SESSION - 1

GATE 2014: General Instructions during Examination

1. Total duration of the GATE examination is **180** minutes.
2. The clock will be set at the server. The countdown timer at the top right corner of screen will display the remaining time available for you to complete the examination. When the timer reaches zero, the examination will end by itself. You need not terminate the examination or submit your paper.
3. Any useful data required for your paper can be viewed by clicking on the **Useful Common Data** button that appears on the screen.
4. Use the scribble pad provided to you for any rough work. Submit the scribble pad at the end of the examination.
5. You are allowed to use a non-programmable type calculator, however, sharing of calculators is not allowed.
6. The Question Palette displayed on the right side of screen will show the status of each question using one of the following symbols:

1 You have not visited the question yet.

3 You have not answered the question.

5 You have answered the question.

7 You have NOT answered the question, but have marked the question for review.

9 You have answered the question, but marked it for review.

The **Marked for Review** status for a question simply indicates that you would like to look at that question again. *If a question is answered, but marked for review, then the answer will be considered for evaluation unless the status is modified by the candidate.*

Navigating to a Question :

7. To answer a question, do the following:
   a. Click on the question number in the Question Palette to go to that question directly.
   b. Select an answer for a multiple choice type question by clicking on the bubble placed before the 4 choices, namely A, B, C and D. Use the virtual numeric keypad to enter a number as answer for a numerical type question.
   c. Click on **Save & Next** to save your answer for the current question and then go to the next question.
   d. Click on **Mark for Review & Next** to save your answer for the current question and also mark it for review, and then go to the next question.

Caution: Note that your answer for the current question will not be saved, if you navigate to another question directly by clicking on a question number without saving the answer to the previous question.

You can view all the questions by clicking on the **Question Paper** button. This feature is provided, so that if you want you can just see the entire question paper at a glance.

<u>Answering a Question :</u>

8. Procedure for answering a multiple choice (MCQ) type question:
    a. Choose one answer from the 4 options (A,B,C,D) given below the question, click on the bubble placed before the chosen option.
    b. To deselect your chosen answer, click on the bubble of the chosen option again or click on the **Clear Response** button.
    c. To change your chosen answer, click on the bubble of another option.
    d. To save your answer, you MUST click on the **Save & Next** button.

9. Procedure for answering a numerical answer type question:
    a. To enter a number as your answer, use the virtual numerical keypad.
    b. A fraction (e.g. -0.3 or -.3) can be entered as an answer with or without '0' before the decimal point. As many as four decimal points, e.g. 12.5435 or 0.003 or -932.6711 or 12.82 can be entered.
    c. To clear your answer, click on the **Clear Response** button.
    d. To save your answer, you MUST click on the **Save & Next** button
10. To mark a question for review, click on the **Mark for Review & Next** button. *If an answer is selected (for MCQ) or entered (for numerical answer type) for a question that is* **Marked for Review**, *that answer will be considered in the evaluation unless the status is modified by the candidate.*

11. To change your answer to a question that has already been answered, first select that question for answering and then follow the procedure for answering that type of question.
12. Note that ONLY Questions for which answers are ***saved*** or ***marked for review after answering*** will be considered for evaluation.

<u>Choosing a Section :</u>

13. Sections in this question paper are displayed on the top bar of the screen. Questions in a Section can be viewed by clicking on the name of that Section. The Section you are currently viewing will be highlighted.
14. A checkbox is displayed for every optional Section, if any, in the Question Paper. To select the optional Section for answering, click on the checkbox for that Section.
15. If the checkbox for an optional Section is not selected, the **Save & Next** button and the **Mark for Review & Next** button will NOT be enabled for that Section. You will

only be able to see questions in this Section, but you will not be able to answer questions in the Section.

16. After clicking the **Save & Next** button for the last question in a Section, you will automatically be taken to the first question of the next Section in sequence.
17. You can move the mouse cursor over the name of a Section to view the answering status for that Section.

Changing the Optional Section :

18. After answering the chosen optional Section, partially or completely, you can change the optional Section by selecting the checkbox for a new Section that you want to attempt. A warning message will appear along with a table showing the number of questions answered in each of the previously chosen optional Sections and a checkbox against each of these Sections. Click on a checkbox against a Section that you want to reset and then click on the **RESET** button. Note that RESETTING a Section will DELETE all the answers for questions in that Section. Hence, if you think that you may want to select this Section again later, you will have to note down your answers for questions in that Section. If you do not want to reset the Section and want to continue answering the previously chosen optional Section, then click on the **BACK** button.

19. If you deselect the checkbox for an optional Section in the top bar, the following warning message will appear: "Deselecting the checkbox will DELETE all the answers for questions in this Section. Do you want to deselect this Section?" If you want to deselect, click on the **RESET** button. If you do not want to deselect, click on the **BACK** button.

20. You can shuffle between different Sections or change the optional Sections any number of times.

GATE 2014 Examination

EC: Electronics & Communications Engineering

Duration: **180 minutes** *Maximum Marks*: **100**

Read the following instructions carefully.

1. To login, enter your Registration Number and password provided to you. Kindly go through the various symbols used in the test and understand their meaning before you start the examination.
2. Once you login and after the start of the examination, you can view all the questions in the question paper, by clicking on the **View All Questions** button in the screen.
3. This question paper consists of **2 sections**, General Aptitude (GA) for **15 marks** and the subject specific GATE paper for **85 marks**. Both these sections are compulsory.
   The GA section consists of **10** questions. Question numbers 1 to 5 are of 1-mark each, while question numbers 6 to 10 are of 2-mark each.
   The subject specific GATE paper section consists of **55** questions, out of which question numbers 1 to 25 are of 1-mark each, while question numbers 26 to 55 are of 2-mark each.
4. Depending upon the GATE paper, there may be useful common data that may be required for answering the questions. If the paper has such useful data, the same can be viewed by clicking on the **Useful Common Data** button that appears at the top, right hand side of the screen.
5. The computer allotted to you at the examination center runs specialized software that permits only one answer to be selected for multiple-choice questions using a mouse and to enter a suitable number for the numerical answer type questions using the virtual keyboard and mouse.
6. Your answers shall be updated and saved on a server periodically and also at the end of the examination. The examination will **stop automatically** at the end of **180 minutes**.
7. In each paper a candidate can answer a total of 65 questions carrying 100 marks.
8. The question paper may consist of questions of **multiple choice type** (MCQ) and **numerical answer type**.
9. Multiple choice type questions will have four choices against A, B, C, D, out of which only **ONE** is the correct answer. The candidate has to choose the correct answer by clicking on the bubble (◯) placed before the choice.
10. For numerical answer type questions, each question will have a numerical answer and there will not be any choices**. For these questions, the answer should be entered**by using the virtual keyboard that appears on the monitor and the mouse.
11. All questions that are not attempted will result in zero marks. However, wrong answers for multiple choice type questions (MCQ) will result in **NEGATIVE** marks. For all MCQ questions a wrong answer will result in deduction of⅓ marks for a 1-mark question and ⅔ marks for a 2-mark question.
12. There is **NO NEGATIVE MARKING** for questions of **NUMERICAL ANSWER TYPE**.
13. Non-programmable type Calculator is allowed. Charts, graph sheets, and mathematical tables are **NOT** allowed in the Examination Hall. You must use the Scribble pad provided to you at the examination centre for all your rough work. The Scribble Pad has to be returned at the end of the examination.

Declaration by the candidate:

"I have read and understood all the above instructions. I have also read and understood clearly the instructions given on the admit card and shall follow the same. I also understand that in case I am found to violate any of these instructions, my candidature is liable to be cancelled. I also confirm that at the start of the examination all the computer hardware allotted to me are in proper working condition".

Q. 1 – Q. 5 carry one mark each.

Q.1 Choose the most appropriate phrase from the options given below to complete the following sentence.

The aircraft ______________ take off as soon as its flight plan was filed.

(A) is allowed to (B) will be allowed to
(C) was allowed to (D) has been allowed to

Q.2 Read the statements:

All women are entrepreneurs.
Some women are doctors.

Which of the following conclusions can be logically inferred from the above statements?

(A) All women are doctors (B) All doctors are entrepreneurs
(C) All entrepreneurs are women (D) Some entrepreneurs are doctors

Q.3 Choose the most appropriate word from the options given below to complete the following sentence.

Many ancient cultures attributed disease to supernatural causes. However, modern science has largely helped _________ such notions.

(A) impel (B) dispel (C) propel (D) repel

Q.4 The statistics of runs scored in a series by four batsmen are provided in the following table. Who is the most <u>consistent</u> batsman of these four?

Batsman	Average	Standard deviation
K	31.2	5.21
L	46.0	6.35
M	54.4	6.22
N	17.9	5.90

(A) K (B) L (C) M (D) N

Q.5 What is the next number in the series?

12 35 81 173 357 ____

Q. 6 – Q. 10 carry two marks each.

Q.6 Find the odd one from the following group:

W,E,K,O I,Q,W,A F,N,T,X N,V,B,D

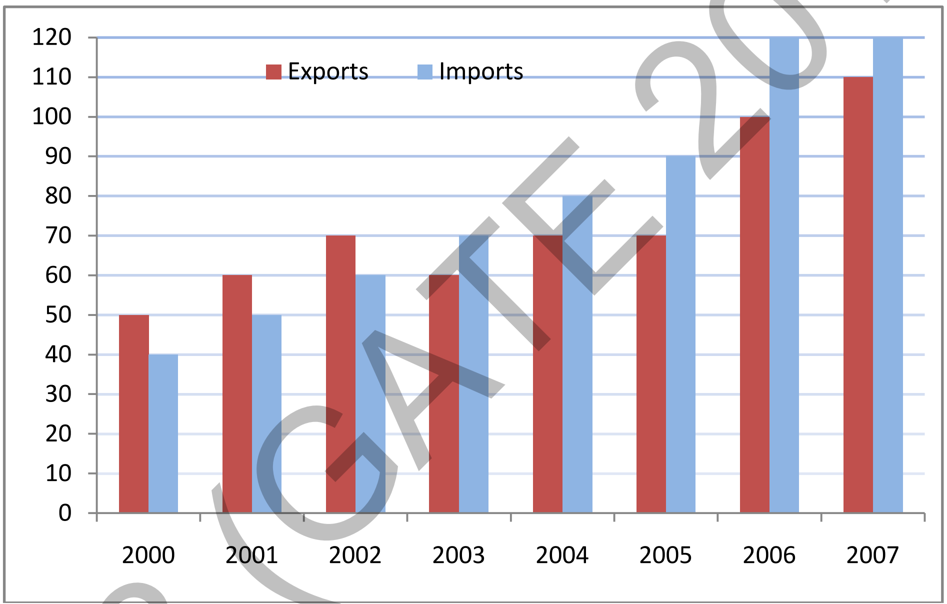
(A) W,E,K,O (B) I,Q,W,A (C) F,N,T,X (D) N,V,B,D

Q.7 For submitting tax returns, all resident males with annual income below Rs 10 lakh should fill up Form P and all resident females with income below Rs 8 lakh should fill up Form Q. All people with incomes above Rs 10 lakh should fill up Form R, except non residents with income above Rs 15 lakhs, who should fill up Form S. All others should fill Form T. An example of a person who should fill Form T is

(A) a resident male with annual income Rs 9 lakh
(B) a resident female with annual income Rs 9 lakh
(C) a non-resident male with annual income Rs 16 lakh
(D) a non-resident female with annual income Rs 16 lakh

Q.8 A train that is 280 metres long, travelling at a uniform speed, crosses a platform in 60 seconds and passes a man standing on the platform in 20 seconds. What is the length of the platform in metres?

Q.9 The exports and imports (in crores of Rs.) of a country from 2000 to 2007 are given in the following bar chart. If the trade deficit is defined as excess of imports over exports, in which year is the trade deficit 1/5th of the exports?



(A) 2005 (B) 2004 (C) 2007 (D) 2006

Q.10 You are given three coins: one has heads on both faces, the second has tails on both faces, and the third has a head on one face and a tail on the other. You choose a coin at random and toss it, and it comes up heads. The probability that the other face is tails is

(A) 1/4 (B) 1/3 (C) 1/2 (D) 2/3

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry one mark each.

Q.1 For matrices of same dimension M, N and scalar c, which one of these properties DOES NOT ALWAYS hold?

(A) $(M^T)^T = M$
(B) $(cM)^T = c(M)^T$
(C) $(M + N)^T = M^T + N^T$
(D) $MN = NM$

Q.2 In a housing society, half of the families have a single child per family, while the remaining half have two children per family. The probability that a child picked at random, has a sibling is _____

Q.3 C is a closed path in the z-plane given by $|z| = 3$. The value of the integral $\oint_C \left(\frac{z^2 - z + 4j}{z + 2j}\right) dz$ is

(A) $-4\pi(1 + j2)$ (B) $4\pi(3 - j2)$ (C) $-4\pi(3 + j2)$ (D) $4\pi(1 - j2)$

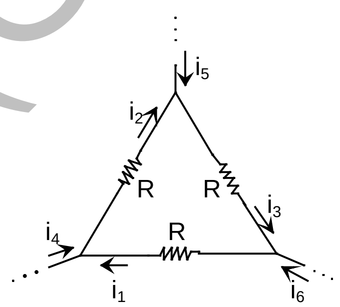
Q.4 A real (4×4) matrix A satisfies the equation $A^2 = I$, where I is the (4×4) identity matrix. The positive eigen value of A is _________.

