GATE 2015 Solved Paper
Electrical Engineering
Set – 2

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**

Select the alternative meaning of the underlined part of the sentence.

The chain snatchers took to their heels when the police party arrived.

(A) took shelter in a thick jungle
(B) open indiscriminate fire
(C) took to flight
(D) unconditionally surrendered

Solution: Took to their heels' means to run away. This supports option (C). The other answer options are incorrect.

Hence, the correct option is (C).

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

The given statement is followed by some courses of action. Assuming the statement to be true, decide the correct option.

Statement: There has been significant drop in the water level in the lakes supplying water to the city.

Course of action:

I. The water supply authority should impose a partial cut in supply to tackle the situation.

II. The government should appeal to all the residents through mass media for minimal use of water.

III. The government should ban the water supply in lower areas.

(A) Statements I and II follow.
(B) Statements I and III follow.
(C) Statements II and III follow.
(D) All statements follow.

Solution: When there is a significant drop in the water level in the lakes supplying water in the city. The plausible course of action has to be the ones which are practically possible.

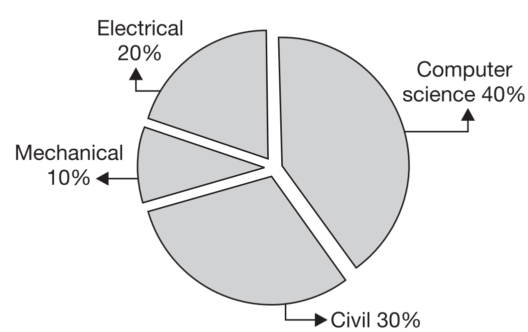
Among the three given courses of action, only I and II are practically possible. III speaks about banning the water supply in lower areas.

This is not an appropriate solution to the existing problem. And stopping or banning water in the lower areas for proper supply in the city is unethical as well.

Hence, the correct option is (A).

Question Number: 3 **Question Type: NAT**

The pie chart below has the breakup of the number of students from different departments in an engineering college for the year 2012. The proportion of male to female students in each department is 5:4. There are 40 males in Electrical Engineering. What is the difference between the numbers of female students in the Civil department and the female students in the Mechanical department?



Solution: Number of students in the Electrical Engineering department

$$= 40\left(\frac{9}{5}\right) = 72.$$

Number of students in the Civil department

$$= \frac{30}{20}(72) = 108$$

Number of students in the Mechanical department

$$= \frac{10}{20}(72) = 36$$

Number of female students in the Civil and the Mechanical departments are $108 -\left(\frac{4}{9}\right)$ and $36\left(\frac{4}{9}\right)$, respectively.

i.e., 48 and 16, respectively.

Difference is 48 – 16, i.e., 32.

Hence, the correct answer is 32.

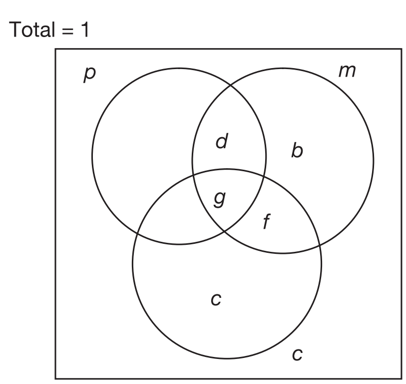
Question Number: 4 **Question Type: MCQ**

The probabilities that a student passes in Mathematics, Physics and Chemistry are m, p and c, respectively. Of these subjects, the student has 75% chance of passing in at least one, a 50% chance of passing in at least two and a 40% chance of passing in exactly two. Following relations are drawn in m, p, c:

I. $p + m + c = 27/20$
II. $p + m + c = 13/20$
III. $(p) \times (m) \times (c) = 1/10$

(A) Only relation I is true.
(B) Only relation II is true.
(C) Relations II and III are true.
(D) Relations I and III are true.

Solution: VD for probabilities



$$p + m + c = a + b + c + 2\,(d + e + f) + 3g$$
$$= (a + b + c + d + e + f + g) + (d + e + f + 2g)$$
$$= \frac{75}{100} + \frac{40}{100} + \frac{20}{100} = \frac{27}{20}$$

$\Rightarrow$ I is true and II is not true.

$(p)\,(m)\,(c)$ = probability (The student passing in all the three subjects)

$$= \frac{50}{100} - \frac{40}{100} = \frac{10}{100} = \frac{1}{10}$$

Hence, I and III are true.

Hence, the correct option is (D).

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

The number of students in a class who have answered correctly, wrongly, or not attempted each question in an exam, are listed in the table below. The marks for each question are also listed. There is no negative or partial marking.

Q. No.	Marks	Answered Correctly	Answered Wrongly	Not Attempted
1	2	21	17	6
2	3	15	27	2
3	1	11	29	4
4	2	23	18	3
5	5	31	12	1

What is the average of the marks obtained by the class in the examination?

(A) 2.290 (B) 2.970
(C) 6.795 (D) 8.795

Solution: Average of the marks obtained by the class

$$= \frac{2(21) + 3(15) + 1(11) + 2(23) + 5(31)}{\text{Total number of students}}$$

$$= \frac{299}{44} = 6.795$$

Hence, the correct option is (C).

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

Didn't you buy __________ when you went shopping?

(A) any paper (B) much paper
(C) no paper (D) a few paper

Solution:

Hence, the correct option is (A).

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

Which of the following options is the closest in meaning to the sentence below?

She enjoyed herself immensely at the party.

(A) She had a terrible time at the party.
(B) She had a horrible time at the party.
(C) She had a terrific time at the party
(D) She had a terrifying time at the party.

Solution:

Hence, the correct option is (C).

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

Which one of the following combinations is incorrect?

(A) Acquiescence—Submission
(B) Wheedle—Roundabout
(C) Flippancy—Lightness
(D) Profligate—Extravagant

Solution:

Hence, the correct option is (B).

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

Based on the given statements, select the most appropriate option to solve the given question.

If two floors in a certain building are 9 feet apart, how many steps are there in a set of stairs that extends from the first floor to the second floor of the building?

Statements:

I. Each step is 3/4th foot high.
II. Each step is 1 foot wide.

(A) Statement I alone is sufficient but statement II alone is not sufficient.
(B) Statement II alone is sufficient, but statement I alone is not sufficient.
(C) Both statements together are sufficient, but neither statement alone is sufficient.
(D) Statements I and II together are not satisfied.

Solution: The distance between the 2 floors of the building is 9 feet. And we are asked to find the number steps from first floor to second floor.

From I: If each step is 3/4th foot.

Let there be a total of n steps from first floor to record floor.

$$\frac{3}{4} \times n = 9; \quad n = \frac{4 \times 9}{3} = 12$$

So, I alone gives this answer

II speaks about the width of each step. From width we cannot get the number of steps between 1st and 2nd floors.

Hence, the correct option is (A).

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

Given Set $A = \{2, 3, 4, 5\}$ and Set $B = \{11, 12, 13, 14, 15\}$, two numbers are randomly selected, one from each set. What is the probability that the sum of the two numbers equals 16?

(A) 0.20 (B) 0.25
(C) 0.30 (D) 0.33

Solution: Let the numbers randomly selected from set A and set B be a and b, respectively.

The number of (a, b) that can be formed taking a from A and b from B is $4 \times 5 = 20$. And the (a, b) for which $a + b = 16$ are (2, 14), (3, 13), (4, 12), (5, 11).

Number of favourable selections = 4

$$\text{Required probability} = \frac{4}{20} = 0.2$$

Hence, the correct option is (A).

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: MCQ**

The primary mmf is least affected by the secondary terminal conditions in a

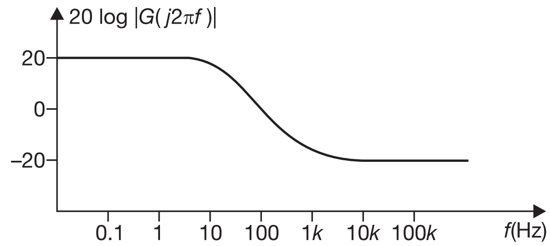
(A) power transformer
(B) potential transformer
(C) current transformer
(D) distribution transformer

Solution: In current transformer least number of secondary turns therefore the effect on primary mmf is least.

Hence, the correct option is (C).

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

A Bode magnitude plot for the transfer function $G(s)$ of a plant is shown in the figure. Which one of the following transfer functions best describes the plant?



(A) $\frac{1000(s+10)}{s+1000}$ (B) $\frac{10(s+10)}{s(s+1000)}$

(C) $\frac{s+1000}{10s(s+10)}$ (D) $\frac{s+1000}{10(s+10)}$

Solution: From the given bode plot one pole at –10 and one zero at 1000. The general transfer function is

$$G(s) = \frac{k\left(1+\frac{S}{1000}\right)}{\left(1+\frac{S}{10}\right)}$$

Finding k ÷ The initial slope 20 log $k = 20$

$\Rightarrow \quad K = 10$

$$G(s) = \frac{10\left(1+\frac{S}{1000}\right)}{1+\frac{S}{10}} = \frac{S+1000}{10(S+10)}$$

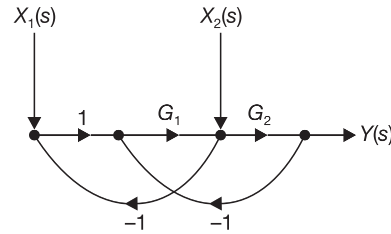
Hence, the correct option is (D).

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

For the signal-flow graph shown in the figure in the next column, which one of the following expressions is equal to the transfer function $\left.\frac{Y(s)}{X_2(s)}\right|_{X_1(s)=0}$?

(A) $\frac{G_1}{1+G_2(1+G_1)}$ (B) $\frac{G_2}{1+G_1(1+G_2)}$

(C) $\frac{G_1}{1+G_1G_2}$ (D) $\frac{G_2}{1+G_1G_2}$



Solution:

The forward path given for $\left.\frac{Y(s)}{X_2(S)}\right|_{X_1(S)=0}$ is G_2.

By using masons gain formula

The transfer function

$$= \frac{G_2}{1+G_1G_2+G_2} = \frac{G_2}{1+G_2(1+G_1)}$$

Hence, the correct option is (B).

