 0$

$\Rightarrow \quad x - 3 = -2, 0 \text{ or } 3$

$\Rightarrow \quad x = 1, 3 \text{ or } 6.$

Hence, the correct option is (D)

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

For what values of k given below is $\frac{(k+2)^2}{k-3}$ an integer?

(A) 4, 8, 18 (B) 4, 10, 16
(C) 4, 8, 28 (D) 8, 26, 28

Solution:
$$\frac{(k+2)^2}{k-3} = \frac{k^2+4k+4}{k-3}$$
$$= \frac{k^2-3k+7k-21+25}{k-3}$$
$$= k + 7 + \frac{25}{k-3}$$

$K - 3$ has to be a factor of 25.

$\therefore K - 3 = 1, 5, 25$ or $-1, -5, -25$

i.e., $K = 4, 8, 28$ or $2, -2, -22$. Among the options only 4, 8, 28 occur.

Hence, the correct option is (C)

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

Functions $F(a, b)$ and $G(a, b)$ are defined as follows:

$F(a, b) - (a - b)^2$ and $G(a, b) = |a - b|$, where $|x|$ represents the absolute value of x. What would be the value of $G(F(1, 3), G(1, 3))$?

(A) 2 (B) 4
(C) 6 (D) 36

Solution: $F(a, b) = (a - b)^2$,

$F(1, 3) = (3 - 1)^2 = 4$

$G(a, b) = |a-b|$

$G(1, 3) = 2$

$\therefore \quad G(4,2) = 2.$

Hence, the correct option is (A)

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

"Since you have gone off the _____, the _____ sand is likely to damage the car." The words that best fill the blanks in the above sentence are

(A) course, coarse (B) course, course
(C) coarse, course (D) coarse, coarse

Solution:

Hence, the correct option is (A)

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

"A common misconception among writers is that sentence structure mirrors though; the more _______ the structure, the more complicated the ideas."

(A) detailed (B) simple
(C) clear (D) convoluted

Solution:

Hence, the correct option is (D)

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

A class of twelve children has two more boys than girls. A group of three children are randomly picked from this class to accompany the teacher on a field trip. What is the probability that the group accompanying the teacher contains more girls than boys?

(A) 0 (B) $\frac{325}{864}$

(C) $\frac{525}{864}$ (D) $\frac{5}{12}$

Solution: Let the number of boys be b and number of girls be g,

As per problem

$$b = g + 2 \quad (1)$$

and also

$$b + g = 12 \quad (2)$$

Solving (1) and (2) we

$\therefore$ Number of boys $b = 7$

Number of girls $g = 5$

probability of selecting a boy $P_b = \frac{7}{12}$

probability of selecting a girl $P_g = \frac{5}{12}$

Assume that three students are selected randomly one after another with replacement. The favorable cases that the group consists girls more than boys is

(i) all are girls

(ii) Two girls and one boy

Case I:The probability that all are girls is $\frac{5}{12}.\frac{5}{12}.\frac{5}{12} = \frac{125}{1728}$

Case II:The probability that two girls and one boy in the group is $\frac{5}{12} x \frac{5}{12} x \frac{7}{12}$

$$\therefore \text{ The probability} = 3x\frac{5}{12}x\frac{5}{12}x\frac{7}{12}$$

$$= \frac{525}{1728}$$

$$\text{Required probability} = \frac{125}{1728} + \frac{525}{1728}$$

$$= \frac{650}{1728} = \frac{325}{864}$$

Hence, the correct option is (B)

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

A designer uses marbles of four different colours for his designs. The cost of each marble is the same irrespective of the colour. The table below shows the percentage of marbles of each colour used in the current design. The cost of each marble increased by 25%. Therefore, the designer decided to reduce equal number of marbles of each colour to keep the total cost unchanged. What is the percentage of blue marbles in the new design?

Blue	Black	Red	Yellow
40%	25%	20%	15%

(A) 35.75 (B) 40.25
(C) 43.75 (D) 46.25

Solution: If we assume the total number of marbles be $100n$. Then the number of blue, black, red, yellow marbles will be $40n$, $25n$, $20n$, $15n$.

The price of each marble increased by 25% (to $\frac{5}{4}$ its original value.) Therefore, the number of marbles has to reduce to $\frac{4}{5}$ so that the cost remains unchanged. It has to be $80n$, i.e., it has to reduce by $20n$. As the number reduced for all the colors are equal, the number in each color has to reduce by $5n$.

The number of blue, black, red, yellow marbles in the new design are $35n$, $20n$, $15n$, $10n$. The percentage of blue marbles in this new design is

35/35 + 20 + 15 + 10, i.e., 7/16, which is 43.75%

Hence, the correct option is (C)

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

P, Q, R and S crossed a lake in a boat that can hold a maximum of two persons, with only one set of oars. The following additional facts are available.

(i) The boat held two persons on each of the three forward trips across the lake and one person on each of the two trips.

(ii) P is unable to row when someone else is in the boat.

(iii) Q is unable to row with anyone else except R.

(iv) Each person rowed for at least one trip.

(v) Only one person can row during a trip.

Who rowed twice?

(A) P (B) Q
(C) R (D) S

Solution: On the first trip Q and R will travel, with Q rowing the boat. R will return alone and take P along with him. R will row the boat this time as P can not row when come one is with him. P alone will come back and take S along with him. S will row the boat this time. Only R rowed the boat twice.

Hence, the correct option is (C)

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

An e – mail password must contain three characters. The password has to contain one numeral from 0 to 9, one upper case and one lower case character from the English alphabet. How many distinct passwords are possible?

(A) 6,760 (B) 13,520
(C) 40,560 (D) 1,05,456

Solution:

$\therefore$ Number of passwords = 10(26) (26) (6)

= 40560.

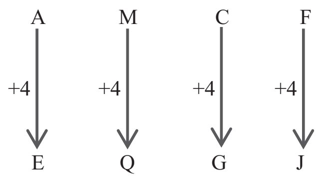
Hence, the correct option is (C)

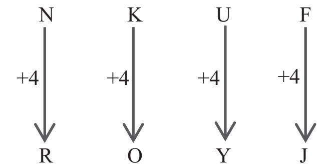
Question Number: 10 **Question Type: MCQ**

In a certain code. AMCF is written as EQGJ and NKUF is written as ROYJ. How will DHLP be written in that code?

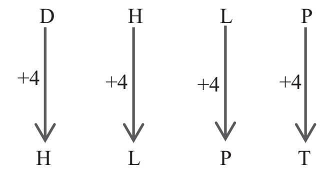
(A) RSTN (B) TLPH
(C) HLPT (D) XSVR

Solution: The code for the given words will be





So the code for the given word will be:



Hence, the correct option is (C)

Electrical Engineering

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

Q.11 to Q.25 carry 1 mark each and Q.26 to Q.65 carry 2 marks each.

Question Number: 11 **Question Type: MCQ**

A single – phase 100 kVA, 1000 V/100 V, 50 Hz transformer has a voltage drop of 5% across its series impedance at full load. Of this, 3% is due to resistance. The percentage regulation of the transformer at full load with 0.8 lagging power factor is

(A) 4.8 (B) 6.8
(C) 8.8 (D) 10.8

Solution:

$\therefore \% X = \sqrt{(\%Z)^2 - (\%R)^2} = \sqrt{5^2 - 3^2} = 4\%$

$\therefore$ % voltage regulation

$= \% R(\cos \phi_2) + \% x (\sin \phi_2)$

(for lagging P.F)

$= 3 \times 0.8 + 4 \times 0.6$

$= 4.8\%$

Hence, the correct option is (A)

Question Number: 12 **Question Type: MCQ**

In a salient pole synchronous motor, the developed reluctance torque attains the maximum value when the load angle in electrical degrees is

(A) 0 (B) 45
(C) 60 (D) 90

Solution: We know that

$$P = \frac{Ev}{X_S}\,\text{Sin}\delta + \frac{v^2}{2}\left[\frac{1}{x_q} - \frac{1}{x_d}\right]\sin(2\delta)$$

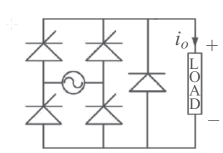
$$\therefore \quad P_{\text{reluctance}} = \frac{v^2}{2}\left[\frac{1}{x_q} - \frac{1}{x_d}\right]\sin(2\delta)$$

If $\delta = 45°$ then $P_{\text{reluctance}}$ is maximum.

Hence, the correct option is (B)

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

A single phase fully controlled rectifier is supplying a load with an anti – parallel diode as shown in the figure. All switches and diodes are ideal. Which one of the following is true for instantaneous load voltage and current?



(A) $v_0 \leq 0$ & $i_0 < 0$ (B) $v_0 <$ & $i_0 < 0$
(C) $v_0 \geq 0$ & $i_0 \geq 0$ (D) $v_0 < 0$ & $i_0 \geq 0$

Solution: No negative ripple appear in the output because the freewheeling diode is connected at output section, therefore

$$\therefore \quad V_0 \geq 0$$

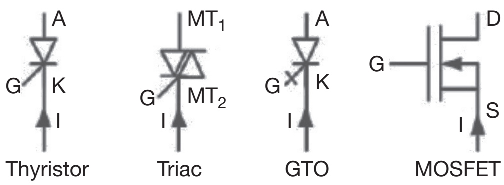
Current flows only from Anode to Cathode because the given bridge is Thyristor based bridge.

$\therefore \quad i_0 \geq 0$

Hence, the correct option is (C)

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

Four power semiconductor devices are shown in the figure along with their relevant terminals. The device(s) that can carry dc current continuously in the direction shown when gated appropriately is (are)



(A) Triac only (B) Triac and MOSFET
(C) Triac and GTO (D) Thyristor and Triac

Solution: only TRIAC allow bidirectional current flow.

Hence, the correct option is (A)

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

Two wattmeter method is used for measurement of power in a balanced three – phase load supplied from a balanced three – phase system– If one of the wattmeters reads half of the other (both positive), then the power factor of the load is

(A) 0.532 (B) 0.632
(C) 0.707 (D) 0.866

Solution: Given,

$$w_2 = w_1/2$$

power factor

$$\text{P.F} = \cos\phi$$

$$\phi = \tan^{-1}\left(\frac{\sqrt{3}(w_1 - w_2)}{w_1 + w_2}\right)$$

$$= \tan^{-1}\left(\frac{\sqrt{3}\left(w_1 - \frac{w_1}{2}\right)}{w_1 + \frac{w_1}{2}}\right)$$

$$= \tan^{-1}\left(\frac{1}{\sqrt{3}}\right) = 30°$$

$$\therefore \quad \text{P.F} = \cos 30° = 0.866$$

Hence, the correct option is (D)

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

Consider a lossy transmission line with V_1 and V_2 as the sending and receiving end voltages respectively. Z and X are the series impedance and reactance of the line respectively. The steady – state stability limit for the transmission line will be

(A) greater than $\left|\frac{V_1V_2}{X}\right|$ (B) less than $\left|\frac{V_1V_2}{X}\right|$

(C) equal to $\left|\frac{V_1V_2}{X}\right|$ (D) equal to $\left|\frac{V_1V_2}{X13.5}\right|$

Solution:

$$P_r = \left\{\frac{|V_s||V_r|}{|B|}\cos(\beta - \delta) - \frac{|A|}{|B|}|V_r|^2\cos(\beta - \alpha)\right\}\text{MW} \quad (1)$$

If Resistance of the transmission line = 0

$$\beta = 90°$$

$$P_r = \frac{|V_s||V_r|}{X}\sin\delta,$$

$$P_{r\max} = \frac{|V_s||V_r|}{X} \quad (2)$$

(1) is always less than (2).