Q.5 Let X_1, X_2, and X_3 be independent and identically distributed random variables with the uniform distribution on [0, 1]. The probability $P\{X_1 \text{ is the largest}\}$ is ________

Q.6 For maximum power transfer between two cascaded sections of an electrical network, the relationship between the output impedance Z_1 of the first section to the input impedance Z_2 of the second section is

(A) $Z_2 = Z_1$ (B) $Z_2 = -Z_1$ (C) $Z_2 = Z_1^*$ (D) $Z_2 = -Z_1^*$

Q.7 Consider the configuration shown in the figure which is a portion of a larger electrical network

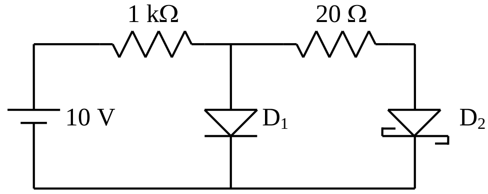


For $R = 1\ \Omega$ and currents $i_1 = 2$ A, $i_4 = -1$ A, $i_5 = -4$ A, which one of the following is **TRUE?**

(A) $i_6 = 5\ A$
(B) $i_3 = -4\ A$
(C) Data is sufficient to conclude that the supposed currents are impossible
(D) Data is insufficient to identify the currents i_2, i_3, and i_6

Q.8 When the optical power incident on a photodiode is 10μW and the responsivity is 0.8 A/W, the photocurrent generated (in μA) is ________.

Q.9 In the figure, assume that the forward voltage drops of the PN diode D_1 and Schottky diode D_2 are 0.7 V and 0.3 V, respectively. If ON denotes conducting state of the diode and OFF denotes non-conducting state of the diode, then in the circuit,



(A) both D_1 and D_2 are ON
(B) D_1 is ON and D_2 is OFF
(C) both D_1 and D_2 are OFF
(D) D_1 is OFF and D_2 is ON

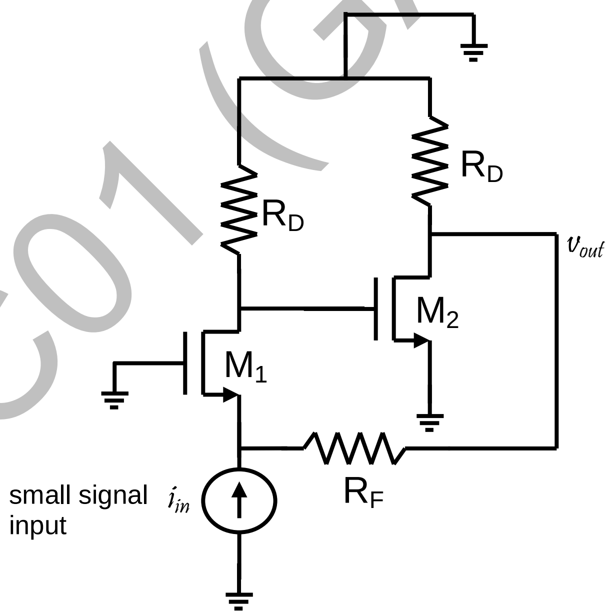
Q.10 If fixed positive charges are present in the gate oxide of an n-channel enhancement type MOSFET, it will lead to

(A) a decrease in the threshold voltage
(B) channel length modulation
(C) an increase in substrate leakage current
(D) an increase in accumulation capacitance

Q.11 A good current buffer has

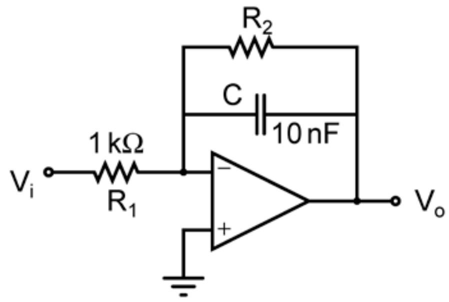
(A) low input impedance and low output impedance
(B) low input impedance and high output impedance
(C) high input impedance and low output impedance
(D) high input impedance and high output impedance

Q.12 In the ac equivalent circuit shown in the figure, if i_{in} is the input current and R_F is very large, the type of feedback is

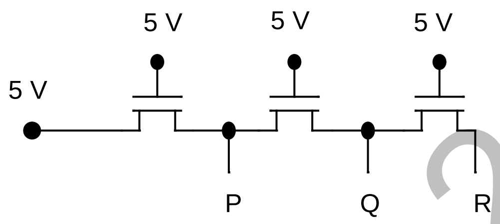


(A) voltage-voltage feedback
(B) voltage-current feedback
(C) current-voltage feedback
(D) current-current feedback

Q.13 In the low-pass filter shown in the figure, for a cut-off frequency of 5 kHz , the value of R_2 (in kΩ) is _____________.



Q.14 In the following circuit employing pass transistor logic, all NMOS transistors are identical with a threshold voltage of 1 V. Ignoring the body-effect, the output voltages at P, Q and R are,

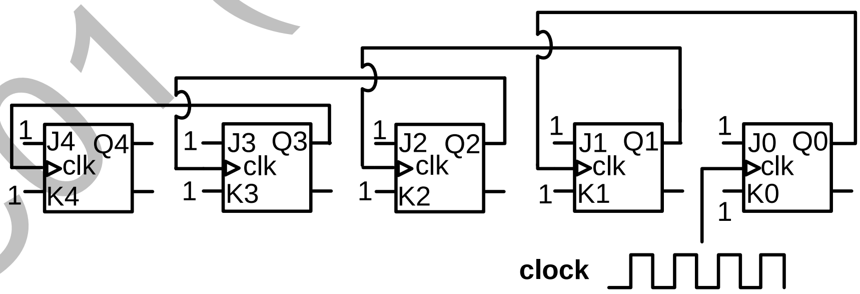


(A) 4 V, 3 V, 2 V
(B) 5 V, 5 V, 5 V
(C) 4 V, 4 V, 4 V
(D) 5 V, 4 V, 3 V

Q.15 The Boolean expression $(X+Y)(X+\overline{Y})+\overline{(X\overline{Y})+\overline{X}}$ simplifies to

(A) X (B) Y (C) XY (D) X+Y

Q.16 Five JK flip-flops are cascaded to form the circuit shown in Figure. Clock pulses at a frequency of 1 MHz are applied as shown. The frequency (in kHz) of the waveform at **Q3** is __________ .



Q.17 A discrete-time signal $x[n] = \sin(\pi^2 n)$, n being an integer, is

(A) periodic with period π.
(B) periodic with period π^2.
(C) periodic with period $\pi/2$.
(D) not periodic.

Q.18 Consider two real valued signals, $x(t)$ band-limited to $[-500\text{ Hz},\ 500\text{ Hz}]$ and $y(t)$ band-limited to $[-1\text{ kHz},\ 1\text{ kHz}]$. For $z(t) = x(t)\cdot y(t)$, the Nyquist sampling frequency (in kHz) is ______.

Q.19 A continuous, linear time-invariant filter has an impulse response $h(t)$ described by

$$h(t) = \begin{cases} 3 & \text{for } 0 \leq t \leq 3 \\ 0 & \text{otherwise} \end{cases}$$

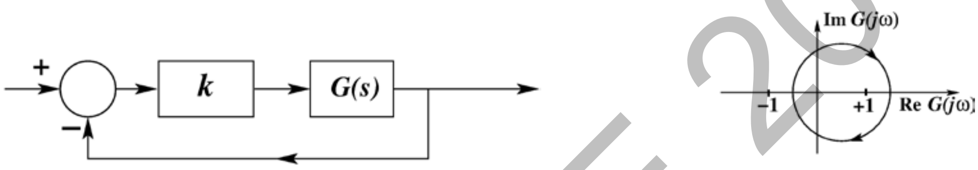
When a constant input of value 5 is applied to this filter, the steady state output is _____.

Q.20 The forward path transfer function of a unity negative feedback system is given by

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

The value of K which will place both the poles of the closed-loop system at the same location, is ______ .

Q.21 Consider the feedback system shown in the figure. The Nyquist plot of $G(s)$ is also shown. Which one of the following conclusions is correct?



(A) $G(s)$ is an all-pass filter
(B) $G(s)$ is a strictly proper transfer function
(C) $G(s)$ is a stable and minimum-phase transfer function
(D) The closed-loop system is unstable for sufficiently large and positive k

Q.22 In a code-division multiple access (CDMA) system with N = 8 chips, the maximum number of users who can be assigned mutually orthogonal signature sequences is ________

Q.23 The capacity of a Binary Symmetric Channel (BSC) with cross-over probability 0.5 is ________

Q.24 A two-port network has scattering parameters given by $[S] = \begin{bmatrix} s_{11} & s_{12} \\ s_{21} & s_{22} \end{bmatrix}$. If the port-2 of the two-port is short circuited, the s_{11} parameter for the resultant one-port network is

(A) $\dfrac{s_{11} - s_{11}s_{22} + s_{12}s_{21}}{1 + s_{22}}$

(B) $\dfrac{s_{11} + s_{11}s_{22} - s_{12}s_{21}}{1 + s_{22}}$

(C) $\dfrac{s_{11} + s_{11}s_{22} + s_{12}s_{21}}{1 - s_{22}}$

(D) $\dfrac{s_{11} - s_{11}s_{22} + s_{12}s_{21}}{1 - s_{22}}$

Q.25 The force on a point charge $+q$ kept at a distance d from the surface of an infinite grounded metal plate in a medium of permittivity ϵ is

(A) 0

(B) $\frac{q^2}{16\pi\epsilon d^2}$ away from the plate

(C) $\frac{q^2}{16\pi\epsilon d^2}$ towards the plate

(D) $\frac{q^2}{4\pi\epsilon d^2}$ towards the plate

Q. 26 – Q. 55 carry two marks each.

Q.26 The Taylor series expansion of $3\sin x + 2\cos x$ is

(A) $2 + 3x - x^2 - \frac{x^3}{2} + \ldots..$

(B) $2 - 3x + x^2 - \frac{x^3}{2} + \ldots..$

(C) $2 + 3x + x^2 + \frac{x^3}{2} + \ldots..$

(D) $2 - 3x - x^2 + \frac{x^3}{2} + \ldots..$

Q.27 For a function $g(t)$, it is given that $\int_{-\infty}^{+\infty} g(t)e^{-j\omega t}\,dt = \omega e^{-2\omega^2}$ for any real value ω.
If $y(t) = \int_{-\infty}^{t} g(\tau)\,d\tau$, then $\int_{-\infty}^{+\infty} y(t)dt$ is

(A) 0 (B) $-j$ (C) $-\frac{j}{2}$ (D) $\frac{j}{2}$

Q.28 The volume under the surface $z(x, y) = x + y$ and above the triangle in the *x*-*y* plane defined by $\{0 \le y \le x$ and $0 \le x \le 12\}$ is _________.

Q.29 Consider the matrix

$$J_6 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

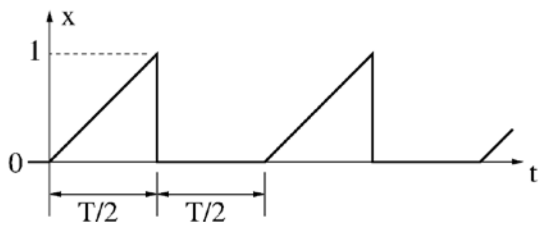
which is obtained by reversing the order of the columns of the identity matrix I_6.
Let $P = I_6 + \alpha\,J_6$, where α is a non-negative real number. The value of α for which $\det(P) = 0$ is ________.

Q.30 A Y-network has resistances of 10Ω each in two of its arms, while the third arm has a resistance of 11Ω. In the equivalent Δ-network, the lowest value (in Ω) among the three resistances is ________.

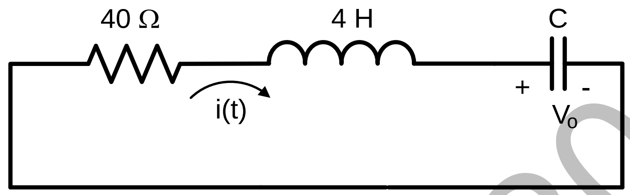
Q.31 A 230 V rms source supplies power to two loads connected in parallel. The first load draws 10 kW at 0.8 leading power factor and the second one draws 10 kVA at 0.8 lagging power factor. The complex power delivered by the source is

(A) (18 + j 1.5) kVA (B) (18 – j 1.5) kVA
(C) (20 + j 1.5) kVA (D) (20 – j 1.5) kVA

Q.32 A periodic variable x is shown in the figure as a function of time. The root-mean-square (rms) value of x is _________.



Q.33 In the circuit shown in the figure, the value of capacitor C (in mF) needed to have critically damped response i(t) is________.



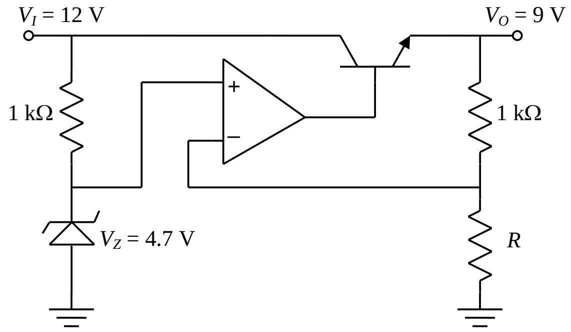
Q.34 A BJT is biased in forward active mode. Assume V_{BE} = 0.7 V, kT/q = 25 mV and reverse saturation current $I_S = 10^{-13}$ A. The transconductance of the BJT (in mA/V) is __________.

