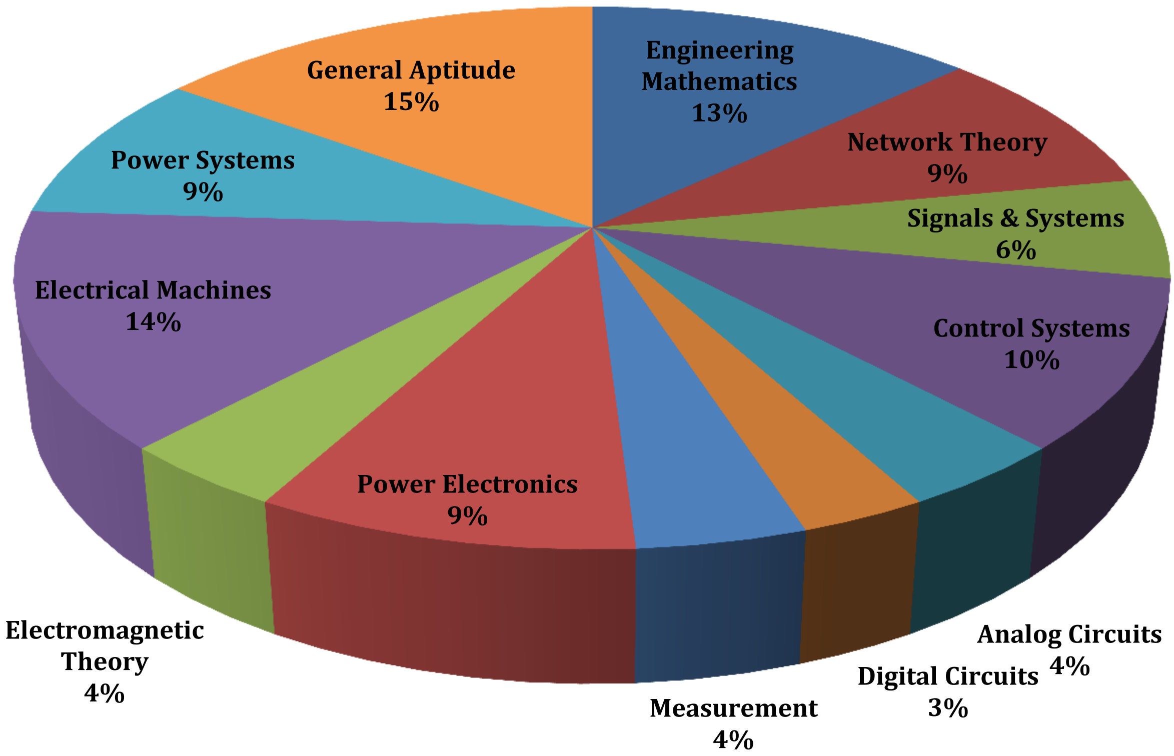
ANALYSIS OF GATE 2017

Electrical Engineering



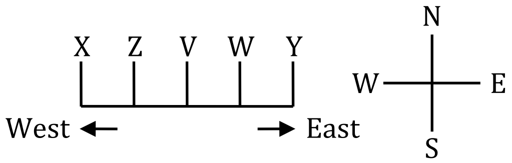
EE ANALYSIS-2017_11-Feb_Afternoon

SUBJECT	No. of Ques.	Topics Asked in Paper(Memory Based)	Level of Ques.	Total Marks
Engineering Mathematics	1 Marks: 5 2 Marks: 4	Linear Algebra; Calculus; Probability and Distribution	Medium	13
Network Theory	1 Marks: 3 2 Marks: 3	Network Solution Methodology; Transient/Steady State Analysis of RLC Circuits to DC Input; Two Port Networks; Sinusoidal Steady State Analysis; Network Topology	Medium	9
Signals & Systems	1 Marks: 2 2 Marks: 2	Fourier Representation of Signals; Z-Transform Frequency Response of LTI Systems and Diversified Topics	Tough	6
Control Systems	1 Marks: 2 2 Marks:4	Compensators & Controllers; Time Domain Analysis; State Variable Analysis; Stability & Routh Hurwitz Criterion; Time Domain Analysis; Root Locus Technique	Medium	10
Analog Circuits	1 Marks: 0 2 Marks: 2	AC & DC Biasing-BJT and FET Operational Amplifiers & Its Applications	Easy	4
Digital Circuits	1 Marks: 1 2 Marks: 1	Combinational and Sequential Digital Circuits	Easy	3
Measurement	1 Marks: 2 2 Marks: 2	Basics of Measurements and Error Analysis Electronic Measuring Instruments 2 Measurements of Basic Electrical Quantities 1	Medium	4
Power Electronics	1 Marks: 3 2 Marks: 3	Inverters; Rectifiers; Choppers	Tough	9
Electromagnetic Theory	1 Marks: 2 2 Marks: 1	Electromagnetic Field	Tough	4
Electrical Machines	1 Marks: 2 2 Marks: 6	Induction Motor; Synchronous Machine; Transformer;DC Machines	Medium	14
Power Systems	1 Marks: 3 2 Marks:3	Symmetrical Components and Faults Calculations; Transmission & Distribution Power Factor Correction	Tough	9
General Aptitude	1 Marks:5 2 Marks:5	Distance time, Probability, Permutation and Combination	Medium	15
Total	**65**			**100**
Faculty Feedback	Majority of the question were concept based. Maths, Control Systems, PE, PS and EM weightage was comparatively high. GA was medium as compared to the last year.			

Section: General Aptitude

1. Choose the option with words that are not synonyms.
   (A) aversion, dislike
   (B) luminous, radiant
   (C) plunder, loot
   (D) yielding, resistant
   [Ans. D]
   'Yielding' means tending to do where as 'resistant' means opposed to something, so both are not synonyms.

2. There are five building called V, W, X, Y and Z in a row (not necessarily in that order). V is to the West of W, Z is to the East of X and the West of V, W is the West of Y. Which is the building in the middle?
   (A) V
   (B) W
   (C) X
   (D) Y
   [Ans. A]
   From the given data, the following Row is formed



   ∴ The building 'V' is in the middle

3. Saturn is __________ to be seen on a clear night with the naked eye.
   (A) enough bright
   (B) bright enough
   (C) as enough bright
   (D) bright as enough
   [Ans. B]
   The word 'enough' as an adverb falts after the adjective so 'bright enough' is the right answer

4. There are 3 red socks, 4 green socks and 3 blue socks. You choose 2 socks. The probability that they are of the same colour is
   (A) 1/5
   (B) 7/30
   (C) 1/4
   (D) 4/15
   [Ans. D]
   Red socks = 3
   Green socks = 3
   Blue socks = 3
   ∴ The probability that they are of the same colours of pair $= \frac{{}^{3}C_2}{{}^{10}C_2} + \frac{{}^{4}C_2}{{}^{10}C_2} + \frac{{}^{3}C_2}{{}^{10}C_2}$
   $= \frac{3}{45} + \frac{6}{45} + \frac{3}{45}$
   $= \frac{12}{45} = \frac{4}{15}$

5. A test has twenty questions worth 100 marks in total. There are two types of questions. Multiple choice questions are worth 3 marks each and essay questions are worth 11 marks each. How many multiple choice questions does the exam have?

(A) 12
(B) 15
(C) 18
(D) 19

[Ans. B]

Total marks in the test = 100

For multiple choice questions = 3 marks

For essay questions = 11 marks

Option (A)

Marks for multiple choice questions $= 12 \times 3 = 36$

Marks for essay type questions $= 100 - 36 = 64$

64 is not divisible by 11

$\therefore$ Option (A) is not correct.

Option (B)

Marks for multiple choice questions $= 15 \times 3 = 45$

Marks for essay type questions $= 100 - 45 = \frac{55}{11} = 5$

Essay type questions are 5 No's

$\therefore$ Option (B) is correct

Option(C)

Marks for multiple choice questions $= 18 \times 3 = 54$

Marks for essay type questions $= -100 - 54 = 46$

46 is not divisible by 11

$\therefore$ Option (C) is not correct.

Option (D)

Marks for multiple choice questions $= 19 \times 3 = 57$

Marks for essay type questions $= 100 - 57 = 43$

46 is not divisible by 11

$\therefore$ Option (D) is not correct.

6. The number of roots or $e^x + 0.5x^2 - 2 = 0$ in the range $[-5, 5]$ is

(A) 0
(B) 1
(C) 2
(D) 3

[Ans. C]

$e^x + 0.5\,x^2 - 2 = 0$ in the range$[-5, 5]$

$f(x) = e^x + 0.5\,x^2 - 2$

$f(-5) = 10.50$

$f(-4) = 6.01$

$\left.\begin{matrix} f(-2) = 0.135 \\ f(-1) = -1.13 \end{matrix}\right\} \ldots\ldots\ldots (1)$

$\left.\begin{matrix} f(0) = -1 \\ f(1) = 1.21 \end{matrix}\right\} \ldots\ldots\ldots (2)$

$f(2) = 7.38$

As there are 2 sign changes from +ve to − ve and − ve to + ve

Two roots will be there in the range $[-5, 5]$

7. "We lived in a culture that denied any merit to literary works, considering them important only when they were handmaidens to something seemingly more urgent-namely ideology. This was a country where all gestures, even the most private, were interpreted in political terms".

The author's belief that ideology is not as important as literature is revealed by the word:

(A) 'culture'
(B) 'seemingly'
(C) 'urgent'
(D) 'political'

[Ans. B]

It appears to be 'B', so the right option is 'B'.

8. X is a 30 digit number starting with the digit 4 followed by the digit 7. Then the number X^3 will have

(A) 90 digits
(B) 91 digits
(C) 92 digits
(D) 93 digits

[Ans. A]

$X = (47\ldots)_{30 \text{ digits}}$

Suppose $(47)^3 = 2 + 2 + 2$ digits in $(47)^3$

Similarly $(47\ldots)^3_{30 \text{ digits}} =$ contains $30 + 30 + 30$ digits $= 90$ digits

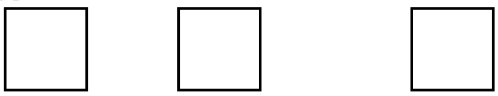
9. There are three boxes. One contains apples, another contains oranges and the last one contains both apples and oranges. All three are known to be incorrectly labelled. If you are permitted to open just one box and then pull out and inspect only one fruit, which box would you open to determine the contents of all three boxes?

(A) The box labelled 'Apples'
(B) The box labelled 'Apples and Oranges'
(C) The box labelled 'Oranges'
(D) Cannot be determined

[Ans. B]

The person who is opening the boxes, he knew that all 3 are marked wrong.

