GATE 2026 Electronics & Communication Engineering Question Paper

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General Instructions

(i) This question paper contains 65 questions. All questions are compulsory.

(ii) It comprises 42 single-correct multiple-choice questions, 10 multiple-correct questions and 13 numerical / integer-type questions.

(iii) These questions follow the GATE Electronics and Communication Engineering examination pattern.

(iv) Questions carry 1 or 2 marks. MCQs have negative marking (1/3 or 2/3 of the marks); MSQ and numerical-answer (NAT) questions carry no negative marking.

(v) GATE is a 3-hour paper of 65 questions (100 marks).

(vi) A virtual scientific calculator is provided; physical calculators are not allowed.

(vii) Attempt every question; detailed solutions are provided in the companion solutions booklet.

(viii) For multiple-correct questions, all correct options must be selected to earn full marks.

(ix) For numerical questions, report the answer rounded exactly as asked.

1. Among the following options, the antonym of the word 'nocturnal' is _____.

(A) normal

(B) diurnal

(C) abnormal

(D) exceptional

2. The statements (S1), (S2), and (S3) pertain to the scores obtained by students in an exam. The maximum possible marks in the exam is 150.
(S1) The highest score is 100.
(S2) The fourth highest score is 76.
(S3) There are at least four students whose scores are within 25 of each other.
Which one of the following options is necessarily correct?

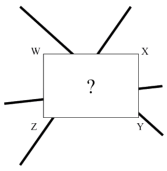
(A) (S1) and (S2) together imply (S3)

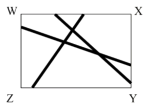
(B) (S1) and (S3) together imply (S2)

(C) (S2) and (S3) together imply (S1)

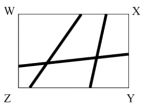
(D) (S1) implies (S3)

3. The figure below has exactly three intersecting line segments with a rectangular portion WXYZ missing. Which one of the following options P, Q, R, and S is the missing portion WXYZ?





P



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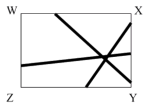
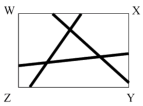


R



S

(A) P

(B) Q

(C) R

(D) S

4. Real numbers y, p, and n (all greater than 1) satisfy

$$\left(\log_{p^{1/n}} y\right)\left(\log_{y^{1/n}} p\right) = 16,$$

where the logarithms are taken to the bases $p^{1/n}$ and $y^{1/n}$.
The value of n is _____

(A) 2

(B) 4

(C) 8

(D) 16

5. The following observation is made about the scores obtained by 100 students in an exam:
'For each student, there exists another student in the class such that their scores are at most ten marks away.'
If the above statement is **false**, which one of the following statements is necessarily true?

(A) For each student, the scores of all the other students are more than 10 marks away.

(B) There exists at least one student in the class for whom the scores of all the other students are more than 10 marks away.

(C) There is exactly one student in the class for whom the scores of some students are more than 10 marks away.

(D) For each student, the score of exactly one other student is more than 10 marks away.

6. Each one of the following clues contains a keyword that is partially filled.
Clue 1: Synonym of recognize (8 letters): _D_NT_FY
Clue 2: A story long enough to fill a book (5 letters): _ _ _ EL
Clue 3: Two of something (6 letters): _ _ _ PLE
Clue 4: A fraction of something, split equally into two parts (4 letters): _ _ _ F
The first letter of each of the keywords can be rearranged to form a four-letter word.
Which one of the options below is a possible choice for the four-letter word?

(A) CHIN

(B) COIN

(C) ITCH

(D) NOSE

7. Three children P, Q, R and two grown-ups X, Y play a badminton doubles tournament. X and Y are parents to two of the children playing. The child of X is not the same as the child of Y. Exactly one of the children does not have a parent playing in the tournament. The following rules are followed:
(i) A parent and his/her child cannot be on the same team.
(ii) A match can feature at most one parent and his/her child, that is, a maximum of one parent-child pair can play in a match.
The following matches were played:

	TEAM 1	**TEAM 2**
MATCH 1	P and X	Q and R
MATCH 2	P and R	X and Y

MATCH 3 R and X Q and Y

Which one of the following options is correct?

(A) P does not have any parent playing

(B) Q does not have any parent playing

(C) R does not have any parent playing

(D) X does not have a child playing

8. Let P_k represent the perimeter of a square with sides of length k. The value of the expression $P_1 + P_2 + P_3 + \cdots + P_{10}$ is _____

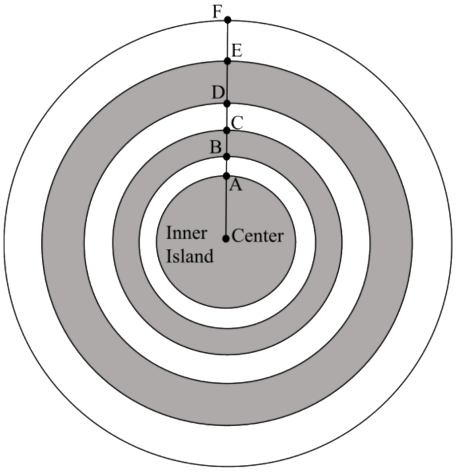
(A) 55

(B) 110

(C) 220

(D) 440

9. The city of Atlantis was crafted by the God of the seas, Poseidon. It was made of alternating concentric circular rings of land (shaded) and water (not shaded) as represented in the figure (not to scale). The radius of Inner Island was **2.5** stades (a unit of length used in ancient Greece). The water surrounding Inner Island was one stade wide (length AB). This was surrounded by two pairs of alternating rings of land and water. The first pair of land and water was two stades wide each (lengths BC and CD), and the outer pair is three stades wide each (lengths DE and EF).



