

GATE-2014

Question Paper

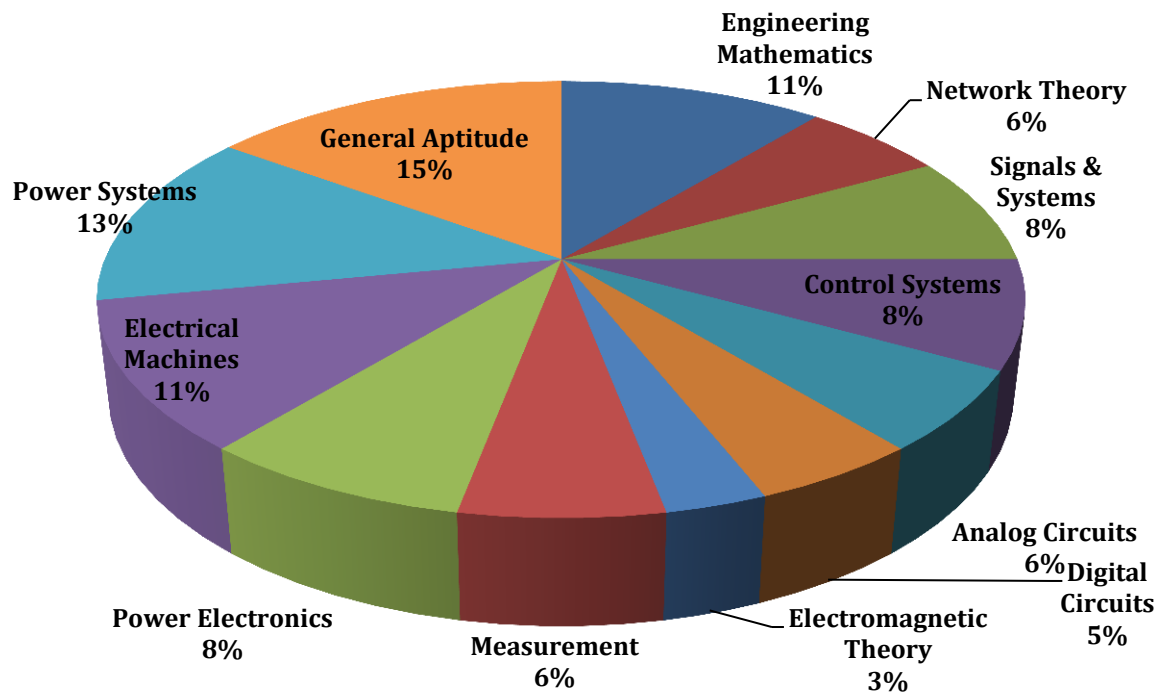
&

Answer Keys

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1. Question Paper Analysis
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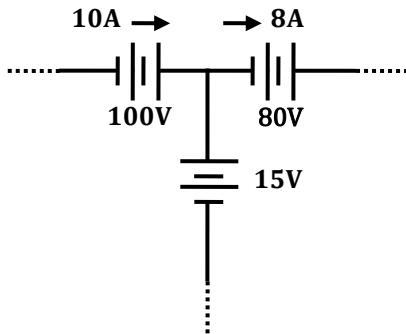
ANALYSIS OF GATE 2014 Electrical Engineering



GATE-2014- EE

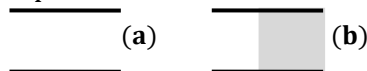
SUBJECT	NO OF QUESTION	Topics Asked in Paper	Total Marks
Engineering Mathematics	1M:5 2M:3	Linear Algebra Probability & distribution Calculus Differential Equations Complex Variables; Laplace Transform	11
Network Theory	1M:2 2M:2	Network Solution and methodology Transient /Study State Analysis of RLC Circuit to DC input Sinusoidal study state Analysis	6
Signals & Systems	1M:2 2M:3	Introduction to S&S Linear Time invariant (LTI) System Fourier Representation of signal Z-Transform	8
Control Systems	1M:2 2M:3	Stability & Routh Hurwitz Criterion Root Locus Technique Frequency response Analysis using bode plot State Variable Analysis	8
Analog Circuits	1M:2 2M:2	BJT & JFET Frequency Response Feedback Oscillator Circuit Operational Amplifiers And Its Applications	6
Digital Circuits	1M:1 2M:2	Number System & Code Conversion Boolean Algebra & K Map Microprocessor	5
Electromagnetic Theory	1M:1 2M:1	Electric & Magnetic field	3
Measurement	1M:2 2M:2	Measurement of Basic Electrical Quantities-1 Measurement of Basic Electrical Quantities-2 Electronic measuring Instrument-1 Electronic measuring Instrument-2	6
Power Electronics	1M:2 2M:3	Basics of power semiconductor devices Phase control rectifier Choppers; Inverters	8
Electrical Machines	1M:3 2M:4	Transformer; D.C. Machine Induction Machines Induction Machines	11
Power Systems	1M:3 2M:5	Transmission and Distribution, Economics and power Generation Symmetrical Components & Fault Calculation Power System and Stability Protection & Circuit Breakers Generating Station	13
General Aptitude	1M:5 2M:5	Numerical Ability Verbal Ability	15
Total	65		100

6. The three circuit elements shown in the figure are part of an electric circuit. The total power absorbed by the three circuit elements in watts is _____



[Ans. *] Range 330 to 330

7. C_0 is the capacitance of a parallel plate capacitor with air as dielectric (as in figure (a)). If half of the entire gap as shown in figure (b) is filled with a dielectric of permittivity ϵ_r , the expression for the modified capacitance is



(A) $\frac{C_0}{2} (1 + \epsilon_r)$

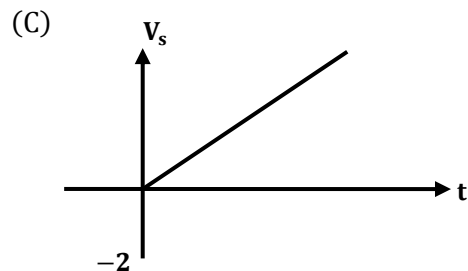
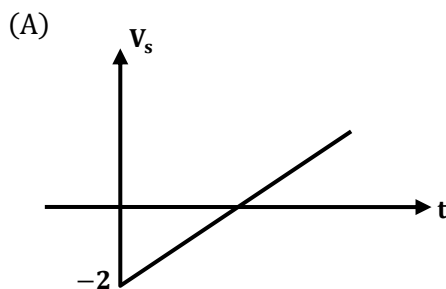
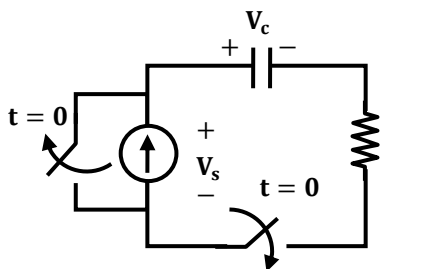
(C) $\frac{C_0}{2} \epsilon_r$