Suppose if three boxes are labelled as below.



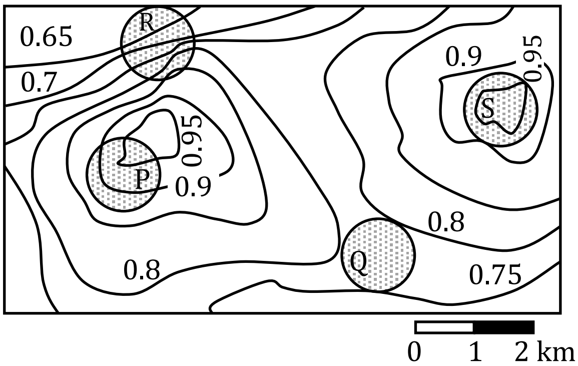
(1) Apples (2) Oranges (3) Apples & Oranges

If he inspected from Box (1), picked one fruit, found orange, then he don't know whether Box contains oranges (or) both apples & oranges.

Similarly if he picked one fruit from box(2), found apple then he don't know whether box contain apples (or) both apples & oranges.

But if he picked one fruit from box(3), i.e., labelled as 'apples & oranges', if he found apple then he can decide compulsorily that box (3) contain apples and as he knew all boxes are labeled as incorrect, he can tell box(2) contains both apples & oranges, box(1) contain remaining oranges. So, he should open box labelled 'apples & oranges' to determine contents of all the three boxes.

10. An air pressure contour line joins locations in a region having the same atmospheric pressure. The following is an air pressure contour plot of a geographical region. Contour lines are shown at 0.05 bar intervals in this plot.



If the possibility of a thunderstorm is given by how fast air pressure rises or drops over a region. Which of the following regions is most likely to have a thunderstorm?

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

[Ans. C]

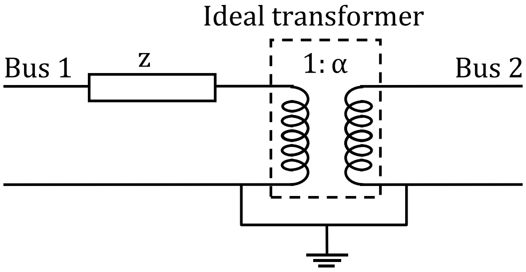
Region	Air pressure difference
P	$0.95 - 0.90 = 0.05$
Q	$0.80 - 0.75 = 0.05$
R	$0.85 - 0.65 = 0.20$
S	$0.95 - 0.90 = 0.05$

In general thunderstorms are occurred in a region where suddenly air pressure changes (i.e.,) sudden rise (or) sudden fall of air pressure. From the given contour map in 'R' Region only more changes in air pressure so, the possibility of a thunderstorm in this region.

$\therefore$ option (C) is correct.

Section: Technical

1. The figure shows the per-phase representation of a phase-shifting transformer connected between buses 1 and 2 where α is a complex number with non-zero real and imaginary parts.

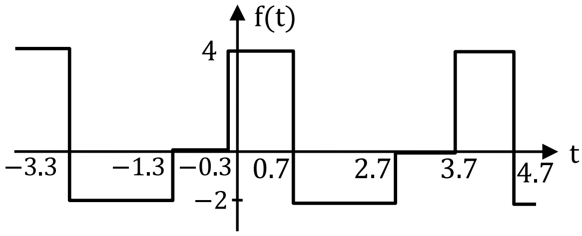


For the given circuit, Y_{bus} and Z_{bus} are bus admittance matrix and bus impedance matrix, respectively, each of size 2×2. Which one of the following statements is true?

(A) Both Y_{bus} and Z_{bus} are symmetric
(B) Y_{bus} is symmetric and Z_{bus} is unsymmetric
(C) Y_{bus} is unsymmetric and Z_{bus} is symmetric
(D) Both Y_{bus} and Z_{bus} are unsymmetric

[Ans. D]

2. The mean square value of the given periodic waveform f(t) is _________



[Ans. *] Range: 6 to 6

One cycle time = 1 + 2 + 1 = 4 units

Mean square value $= 4^2 \times \frac{1}{4} + 2^2 \times \frac{2}{4} = 6$

3. 3-phase, 4-pole, 400 V, 50 Hz squirrel-cage induction motor is operating at a slip of 0.02. The speed of the rotor flux in mechanical rad/sec. sensed by a stationary observer, is closest to

(A) 1500
(B) 1470
(C) 157
(D) 154

[Ans. C]

A $3-\phi$, 4 pole, 50Hz squirrel cage induction motor operating at a slip of 0.02

Synchronous speed $= \frac{120F}{p}$ rpm

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

∴ Rotor speed $= (1-s)N_s$

$= (1-0.02)(1500)$

$= 1470$ rpm

The speed of rotor field with respect to rotor is $= 120 \times \frac{sF}{p} = 30$ rpm

The speed of rotor field with respect to stator is = 1470 + 30 = 1500 rpm

$= \frac{2\pi(1500)}{60}$ rad/sec

$= 157.07$ rad/sec

4. A Let x and y be integers satisfying the following equations

$2x^2 + y^2 = 34$

$x + 2y = 11$

The value of $(x+y)$ is _______

[Ans. C]

$2x^2 + y^2 = 34$ ………. ①

$x + 2y = 11$ ………. ②

Solving ① and ②, we have

$x = 3, y = 4$

$\Rightarrow x + y = 7$

5. A phase-controlled, single-phase, full-bridge converter is supplying a highly inductive DC load. The converter is fed from a 230 V, 50 Hz AC source. The fundamental frequency in Hz of the voltage ripple on the DC side is

(A) 25
(B) 50
(C) 100
(D) 300

[Ans. C]

Output ripple frequency of 2 pulse converter, $f_0 = 2 \times f_i = 2 \times 50 = 100$ HZ

6. In a load flow problem solved by Newton-Raphson method with polar coordinates, the size of the Jacobian is 100 × 100. If there are 20 PV buses in addition to PQ buses and a slack bus, the total number of buses in the system is _________.

[Ans. *] Range: 61 to 61

Size of jacobian matrix is 100 × 100
PV Buses → 1equation
PQ Buses→ 2 equation
Slack Bus → 1
20PV Buses→ 20equations
Total number of equations→ 100
Load Bus equation → 100 − 20 = 80
Number of load Buses→ 40
Total number of buses are → 20 + 40 + 1 = 61

7. Two resistors with nominal resistance values R_1 and R_2 have additive uncertainties ΔR_1 and ΔR_2, respectively. When these resistances are connected in parallel, the standard deviation of the error in the equivalent resistance R is

(A) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_1}\Delta R_1\right\}^2 + \left\{\frac{\partial R}{\partial R_2}\Delta R_2\right\}^2}$

(B) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_2}\Delta R_1\right\}^2 + \left\{\frac{\partial R}{\partial R_1}\Delta R_2\right\}^2}$

(C) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_1}\right\}^2 \Delta R_2 + \left\{\frac{\partial R}{\partial R_2}\right\}^2 \Delta R_1}$

(D) $\pm\sqrt{\left\{\frac{\partial R}{\partial R_1}\right\}^2 \Delta R_1 + \left\{\frac{\partial R}{\partial R_2}\right\}^2 \Delta R_2}$

[Ans. A]

$$\sigma_{res} = \sqrt{\left\{\frac{\partial R}{\partial R_1}\right\}^2 \sigma_1^2 + \left\{\frac{\partial R}{\partial R_2}\right\}^2 \sigma_2^2}$$

$$= \sqrt{\left\{\frac{\partial R}{\partial R_1}\right\}^2 \Delta R_1^2 + \left\{\frac{\partial R}{\partial R_2}\right\}^2 \Delta_2^2}$$

8. The transfer function C(s) of a compensator is given below:

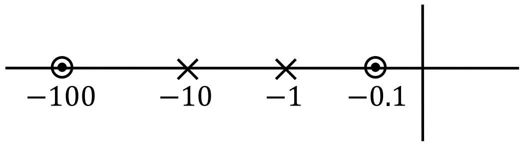
$$C(s) = \frac{\left(1+\frac{S}{0.1}\right)\left(1+\frac{S}{100}\right)}{(1+S)\left(1+\frac{S}{10}\right)}$$

The frequency range in which the phase (lead) introduce by the compensator reaches the maximum is

(A) $0.1 < \omega < 1$
(B) $1 < \omega < 10$
(C) $10 < \omega < 100$
(D) $\omega > 100$

[Ans. A]

Pole zero plot is given below



Lead $G(s) = \frac{s+0.1}{s+1}$

$\angle G(s) = \angle \tan^{-1}\frac{\omega}{0.1} - \tan^{-1}\frac{\omega}{1}$

Phase lead occur form $\omega = 0.1$ to $\omega = 1$

Range $0.1 < \omega < 1$

9. A stationary closed Lissajous pattern on an oscilloscope has 3 horizontal tangencies and 2 vertical tangencies for a horizontal input with frequency 3 kHz. The frequency of the vertical input is

(A) 1.5 kHz
(B) 2 kHz
(C) 3 kHz
(D) 4.5 kHz

[Ans. D]

$f_y = \frac{\text{Horizontal tangencies}}{\text{Vertical tangecies}} \times f_x$

$= \frac{3}{2} \times 3\text{ kHZ} = 4.5\text{ kHz}$

10. Consider a function f(x, y, z) given by $f(x,y,z) = (x^2 + y^2 - 2z^2)(y^2 + z^2)$. The partial derivative of this function with respect to x at the point x = 2, y = 1 and z = 3 is _______.