The ratio of the surface area of the land to that of the water in the city of Atlantis is _____ (round off to two decimal places).

(A) 0.45

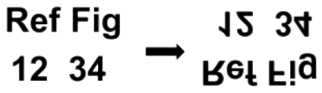
(B) 0.60

(C) 0.75

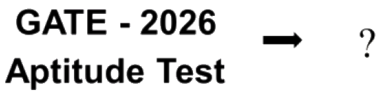
(D) 0.90

10. Consider the visual pattern rule shown below.

If

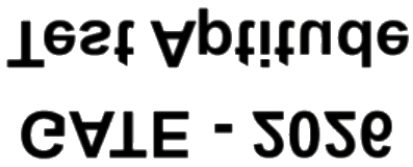


Then



If the label "Ref Fig / 12 34" transforms into the pattern shown after the arrow under a fixed rule, then applying the same rule to the label "GATE - 2026 / Aptitude Test" produces which one of the patterns P, Q, R, S shown below?

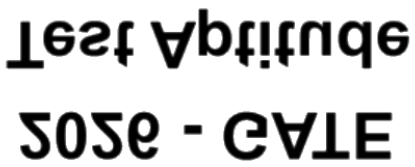
(A) Pattern P



(B) Pattern Q

(C) Pattern R

(D) Pattern S



11. Consider the differential equation $\dot{\vec{w}} = A\vec{w}$, with $\vec{w}(t=0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$. If $\vec{w}(t) = e^{t}\vec{u}_x + e^{-2t}\vec{u}_y$ is the solution to the equation, where $\vec{u}_x$ and $\vec{u}_y$ are unit vectors along the positive x and y axes respectively, then which of the following options is the correct matrix representing A?

(A) $\begin{bmatrix} 1 & 0 \\ 0 & -2 \end{bmatrix}$

(B) $\begin{bmatrix} -1 & 0 \\ 0 & 2 \end{bmatrix}$

(C) $\begin{bmatrix} 0 & -2 \\ 1 & 0 \end{bmatrix}$

(D) $\begin{bmatrix} 0 & 2 \\ -1 & 0 \end{bmatrix}$

12. A surface is given by $z^2 = 2x^2 - y^2$ and $\vec{n}$ and $-\vec{n}$ are unit normal vectors to the surface at the point $\vec{P} = \hat{\imath} + \sqrt{2}\,\hat{k}$. Which of the following vectors can be $\vec{n}$, where $\hat{\imath}, \hat{\jmath}$ and $\hat{k}$ are the unit vectors along x, y and z axes, respectively?

(A) $\hat{\imath} - \sqrt{2}\,\hat{k}$

(B) $\frac{2}{3}\hat{\imath} - \frac{1}{3}\hat{k}$

(C) $\sqrt{2}\hat{\imath} - \sqrt{3}\,\hat{k}$

(D) $\frac{\sqrt{2}\hat{\imath} - \hat{k}}{\sqrt{3}}$

13. The Laplace Transform of the signal $x(t) = u(t-2) * (t\,u(t))$ is given by which of the following expressions? ["$*$" represents the convolution operator]

(A) $\frac{e^{-2s}}{s^2(s-2)}$

(B) $\frac{e^{-2(s-2)}}{s^3}$

(C) $\frac{se^{-2s}}{(s-2)^2}$

(D) $\frac{e^{-2s}}{s^3}$

14. Consider carrier transport in a Zener diode in the breakdown region. Which is the dominant transport mechanism for current flow in this case?

(A) Drift

(B) Diffusion

(C) Tunneling

(D) Ballistic transport

15. Two analog signals $x_1(t)$ and $x_2(t)$ (t in second) are sampled at a rate $F_s = 40$ Hz, where

$$x_1(t) = \cos(20\pi t),\ t \geq 0, \qquad x_2(t) = \cos(100\pi t),\ t \geq 0.$$

The first ten samples (starting from $t = 0$) are considered for the analysis. Which of the following statements is TRUE?

(A) All of the first three samples of $x_1(t)$ are greater than the corresponding samples of $x_2(t)$.

(B) All of the last three samples of $x_1(t)$ are greater than the corresponding samples of $x_2(t)$.

(C) All of the samples of $x_2(t)$ are greater than the corresponding samples of $x_1(t)$.

(D) All of the fourth to seventh samples of $x_1(t)$ are equal to the corresponding samples of $x_2(t)$.

16. The response of a discrete time system $y[n]$ obeys the following relation:

$$y[n] = \frac{5}{6}y[n-1] - \frac{1}{6}y[n-2] + x[n].$$

The input to the system is $x[n] = \delta[n] - \frac{1}{3}\delta[n-1]$. Which of the following options is TRUE for $y[n]$?

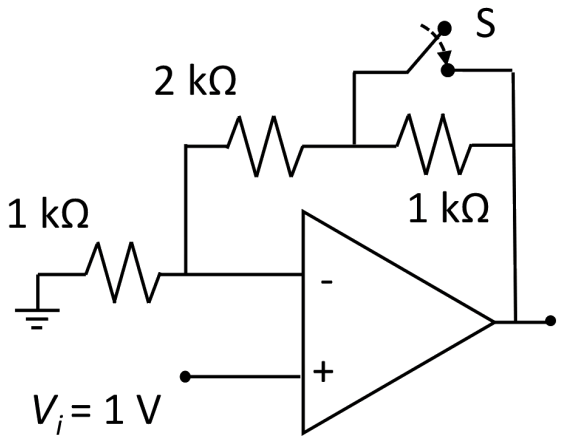
(A) Stable and causal response

(B) Stable and non-causal response

(C) Unstable and causal response

(D) Unstable and non-causal response

17. The ideal OP-AMP circuit shown in the Figure produces output voltage $V_o = x$ when the Switch, S, is open.



Which of the options represents the output voltage when S is closed?