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

The maximum value of 'a' such that the matrix $\begin{pmatrix} -3 & 0 & -2 \\ 1 & -1 & 0 \\ 0 & a & -2 \end{pmatrix}$ has three linearly independent real eigenvectors is:

(A) $\frac{2}{3\sqrt{3}}$ (B) $\frac{1}{3\sqrt{3}}$

(C) $\frac{1+2\sqrt{3}}{3\sqrt{3}}$ (D) $\frac{1+\sqrt{3}}{3\sqrt{3}}$

Solution: Let the given matrix be

$$A = \begin{bmatrix} -3 & 0 & -2 \\ 1 & -1 & 0 \\ 0 & a & -2 \end{bmatrix}.$$

The characteristic equation of A is

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

$$\begin{vmatrix} -3-\lambda & 0 & -2 \\ 1 & -1-\lambda & 0 \\ 0 & a & -2-\lambda \end{vmatrix} = 0$$

$\Rightarrow (-3-\lambda)(-1-\lambda)(-2-\lambda) - 2a = 0$

$\Rightarrow \quad (\lambda+1)(\lambda+2)(\lambda+3) + 2a = 0 \qquad (1)$

We know that if A has three district Eigen values then A has three linearly independent eigen vectors

Let $f(\lambda) = (\lambda + 1)(\lambda + 2)(\lambda + 3)$

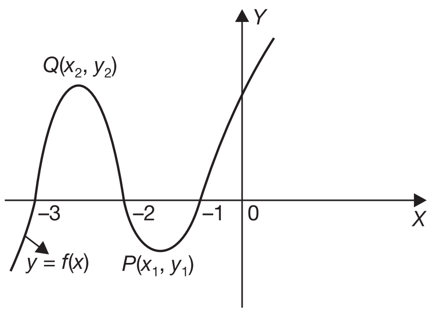
$\therefore$ Equation (1) becomes,

$$f(\lambda) + 2a = 0$$

$$\Rightarrow \quad f(\lambda) = -2a \quad (2)$$

Consider $f(x) = (x + 1)(x + 2)(x + 3)$

The graph of $f(x)$ is as shown in the figure below:



We know that the number of distinct real roots of an equation $F(x) = k$ (k is real) is same as that of the number of points of intersection of the curve $y = F(x)$ and the line $y = k$.

The curve $y = f(x)$ intersects at three points with a line $y = y_0$ only when $y_1 \le y_0 \le y_2$

i.e., for $f(x) + 2a = 0$ (OR) $f(x) = -2a$, three distinct real roots exist for

$$y_1 \le -2a \le y_2 \quad (3)$$

i.e. $$y_1 \le f(x) \le y_2 \quad (4)$$

[from Equation (2)]

Now we will find y_1 and y_2 [i.e. the minimum and maximum values of $f(x)$]

$$f(x) = (x + 1)(x + 2)(x + 3)$$
$$= x^3 + 6x^2 + 11x + 6$$

$$\Rightarrow \quad f^1(x) = 3x^2 + 12x + 11$$

$$f^1(x) = 0$$

$$\Rightarrow \quad 3x^2 + 12x + 11 = 0$$

$$\Rightarrow \quad x = \frac{-6 \pm \sqrt{3}}{3}$$

And $f^{11}(x) = 6x + 12$

At $x = \frac{-6 + \sqrt{3}}{3}$; $f^{11}(x) = 2\sqrt{3} > 0$ and at $x = \frac{-6 - \sqrt{3}}{3}$; $f^{11}(x) = -2\sqrt{3} < 0$.

$\therefore f(x)$ has a maximum at

$$x = \frac{-6 - \sqrt{3}}{3} \text{ and a minimum at}$$

$$x = \frac{-6 + \sqrt{3}}{3}$$

The maximum value of

$$f(x) = y_2 = f(x) = \frac{2}{3\sqrt{3}} \text{ at } x = \frac{-6 - \sqrt{3}}{3}$$

The minimum value of

$$f(x) = y_1 = f(x)$$

at x $$= \frac{-6 - \sqrt{3}}{3} = \frac{-2}{3\sqrt{3}}$$

From Equation (4)

$$\frac{-2}{3\sqrt{3}} \le f(x) \le \frac{2}{3\sqrt{3}}$$

$$\Rightarrow \quad \frac{-2}{3\sqrt{3}} \le -2a \le \frac{2}{3\sqrt{3}} \text{ [from Equation (3)]}$$

$$\Rightarrow \quad \frac{1}{3\sqrt{3}} \ge a \ge \frac{-1}{3\sqrt{3}} \Rightarrow \frac{-1}{3\sqrt{3}} \le a \le \frac{1}{3\sqrt{3}}$$

$\therefore$ The maximum value of 'a' such that the matrix A has three real linearly independent eigen vectors is $\frac{1}{3\sqrt{3}}$.

Hence, the correct option is (B).

Question Number: 15 Question Type: NAT

A solution of the ordinary differential equation

$$\frac{d^2y}{dt^2} + 5\frac{dy}{dt} + 6y = 0$$

is such that $y(0) = 2$ and $y(1) = -\frac{1-3e}{e^3}$.

The value of $\frac{dy}{dt}(0)$ is ____.

Solution: Given differential equation is

$$\frac{d^2y}{dt^2} + 5\frac{dy}{dt} + 6y = 0 \quad (1)$$

where $$y(0) = 2 \text{ and } y(1) = -\frac{1 - 3e}{e^3} \quad (2)$$

The auxiliary equation of (1) is

$$D^2 + 5D + 6 = 0 \Rightarrow D = -2, -3$$

The general solution of Equation (1) is

$$y = c_1 e^{-2t} + c_2 e^{-3t}$$

From Equation (2),

$$y(0) = 2 \Rightarrow c_1 + c_2 = 2 \quad (3)$$

and $$y(1) = -\frac{1-3e}{e^3}$$

$$\Rightarrow \quad c_1 e^{-2} + c_2 e^{-3} = 3e^{-2} - e^{-3} \quad (4)$$

Solving Equations (3) and (4)

$$\Rightarrow \quad c_1 = 3 \text{ and } c_2 = -1$$

$\therefore$ The solution of given differential equation is

$$y = 3e^{-2t} - e^{-3t}$$

$$\Rightarrow \quad \frac{dy}{dt} = -6e^{-2t} + 3e^{-3t}$$

$$\therefore \quad \frac{dy}{dt}(0) = \frac{dy}{dt} \text{ at } t = 0 = -6 + 3 = -3.$$

Hence, the correct Answer is (–3).

Question Number: 16 Question Type: MCQ

The signum function is given by

$$\text{sgn}(x) = \begin{cases} \frac{x}{|x|}; & x \neq 0 \\ 0; & x = 0 \end{cases}$$

The Fourier series expansion of sgn [cos (t)] has

(A) only sine terms with all harmonics.
(B) only cosine terms with all harmonics.
(C) only sine terms with even numbered harmonics.
(D) only cosine terms with odd numbered harmonics.

Solution:

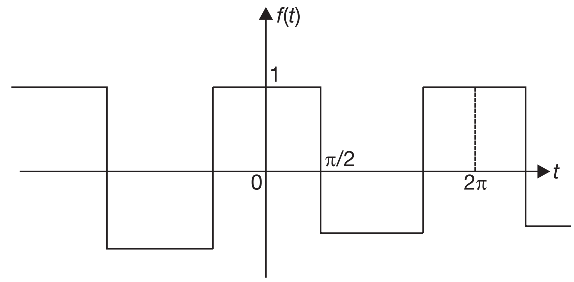
Given $$\text{sgn}(x) = \begin{cases} \frac{x}{|x|}; & x \neq 0 \\ 0; & x = 0 \end{cases}$$

$$\therefore \quad \text{sgn}[\cos(t)] = \begin{cases} \frac{\cos(t)}{|\cos t|}; & t \neq \frac{\pi}{2} \\ 0; & t = \frac{\pi}{2} \end{cases}$$

Its wave form is shown in figure given in next column.

The function is half wave symmetric. So, its Fourier series consists of only cosine terms with odd numbered harmonics.

Hence, the correct option is (D).



Question Number: 17 Question Type: MCQ

Two players, A and B, alternately keep rolling a fair dice. The person to get a six first wins the game. Given that player A starts the game, the probability that A wins the game is:

(A) 5/11 (B) 1/2
(C) 7/13 (D) 6/11

Solution: Let A and B denote the events of player A getting six on the die and player B getting six on the die, respectively

$$\therefore \quad P(A) = \frac{1}{6},\ P(B) = \frac{1}{6},\ P(\bar{A}) = \frac{5}{6}$$

and $$P(\bar{B}) = \frac{5}{6}$$

Probability of A winning the game

$$= P(A) + P(\bar{A} \cap \bar{B} \cap A) + P(\bar{A} \cap \bar{B} \cap \bar{A} \cap \bar{B} \cap A) + \ldots$$

$$= P(A) + P(\bar{A})\, P(\bar{B})\, P(A) + P(\bar{A})\, P(\bar{B})\, P(\bar{A}) P(\bar{B})\, P(A) + \ldots\infty$$

$$= \frac{1}{6} + \frac{5}{6} \times \frac{5}{6} \times \frac{1}{6} + \frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} \times \frac{5}{6} \times \frac{1}{6} + \ldots\infty$$

$$= \frac{1}{6} + \left(\frac{5}{6}\right)^2 \times \frac{1}{6} + \left(\frac{5}{6}\right)^4 \times \frac{1}{6} + \ldots\infty$$

$\left[\text{which is a geometric series with } a = \frac{1}{6} \text{ and } r = \left(\frac{5}{6}\right)^2 = \frac{25}{36}\right]$

$$\therefore \quad S_\infty = \frac{a}{1-r}$$

$$= \frac{\frac{1}{6}}{1 - \left(\frac{25}{36}\right)}$$

$$= \frac{6}{11}.$$

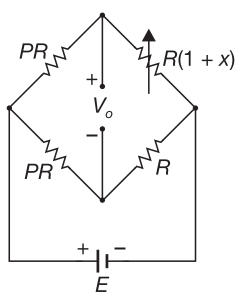
∴ Hence, probability of A winning the game

$$= \frac{6}{11}$$

Hence, the correct option is (D).

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

An unbalanced DC Wheatstone bridge is shown in the figure. At what value of p will the magnitude of V_0 be maximum?