Hence, the correct option is (B)

Question Number: 17 **Question Type: MCQ**

The graph of a network has 8 nodes and 5 independent loops. The number of branches of the graph is

(A) 11 (B) 12
(C) 13 (D) 14

Solution:

$$\ell = b - n + 1$$

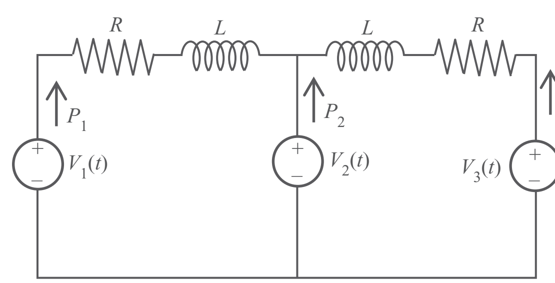
$$5 = b - 8 + 1$$

$$b = 12$$

Hence, the correct option is (B)

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

In the figure the voltages are $v_1(t) = 100\cos(\omega t)$, $v_2(t) = 100\cos(\omega t + \pi/18)$ and $v_3(t) = 100\cos(\omega t + \pi/36)$. The circuit is in sinusoidal steady state, and $P << \omega L$. P_1, P_2 and P_3 are the average power outputs. Which one of the following statement is true?



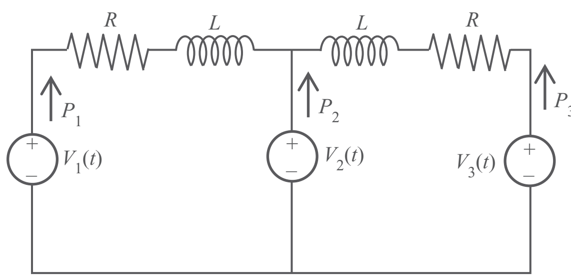
(A) $P_1 = P_2 = P_3 = 0$ (B) $P_1 < 0, P_2 > 0, P_3 > 0$
(C) $P_1 < 0, P_2 > 0, P_3 < 0$ (D) $P_1 > 0, P_2 < 0, P_3 > 0$

Solution: As we know that

$$V_1(t) = 100 \cos\omega t$$

$$V_2(t) = 100 \cos\left(\omega t + \frac{\pi}{18}\right)$$

$$V_3(t) = 100 \cos\left(\omega t + \frac{\pi}{36}\right)$$



from the given data

$$V_1 = V_m \angle 0$$

$$V_2 = V_m \angle 10°$$

$$V_3 = V_m \angle 5°$$

So V_2 leads V_1 and V_3

$$P_2 > 0, P_1 \text{ and } P_3 < 0.$$

Hence, the correct option is (C)

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

Match the transfer functions of the second – order systems with the nature of the systems given below

	Transfer function		Nature of system
P.	$\frac{15}{s^2+5s+15}$	I.	Over damped
Q.	$\frac{25}{s^2+10s+25}$	II.	Critically damped
R.	$\frac{35}{s^2+18s+35}$	III.	Under damped

(A) P – I, Q – II, R - III (B) P – II, Q – I, R – III
(C) P – III, Q – II, R – I (D) P – III, Q – I, R – II

Solution: P: $\dfrac{15}{S^2+5S+15}$

$$\xi = \frac{5}{2\sqrt{15}} = 0.2581 \rightarrow \text{underdamped system}$$

$$Q: \frac{25}{S^2+5S+25}$$

$$\xi = \frac{10}{2\sqrt{15}} = 1 \rightarrow \text{Critically damped system.}$$

$$R: \frac{35}{S^2+18S+35} = 1.521 \rightarrow \text{over damped system}$$

P – III
Q – II
R – I.

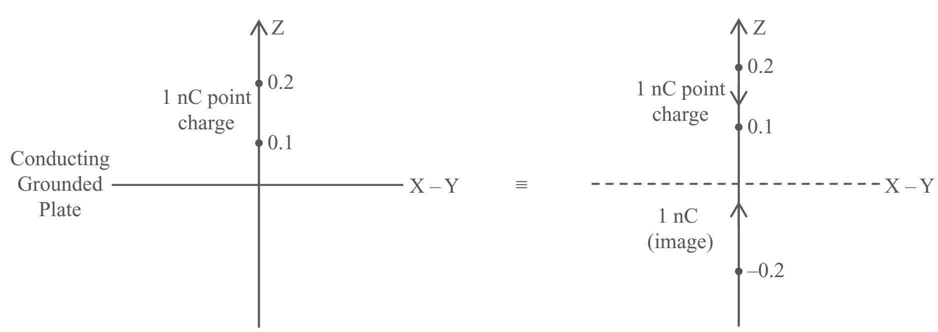
Hence, the correct option is (C)

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

A positive charge of 1 nC is placed at (0, 0, 0.2) where all dimensions are in metres. Consider the $x - y$ plane to be a conducting ground plane. Take $\in_0 = 8.85 \times 10^{-12}$ F/– The z component of the E field at (0, 0, 0.1) closest to

(A) 899.18 V/m (B) –899.18 V/m
(C) 999.09 V/m (D) –999.09 V/m

Solution:



Electric field intensity due to point charge $\bar{E} = \dfrac{Q}{4\pi \in_0 R^2}\hat{a}_R$

The Z – component of $\bar{E}$ at P(0, 0, 0.1) due to point charge (+1nC) and due to its image (–1 nC) is given by

$$\bar{E} = E_z\hat{a}_Z$$

$$= \frac{10^{-9}(-\hat{a}_Z)}{4\pi \times 8.85\times 10^{-12}\times (0.1)^2} + \frac{10^{-9}(-\hat{a}_Z)}{4\pi \times 8.85\times 10^{-12}\times (0.3)^2}$$

$E_z \approx -\,999.09$ v/m

Hence, the correct option is (D)

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

Let f be a real-valued function of a real variable defined as $f(x) = x^2$ for $x \le 0$, and $f(x) = -x^2$ for $x < 0$. Which one of the following statements is true?

(A) $f(x)$ is discontinuous at $x = 0$
(B) $f(x)$ is continuous but not differentiable at $x = 0$
(C) $f(x)$ is differentiable but its first derivative is not continuous at $x = 0$
(D) $f(x)$ is differentiable but its first derivative is not differentiable at $x = 0$

Solution: The given function is

$$f(x) = \begin{cases} x^2 & \text{for } x \ge 0 \\ -x^2 & \text{for } x < 0 \end{cases}$$

function $f(x)$ is continuous at $x = 0$

$$f'(x) = \begin{cases} 2x & \text{for } x \ge 0 \\ -2x & \text{for } x < 0 \end{cases}$$

Also at $x = 0$; LHD = RHD for $f(x)$

Therefore function $f(x)$ is differentiable at $x = 0$ as well as $f'(x)$ is continuous at $x = 0$

$$f''(x) = \begin{cases} 2 & \text{for } x \ge 0 \\ -2 & \text{for } x < 0 \end{cases}$$

At $x = 0$; $f''(0^-) \ne f''(0^+)$

so, $f'(x)$ is not differentiable at $x = 0$

Hence, the correct option is (D)

Question Number: 22 **Question Type: MCQ**

The value of the directional derivative of the function $\Phi(x, y, z) = xy^2 + yz^2 + zx^2$ at the point (2, –1, 1) in the direction of the vector $p = I + 2j + 2k$ is

(A) 1 (B) 0.84
(C) 0.93 (D) 0.9

Solution: The given function is

$$\phi(x, y, z) = xy^2 + yz^2 + zx^2$$

Gradient of the given function

$$\nabla\varphi = (y^2 + 2zx)\bar{i} + (2xy + z^2)\bar{j} + (2yz + x^2)\bar{k}$$

$$\nabla\varphi_{at(2,-1,1)} = 5\,\bar{i} - 3\,\bar{j} + 2\,\bar{k}$$

We know that $\bar{P} = \bar{i} + 2\,\bar{j} + 2\,\bar{k}$

$$\therefore \quad \hat{n} = \frac{\bar{P}}{|\bar{P}|} = \frac{\bar{i} + 2\bar{j} + 2\bar{k}}{\sqrt{1^2 + 2^2 + 2^2}}$$

$$= \frac{\bar{i} + 2\bar{j} + 2\bar{k}}{3}$$

$$\therefore \quad \hat{n} = \frac{1}{3}\bar{i} + \frac{2}{3}\bar{j} + \frac{2}{3}\bar{k}$$

directional derivative of ϕ (x, y, z) in the direction of the vector $\bar{P}$ is $\nabla\phi\cdot\hat{n}$

$$= (5\bar{i} - 3\bar{j} + 2\bar{k})\cdot\left(\frac{1}{3}\bar{i} + \frac{2}{3}\bar{j} + \frac{2}{3}\bar{k}\right)$$

$$= \frac{5}{3} - 2 + \frac{4}{3} = 1$$

Hence, the correct option is (A)

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

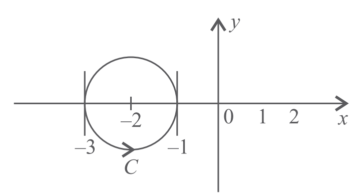
The value of the integral $\oint_C \dfrac{z+1}{z^2-4}dz$ in a counter clock-wise direction around a circle C of radius 1 with centre at the point $z = -2$ is

(A) $\dfrac{\pi i}{2}$ (B) $2\pi i$
(C) $-\dfrac{\pi i}{2}$ (D) $-2\pi i$

Solution: The given integral is

$$I = \oint_c \frac{Z+1}{Z^2-4}dZ$$

$Z = \pm\ 2$ are the singularities of $\dfrac{Z+1}{Z^2-4}$, of which $Z = -2$ lies inside C and $Z = 2$ lies outside C.



$$\therefore \quad I = \oint_c \frac{Z+1}{Z^2-4}dZ$$

$$= \oint_c \frac{\left(Z+1/Z-2\right)}{Z+2} dZ$$

$$= 2\pi i \left(\frac{Z+1}{Z-2}\right)_{at\,Z=-2}$$

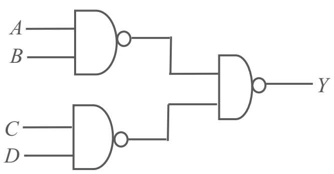
$$= 2\pi i \left(\frac{-1}{-4}\right)$$

$$= \frac{\pi i}{2}$$

Hence, the correct option is (A)

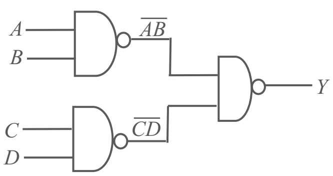
Question Number: 24 **Question Type: MCQ**

In the logic circuit shown in the figure, Y is given by



(A) $Y = ABCD$
(B) $Y = (A + B)(C + D)$
(C) $Y = A + B + C + D$
(D) $Y = AB + CD$

Solution: Consider the logic GATE given below

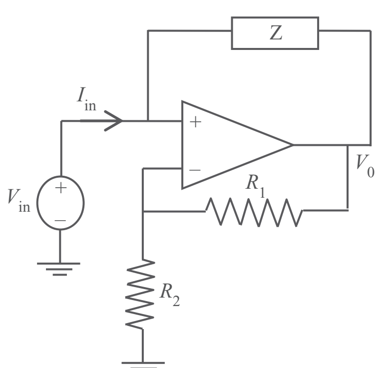


$$Y = \overline{\overline{AB} \cdot \overline{CD}} = AB + CD$$

Hence, the correct option is (D)