[Ans. *] Range: 40 to 40

$f(x,y,z) = (x^2 + y^2 - 2z^2)\,(y^2 + z^2)$

$\frac{\partial f}{\partial x} = 2x(y^2 + z^2)$

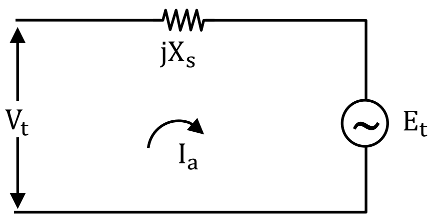
$\text{At}(2,1,3), \frac{\partial f}{\partial x} = 2(2)(1+9) = 40$

11. If a synchronous motor is running at a leading power factor, its excitation induced voltage (E_f) is

(A) equal to terminal voltage V_t
(B) higher than the terminal voltage V_t
(C) less than terminal voltage V_t
(D) dependent upon supply voltage V_t

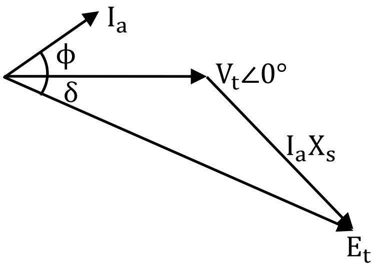
[Ans. B]

For a synchronous motor



$E_t = V_t - jI_aX_s$

For a leading pf condition

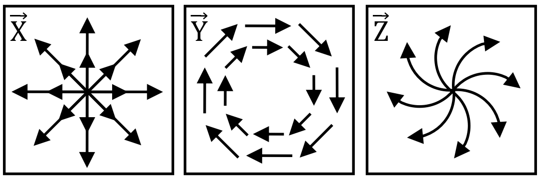


I_a, leading V_t

$\therefore$ E_t magnitude is higher than V_t

It is over excited

12. The figures show diagramatic representations of vector fields $\vec{X}, \vec{Y}$ and $\vec{Z}$, respectively. Whichone of the following choices is true?



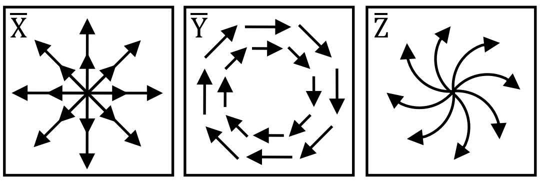
(A) $\nabla.\vec{X} = 0, \nabla \times \vec{Y} \neq 0, \nabla \times \vec{Z} = 0$

(B) $\nabla.\vec{X} \neq 0, \nabla \times \vec{Y} = 0, \nabla \times \vec{Z} \neq 0$

(C) $\nabla.\vec{X} \neq 0, \nabla \times \vec{Y} \neq 0, \nabla \times \vec{Z} \neq 0$

(D) $\nabla.\vec{X} = 0, \nabla \times \vec{Y} = 0, \nabla \times \vec{Z} = 0$

[Ans. C]



$\nabla.\bar{X} \neq 0$	$\nabla.\bar{Y} = 0$	$\nabla.\bar{Z} \neq 0$
$\nabla \times \bar{X} \neq 0$	$\nabla \times \bar{Y} \neq 0$	$\nabla \times \bar{Z} \neq 0$

13. When a unit ramp input is applied to the unity feedback system having closed loop transfer function

$\frac{C(s)}{R(s)} = \frac{Ks+b}{s^2+as+b}$, $(a > 0, b > 0, k > 0)$, the steady state error will be

(A) 0

(B) $\frac{a}{b}$

(C) $\frac{a+k}{b}$

(D) $\frac{a-k}{b}$

[Ans. D]

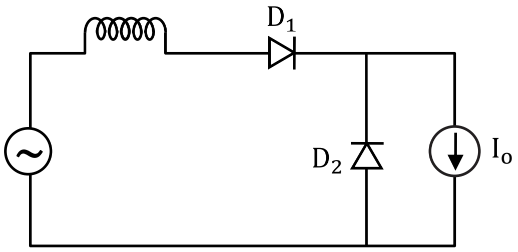
$$OLTF = \frac{CLTF}{1 - CLTF} = +\frac{\frac{ks+b}{s^2+as+b}}{1 - \frac{ks+b}{s^2+as+b}}$$

$$G(s) = \frac{Ks+b}{s^{2+(a-k)s}}$$

$$k_v = \lim_{s\to 0} s.G(s) = \frac{b}{a-k}$$

$$\text{Error} = \frac{1}{k_v} = \frac{a-k}{b}$$

14. In the circuit shown, the diodes are ideal, the inductance is small, and $I_0 \neq 0$. Which one of the following statements is true?



(A) D_1 conducts for greater than 180° and D_2 conducts for greater than 180°
(B) D_2 conducts for more than 180° and D_1 conducts for 180°
(C) D_1 conducts for 180° and D_2 conducts for 180°
(D) D_1 conducts for more than 180° and D_2 conducts for 180°
[Ans. A]

15. An urn contains 5 red balls and 5 black balls. In the first draw, one ball is picked at random and discarded without noticing its colour. The probability to get a red ball in the second draw is

(A) $\frac{1}{2}$ (C) $\frac{5}{9}$
(B) $\frac{4}{9}$ (D) $\frac{6}{9}$

[Ans. A]
Given Urn contains 5 red & 5 black balls here we come across two cases
(i) First drawn ball can be red or black
(ii) Second drawn ball is red

Probability of first drawn ball is red and second drawn ball is red $= \frac{5}{10} \times \frac{4}{9} = \frac{20}{90}$

Probability of first drawn ball is black and second drawn ball is red $= \frac{5}{5} \times \frac{5}{9} = \frac{25}{90}$

$$\therefore P = \frac{20}{90} + \frac{25}{90} = \frac{1}{2}$$

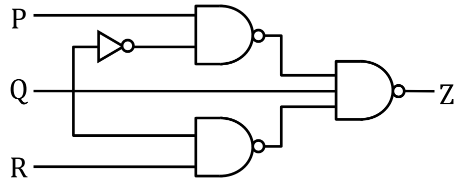
16. Assume that in a traffic junction, the cycle of the traffic signal lights is 2 minutes of green (vehicle does not stop) and 3 minutes of red (vehicle stops). Consider that the arrival time of vehicles at the junction is uniformly distributed over 5 minute cycle. The expected waiting time (in minutes) for the vehicle at the junction is __________

[Ans. *] Range: 0.9 to 0.9
Let x be the arrival time at the light (that has U (0, 5) and y be the waiting at the junction.
Then

$$y = \begin{cases} 0, & x < 2 \\ 5 - x, & x \geq 2 \Rightarrow 2 \leq x < 5 \end{cases}$$

$$E(y) = \int_0^5 y f(y) dy \Rightarrow \int_2^5 y \frac{1}{5} dy$$
$$= \int_2^5 \frac{1}{5}(5-x)dx \Rightarrow \frac{1}{5}\left\{5x - \frac{x^2}{2}\right\}_2^5$$
$$= \frac{1}{5}\left\{\left(25 - \frac{25}{2}\right) - \left(10 - \frac{4}{2}\right)\right\} = 0.9 \text{ minutes}$$

17. For a 3-input logic circuit shown below, the output Z can be expressed as



(A) $Q + \overline{R}$

(B) $P\vec{Q} + R$

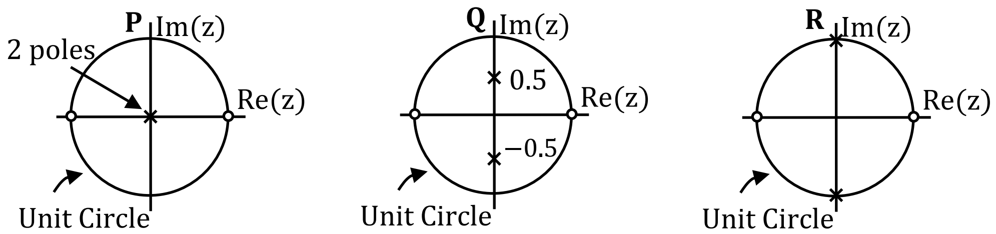
(C) $\vec{Q} + R$

(D) $P + \vec{Q} + R$

[Ans. C]

$$Z = \overline{\overline{P.\overline{Q}}.Q.\overline{Q.R}}$$
$$= P.\overline{Q} + \overline{Q} + Q.R$$
$$= \overline{Q} + Q.R$$
$$= \overline{Q} + R$$

18. The pole-zero plots of three discrete-time systems P, Q and R on the z-plane are shown below



Which one of the following is TRUE about the frequency selectivity of these systems?

(A) All three are high-pass filters

(B) All three are band-pass filters

(C) All three are low-pass filters

(D) P is a low-pass filter, Q is a band-pass filter and R is a high-pass filter.

[Ans. B]

Consider 'P':

$$H(z) = \frac{(z-1)(z+1)}{z-0} = \frac{z^2-1}{z}$$
$$H(e^{j\omega}) = \frac{e^{2j\omega}-1}{e^{j\omega}}$$

ω	$H(e^{j\omega})$	$\lvert H(e^{j\omega})\rvert$
0	0	0
$\frac{\pi}{2}$	2j	2
π	0	0

It is a band pass filter.

Consider 'Q':

$$H(z) = \frac{(z-1)(z+1)}{(z+0.5j)(z-0.5j)} = \frac{z^2-1}{z^2+0.25}$$

$$H(e^{j\omega}) = \frac{e^{2j\omega}-1}{e^{2j\omega}+0.25}$$

ω	$H(e^{j\omega})$	$\|H(e^{j\omega})\|$
0	0	0
$\frac{\pi}{2}$	2.66	2.66
π	0	0

It is also band pass filter.

Consider 'R':

$$H(z) = \frac{(z-1)(z+1)}{(z+j)(z-j)} = \frac{z^2-1}{z^2+1}$$

$$H(e^{j\omega}) = \frac{e^{2j\omega}-1}{e^{2j\omega}+1}$$

ω	$H(e^{j\omega})$	$\|H(e^{j\omega})\|$
0	0	0
$\frac{\pi}{2}$	$-\infty$	∞
π	0	0

It is a band pass filter

19. Let $y^2 - 2y + 1 = x$ and $\sqrt{x} + y = 5$. The value of $x + \sqrt{y}$ equals ______. (Given the answer up to three decimal places)

[Ans. *] Range: 5.7 to 5.8

Let $y^2 - 2y + 1 = x$

$(y-1)^2 = x$

$y + \sqrt{x} = 5$

$\Rightarrow y = 5 - \sqrt{x}$

$\Rightarrow (y-1) = 4 - \sqrt{x}$

$\Rightarrow (y-1)^2 = (4-\sqrt{x})^2 = 16 + x - 8\sqrt{x}$

$x = 16 + x - 8\sqrt{x}$

$= 16 - 8\sqrt{x} = 0$

$= 8(2 - \sqrt{x}) = 0$

$\sqrt{x} = 2 \Rightarrow x = 4$

Also we know that $y = 5 - \sqrt{x} = 3$

$\therefore x + \sqrt{y} = 4 + \sqrt{3} = 4 + 1.732 = 5.732$

20. A three-phase voltage source inverter with ideal devices operating in 180° conduction mode is feeding a balanced star-connected resistive load. The DC voltage input is V_{dc}. The peak of the fundamental component of the phase voltage is