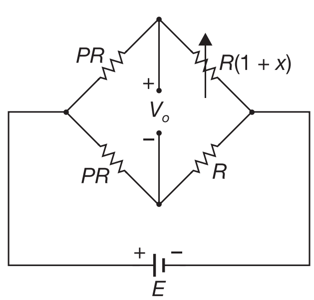
(A) $\sqrt{(1+x)}$

(B) $(1+x)$

(C) $1/\sqrt{(1+x)}$

(D) $\sqrt{(1-x)}$

Solution: Given



$$V = \frac{ER(1+x)}{PR + R(1+x)} - E\frac{R}{PR+R}$$

$$= E\left[\frac{1+x}{P+1+x} - \frac{1}{1+P}\right]$$

For the maximum V_o w.r.t

$$P = \frac{dV_o}{dP} = 0$$

$$\frac{d}{dP}\left[E\left[\frac{1+x}{1+x+P} - \frac{1}{1+P}\right]\right] = 0$$

$$\frac{1}{(1+P)^2} = \frac{1+x}{(1+x+P)^2}$$

$$\frac{1}{1+P} = \frac{\sqrt{1+x}}{1+x+P}$$

$$1 + x + P = (1+P)\sqrt{1+x}$$

$$1 + x + P = \sqrt{(1+x} + P(\sqrt{1+x})$$

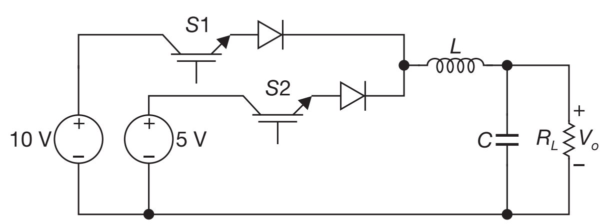
$$P(1 - \sqrt{1+x}) = \sqrt{(1+x}(1 - \sqrt{1+x})$$

$$P = \sqrt{1+x}$$

Hence, the correct option is (A).

Question Number: 19 **Question Type: NAT**

The circuit shown is meant to supply a resistive load R_L from two separate DC voltage sources. The switches $S1$ and $S2$ are controlled so that only one of them is ON at any instant. $S1$ is turned on for 0.2 ms and $S2$ is turned on for 0.3 ms in a 0.5 ms switching cycle time period. Assuming continuous conduction of the inductor current and negligible ripple on the capacitor voltage, the output voltage V_o (in Volt) across R_L is ______.



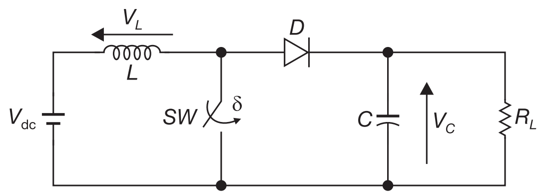
Solution: The average output voltage

$$V_o = \frac{10 \times 0.2 + 5 \times 0.3}{0.5} = 7 \text{ V}$$

Hence, the correct Answer is (7).

Question Number: 20 Question Type: MCQ

A self commutating switch SW, operated at duty cycle δ is used to control the load voltage as shown in the figure.



Under steady-state operating conditions, the average voltage across the inductor and the capacitor respectively, are:

(A) $V_L = 0$ and $V_C = \frac{1}{1-\delta}V_{dc}$

(B) $V_L = \frac{\delta}{2}V_{dc}$ and $V_C = \frac{1}{1-\delta}V_{dc}$

(C) $V_L = 0$ and $V_C = \frac{\delta}{1-\delta}V_{dc}$

(D) $V_L = \frac{\delta}{2}V_{dc}$ and $V_C = \frac{\delta}{1-\delta}V_{dc}$

Solution: The circuit represents step up chopper. So,

$$V_c = \frac{1}{1-\delta}V_{dc}$$

Hence, the average output voltage of inductor is zero.

Hence, the correct option is (A).

Question Number: 21 Question Type: NAT

The single-phase full-bridge voltage source inverter (VSI), shown in figure, has an output frequency of 50 Hz. It uses unipolar pulse width modulation with switching frequency of 50 kHz and modulation index of 0.7. For $V_{in} = 100$ V DC, $L = 9.55$ mH, $C = 63.66$ μF, and $R = 5\Omega$, the amplitude of the fundamental component in the output voltage V_o (in Volts) under steady-state is ___________.

Solution:

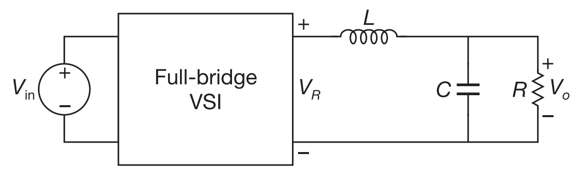
$$V_o = \text{modulation index} \times \frac{2\sqrt{2}V_s}{\pi}$$

$$= 0.7 \times \frac{2\sqrt{2} \times 100}{3.14} = 63.05 \text{ V}$$

Hence, the correct Answer is (63.05).

Question Number: 22 Question Type: NAT

A 3-phase 50 Hz square wave (6-step) VSI feeds a 3-phase, 4 pole induction motor. The VSI line voltage has a dominant 5th harmonic component. If the operating slip of the motor with respect to fundamental component voltage is 0.04, the slip of the motor with respect to 5th harmonic component of voltage is ______.



Solution:

Synchronous speed $N_s = \frac{120 \times 50}{4} = 1500$ rpm

5th harmonic speed $= N_s/5 = 300$ rpm

Slip at 5th harmonic $= \frac{N_s + N_s/5}{N_s}$

$$= \frac{1500 + 300}{1500} = 1.2$$

Hence, the correct Answer is (1.2).

Question Number: 23 Question Type: MCQ

Consider a discrete time signal given by

$$x[n] = (-0.25)^n u[n] + (0.5)^n u[-n-1]$$

The region of convergence of its Z-transform would be:

(A) the region inside the circle of radius 0.5 and centered at origin.

(B) the region outside the circle of radius 0.25 and centered at origin.

(C) the annular region between the two circles, both centered origin and having radii 0.25 and 0.5.

(D) the entire Z plane.

Solution:

Given $x(n) = (-0.25)^n u(n) + (0.5)^n u(-n-1)$

$(-0.25)^n u(n)$ is similar to $(-1)^n u(n)$

So, ROC is

$|Z| > |-0.25|$ and for $(0.5)^n$

$u(-n-1)$ the ROC is $|Z| < |0.5|$

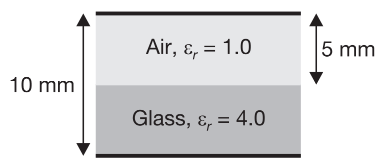
∴ ROC is

$$0.25 < |Z| < 0.5$$

Hence, the correct option is (C).

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

A parallel plate capacitor is partially filled with glass of dielectric constant 4.0 as shown below. The dielectric strengths of air and glass are 30 kV/cm and 300 kV/cm, respectively. The maximum voltage (in kilovolts), which can be applied across the capacitor without any breakdown, is _____.



Solution:

$$C_1 = \frac{\varepsilon_{r_1}\varepsilon_o A}{d} = \frac{\varepsilon_o A}{d}$$

$$C_2 = \frac{\varepsilon_{r_2}\varepsilon_o A}{d} = \frac{4\varepsilon_o A}{d}$$

$$C_{eq} = \frac{C_1C_2}{C_1 + C_2} = \frac{4A\varepsilon_o}{5d}$$

Electric field

$$E = \frac{V}{d}$$

$$\Rightarrow \quad E = \frac{D_n}{\varepsilon_o} = \frac{\rho_s}{\varepsilon_o} = \frac{Q}{A\times\varepsilon_o} = \frac{CV}{A\varepsilon_o} = \frac{C_{eq}\cdot V}{A\varepsilon_o}$$

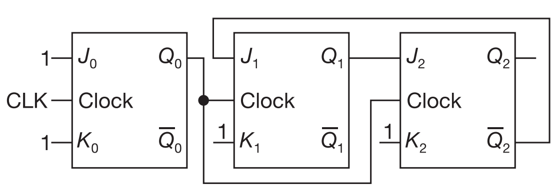
$$30 \times 10^5 = \frac{4\times A\times\varepsilon_o}{5\times5\times10^{-3}} \times \frac{V}{A\varepsilon_o}$$

$$\Rightarrow \quad V = \frac{75}{4}\times10^3 = 18.75 \text{ kV}$$

Hence, the correct Answer is (17 to 20).

Question Number: 25 **Question Type: NAT**

The figure shows a digital circuit constructed using negative edge triggered J-K flip-flops. Assume a starting state of $Q_2\, Q_1\, Q_0 = 000$. This state $Q_2\, Q_1\, Q_0 = 000$ will repeat after ______ number of cycles of the clock CLK.



Solution: By observing the circuit, it is Asynchronous, as well as synchronous circuits.

The output of Q_o is connected as CLK pulse to Q_1, Q_0 flip-flops synchronously.

For Q_0 flip-flop, $J_o = K_o = 1$, so it works as toggle switch $Q_{n+1} = \overline{Q}_n$, for every CLK pulse it will change its state.

$Q_1\, Q_2$ work as synchronous circuit with Q_0 as CLK pulse negative edge CLK ($1 \to 0$)

CLK	Q_2	Q_1	Q_0	J_2 (Q_1)	K_2	$J_1(\overline{Q}_2)$	K_1	J_0	K_0
0	0	0	0	0	1	1	1	1	1
1	0	0	1	0	1	1	1	1	1
2	0	1	0	1	1	1	1	1	1
3	0	1	1	1	1	1	1	1	1
4	1	0	0	0	1	0	1	1	1
5	1	0	1	0	1	0	1	1	1
6	0	0	0	0	1	1	1	1	1
7	0	0	1	0	1	1	1	1	1

Hence, the correct Answer is (6).