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

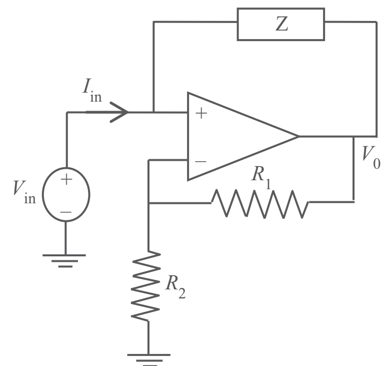
To op – amp shown in the figure is ideal. The input impedance $\frac{v_{in}}{i_{in}}$ is given by



(A) $Z\frac{R_1}{R_2}$ (B) $-Z\frac{R_2}{R_1}$

(C) Z (D) $-Z\frac{R_1}{R_1 + R_2}$

Solution: Consider the circuit given below



Input current

$$I_{in} = \frac{V_{in} - V_0}{z}$$

$$\frac{V_{out}\, R_2}{R_1 + R_2} = V_{in}$$

The output voltage will be

$$V_{out} = \frac{V_{in}(R_1 + R_2)}{R_2}$$

$$I_{in} = \frac{1}{z}\left[V_{in} - V_{in}\left(1 + \frac{R_1}{R_2}\right)\right]$$

$$I_{in} = \frac{1}{z}\left[\frac{-V_{in}\, R_1}{R_2}\right]$$

$$R_{in} = \frac{V_{in}}{I_{in}} = \frac{-z\, R_2}{R_1}$$

Hence, the correct option is (B)

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

A continuous – time input signal $x(t)$ is an eigen function of an LTI system, if the output is

(A) $kx(t)$, where k is an eigen value
(B) $ke^{j\omega t}x(t)$, where k is an eigen value and $e^{j\omega t}$ is a complex exponential signal
(C) $x(t)e^{j\omega t}$, where $e^{j\omega t}$ is a complex exponential signal.
(D) $kH(\omega)$, where k is an eigenvalue and $H(\omega)$ is a frequency response of the system

Solution:

Hence, the correct option is (A)

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

Consider a non-singular 2×2 square matrix A. If trace(A) = 4 and trace (A^2) = 5, the determinant of the matrix A is _____ (up to 1 decimal place).

Solution: Given A is a 2×2 non-singular matrix.

Let λ_1 and λ_2 be the eigen values of A.

$\Rightarrow$ λ_1^2 and λ_2^2 will be the eigen values of A^2.

Trace $(A) = 4 \Rightarrow \lambda_1 + \lambda_2 = 4$

Trace $(A^2) = 5 \Rightarrow \lambda_1^2 + \lambda_2^2 = 5$

Now $(\lambda_1 + \lambda_2)^2 = \lambda_1^2 + \lambda_2^2 + 2\lambda_1\lambda_2$

$$\Rightarrow \quad 4^2 = 5 + 2\lambda_1\lambda_2$$

$$\Rightarrow \quad \lambda_1\lambda_2 = \frac{11}{2} = 5.5$$

Hence, the correct answer is 5.5

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

Let f be a real-valued function of a real variable defined as $f(x) = x - [x]$, where $[x]$ denotes the largest integer less than or equal to x. The value of $\int_{0.25}^{1.25} f(x)\,dx$ is ______ (up to 2 decimal places).

Solution: Real-valued function is given as

$$f(x) = x - [x]$$

Integrating both sides we get

$$\int_{0.25}^{1.25} f(x)dx = \int_{0.25}^{1.25} (x - [x])dx$$

$$= \int_{0.25}^{1.25} xdx - \int_{0.25}^{1.25} [x]dx$$

$$= \left.\frac{x^2}{2}\right]_{0.25}^{1.25} - \left(\int_{0.25}^{1} 0dx + \int_{1}^{1.25} 1dx \right)$$

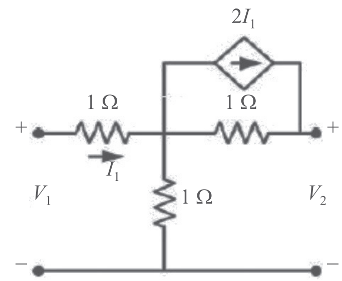
$$= \left[\frac{3}{4} - x\right]_{1}^{1.25}$$

$$= \frac{3}{4} - \frac{1}{4} = \frac{1}{2} = 0.5$$

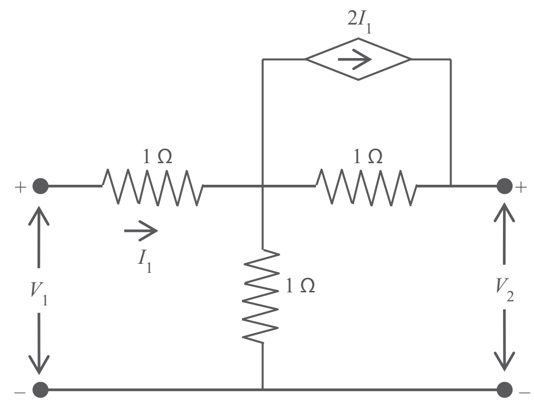
Hence, the correct answer is 0.5

Question Number: 29 **Question Type: NAT**

In the two – port network shown, the h_{11} parameter (where, $h_{11} = \frac{V_1}{I_1}$, when $V_2 = 0$) in ohms is _____ (up to 2 decimal places).



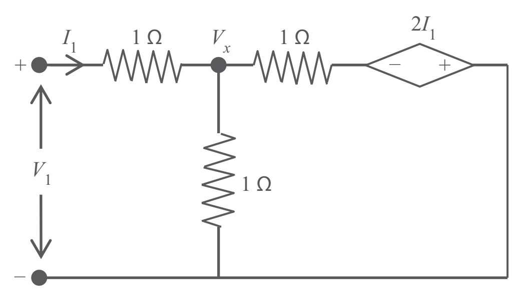
Solution: Consider the circuit diagram given below



$$h_{11} = ?$$

$$h_{11} = \frac{V_1}{I_1} \text{ at } V_2 = 0$$

Applying source transform to given network and short circuiting the second port.



$$\frac{V_X - V_1}{1} + \frac{V_X}{1} + \frac{V_X + 2I_1}{1} = 0$$

$$-I_1 + V_X + V_X + 2I_1 = 0$$

$$2V_X + I_1 = 0$$

$$V_X = -\frac{I_1}{2}$$

But

$$\frac{V_1 - V_X}{1} = I_1$$

$$V_1 + 0.5I_1 = I_1$$

$$V_1 = 0.5I_1$$

$$\frac{V_1}{I_1} = h_{11} = 0.5\,\Omega$$

Hence, the correct answer is 0.5

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

The series impedance matrix of a short three – phase transmission line in phase coordinates is $\begin{bmatrix} Z_s & Z_m & Z_m \\ Z_m & Z_s & Z_m \\ Z_m & Z_m & Z_s \end{bmatrix}$. If the positive sequence impedance is $(1 + j10)\,\Omega$, and the zero sequence is $(4 + j31)\Omega$, then the imaginary part of Z_m(in Ω) is _____ (upto 2 decimal places).

Solution:

$$Z_s - Z_m = 1 + j10$$
$$Z_s + 2Z_m = 4 + j31$$
$$2Z_s - 2Z_m = 2 + j20$$
$$Z_s + 2Z_m = 4 + j31$$
$$3Z_s = 6 + j51$$
$$Z_s = (2 + j17)\,\Omega$$
$$2 + j17 - 1 - j10 = Z_m$$
$$Z_m = j7 + 1$$

Imaginary part is 7.

Hence, the correct answer is 7 to 7.

Question Number: 31 **Question Type: NAT**

The positive, negative and zero sequence impedances of a 125 MVA, three – phase 15.5 kV, start – grounded, 50 Hz generator are $j0.1$ pu, $j0.05$ and $j0.01$ pu respectively on the machine rating base. The machine is unloaded and working at the rated terminal voltage. If the grounding impedance of the generator is $j0.01$ pu, then the magnitude of fault current for a b – phase to ground fault (in kA) is _____ (up to 2 decimal places)

Solution:

Fault current will be

$$I_f = \frac{3\,Ea1}{Z_1 + Z_2 + Z_0 + 3Z_n}\ \text{pu}$$

Base current

$$I_{base} = \frac{125}{\sqrt{3}\times 15.5}\times 10^3 = 4656.050\ (\text{A})$$

Now we have

$$I_f(\text{KA}) = I_f(\text{pu}) \times I_{base}$$

$$I_f = \frac{3\times 1\times 4656.050}{0.1+0.05+0.01+3(0.01)}$$

$$= 73.5236\ (\text{KA})$$

Hence, the correct answer is 73.5236.

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

A 1000 × 1000 bus admittance matrix for an electric power system has 8000 non – zero elements. The minimum number of branches (transmission lines and transformers) in this system are ______ (up to 2 decimal points)

Solution: Number of transmission lines

$$= \left(\frac{\text{Number of non zero off diagonal elements}}{2}\right)$$

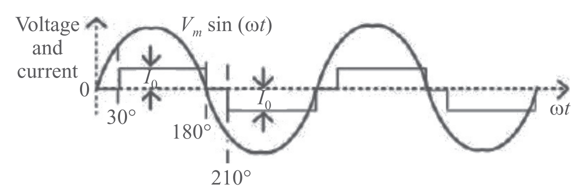
Number of non-zero off diagonal elements

$$= \frac{8000 - 1000}{2} = 3500.$$

Hence, the correct answer is 3500.

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

The waveform of the current drawn by a semi – converter from a sinusoidal AC voltage source is shown in the figure. If $I_0 = 20$A, the rms value of fundamental component of the current is _____ A (up to 2 decimal places)



Solution: From the give figure we get

$$I_{S1} = \frac{4I_s}{\pi}\cos\frac{\alpha}{2}$$

$$I_{S1r} = \frac{2\sqrt{2}x20}{\pi}\cos 15 = 17.40\,A$$

Hence, the correct answer is 17.40.

Question Number: 34 **Question Type: NAT**

A separately excited dc motor has an armature resistance R_a = 0.05 Ω The field excitation is kept constant. At an armature voltage of 100 V, the motor produces a torque of 500 Nm at zero speed. Neglecting all mechanical losses, the no – load speed of the motor (in radian/s) for an armature voltage of 150 V is _____ (up to 2 decimal places)

Solution: For separately excited d.c. motor

$$\therefore \quad v_{t_1} = E_{b_1} + I_{a_1}R_a \quad (1)$$

$$E_{b_1} = k_a\phi w_1$$

$$E_{b_1} = 0 \quad (\because\ \omega_1 = 0)$$

∴ From eqn 1,

$$\therefore \quad 100 = I_{a_1} \times 0.05$$

$$\Rightarrow \quad I_{a_1} = 2000\text{ A}$$

Under no-load condition, no-load voltage drop is very small.

$\therefore \quad E_b \cong v_t \Rightarrow v_{t_2} = E_{b_2}$

$\therefore \quad E_{b_2} = 150$ V.

$$T_{em_1} = k_a \phi I_{a1}$$

$$500 = (k_a\phi) \times 2000 \Rightarrow (k_a\phi) = \frac{1}{4} \qquad (2)$$

$$E_{b_2} = k_a\phi \cdot \omega_2 \Rightarrow \omega_2 = \frac{E_{b_2}}{K_a\phi}$$

$\therefore \quad \omega_2 = 150 \times 4 = 600$ rad/sec.