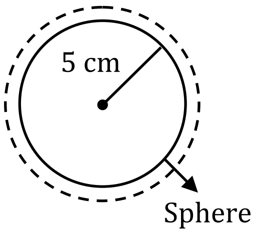
(A) $\frac{V_{dc}}{\pi}$ (C) $\frac{3V_{dc}}{\pi}$

(B) $\frac{2V_{dc}}{\pi}$ (D) $\frac{4V_{dc}}{\pi}$

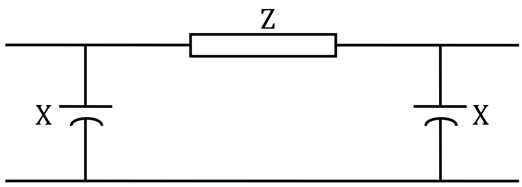
[Ans. B]

Peak value of fundamental component of phase voltage is $\frac{6\times\left(\frac{V_{dc}}{3}\right)}{\pi} = \frac{2V_{dc}}{\pi}$

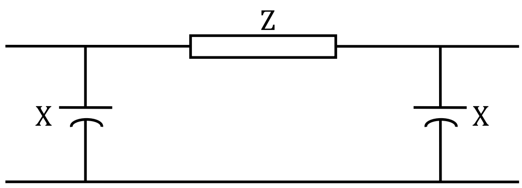
21. Consider a solid sphere, of radius 5 cm made of a perfect electric conductor. If one million electrons are added to this sphere, these electrons will be distributed
(A) uniformly over the entire volume of the sphere
(B) uniformly over the outer surface of the sphere
(C) concentrated around the centre of the sphere
(D) along a straight line passing through the centre of the sphere
[Ans. B]
Even if we give any number of charges, the charge will resides on its surface only.



22. The normal $-\pi$ circuit of a transmission line is shown in the figure.



Impedance $Z = 100\angle 80°$ and reactance $X = 3300\ \Omega$. The magnitude of the characteristic impedance of the transmission line, in Ω, is ______. (Give the answer up to one decimal place.)
[Ans. *] Range: 404 to 408



$Z = 100\angle 80°$

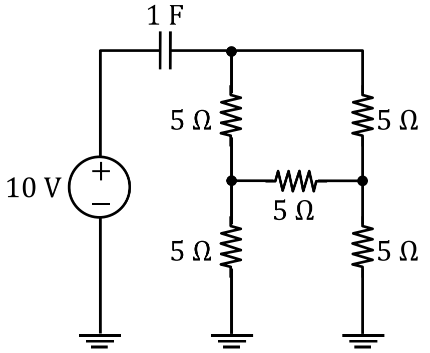
$X = 3300\ \Omega$

$\frac{y}{2} = \frac{1}{X} \Rightarrow \frac{1}{3300}$

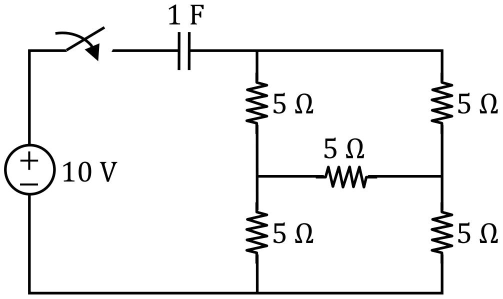
$y = \frac{2}{3300} = 6.06\times 10^{-4}$

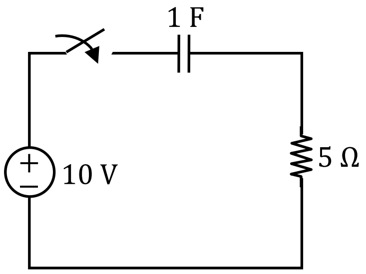
$Z_C = \sqrt{\frac{Z}{y}} = \sqrt{\frac{100}{6.06\times 10^{-4}}} = 406.2\ \Omega$

23. The initial charge in the 1 F capacitor present in the circuit shown is zero. The energy in joules transferred from the DC source until steady state condition is reached equals ______ . (Give the answer up to one decimal place.)



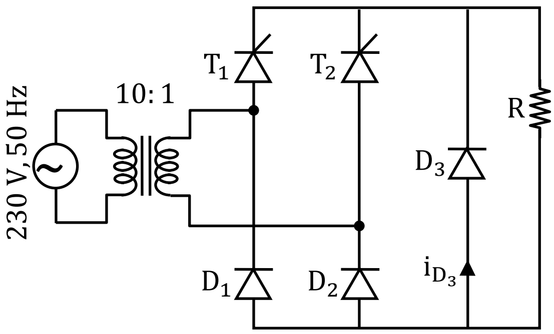
[Ans. *] Range: 99 to 101





Total energy transferred capacitor $= CV^2$
$= 1(10)^2 = 100J$

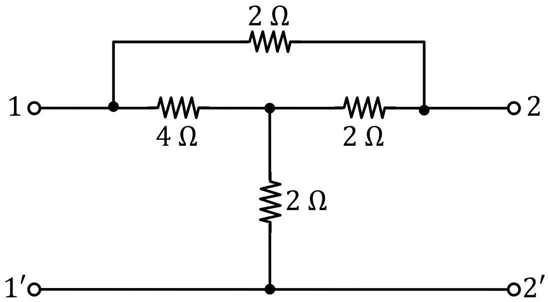
24. The figure below shows the circuit diagram of a controlled rectifier supplied from a 230 V, 50 Hz, 1-phase voltage source and a 10:1 ideal transformer. Assume that all devices are ideal. The firing angles of the thyristors T_1 and T_2 are 90° and 270°, respectively



The RMS value of the current through diode D_3 in amperes is ________
[Ans. *] Range: 0 to 0

D_3 is freewheeling diode and there is no freewheeling action when load is resistive in nature. Hence, RMS value of current through the diode $D_3 = 0$ A

25. For the given 2-port network, the value of transfer impedance Z_{21} in ohms is ________



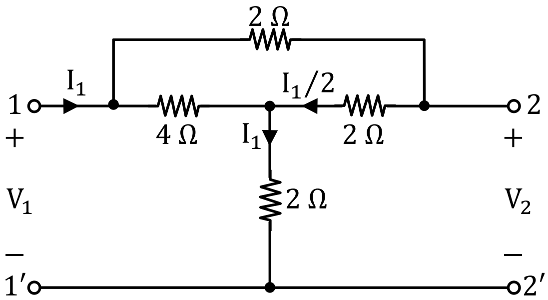
[Ans. *] Range: 3 to 3

$V_1 = Z_{11}I_1 + Z_{12}I_2$

$V_2 = Z_{21}I_1 + Z_{22}I_2$

$Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0}$

By applying KVL

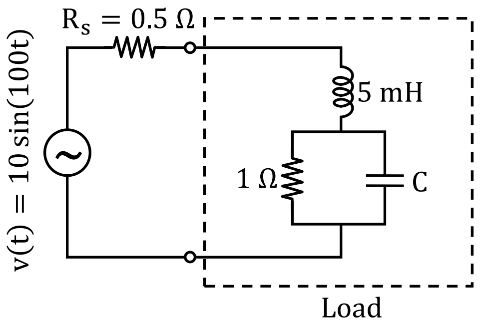


$-V_2 + I_1 + 2I_1 = 0$

$V_2 = 3I_1$

$Z_{21} = 3\Omega$

26. In the circuit shown below, the value of capacitor C required for maximum power to be transferred to the load is



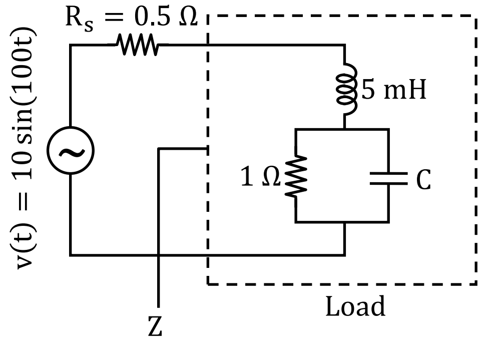
(A) 1 nF

(B) 1 μF

(C) 1 mF

(D) 10 mF

[Ans. D]



$$Z = \frac{j}{2} + [1 \| (-jX_c)]$$

$$= \frac{j}{2} + \frac{-jX_c}{1 - jX_c}$$

$$\frac{j}{2} + \frac{-jX_c[1 + jX_c]}{1 + X_c^2}$$

$$\frac{j}{2} - j\left[\frac{X_c}{1 + X_c^2}\right] + \frac{X_c^2}{1 + X_c^2}$$

$$\frac{1}{2} - \frac{X_c}{1 + X_c^2} = 0$$

$$1 + X_c^2 = 2X_c$$

$$X_c^2 - 2X_c + 1 = 0$$

$$X_c = \frac{2 \pm \sqrt{4 - 4(1)}}{2} \Rightarrow X_c = 1$$

$$= \frac{1}{\omega c} = 1$$

$$\Rightarrow C = \frac{1}{\omega} = \frac{1}{100}$$

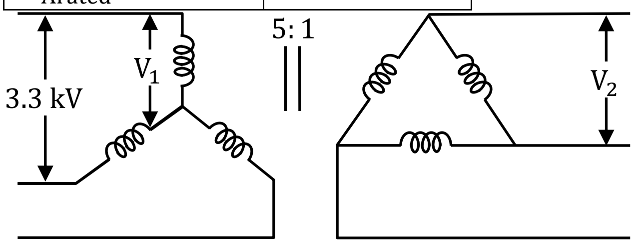
$$= 0.01\text{F} = 10\text{ mF}$$

27. If the primary line voltage rating is 3.3 kV (Y side) of a 25 kVA, Y-Δ transformer (the per phase turns ratio is 5 : 1), then the line current rating of the secondary side (in Ampere) is ________

[Ans. *] Range: 37 to 39

Given transformer is Y/Δ

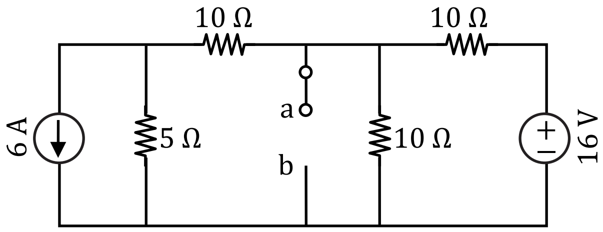
Primary (Y)	Secondary(Δ)
$V_{line} = 3.3$ kV $VA_{rated} = 25$ kVA	$I_{line} = ?$



$$\frac{V_1(\text{phase voltage primary})}{V_2(\text{phase voltage secondary})} = \frac{5}{1}$$