(B) $(C_0 + \epsilon_r)$

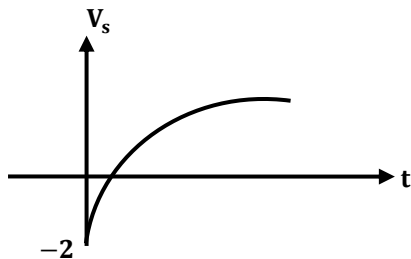
(D) $C_0(1 + \epsilon_r)$

[Ans. A]

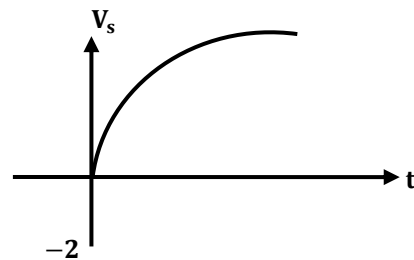
8. A combination of $1 \mu\text{F}$ capacitor with an initial voltage $V_c(0) = -2\text{V}$ in series with a 100Ω resistor is connected to a 20 mA ideal dc current source by operating both switches at $t = 0\text{s}$ as shown. Which of the following graphs shown in the options approximates the voltage V_s across the current source over the next few seconds?



(B)



(D)



[Ans. C]

9. $x(t)$ is nonzero only for $T_x < t < T'_x$, and similarly, $y(t)$ is nonzero only for $T_y < t < T'_y$. Let $z(t)$ be convolution of $x(t)$ and $y(t)$. Which one of the following statements is TRUE?
- (A) $z(t)$ can be nonzero over an unbounded interval.
 (B) $z(t)$ is nonzero for $t < T_x + T_y$.
 (C) $z(t)$ is zero outside of $T_x + T_y < t < T'_x + T'_y$.
 (D) $z(t)$ is nonzero for $t > T'_x + T'_y$.

[Ans. C]

10. For a periodic square wave, which one of the following statements is TRUE?
- (A) The Fourier series coefficients do not exist.
 (B) The Fourier series coefficients exist but the reconstruction converges at no point.
 (C) The Fourier series coefficients exist and the reconstruction converges at most points.
 (D) The Fourier series coefficients exist and the reconstruction converges at every point.

[Ans. C]

11. An 8-pole, 3-phase, 50 Hz induction motor is operating at a speed of 700 rpm. The frequency of the rotor current of the motor in Hz is _____

[Ans. *] Range 3.2 to 3.5

12. For a specified input voltage and frequency, if the equivalent radius of the core of a transformer is reduced by half, the factor by which the number of turns in the primary should change to maintain the same no load current is

(A) 1/4 (B) 1/2 (C) 2 (D) 4

[Ans. C]

13. A star connected 400 V, 50 Hz, 4 pole synchronous machine gave the following open circuit and short circuit test results:

Open circuit test: $V_{OC} = 400$ V (rms, line-to-line) at field current, $I_f = 2.3$ A

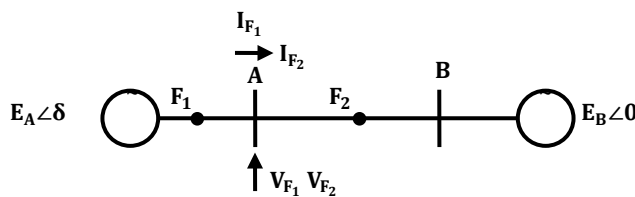
Short circuit test: $I_{SC} = 10$ A (rms, phase) at field current, $I_f = 1.5$ A

The value of per phase synchronous impedance in Ω at rated voltage is _____

[Ans. *] Range 14.5 to 15.5

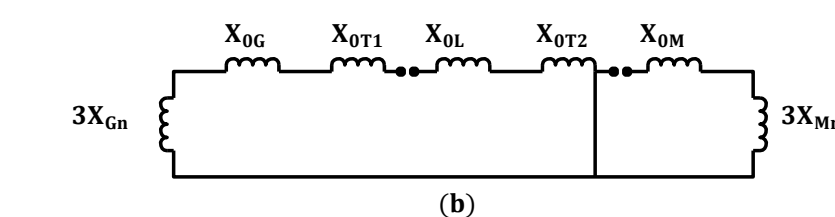
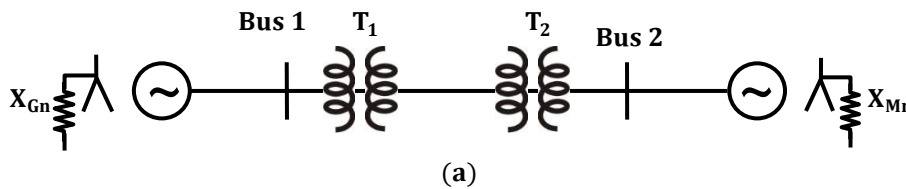
14. The undesirable property of an electrical insulating material is
 (A) high dielectric strength (C) high thermal conductivity
 (B) high relative permittivity (D) high insulation resistivity
[Ans. B]

15. Three-phase to ground fault takes place at locations F_1 and F_2 in the system shown in the figure. If the fault takes place at location F_1 , then the voltage and the current at bus A are V_{F_1} and I_{F_1} respectively. If the fault takes place at location F_2 , then the voltage and the current at bus A are V_{F_2} and I_{F_2} respectively. The correct statement about voltages and currents during faults at F_1 and F_2 is



- (A) V_{F_1} leads I_{F_1} and V_{F_2} leads I_{F_2} (B) V_{F_1} leads I_{F_1} and V_{F_2} lags I_{F_2}
 (C) V_{F_1} lags I_{F_1} and V_{F_2} leads I_{F_2} (D) V_{F_1} lags I_{F_1} and V_{F_2} lags I_{F_2}
[Ans. C]

16. A 2-bus system and corresponding zero sequence network are shown in the figure.



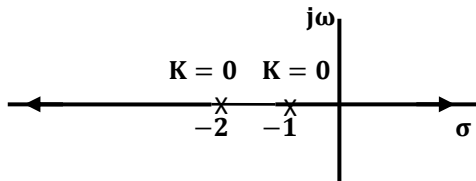
The transformers T_1 and T_2 are connected as

- (A) Δ Δ and Δ Δ (C) Δ Δ and Δ Δ
 (B) Δ Δ and Δ Δ (D) Δ Δ and Δ Δ

[Ans. B]