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

$f(A, B, C, D) = \prod M(0, 1, 3, 4, 5, 7, 9, 11, 12, 13, 14, 150$ is a maxterm representation of a Boolean function $f(A, B, C, D)$ where A is the MSB and D is the LSB. The equivalent minimized representation of this function is:

(A) $(A + \overline{C} + D)(\overline{A} + B + D)$

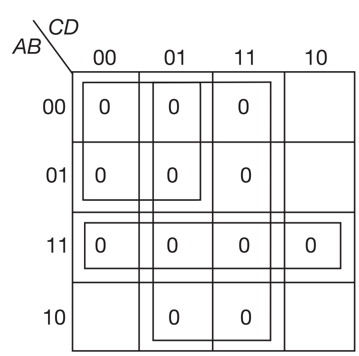
(B) $A\overline{C}D + \overline{A}BD$

(C) $\overline{A}C\overline{D} + A\overline{B}C\overline{D} + A\overline{B}\,\overline{C}\,\overline{D}$

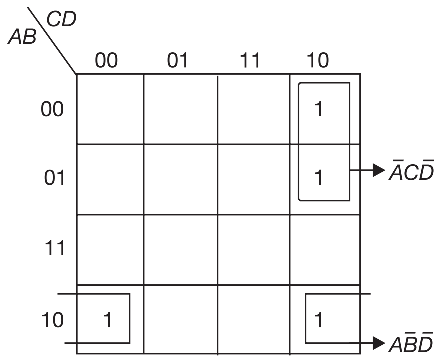
(D) $(B+\overline{C}+D)(A+\overline{B}+\overline{C}+D)(\overline{A}+B+C+D)$

Solution:

$$F(A, B, C, D) = \pi M(0, 1, 3, 4, 5, 7, 9, 11, 12, 13, 14, 15)$$



$\overline{D}(\overline{A}+\overline{B})(A+C)$

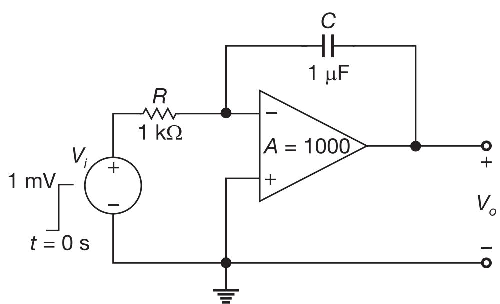


$\bar{A}C\bar{D} + A\bar{B}\bar{D}$

Hence, the correct option is (C).

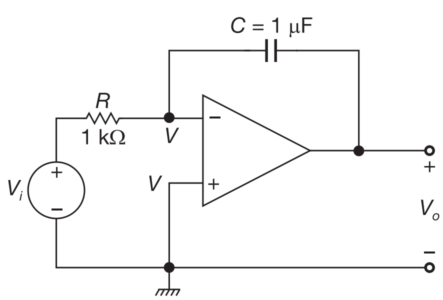
Question Number: 27 **Question Type: MCQ**

The op-amp shown in the figure has finite gain A = 1000 and an infinite input resistance. A step-voltage V_i = 1 mV is applied at the input at time t = 0 as shown. Assuming that the operational amplifier is not saturated, the time constant (in millisecond) of the output voltage V_o is:



(A) 1001 (B) 101
(C) 11 (D) 1

Solution:



$$V_2 = 0;\quad V_o = A\,(V_2 - V_1)$$
$$V_o = -1000V_1$$

$$V_1 = \frac{-V_o}{1000}$$

$$I_R = I_C$$

$$\left(\frac{V_s - V_1}{R}\right) = C\cdot\frac{d}{dt}(V_1 - V_0)$$

$$\left(\frac{V_s + \dfrac{V_0}{1000}}{1000}\right) = C\frac{d}{dt}\left(\frac{-V_0}{1000} - V_0\right)$$

$$10^{-3}\,V_s + 10^{-6}\,V_o = -\frac{10^{-6}}{1000}\frac{d}{dt}[1001V_o]$$

$$10^{-3}\times 10^{-3} + 10^{-6}\,V_o = -1.001\times 10^{-6}\,\frac{dV_o}{dt}$$

$$1 + V_o = -1.001\,\frac{dV_o}{dt}$$

$$\Rightarrow\quad 1.001\frac{dV_o}{dt} + V_o = -1$$

$$\Rightarrow\quad V_o(S) = \frac{-1}{1.001S + 1}$$

Time constant τ = 1.001 sec
T = 1001 msec

Hence, the correct option is (A).

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

A random variable X has probability density function $f(x)$ as given below:

$$f(x) = \begin{cases} a + bx; & \text{for } 0 < x < 1 \\ 0; & \text{otherwise} \end{cases}$$

If the expected value $E[X] = 2/3$, then $\Pr[X < 0.5]$ is _______.

Solution: Given the probability density function of a random variable X is

$$f(x) = \begin{cases} a + bx & \text{for } 0 < x < 1 \\ 0 & \text{otherwise} \end{cases}$$

We know that for any probability density function $f(x)$ of a random variable X,

$$\int_{-\infty}^{\infty} f(x)\,dx = 1$$

$$\Rightarrow \int_{-\infty}^{\infty} 0dx + \int_0^1 (a+bx)\,dx + \int_1^{\infty} 0dx = 1$$

$$\Rightarrow \int_0^1 (a+bx)dx = 1$$

$$\Rightarrow \left. ax + \frac{bx^2}{2} \right]_0^1 = 1$$

$$\Rightarrow a + \frac{b}{2} = 1$$

$$\Rightarrow 2a + b = 2 \qquad (1)$$

Given the expected value of

$$X = E(X) = \frac{2}{3}$$

i.e., $$\int_{-\infty}^{\infty} xf(x)dx = \frac{2}{3}$$

$$\Rightarrow \int_{-\infty}^{0} x \times 0dx + \int_0^1 x \times (a+bx)\,dx + \int_1^{\infty} x \times 0dx = \frac{2}{3}$$

$$\Rightarrow \int_0^1 (ax+bx^2)\,dx = \frac{2}{3}$$

$$\Rightarrow \left. \frac{ax^2}{2} + \frac{bx^3}{3} \right]_0^1 = \frac{2}{3}$$

$$\Rightarrow \frac{a}{2} + \frac{b}{3} = \frac{2}{3}$$

$$\Rightarrow 3a + 2b = 4 \qquad (2)$$

Solving Equations (1) and (2), we get $a = 0$ and $b = 2$

$\therefore f(x)$ becomes

$$f(x) = \begin{cases} 2x & \text{for } 0 < x < 1 \\ 0 & \text{otherwise} \end{cases}$$

Now $$P(x < 0.5) = \int_{-\infty}^{0.5} f(x)\,dx$$

$$= \int_{-\infty}^{0} 0dx + \int_0^{0.5} 2xdx$$

$$= \left. x^2 \right]_0^{0.5}$$

$$= (0.5)^2$$

$$= 0.25.$$

Hence, the correct Answer is (0.25).

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

If a continuous function $f(x)$ does not have a root in the interval $[a, b]$, then which one of the following statements is TRUE?

(A) $f(a) \cdot f(b) = 0$ (B) $f(a) \cdot f(b) < 0$

(C) $f(a) \cdot f(b) > 0$ (D) $f(a)/f(b) \leq 0$

Solution: As $f(x)$ is continuous in $[a, b]$ and $f(x)$ has no root in $[a, b]$, $f(x)$ does not cut x-axis for all x in $[a, b]$

$\Rightarrow f(x)$ is either above x-axis or below x-axis for both $x = a$ and $x = b$

$\Rightarrow f(a)$ and $f(b)$ are both positive or both negative

$$\Rightarrow f(a) \cdot f(b) > 0$$

Hence, the correct option is (C).

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

If the sum of the diagonal elements of a 2 × 2 matrix is –6, then the maximum possible value of determinant of the matrix is _______.

Solution: Let A be a 2 × 2 matrix with the sum of the diagonal elements as –6

Let λ_1 and λ_2 be the eigen values of A

$\therefore$ The sum of the diagonal elements of $A = -6$

$$\Rightarrow \lambda_1 + \lambda_2 = -6 \qquad (1)$$

$$\text{Det of } A = |A| = \lambda_1\lambda_2$$

Now we have to find the maximum value of $\lambda_1\lambda_2$

Let $$f = \lambda_1\lambda_2$$

$$= \lambda_1(-6 - \lambda_1)$$

[from Equation (1)]

$$\therefore f = -6\lambda_1 - \lambda_1^2$$

$$\Rightarrow f^1 = -6 - 2\lambda_1$$

For f to have maximum,

$$f^1 = 0$$

$$\Rightarrow -6 - 2\lambda_1 = 0$$

$$\Rightarrow \lambda_1 = -3$$

Now $$f^{11} = -2 < 0$$

$\therefore f$ has a maximum at $\lambda_1 = -3$

From Equation (1),

$$\lambda_1 + \lambda_2 = -6$$

$$\Rightarrow \quad -3 + \lambda_2 = -6$$
$$\Rightarrow \quad \lambda_2 = -3$$

The maximum value of the determinant of $A = \lambda_1 \lambda_2$
$$= (-3) \times (-3) = 9.$$

Hence, the correct Answer is (9).

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

Consider a function $\vec{f} = \frac{1}{r^2}\hat{r}$, where r is the distance from the origin and $\hat{r}$ is the unit vector in the radial direction. The divergence of this function over a sphere of radius R, which includes the origin, is:

(A) 0 (B) 2π
(C) 4π (D) $R\pi$

Solution:

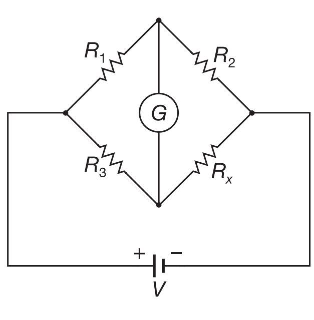
$$\nabla \bar{f} = \frac{\partial}{\partial r}(r^2 f_r) + \frac{1}{r \sin\theta}\frac{\partial}{\partial \theta}(f_\theta \sin\theta) + \frac{1}{r \sin\theta}\frac{\partial}{\partial \theta}(f_\theta \sin\theta) + \frac{1}{r \sin\theta}\frac{\partial}{\partial \theta}(f_\theta)$$

$$\nabla \bar{f} = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 \times \frac{1}{r^2}\right) = 0$$

Hence, the correct option is (A).