Q.35 The doping concentrations on the p-side and n-side of a silicon diode are 1×10^{16} cm^{-3} and 1×10^{17} cm^{-3}, respectively. A forward bias of 0.3 V is applied to the diode. At T = 300 K, the intrinsic carrier concentration of silicon $n_i = 1.5 \times 10^{10}$ cm^{-3} and $\frac{kT}{q}$ = 26 mV. The electron concentration at the edge of the depletion region on the p-side is

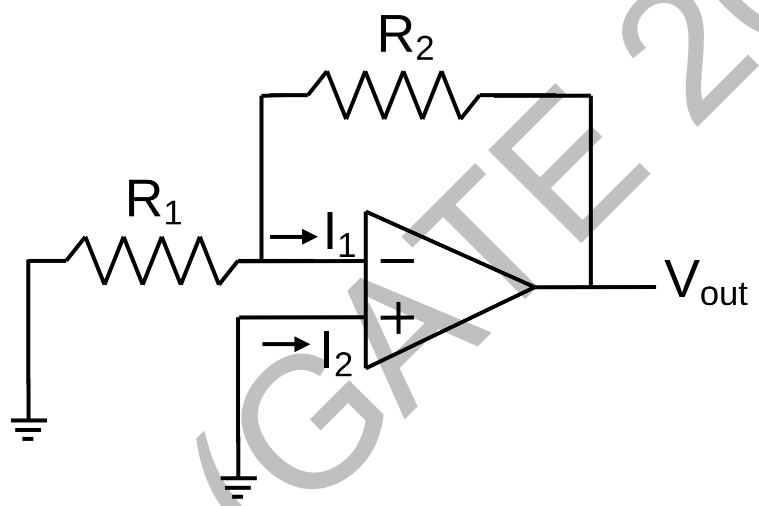
(A) 2.3×10^{9} cm^{-3}
(B) 1×10^{16} cm^{-3}
(C) 1×10^{17} cm^{-3}
(D) 2.25×10^{6} cm^{-3}

Q.36 A depletion type N-channel MOSFET is biased in its linear region for use as a voltage controlled resistor. Assume threshold voltage V_{TH} = -0.5 V, V_{GS} = 2.0 V, V_{DS} = 5 V, W/L = 100, $C_{ox} = 10^{-8}$ F/cm^2 and μ_n = 800 cm^2/V-s. The value of the resistance of the voltage controlled resistor (in Ω) is __________.

Q.37 In the voltage regulator circuit shown in the figure, the op-amp is ideal. The BJT has V_{BE} = 0.7 V and β = 100, and the zener voltage is 4.7 V. For a regulated output of 9 V, the value of R (in Ω) is _______.

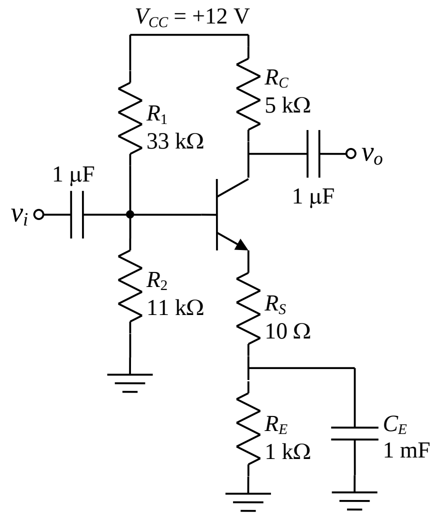


Q.38 In the circuit shown, the op-amp has finite input impedance, infinite voltage gain and zero input offset voltage. The output voltage V_{out} is

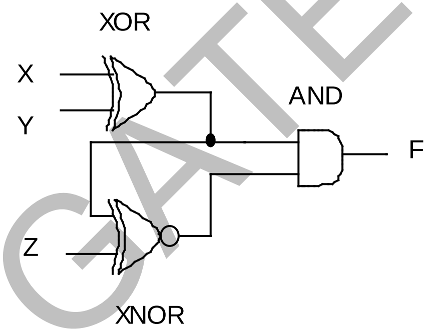


(A$-I_2(R_1 + R_2)$
(B) I_2R_2
(C)) I_1R_2
(D) $-I_1(R_1 + R_2)$

Q.39 For the amplifier shown in the figure, the BJT parameters are V_{BE} = 0.7 V, β = 200, and thermal voltage V_T = 25 mV. The voltage gain (v_o/v_i) of the amplifier is _______ .



Q.40 The output F in the digital logic circuit shown in the figure is

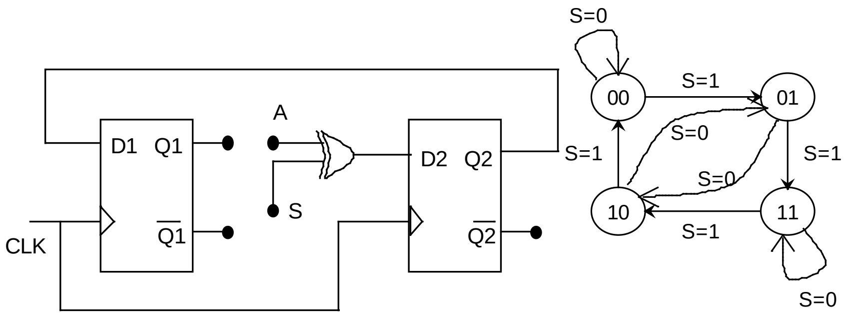


(A) $F = \bar{X}YZ + X\bar{Y}Z$
(B) $F = \bar{X}Y\bar{Z} + X\bar{Y}\bar{Z}$
(C) $F = \bar{X}\bar{Y}Z + XYZ$
(D) $F = \bar{X}\bar{Y}\bar{Z} + XYZ$

Q.41 Consider the Boolean function, $F(w,x,y,z) = wy + xy + \bar{w}xyz + \bar{w}\bar{x}y + xz + \bar{x}\bar{y}\bar{z}$. Which one of the following is the complete set of essential prime implicants?

(A) $w, y, xz, \bar{x}\bar{z}$
(B) w, y, xz
(C) $y, \bar{x}\bar{y}\bar{z}$
(D) $y, xz, \bar{x}\bar{z}$

Q.42 The digital logic shown in the figure satisfies the given state diagram when Q1 is connected to input A of the XOR gate.



Suppose the XOR gate is replaced by an XNOR gate. Which one of the following options preserves the state diagram?

(A) Input A is connected to $\overline{Q2}$
(B) Input A is connected to $Q2$
(C) Input A is connected to $\overline{Q1}$ and S is complemented
(D) Input A is connected to $\overline{Q1}$

Q.43 Let $x[n] = \left(-\frac{1}{9}\right)^n u(n) - \left(-\frac{1}{3}\right)^n u(-n-1)$. The Region of Convergence (ROC) of the *z*-transform of $x[n]$

(A) is $|z| > \frac{1}{9}$.
(B) is $|z| < \frac{1}{3}$.
(C) is $\frac{1}{3} > |z| > \frac{1}{9}$.
(D) does not exist.

Q.44 Consider a discrete time periodic signal $x[n] = sin\left(\frac{\pi n}{5}\right)$. Let a_k be the complex Fourier series coefficients of $x[n]$. The coefficients $\{a_k\}$ are non-zero when $k = Bm \pm 1$, where m is any integer. The value of B is______.

Q.45 A system is described by the following differential equation, where $u(t)$ is the input to the system and $y(t)$ is the output of the system.

$$\dot{y}(t) + 5y(t) = u(t)$$

When $y(0) = 1$ and $u(t)$ is a unit step function, $y(t)$ is

(A) $0.2 + 0.8e^{-5t}$ (B) $0.2 - 0.2e^{-5t}$ (C) $0.8 + 0.2e^{-5t}$ (D) $0.8 - 0.8e^{-5t}$

Q.46 Consider the state space model of a system, as given below

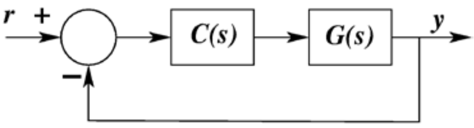
$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{bmatrix} = \begin{bmatrix}-1 & 1 & 0\\ 0 & -1 & 0\\ 0 & 0 & -2\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix} + \begin{bmatrix}0\\ 4\\ 0\end{bmatrix}u; \quad y = \begin{bmatrix}1 & 1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\\ x_3\end{bmatrix}.$$

The system is

(A) controllable and observable
(B) uncontrollable and observable
(C) uncontrollable and unobservable
(D) controllable and unobservable

Q.47 The phase margin in degrees of $G(s) = \frac{10}{(s+0.1)(s+1)(s+10)}$ calculated using the asymptotic Bode plot is ________.

Q.48 For the following feedback system $G(s) = \frac{1}{(s+1)(s+2)}$. The 2%-settling time of the step response is required to be less than 2 seconds.



Which one of the following compensators $C(s)$ achieves this?

(A $3\left(\frac{1}{s+5}\right)$

(B) $5(\frac{0.03}{s} + 1)$

(C) $2(s+4)$

(D) $4\left(\frac{s+8}{s+3}\right)$

Q.49 Let X be a real-valued random variable with $E[X]$ and $E[X^2]$ denoting the mean values of X and X^2, respectively. The relation which always holds true is

(A) $(E[X])^2 > E[X^2]$
(B) $E[X^2] \geq (E[X])^2$
(C) $E[X^2] = (E[X])^2$
(D) $E[X^2] > (E[X])^2$

Q.50 Consider a random process $X(t) = \sqrt{2}\sin(2\pi t + \varphi)$, where the random phase φ is uniformly distributed in the interval $[0,2\pi]$. The auto-correlation $E[X(t_1)X(t_2)]$ is

(A) $\cos(2\pi(t_1 + t_2))$

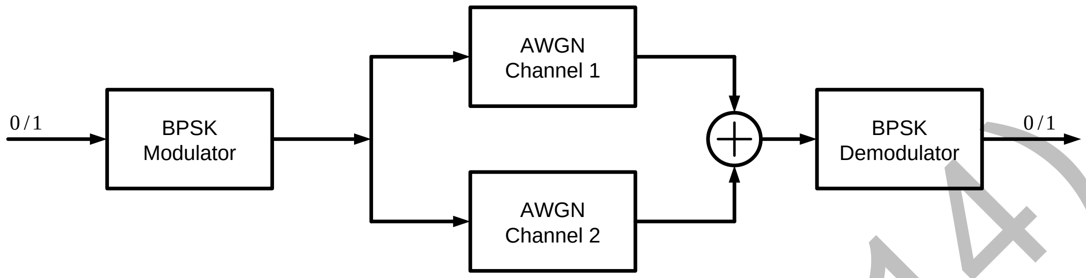
(B) $\sin(2\pi(t_1 - t_2))$

(C) $\sin(2\pi(t_1 + t_2))$

(D) $\cos(2\pi(t_1 - t_2))$

Q.51 Let $Q(\sqrt{\gamma})$ be the BER of a BPSK system over an AWGN channel with two-sided noise power spectral density $N_0/2$. The parameter γ is a function of bit energy and noise power spectral density.

A system with two independent and identical AWGN channels with noise power spectral density $N_0/2$ is shown in the figure. The BPSK demodulator receives the sum of outputs of both the channels.



If the BER of this system is $Q(b\sqrt{\gamma})$, then the value of b is _____.

Q.52 A fair coin is tossed repeatedly until a 'Head' appears for the first time. Let L be the number of tosses to get this first 'Head'. The entropy $H(L)$ in bits is ________.

Q.53 In spherical coordinates, let $\hat{a}_\theta, \hat{a}_\phi$ denote unit vectors along the θ, ϕ directions.

$$\boldsymbol{E} = \frac{100}{r}\sin\theta\cos(\omega t - \beta r)\,\hat{a}_\theta V/m$$

and

$$\boldsymbol{H} = \frac{0.265}{r}\sin\theta\cos(\omega t - \beta r)\,\hat{a}_\phi A/m$$

represent the electric and magnetic field components of the EM wave at large distances r from a dipole antenna, in free space. The average power (W) crossing the hemispherical shell located at $r = 1km, 0 \le \theta \le \pi/2$ is ________

Q.54 For a parallel plate transmission line, let v be the speed of propagation and Z be the characteristic impedance. Neglecting fringe effects, a reduction of the spacing between the plates by a factor of two results in

(A) halving of v and no change in Z
(B) no changes in v and halving of Z
(C) no change in both v and Z
(D) halving of both v and Z

Q.55 The input impedance of a $\frac{\lambda}{8}$ section of a lossless transmission line of characteristic impedance $50\,\Omega$ is found to be real when the other end is terminated by a load $Z_L\left(= R + jX\right)\Omega$. If X is 30Ω, the value of R (in Ω) is _______

END OF THE QUESTION PAPER

GATE 2014

Answer Keys for EC - Electronics and Communication Engineering

Section	Q. No.	SESSION - 1	
		Key / Range	Marks
GA	1	C	1
GA	2	D	1
GA	3	B	1
GA	4	A	1
GA	5	725 to 725	1
GA	6	D	2
GA	7	B	2
GA	8	560 to 560	2
GA	9	D	2
GA	10	B	2
EC	1	D	1
EC	2	0.65 to 0.68	1
EC	3	C	1
EC	4	0.99 to 1.01	1
EC	5	0.32 to 0.34	1
EC	6	C	1
EC	7	A	1
EC	8	7.99 to 8.01	1
EC	9	D	1
EC	10	A	1
EC	11	B	1
EC	12	B	1
EC	13	3.1 to 3.26	1
EC	14	C	1
EC	15	A	1
EC	16	62.4 to 62.6	1
EC	17	D	1
EC	18	2.99 to 3.01	1
EC	19	44 to 46	1
EC	20	2.24 to 2.26	1
EC	21	D	1
EC	22	7.99 to 8.01	1
EC	23	-0.01 to 0.01	1

Section	Q. No.	SESSION - 1	
		Key / Range	Marks
EC	24	B	1
EC	25	C	1
EC	26	A	2
EC	27	B	2
EC	28	862 to 866	2
EC	29	0.99 to 1.01	2
EC	30	29.08 to 29.10	2
EC	31	B	2
EC	32	0.39 to 0.42	2
EC	33	9.99 to 10.01	2
EC	34	5.7 to 5.9	2
EC	35	A	2
EC	36	499 to 501	2
EC	37	1092 to 1094	2
EC	38	C	2
EC	39	-240 to -230	2
EC	40	A	2
EC	41	D	2
EC	42	D	2
EC	43	C	2
EC	44	9.99 to 10.01	2
EC	45	A	2
EC	46	B	2
EC	47	42 to 48	2
EC	48	C	2
EC	49	B	2
EC	50	D	2
EC	51	1.4 to 1.42	2
EC	52	1.99 to 2.01	2
EC	53	55.4 to 55.6	2
EC	54	B	2
EC	55	39 to 41	2

SESSION - 2

GATE 2014: General Instructions during Examination

1. Total duration of the GATE examination is **180** minutes.
2. The clock will be set at the server. The countdown timer at the top right corner of screen will display the remaining time available for you to complete the examination. When the timer reaches zero, the examination will end by itself. You need not terminate the examination or submit your paper.
3. Any useful data required for your paper can be viewed by clicking on the **Useful Common Data** button that appears on the screen.
4. Use the scribble pad provided to you for any rough work. Submit the scribble pad at the end of the examination.
5. You are allowed to use a non-programmable type calculator, however, sharing of calculators is not allowed.
6. The Question Palette displayed on the right side of screen will show the status of each question using one of the following symbols:

You have not visited the question yet.