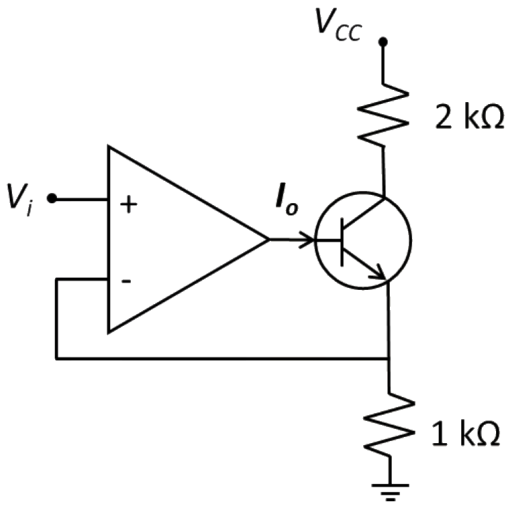
(A) x

(B) $\frac{2}{3}x$

(C) $\frac{3}{4}x$

(D) $\frac{1}{2}x$

18. Consider the circuit shown in the Figure with $V_i = 3\,\text{V}$ and $V_{CC} = 12\,\text{V}$.



Assume $V_{BE} = 0.7\,\text{V}$ and $\beta_{dc} = 99$ for the BJT.
Which of the following options is the correct value of the current I_o?

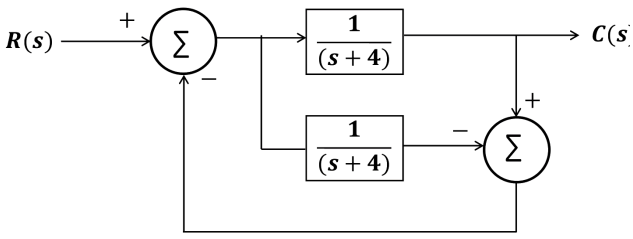
(A) $60\,\mu\text{A}$

(B) $6\,\mu\text{A}$

(C) $3\,\mu\text{A}$

(D) $30\,\mu\text{A}$

19. A control system is shown in the Figure.



Which option represents the correct transfer function of the system?

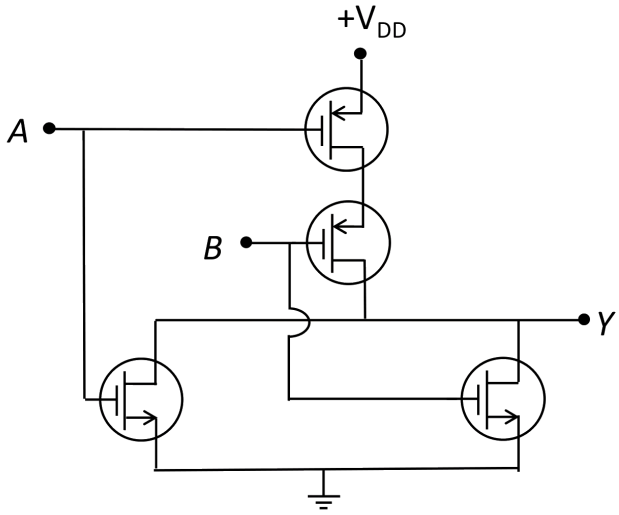
(A) $\frac{1}{(s+4)^2}$

(B) $\frac{1}{(s+4)}$

(C) $\frac{2}{(s+4)}$

(D) $\frac{1}{(s^2+8s+17)}$

20. In the circuit shown in the Figure, A and B are logic inputs and Y is the logic output.



Which of the following logic operations is realized by the circuit?

(A) NOR

(B) OR

(C) XOR

(D) AND

21. Consider the Friis' transmission equation $P_R = \frac{P_T G_T G_R \lambda^2}{(4\pi D)^2}$, where P_R and P_T are the received and the transmitted powers, respectively. G_T and G_R are the gain of transmitting and receiving antennas, respectively, D is the distance between the transmitting and receiving antennas, and λ is the wavelength in free space.

Given: $G_T = G_R = 1.0$, $\lambda = 0.30$ m and $P_T = +10$ dBm.

Choose the distance (D), in km, from the following options at which the received power, $P_R = -90$ dBm?

(A) $\frac{15}{4\pi}$

(B) $\frac{15}{2\pi}$

(C) $\frac{75}{2\pi}$

(D) $\frac{3}{4\pi}$

22. Consider a discrete memoryless source with an alphabet of four source symbols. $s(t)$ is a multi-level $(-1, 0, +1, +2)$ signal representing a long sequence of random symbols from the above source which is generating 10^4 symbols per second.

Which of the following options is the correct value of equivalent Nyquist bandwidth of $s(t)$?

(A) 10 kHz

(B) 64 kHz

(C) 5 kHz

(D) 20 kHz

23. The relation between the input current (I) and the output voltage (V) of a circuit is governed by the equation: $C\frac{dV}{dt} = I(t) - m(t)$. The circuit is excited by $I(t) = q\,\delta(t)$, where q is a real valued constant. V at $t = 0^-$ is V_0. Which of the following is an equivalent representation of the above case?