17. In the formation of Routh-Hurwitz array for a polynomial, all the elements of a row have zero values. This premature termination of the array indicates the presence of
 (A) only one root at the origin (C) only positive real roots
 (B) imaginary roots (D) only negative real roots
[Ans. B]

18. The root locus of a unity feedback system is shown in the figure



The closed loop transfer function of the system is

(A) $\frac{C(s)}{R(s)} = \frac{K}{(s+1)(s+2)}$

(C) $\frac{C(s)}{R(s)} = \frac{K}{(s+1)(s+2) - K}$

(B) $\frac{C(s)}{R(s)} = \frac{-K}{(s+1)(s+2) + K}$

(D) $\frac{C(s)}{R(s)} = \frac{K}{(s+1)(s+2) + K}$

[Ans. C]

19. Power consumed by a balanced 3-phase, 3-wire load is measured by the two wattmeter method. The first wattmeter reads twice that of the second. Then the load impedance angle in radians is

(A) $\pi/12$

(B) $\pi/8$

(C) $\pi/6$

(D) $\pi/3$

[Ans. C]

20. In an oscilloscope screen, linear sweep is applied at the

(A) vertical axis

(B) horizontal axis

(C) origin

(D) both horizontal and vertical axis

[Ans. B]

21. A cascade of three identical modulo-5 counters has an overall modulus of

(A) 5

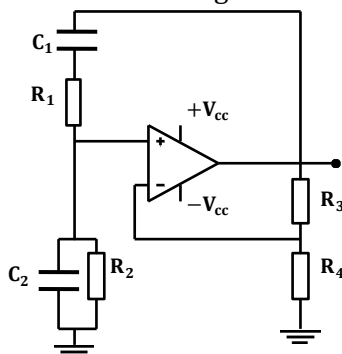
(B) 25

(C) 125

(D) 625

[Ans. C]

22. In the Wien Bridge oscillator circuit shown in figure, the bridge is balanced when



(A) $\frac{R_3}{R_4} = \frac{R_1}{R_2}, \omega = \frac{1}{\sqrt{R_1 C_1 R_2 C_2}}$

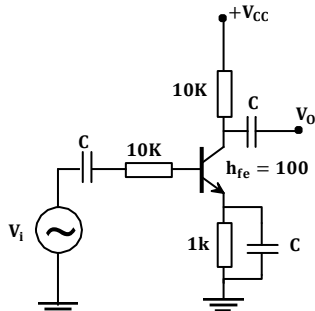
(C) $\frac{R_3}{R_4} = \frac{R_1}{R_2} + \frac{C_2}{C_1}, \omega = \frac{1}{\sqrt{R_1 C_1 R_2 C_2}}$

(B) $\frac{R_2}{R_1} = \frac{C_2}{C_1}, \omega = \frac{1}{R_1 C_1 R_2 C_2}$

(D) $\frac{R_3}{R_4} + \frac{R_1}{R_2} = \frac{C_2}{C_1}, \omega = \frac{1}{R_1 C_1 R_2 C_2}$

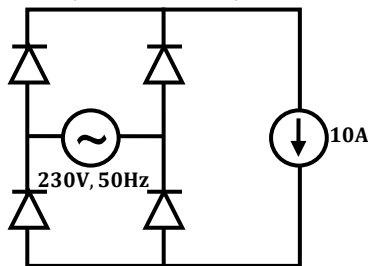
[Ans. C]

23. The magnitude of the mid-band voltage gain of the circuit shown in figure is (assuming h_{fe} of the transistor to be 100)



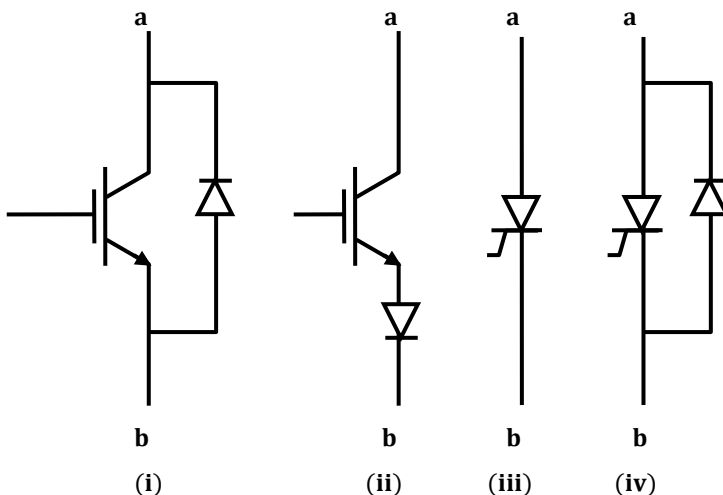
- (A) 1 (B) 10 (C) 20 (D) 100
[Ans. D]

24. The figure shows the circuit of a rectifier fed from a 230-V (rms), 50-Hz sinusoidal voltage source. If we want to replace the current source with a resistor so that the rms value of the current supplied by the voltage source remains unchanged, the value of the resistance (in ohms) is _____ (Assume diodes to be ideal.)



[Ans. *] Range 23 to 23

25. Figure shows four electronic switches (i), (ii), (iii) and (iv). Which of the switches can block voltages of either polarity (applied between terminals 'a' and 'b') when the active device is in the OFF state?



- (A) (i), (ii) and (iii) (C) (ii) and (iii)
(B) (ii), (iii) and (iv) (D) (i) and (iv)
[Ans. C]

Q.26 - Q.55 Carry Two Marks each.

26. Let $g: [0, \infty) \rightarrow [0, \infty)$ be a function defined by $g(x) = x - [x]$, where $[x]$ represents the integer part of x . (That is, it is the largest integer which is less than or equal to x). The value of the constant term in the Fourier series expansion of $g(x)$ is _____

[Ans. *] Range 0.5 to 0.5

27. A fair coin is tossed n times. The probability that the difference between the number of heads and tails is $(n - 3)$ is

(A) 2^{-n} (B) 0 (C) ${}^n C_{n-3} 2^{-n}$ (D) 2^{-n+3}

[Ans. B]

28. The line integral of function $F = yzi$, in the counterclockwise direction, along the circle $x^2 + y^2 = 1$ at $z = 1$ is

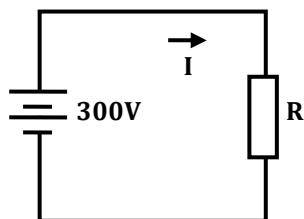
(A) -2π (B) $-\pi$ (C) π (D) 2π

[Ans. B]