You have not answered the question.

You have answered the question.

You have NOT answered the question, but have marked the question for review.

You have answered the question, but marked it for review.

The **Marked for Review** status for a question simply indicates that you would like to look at that question again. *If a question is answered, but marked for review, then the answer will be considered for evaluation unless the status is modified by the candidate.*

<u>Navigating to a Question :</u>

7. To answer a question, do the following:
    a. Click on the question number in the Question Palette to go to that question directly.
    b. Select an answer for a multiple choice type question by clicking on the bubble placed before the 4 choices, namely A, B, C and D. Use the virtual numeric keypad to enter a number as answer for a numerical type question.
    c. Click on **Save & Next** to save your answer for the current question and then go to the next question.
    d. Click on **Mark for Review & Next** to save your answer for the current question and also mark it for review, and then go to the next question.

Caution: Note that your answer for the current question will not be saved, if you navigate to another question directly by clicking on a question number without saving the answer to the previous question.

You can view all the questions by clicking on the **Question Paper** button. This feature is provided, so that if you want you can just see the entire question paper at a glance.

<u>**Answering a Question :**</u>

8. Procedure for answering a multiple choice (MCQ) type question:
    a. Choose one answer from the 4 options (A,B,C,D) given below the question, click on the bubble placed before the chosen option.
    b. To deselect your chosen answer, click on the bubble of the chosen option again or click on the **Clear Response** button.
    c. To change your chosen answer, click on the bubble of another option.
    d. To save your answer, you MUST click on the **Save & Next** button.

9. Procedure for answering a numerical answer type question:
    a. To enter a number as your answer, use the virtual numerical keypad.
    b. A fraction (e.g. -0.3 or -.3) can be entered as an answer with or without '0' before the decimal point. As many as four decimal points, e.g. 12.5435 or 0.003 or -932.6711 or 12.82 can be entered.
    c. To clear your answer, click on the **Clear Response** button.
    d. To save your answer, you MUST click on the **Save & Next** button

10. To mark a question for review, click on the **Mark for Review & Next** button. *If an answer is selected (for MCQ) or entered (for numerical answer type) for a question that is* **Marked for Review***, that answer will be considered in the evaluation unless the status is modified by the candidate.*

11. To change your answer to a question that has already been answered, first select that question for answering and then follow the procedure for answering that type of question.
12. Note that ONLY Questions for which answers are ***saved*** or ***marked for review after answering*** will be considered for evaluation.

<u>**Choosing a Section :**</u>

13. Sections in this question paper are displayed on the top bar of the screen. Questions in a Section can be viewed by clicking on the name of that Section. The Section you are currently viewing will be highlighted.
14. A checkbox is displayed for every optional Section, if any, in the Question Paper. To select the optional Section for answering, click on the checkbox for that Section.
15. If the checkbox for an optional Section is not selected, the **Save & Next** button and the **Mark for Review & Next** button will NOT be enabled for that Section. You will

only be able to see questions in this Section, but you will not be able to answer questions in the Section.

16. After clicking the **Save & Next** button for the last question in a Section, you will automatically be taken to the first question of the next Section in sequence.
17. You can move the mouse cursor over the name of a Section to view the answering status for that Section.

Changing the Optional Section :

18. After answering the chosen optional Section, partially or completely, you can change the optional Section by selecting the checkbox for a new Section that you want to attempt. A warning message will appear along with a table showing the number of questions answered in each of the previously chosen optional Sections and a checkbox against each of these Sections. Click on a checkbox against a Section that you want to reset and then click on the **RESET** button. Note that RESETTING a Section will DELETE all the answers for questions in that Section. Hence, if you think that you may want to select this Section again later, you will have to note down your answers for questions in that Section. If you do not want to reset the Section and want to continue answering the previously chosen optional Section, then click on the **BACK** button.

19. If you deselect the checkbox for an optional Section in the top bar, the following warning message will appear: "Deselecting the checkbox will DELETE all the answers for questions in this Section. Do you want to deselect this Section?” If you want to deselect, click on the **RESET** button. If you do not want to deselect, click on the **BACK** button.

20. You can shuffle between different Sections or change the optional Sections any number of times.

GATE 2014 Examination

EC: Electronics & Communications Engineering

Duration: **180 minutes** *Maximum Marks*: **100**

Read the following instructions carefully.

1. To login, enter your Registration Number and password provided to you. Kindly go through the various symbols used in the test and understand their meaning before you start the examination.
2. Once you login and after the start of the examination, you can view all the questions in the question paper, by clicking on the **View All Questions** button in the screen.
3. This question paper consists of **2 sections**, General Aptitude (GA) for **15 marks** and the subject specific GATE paper for **85 marks**. Both these sections are compulsory.
   The GA section consists of **10** questions. Question numbers 1 to 5 are of 1-mark each, while question numbers 6 to 10 are of 2-mark each.
   The subject specific GATE paper section consists of **55** questions, out of which question numbers 1 to 25 are of 1-mark each, while question numbers 26 to 55 are of 2-mark each.
4. Depending upon the GATE paper, there may be useful common data that may be required for answering the questions. If the paper has such useful data, the same can be viewed by clicking on the **Useful Common Data** button that appears at the top, right hand side of the screen.
5. The computer allotted to you at the examination center runs specialized software that permits only one answer to be selected for multiple-choice questions using a mouse and to enter a suitable number for the numerical answer type questions using the virtual keyboard and mouse.
6. Your answers shall be updated and saved on a server periodically and also at the end of the examination. The examination will **stop automatically** at the end of **180 minutes**.
7. In each paper a candidate can answer a total of 65 questions carrying 100 marks.
8. The question paper may consist of questions of **multiple choice type** (MCQ) and **numerical answer type**.
9. Multiple choice type questions will have four choices against A, B, C, D, out of which only **ONE** is the correct answer. The candidate has to choose the correct answer by clicking on the bubble (○) placed before the choice.
10. For numerical answer type questions, each question will have a numerical answer and there will not be any choices**. For these questions, the answer should be entered**by using the virtual keyboard that appears on the monitor and the mouse.
11. All questions that are not attempted will result in zero marks. However, wrong answers for multiple choice type questions (MCQ) will result in **NEGATIVE** marks. For all MCQ questions a wrong answer will result in deduction of⅓ marks for a 1-mark question and ⅔ marks for a 2-mark question.
12. There is **NO NEGATIVE MARKING** for questions of **NUMERICAL ANSWER TYPE**.
13. Non-programmable type Calculator is allowed. Charts, graph sheets, and mathematical tables are **NOT** allowed in the Examination Hall. You must use the Scribble pad provided to you at the examination centre for all your rough work. The Scribble Pad has to be returned at the end of the examination.

Declaration by the candidate:

"I have read and understood all the above instructions. I have also read and understood clearly the instructions given on the admit card and shall follow the same. I also understand that in case I am found to violate any of these instructions, my candidature is liable to be cancelled. I also confirm that at the start of the examination all the computer hardware allotted to me are in proper working condition".

Q. 1 – Q. 5 carry one mark each.

Q.1 Choose the most appropriate word from the options given below to complete the following sentence.

Communication and interpersonal skills are _________ important in their own ways.

(A) each (B) both (C) all (D) either

Q.2 Which of the options given below best completes the following sentence?

She will feel much better if she ________________.

(A) will get some rest
(B) gets some rest
(C) will be getting some rest
(D) is getting some rest

Q.3 Choose the most appropriate pair of words from the options given below to complete the following sentence.

She could not _____ the thought of _________ the election to her bitter rival.

(A) bear, loosing (B) bare, loosing (C) bear, losing (D) bare, losing

Q.4 A regular die has six sides with numbers 1 to 6 marked on its sides. If a very large number of throws show the following frequencies of occurrence: $1 \rightarrow 0.167$; $2 \rightarrow 0.167$; $3 \rightarrow 0.152$; $4 \rightarrow 0.166$; $5 \rightarrow 0.168$; $6 \rightarrow 0.180$. We call this die

(A) irregular (B) biased (C) Gaussian (D) insufficient

Q.5 Fill in the missing number in the series.

2 3 6 15 ___ 157.5 630

Q. 6 – Q. 10 carry two marks each.

Q.6 Find the odd one in the following group

Q,W,Z,B B,H,K,M W,C,G,J M,S,V,X

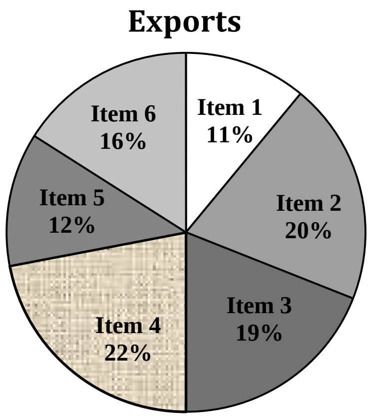
(A) Q,W,Z,B (B) B,H,K,M (C) W,C,G,J (D) M,S,V,X

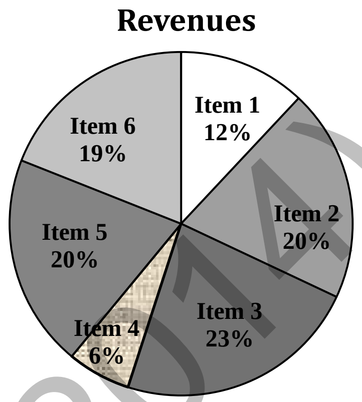
Q.7 Lights of four colors (red, blue, green, yellow) are hung on a ladder. On every step of the ladder there are two lights. If one of the lights is red, the other light on that step will always be blue. If one of the lights on a step is green, the other light on that step will always be yellow. Which of the following statements is not necessarily correct?

(A) The number of red lights is equal to the number of blue lights
(B) The number of green lights is equal to the number of yellow lights
(C) The sum of the red and green lights is equal to the sum of the yellow and blue lights
(D) The sum of the red and blue lights is equal to the sum of the green and yellow lights

Q.8 The sum of eight consecutive odd numbers is 656. The average of four consecutive even numbers is 87. What is the sum of the smallest odd number and second largest even number?

Q.9 The total exports and revenues from the exports of a country are given in the two charts shown below. The pie chart for exports shows the quantity of each item exported as a percentage of the total quantity of exports. The pie chart for the revenues shows the percentage of the total revenue generated through export of each item. The total quantity of exports of all the items is 500 thousand tonnes and the total revenues are 250 crore rupees. Which item among the following has generated the maximum revenue per kg?





(A) Item 2 (B) Item 3 (C) Item 6 (D) Item 5

Q.10 It takes 30 minutes to empty a half-full tank by draining it at a constant rate. It is decided to simultaneously pump water into the half-full tank while draining it. What is the rate at which water has to be pumped in so that it gets fully filled in 10 minutes?

(A) 4 times the draining rate (B) 3 times the draining rate
(C) 2.5 times the draining rate (D) 2 times the draining rate

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry one mark each.

Q.1 The determinant of matrix A is 5 and the determinant of matrix B is 40. The determinant of matrix AB is ________.

Q.2 Let X be a random variable which is uniformly chosen from the set of positive odd numbers less than 100. The expectation, $E[X]$, is __________.