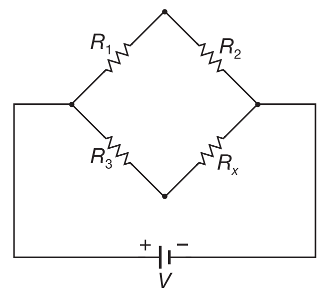
Question Number: 32 **Question Type: MCQ**

When the Wheatstone bridge shown in the figure is used to find the value of resistor R_x, the galvanometer G indicates zero current when $R_1 = 50\Omega$, $R_2 = 65\Omega$ and $R_3 = 100\Omega$. If R_3 is known with ±5% tolerance on its nominal value of 100Ω, what is the range of R_x in Ohms?



(A) [123.50, 136.50]
(B) [125.89, 134.12]
(C) [117.00, 143.00]
(D) [120.25, 139.75]

Solution:



Given $R_1 = 50\Omega$
$R_2 = 65\Omega$
$R_3 = 100\Omega$

R_3 tolerance ±5%

Then $R_3 = 95 \Rightarrow 105$

When bridge is balanced
$$R_1 R_x = R_2 R_3$$

When $R_3 = 95 \Rightarrow 50R_x = 65 \times 95$
$$R_x = \frac{65 \times 95}{50} = 123.5\Omega$$

When $R_3 = 105 \Rightarrow 50 R_x = 65 \times 105$
$$R_x = \frac{65 \times 105}{50} = 136.5\Omega$$

Hence, the correct option is (A).

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

A (0–50 A) moving coil ammeter has a voltage drop of 0.1 V across its terminals at full scale deflection. The external shunt resistance (in milliohms) needed to extend its range to (0–500 A) is ________.

Solution: Voltage drop of (0–50 A) ammeter is
$$= 0.1 \text{ V}$$

External shunt resistance
$$R_{sh} = ?$$

Extend range–(0–500 A)
$$I = 50 \text{ A}$$
$$I_m = 500 \text{ A}$$

Voltage drop $IR_m = 0.1$
$$R_m = \frac{0.1}{50} = 2 \text{ m}\Omega$$

Shunt resistance $R_{sh} = \dfrac{R_m}{\left[\left(\frac{I_m}{I}\right) - 1\right]}$

$$= \frac{2\times10^{-3}}{\left[\left(\frac{500}{50}\right)-1\right]}$$

$$= 2.22 \times 10^{-4}$$

$$= 0.22 \text{ m}\Omega$$

Hence, the correct Answer is (0.22 to 0.23).

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

Of the four characteristics given below, which are the major requirements for an instrumentation amplifier?

P. High common mode rejection ratio
Q. High input impedance
R. High linearity
S. High output impedance

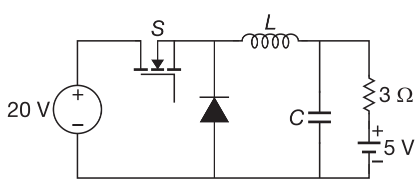
(A) P, Q and R only (B) P and R only
(C) P, Q and S only (D) Q, R and S only

Solution: Instrumentation amplifier has to amplify small changes in the bridge circuit. So, for ideal instrumentation amplifier high CMMR, high, input impedance, high, linearity and low output impedance required.

Hence, the correct option is (A).

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

In the following chopper, the duty ratio of switch is 0.4. If the inductor and capacitor are sufficiently large to ensure continuous inductor current and ripple free capacitor voltage, the charging current (in Ampere) of the 5 V battery, under steady-state is ______.



Solution: Given data duty ratio $\delta = 0.4$

Input voltage $V_i = 20$ V
Battery voltage $E = 5$ V
Resistance $R = 3\Omega$
Output voltage $V_o = \delta V_i$
$V_o = 0.4 \times 20 = 8$ V

Charging current

$$I = \frac{V_o - E}{R} = \frac{3}{3} = 1 \text{ A}$$

Hence, the correct Answer is (1).

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

A moving average function is given by

$$y(t) = \frac{1}{T}\int_{t-T}^{t} u(\tau)\,d\tau.$$

If the input u is a sinusoidal signal of frequency $\frac{1}{2T}$ Hz, then in steady-state, the output y will lag u (in degree) by ______.

Solution:

$$u(\tau) = \sin \omega\tau$$

$$y(t) = \frac{1}{T}\int_{t-T}^{t} \sin(\omega\tau)\,d\tau = \left.\frac{\cos(\omega\tau)}{\omega\tau}\right|_{t}^{t-\tau}$$

$$= \frac{1}{\pi}\,[\cos \omega\,(t-\tau) - \cos \omega t]$$

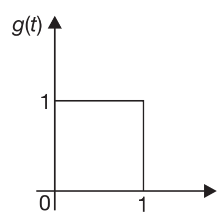
$$y(t) = -\frac{2}{\pi}\cos \omega t = \frac{2}{\pi}\sin(90 + \omega t)$$

$y(t)$ will lag u by 90°

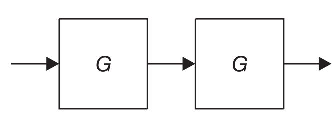
Hence, the correct Answer is (90°).

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

The impulse response $g(t)$ of a system G, is as shown in Figure (a). What is the maximum value attained by the impulse response of two cascaded blocks of G as shown in Figure (b)?



(a)



(b)

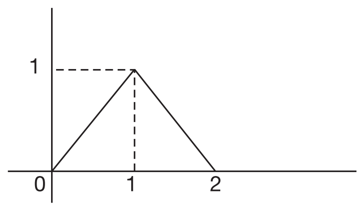
(A) $\frac{2}{3}$ (B) $\frac{3}{4}$

(C) $\frac{4}{5}$ (D) 1

Solution: Given

$$h(t) = g(t) \times g(t)$$

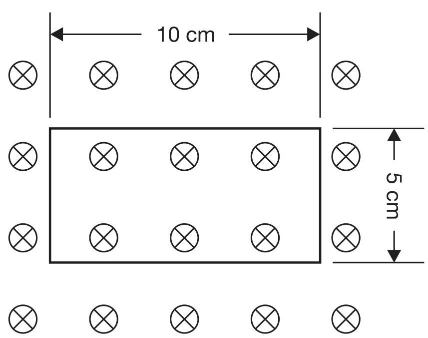
The $h(t)$ waveform



So, maximum value of cascaded response is 1.
Hence, the correct option is (D).

Question Number: 38 **Question Type: NAT**

Consider a one-turn rectangular loop of wire placed in a uniform magnetic field as shown in the figure. The plane of the loop is perpendicular to the field lines. The resistance of the loop is 0.4Ω, and its inductance is negligible. The magnetic flux density (in Tesla) is a function of time, and is given by $B(t) = 0.25 \sin \omega t$, where $\omega = 2\pi \times 50$ radian/second. The power absorbed (in Watt) by the loop from the magnetic field is _____.



Solution: Resistance of loop

$$R = 0.4\Omega; \quad B(t) = 0.25 \sin \omega t$$
$$\omega = 2\pi \times 50 \text{ radian/second}$$

flux $$\phi = \int B \cdot ds = \frac{1}{800} \sin \omega t$$

$$V = -\frac{d\phi}{dt} = \frac{-1}{8} \pi \cos \omega t$$

$$P = \frac{V^2}{R} = \frac{\pi^2}{64R} \cos^2 \omega t$$

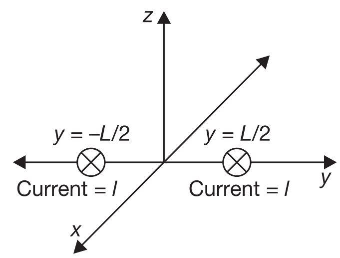
$$P = \frac{\pi^2}{0.4 \times 64} \left(\frac{1 + \cos 2\omega t}{2} \right)$$

$$P_{avg} = \frac{\pi^2}{2 \times 0.4 \times 64} = 0.193$$

Hence, the correct Answer is (0.193).

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

A steady current I is flowing in the x-direction through each of two infinitely long wires at $y = \pm\frac{L}{2}$ as shown in the figure. The permeability of the medium is μ_0. The $\vec{B}$-field at (0, L, 0) is:



(A) $-\frac{4\mu_0 t}{3\pi L}\hat{Z}$ (B) $+\frac{4\mu_0 I}{3\pi L}\hat{Z}$

(C) 0 (D) $-\frac{3\mu_0 I}{4\pi L}\hat{Z}$

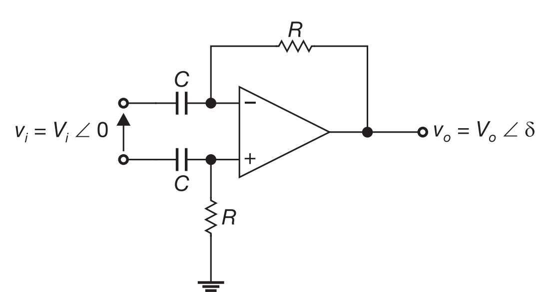
Solution:

$$H = H_1 + H_2$$
$$= \frac{I}{2\pi(L/2)}(-a_z) + \frac{I}{2\pi\left(\frac{3L}{2}\right)}$$
$$= \frac{4I}{3\pi L}(-a_z); \; B = \mu_o H$$

Hence, the correct option is (A).

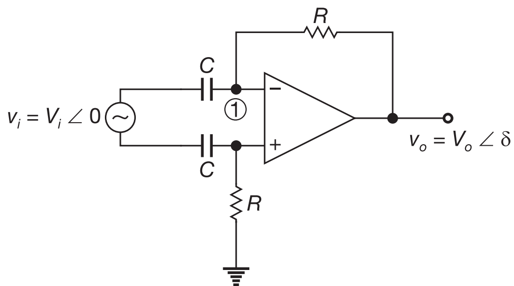
Question Number: 40 **Question Type: MCQ**

Consider the circuit shown in the figure. In this circuit $R = 1$ kΩ, and $C = 1$ μF. The input voltage is sinusoidal with a frequency of 50 Hz, represented as a phasor with magnitude V_i and phase angle 0 radian as shown in the figure. The output voltage is represented as a phasor with magnitude V_o and phase angle δ radian. What is the value of the output phase angle δ (in radian) relative to the phase angle of the input voltage?