29. An incandescent lamp is marked 40 W, 240V. If resistance at room temperature (26°C) is 120Ω , and temperature coefficient of resistance is $4.5 \times 10^{-3}/^\circ\text{C}$, then its 'ON' state filament temperature in $^\circ\text{C}$ is approximately _____

[Ans. *] Range 2470 to 2471

30. In the figure, the value of resistor R is $(25 + I/2)$ ohms, where I is the current in amperes. The current I is _____



[Ans. *] Range 10 to 10

31. In an unbalanced three phase system, phase current $I_a = 1\angle(-90^\circ)$ pu, negative sequence current $I_{b2} = 4\angle(-150^\circ)$ pu, zero sequence current $I_{c0} = 3\angle 90^\circ$ pu. The magnitude of phase current I_b in pu is

(A) 1.00 (B) 7.81 (C) 11.53 (D) 13.00

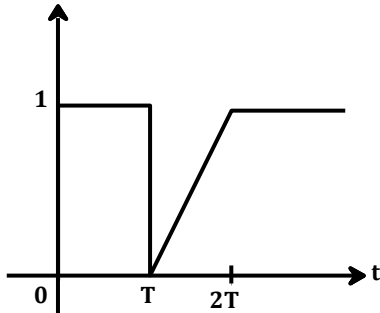
[Ans. C]

32. The following four vector fields are given in Cartesian co-ordinate system. The vector field which does not satisfy the property of magnetic flux density is

(A) $y^2 a_x + z^2 a_y + x^2 a_z$ (C) $x^2 a_x + y^2 a_y + z^2 a_z$
(B) $z^2 a_x + x^2 a_y + y^2 a_z$ (D) $y^2 z^2 a_x + x^2 z^2 a_y + x^2 y^2 a_z$

[Ans. C]

33. The function shown in the figure can be represented as



- (A) $u(t) - u(t - T) + \frac{(t - T)}{T} u(t - T) - \frac{(t - 2T)}{T} u(t - 2T)$
 (B) $u(t) + \frac{t}{T} u(t - T) - \frac{t}{T} u(t - 2T)$
 (C) $u(t) - u(t - T) + \frac{(t - T)}{T} u(t) - \frac{(t - 2T)}{T} u(t)$
 (D) $u(t) + \frac{(t - T)}{T} u(t - T) - 2 \frac{(t - 2T)}{T} u(t - 2T)$

[Ans. A]

34. Let $X(z) = \frac{1}{1-z^{-3}}$ be the Z-transform of a causal signal $x[n]$. Then, the values of $x[2]$ and $x[3]$ are
 (A) 0 and 0 (B) 0 and 1 (C) 1 and 0 (D) 1 and 1

[Ans. B]

35. Let $f(t)$ be a continuous time signal and let $F(\omega)$ be its Fourier Transform defined by

$$F(\omega) = \int_{-\infty}^{\infty} f(t)e^{-j\omega t} dt$$

Define $g(t)$ by

$$g(t) = \int_{-\infty}^{\infty} F(u)e^{-jut} du$$

What is the relationship between $f(t)$ and $g(t)$?

- (A) $g(t)$ would always be proportional to $f(t)$.
 (B) $g(t)$ would be proportional to $f(t)$ if $f(t)$ is an even function.
 (C) $g(t)$ would be proportional to $f(t)$ only if $f(t)$ is a sinusoidal function.
 (D) $g(t)$ would never be proportional to $f(t)$.

[Ans. B]

36. The core loss of a single phase, 230/115 V, 50 Hz power transformer is measured from 230 V side by feeding the primary (230 V side) from a variable voltage, variable frequency source while keeping the secondary open circuited. The core loss is measured to be 1050 W for 230 V, 50 Hz input. The core loss is again measured to be 500 W for 138 V, 30 Hz input. The hysteresis and eddy current losses of the transformer for 230 V, 50 Hz input are respectively,

- (A) 508 W and 542 W. (C) 498 W and 552 W.
 (B) 468 W and 582 W. (D) 488 W and 562 W.

[Ans. A]

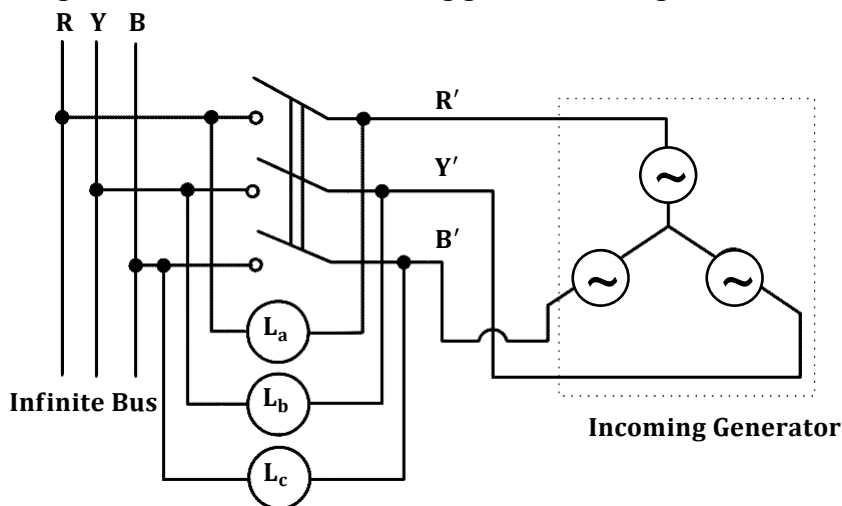
37. A 15 kW, 230 V dc shunt motor has armature circuit resistance of 0.4Ω and field circuit resistance of 230Ω . At no load and rated voltage, the motor runs at 1400 rpm and the line current drawn by the motor is 5 A. At full load, the motor draws a line current of 70 A. Neglect armature reaction. The full load speed of the motor in rpm is _____

[Ans. *] Range 1239 to 1242

38. A 3 phase, 50 Hz, six pole induction motor has a rotor resistance of 0.1Ω and reactance of 0.92Ω . Neglect the voltage drop in stator and assume that the rotor resistance is constant. Given that the full load slip is 3%, the ratio of maximum torque to full load torque is
(A) 1.567 (B) 1.712 (C) 1.948 (D) 2.134

[Ans. C]

39. A three phase synchronous generator is to be connected to the infinite bus. The lamps are connected as shown in the figure for the synchronization. The phase sequence of bus voltage is R-Y-B and that of incoming generator voltage is R'-Y'-B'.