(A) $C\frac{dV}{dt} = -m(t)$, with $V(t = 0^-) = V_0 + q/C$

(B) $C\frac{dV}{dt} = -m(t)$, with $V(t = 0^-) = V_0 + q/C + m(t = 0^-)$

(C) $C\frac{dV}{dt} = -m(t)$, with $V(t = 0^-) = V_0 - q/C + m(t = 0^-)$

(D) $C\frac{dV}{dt} = -m(t)$, with $V(t = 0^-) = q/C$

24. The electric field of a monochromatic plane wave travelling in a lossless isotropic and homogenous medium is given by

$$\vec{E}(z,t) = E_0\left[\hat{x}\cos(\omega t - kz) + \hat{y}\sin(\omega t - kz)\right]$$

in a right-handed orthogonal co-ordinate system.
Which of the following is the correct polarization of the electromagnetic wave?

(A) Right-handed circularly polarized

(B) Left-handed circularly polarized

(C) Linearly polarized

(D) Linearly polarized with $-45°$ angle to $\hat{x}$

25. Consider a p-n junction diode when it is forward biased with 2 V.

Which of the following is/are the correct magnitude(s) of the energy difference between quasi Fermi-levels, E_{fn} in the n-side and E_{fp} in the p-side?

(A) 2 eV

(B) 1 eV

(C) 2 V

(D) 1 V

26. Consider the matrix $M = \begin{bmatrix} 2 & 1 & 1 \\ 1 & 3 & 0 \\ -1 & a & b \end{bmatrix}$.

Which of the following options is/are TRUE if $\det(M) \neq 0$?

(A) $a = -\frac{1}{2}$ and $b = -\frac{1}{2}$

(B) $a = \frac{1}{2}$ and $b = \frac{1}{2}$

(C) $a = -3$ and $b = 0$

(D) $a = \frac{1}{2}$ and $b = -3$

27. A binary ripple counter is designed to count $(0)_{10}$ to $(64)_{10}$.

Which of the following is/are the number of flip-flops required to design the counter?

(A) 6

(B) 7

(C) 4

(D) 5

28. Which option(s) represents/represent the dielectric loss tangent of a substrate?

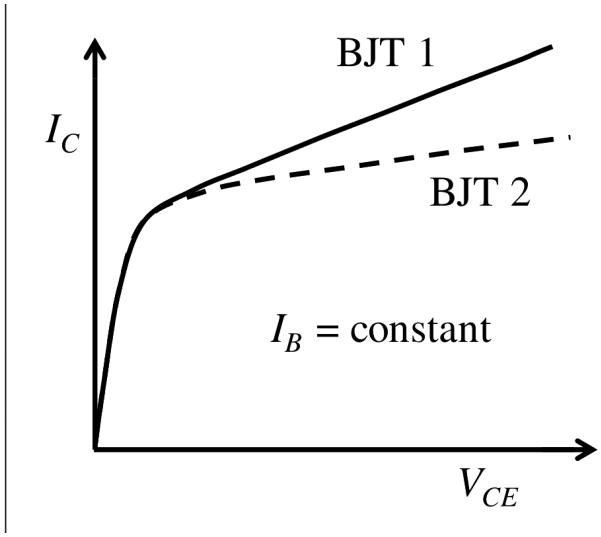
(A) Ratio of the real to imaginary parts of the total displacement current

(B) $(\omega\epsilon'' + \sigma)/(\omega\epsilon')$

(C) Ratio of the electric susceptibility to permittivity

(D) Ratio of the polarization vector $\vec{P}$ to the displacement vector $\vec{D}$

29. Figure shows the output characteristics of two different Bipolar Junction Transistors (BJT), BJT 1 with magnitude of Early voltage $|V_{A1}|$, and BJT 2 with magnitude of Early voltage $|V_{A2}|$.



Which of the following options is/are correct regarding the Early voltages?

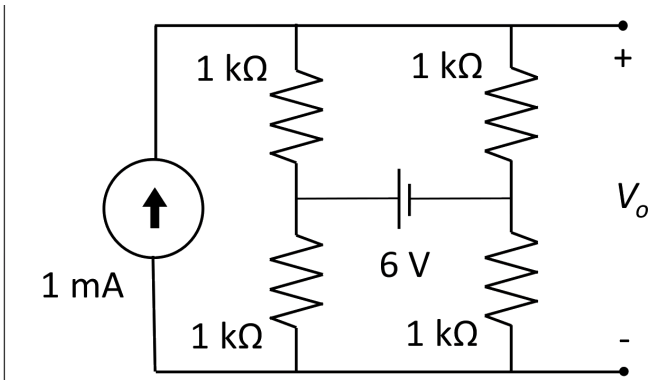
(A) $|V_{A1}| > |V_{A2}|$

(B) $|V_{A1}|$ is infinitely large

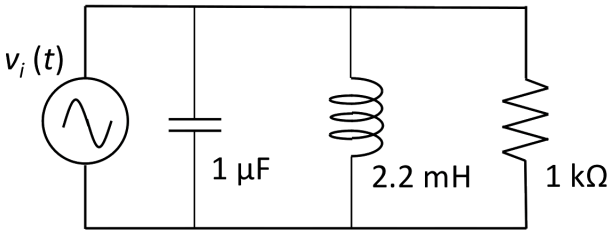
(C) $|V_{A1}| < |V_{A2}|$

(D) $|V_{A2}|$ is finite

30. The output voltage V_o (in Volt) for the network given in the Figure is (rounded off to two decimal places).



31. Consider the circuit shown in the Figure, where the input $v_i(t)$ is in Volt.



$v_i(t) = 12\sin(\omega t)$

The average power (in mW) dissipated in the load resistance of **1 kΩ** at the resonant frequency is (rounded off to two decimal places).

32. A wireless digital transmission scheme is using 16-QAM over an additive white Gaussian noise channel and a maximum-likelihood receiver. Consider the information bit rate from source to be 4×10^6 bits per second.