Hence, the correct answer is 600.

Question Number: 35 **Question Type: NAT**

Consider a unity feedback system with forward transfer function given by

$$G(s) = \frac{1}{(s+1)(s+2)}$$

The steady – state error in the output of the system for a unit – step input is ______ (up to 2 decimal places)

Solution: transfer function is given as

$$G(S) = \frac{1}{(S+1)(S+2)}$$

$$R(S) = \frac{1}{S}$$

Steady – state error in the output of the system for a unit – step input will be

$$e_{ss} = \frac{A}{1+K_P}$$

$$K_P = \underset{S\to 0}{Lt}\ G(S) = \frac{1}{2}$$

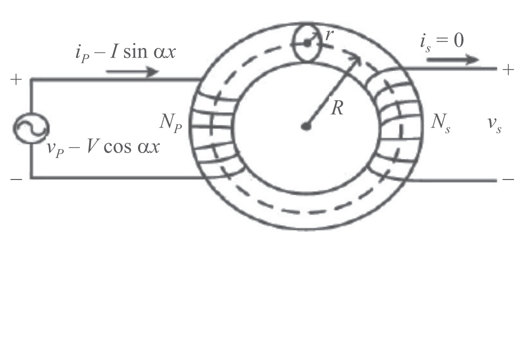
$$e_{ss} = \frac{1}{1+\frac{1}{2}} = \frac{2}{3}$$

$$= 0.6666$$

Hence, the correct answer is 0.6666.

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

A transformer with toroidal core of permeability μ is shown in the figure. Assuming uniform flux density across the circular core cross – section of radius $r << R$, and neglecting any leakage flux, the best estimate for the mean radius R is



(A) $\dfrac{\mu V r^2 N_P^2 \omega}{I}$ (B) $\dfrac{\mu I r^2 N_P N_s \omega}{V}$

(C) $\dfrac{\mu V r^2 N_P^2 \omega}{2I}$ (D) $\dfrac{\mu I r^2 N_P^2 \omega}{2V}$

Solution:

$$\text{Flux}(\phi) = \frac{\text{MMF}}{\text{Reluctance}}$$

$$\therefore \quad \text{Reluctance} = \frac{\text{MMF}}{\text{Flux}(\phi)}$$

$\therefore$ In General, EMF induced $E = N\dfrac{d\phi}{dt}$

$$\therefore \quad \phi = \frac{1}{N}\int_0^t E\,dt$$

$$\therefore \quad \phi = \frac{1}{Np}\int_0^t E\,dt$$

As per Lenz law $E = -Vp$

$$\therefore \quad \phi = \frac{1}{Np}\int_0^t -Vpdt$$

$$\therefore \quad \phi = \frac{1}{Np}\int_0^t v\cos\omega t\,dt$$

$$\Rightarrow \quad \phi = \frac{v}{\omega Np}\sin\omega t$$

$$\therefore \quad \text{Reluctance} = \frac{Np.I}{\frac{V}{\omega Np}} \qquad \because (I_P = I\sin\omega t)$$

$$\Rightarrow \quad \text{Reluctance} = \frac{Np^2.\omega I}{V}$$

Reluctance in terms of radius $\Rightarrow \dfrac{2R}{\mu r^2}$

$$\therefore \quad \frac{2R}{\mu r^2} = \frac{Np^2.\omega I}{V}$$

$$\therefore \quad R = \frac{Np^2.\omega I\ \mu r^2}{2V}$$

Hence, the correct option is (D)

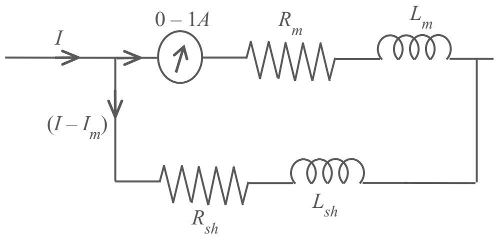
Question Number: 37 **Question Type: MCQ**

A 0-1 Ampere moving iron ammeter has an internal resistance of 50 mΩ And inductance of 0.1 mH. A shunt coil is connected to extend its range to 0-10 Ampere for all operating frequencies. The time constant in milliseconds and resistance in mΩ of the shunt coil respectively are

(A) 2, 5.55 (B) 2, 1

(C) 2.18, 0.55 (D) 11.1, 2

Solution:



We know that meter time constant should be equal to shunt coil time constant in order to make the meter independent of frequency,.

$$\tau_m = \tau_{sh} \Rightarrow \tau_{sh} = \frac{0.1}{50\times10^{-3}} = 2$$

$$\frac{L_m}{R_m} = \tau_{sh}$$

To extend meter range to 10 A,

$$I_m R_m = (I - I_m)R_{sh}$$

$$\Rightarrow \quad 1 \times 50 \times 10^{-3} = 9 \times R_{sh}$$

$$R_{sh} = 5.55$$

Hence, the correct option is (A)

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

The positive, negative and zero sequence impedances of a three phase generator are Z_1, Z_2 and Z_0 respectively. For a line – to – line fault with fault impedance Z_f, the fault current is $I_{f1} = kI_f$, where I_f is the fault current with zero fault impedance. The relation between Z_f and k is

(A) $Z_f \dfrac{(z_1 + z_{2)(1-k)}}{k}$ (B) $Z_f \dfrac{(z_1 + z_{2)(1+k)}}{k}$

(C) $Z_f \dfrac{(z_1 + z_{2)k}}{1-k}$ (D) $Z_f \dfrac{(z_1 + z_{2)k}}{1+k}$

Solution: fault current without fault impedance

$$|I_{f_1}| = \frac{\sqrt{3}\,Ea1}{Z_1 + Z_2}$$

fault current with fault impedance

$$|I_{f_1}| = \frac{\sqrt{3}\,Ea1}{Z_1 + Z_2 + Z_f}$$

$$I_{f_1} = K I_f$$

$$\frac{1}{Z_1 + Z_2 + Z_f} = \frac{K}{Z_1 + Z_2}$$

$$Z_1 + Z_2 = K\,(Z_1 + Z_2) + KZ_f$$

$$Z_1 + Z_2 - K\,(Z_1 + Z_2) = KZ_f$$

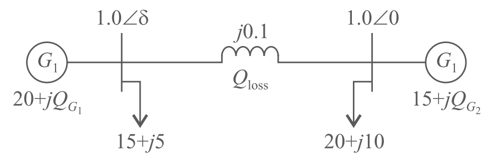
$$(Z_1 + Z_2)\,(1 - K) = Z_f K$$

$$Z_f = \left(\frac{1-K}{K}\right)(Z_1 + Z_2)$$

Hence, the correct option is (A)

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

Consider the two bus power system network with given loads as shown in the figure. All the values shown in the figure are in per unit. The reactive power supplied by generator G_1 and G_2 are Q_{G1} and Q_{G2} respectively. The per unit values of Q_{G1} and Q_{G2}, and line reactive power loss (Q_{loss}) respectively are.



(A) 5.00, 12.68, 2.68 (B) 6.34, 10.00, 1.34
(C) 6.34, 11.34, 2.68 (D) 5.00, 11.34, 1.34

Solution:

$$P_s = \frac{|V_s||V_r|}{X}\sin\delta$$

$$5 = 10\sin\delta$$

$$\delta = 30°$$

$$Q_S = \left\{\frac{|V_S|^2}{X}\sin 90° - \frac{|V_s||V_r|}{X}\cos\delta\right\}$$

$$Q_S = 10 - 10\cos 30° = 1.33974$$

$$Q_R = -1.33974$$

(Receiving end supplies)

$$Q_{Line} = Q_{Loss} = Q_S - Q_R$$

$$= 2.68 \text{ pu}$$

$$Q_{G1} = Q_{Load} + Q_S$$

$$= 6.34 \text{ pu}$$

$$Q_{G2} = 11.34 \text{ pu.}$$

Hence, the correct option is (C)

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

The pre – unit power output of a salient – pole generator which is connected to an infinite bus, is given by the expression, $P = 1.4 \sin\ \delta + 0.15 \sin 2\ \delta$, where δ is the load angle. Newton – Raphson method is used to calculate the vaue of δ for $P = 0.8$ pu. If the initial guess is 30°, then its value (in degree) at the end of the first iteration is

(A) 15° (B) 27.48°
(C) 28.74° (D) 31.20°

Solution: $P = 1.4 \sin\delta + 0.15 \sin 2\delta$

$$\delta_o = 30°$$

$$\frac{\partial P}{\partial \delta} = 1.4\cos\delta + 0.30\cos 2\delta$$

$$\begin{bmatrix}\Delta P \\ \Delta Q\end{bmatrix} = \begin{bmatrix}J_1 & J_2 \\ J_3 & J_4\end{bmatrix}\begin{bmatrix}\Delta \delta \\ \Delta |V|\end{bmatrix}$$

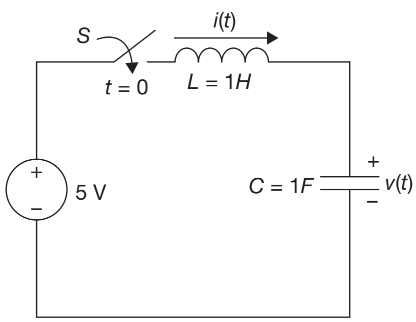
$$\Delta P = J_1\,\Delta\delta$$

$$\Delta\delta = [J_1]^{-1}\,\Delta P$$

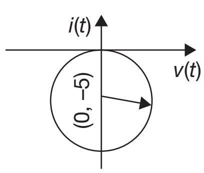
$$\delta = \delta_o - \Delta\delta = 28.79°$$

Question Number: 41 **Question Type: MCQ**

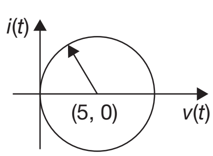
A DC voltage source is connected to a series L – C circuit by turning on the switch S at time $t = 0$ as shown in the figure. Assume $i(0) = 0$, $v(0) = 0$. Which one of the following circular loci represents the plot of $i(t)$ versus $v(t)$?



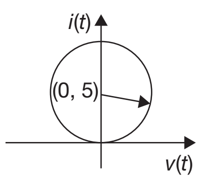
(A)



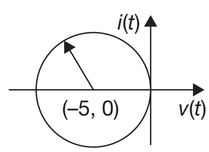
(B)



(C)

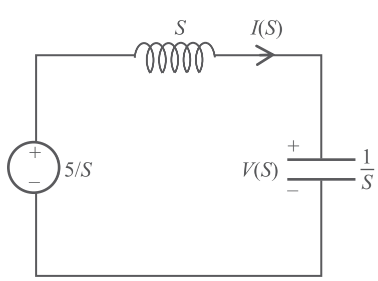


(D)



Solution: As per problem $i(0) = 0$, $V(0) = 0$

Redrawing the circuit in S domain



$$I(S) = \frac{\frac{5}{S}}{S + \frac{1}{S}} = \frac{5}{S^2 + 1}$$

$$i(t) = 5\sin t \text{ Amp} \qquad \text{(i)}$$

$$V_c(t) = \frac{1}{C}\int_0^t i\,dt = \int_0^t 5\sin t\,dt$$

$$V_c(t) = 5[1 - \cos t]V \qquad \text{(ii)}$$

From (i) and (ii)

$$i^2(t) + (V_c(t) - 5)^2 = (5\sin t)^2 + (-5\cos t)^2$$

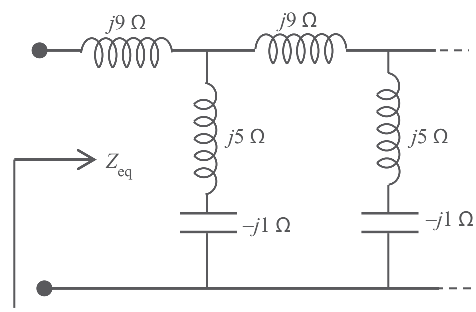
$$(V_c(t) - 5)^2 + i^2(t) = 5^2$$

It representing a circle with centre (5,0) and $r = 5$.