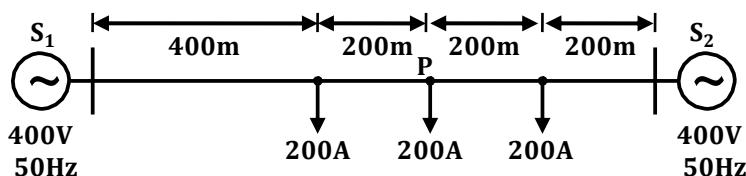


It was found that the lamps are becoming dark in the sequence L_a - L_b - L_c . It means that the phase sequence of incoming generator is

- (A) opposite to infinite bus and its frequency is more than infinite bus
(B) opposite to infinite bus but its frequency is less than infinite bus
(C) same as infinite bus and its frequency is more than infinite bus
(D) same as infinite bus and its frequency is less than infinite bus

[Ans. A]

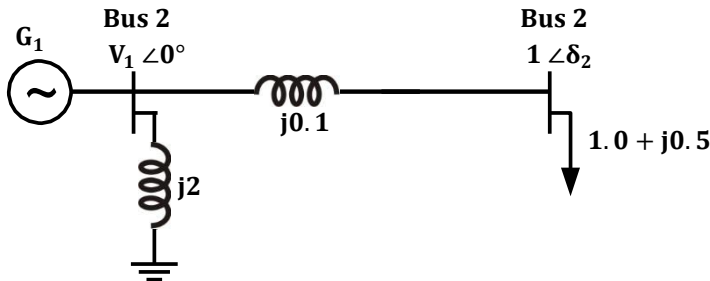
40. A distribution feeder of 1 km length having resistance, but negligible reactance, is fed from both the ends by 400V, 50 Hz balanced sources. Both voltage sources S_1 and S_2 are in phase. The feeder supplies concentrated loads of unity power factor as shown in the figure.



The contributions of S_1 and S_2 in 100 A current supplied at location P respectively, are
 (A) 75 A and 25 A (C) 25 A and 75 A
 (B) 50 A and 50 A (D) 0 A and 100 A

[Ans. D]

41. A two bus power system shown in the figure supplies load of $1.0+j0.5$ p.u.



The values of V_1 in p.u. and δ_2 respectively are

- (A) 0.95 and 6.00° (C) 1.1 and -6.00°
 (B) 1.05 and -5.44° (D) 1.1 and -27.12°

[Ans. B]

42. The fuel cost functions of two power plants are

$$\text{Plant } P_1: C_1 = 0.05Pg_1^2 + APg_1 + B$$

$$\text{Plant } P_2: C_2 = 0.10Pg_2^2 + 3APg_2 + 2B$$

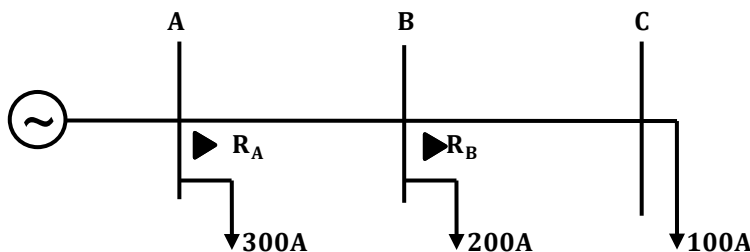
where, P_{g_1} and P_{g_2} are the generated powers of two plants, and A and B are the constants.

If the two plants optimally share 1000 MW load at incremental fuel cost of 100 Rs/MWh, the ratio of load shared by plants P_1 and P_2 is

- (A) 1:4 (B) 2:3 (C) 3:2 (D) 4:1

[Ans. D]

43. The overcurrent relays for the line protection and loads connected at the buses are shown in the figure.



The relays are IDMT in nature having the characteristic

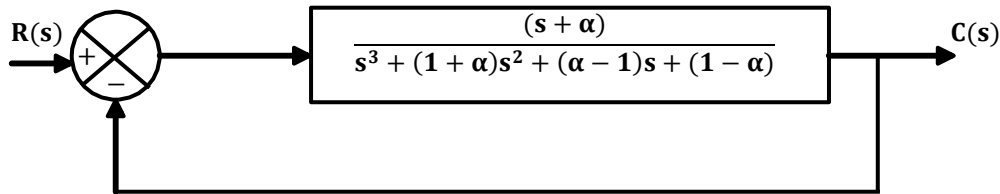
$$t_{op} = \frac{0.14 \times \text{Time Multiplier Setting}}{(\text{Plug setting Multiplier})^{0.02} - 1}$$

The maximum and minimum fault currents at bus B are 2000 A and 500 A respectively.

Assuming the time multiplier setting and plug setting for relay R_B to be 0.1 and 5A respectively, the operating time of R_B (in seconds) is _____

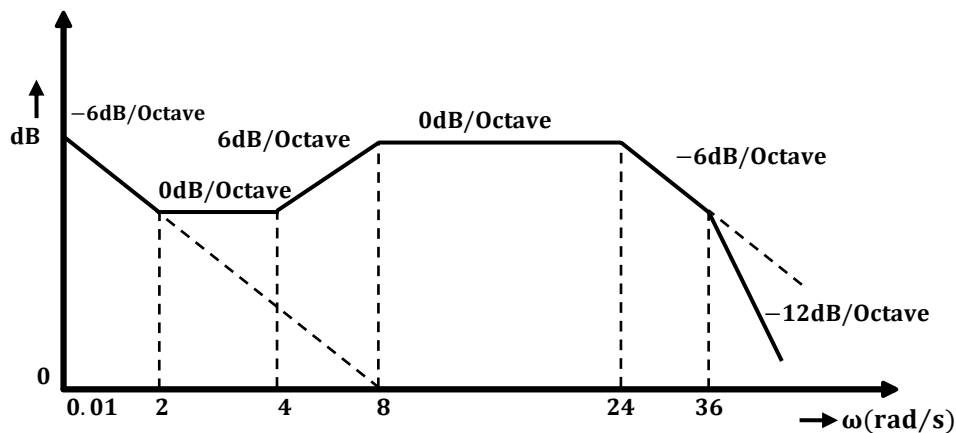
[Ans. *] Range 0.21 to 0.23

44. For the given system, it is desired that the system be stable. The minimum value of α for this condition is _____



[Ans. *] Range 0.61 to 0.63

45. The Bode magnitude plot of the transfer function $G(s) = \frac{K(1+0.5s)(1+as)}{s(1+\frac{s}{8})(1+bs)(1+\frac{s}{36})}$ is shown below:
Note that $-6 \text{ dB/octave} = -20 \text{ dB/decade}$. The value of $\frac{a}{bK}$ is _____