Q.3 For $0 \leq t < \infty$, the maximum value of the function $f(t) = e^{-t} - 2\,e^{-2t}$ occurs at

(A) $t = \log_e 4$ (B) $t = \log_e 2$ (C) $t = 0$ (D) $t = \log_e 8$

Q.4 The value of

$$\lim_{x\to\infty}\left(1+\frac{1}{x}\right)^x$$

is

(A) $ln2$ (B) 1.0 (C) e (D) ∞

Q.5 If the characteristic equation of the differential equation

$$\frac{d^2y}{dx^2} + 2\,\alpha\frac{dy}{dx} + y = 0$$

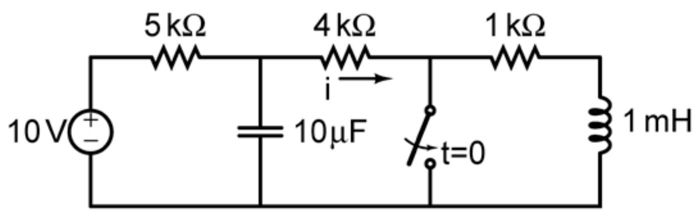
has two equal roots, then the values of α are

(A) ±1 (B) 0,0 (C) $\pm j$ (D) ±1/2

Q.6 Norton's theorem states that a complex network connected to a load can be replaced with an equivalent impedance

(A) in series with a current source
(B) in parallel with a voltage source
(C) in series with a voltage source
(D) in parallel with a current source

Q.7 In the figure shown, the ideal switch has been open for a long time. If it is closed at $t = 0$, then the magnitude of the current (in mA) through the 4 kΩ resistor at $t = 0^+$ is _______.



Q.8 A silicon bar is doped with donor impurities N_D = 2.25 x 10^{15} atoms / cm^3. Given the intrinsic carrier concentration of silicon at T = 300 K is n_i = 1.5 x 10^{10} cm^{-3}. Assuming complete impurity ionization, the equilibrium electron and hole concentrations are

(A) n_0 = 1.5 x 10^{16} cm^{-3}, p_0 = 1.5 x 10^5 cm^{-3}
(B) n_0 = 1.5 x 10^{10} cm^{-3}, p_0= 1.5 x 10^{15} cm^{-3}
(C) n_0 = 2.25 x 10^{15} cm^{-3}, p_0 = 1.5 x 10^{10} cm^{-3}
(D) n_0 = 2.25 x 10^{15} cm^{-3}, p_0 = 1 x 10^5 cm^{-3}

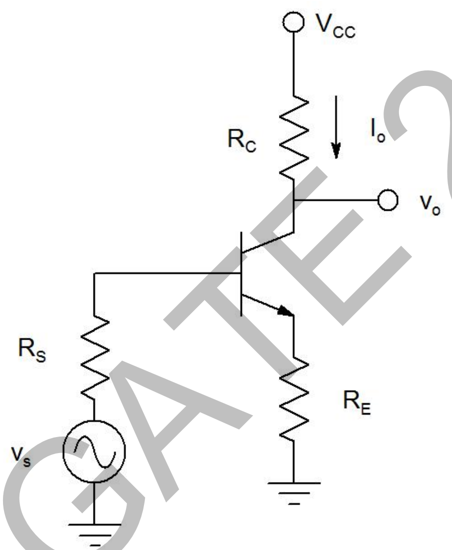
Q.9 An increase in the base recombination of a BJT will increase

(A) the common emitter dc current gain β
(B) the breakdown voltage BV_{CEO}
(C) the unity-gain cut-off frequency f_T
(D) the transconductance g_m

Q.10 In CMOS technology, shallow P-well or N-well regions can be formed using

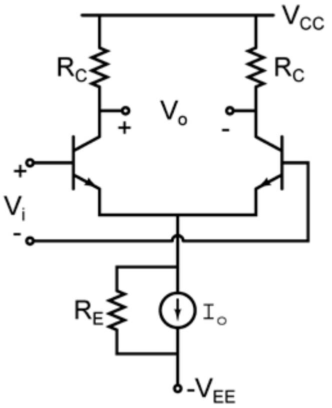
(A) low pressure chemical vapour deposition
(B) low energy sputtering
(C) low temperature dry oxidation
(D) low energy ion-implantation

Q.11 The feedback topology in the amplifier circuit (the base bias circuit is not shown for simplicity) in the figure is



(A) Voltage shunt feedback
(B) Current series feedback
(C) Current shunt feedback
(D) Voltage series feedback

Q.12 In the differential amplifier shown in the figure, the magnitudes of the common-mode and differential-mode gains are A_{cm} and A_d, respectively. If the resistance R_E is increased, then

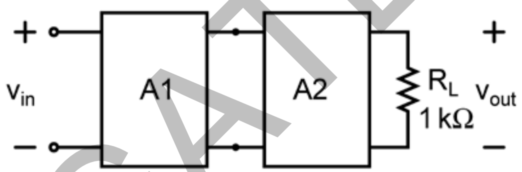


(A) A_{cm} increases
(B) common-mode rejection ratio increases
(C) A_d increases
(D) common-mode rejection ratio decreases

Q.13 A cascade connection of two voltage amplifiers A1 and A2 is shown in the figure. The open-loop gain A_{v0}, input resistance R_{in}, and output resistance R_o for A1 and A2 are as follows:

A1: $A_{v0} = 10, R_{in} = 10\ \text{k}\Omega,\ R_o = 1\ \text{k}\Omega.$
A2: $A_{v0} = 5,\ R_{in} = 5\ \text{k}\Omega,\ R_o = 200\ \Omega.$

The approximate overall voltage gain v_{out}/v_{in} is ___________.



Q.14 For an n-variable Boolean function, the maximum number of prime implicants is

(A) $2(n-1)$ (B) $n/2$ (C) 2^n (D) $2^{(n-1)}$

Q.15 The number of bytes required to represent the decimal number 1856357 in packed BCD (Binary Coded Decimal) form is ___________ .

Q.16 In a half-subtractor circuit with X and Y as inputs, the Borrow (M) and Difference ($N = X - Y$) are given by

(A) $M = X \oplus Y,\ N = XY$
(B) $M = XY,\quad N = X \oplus Y$
(C) $M = \bar{X}Y,\quad N = X \oplus Y$
(D) $M = X\bar{Y},\quad N = \overline{X \oplus Y}$

Q.17 An FIR system is described by the system function

$$H(z) = 1 + \frac{7}{2}z^{-1} + \frac{3}{2}z^{-2}$$

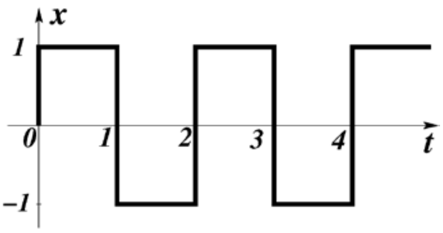
The system is

(A) maximum phase (B) minimum phase (C) mixed phase (D) zero phase

Q.18 Let $x[n] = x[-n]$. Let $X(z)$ be the z-transform of $x[n]$. If $0.5 + j\,0.25$ is a zero of $X(z)$, which one of the following must also be a zero of $X(z)$.

(A) $0.5 - j\,0.25$ (B) $1/(0.5 + j\,0.25)$ (C) $1/(0.5 - j\,0.25)$ (D) $2+j\,4$

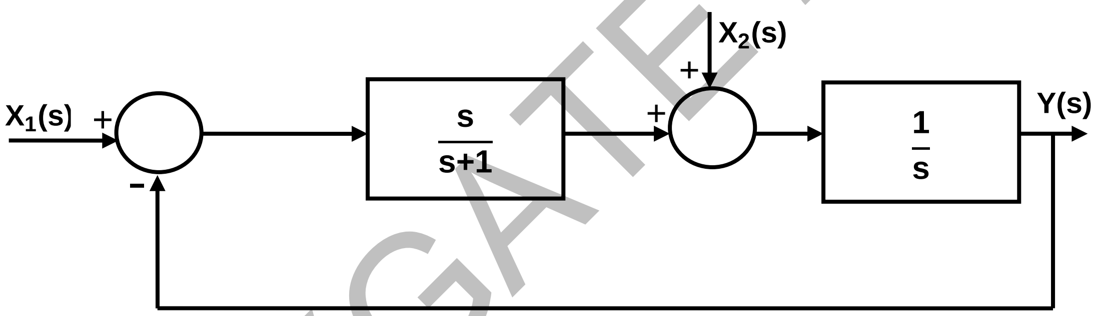
Q.19 Consider the periodic square wave in the figure shown.



The ratio of the power in the 7th harmonic to the power in the 5th harmonic for this waveform is closest in value to _______.

Q.20 The natural frequency of an undamped second-order system is 40 rad/s. If the system is damped with a damping ratio 0.3, the damped natural frequency in rad/s is ________.

Q.21 For the following system,



when $X_1(s) = 0$, the transfer function $\frac{Y(s)}{X_2(s)}$ is

(A) $\frac{s+1}{s^2}$ (B) $\frac{1}{s+1}$ (C) $\frac{s+2}{s(s+1)}$ (D) $\frac{s+1}{s(s+2)}$

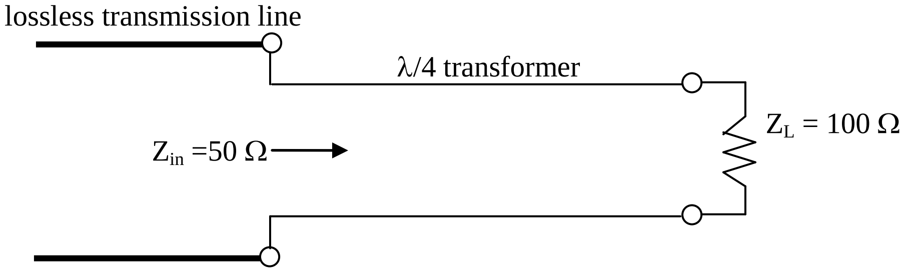
Q.22 The capacity of a band-limited additive white Gaussian noise (AWGN) channel is given by $C = W\ \log_2\left(1 + \frac{P}{\sigma^2\,W}\right)$ bits per second (bps), where W is the channel bandwidth, P is the average power received and σ^2 is the one-sided power spectral density of the AWGN.

For a fixed $\frac{P}{\sigma^2}$ = 1000, the channel capacity (in kbps) with infinite bandwidth $(W \to \infty)$ is approximately

(A) 1.44 (B) 1.08 (C) 0.72 (D) 0.36

Q.23 Consider sinusoidal modulation in an AM system. Assuming no overmodulation, the modulation index (μ) when the maximum and minimum values of the envelope, respectively, are 3 V and 1 V, is ________.

Q.24 To maximize power transfer, a lossless transmission line is to be matched to a resistive load impedance via a λ/4 transformer as shown.



The characteristic impedance (in Ω) of the λ/4 transformer is _________.

Q.25 Which one of the following field patterns represents a TEM wave travelling in the positive x direction?

(A) $E = +8\hat{y},\ H = -4\hat{z}$
(B) $E = -2\hat{y},\ H = -3\hat{z}$
(C) $E = +2\hat{z},\ H = +2\hat{y}$
(D) $E = -3\hat{y},\ H = +4\hat{z}$

Q. 26 – Q. 55 carry two marks each.

Q.26 The system of linear equations

$$\begin{pmatrix} 2 & 1 & 3 \\ 3 & 0 & 1 \\ 1 & 2 & 5 \end{pmatrix}\begin{pmatrix} a \\ b \\ c \end{pmatrix} = \begin{pmatrix} 5 \\ -4 \\ 14 \end{pmatrix} \text{ has}$$

(A) a unique solution
(B) infinitely many solutions
(C) no solution
(D) exactly two solutions

Q.27 The real part of an analytic function $f(z)$ where $z = x + jy$ is given by $e^{-y}\cos(x)$. The imaginary part of $f(z)$ is

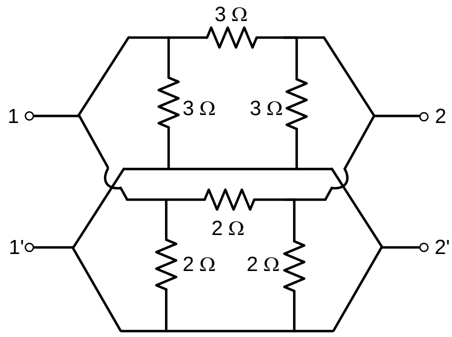
(A) $e^{y}\cos(x)$
(B) $e^{-y}\sin(x)$
(C) $-e^{y}\sin(x)$
(D) $-e^{-y}\sin(x)$

Q.28 The maximum value of the determinant among all 2×2 real symmetric matrices with trace 14 is ________.

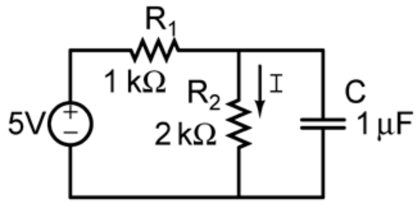
Q.29 If $\vec{r} = x\hat{a}_x + y\hat{a}_y + z\hat{a}_z$ and $|\vec{r}| = r$, then $\mathrm{div}\left(r^2 \nabla(\ln r)\right) =$ ______ .

Q.30 A series LCR circuit is operated at a frequency different from its resonant frequency. The operating frequency is such that the current leads the supply voltage. The magnitude of current is half the value at resonance. If the values of L, C and R are 1 H, 1 F and 1 Ω, respectively, the operating angular frequency (in rad/s) is ________.

Q.31 In the h-parameter model of the 2-port network given in the figure shown, the value of h_{22} (in S) is ______ .

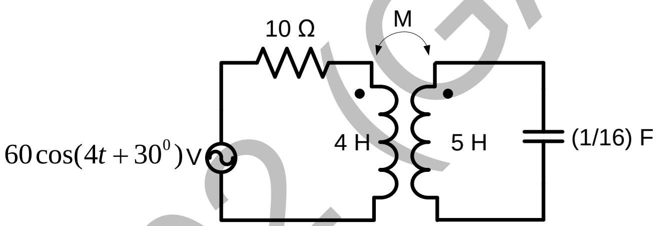


Q.32 In the figure shown, the capacitor is initially uncharged. Which one of the following expressions describes the current I(t) (in mA) for $t > 0$?