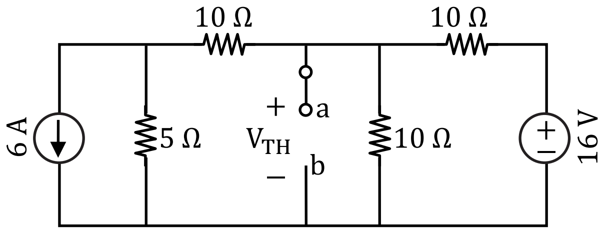
$$V_2 = \left(\frac{1}{5}\right)(V_1)$$
$$= \left(\frac{1}{5}\right)\left(\frac{3300}{\sqrt{3}}\right) = 381 \text{ Volts}$$
$$VA = \sqrt{3}\, V_L I_L (\text{Delta side})$$
$$25000 = (\sqrt{3})(381) I_L$$
$$I_L = 37.88A$$

28. For the network given in figure below, the Thevenin's voltage V_{ab} is



(A) −1.5 V
(B) −0.5 V
(C) 0.5 V
(D) 1.5 V

[Ans. A]



$$\frac{V_{TH}}{10} + \frac{(V_{TH} - 16)}{10} + \frac{(V_{TH} + 30)}{15} = 0$$
$$\frac{3V_{TH} + 3V_{TH} - 48 + 2V_{TH} + 60}{6} = 0$$
$$8V_{TH} = 12$$
$$V_{TH} = \frac{-3}{2} = -1.5 \text{ V}$$

29. A 3-phase, 50 Hz generator supplies power of 3 MW at 17.32 kV to a balanced 3-phase inductive load through an overhead line. The per phase line resistance and reactance are 0.25 Ω and 3.925 Ω respectively. If the voltage at the generator terminal is 17.87 kV, the power factor of the load is_________.

[Ans. *] Range: 0.75 to 0.85

$$|V_S| = 17.87 \text{ kV}$$
$$|V_r| = 17.32 \text{ kV}$$
$$R = 0.25\ \Omega$$
$$R = 0.25\ \Omega$$
$$X_L = 3.925\ \Omega$$
$$Z = \sqrt{0.25^2 + 3.925^2}$$
$$= 3.933\ \Omega$$

$$P_r = \frac{17.87 \times 17.32}{3.933}\cos(\theta - \delta) - \frac{0.25(17.32)^2}{3.933^2}$$
$$3 = \frac{17.87 \times 17.32}{3.933}\cos(\theta - \delta) - \frac{0.25(17.32)^2}{3.933^2}$$
$$\cos(\theta - \delta) = 0.0997$$
$$(\theta - \delta) = 84.276°$$
$$Q_r = \frac{|V_S||V_r|}{|Z|}\sin(\theta - 8) - \frac{X|V_r|^2}{|Z|^2}$$
$$= \frac{1787 \times 17.32}{3.933}\sin(84.276) - \frac{3.925 \times 17.32^2}{3.933^2}$$
$$= 2.18483\text{VAR}$$
$$\text{pf} = \cos\tan^{-1}\left(\frac{Q_r}{P_r}\right)$$
$$= \cos\tan^{-1}\left(\frac{2.18483}{3}\right)$$
$$= 0.8083 \text{ lag}$$

30. Consider the system described by the following state space representation

$$\begin{bmatrix}\dot{x}_1(t)\\ \dot{x}_2(t)\end{bmatrix} = \begin{bmatrix}0 & 1\\ 0 & -2\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\end{bmatrix} + \begin{bmatrix}0\\ 1\end{bmatrix}u(t)$$
$$y(t) = \begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}x_1(t)\\ x_2(t)\end{bmatrix}$$

If u(t) is a unit step input and $\begin{bmatrix}x_1(0)\\ x_2(0)\end{bmatrix} = \begin{bmatrix}1\\ 0\end{bmatrix}$, the value of output y(t) at t = 1 sec (rounded off to three decimal places) is _______

[Ans. *] Range: 0.75 to 0.85

$$A = \begin{bmatrix}0 & 1\\ 0 & -2\end{bmatrix}, B = \begin{bmatrix}0\\ 1\end{bmatrix}, C = \begin{bmatrix}1 & 0\end{bmatrix}, x(0) = \begin{bmatrix}1\\ 0\end{bmatrix}$$
$$\text{Input} = \frac{1}{s}(\text{unit step})$$
$$y(t) = cx(t)$$
$$x(t) = L^{-1}[x(s)]$$
$$x(s) = (SI - A^{-1})x(0) + (SI - A)^{-1}BU(s)$$
$$[SI - A] = \begin{bmatrix}s & -1\\ 0 & s+2\end{bmatrix}$$
$$[SI - A]^{-1} = \begin{bmatrix}\frac{1}{s} & \frac{1}{s(s+2)}\\ 0 & \frac{1}{s+2}\end{bmatrix}$$
$$x(s) = \begin{bmatrix}\frac{1}{s} & \frac{1}{s(s+2)}\\ 0 & \frac{1}{s+2}\end{bmatrix}\begin{bmatrix}1\\ 0\end{bmatrix} + \begin{bmatrix}\frac{1}{s} & \frac{1}{s(s+2)}\\ 0 & \frac{1}{s+2}\end{bmatrix}\begin{bmatrix}0\\ 1\end{bmatrix}\frac{1}{s}$$

$$= \begin{bmatrix} \frac{1}{s} + \frac{1}{s^2(s+2)} \\ \frac{1}{s(s+2)} \end{bmatrix}$$

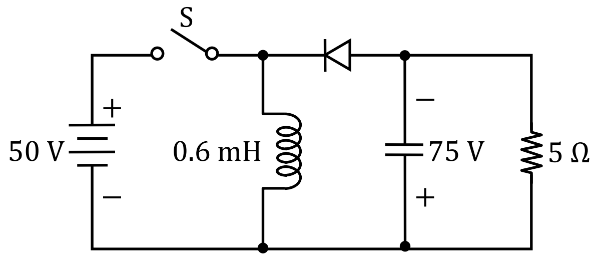
$$x(t) = L^{-1}[x(s)] = \begin{bmatrix} 1 + 0.5t - 0.25 + 0.25e^{-2t} \\ 0.5 - 0.5e^{-2t} \end{bmatrix}$$

$$y(t) = [1 \quad 0]x(t) = [1 + 0.5t - 0.25 + 0.25e^{-2t}]$$

$$y(1) = 1 + 0.5 - 0.25 + 0.135$$

$$= 1.284$$

31. In the circuit shown all elements are ideal and the switch S is operated at 10 kHz and 60% duty ratio. The capacitor is large enough so that the ripple across it is negligible and at steady state acquires a voltage as shown. The peak current in amperes drawn from the 50 V DC source is_______. (Give the answer up to one decimal place.)



[Ans. *] Range: 39 to 41

Given circuit is buck boost converter.

Source current is same switch current.

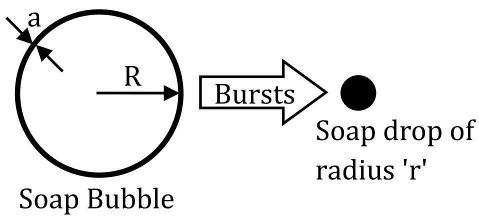
Peak value of switch current means, $i_{sw,peak} = I_{L,max} = I_L + \frac{\Delta I_L}{2}$

$$\Delta I_L = \frac{V_{dc}}{L} DT = \frac{50}{0.6 \times 10^{-3}} \times 0.6 \times 0.1 \times 10^{-3} = 5 \text{ A}$$

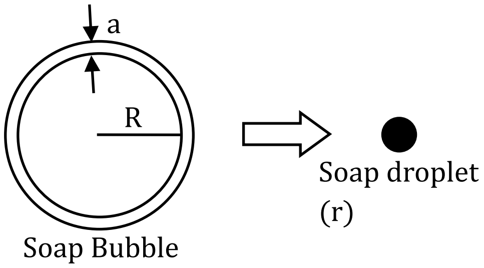
$$I_L = \frac{I_o}{1-D} = \frac{\left(\frac{75}{5}\right)}{1-0.6} = 37.5 \text{ A}$$

$$\therefore I_{L,max} = 37.5 + \frac{5}{2} = 40 \text{ A}$$

32. A thin soap bubble of radius R = 1 cm, and thickness a = 3.3 μm (a << R), is at a potential of 1 V with respective to a reference point at infinity. The bubble bursts and becomes a single spherical drop of soap (assuming all the soap is contained in the drop) of radius r. The volume of the soap in the thin bubble is $4\pi R^2 a$ and that of the drop is $\frac{4}{3}\pi r^3$. The potential in volts, of the resulting single spherical drop with respect to the same reference point at infinity is _________. (Give the answer up to two decimal places.)



[Ans. *] Range: 9.50 to 10.50



$(4\pi R^2 a)\rho = \left(\frac{4}{3}\pi r^3\right)\rho$

$\rho \rightarrow$ charge density(c/m^3)

$Y = (3R^2 a)^{1/3}$

The potential of the bubble.

$$V = \frac{1}{4\pi\epsilon}.\frac{Q}{R}$$

$Q = (4\pi\epsilon R)V$

$Q = 4\pi\epsilon\ 1 \times 10^{-2}$

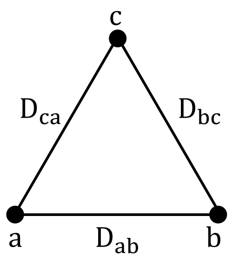
Potential of the soap drop

$$V' = \frac{1}{4\pi\epsilon}.\frac{Q}{r}$$

$$V' = \frac{1}{4\pi\epsilon_o}\ \frac{4\pi\epsilon_o\ 1 \times 10^{-2}}{(3 \times 1 \times 10^{-4} \times 3.3 \times 10^{-6})^{1/3}}$$

$V' = 10.03$

33. Consider an overhead transmission line with 3-phase, 50 Hz balanced system with conductors located at the vertices of an equilateral triangle of length $D_{ab} = D_{bc} = D_{ca} = 1$ m as shown in figure below. The resistances of the conductors are neglected. The geometric mean radius (GMR) of each conductor is 0.01 m. Neglect the effect of ground, the magnitude of positive sequence reactance in Ω/km (rounded off to three decimal places) is __________



[Ans. *] Range: 0.271 to 0.301

$$L_{phase} = 2 \times 10^{-7} \ln\left(\frac{GMD}{GMR}\right) \text{H/km}$$

$$= 2 \times 10^{-7} n\left(\frac{1}{0.01}\right) = 2 \times 10^{-4} \times \ln(100)$$

$$= 0.921 \times 10^{-3} \text{H/km}$$

$X = 2\pi f L = 314 \times 0.921 \times 10^{-3}$

$= 0.289\ \Omega$

34. A 120 V DC shunt motor takes 2 A at no load. It takes 7 A on full load while running at 1200 rpm. The armature resistance is 0.8 Ω and the shunt field resistance is 240 Ω. The no load speed, in rpm, is ________