Hence, the correct option is (B)

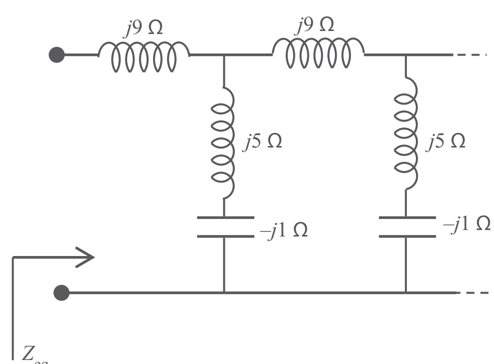
Question Number: 42 **Question Type: MCQ**

The equivalent impedance Z_{eq} for the infinite ladder circuit shown in the figure is



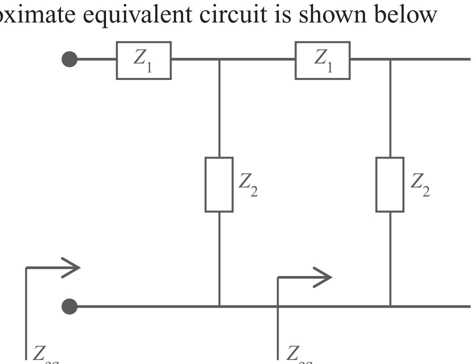
(A) $j12\Omega$ (B) $-j12\Omega$
(C) $j13\Omega$ (D) $13\ \Omega$

Solution: infinite ladder circuit is shown below



Assume $Z_1 = j9\Omega$ and $Z_2 = j5 - j1 = j4\Omega$

Approximate equivalent circuit is shown below



$$Z_{eq} = Z_1 + \{Z_2 \| Z_{eq}\}$$

$$Z_{eq} = Z_1 + \frac{Z_2 \cdot Z_{eq}}{Z_2 + Z_{eq}}$$

$$Z_{eq}\{Z_2 + Z_{eq}\} = Z_1Z_2 + Z_1Z_{eq} + Z_2Z_{eq}$$

sub $Z_1 = j9\Omega$ and $Z_2 = j4\Omega$

$$Z_{eq}^2 + j4Z_{eq} = -36 + j9\,Z_{eq} + j4Z_{eq}$$

$$Z_{eq}^2 - j9Z_{eq} + 36 = 0$$

from the given options

$$Z_{eq} = j12\Omega$$

Hence, the correct option is (A)

Question Number: 43 **Question Type: MCQ**

Consider a system governed by the following equation

$$\frac{dx_1(t)}{dt} = x_2(t) - x_1(t)$$

$$\frac{dx_2(t)}{dt} = x_1(t) - x_2(t)$$

The initial conditions are such that $x_1(0) < x_2(0) < \infty$. Let $x_{1f} = \lim_{t\to\infty} x_1(t)$ and $x_{2f} = \lim_{t\to\infty} x_2(t)$. Which one of the following is true?

(A) $x_{1f} < x_{2f} < \infty$ (B) $x_{2f} < x_{1f} < \infty$
(C) $x_{1f} = x_{2f} < \infty$ (D) $x_{1f} = x_{2f} = \infty$

Solution:

$$\frac{dx_1(t)}{dt} = x_2(t) - x_1(t) \quad (1)$$

$$\frac{dx_2(t)}{dt} = x_1(t) - x_2(t) \quad (2)$$

Applying laplace transform to both

$$Sx_1(s) - x_1(0) = x_2(s) - x_1(s) \quad (3)$$

$$Sx_2(s) - x_2(0) = x_1(s) - x_2(s) \quad (4)$$

Where $x_1(0)$ and $x_2(0)$ are initial conditions

from (4) $x_2(s) = \frac{x_1(s)}{s+1} + \frac{x_2(0)}{s+1}$ (5)

substituting (5) in (3)

$$x_1(s)\left[s+1-\frac{1}{s+1}\right] = \frac{x_2(0)}{s+1} + x_1(0)$$

$$x_1(s) = \left[\frac{1}{s(s+2)}\right]x_2(0) + \frac{(s+1)}{s(s+2)}x_1(0)$$

$$x_1(s) = \left[\frac{1}{2s} - \frac{1}{2(s+2)}\right]x_2(0) + \left[\frac{1}{2s} + \frac{1}{2(s+2)}\right]x_1(0)$$

$$x_1(t) = (0.5 + 0.5e^{-2t})x_1(0) + (0.5 - 0.5e^{-2t})x_2(0)$$

Similarly,

$$x_{1f} = \underset{t\to\infty}{Lt}\, x_1(t) = 0.5x_1(0) + 0.5x_2(0)$$

$$x_{2f} = \underset{t\to\infty}{Lt}\, x_2(t) = 0.5x_1(0) + 0.5x_2(0)$$

Here x_{1f} and x_{2f} are equal and as per the given data $x_1(0) < x_2(0) < \infty$, means

$$x_{1f} = x_{2f} < \infty$$

Hence, the correct option is (C)

Question Number: 44 **Question Type: MCQ**

The number of roots of the polynomial. $s^7 + s^6 + 7s^5 + 14s^4 + 31\,s^3 + 73s^2 + 25s + 200$, in the open left half of the complex plane is

(A) 3 (B) 4
(C) 5 (D) 6

Solution:

C. E $= S^7 + 3^6 + 7S^5 + 14S^4 + 31S^3 + 73S^2 + 25S + 200 = 0$

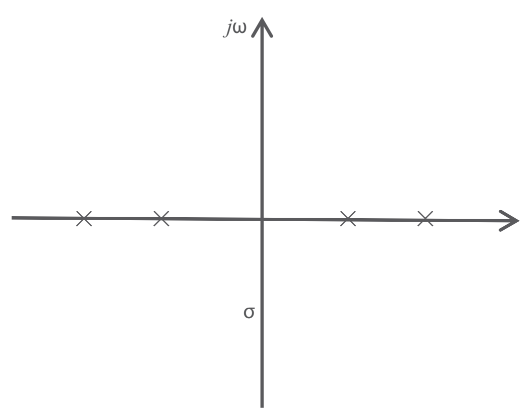
$+S^7$	1	7	31	25
$+S^6$	1	14	73	200
$-S^5$	–7	–42	–175	0
$+S^4$	8	48	200	
$+S^3$	0 (32)	0 (96)	0	
$+S^2$	24	200		
$-S^1$	$\frac{-512}{3}$			
$+S^0$	200			

A. E $= 8S^4 + 48S^2 + 200$

$$\frac{dAE}{dS} = 32S^3 + 96S$$

Number of sign changes below A. E = 2

∴



And number of sign changes above auxiliary equation are 2.

Total number of RHP = 4

Total number of $j\omega$ poles = 0

Total number of LHP = 3.

Hence, the correct option is (A)

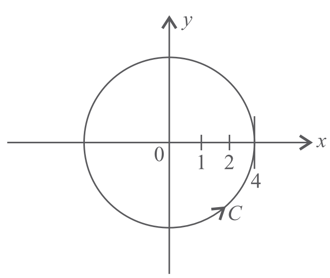
Question Number: 45 **Question Type: MCQ**

If C is a circle $|z|$ = 4 and $f(z) = Z_f \dfrac{z^2}{(z^2-3z+2)^2}$, then $\oint_C f(z)\,dz$ is

(A) 1 (B) 0

(C) –1 (D) –2

Solution:
$$f(Z) = \frac{Z^2}{(Z^2-3Z+2)^2}$$
$$= \frac{Z^2}{((Z-1)(Z-2))^2}$$
$$\therefore \quad f(Z) = \frac{Z^2}{(Z-1)^2(Z-2)^2}$$



$z = 1$ and $z = 2$ are the singularities of $f(z)$ and both of them lie inside C.

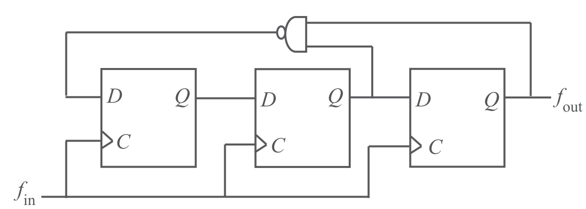
$\therefore$ By residue theorem,
$$\oint_C f(z)dz = 2\pi i\begin{bmatrix}\operatorname{Res} f(z) + \operatorname{Res}(f(z)) \\ z=1 \qquad z=2\end{bmatrix} \qquad (1)$$
$$\underset{z=1}{\operatorname{Res}} f(z) = \underset{z\to1}{Lt}\left[\frac{d}{dz}\left((z-1)^2 f(z)\right)\right]$$
$$= \underset{z\to1}{Lt}\left[\frac{d}{dz}\left(\frac{z^2}{(z-2)^2}\right)\right]$$
$$= \underset{z\to1}{Lt}\left[\frac{2z(z-2)^2-2z^2(z-2)}{(z-2)^4}\right]$$
$$= \underset{z\to1}{Lt}\left[\frac{2z(z^2-4z+4)-2z^3+4z^2)}{(z-2)^4}\right]$$
$$= \underset{z\to1}{Lt}\left[\frac{8z-4z^2}{(z-2)^4}\right]$$
$$\therefore \quad \operatorname{Res} f(z) = 4z = 1 \qquad (2)$$
$$\underset{z=2}{\operatorname{Res}} f(z) = \underset{z\to2}{Lt}\left[\frac{d}{dz}\left((z-2)^2 f(z)\right)\right]$$
$$= \underset{z\to2}{Lt}\left[\frac{d}{dz}\left(\frac{z^2}{(z-1)^2}\right)\right]$$
$$= \underset{z\to2}{Lt}\left[\frac{2z(z-1)^2-2z^2(z-1)}{(z-1)^4}\right]$$
$$= \underset{z\to2}{Lt}\left[\frac{2z(z^2-2z+1)-2z^3+2z^2}{(z-1)^4}\right]$$
$$= \underset{z\to2}{Lt}\left[\frac{2z-2z^2}{(z-1)^4}\right]$$
$$\therefore \quad \underset{z=2}{\operatorname{Res}} f(z) = -4 \qquad (3)$$

Substituting (2) and (3) in (1), we have
$$\oint_c f(z)dz = 2\pi i[4-4] = 0$$

Hence, the correct option is (B)

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

Which one of the following statements is true about the digital circuit shown in the figure.



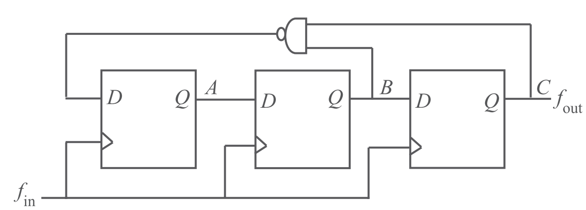
(A) It can be sued for dividing the input frequency by *e*.

(B) It can be used for dividing the input frequency by 5.

(C) It can be used for dividing the input frequency by 7.