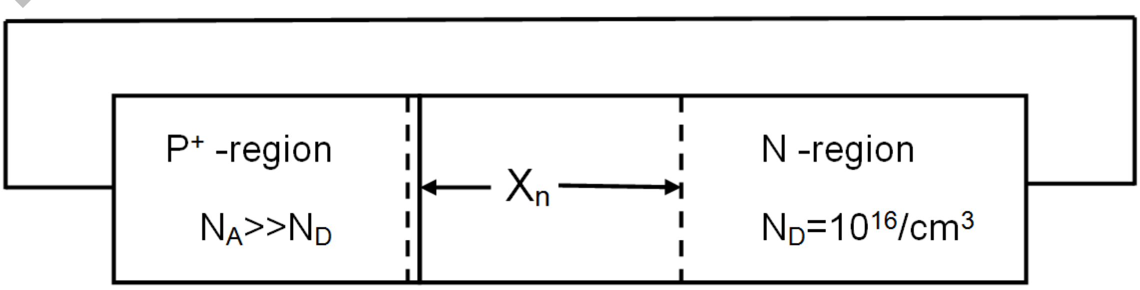
(A) $\mathrm{I}(t) = \frac{5}{3}(1 - e^{-t/\tau}),\ \tau = \frac{2}{3}$ msec
(B) $\mathrm{I}(t) = \frac{5}{2}(1 - e^{-t/\tau}),\ \tau = \frac{2}{3}$ msec
(C) $\mathrm{I}(t) = \frac{5}{3}(1 - e^{-t/\tau}),\ \tau = 3$ msec
(D) $\mathrm{I}(t) = \frac{5}{2}(1 - e^{-t/\tau}),\ \tau = 3$ msec

Q.33 In the magnetically coupled circuit shown in the figure, 56 % of the total flux emanating from one coil links the other coil. The value of the mutual inductance (in H) is ______ .



Q.34 Assume electronic charge q = 1.6×10^{-19} C, kT/q = 25 mV and electron mobility μ_n = 1000 cm^2/V-s. If the concentration gradient of electrons injected into a P-type silicon sample is 1×10^{21}/cm^4, the magnitude of electron diffusion current density (in A/cm^2) is _________.

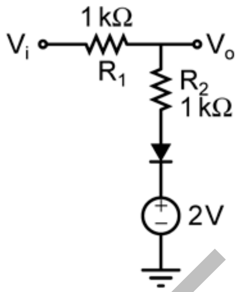
Q.35 Consider an abrupt PN junction (at T = 300 K) shown in the figure. The depletion region width X_n on the N-side of the junction is 0.2 μm and the permittivity of silicon (ε_{si}) is 1.044×10^{-12} F/cm. At the junction, the approximate value of the peak electric field (in kV/cm) is _________.



Q.36 When a silicon diode having a doping concentration of $N_A = 9 \times 10^{16}$ cm^{-3} on p-side and $N_D = 1 \times 10^{16}$ cm^{-3} on n-side is reverse biased, the total depletion width is found to be 3 μm. Given that the permittivity of silicon is 1.04×10^{-12} F/cm, the depletion width on the p-side and the maximum electric field in the depletion region, respectively, are

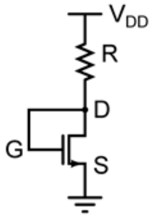
(A) 2.7 μm and 2.3×10^5 V/cm
(B) 0.3 μm and 4.15×10^5 V/cm
(C) 0.3 μm and 0.42×10^5 V/cm
(D) 2.1 μm and 0.42×10^5 V/cm

Q.37 The diode in the circuit shown has V_{on} = 0.7 Volts but is ideal otherwise.
If $V_i = 5\sin(\omega t)$ Volts, the minimum and maximum values of V_o (in Volts) are, respectively,



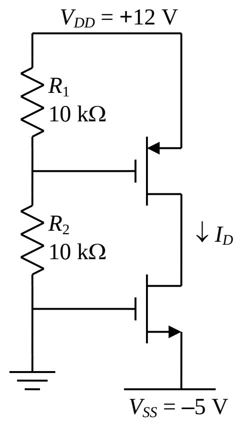
(A) −5 and 2.7
(B) 2.7 and 5
(C) −5 and 3.85
(D) 1.3 and 5

Q.38 For the n-channel MOS transistor shown in the figure, the threshold voltage V_{Th} is 0.8 V. Neglect channel length modulation effects. When the drain voltage $V_D = 1.6$ V, the drain current I_D was found to be 0.5 mA. If V_D is adjusted to be 2 V by changing the values of R and V_{DD}, the new value of I_D (in mA) is

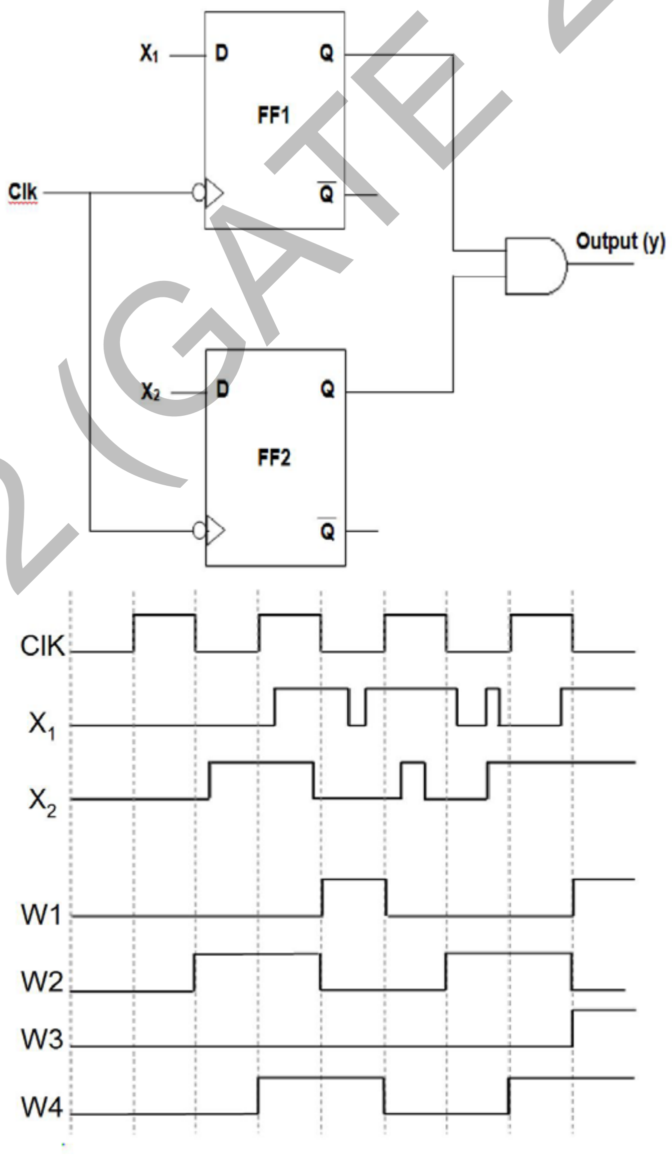


(A) 0.625
(B) 0.75
(C) 1.125
(D) 1.5

Q.39 For the MOSFETs shown in the figure, the threshold voltage $|V_t|$ = 2 V and $K = \frac{1}{2}\mu C_{ox}\left(\frac{W}{L}\right)$ = 0.1 mA/V^2. The value of I_D (in mA) is _______ .

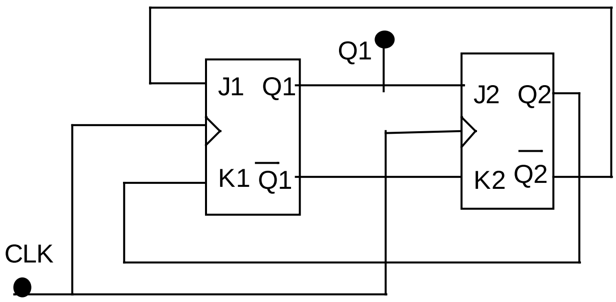


Q.40 In the circuit shown, choose the correct timing diagram of the output (y) from the given waveforms W1, W2, W3 and W4.



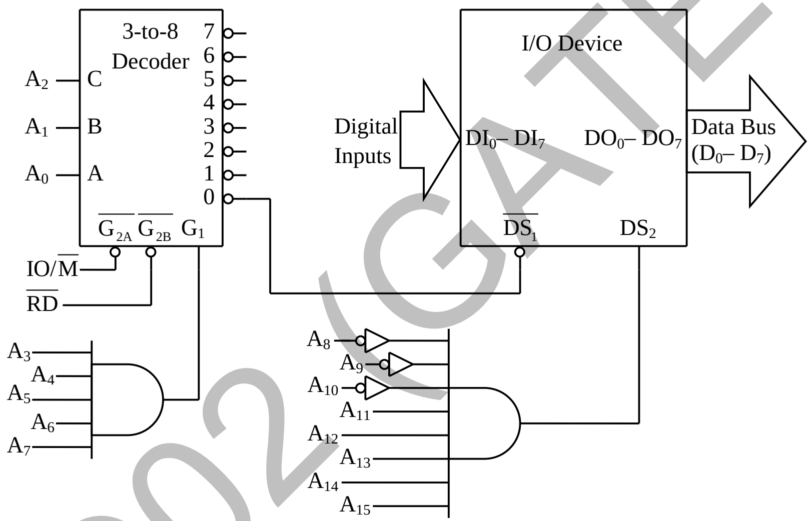
(A) W1 (B) W2 (C) W3 (D) W4

Q.41 The outputs of the two flip-flops Q1, Q2 in the figure shown are initialized to 0, 0. The sequence generated at Q1 upon application of clock signal is



(A) 01110…
(B) 01010…
(C) 00110…
(D) 01100…

Q.42 For the 8085 microprocessor, the interfacing circuit to input 8-bit digital data ($DI_0 – DI_7$) from an external device is shown in the figure. The instruction for correct data transfer is



(A) MVI A, F8H (B) IN F8H (C) OUT F8H (D) LDA F8F8H

Q.43 Consider a discrete-time signal

$$x[n] = \begin{cases} n & \text{for } \ 0 \le n \le 10 \\ 0 & \text{otherwise} \end{cases} .$$

If $y[n]$ is the convolution of $x[n]$ with itself, the value of $y[4]$ is _________.

Q.44 The input-output relationship of a causal stable LTI system is given as

$$y[n] = \alpha\, y[n-1] + \beta\, x[n]$$

If the impulse response $h[n]$ of this system satisfies the condition $\sum_{n=0}^{\infty} h[n] = 2$, the relationship between α and β is

(A) $\alpha = 1 - \beta/2$ (B) $\alpha = 1 + \beta/2$ (C) $\alpha = 2\beta$ (D) $\alpha = -2\beta$

Q.45 The value of the integral $\int_{-\infty}^{\infty} \text{sinc}^2(5t)\, dt$ is ________.

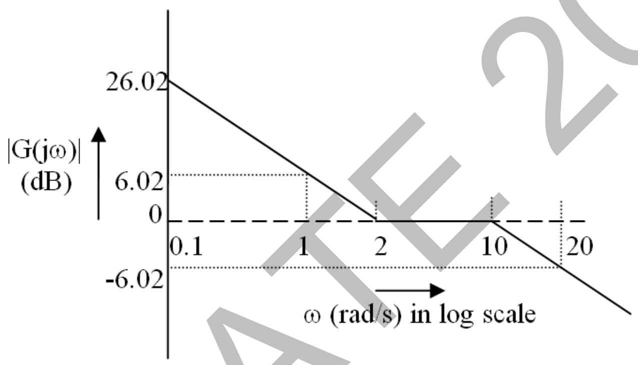
Q.46 An unforced linear time invariant (LTI) system is represented by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

If the initial conditions are $x_1(0) = 1$ and $x_2(0) = -1$, the solution of the state equation is

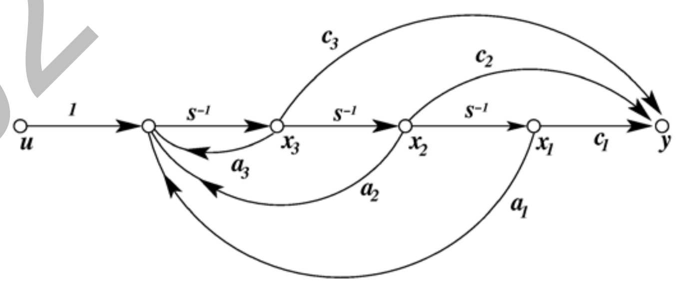
(A) $x_1(t) = -1,\ x_2(t) = 2$
(B) $x_1(t) = -e^{-t},\ x_2(t) = 2e^{-t}$
(C) $x_1(t) = e^{-t},\ x_2(t) = -e^{-2t}$
(D) $x_1(t) = -e^{-t},\ x_2(t) = -2e^{-t}$

Q.47 The Bode asymptotic magnitude plot of a minimum phase system is shown in the figure.



If the system is connected in a unity negative feedback configuration, the steady state error of the closed loop system, to a unit ramp input, is_________.

Q.48 Consider the state space system expressed by the signal flow diagram shown in the figure.