[Ans. *] Range: 1235 to 1250

$V_t = 120V$, DC Shunt motor

At No-load:

$I_{L_1} = 2A$

$I_{f_1} = \frac{V_t}{r_f} = \frac{120}{240} = 0.5A$

$\Rightarrow I_{a_1} = 1.5A;$

$E_{b_1} = V_t - I_{a_1} r_a = 120 - (1.5)(0.8)$

$= 118.8\text{ V}$

$N_{\text{no-load}} = ?$

At Full load:

$I_{L_2} = 7A$

$I_{f_2} = \frac{V_t}{r_f} = \frac{120}{240} = 0.5A$

$I_{a_2} = 6.5A$

$E_{a_2} = V_t - I_{a_2} r_a = 120 - (6.5)(0.8)$

$= 114.8\text{ V}$

$N_{\text{full-load}} = 1200\text{ rpm}$

$E_b = K_a \phi \omega; \phi = \text{cost}[\therefore I_f = \text{const}]$

$\Rightarrow \frac{E_{b_1}}{E_{b_2}} = \frac{N_1}{N_2}$

$N_1 = (N_2)\left(\frac{E_{b_1}}{E_{b_1}}\right)$

$= (1200)\left(\frac{118.8}{114.8}\right) = 1241.8\text{ rpm}$

35. The value of the contour integral in the complex-plane

$$\oint \frac{z^3 - 2z + 3}{z - 2} dz$$

along the contour $|z| = 3$, taken counter-clockwise is

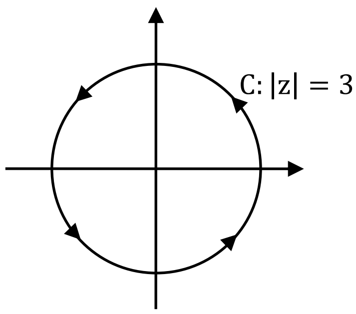
(A) $-18\pi i$

(B) 0

(C) $14\pi i$

(D) $48\pi i$

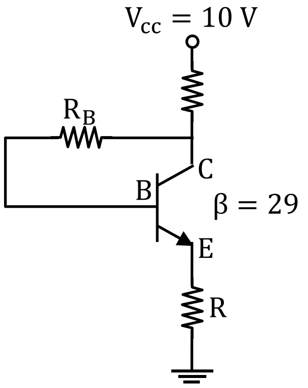
[Ans. C]



$z = 2$ lies inside $|z| = 3$

$$\oint_c \frac{z^3 - 2z + 3}{z - 2} dz = \oint_c \frac{\phi(z)}{z - 2} dz$$
$= 2\pi i \phi(2)[\text{where } \phi(z) = z^3 - 2z + 3]$
$= 2\pi i[8 - 4 + 3]$
$= 14\pi i$

36. For the circuit shown in the figure below, it is given that $V_{CE} = \frac{V_{CC}}{2}$.The transistor has $\beta = 29$ and $V_{BE} = 0.7$ V when the B-E junction is forward biased.

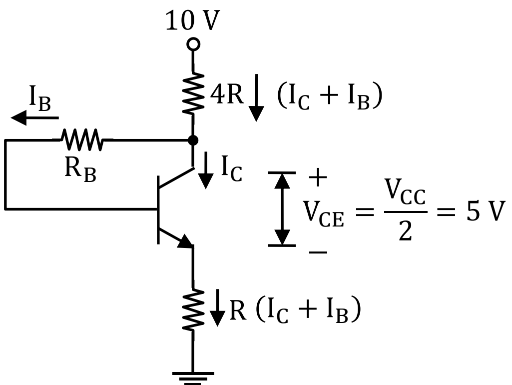


For this circuit, the value of $\frac{R_B}{R}$ is

(A) 43
(B) 92
(C) 121
(D) 129

[Ans. D]

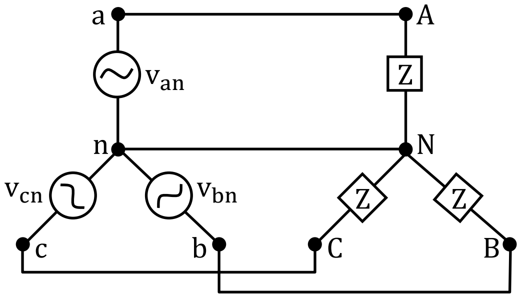
Given that,
$V_{cc} = 10V$
$V_{cE} = \frac{V_{cc}}{2} = 5V, \beta = 29$
$V_{BE} = 0.7V$



Apply KCL through C-E
$10 - (I_C + I_B)4R - 5 - (I_C + I_B)R = 0$
$5R(I_C + I_B) = 5$
$R(1 + \beta)I_B = 1$
Apply KVL through C-E
$10 - 4R(I_C + I_b) - I_B R_B - 0.7 - 0.7R(I_C + I_B) = 0$

$9.3 - 5R(I_C + I_B) = I_B R_B$
$9.3 - 5 = I_B R_B = 4.3$
Then $\frac{I_B R_B}{R(1+\beta)I_B} = \frac{4.3}{1}$
$\frac{R_B}{R} = 4.3(1+\beta)$
$= 4.3 \times 30 = 129$

37. For the balanced Y-Y connected 3-phase circuit shown in the figure below, the line-line voltage is 208 V rms and the total power absorbed by the load is 432 W at a power factor of 0.6 leading.



The approximate value of the impedance Z is

(A) $33\angle -53.1°\Omega$
(B) $60\angle 53.1°\Omega$
(C) $60\angle -53.1°\Omega$
(D) $180\angle -53.1°\Omega$

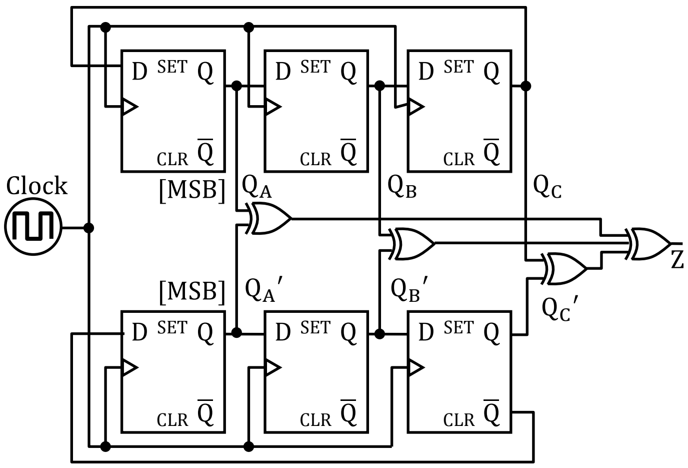
[Ans. C]

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

$I_L = \frac{432}{\sqrt{3} \times 208 \times 0.6} = 2\angle 53.1°$

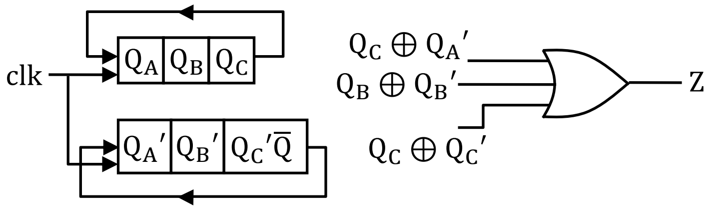
$Z_{phase} = \frac{V_{phase}}{I_{phase}} = \frac{208}{\frac{\sqrt{3}}{2}} = 60\angle -53.1°$

38. For the synchronous sequential circuit shown below, the output Z is zero for the initial conditions $Q_A Q_B Q_C = Q'_A Q'_B Q'_C = 100$.



The minimum number of clock cycles after which the output Z would again become zero is __________

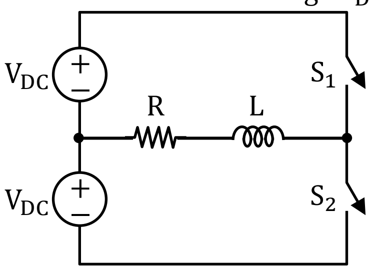
[Ans. *] Range: 6 to 6



Thus after (6) pulses, Z again becomes 0

Clk	$Q_AQ_BQ_C$	$Q_A'Q_B'Q_C'$
0	1 0 0	1 0 0
1	0 1 0	1 1 0
2	0 0 1	1 1 1
3	1 0 0	0 1 1
4	0 1 0	0 0 1
5	0 0 1	0 0 0
6	1 0 0	1 0 0

39. The figure below shows a half-bridge voltage source inverter supplying a RL-load with $R = 40\ \Omega$ and $L = \left(\frac{0.3}{\pi}\right)$ H. The desired fundamental frequency of the load voltage is 50 Hz. The switch control signals of the converter are generated using sinusoidal pulse width modulation with modulation index, M = 0.6. At 50 Hz, the RL-load draws an active power of 1.44 kW. The value of DC source voltage V_{DC} in volts is



(A) $300\sqrt{2}$
(B) 500
(C) $500\sqrt{2}$
(D) $1000\sqrt{2}$

[Ans. C]

$V_{01peak} = m.V_{DC}$

$$V_{01rms} = \frac{m.V_{DC}}{\sqrt{2}}$$

Here m = 0.6

$$V_{01rms} = \frac{0.6\ V_{DC}}{\sqrt{2}}$$

$$V_{01rms} = \frac{0.6}{\sqrt{2}} V_{DC}$$

$$|Z_1| = \sqrt{R^2 + (\omega L)^2} = \sqrt{40^2 + (2\pi f.L)^2}$$

$$= \sqrt{40^2 + \left(2\pi \times 50 \times \frac{0.3}{\pi}\right)^2} = \sqrt{40^2 + 30^2} = 50$$

$\phi_1 = \tan^{-1}\frac{\omega L}{R} = \tan^{-1}\frac{30}{40} = 36.869°$

$\phi_1 = 36.869°$

Active power $= V_{01rms}\, I_{01rms} \cos\phi_1 = V_{01rms}.\frac{V_{01rms}}{|Z_1|}.\cos\phi_1$

$1.44 \times 10^3 = \left(\frac{0.6}{\sqrt{2}} V_{DC}\right)^2 . \frac{1}{50}(\cos 36.869°)$