The minimum transmission bandwidth (in MHz) of the modulated signal necessary for optimum recovery of information at the receiver is (rounded off to two decimal places).

33. The cutoff frequency (in GHz) for the dominant TE_{10} mode of an air-filled rectangular waveguide of inner dimension 0.28 inch $\times$ 0.14 inch is .
(rounded off to two decimal places)

34. For a lossless passive two-port network, $|S_{11}|$ and $|S_{21}|$ intersect at -3 dB.
For a lossy passive two-port network, $|S_{11}|$ and $|S_{21}|$ intersect at -4 dB.
The percentage of power dissipated in the lossy network at the intersection frequency is .
(rounded off to two decimal places)

35. The negative edge triggered JK flip-flop shown has J and K inputs tied to Logic High, and a square wave of 10 cycles/second is applied to its clock (C) input.
The frequency of the output Q (in cycles/second) is .
(rounded off to two decimal places)

36. Consider the two series, S_A and S_B, where

$$S_A = \sum_{n=1}^{\infty} \frac{n^2}{2^n}$$

$$S_B = 1 + \frac{1}{2} + \frac{1}{8} + \frac{1}{16} + \frac{1}{64} + \frac{1}{128} + \frac{1}{512} + \cdots$$

Which of the following statements is correct for the two given series?

(A) Both S_A and S_B converge.

(B) Neither S_A nor S_B converges.

(C) S_A converges but S_B does not converge.

(D) S_B converges but S_A does not converge.

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37. The continuous time signal $x(t)$ is real, periodic with period T, and satisfies the Dirichlet conditions.
The Fourier series representation of $x(t)$ is

$$x(t) = \sum_{n=-\infty}^{\infty} a_n e^{j\left(\frac{2\pi nt}{T}\right)}$$

and $x(t)$ satisfies the following:

$$x\left(t - \frac{T}{2}\right) = -x(t).$$

For any integer m, which of the following options is correct?

(A) $a_{2m} = 0$

(B) $a_{2m} = 1$

(C) $a_{2m} = a_{2m+1}$

(D) $a_{2m} = -1$

38. Let X, N, Y and Z be random variables. The variables X and N are independent of each other. X is uniformly distributed between -1 and 1; N follows Normal distribution with zero mean and unity variance.
Y and Z are defined as $Y = X + N$ and $Z = X^2 + N$.
Which of the following pairs represents the values of correlation between X and Y, and that between X and Z?

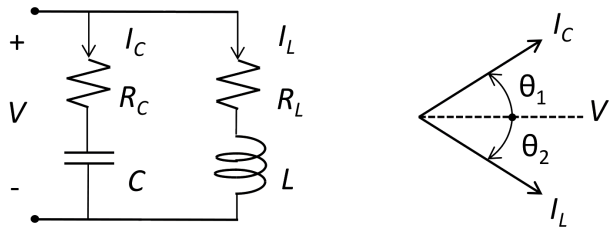
(A) $\frac{1}{3}$ and 0

(B) $\frac{1}{3}$ and $\frac{1}{9}$

(C) $\frac{1}{3}$ and $\frac{1}{3}$

(D) 1 and 0

39. In the given circuit, $L = 1\ \mu H$ and $C = 1\ \mu F$. The phasor diagram for I_C and I_L is also shown. Assume that the phase $(\theta_1 + \theta_2)$ is $90°$ at a frequency of 159.15 kHz.



Among the following options, what is the nearest integer value of $R_C \times R_L$?

(A) 0

(B) 1

(C) 2

(D) 10

40. For the control system shown in the Figure, the transfer function of a plant,

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

is connected in cascade with a compensator

$$C(s) = K(s+\alpha),$$

where K and α are positive real valued constants. The compensator and plant are placed in the forward path of a unity negative feedback system with input $R(s)$ and output $Y(s)$.
Which of the following pairs (K, α) represent the correct values for the closed loop system to have poles at $\left(-3 \pm j\sqrt{5}\right)$?

(A) 2, 3

(B) 3, 4

(C) 2, 4

(D) 3, 3

41. The state and output equations for a control system are:

$$\dot{x} = \begin{bmatrix} -4 & -1.5 \\ 4 & 0 \end{bmatrix} x + \begin{bmatrix} 2 \\ 0 \end{bmatrix} u$$

$$y = [1.5 \quad 0.625]\, x$$

Which of the following expressions correctly represents the transfer function $\frac{Y(s)}{U(s)}$ of the system with zero initial conditions?

(A) $\frac{3s}{s^2 + 4s - 6}$

(B) $\frac{3s + 5}{s^2 + 4s - 6}$

(C) $\frac{3s + 5}{s^2 + 4s + 6}$

(D) $\frac{3s}{s^2 + 4s + 6}$

42. The address of the first location of a 256 kilo byte (KB) memory is $(2500)_H$.

Choose the correct address of the last location of the memory.

(A) $(2FFF)_H$

(B) $(124FF)_H$

(C) $(424FF)_H$

(D) $(324FF)_H$

43. Consider a real signal $x(t)$, $-\infty < t < \infty$, such that $x(t) = 0$ for $t < 0$, $x(t) = 2$ for $0 \leq t < 1$ and $x(t) = 0$ for $t \geq 1$.

Let $E[x(t)] = \int_{-\infty}^{\infty} [x(t)]^2 \, dt$.

Which of the following options correctly represents the ratio, $E[x(t)]/E[3\ x(-3t + 5)]$?

(A) 3

(B) 1

(C) 1/3

(D) 1/9

44. A QPSK modulated signal from an additive white Gaussian noise (AWGN) channel is received with an $E_b/N_o = 8.4$ dB at the input of a coherent QPSK demodulator. A maximum likelihood reception method is used in the demodulator.