The corresponding system is

(A) always controllable
(B) always observable
(C) always stable
(D) always unstable

Q.49 The input to a 1-bit quantizer is a random variable X with pdf $f_X(x) = 2e^{-2x}$ for $x \geq 0$ and $f_X(x) = 0$ for $x < 0$. For outputs to be of equal probability, the quantizer threshold should be _____.

Q.50 Coherent orthogonal binary FSK modulation is used to transmit two equiprobable symbol waveforms $s_1(t) = \alpha \cos 2\pi f_1 t$ and $s_2(t) = \alpha \cos 2\pi f_2 t$, where $\alpha = 4$ mV. Assume an AWGN channel with two-sided noise power spectral density $\frac{N_0}{2} = 0.5 \times 10^{-12}$ W/Hz. Using an optimal receiver and the relation $Q(v) = \frac{1}{\sqrt{2\pi}}\int_v^\infty e^{-u^2/2}\,du$, the bit error probability for a data rate of 500 kbps is

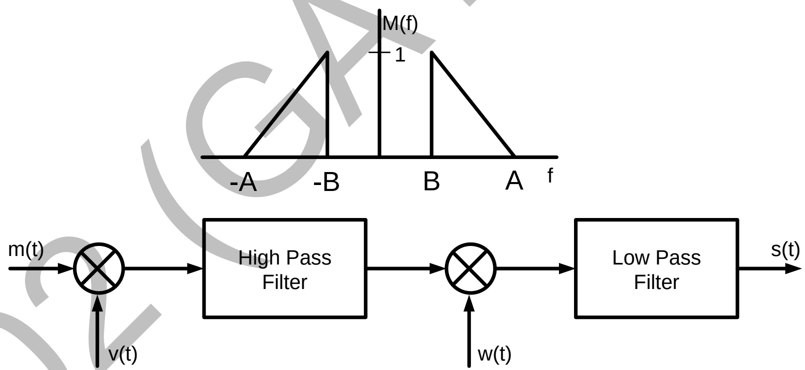
(A) $Q(2)$ (B) $Q(2\sqrt{2})$ (C) $Q(4)$ (D) $Q(4\sqrt{2})$

Q.51 The power spectral density of a real stationary random process $X(t)$ is given by

$$S_X(f) = \begin{cases} \frac{1}{W}, & |f| \leq W \\ 0, & |f| > W \end{cases}.$$

The value of the expectation $E\left[\pi X(t)\, X\left(t - \frac{1}{4W}\right)\right]$ is________.

Q.52 In the figure, $M(f)$ is the Fourier transform of the message signal $m(t)$ where A = 100 Hz and B = 40 Hz. Given $v(t) = \cos(2\pi f_c t)$ and $w(t) = \cos(2\pi(f_c + A)t)$, where $f_c > A$. The cutoff frequencies of both the filters are f_c.



The bandwidth of the signal at the output of the modulator (in Hz) is _____.

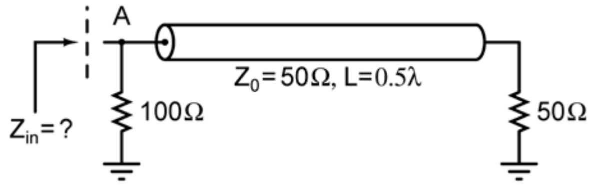
Q.53 If the electric field of a plane wave is

$$\vec{E}(z,t) = \hat{x}3\cos(\omega t - kz + 30°) - \hat{y}4\sin(\omega t - kz + 45°) \text{ (mV/m)},$$

the polarization state of the plane wave is

(A) left elliptical
(B) left circular
(C) right elliptical
(D) right circular

Q.54 In the transmission line shown, the impedance Z_{in} (in ohms) between node A and the ground is _________.



Q.55 For a rectangular waveguide of internal dimensions $a \times b$ $(a > b)$, the cut-off frequency for the TE_{11} mode is the arithmetic mean of the cut-off frequencies for TE_{10} mode and TE_{20} mode. If $a = \sqrt{5}$ cm, the value of b (in cm) is _____.

END OF THE QUESTION PAPER

GATE 2014

Answer Keys for EC - Electronics and Communication Engineering

Section	Q. No.	SESSION - H	
		Key / Range	Marks
GA	1	B	1
GA	2	B	1
GA	3	C	1
GA	4	B	1
GA	5	45 to 45	1
GA	6	C	2
GA	7	D	2
GA	8	163 to 163	2
GA	9	D	2
GA	10	A	2
EC	1	199 to 201	1
EC	2	49.9 to 50.1	1
EC	3	A	1
EC	4	C	1
EC	5	A	1
EC	6	D	1
EC	7	1.2 to 1.3	1
EC	8	D	1
EC	9	B	1
EC	10	D	1
EC	11	B	1
EC	12	B	1
EC	13	34.0 to 35.3	1
EC	14	D	1
EC	15	3.9 to 4.1	1
EC	16	C	1
EC	17	C	1
EC	18	B	1
EC	19	0.50 to 0.52	1
EC	20	38.13 to 38.19	1
EC	21	D	1
EC	22	A	1
EC	23	0.45 to 0.55	1

Section	Q. No.	SESSION - H	
		Key / Range	Marks
EC	24	70 to 72	1
EC	25	B	1
EC	26	B	2
EC	27	B	2
EC	28	48.9 to 49.1	2
EC	29	2.9 to 3.1	2
EC	30	0.45 to 0.47	2
EC	31	1.24 to 1.26	2
EC	32	A	2
EC	33	2.49 to 2.52	2
EC	34	3990 to 4010	2
EC	35	30 to 32	2
EC	36	B	2
EC	37	C	2
EC	38	C	2
EC	39	0.88 to 0.92	2
EC	40	C	2
EC	41	D	2
EC	42	D	2
EC	43	9.9 to 10.1	2
EC	44	A	2
EC	45	0.19 to 0.21	2
EC	46	C	2
EC	47	0.49 to 0.51	2
EC	48	A	2
EC	49	0.34 to 0.36	2
EC	50	C	2
EC	51	3.9 to 4.1	2
EC	52	59.9 to 60.1	2
EC	53	A	2
EC	54	32.99 to 34.01	2
EC	55	1.9 to 2.1	2

SESSION - 3

GATE 2014: General Instructions during Examination

1. Total duration of the GATE examination is **180** minutes.
2. The clock will be set at the server. The countdown timer at the top right corner of screen will display the remaining time available for you to complete the examination. When the timer reaches zero, the examination will end by itself. You need not terminate the examination or submit your paper.
3. Any useful data required for your paper can be viewed by clicking on the **Useful Common Data** button that appears on the screen.
4. Use the scribble pad provided to you for any rough work. Submit the scribble pad at the end of the examination.
5. You are allowed to use a non-programmable type calculator, however, sharing of calculators is not allowed.
6. The Question Palette displayed on the right side of screen will show the status of each question using one of the following symbols:

You have not visited the question yet.

You have not answered the question.

You have answered the question.

You have NOT answered the question, but have marked the question for review.

You have answered the question, but marked it for review.

The **Marked for Review** status for a question simply indicates that you would like to look at that question again. *If a question is answered, but marked for review, then the answer will be considered for evaluation unless the status is modified by the candidate.*

<u>Navigating to a Question :</u>

7. To answer a question, do the following:
   a. Click on the question number in the Question Palette to go to that question directly.
   b. Select an answer for a multiple choice type question by clicking on the bubble placed before the 4 choices, namely A, B, C and D. Use the virtual numeric keypad to enter a number as answer for a numerical type question.
   c. Click on **Save & Next** to save your answer for the current question and then go to the next question.
   d. Click on **Mark for Review & Next** to save your answer for the current question and also mark it for review, and then go to the next question.

Caution: Note that your answer for the current question will not be saved, if you navigate to another question directly by clicking on a question number without saving the answer to the previous question.

You can view all the questions by clicking on the **Question Paper** button. This feature is provided, so that if you want you can just see the entire question paper at a glance.

Answering a Question :

8. Procedure for answering a multiple choice (MCQ) type question:
    a. Choose one answer from the 4 options (A,B,C,D) given below the question, click on the bubble placed before the chosen option.
    b. To deselect your chosen answer, click on the bubble of the chosen option again or click on the **Clear Response** button.
    c. To change your chosen answer, click on the bubble of another option.
    d. To save your answer, you MUST click on the **Save & Next** button.

9. Procedure for answering a numerical answer type question:
    a. To enter a number as your answer, use the virtual numerical keypad.
    b. A fraction (e.g. -0.3 or -.3) can be entered as an answer with or without '0' before the decimal point. As many as four decimal points, e.g. 12.5435 or 0.003 or -932.6711 or 12.82 can be entered.
    c. To clear your answer, click on the **Clear Response** button.
    d. To save your answer, you MUST click on the **Save & Next** button
10. To mark a question for review, click on the **Mark for Review & Next** button. *If an answer is selected (for MCQ) or entered (for numerical answer type) for a question that is* **Marked for Review**, *that answer will be considered in the evaluation unless the status is modified by the candidate.*

11. To change your answer to a question that has already been answered, first select that question for answering and then follow the procedure for answering that type of question.
12. Note that ONLY Questions for which answers are ***saved*** or ***marked for review after answering*** will be considered for evaluation.

Choosing a Section :

13. Sections in this question paper are displayed on the top bar of the screen. Questions in a Section can be viewed by clicking on the name of that Section. The Section you are currently viewing will be highlighted.
14. A checkbox is displayed for every optional Section, if any, in the Question Paper. To select the optional Section for answering, click on the checkbox for that Section.
15. If the checkbox for an optional Section is not selected, the **Save & Next** button and the **Mark for Review & Next** button will NOT be enabled for that Section. You will

only be able to see questions in this Section, but you will not be able to answer questions in the Section.

16. After clicking the **Save & Next** button for the last question in a Section, you will automatically be taken to the first question of the next Section in sequence.
17. You can move the mouse cursor over the name of a Section to view the answering status for that Section.

Changing the Optional Section :

18. After answering the chosen optional Section, partially or completely, you can change the optional Section by selecting the checkbox for a new Section that you want to attempt. A warning message will appear along with a table showing the number of questions answered in each of the previously chosen optional Sections and a checkbox against each of these Sections. Click on a checkbox against a Section that you want to reset and then click on the **RESET** button. Note that RESETTING a Section will DELETE all the answers for questions in that Section. Hence, if you think that you may want to select this Section again later, you will have to note down your answers for questions in that Section. If you do not want to reset the Section and want to continue answering the previously chosen optional Section, then click on the **BACK** button.

19. If you deselect the checkbox for an optional Section in the top bar, the following warning message will appear: "Deselecting the checkbox will DELETE all the answers for questions in this Section. Do you want to deselect this Section?" If you want to deselect, click on the **RESET** button. If you do not want to deselect, click on the **BACK** button.

20. You can shuffle between different Sections or change the optional Sections any number of times.

GATE 2014 Examination

EC: Electronics & Communications Engineering

Duration: **180 minutes** *Maximum Marks*: **100**

Read the following instructions carefully.

1. To login, enter your Registration Number and password provided to you. Kindly go through the various symbols used in the test and understand their meaning before you start the examination.
2. Once you login and after the start of the examination, you can view all the questions in the question paper, by clicking on the **View All Questions** button in the screen.
3. This question paper consists of **2 sections**, General Aptitude (GA) for **15 marks** and the subject specific GATE paper for **85 marks**. Both these sections are compulsory.
   The GA section consists of **10** questions. Question numbers 1 to 5 are of 1-mark each, while question numbers 6 to 10 are of 2-mark each.
   The subject specific GATE paper section consists of **55** questions, out of which question numbers 1 to 25 are of 1-mark each, while question numbers 26 to 55 are of 2-mark each.
4. Depending upon the GATE paper, there may be useful common data that may be required for answering the questions. If the paper has such useful data, the same can be viewed by clicking on the **Useful Common Data** button that appears at the top, right hand side of the screen.
5. The computer allotted to you at the examination center runs specialized software that permits only one answer to be selected for multiple-choice questions using a mouse and to enter a suitable number for the numerical answer type questions using the virtual keyboard and mouse.
6. Your answers shall be updated and saved on a server periodically and also at the end of the examination. The examination will **stop automatically** at the end of **180 minutes**.
7. In each paper a candidate can answer a total of 65 questions carrying 100 marks.
8. The question paper may consist of questions of **multiple choice type** (MCQ) and **numerical answer type**.
9. Multiple choice type questions will have four choices against A, B, C, D, out of which only **ONE** is the correct answer. The candidate has to choose the correct answer by clicking on the bubble (○) placed before the choice.
10. For numerical answer type questions, each question will have a numerical answer and there will not be any choices**. For these questions, the answer should be entered**by using the virtual keyboard that appears on the monitor and the mouse.
11. All questions that are not attempted will result in zero marks. However, wrong answers for multiple choice type questions (MCQ) will result in **NEGATIVE** marks. For all MCQ questions a wrong answer will result in deduction of⅓ marks for a 1-mark question and ⅔ marks for a 2-mark question.
12. There is **NO NEGATIVE MARKING** for questions of **NUMERICAL ANSWER TYPE**.
13. Non-programmable type Calculator is allowed. Charts, graph sheets, and mathematical tables are **NOT** allowed in the Examination Hall. You must use the Scribble pad provided to you at the examination centre for all your rough work. The Scribble Pad has to be returned at the end of the examination.

Declaration by the candidate:

"I have read and understood all the above instructions. I have also read and understood clearly the instructions given on the admit card and shall follow the same. I also understand that in case I am found to violate any of these instructions, my candidature is liable to be cancelled. I also confirm that at the start of the examination all the computer hardware allotted to me are in proper working condition".