$V_{DC}^2 = \frac{1.44 \times 10^3 \times 100}{0.6^2 \times 0.8} = 5 \times 10^5$

$V_{DC} = 500\sqrt{2}$ V

40. The eigen values of the matrix given below are $\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -3 & -4 \end{bmatrix}$

(A) $(0, -1, -3)$ (C) $(0, 2, 3)$
(B) $(0, -2, -3)$ (D) $(0, 1, 3)$

[Ans. A]

Tr (A) $= 0 + 0 + (-4) = -4$

$|A| = 0$

Tr (A) = sum of eigen values

$|A|$ = Product of eigen values

∴ By verification from options,

The eigen values are $(0, -1, -3)$

41. A 25 kVA, 400 V, Δ-connected, 3-phase, cylindrical rotor synchronous generator requires a field current of 5 A to maintain the rated armature current under short-circuit condition. For the same field current, the open-circuit voltage is 360 V. Neglecting the armature resistance and magnetic saturation, its voltage regulation (in % with respect to terminal voltage), when the generator delivers the rated load at 0.8 pf leading at rated terminal voltage is ______

[Ans.*]Range: −15 to − 14

25kVA, 400V, Δ − connected

$\therefore I_L = \frac{25 \times 1000}{\sqrt{3} \times 400} = 36.08A$

$\Rightarrow I_{ph} = \frac{36.08}{\sqrt{3}} = 20.83A$

$I_{sc} = 20.83A$ when $I_f = 5A$

$V_{oc(line)} = 360V$ when $I_f = 5A$

$x_s = \left.\frac{V_{oc}}{I_{sc}}\right|_{I_f = given}$

$= \frac{360(\text{phase voltage})}{20.83(\text{phase current})} = 17.28\Omega$

For a given leading pf load$[\cos\phi = 0.8\text{lead}]$

$$\Rightarrow E_o = \sqrt{(V\cos\phi + I_a r_a)^2 + (V\sin\phi - I_a X_s)^2}$$
$$= \sqrt{[400 \times 0.8]^2 + [400 \times 0.6 - 20.83 \times 17.28]^2}$$
$$= 341.\text{Volts/ph}$$
$$\Rightarrow \text{Voltage regulation} = \frac{|E| - |V|}{|V|} \times 100$$
$$= \frac{341 - 400}{400} \times 100$$
$$= -14.56\%$$

42. A 10 ½ digit timer counter possesses a base clock of frequency 100 MHz. When measuring a particular input, the reading obtained is the same in: (i) Frequency mode of operation with a gating time of one second and (ii) Period mode of operation (in the x 10 ns scale). The frequency of the unknown input (reading obtained) in Hz is_______

[Ans.*]Range: 10000 to 10000

43. A person decides to toss a fair coin repeatedly until he gets a head. He will make at most 3 tosses. Let the random variable Y denotes the number of heads. The value of var{Y}, where var{.} denotes the variance, equal

(A) $\frac{7}{8}$

(B) $\frac{49}{64}$

(C) $\frac{7}{64}$

(D) $\frac{105}{64}$

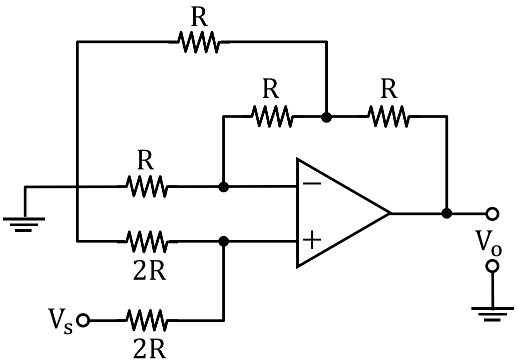
[Ans. A]

Let y=number of head

Y	0	1
P(Y)	$\frac{1}{8}$	$\frac{7}{8}$

$$E(Y) = \frac{7}{8}$$
$$E(Y^2) = \frac{7}{8}$$
$$V(Y) = E(Y)^2 - E(Y)^2$$
$$= \frac{7}{8} - \left(\frac{7}{8}\right)^2$$
$$= \frac{7}{8} - \frac{49}{64}$$
$$= \frac{7}{64}$$

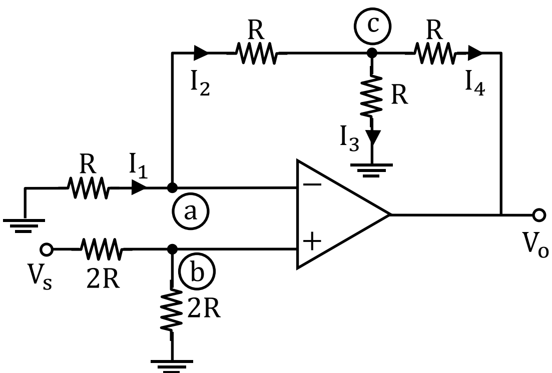
44. For the circuit shown below, assume that the OPAMP is ideal.



Which one of the following is TRUE?

(A) $V_o = V_s$
(B) $V_o = 1.5V_S$
(C) $V_o = 2.5\ v_s$
(D) $V_o = 5v_s$

[Ans. A]



Since $V_d \approx 0$

$V_a = V_b$

$$V_b = V_s\left(\frac{2R}{4R}\right) = \frac{V_S}{2}$$

Apply KCL at 'a'

$I_1 = I_2$

$$-\frac{V_a}{r} = V_a - \frac{V_c}{R} \Rightarrow V_c = 2V_a = V_s$$

Apply KCL at 'c'

$I_2 = I_3 + I_4$

$$\frac{V_a - V_c}{R} = \frac{V_c}{R} + \frac{V_c - V_o}{R}$$

$V_o = 3V_c - V_a$

$$= 3V_s - \frac{V_s}{2}$$

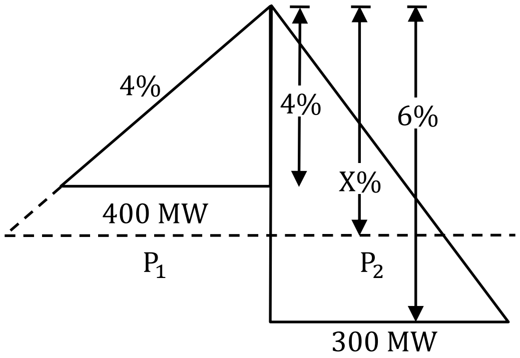
$\Rightarrow V_o = 2.5V_s$

45. Two generating units rated 300 MW and 400 MW have governor speed regulation of 6% and 4% respectively from no load to full load. Both the generating units are operating in parallel to share a load of 600 MW. Assuming free governor action, the load shared by the larger units is ________

[Ans.*]Range: 395 to 405

If both are having same no load frequencies.

From the symmetrical triangles



$\frac{P_1}{400} = \frac{x}{4} \Rightarrow P_1 = 100x \ldots\ldots\ldots (1)$

$\frac{P_2}{300} = \frac{x}{6} \Rightarrow P_2 = 50x \ldots\ldots\ldots (2)$

$P_1 + P_2 = 100x + 50x = 600$

$x = 4$

∴ The load shared by larger unit i,e., 400 MW unit is $P_1 = 100\,x = 100 \times 4 = 400$ MW

46. Let $g(x) = \begin{cases} -x, & x \le 1 \\ x+1 & x \ge 1 \end{cases}$ and

$f(x) = \begin{cases} 1-x, & x \le 0 \\ x^2 & x > 0 \end{cases}$

Consider the composition of f and g, i.e., $(f \circ g)(x) = f(g(x))$. The number of discontinuities in $(f \circ g)$ (x) present in the interval $(-\infty, 0)$ is

(A) 0

(B) 1

(C) 2

(D) 4

[Ans. A]

$(f \circ g)(x) = f[g(x)]$

In$(-\infty, 0)$, $g(x) = -x$

$\Rightarrow f[g(x)] = f(-x)$

$= 1 - (-x)$

$f[g(x)] = 1 + x$

$\Rightarrow f[g(x)]$ has no discontinuous point in $(-\infty, 0)$

47. The range of K for which all the roots of the equation $s^3 + 3s^2 + 2s + K = 0$ are in the left half of the complex s-plane is-----

(A) $0 < K < 6$

(B) $0 < K < 16$

(C) $6 < K < 36$

(D) $6 < K < 16$

[Ans. A]

s^3	1	2
s^2	3	K
s^1	$6-K$	
s^0	K^3	

$K < 0$ and $K < 6$

$0 < K < 6$

48. A 220 V, 10 kW, 900 rpm separately excited DC motor has an armature resistance $R_a = 0.02\Omega$ When the motor operates at rated speed and with rated terminal voltage, the electromagnetic torque developed by the motor is 70 Nm. Neglecting the rotational losses of the machine, the current drawn by the motor from the 220 V supply is

(A) 34.2A
(B) 30A
(C) 22A
(D) 4.84A

[Ans. B]

$V_t = 220V;$

$N = 900$ rpm

$T_e = 70$ N-m

$T_e = K_a \phi I_a = 70$ N-m

$\therefore$ Developed power $= T_e \omega = E_b I_a$

$(70)\left(\frac{2\pi \times 900}{60}\right) = E_b I_a$

$\Rightarrow (V_t - I_a r_a) I_a = 6597.3$

$[220 - I_a(0.02)] I_a = 6597.3$

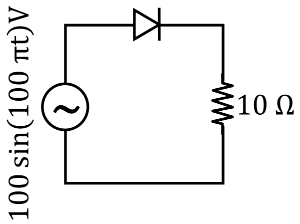
$220 I_a - 0.02\, I_a^2 = 6597.3$

$0.02 I_a^2 - 220 I_a + 6597.3 = 0$

Solving above equation

$I_a = 30.06A$

49. In the circuit shown in the figure, the diode used is ideal. The input power factor is ________ (Give the answer up to two decimal places)



[Ans. *] Range: 0.707

$$\text{input power factor} = \frac{P_o}{V_s I_s} = \left(\frac{\frac{V_{or}^2}{R}}{V_s \times \frac{V_{or}}{R}}\right) = \frac{V_{or}}{V_s}$$

$$= \frac{\left(\frac{V_m}{2}\right)}{\left(\frac{V_m}{\sqrt{2}}\right)} = \frac{\sqrt{2}}{2} = 0.707 \text{ lag}$$

50. Which of the following systems has maximum peak overshoot due to a unit step input?

(A) $\frac{100}{s^2 + 10s + 100}$
(B) $\frac{100}{s^2 + 15s + 160}$
(C) $\frac{100}{s^2 + 5s + 100}$
(C) $\frac{100}{s^2 + 20s + 100}$

[Ans. C]

(a) $\frac{100}{s^2 + 10s + 100}$

$$\omega_n = 10, \xi = \frac{10}{2\omega_n} = 0.5$$

(b) $\frac{100}{s^2 + 15s + 160}$

$$\omega_n = 10, \xi = \frac{15}{2\omega_n} = 0.75$$

(c) $\frac{100}{s^2 + 5s + 100}$

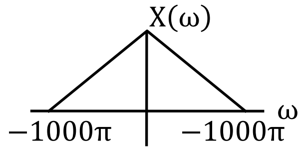
$$\omega_n = 10, \xi = \frac{5}{2\omega_n} = 0.25$$

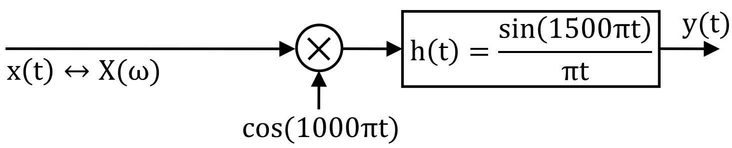
This has maximum peak over shoot.