[Ans. *] Range 0.7 to 0.8

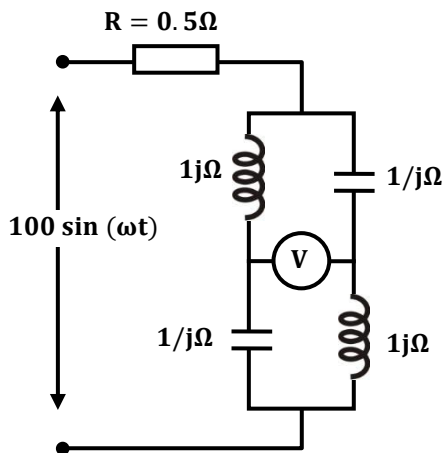
46. A system matrix is given as follows.

$$A = \begin{bmatrix} 0 & 1 & -1 \\ -6 & -11 & 6 \\ -6 & -11 & 5 \end{bmatrix}$$

The absolute value of the ratio of the maximum eigenvalue to the minimum eigenvalue is _____

[Ans. *] Range 2.9 to 3.1

47. The reading of the voltmeter (rms) in volts, for the circuit shown in the figure is _____

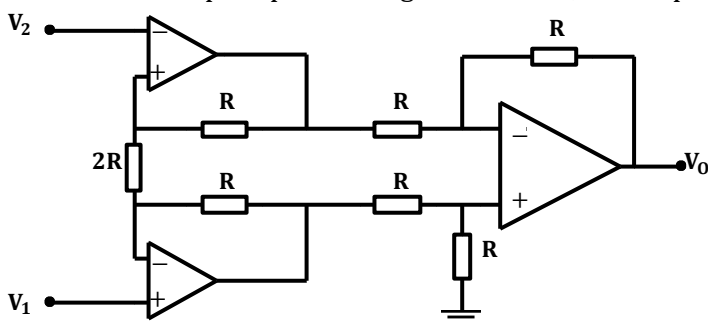


[Ans. *] Range 140 to 142

48. The dc current flowing in a circuit is measured by two ammeters, one PMMC and another electro-dynamometer type, connected in series. The PMMC meter contains 100 turns in the coil, the flux density in the air gap is 0.2 Wb/m^2 , and the area of the coil is 80 mm^2 . The electro-dynamometer ammeter has a change in mutual inductance with respect to deflection of 0.5 mH/deg . The spring constants of both the meters are equal. The value of current, at which the deflections of the two meters are same, is _____

[Ans. *] Range 3.0 to 3.4

49. Given that the op-amps in the figure are ideal, the output voltage V_0 is



- (A) $(V_1 - V_2)$
(B) $2(V_1 - V_2)$

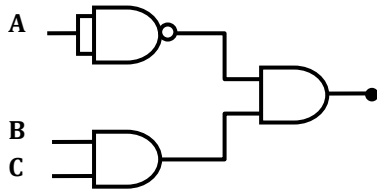
- (C) $(V_1 - V_2)/2$
(D) $(V_1 + V_2)$

[Ans. B]

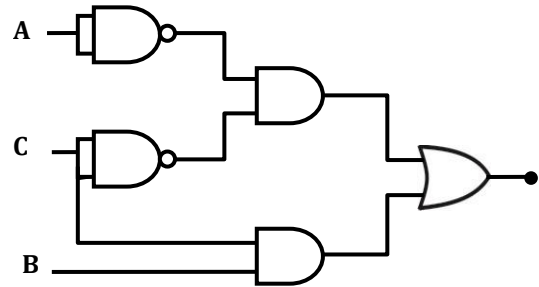
50. Which of the following logic circuits is a realization of the function F whose Karnaugh map is shown in figure

		AB			
		00	01	11	10
C	0	1	1		
	1		1	1	

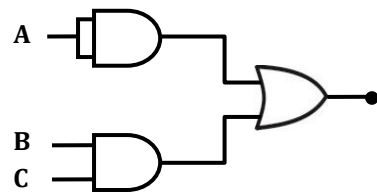
(A)



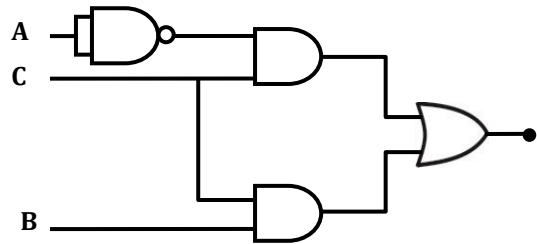
(C)



(B)

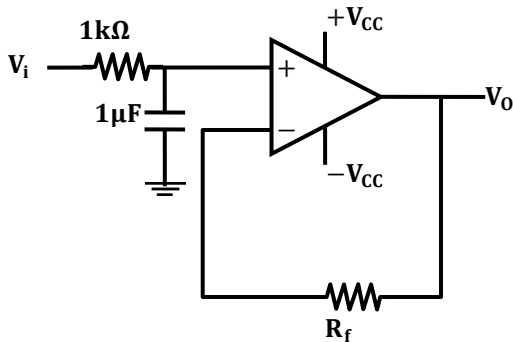


(D)

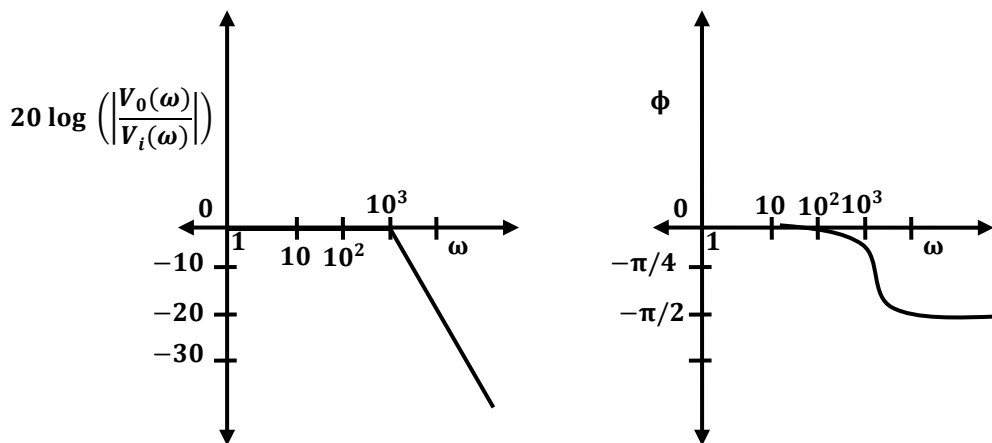


[Ans. C]