(D) It cannot be reliably used as a frequency divider due to disjoint internal cycles.

Solution:



C l K	A	B	C
0	0	0	0
1	1	0	0

CLK	A	B	C
2	1	1	0
3	1	1	1
4	0	1	1
5	0	0	1
6	1	0	0
7	1	1	0

the modulus of he given counter is 5 so it is used to divide the input frequency by 5.

Hence, the correct option is (B)

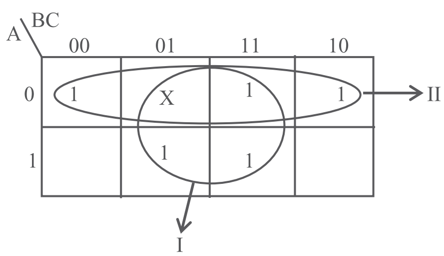
Question Number: 47 **Question Type: MCQ**

Digital input signals A, B, C with A as the MSB and C as the LSB are used to realized the Boolean function $F = m_0 + m_2 + m_3 + m_5 + m_7$, where m_1 denotes the i^{th} minterm– In addition, F has a don't care for m_1. The simplified expression for F is given by

(A) $\bar{A}\bar{B} + \bar{B}C + AC$ (B) $\bar{A} + C$

(C) $\bar{C} + A$ (D) $\bar{A}C + BC + A\bar{C}$

Solution:



$$F = \text{I} + \text{II} \quad \text{where } I = C$$

$$F = \bar{A} + C \quad \text{II} = \bar{A}$$

Hence, the correct option is (B)

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

Consider the two continuous – time signals defined below:

$$x_1(t) = \begin{cases} |t|, -1 \le t \le 1 \\ 0, \text{otherwise} \end{cases}$$

$$x_2(t) = \begin{cases} 1 - |t|, -1 \le t \le 1 \\ 0, \text{otherwise} \end{cases}$$

These signals are sampled with a sampling period of $T = 0.25$ seconds to obtain discrete time signals $x_1[n]$ and $x_2[n]$, respectively. Which one of the following statements is true?

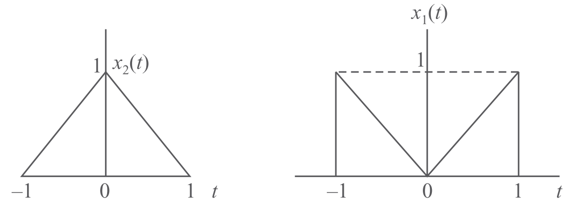
(A) The energy of $x_1[n]$ is greater than the energy of x_2[n].

(B) The energy of $x_2[n]$ is greater than the energy of x_1[n]

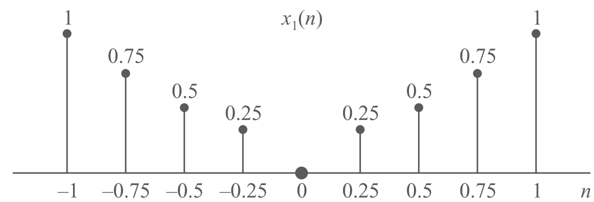
(C) $x_1[n]$ and $x_2[n]$ have equal energies.

(D) Neither $x_1[n]$ nor $x_2[n]$ is a finite – energy signal.

Solution: Plot for $x_1(t)$ and $x_2(t)$ are shown below



Sampled Versions $x_1[n]$ and $x_2[n]$ can be shown as

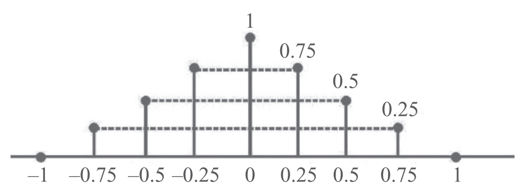


$$X_1[n] = \delta[n+1] + 0.75\ \delta[n+0.75] + 0.5\ \delta[n+0.5] + 0.25\ \delta[n+0.25] + 0.25\ \delta[n-0.25] + 0.5\ \delta[n-0.5] + 0.75\ \delta[n-0.75] + \delta[n-1]$$

Energy in $X_1[n]$ is $\sum_{n=-1}^{1} x_1^2[n]$

$$Ex_{1[n]} = 3.75$$

Sampled Version of $x_2[n]$ is



$$X_2[n] = 0.25\ \delta[n+0.75] + 0.5\ \delta[n+0.5] + 0.75\ \delta[n+0.25] + \delta[n] + 0.75\ \delta[n-0.25] + 0.5\ \delta[n-0.5] + 0.25\ \delta[n-0.75]$$

Energy in $X_2[n]$ is $\sum_{n=-1}^{1} x_2^2[n]$

$$Ex_{2[n]} = 2.75$$

Energy of x_1[n] is greater than energy of $x_2[n]$

Hence, the correct option is (A)

Question Number: 49 **Question Type: MCQ**

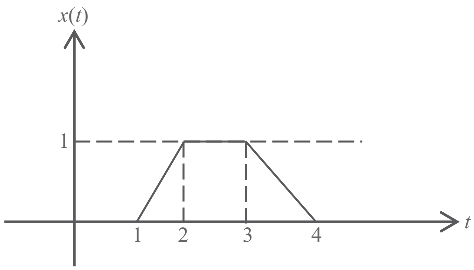
The signal energy of the continuous – time signal

$$x(t) = [(t-1)\ u(t-1)] - [(t-2)\ u(t-2)] - [(t-3)\ u(t-3)] + [(t-4)\ u(t-4)] \text{ is}$$

(A) 11/3 (B) 7/3

(C) 1/3 (D) 5/3

Solution: Consider the figure given below



$$1 \le t \le 2: x(t) = (t - 1)$$
$$2 \le t \le 3: x(t) = 1$$
$$3 \le t \le 4: x(t) = (4 - t)$$

Energy of $x(t)$ is given by,

$$E = \int_{-\infty}^{\infty} \left(x(t)\right)^2 dt$$

$$\int_1^2 (t-1)^2 dt + \int_2^3 1^2 dt + \int_3^4 (4-5)^2 dt$$

$$\int_1^2 (t^2 - 2t + 1)\, dt + \int_2^3 1 dt + \int_3^4 (16 + t^2 - 8t)\, dt$$

$$1/3 + 1 + 1/3 = 5/3$$

Hence, the correct option is (D)

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

The Fourier transform of a continuous – time single $x(t)$ is given by $X(\omega) = \frac{1}{(10 + j\omega)^2}, -\infty < \omega < \infty$, where $j = \sqrt{-1}$ and ω denotes frequency. Then the value of |?In $x(t)$| at $t = 1$ is _____ (up to 1 decimal place). (In denotes the logarithm to base e)

Solution: We know that

$$x(\omega) = \frac{1}{\left(10 + j\omega\right)^2}, -\infty < \omega < \infty$$

$$x(t) \xleftrightarrow{\text{F.T}} x(\omega)$$

$$-jt\, x(t) \xleftrightarrow{\text{F.T}} \frac{dx(\omega)}{d\omega}$$

$$e^{-10t} \longleftrightarrow \frac{1}{10 + j\omega}$$

$$-jt\, e^{-10t} \longleftrightarrow \frac{-j}{(10 + j\omega)^2}$$

$$\Rightarrow \quad te^{-10t} \xleftrightarrow{\text{F.T}} \frac{1}{(10 + j\omega)^2}$$

$$\therefore \quad X(t) = te^{-10t}$$

Now, $\left|In\, x(t)\right| = \left|\ln t\, e^{-10t}\right|$

$$= \left|\ln t - 10\, In\, e\right|$$

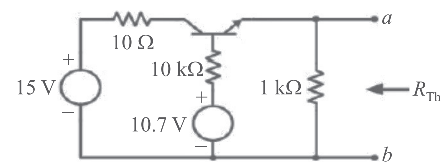
at $t = 1$

$$= \left|In 1 - 10\right| = 10$$

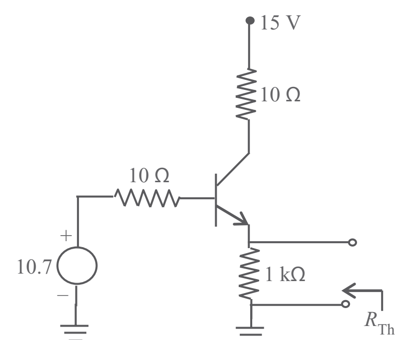
Hence, the correct answer is 10.

Question Number: 51 **Question Type: NAT**

In the circuit shown in the figure, the bipolar junction transistor (BJT) has a current gain $\beta = 100$. The base – emitter voltage drop is a constant. $V_{BE} = 0.7$ V. The value of the Thevenin equivalent resistance R_{Th} (in Ω) as shown in the figure is _____ (up to 2 decimal places.



Solution: Consider the circuit below



Emitter current

$$I_E = \frac{10.7 - 0.7}{1 + \frac{10}{101}} = 9.17 mA$$

Collector current

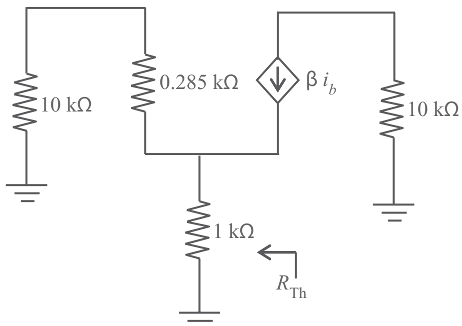
$$I_C = \left(\frac{\beta}{\beta + 1}\right)$$

$$I_E = 9.08 \text{ mA}$$

$$\Rightarrow \quad g_m = \frac{I_C}{V_T} = 0.35$$

$$r_\pi = \frac{\beta}{g_m} = 0.285 \text{ k}\Omega$$

a.c equivalent circuit of given circuit will be



Thevenin equivalent resistance

$$R_{th} = 1k\Omega \parallel \left(\frac{10}{101} + \frac{0.285}{101}\right)$$

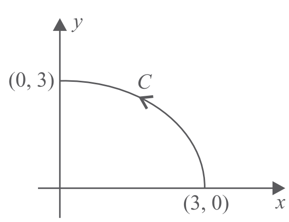
$$R_{th} = 1\ k\Omega \parallel 0.1\ k\Omega$$

$$R_{th} = 91\ \Omega$$

Hence, the correct answer is 91.

Question Number: 52 **Question Type: NAT**

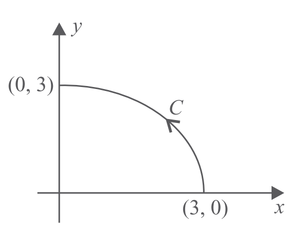
As shown in the figure C is the arc from the point (3, 0) to the point (0, 3) on the circle $x^2 + y^2 = 9$. The value of the integral $\int_C (y^2 + 2yx)dx + (2xy + x^2)dy$ is ______ (up to 2 decimal places).



Solution: We have to evaluate

$$\int_c (y^2 + 2yx)dx + (2xy + x^2)dy$$

along the boundary of the circle $x^2 + y^2 = 9$ from (3,0) to (0,3)



$$\therefore \quad \int_C \left(y^2 + 2yx\right)dx + \left(2xy + x^2\right)dy$$

$$= \int_C \left[y^2dx + 2yxdx + 2xydy + x^2dy\right]$$

$$= \int_C \left[\left(y^2dx + 2xydy\right) + \left(2yxdx + x^2dy\right)\right]$$

$$= \int_C \left[d(xy^2) + d(x^2y)\right]$$

$$= \int_{(3,0)}^{(0,3)} \left[d\left(xy^2 + x^2y\right)\right]$$

$$= xy^2 + x^2y\Big]_{(3,0)}^{(0,3)} = 0$$

Hence, the correct answer is 0.