(d) $\frac{100}{s^2 + 20s + 100}$

$$\omega_n = 10, \xi = \frac{20}{2\omega_n} = 1$$

51. The output y(t) of the following system is to be sampled, so as to reconstruct it from its samples uniquely. The required minimum sampling rate is





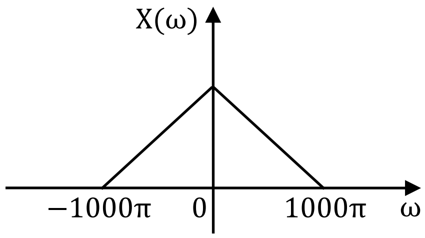
(A) 1000 samples/s

(B) 1500 samples/s

(C) 2000 samples/s

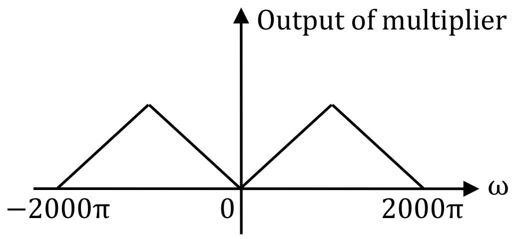
(D) 3000 samples/s

[Ans. B]

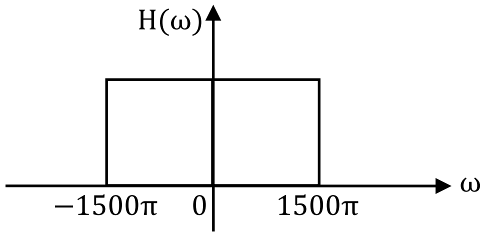


Output of multiplier is $= x(t). \cos(1000\pi t)$

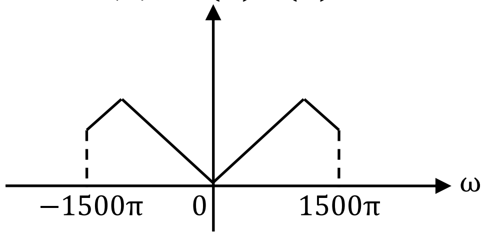
$$= \frac{1}{2} \times (\omega - 1000\pi) + \frac{1}{2} \times (\omega + 1000\pi)$$



$$h(t) = \frac{\sin(1500\pi t)}{\pi t}$$



$Y(\omega) = X(\omega).H(\omega)$



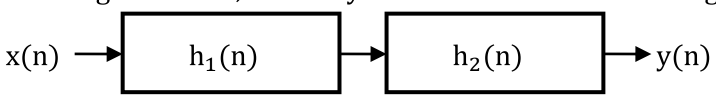
The maximum frequency in $y(t) = 1500\pi$

$\omega_m = 1500\pi$

$f_n = 750$

$(f_s)_{min} = 2f_n = 1500\ H_z = 1500$ samples/sec

52. A cascade system having the impulse responses $h_1(n) = \{\underset{\uparrow}{1}, -1\}$ and $h_2(n) = \{\underset{\uparrow}{1}, 1\}$ is shown in the figure below, where symbol ↑ denotes the time origin.



The input sequence x(n) for which the cascade system produces an output sequence $y(n) = \{\underset{\uparrow}{1}, 2, 1, -1, -2, -1\}$ is

(A) $x(n) = \{\underset{\uparrow}{1}, 2, 1, 1\}$

(B) $x(n) = \{\underset{\uparrow}{1}, 1, 2, 2\}$

(C) $x(n) = \{\underset{\uparrow}{1}, 1, 1\}$

(D) $x(n) = \{\underset{\uparrow}{1}, 2, 2, 1\}$

[Ans. D]

$h(n) = h_1(n) * h_2(n)$

$$\begin{array}{c|cc} & 1 & -1 \\ \hline 1 & 1 & -1 \\ 1 & 1 & -1 \end{array}$$

$h(n) = [1, 0, -1]$

Given $y(n) = [1, 2, 1, -1, -2, -1]$

$y(n) = x(n) * h(n)$

$y(z) = x(z)H(z)$

$$x(z) = \frac{y(z)}{H(z)}$$

$y(z) = 1 + 2z^{-1} + z^{-2} - z^{-3} - 2z^{-4} - z^{-5}$

$H(z) = 1 - z^{-2}$

$1 - z^{-2} \overline{)\, 1 + 2z^{-1} + z^{-2} - z^{-3} - 2z^{-4} - z^{-5}} \left(1 + 2z^{-1} + 2z^{-2} - z^{-3} \right.$

$\quad 1 - z^{-2}$ ($-$, $+$)

$\quad 2z^{-2} + 2z^{-1}$

$\quad 2z^{-1} - 2z^{3}$ ($-$, $+$)

$\quad\quad 2z^{-2} + z^{-3}$

$\quad\quad 2z^{-2} - 2z^{-4}$ ($-$, $+$)

$\quad\quad\quad z^{-3} - z^{-5}$

$\quad\quad\quad z^{-3} - z^{-5}$

$\quad\quad\quad\quad 0$

$x(z) = 1 + 2z^{-1} + 2z^{-2} + z^{-3}$

$x(n) = [1, 2, 2, 1]$

53. A star-connected, 12.5 kW, 208 V (line), 3-phase, 60 Hz squirrel cage induction motor has following equivalent circuit parameters per phase referred to the stator. $R_1 = 0.3\Omega$, $R_2 = 0.3\Omega$ $X_1 = 0.41\Omega$, $X_2 = 0.41\Omega$. Neglect shunt branch in the equivalent circuit. The starting current (in Ampere) for this motor when connected to an 80 V (line), 20 Hz, 3-phase, AC source is ______

[Ans. *] Range: 69 to 71

Given parameters of star-connected SCIM at 60Hz are

$r_1 = 0.3\Omega$

$r_2 = 0.3\Omega$

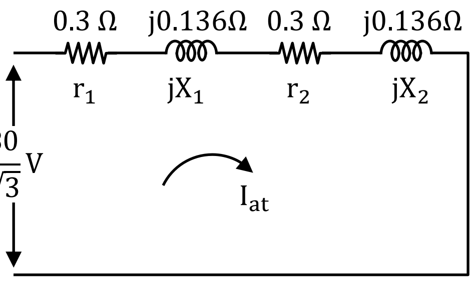
$X_1 = 0.41\Omega$

$X_2 = 0.41\Omega$

Now, if frequency changed to 20 Hz, leakage reactance magnitude will change.

$$\therefore X_{1(\text{new})} = \frac{20}{60}(0.41) = 0.136\Omega$$

$$\therefore X_{2(\text{new})} = \frac{20}{60}(0.41) = 0.136\Omega$$



$$I_{st} = \frac{\frac{80}{\sqrt{3}}}{\sqrt{(0.3+0.3)^2 + (0.136+0+36)^2}}$$

$$= 70.19\text{A}$$

54. A 3-phase, 2-pole, 50 Hz, synchronous generator has a rating of 250 MVA, 0.8 pf lagging. The kinetic energy of the machine at synchronous speed is 100 MJ. The machine is running steadily at synchronous speed and delivering 60 MW power at a power angle of 10 electrical degrees. If the load is suddenly removed, assuming the acceleration is constant for 10 cycles, the value of the power angle after 5 cycles is ________ electrical degrees.

[Ans. *]Range: 12.5 to 12.9

$$H = \frac{1000}{250} = 4MJ$$

$\delta = 10°$

$P_s = P_e = 60MW$

$\delta = \delta + \Delta\delta$

$$\Delta\delta = \delta\frac{(\Delta t)^2}{2} = \frac{P_s - P_e}{M} = \frac{(\Delta t)^2}{2} = \frac{60-0}{5H/180f} \times \frac{(0.1)^2}{2}$$

$$\Delta\delta = \frac{60 \times 186 \times 50}{250\ \times 4} \times \frac{(0.1)^2}{2}$$

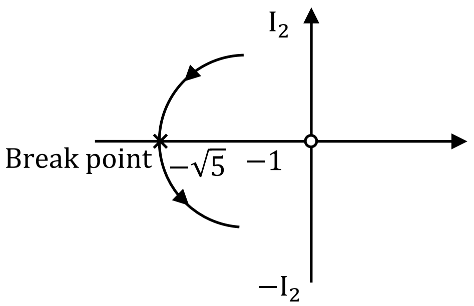
$$6 \times 180 \times 5 \times \frac{(0.1)^2}{2} = 2.7°$$

$\delta = 10 + 2.7 = 12.7°$

55. The root locus of the feedback control system having the characteristic equation $s^2 + 6Ks + 2s + 5 = 0$ where $K > 0$, enters into the real axis at

(A) $s = -1$
(B) $s = -\sqrt{5}$
(C) $s = -5$
(D) $s = \sqrt{5}$

[Ans. B]



$CF = s^2 + 6Ks + 2s + 5 = 0$

$$1 + \frac{6Ks}{s^2 + 2s + 5} = 0$$

$1 + G(s)H(s) = 0$

$$G(s)H(s) = \frac{6Ks}{s^2 + 2s + s} = 0$$

$$\frac{d}{ds}\left[\frac{6s}{s^2 + 2s + s}\right] = 0$$

$(s^2 + 2s + s)(6) - 6s(2s + 2) = 0$

$6s + 125 + 30 - 12s^2 - 12s = 0$

$-6s^2 + 30 = 0$

$s = \pm\sqrt{5}$

$s = -\sqrt{5}$ is a breakpoint