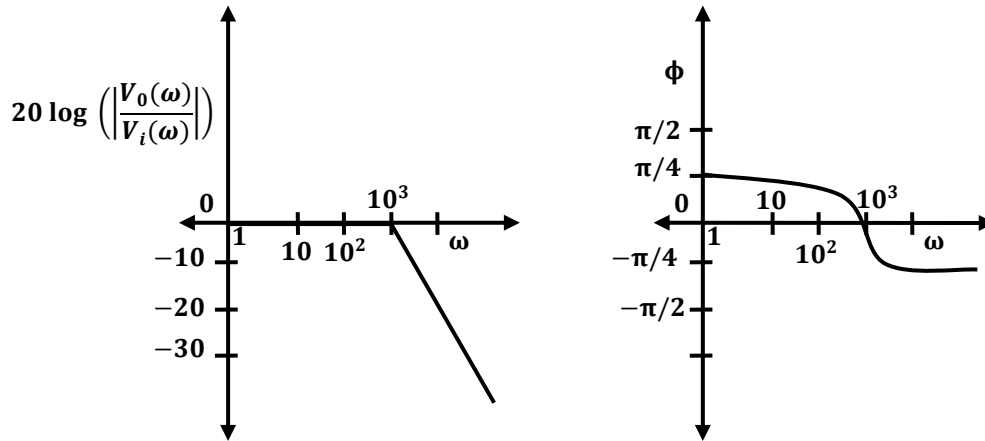
51. In the figure shown, assume the op-amp to be ideal. Which of the alternatives gives the correct Bode plots for the transfer function $\frac{V_o(\omega)}{V_i(\omega)}$?



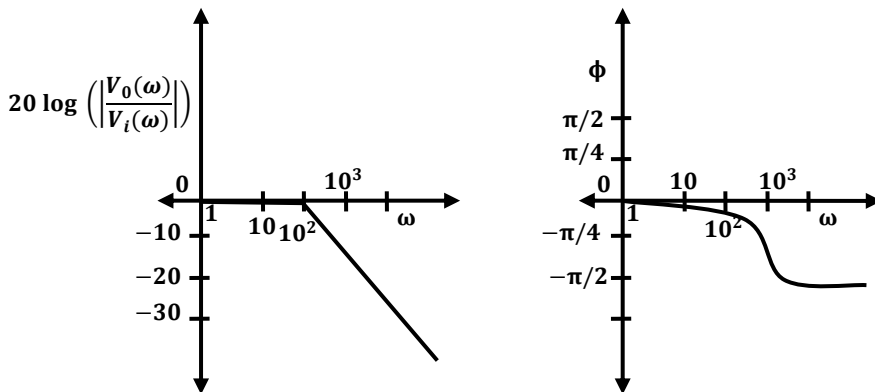
(A)



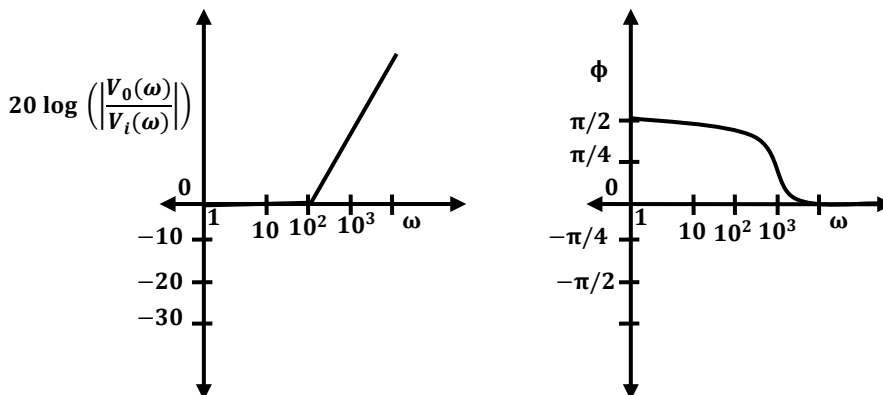
(B)



(C)



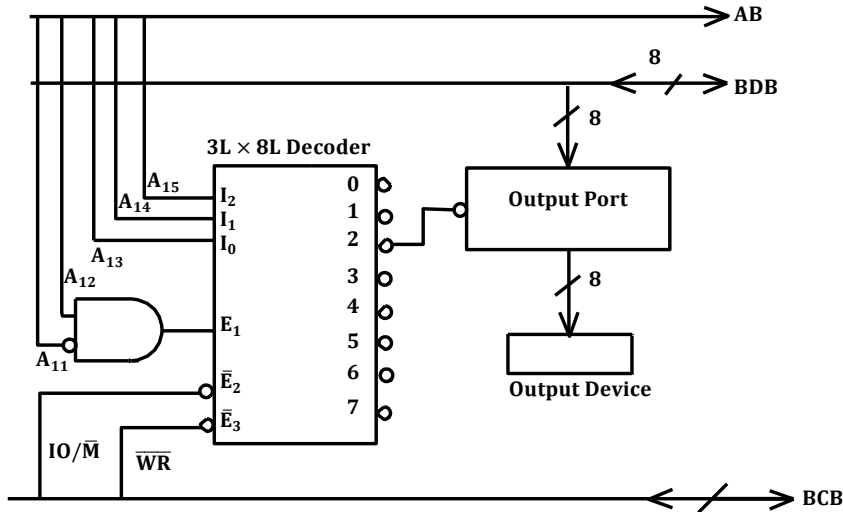
(D)



[Ans. A]

52. An output device is interfaced with 8-bit microprocessor 8085A. The interfacing circuit is shown in figure

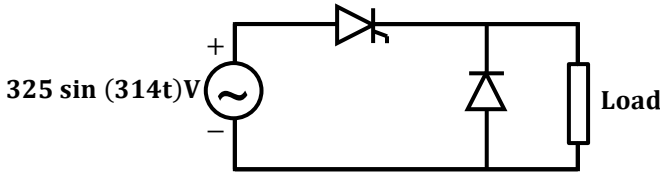
The interfacing circuit makes use of 3 Line to 8 Line decoder having 3 enable lines $E_1, \bar{E}_2, \bar{E}_3$. The address of the device is



- (A) 50_H (B) 5000_H (C) $A0_H$ (D) $A000_H$

[Ans. B]

53. The figure shows the circuit diagram of a rectifier. The load consists of a resistance 10Ω and an inductance 0.05 H connected in series. Assuming ideal thyristor and ideal diode, the thyristor firing angle (in degree) needed to obtain an average load voltage of 70 V is _____



[Ans. *] Range 69 to 70

54. Figure (i) shows the circuit diagram of a chopper. The switch S in the circuit in figure (i) is switched such that the voltage V_D across the diode has the wave shape as shown in figure (ii). The capacitance C is large so that the voltage across it is constant. If switch S and the diode are ideal, the peak to peak ripple (in A) in the inductor current is _____