Question Number: 53 **Question Type: NAT**

Let $f(x) = 3x^3 - 7x^2 + 5x + 6$. The maximum value of $f(x)$ over the interval [0, 2] is _____ (up to 1 decimal place).

Solution: The function is

$$f(x) = 3x^3 - 7x^2 + 5x + 6$$

the derivative of above function will be

$$\Rightarrow \quad f'(x) = 9x^2 - 14x + 5$$

$$f'(x) = 0 \Rightarrow 9x^2 - 14x + 5 = 0$$

$$\Rightarrow \quad (9x - 5)(x - 1) = 0 \Rightarrow x = \frac{5}{9}; x = 1$$

$\therefore$ The maximum value of $f(x)$ in [0,2]

$$= \text{Max.}\left\{f(0), f(2), f\left(\frac{5}{9}\right), f(1)\right\}$$

$$= \text{Max.}\{6, 12, 7.1317, 7\}$$

$$= 12$$

Hence, the correct answer is 12.

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

Let $A = \begin{bmatrix} 1 & 0 & -1 \\ -1 & 2 & 0 \\ 0 & 0 & -2 \end{bmatrix}$ and $B = A^3 - A^2 - 4A + 5I$, where I is the 3×3 identity matrix. The determinant of B is ______ (up to 1 decimal place)

Solution: Matrix $A = \begin{bmatrix} 1 & 0 & -1 \\ -1 & 2 & 0 \\ 0 & 0 & -2 \end{bmatrix}$

Characteristic equation of matrix A will be

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

$$\Rightarrow \quad \begin{vmatrix} 1-\lambda & 0 & -1 \\ -1 & 2-\lambda & 0 \\ 0 & 0 & -2-\lambda \end{vmatrix} = 0$$

$$\Rightarrow \quad (-2-\lambda)(2-\lambda)(1-\lambda) = 0$$

$$\Rightarrow \quad \lambda = 1, 2, -2$$

eigen values of A are 1, 2 and –2 we know that

$$B = A^3 - A^2 - 4A + 5I$$

Eigen Values of A		**Eigen Values of B**
$\lambda = 1$	$\longrightarrow$	$1^3 - 1^2 - 4\times 1 + 5 = 1$
$\lambda = 2$	$\longrightarrow$	$2^3 - 2^2 - 4\times 2 + 5 = 1$
$\lambda = -2$	$\longrightarrow$	$(-2)^3 - (-2)^2 - 4\times(-2) + 5 = 1$

$\therefore$ The eigen values of B are 1,1 and 1.

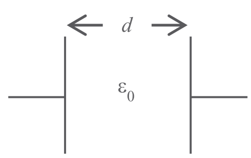
So, the determinant of $B = 1 \times 1 \times 1 = 1$

Hence, the correct answer is 1.

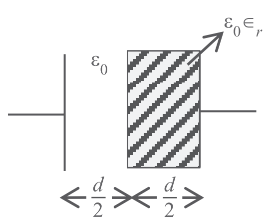
Question Number: 55 **Question Type: NAT**

The capacitance of an air – filled parallel – plate capacitor is 60 pF. When a dielectric slab whose thickness, is half the distance between the plates, is placed on one of the plates covering it entirely, the capacitance becomes 86 pF. Neglecting the fringing effects, the relative permittivity of the dielectric is ______ (up to 2 decimal places)

Solution: Parallel plate capacitor with air gap



Parallel plate capacitor with dielectric is given below



Capacitance of parallel plate capacitor is

$$C_0 = \frac{\varepsilon_0 A}{d} = 60 \text{ pF}$$

Now we have

$$C_1 = 2C_0$$

$$C_2 = 2C_0 \in_r$$

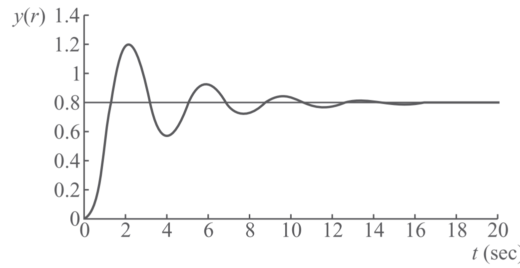
$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{120 \in_r}{1 + \in_r} = 86\, pF$$

$$\in_r = 2.53$$

Hence, the correct answer is 2.53.

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

The unit step response $y(t)$ of a unity feedback system with open loop transfer function $G(s)H(s) = \dfrac{K}{(s+1)^2(s+2)}$ is shown in the figure. The value of K is ______ (up to 2 decimal places)



Solution: $\text{CLTF} = \dfrac{K}{(S+1)^2(S+2)+K}$

$$0.8 = \underset{S\to 0}{Lt}\left(\frac{1}{S}\right) S\left\{\frac{K}{(S+1)^2(S+2)+K}\right\}$$

$$0.8 = \frac{K}{2+K}$$

$\Rightarrow$ $1.6 + 0.8K = K$

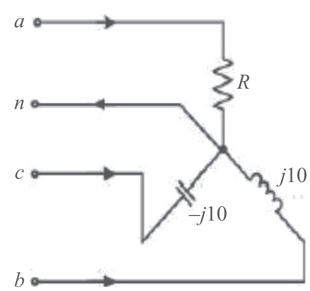
$\Rightarrow$ $0.2K = 1.6$

$\Rightarrow$ $K = 8.$

Hence, the correct answer is 8.

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

A three – phase load is connected to a three – phase balanced supply as shown in the figure. If $V_{an} = 100\angle 0°$ V, $V_{bn} = 100\angle -120°$ V and $V_{cn} = 100\angle -240°$ V(angles are consider positive in the anti – clockwise direction), the value of R for zero current in the neutral wire is ____ Ω



Solution:

We know that

$$I_N = I_R + I_Y + I_B = 0$$

$$I_R = \frac{V\angle 0°}{R}$$

$$I_y = \frac{V\angle -120°}{j\omega L}$$

$$I_B = \frac{V\angle -240°}{\left(\dfrac{1}{j\omega c}\right)}$$

$$\frac{1}{R}+\frac{1\angle-120°}{j\omega L}+j\omega c\ \angle-240° = 0$$

$$\frac{1}{R}\cos 0°+\frac{1}{j\omega L}\ \cos120° + j\omega c\ \cos 240° = 0 \quad (1)$$

$$\frac{1}{R}\sin 0°+\frac{1}{j\omega L}\ \sin(-120°) + j\omega c\ \sin(-240°) = 0 \quad (2)$$

Solve equation (2) $\Rightarrow \omega = \dfrac{1}{\sqrt{LC}}$ put in equation (1) then

$$R = \frac{1}{\sqrt{3}}\sqrt{L/C}$$

$$R = \frac{1}{\sqrt{3}}\sqrt{100} = 5.77\ (\Omega)$$

Hence, the correct answer is 5.77.

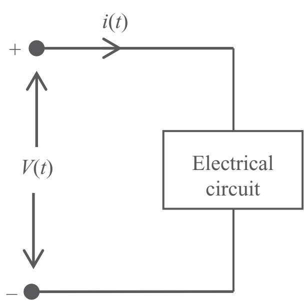
Question Number: 58 **Question Type: NAT**

The voltage across the circuit in figure, and the current through it, are given by the following expressions:

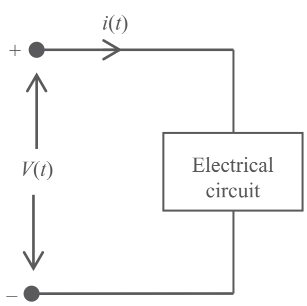
$$V(t) = 5 - 10\ \cos(\omega t + 60°)\text{V}$$

$$I(t) = 5 + X\cos(\omega t)\ \text{A}$$

Where $\omega = 100\ \pi$ radian/s. If the average power delivered to the circuit is zero, then the value of X (in ampere) is _____ (up to 2 decimal places)



Solution:



$$P = V\cdot I$$

$$V(t) = 5 - 10\ \{\cos\omega t\cdot\cos 60° - \sin \omega t\cdot\sin 60°\}$$

$$V(t) = 5 - 5\ \cos\omega t + 5\sqrt{3}\ \sin \omega t$$

$$i(t) = 5 + X\cos \omega t$$

$$P = V(t)\cdot i(t)$$

$$P = [5 - 5\ \cos \omega t + 5\sqrt{3}\ \sin \omega t]\ [5 + X\cos \omega t]$$

$$= 25 + 5X\cos \omega t - 25\ \cos \omega t - 5X\cos^2\omega t + \ldots \text{ etc}$$

$$P = 25 - \frac{5X}{2}\ \{1 + \cos 2\omega t\} + 5X\cos\omega t - 25\ \cos \omega t + \ldots \text{ etc.}$$

$$P = 25 - 2.5X - 2.5X\cos \omega t + 5X\cos \omega t \ldots \text{ etc}$$

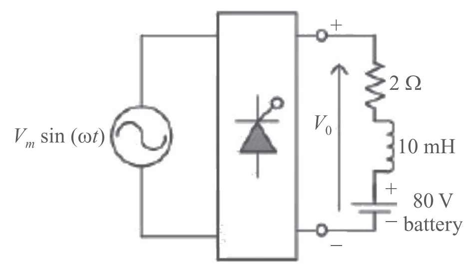
given $P_{avg} = 0$

So, $25 - 2.5X = 0 \Rightarrow X = 10$

Hence, the correct answer is 10.

Question Number: 59 **Question Type: NAT**

A phase controlled single phase rectifier, supplied by an AC source, feeds power to an R – L – E load as shown in the figure. The rectifier output voltage has an average value given by $V_0 = \dfrac{V_m}{2\pi}$ (3 + cos α), where $V_m = 80\pi$ volts and α is the firing angle. If the power delivered to the lossless battery is 1600 W, α in degree is ____ (up to 2 decimal places).



Solution: We know that

$$V_0 = \frac{V_m}{2\pi}(3 + \cos\alpha)$$

$$V_m = 80\pi$$

$$\Rightarrow \quad V_0 = \frac{80\pi}{2\pi}(3 + \cos\alpha) = 40\,(3 + \cos\alpha)$$

Current through battery,

$$I_0 = \frac{V_0 - E}{R} \quad (1)$$

Also as per problem $P_{battery} = 80 \times I_0 = 1600$

$$I_0 = 20\text{A}$$

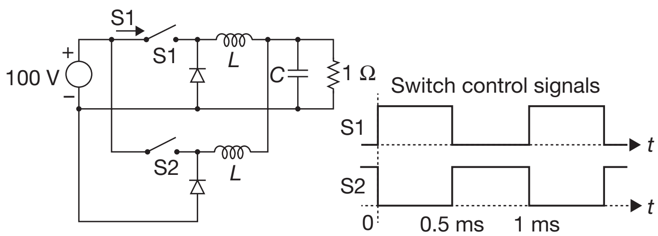
$$(1) \Rightarrow 20 = \frac{40(3+\cos\alpha) - 80}{1}\ \cos\alpha = 0$$

$$\alpha = 90°$$

Hence, the correct answer is 90°.