(A) 0 (B) π
(C) $\pi/2$ (D) $-\pi/2$

Solution:



By considering virtual grounding concept the nodal equation at node (1) is

$$\frac{0 - V_i \angle 0^o}{X_C} + \frac{0 - V_o \angle \delta}{R} = 0$$

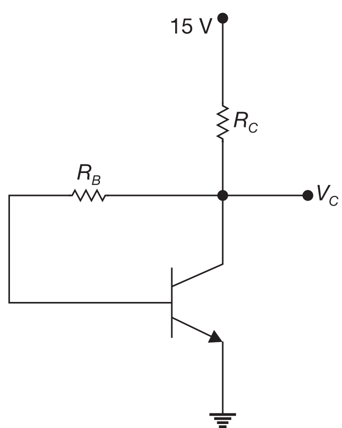
$$V_o \angle \delta = -j\omega RC\, V_i \angle 0°$$

$$\delta = -90°$$

Hence, the correct option is (D).

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

In the given circuit, the silicon transistor has $\beta = 75$ and a collector voltage $V_C = 9$ V. Then the ratio of R_B and R_C is ______.



Solution:

Given $\beta = 75$; $V_C = 9$ V

Collector equation

$\Rightarrow$ $15 - 9 - (I_C + I_B) R_C = 0$

$$76 I_B R_C = 6 \quad (1)$$

Base $\Rightarrow$ $15 - 76 I_B R_C - I_B R_B - 0.7 = 0$

$\Rightarrow$ $15 - 6.7 = I_B R_B$

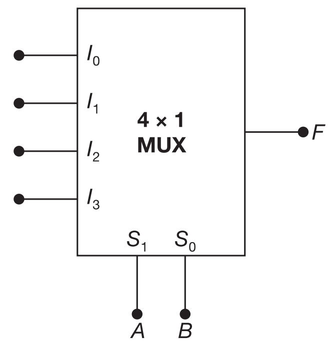
$\Rightarrow$ $I_B R_B = 8.3 \quad (2)$

$$\frac{(2)}{(1)} \frac{R_B}{R_C} = \frac{8.3 \times 76}{6} = 105.133$$

Hence, the correct Answer is (105.133).

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

In the 4 × 1 multiplexer, the output F is given by $F = A + B$. Find the required input '$I_3\, I_2\, I_1\, I_0$'.



(A) 1010 (B) 0110
(C) 1000 (D) 1110

Solution:

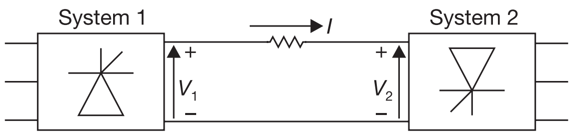
$$F = A + B = \bar{A}B + A\bar{B}$$

$S_1\, S_0$
$\bar{A}\bar{B} - 0 - I_0$
$A\bar{B} - 1 - I_1$
$\bar{A}B - 1 - I_2$
$\bar{A}\bar{B} - 0 - I_3$

Hence, the correct option is (B).

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

Consider a HVDC link which uses thyristor based line-commutated converters as shown in the figure. For a power flow of 750 MW from system 1 to system 2, the voltages at the two ends, and the current, are given by: $V_1 = 500$ kV, $V_2 = 485$ kV and $I = 1.5$ kA. If the direction of power flow is to be reversed (that is, from system 2 to system 1) without changing the electrical connections, then which one of the following combinations is feasible?



(A) $V_1 = -500$ kV, $V_2 = -485$ kV and $I = 1.5$ kA
(B) $V_1 = -485$ kV, $V_2 = -500$ kV and $I = 1.5$ kA
(C) $V_1 = 500$ kV, $V_2 = 485$ kV and $I = -1.5$ kA
(D) $V_1 = -500$ kV, $V_2 = -485$ kV and $I = -1.5$ kA

Solution: For reversing power flow in HVDC system the direction of current same.

$$I = \frac{V_1 - V_2}{R}$$

Option (A): $V_1 = -500$ kV, $V_2 = -485$ kV
$I = -1.5$ kA

Option (B): $V_1 = -485$ kV, $V_2 = -500$ kV
$I = 1.5$ kA

Hence, the correct option is (B).

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

Base load power plants are:

P: wind farms.
Q: run-of-river plants.
R: nuclear power plants.
S: diesel power plants.

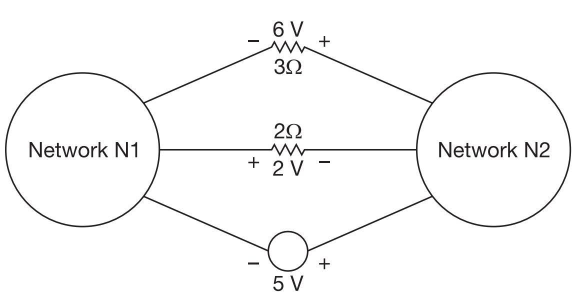
(A) P, Q and S only (B) P, R and S only
(C) P, Q and R only (D) Q and R only

Solution: Diesel power plants are peak load plants and wind plants are base load plants because once wind plants comes into operation it used for all times because no fuel cost.

Hence, the correct option is (C).

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

The voltages developed across the 3Ω and 2Ω resistors shown in the figure are 6 V and 2 V respectively, with the polarity as marked. What is the power (in Watt) delivered by the 5 V voltage source?

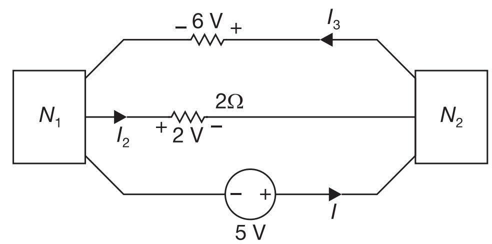


(A) 5
(B) 7
(C) 10
(D) 14

Solution:

Given $$I_3 = \frac{6}{3} = 2$$

$$I_2 = \frac{2}{2} = 1$$



$$I + I_2 = I_3$$
$$I + 1 = 2 \Rightarrow 1 \text{ A}$$

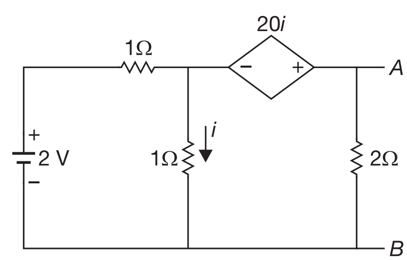
Power of voltage source

$$P = VI = 5 \text{ W}$$

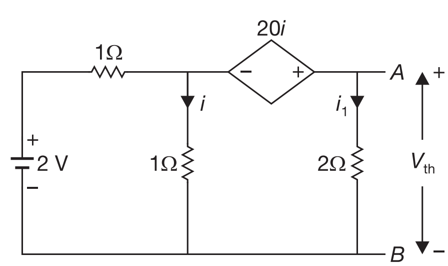
Hence, the correct option is (A).

Question Number: 46 **Question Type: NAT**

For the given circuit, the Thevenin equivalent is to be determined. The Thevenin voltage, V_{th} (in Volt), seen from terminal AB is ______.



Solution: Given



$$V_{th} = 2i_1$$

$$2 = 1\,(i + i_1) + i$$

$$2 = 2i + i_1 \qquad (1)$$

$$21i = 2i_1 \Rightarrow i_1 = \frac{21}{2}i \qquad (2)$$

Solving Equation (1) and (2),

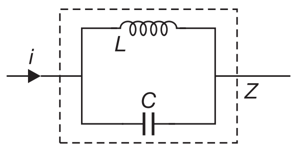
$$i_1 = 1.68\text{ A}$$

$$V_{th} = 2i_1 = 2 \times 1.68 = 3.36\text{ V}$$

Hence, the correct Answer is (3.36 V).

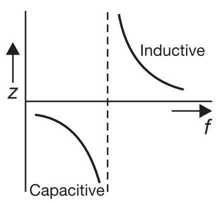
Question Number: 47 Question Type: MCQ

An inductor is connected in parallel with a capacitor as shown in the figure.

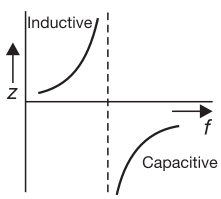


As the frequency of current i is increased, the impedance (Z) of the network varies as:

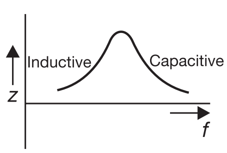
(A)



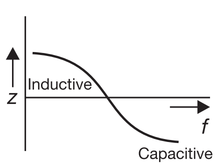
(B)



(C)



(D)



Solution:

$$Z = \frac{Z_L\, Z_C}{Z_L + Z_C} = \frac{j\omega L \times \frac{1}{j\omega c}}{j\omega L + \frac{1}{j\omega c}}$$

$$Z = j\left[\frac{\omega L}{1 - \omega^2 LC}\right]$$

For different frequencies the curves similar to option (B).

Question Number: 48 Question Type: MCQ

A separately excited DC generator has an armature resistance of 0.1Ω and negligible armature inductance. At rated field current and rated rotor speed, its open-circuited voltage is 200 V. When this generator is operated at half the rated speed, with half the rated field current, an uncharged 1000 μF capacitor is suddenly connected across the armature terminals. Assume that the speed remains unchanged during the transient. At the time (in microsecond) after the capacitor is connected will the voltage across it reach 25 V?

(A) 62.25 (B) 69.3
(C) 73.25 (D) 77.3

Solution: Armature resistance

$$R_a = 0.1\Omega$$

rated field current and rated rotor speed open circuit voltage

$$E_1 = 200\text{ V}$$

With half rated field current and half rated speed

i.e., $\frac{\phi_1}{2}$ and $\frac{N_1}{2}$

Capacitance $C = 1000\ \mu\text{F}$

$$E \propto N$$

$$\Rightarrow \quad \frac{E_1}{E_2} = \frac{\phi_1 N_1}{\phi_2 N_2}$$

$$\Rightarrow \quad \frac{200}{E_2} = \frac{\phi_1 N_1}{\frac{\phi_1}{2} \times \frac{N_1}{2}} \Rightarrow E_2 = 50\text{ V}$$

$$\tau = RC = 0.1 \times 1000 \times 10^{-6}$$

$$E = 2000e^{-t/RC}$$

$$50 = 2000e^{-t/(0.1\times 1000\times 10^{-6})}$$

$$t = 69.3\ \mu s$$

Hence, the correct option is (B).