Assume the complementary error function

$$erfc(u) \cong \left[1/(u\sqrt{\pi})\right] \exp(-u^2).$$

Which is the nearest bit error rate (BER) at the output of the demodulator?

(A) 10^{-3}

(B) 10^{-4}

(C) 10^{-5}

(D) 10^{-6}

45. What is the 10's complement of $(47)_{10}$?

(A) 52

(B) 53

(C) 54

(D) 55

46. Consider a real baseband signal $x(t) = e^{-2t}$, for t (in seconds) ≥ 0. If 99% of the energy of $x(t)$ lies within B Hz, then which of the following options is TRUE for the value of B?

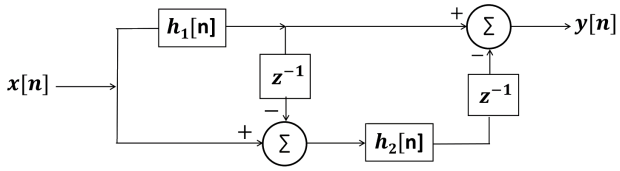
(A) $B > 1$ kHz

(B) $63/\pi$ Hz $< B < 64/\pi$ Hz

(C) $126/\pi$ Hz $< B < 128/\pi$ Hz

(D) $B < 1$ Hz

47. Consider the discrete time system (S) with input $x[n]$ and output $y[n]$ as shown in the figure. The two sub-systems, represented by their impulse responses $h_1[n]$ and $h_2[n]$, are linear and time invariant.



Which of the following statements is necessarily TRUE?

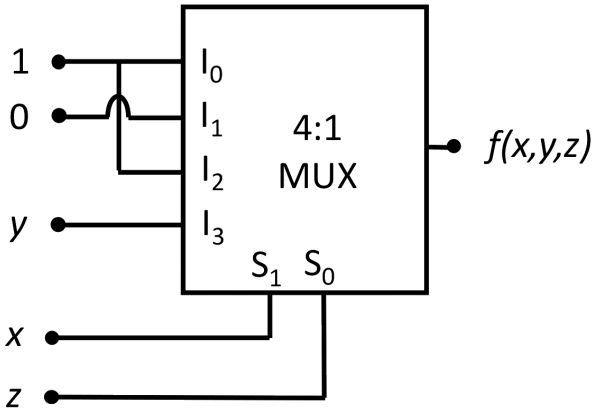
(A) S is causal.

(B) S is linear and time invariant.

(C) S is linear and time varying.

(D) S is non-linear.

48. A Boolean function, $f(x, y, z)$, with x as MSB and z as LSB, is realized by a 4:1 multiplexer (MUX) with select lines S_1 and S_0 (S_1 is MSB, S_0 is LSB) and inputs I_0, I_1, I_2, I_3 as shown in the figure.



Which of the following options is the correct expression of $f(x, y, z)$?

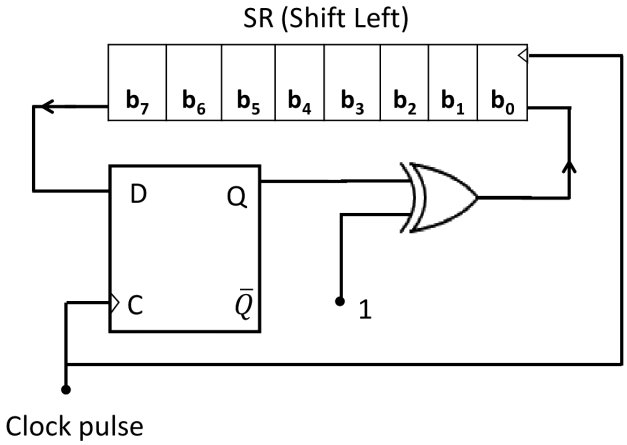
(A) $xz + y$

(B) $x\bar{y} + z$

(C) $xy + \bar{z}$

(D) $\bar{x}y + \bar{z}$

49. A shift-left Shift Register (SR) and a D flip-flop are connected to a synchronized clock as shown in the figure. Assume that the SR and D flip-flops are initially cleared and the XOR gate has no propagation delay.



Which of the following options gives the correct binary representation $b_7b_6b_5b_4b_3b_2b_1b_0$ of the content of the shift register immediately after the 5^{th} clock transition (positive edge)?

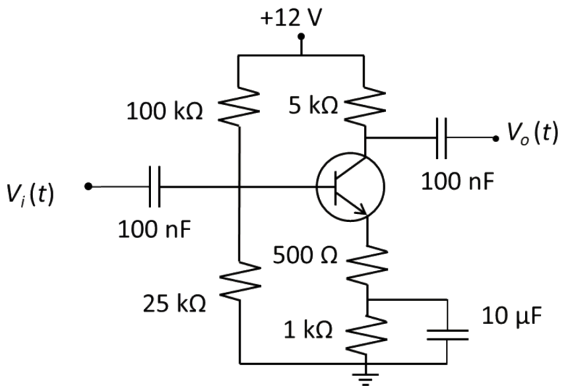
(A) 00011111

(B) 10111111

(C) 00111111

(D) 11000011

50. A small signal source, $V_i(t) = A\cos(10^5 t) + B\sin(10^7 t)$ is applied to a BJT circuit as shown in the figure.



Assume zero source resistance, $V_{BE} = 0.7$ V, $\beta_{dc} = 99$, Early voltage $= 100$ V and thermal voltage $= 25$ mV. Effect of internal parasitic capacitances of the BJT may be neglected.

Which expression is the best approximation of the output voltage $V_o(t)$?