Question Number: 60 **Question Type: NAT**

The figure shown two buck converters connected in parallel. The common input dc voltage for the converters has a value of 100 V. The converters have inductors of identical value. The load resistance is 1 Ω. The capacitor voltage has negligible ripple. Both converters operate in the continuous conduction mode. The switching frequency in 1 kHz and the switch control signals are as shown. The circuit operates in the steady state. Assuming that the converters share the load equally, the average value of i_{s1}, the current of switch $S1$ (in Ampere), is _____ (up to 2 decimal places)



Solution: Voltage $V_s = 100$ V

Current $I_D = 100/1 = 100$ A

We know that input power = output power

$$P_{in} = P_{out}$$

$$V_s \cdot I_s = V_0 \cdot I_0$$

$$100 \times I_s = 100 \times 100$$

$$I_s = 100 \text{ A}$$

$$I_{s1} = 50 \text{ A}$$

Hence, the correct answer is 50.

Question Number: 61 **Question Type: NAT**

A 3 – phase 900 kVA, 3kV/$\sqrt{3}$ kV(Δ/Y), 50 Hz transformer has primary (high voltage side) resistance per phase of 0.3 Ω and secondary (low voltage side) resistance per phase of 0.02 Ω Iron loss of the transformer is 10 kW. The full load % efficiency of the transformer operated at unity power factor is ______ (up to 2 decimal places).

Solution:

Primary current, I_1/Ph

$$= \frac{I_1(line)}{\sqrt{3}}$$

$$= \frac{1}{\sqrt{3}} \times \frac{900 \times 10^3}{\sqrt{3} \times 3 \times 10^3} = 100\text{A}$$

Secondary current, I_2/ph

$$= I_2(\text{line})$$

$$= \frac{900 \times 10^3}{\sqrt{3} \times \sqrt{3} \times 10^3} = 300\text{A}$$

∴ Total Cu losses in a transformer

$$= 3\ I_1^2 / \text{ph}\ R_1/\text{ph} + 3\ I_2^2/\text{ph}\ R_2/\text{ph}.$$

$$= 3 \times 10^4 \times 0.3 + 3 \times 9 \times 10^4 \times 0.02$$

$$= 9000 + 5400 = 14400 \text{ w.}$$

∴ η at F.L,

(U.P.F)

$$= \frac{(1 \times 900 \times 10^3 \times 1)}{(1 \times 900 \times 10^3 \times 1) + (10 \times 10^3 + 14,400)}$$

$$= 0.9736$$

$$\therefore \quad \%\ \eta = 97.36\%$$

Hence, the correct answer is 97.36.

Question Number: 62 **Question Type: NAT**

A 200 V DC series motor, when operating from rated voltage while driving a certain load, draws 10 A current and runs at 1000 r.p.m. The total series resistance is 1 Ω. the magnetic circuits is assumed to be linear. At the same supply voltage, the load torque is increased by 44%. The speed of the motor in r.p.m. (rounded to the nearest integer) is _____.

Solution:

For, D.C. series motor, $\phi \alpha I_a$

$$\therefore \quad T_{e_m} \ \alpha\ I_a^2$$

$$\frac{T_{L_1}}{1.44 T_L} = \left[\frac{I_{a_1}}{I_{a_2}}\right]^2$$

$$\therefore \quad \frac{I_{a_1}}{I_{a_2}} = \frac{1}{1.2} \Rightarrow I_{a_2} = 12 \text{ A}$$

$$E_{b_1} = V_t - I_{a_1}$$

$$R_a = 200 - (10 \times 1) = 190 \text{ V}$$

$$E_{b2} = V_t - I_{a_2}$$

$$R_a = 200 - (12 \times 1) = 188 \text{ V}$$

$$E_b = K_a \phi \omega$$

$$E_b \ \alpha\ I_a N \qquad (\because \phi \ \alpha\ I_a)$$

$$\frac{E_{b_1}}{E_{b_2}} = \frac{I_{a_1}}{I_{a_2}} \times \frac{N_1}{N_2}$$

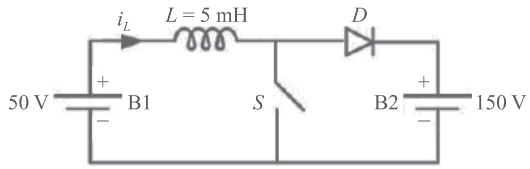
$$\Rightarrow \quad \frac{190}{188} = \frac{1}{1.2} \times \frac{1000}{N_2}$$

$$\therefore \quad N_2 = 824.561 \text{ rpm}$$

Hence, the correct answer is 824.56.

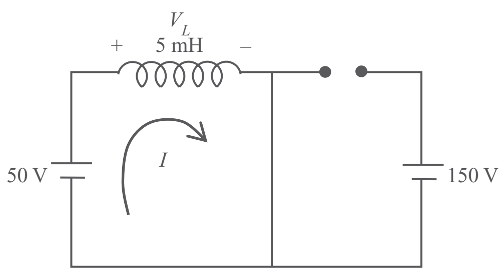
Question Number: 63 **Question Type: NAT**

A dc to dc converter shown in the figure is charging a battery bank. B_2 whose voltage is constant 150 V. B_1 is another battery bank whose voltage is constant at 50 V. The value of the inductor, L is 5 mH and the ideal switch, S is operated with a switching frequency of 5 kHz with a duty ratio of 0.4. Once the circuit has attained steady state and assuming the diode D to be ideal, the power transferred from B_1 to B_2 (in Watt) is ______ (up to 2 decimal places)



Solution:

Switch ON:



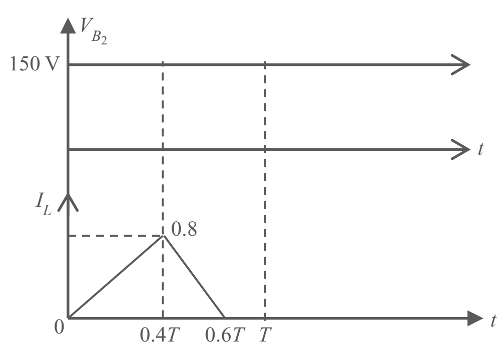
$$V_L = 50\text{ V}$$

Inductor charges linearly.

$$V_L = \frac{LdI}{dt}$$

$$\int dI = \frac{V_L}{L}\int_0^{T_{ON}} dt$$

$$\Delta I = \frac{V_L}{L}T_{ON}[T_{ON} = DT]$$



Power transferred to B_2 is given by

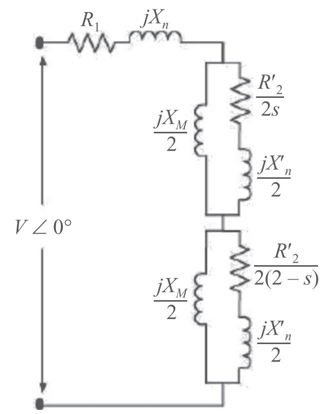
$$P = \frac{1}{T}\int_{0.4T}^{0.6T} 150 \times I_L dt$$

$$= \frac{1}{T}\times 0.2T \times \frac{0.8T}{2}\times 150 = 12W$$

Hence, the correct answer is 12.

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

The equivalent circuit of a single phase induction motor is shown in the figure, where the parameters are $R_1 = R_2^1 = X_{l1} = X_{l2}^1 = 12\ \Omega$, $X_M = 240\ \Omega$. And s is the slip. At no – load, the motor speed can be approximated to be the synchronous speed. The no – load lagging power factor of the motor is ______ (up to 3 decimal places.)

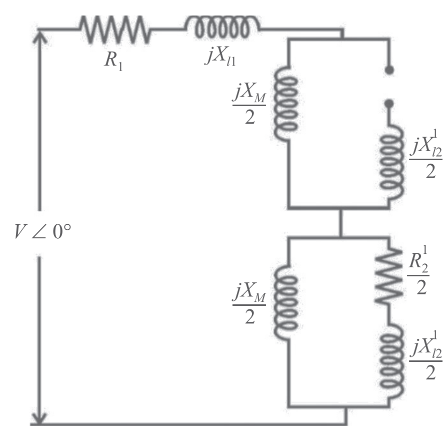


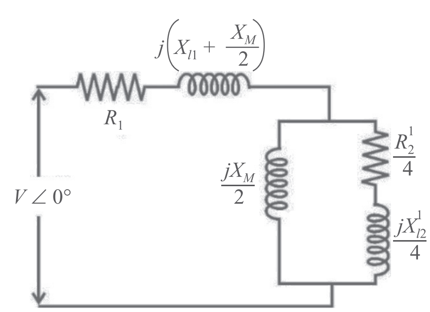
Solution:

At no-load, $N_r = N_s$

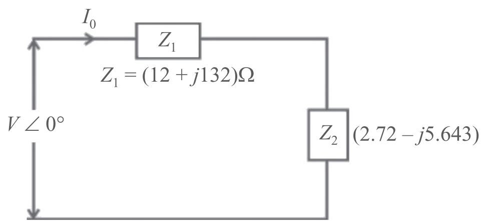
$\therefore$ $S = \frac{N_s - N_r -}{Ns} = 0$

$\therefore$ The equivalent circuit becomes,





$\therefore$ No load current, $I_0 = \dfrac{V\angle 0°}{Z\angle\theta}$



$$Z_{eq} = 138.56\,\angle 83.9\,\Omega$$

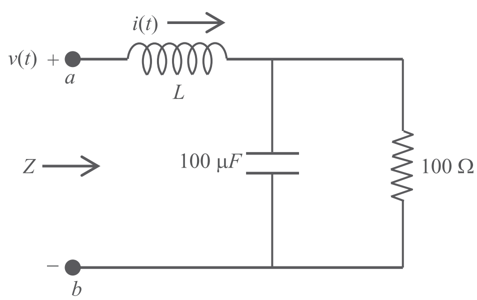
$\therefore$ No load P.F = cos(83.9)

= 0.106 lagging

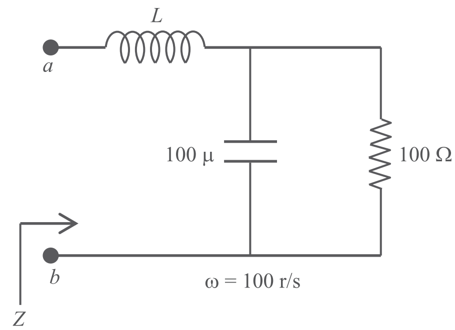
Hence, the correct answer is 106.

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

The voltage $v(t)$ across the terminal a and b as shown in the figure, is a sinusoidal voltage having a frequency ω = 100 radian/s. When the inductor current $i(t)$ is in phase with the voltage $v(t)$, the magnitude of the impedance Z (in Ω) seen between the terminals a and b is ______ (up to 2 decimal places).



Solution: Consider the circuit given below



at Resonance

$$Z_{ab} = (Z_{ab})_{\text{real}}$$

$$\text{Imag }\{Z_{ab}\} = 0$$

$$Z_{ab} = j\omega L + \left(100 \,||\, \frac{1}{SC}\right)$$

$$Z_{ab} = j\omega L + \frac{100 \times \frac{1}{SC}}{100 + \frac{1}{SC}}$$

$$Z_{ab} = j\omega L + \frac{100}{I + 100SC}$$

$$= j\omega L + \frac{100}{1 + j100 \times 100 \times 10^{-6} \times 100}$$

$$Z_{ab} = j\omega L + \frac{100}{1 + j1}$$

$$Z_{ab} = j\omega L + \frac{100\{1 - j\}}{1 + (1)^2}$$

At resonance,

$$Z_{ab} = Z_{\text{real}} = \frac{100}{2} = 50\,\Omega$$

Hence, the correct answer is 50.