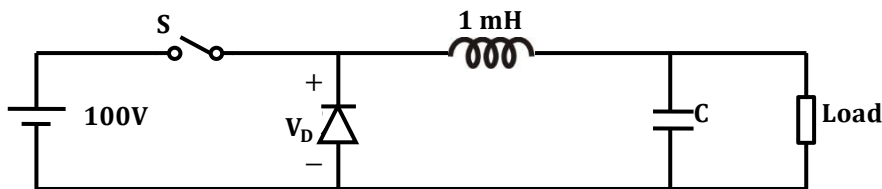


Figure (i)

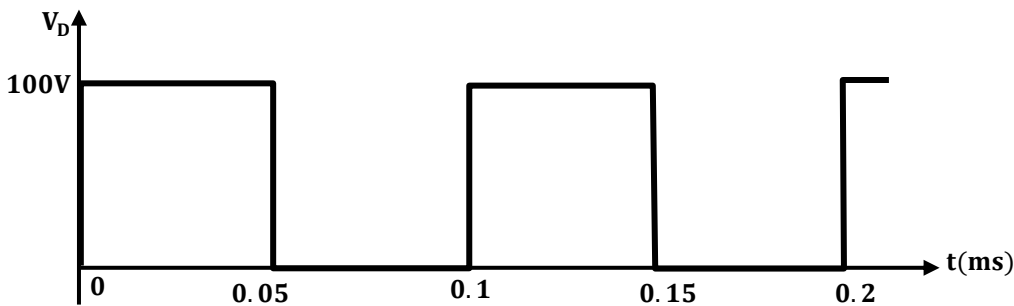
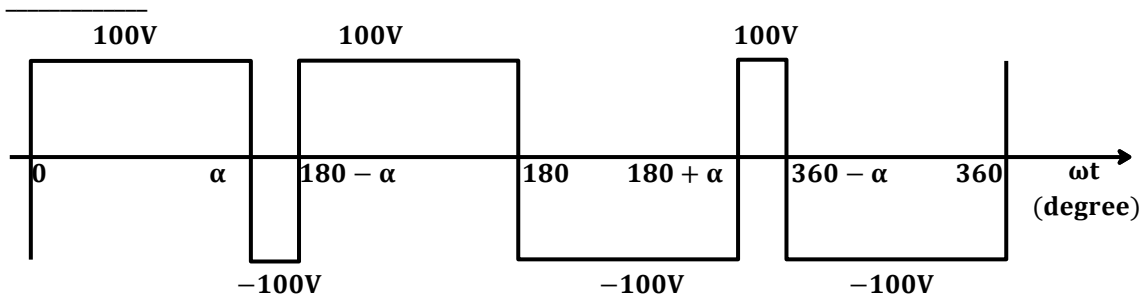


Figure (ii)

[Ans. *] Range 2.49 to 2.51

55. The figure shows one period of the output voltage of an inverter. α should be chosen such that $60^\circ < \alpha < 90^\circ$. If rms value of the fundamental component is 50 V, then α in degree is



[Ans. *] Range 76.5 to 78.0

General Aptitude (Set – 7)

General Aptitude One Marks Question Q. 56 to Q. 60

56. Which of the following options is the closest in meaning to the phrase underlined in the sentence below?

It is fascinating to see life forms cope with varied environmental conditions.

- (A) adopt to (C) adept in
(B) adapt to (D) accept with

[Ans. B]

57. Choose the most appropriate word from the options given below to complete the following sentence.

He could not understand the judges awarding her the first prize, because he thought that her performance was quite _____.

- (A) superb (C) mediocre
(B) medium (D) exhilarating

[Ans. C]

58. In a press meet on the recent scam, the minister said, "The buck stops here". What did the minister convey by the statement?

- (A) He wants all the money
(B) He will return the money
(C) He will assume final responsibility
(D) He will resist all enquiries

[Ans. C]

59. If $(z + 1/z)^2 = 98$, compute $(z^2 + 1/z^2)$

[Ans. *] Range 96 to 96

60. The roots of $ax^2 + bx + c = 0$ are real and positive. a, b and c are real. Then $ax^2 + b|x| + c$ has
- (A) no roots (C) 3 real roots
(B) 2 real roots (D) 4 real roots
- [Ans. D]**

General Aptitude Two Marks Question Q. 61 to Q. 65

61. The Palghat Gap (or Palakkad Gap), a region about 30 km wide in the southern part of the Western Ghats in India, is lower than the hilly terrain to its north and south. The exact reasons for the formation of this gap are not clear. It results in the neighbouring regions of Tamil Nadu getting more rainfall from the South West monsoon and the neighbouring regions of Kerala having higher summer temperatures.
- What can be inferred from this passage?
- (A) The Palghat gap is caused by high rainfall and high temperatures in southern Tamil Nadu and Kerala
(B) The regions in Tamil Nadu and Kerala that are near the Palghat Gap are low-lying
(C) The low terrain of the Palghat Gap has a significant impact on weather patterns in neighbouring parts of Tamil Nadu and Kerala
(D) Higher summer temperatures result in higher rainfall near the Palghat Gap area
- [Ans. C]**
62. Geneticists say that they are very close to confirming the genetic roots of psychiatric illnesses such as depression and schizophrenia, and consequently, that doctors will be able to eradicate these diseases through early identification and gene therapy.
- On which of the following assumptions does the statement above rely?
- (A) Strategies are now available for eliminating psychiatric illnesses
(B) Certain psychiatric illnesses have a genetic basis
(C) All human diseases can be traced back to genes and how they are expressed
(D) In the future, genetics will become the only relevant field for identifying psychiatric illnesses
- [Ans. B]**
63. Round-trip tickets to a tourist destination are eligible for a discount of 10% on the total fare. In addition, groups of 4 or more get a discount of 5% on the total fare. If the one way single person fare is Rs 100, a group of 5 tourists purchasing round-trip tickets will be charged Rs_____
- [Ans. *] Range 850 to 850**

64. In a survey, 300 respondents were asked whether they own a vehicle or not. If yes, they were further asked to mention whether they own a car or scooter or both. Their responses are tabulated below. What percent of respondents do not own a scooter?

		Men	Women
Own vehicle	Car	40	34
	Scooter	30	20
	Both	60	46
Do not own vehicle		20	50

[Ans. *] Range 48 to 48

65. When a point inside of a tetrahedron (a solid with four triangular surfaces) is connected by straight lines to its corners, how many (new) internal planes are created with these lines? _____.

[Ans. *] Range 6 to 6