Question Number: 49 Question Type: MCQ

The self inductance of the primary winding of a single phase, 50 Hz, transformer is 800 mH, and that of the secondary winding is 600 mH. The mutual inductance between these two windings is 480 mH. The secondary winding of this transformer is short circuited and the primary winding is connected to a 50 Hz, single phase, sinusoidal voltage source. The current flowing in both the windings is less than their respective rated currents. The resistance of both windings can be neglected. In this condition, what is the effective inductance (in mH) seen by the source?

(A) 416 (B) 440
(C) 200 (D) 920

Solution:

$$L_1 = 800 \text{ mH}$$
$$L_2 = 600 \text{ mH}$$
$$M = 480 \text{ mH}$$
$$jX_L = \left(jX_1 + \frac{\omega^2 M^2}{jX_2^2} \right)$$
$$L_{\text{eff}} = \left[314 \times 0.8 - \frac{314^2 \times 0.48}{0.6 \times 314} \right] \Big/ 314$$
$$= \frac{130.744}{314}$$
$$L_{\text{eff}} = 416 \text{ mH}$$

Hence, the correct option is (A).

Question Number: 50 **Question Type: MCQ**

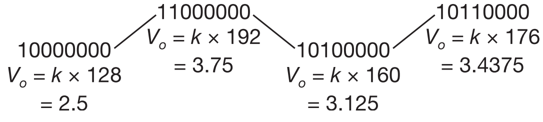
An 8-bit, unipolar Successive Approximation Register type *ADC* is used to convert 3.5 V to digital equivalent output. The reference voltage is + 5 V. The output of the *ADC*, at the end of 3rd clock pulse after the start of conversion, is

(A) 1010 0000 (B) 1000 0000
(C) 0000 0001 (D) 0000 0011

Solution: 8-bit SAR type *ADC*, reference voltage = +5 V

$$k = \text{resolution} = \frac{5}{2^8} = 0.0195$$

input = 3.5 V



Hence, the correct option is (A).

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

Consider the economic dispatch problem for a power plant having two generating units. The fuel costs in ₹/MWh along with the generation limits for the two units are given below:

$$C_1(P_1) = 0.01P_1^2 + 30P_1 + 10;$$
$$100 \text{ MW} \le P_1 \le 150 \text{ MW}$$
$$C_2(P_2) = 0.05P_2^2 + 10P_2 + 10;$$
$$100 \text{ MW} \le P_2 \le 180 \text{ MW}$$

The incremental cost (in ₹/MWh) of the power plant when it supplies 200 MW is _______.

Solution: Given

$$G(P_1) = 0.01P_1^2 + 30P_1 + 10;$$
$$100 \text{ MW} \le P_1 \le 150 \text{ MW}$$
$$C_2(P_2) = 0.05P_2^2 + 10P_2 + 10;$$
$$10 \text{ MW} \le P_2 \le 180 \text{ MW}$$
$$P_1 + P_2 = 200 \text{ MW} \quad (1)$$
$$\frac{dC_1}{dP_1} = \frac{dC_2}{dP_2}$$
$$0.02P_1 + 30 = 0.1P_2 + 10$$
$$0.1P_2 - 0.02P_1 = 20 \quad (2)$$

By solving Equations (1) and (2)

$$P_2 = 200; P_1 = 0$$

But P_2 is more than maximum limit therefore the load distribution between the units is $P_1 = 100$ MW and

$$P_2 = 100 \text{ MW}$$
$$\Rightarrow \quad \frac{dC_2}{dP_2} = 20 \text{ ₹/MWh}$$

Hence, the correct Answer is (20).

Question Number: 52 **Question Type: MCQ**

Determine the correctness or otherwise of the following Assertion [*a*] and the Reason [*r*].

Assertion: Fast decouples load flow method gives approximate load flow solution because it uses several assumptions.

Reason: Accuracy depends on the power mismatch vector tolerance.

(A) both [*a*] and [*r*] are true and [*r*] is the correct reason for [*a*].
(B) both [*a*] and [*r*] are true but [*r*] is not the correct reason for [*a*].
(C) both [*a*] and [*r*] are false.
(D) [*a*] is false and [*r*] is true.

Solution:

Hence, the correct option is (D).

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

A 50 Hz generating unit has H-constant of 2 mJ/MVA. The machine is initially operating in steady-state at synchronous speed, and producing 1 pu of real power. The initial value of the rotor angle δ is 5°, when a bolted three phase to ground short circuit fault occurs at the terminal of the generator. Assuming the input mechanical power to remain at 1 pu, the value of δ in degrees, 0.02 second after the fault is _____.

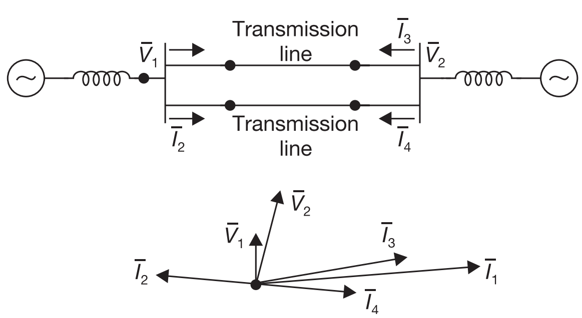
Solution: Given

$$H = 2 \text{ mJ/MVA}$$
$$P = 1 \text{ p.u.}$$
$$\delta_o = 5°$$
$$t_{cr} = 0.02$$
$$P_m = 1 \text{ p.u.}$$
$$t_{cr} = \sqrt{\frac{2H(\delta_{cr} - \delta_o)}{\pi f P_m}}$$
$$0.02 = \sqrt{\frac{2 \times 2(\delta_{cr} - 50°)}{\pi \times 50 \times 1}}$$
$$\delta_{cr} = 5.90°$$

Hence, the correct Answer is (5.90°).

Question Number: 54 **Question Type: MCQ**

A sustained three-phase fault occurs in the power system shown in the figure. The current and voltage phasors during the fault (on a common reference), after the natural transients have died down, are also shown. Where is the fault located?



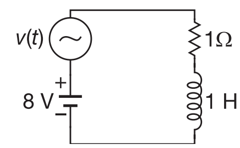
(A) Location P (B) Location Q
(C) Location R (D) Location S

Solution: The Voltage magnitude of BUS 1 is small therefore the fault is at Q (or) R. The direction of I_2 and I_4 are quite opposite then there is not fault at R.

Hence, the correct option is (B).

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

The circuit shown in the figure has two sources connected in series. The instantaneous voltage of the AC source (in Volts) is given by $v(t) = 12 \sin t$. If the circuit is in steady-state, then the rms value of the current (in Ampere) flowing in the circuit is _______.



Solution: Given

$$V = 12 \sin t$$
$$V = 8 \text{ V}$$
$$I_{dc} = \frac{8}{1} = 8 \text{ A}$$
$$I_{AC\,max} = \frac{12}{\sqrt{1^2 + 1^2}} = 8.485 \text{ A}$$
$$I_{rms} = \sqrt{I_{dc}^2 + \left(\frac{I_{AC\,m}}{\sqrt{2}}\right)^2}$$
$$= \sqrt{8^2 + \frac{8.485^2}{2}} = 9.99 \text{ A}$$

Hence, the correct Answer is (9.99 A).

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

In a linear two-port network, when 10 V is applied to Port 1, a current of 4 A flows through Port 2 when it is short-circuited. When 5 V is applied to Port 1, a current of 1.25 A flows through a 1Ω resistance connected across Port 2. When 3 V is applied to Port 1, the current (in Ampere) through a 2Ω resistance connected across Port 2 is ______.

Solution: Consider Y-parameter two port network

$$I_1 = y_{11} V_1 + y_{22} V_2$$
$$I_2 = y_{21} V_1 + y_{22} V_2$$

When port-2 short circuited

$$V_2 = 0$$
$$y_{21} = \frac{I_2}{V_1} = \frac{4}{10} = 0.4$$

In second case: $1.25 = 0.4 \times 5 + 1.25 y_{22}$

$$y_{22} = -0.6$$

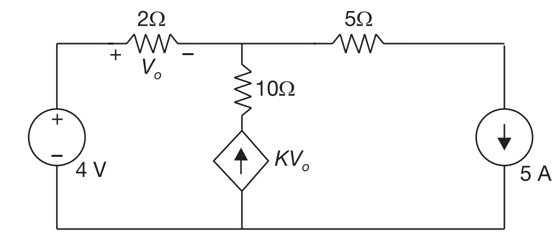
⇒ at 3 V supply $I_2 = 3 \times 0.4 - 0.6\,(2I_2)$

$\Rightarrow \quad I_2 = 0.545$ A

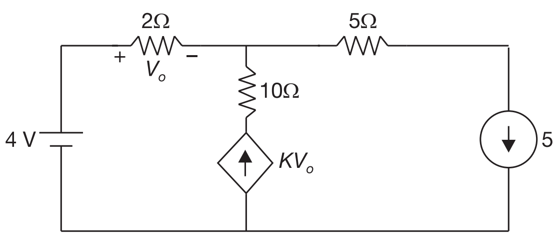
Hence, the correct Answer is (0.5454).

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

In the given circuit, the parameter k is positive, and the power dissipated in the 2Ω resistor is 12.5 W. The value of k is ______



Solution: Given



Power dissipation in 2Ω resistor

$$\frac{V^2}{R} = 12.5 \text{ W}$$

$\Rightarrow \quad V_0^2 = 12.5 \times 2$

$\Rightarrow \quad V_o = 5$ V

Current in 2Ω resistor

$$= \frac{V_o}{2} = 2.5 \text{ A}$$

KCL–nodal analysis $2.5 + kV_o = 5$

$$K = \frac{2.5}{5} = 0.5$$

Hence, the correct Answer is (0.5).

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

A separately excited DC motor runs at 1000 rpm on no load when its armature terminals are connected to a 200 V DC source and the rated voltage is applied to the field winding. The armature resistance of this motor is 1Ω. The no-load armature current is negligible. With the motor developing its full load torque, the armature voltage is set so that the rotor speed is 500 rpm. When the load torque is reduce to 50% of the full load value under the same armature voltage conditions, the speed rises to 520 rpm. Neglecting the rotational losses, the full load armature current (in Ampere) is ______.