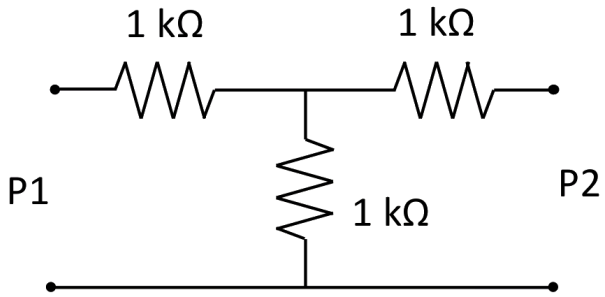
(A) $-9.1[A\cos(10^5 t) + B\sin(10^7 t)]$

(B) $9.1[A\cos(10^5 t) - B\sin(10^7 t)]$

(C) $-190.4[A\cos(10^5 t) + B\sin(10^7 t)]$

(D) $190.4[A\cos(10^5 t) - B\sin(10^7 t)]$

51. Consider the two-port network as shown in the figure.



Which of the following options provides the correct set of values of A, B, C and D parameters?

(A) $A = \frac{1}{2}, B = 3 \times 10^3\ \Omega, C = 10^{-3}\ \Omega^{-1}, D = \frac{1}{2}$

(B) $A = 2, B = 3\ \Omega, C = 1\ \Omega^{-1}, D = 2$

(C) $A = 2, B = 6 \times 10^3\ \Omega, C = 2 \times 10^{-3}\ \Omega^{-1}, D = 2$

(D) $A = 2, B = 3 \times 10^3\ \Omega, C = 10^{-3}\ \Omega^{-1}, D = 2$

52. A complex load (in Ω) is represented as $\Gamma_L = 0.5\angle 30°$ on the Smith chart. A co-axial cable with a characteristic impedance of $50\ \Omega$ is connected to the load. The new input impedance of the load now moves to a diametrically opposite point on the same Γ circle on the Smith chart. Which option is the nearest input impedance of the cable connected load (in Ω)?

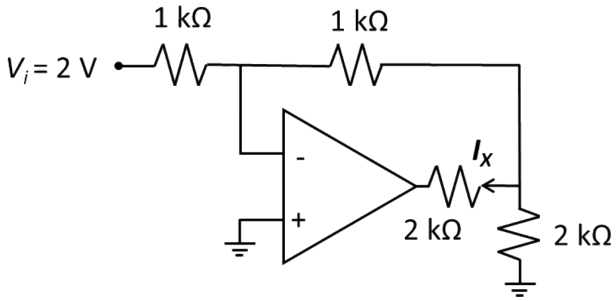
(A) $20.7 - j5.1$

(B) $17.7 - j11.8$

(C) $97.5 - j65.0$

(D) $97.5 + j65.0$

53. A circuit using an ideal OP-AMP is shown in the figure.



Which of the following options gives the correct value of the current I_X?

(A) 2.0 mA

(B) 1.5 mA

(C) 3.0 mA

(D) 0 mA

54. Consider an LED based on a direct bandgap semiconductor material with energy bandgap 1.3 eV.

Given: Planck's constant, $h = 6.63 \times 10^{-34}$ J s and speed of light in free space is 3×10^8 m s^{-1}.

In which of the following wavelength ranges the LED will NOT emit?

(A) 1410 ± 20 nm

(B) 1090 ± 20 nm

(C) 950 ± 20 nm

(D) 510 ± 20 nm

55. Let the relevant bandwidth (B) of a digital communication system be 1 MHz and $kT = -174$ dBm/Hz, where k is Boltzmann's constant and T is the equivalent noise temperature of the receiver. The power (S) of signal received through an additive Gaussian channel is -80 dBm.
Which of the following options is/are TRUE about Shannon capacity (C) of the channel?

(A) $C = B$

(B) $C = 2B$

(C) $C > 3B$

(D) $C < B$

56. Consider the four-variable Boolean function,

$$f(w, x, y, z) = \sum m(0, 2, 5, 7, 8, 10, 13, 14, 15)$$

with w as MSB and z as LSB.
Which of the following expressions is/are the valid form(s) of $f(w, x, y, z)$?

(A) $\bar{x}\bar{z} + xz + wxy$

(B) $xz + wxy + w\bar{x}\bar{z} + \bar{w}xy\bar{z}$

(C) $\bar{x}\bar{z} + wxy + w\bar{x}\bar{z} + \bar{w}xy\bar{z}$

(D) $\bar{x}\bar{z} + xz + wy\bar{z}$

57. Consider a real, narrowband signal $x(t) = A(t)\cos[2\pi f_c t + \theta(t)]$ where the maximum frequency components of $A(t)$ and $\theta(t)$ are f_M and f_c ($= 1000 f_M$), respectively. Which of the following statements is/are correct for $-\infty < t < \infty$?

(A) $x(t)$ represents a PSK modulated signal for suitable choices of $A(t)$ and $\theta(t)$.

(B) $x(t)$ represents an amplitude modulated signal for suitable choices of $A(t)$ and $\theta(t)$.

(C) $x(t)$ represents a band-limited Gaussian noise process.

(D) $x(t)$ never represents a narrowband FM signal.

58. Let $x_1(t) = \cos(2\pi nt)$ and $x_2(t) = 2\sin(4\pi nt)$ represent two sinusoids for a positive integer n and $-\infty < t < \infty$. Which of the following statements about $x_1(t)$ and $x_2(t)$ is/are valid?

(A) $x_1(t)$ and $x_2(t)$ are orthogonal to each other over $0 \le t < 1/n$.