Solution:

Given $\quad N_1 = 1000$ rpm

$V = 200$ V

$R_a = 1\Omega$

No load back e.m.f.

$E_{b1} = 200$ V

$N_2 = 500$ rpm

$T_3 = 0.5T_2$

$N_3 = 520$ rpm

$$\frac{E_{b_1}}{E_{b_2}} = \frac{1000}{500} \Rightarrow E_{b2} = 100 \text{ V}$$

$$100 = V - I_{a2} \qquad (1)$$

$$\frac{E_{b_1}}{E_{b_2}} = \frac{1000}{500} \Rightarrow E_{b3} = 104$$

$$104 = V - I_{a3} \qquad (2)$$

$$\frac{T_2}{T_3} \propto \frac{I_{a2}}{I_{a3}} \Rightarrow \frac{T_2}{0.5T_2} = \frac{I_{a2}}{I_{a3}} \Rightarrow I_{a3} = \frac{I_{a2}}{2} \qquad (3)$$

Solving Equation (1), (2) and (3)

$I_{a2} = 8$ A

Hence, the correct Answer is (8).

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

A DC motor has the following specifications: 10 hp, 37.5 A, 230 V; flux/pole = 0.01 Wb, number of poles = 4, number of conductors = 666, number of parallel paths = 2. Armature resistance = 0.267Ω. The armature reaction is negligible and rotational losses are 600 W. The motor operates from a 230 V DC supply. If the motor runs at 1000 rpm, the output torque produced (in Nm) is ________.

Solution: Given flux/pole

$\phi = 0.01\omega b$

$P = 4$

$Z = 666$

Parallel path $\quad A = 2$

Armature resistance

$R_a = 0.267\Omega$

Rotational losses $\quad = 600\omega$

Supply voltage $V = 230$ V

Speed $N = 1000$ rpm

$$E_b = \frac{\phi ZN}{60} \times \frac{P}{A}$$

$$E_b = \frac{0.01 \times 666 \times 1000}{60} \times \frac{4}{2}$$

$$E_b = 222 \text{ V}$$

$$I_a = \frac{V - E_b}{R_a} = \frac{230 - 222}{0.267}$$

$$= 29.96 \text{ A}$$

Output power $= E_b I_a - 600$

$= 222 \times 29.96 - 600$

$= 6051.12$ W

Output torque $= \dfrac{P_{\text{out}}}{W} = \dfrac{6051.12}{\dfrac{2\pi \times 1000}{60}}$

$= 57.78$ N-m

Hence, the correct Answer is (57.78).

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

A 200/400 V, 50 Hz, two-winding transformer is rated at 20 kVA. Its windings are connected as an auto transformer of rating 200/600 V. A resistive load of 12Ω is connected to the high voltage (600 V) side of the auto-transformer. The value of equivalent load resistance (in Ohm) as seen from low voltage side is ______.

Solution: Transformation ratio

$$K = \frac{600}{200} = 3$$

Resistive load $= 12\Omega$

Load resistance on primary side

$$= \frac{12}{9} = 1.33\Omega$$

Hence, the correct Answer is (1.33Ω).

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

Two single-phase transformers T_1 and T_2 each rated at 500 kVA are operated in parallel. Percentage impedances of T_1 and T_2 are $(1 + j6)$ and $(0.8 + j4.8)$, respectively. To share a load of 1000 kVA at 0.8 lagging power factor, the contribution of T_2(in kVA) is _____.

Solution: Given

$$Z_1 = 1 + j6; \quad Z_2 = 0.8 + j4.8$$

$$S_L = 1000 \text{ kVA}$$

$$\cos\phi = 0.8$$

$$S_{T2} = S \times \frac{Z_1}{Z_1 + Z_2} = 1000 \times \frac{6.08}{10.94}$$

$$= 555.75 \text{ kVa}$$

Hence, the correct Answer is (555.75 kVA).

Question Number: 62 **Question Type: MCQ**

In the signal flow diagram given in the figure, u_1 and u_2 are possible inputs whereas y_1 and y_2 are possible outputs. When would the SISO system derived from this diagram be controllable and observable?

(A) When u_1 is the only input and y_1 is the only output.

(B) When u_2 is the only input and y_1 is the only output.

(C) When u_1 is the only input and y_2 is the only output.

(D) When u_2 is the only input and y_2 is the only output.

Solution: From the given block diagram

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \end{bmatrix} = \begin{bmatrix} 5 & -2 \\ 2 & 1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u_1 + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u_2$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix}$$

By considering U_2 is input and y_1 is output. The state equations becomes

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \end{bmatrix} = \begin{bmatrix} 5 & -2 \\ 2 & -1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u_2$$

$$y_1 = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix}$$

$$AB = \begin{bmatrix} 5 & -2 \\ 2 & -1 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} -2 \\ 1 \end{bmatrix}$$

$$Q_c = \begin{bmatrix} B & AB \end{bmatrix} = \begin{bmatrix} 0 & -2 \\ 1 & 1 \end{bmatrix}$$

$\det(Q_C) = 2$ ($\therefore$ controllable)

$$CA = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} 5 & -2 \\ 2 & 1 \end{bmatrix} = \begin{bmatrix} 5 & -2 \end{bmatrix}$$

$$Q_o = \begin{bmatrix} C \\ A \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 5 & -2 \end{bmatrix}$$

det (Q_0) = –2 (observable)

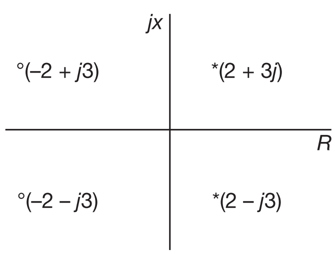
Hence, the correct option is (B).

Question Number: 63 **Question Type: MCQ**

The transfer function of a second order real system with a perfectly flat magnitude response of unity has a pole at $(2 - j3)$. List all the poles and zeroes.

(A) Poles at $(2 \pm j3)$, no zeroes.
(B) Poles at $(\pm 2 - j3)$, one zero at origin.
(C) Poles at $(2 - j3)$, $(-2 + j3)$, zeroes at $(-2 - j3)$, $(2 + j3)$
(D) Poles at $(2 \pm j3)$, zeroes at $(-2 \pm j3)$

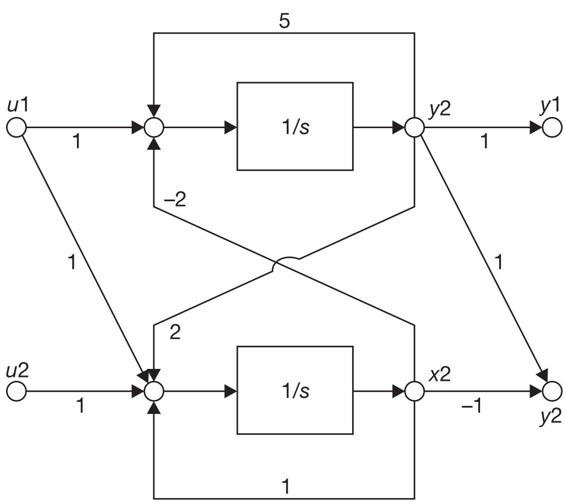
Solution: The second order real system for flat magnitude is

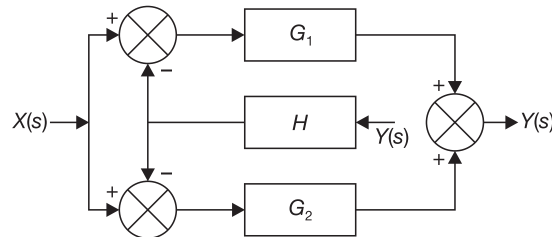


Hence, the correct option is (D).

Question Number: 64 **Question Type: MCQ**

Find the transfer function $\frac{Y(s)}{X(s)}$ of the system given below.





(A) $\frac{G_1}{1 - HG_1} + \frac{G_2}{1 - HG_2}$

(B) $\frac{G_1}{1 + HG_1} + \frac{G_2}{1 + HG_2}$

(C) $\frac{G_1 + G_2}{1 + H(G_1 + G_2)}$

(D) $\frac{G_1 + G_2}{1 - H(G_1 + G_2)}$

Solution: The given block diagram can be analyzed by signal flow graph two forward paths of magnitude $= G_1, G_2$.

Two loops of magnitude

$$= -G_1 H, -G_2 H$$

By masons gain formula

$$T(s) = \frac{G_1 + G_2}{1 + G_1 H + G_2 H}$$

Hence, the correct option is (C).

Question Number: 65 **Question Type: MCQ**

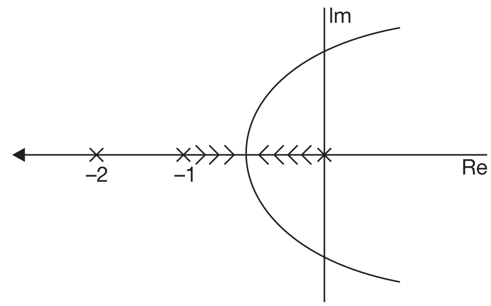
The open loop poles of a third order unity feedback system are at 0, –1, –2. Let the frequency corresponding to the point where the root locus of the system transits to unstable region be K. Now suppose we introduce a zero in the open loop transfer function at –3, while keeping all the earlier open loop poles intact. Which one of the following is TRUE about the point where the root locus of the modified system transits to unstable region?

(A) It corresponds to a frequency greater than K
(B) It corresponds to a frequency less than K
(C) It corresponds to a frequency K
(D) Root locus of modified system never transits to unstable region.

Solution: Given open loop transfer function

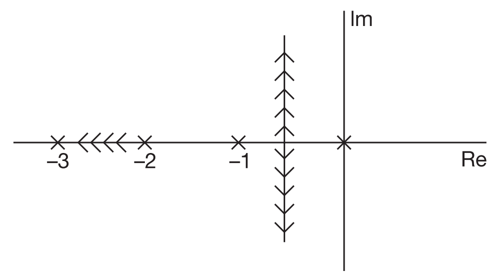
$$T_1 = \frac{K}{S(S+1)(S+2)}$$

The root locus plot is like.



By adding zero the transfer function and root locus plots

$$T_2 = \frac{K(S+3)}{S(S+1)(S+2)}$$



So, in second case the root locus plot never goes to right hand side.

Hence, the correct option is (D).