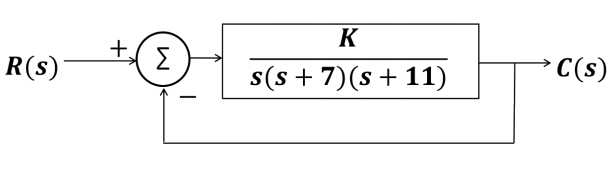
(B) $x_1(t)$ and $x_2(t)$ are orthonormal to each other over $0 \le t < 1/n$.

(C) $x_2(t)$ is a harmonic of $x_1(t)$.

(D) $x_1(t)$ and $x_2(t)$ are non-orthogonal to each other over $0 \le t < 1/(2n)$.

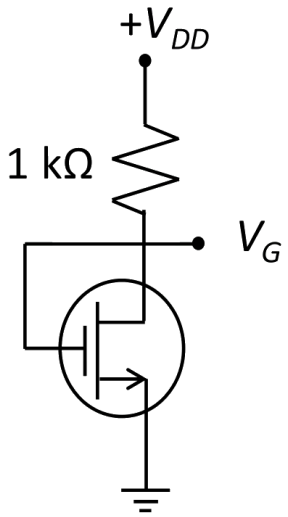
59.

Consider the unity negative feedback control system shown in the figure below, where the forward path transfer function is $G(s) = \dfrac{K}{s(s+7)(s+11)}$. The value of gain K (> 0) at which the given system will remain marginally stable is . (Answer in integer)



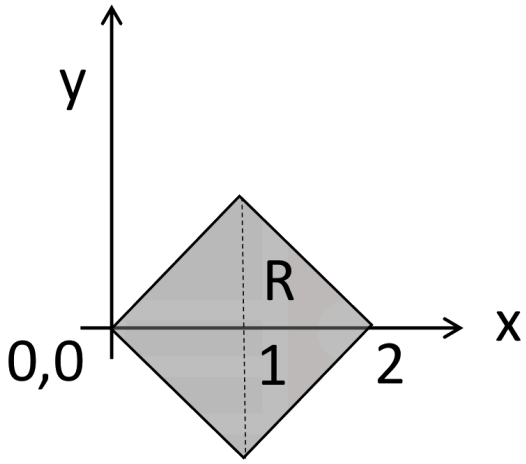
60.

An n-channel MOSFET is connected as shown in the figure below. Assume $V_{TH} = 1$ V, $V_{DD} = 5$ V, and $\mu C_{ox}\left(\frac{W}{L}\right) = 2\ \text{mA V}^{-2}$, and neglect channel length modulation effects. The gate voltage V_G of the n-channel MOSFET (in Volt) is . (Rounded off to two decimal places)

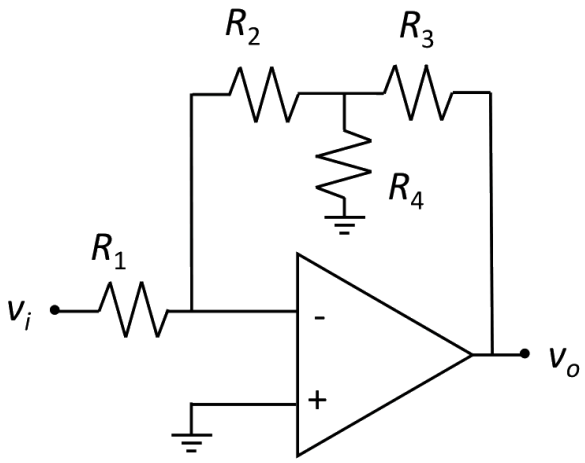


61.

Consider the square region R in the X-Y plane as shown with the dark shading in the figure below. The value of $\iint_R (x^2 + y^2 - 1)\,dx\,dy$ is . (Rounded off to two decimal places)



62. Consider an ideal OP-AMP circuit as shown in the figure.

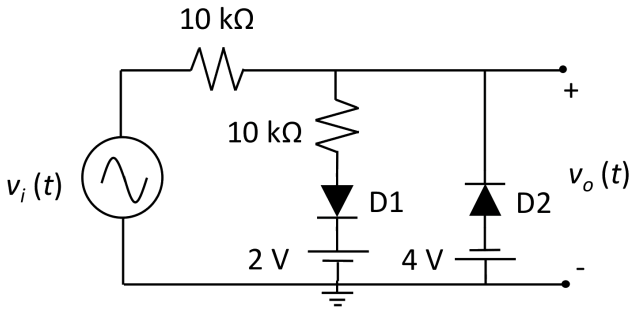


The resistances $R_1 = R_2 = R_3 = R_4 = 50\ \text{k}\Omega$.
The magnitude of the closed loop gain is (rounded off to two decimal places).

63. The average bit error rate at the input of a $(7, 4, 1)$ Hamming decoder is 0.10.
The probability that the decoder will fail to decode a received word correctly is (rounded off to two decimal places).

64. Consider that the concentration of electrons in a semiconductor bar varies linearly from $2 \times 10^{17}\ \text{cm}^{-3}$ at $x = 1\ \mu\text{m}$ to $1 \times 10^{16}\ \text{cm}^{-3}$ at $x = 4\ \mu\text{m}$ along the x-direction. Assume that the concentration of electrons does not vary along the y- and z-directions.
Given: the mobility of electron is $1400\ \text{cm}^2\text{V}^{-1}\text{s}^{-1}$, the thermal voltage is $25\ \text{mV}$ and the electronic charge is 1.6×10^{-19} Coulomb.
The density of electron diffusion current (in A/mm^2) is (rounded off to two decimal places).

65. Consider the ideal diodes D_1 and D_2 as shown in the figure with cut-in voltage $V_\gamma = 0$ Volt and $v_i(t)$ is in Volt.



The maximum voltage (Volt) of the output $v_o(t)$ is (rounded off to two decimal places).