Q. 1 – Q. 5 carry one mark each.

Q.1 “India is a country of rich heritage and cultural diversity.”

Which one of the following facts best supports the claim made in the above sentence?

(A) India is a union of 28 states and 7 union territories.
(B) India has a population of over 1.1 billion.
(C) India is home to 22 official languages and thousands of dialects.
(D) The Indian cricket team draws players from over ten states.

Q.2 The value of one U.S. dollar is 65 Indian Rupees today, compared to 60 last year. The Indian Rupee has _____________.

(A) depressed (B) depreciated (C) appreciated (D) stabilized

Q.3 'Advice' is _________________.

(A) a verb (B) a noun (C) an adjective (D) both a verb and a noun

Q.4 The next term in the series 81, 54, 36, 24, … is ________

Q.5 In which of the following options will the expression $P < M$ be definitely true?

(A) $M < R > P > S$ (B) $M > S < P < F$ (C) $Q < M < F = P$ (D) $P = A < R < M$

Q. 6 – Q. 10 carry two marks each.

Q.6 Find the next term in the sequence: 7G, 11K, 13M, __

(A) 15Q (B) 17Q (C) 15P (D) 17P

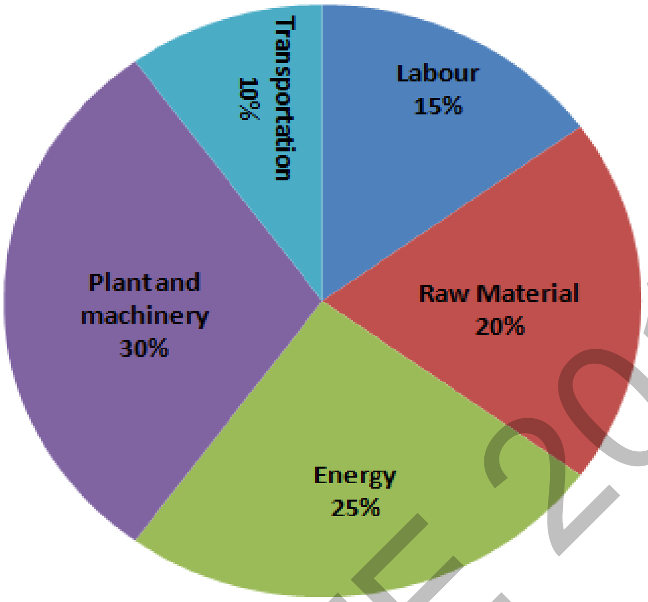
Q.7 The multi-level hierarchical pie chart shows the population of animals in a reserve forest. The correct conclusions from this information are:

(i) Butterflies are birds
(ii) There are more tigers in this forest than red ants
(iii) All reptiles in this forest are either snakes or crocodiles
(iv) Elephants are the largest mammals in this forest

(A) (i) and (ii) only
(B) (i), (ii), (iii) and (iv)
(C) (i), (iii) and (iv) only
(D) (i), (ii) and (iii) only

Q.8 A man can row at 8 km per hour in still water. If it takes him thrice as long to row upstream, as to row downstream, then find the stream velocity in km per hour.

Q.9 A firm producing air purifiers sold 200 units in 2012. The following pie chart presents the share of raw material, labour, energy, plant & machinery, and transportation costs in the total manufacturing cost of the firm in 2012. The expenditure on labour in 2012 is Rs. 4,50,000. In 2013, the raw material expenses increased by 30% and all other expenses increased by 20%. If the company registered a profit of Rs. 10 lakhs in 2012, at what price (in Rs.) was each air purifier sold?



Q.10 A batch of one hundred bulbs is inspected by testing four randomly chosen bulbs. The batch is rejected if even one of the bulbs is defective. A batch typically has five defective bulbs. The probability that the current batch is accepted is ________

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry one mark each.

Q.1 The maximum value of the function $f(x) = ln(1+x) - x$ (where $x > -1$) occurs at $x =$______.

Q.2 Which ONE of the following is a linear non-homogeneous differential equation, where *x* and *y* are the independent and dependent variables respectively?

(A) $\frac{dy}{dx} + xy = e^{-x}$
(B) $\frac{dy}{dx} + xy = 0$
(C) $\frac{dy}{dx} + xy = e^{-y}$
(D) $\frac{dy}{dx} + e^{-y} = 0$

Q.3 Match the application to appropriate numerical method.

Application	Numerical |Method
P1: Numerical integration	M1: Newton-Raphson Method
P2: Solution to a transcendental equation	M2: Runge-Kutta Method
P3: Solution to a system of linear equations	M3: Simpson's 1/3-rule
P4: Solution to a differential equation	M4: Gauss Elimination Method

(A) P1—M3, P2—M2, P3—M4, P4—M1
(B) P1—M3, P2—M1, P3—M4, P4—M2
(C) P1—M4, P2—M1, P3—M3, P4—M2
(D) P1—M2, P2—M1, P3—M3, P4—M4

Q.4 An unbiased coin is tossed an infinite number of times. The probability that the fourth head appears at the tenth toss is

(A) 0.067 (B) 0.073 (C) 0.082 (D) 0.091

Q.5 If $z = xy\ln(xy)$, then

(A) $x\frac{\partial z}{\partial x} + y\frac{\partial z}{\partial y} = 0$ (B) $y\frac{\partial z}{\partial x} = x\frac{\partial z}{\partial y}$

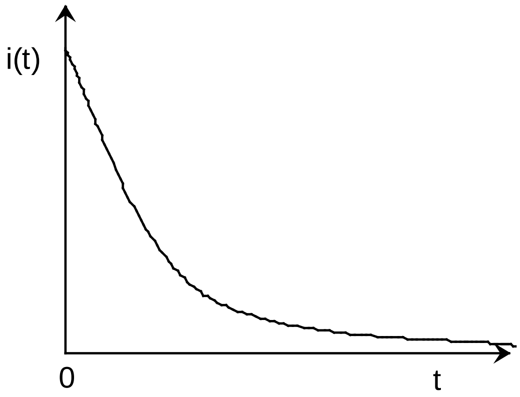
(C) $x\frac{\partial z}{\partial x} = y\frac{\partial z}{\partial y}$ (D) $y\frac{\partial z}{\partial x} + x\frac{\partial z}{\partial y} = 0$

Q.6 A series RC circuit is connected to a DC voltage source at time t = 0. The relation between the source voltage V_S, the resistance R, the capacitance C, and the current $i(t)$ is given below:

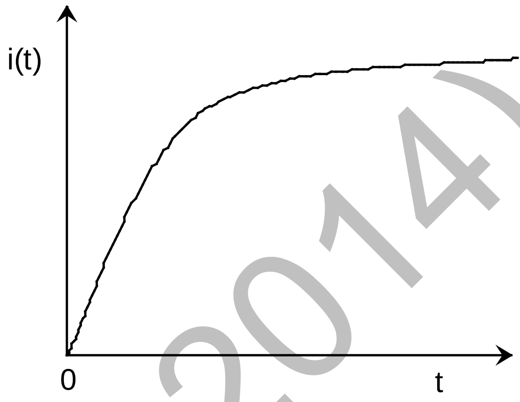
$$V_s = R\, i(t) + \frac{1}{C}\int_o^t i(u)du.$$

Which one of the following represents the current $i(t)$?

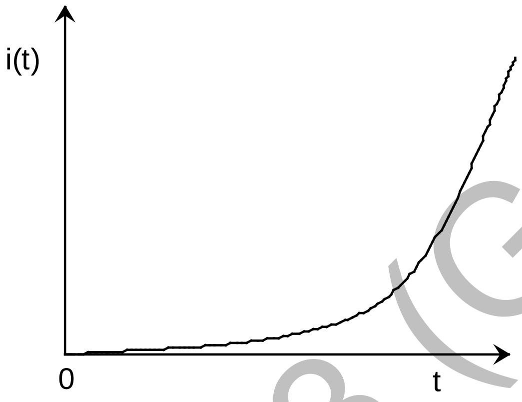
(A)



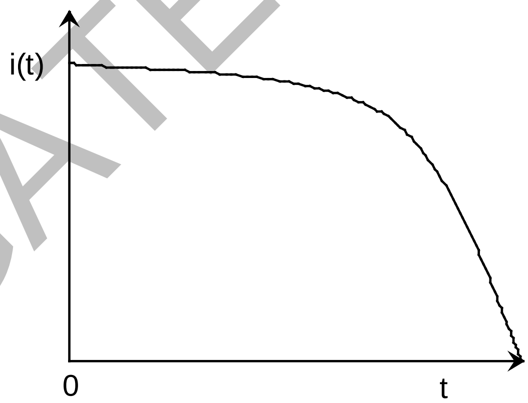
(B)



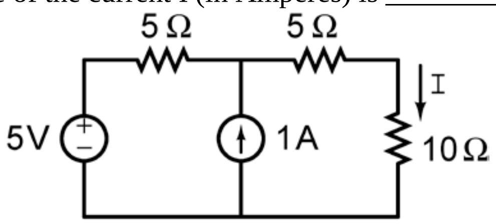
(C)



(D)



Q.7 In the figure shown, the value of the current I (in Amperes) is __________.



Q.8 In MOSFET fabrication, the channel length is defined during the process of

(A) isolation oxide growth
(B) channel stop implantation
(C) poly-silicon gate patterning
(D) lithography step leading to the contact pads

Q.9 A thin P-type silicon sample is uniformly illuminated with light which generates excess carriers. The recombination rate is directly proportional to

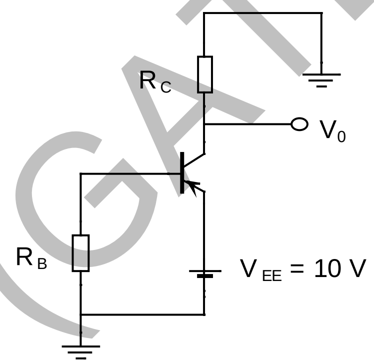
(A) the minority carrier mobility
(B) the minority carrier recombination lifetime
(C) the majority carrier concentration
(D) the excess minority carrier concentration

Q.10 At T = 300 K, the hole mobility of a semiconductor $\mu_p = 500$ cm^2/V-s and $\frac{kT}{q} = 26$ mV. The hole diffusion constant D_p in cm^2/s is ________

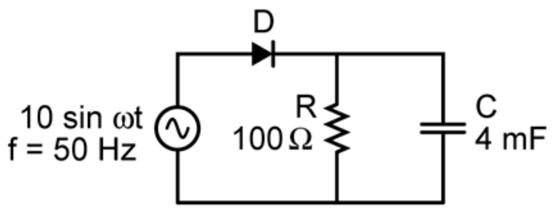
Q.11 The desirable characteristics of a transconductance amplifier are

(A) high input resistance and high output resistance
(B) high input resistance and low output resistance
(C) low input resistance and high output resistance
(D) low input resistance and low output resistance

Q.12 In the circuit shown, the PNP transistor has $|V_{BE}| = 0.7$ V and β = 50. Assume that $R_B = 100\ k\Omega$. For V_0 to be 5 V, the value of R_C (in $k\Omega$) is _______

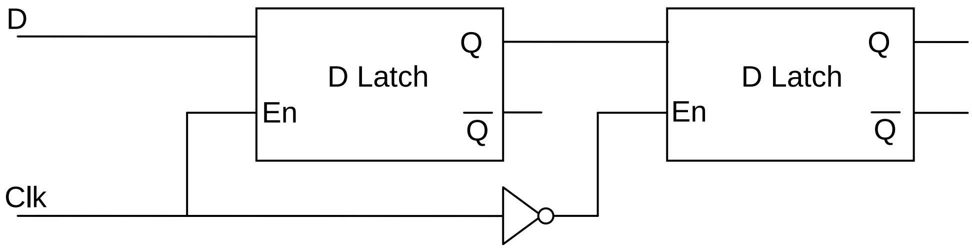


Q.13 The figure shows a half-wave rectifier. The diode D is ideal. The average steady-state current (in Amperes) through the diode is approximately ____________.



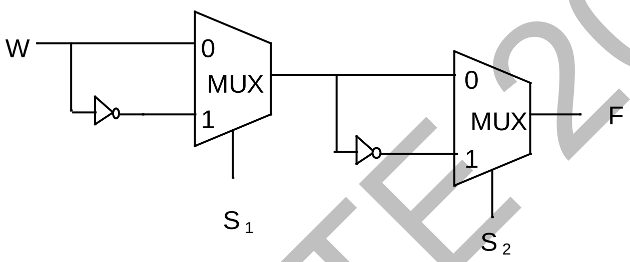
Q.14 An analog voltage in the range 0 to 8 V is divided in 16 equal intervals for conversion to 4-bit digital output. The maximum quantization error (in V) is _________

Q.15 The circuit shown in the figure is a



(A) Toggle Flip Flop
(B) JK Flip Flop
(C) SR Latch
(D) Master-Slave D Flip Flop

Q.16 Consider the multiplexer based logic circuit shown in the figure.



Which one of the following Boolean functions is realized by the circuit?

(A) $F = W\overline{S_1}\,\overline{S_2}$
(B) $F = WS_1 + WS_2 + S_1S_2$
(C) $F = \overline{W} + S_1 + S_2$
(D) $F = W \oplus S_1 \oplus S_2$

Q.17 Let $x(t) = \cos(10\pi t) + \cos(30\pi t)$ be sampled at 20 Hz and reconstructed using an ideal low-pass filter with cut-off frequency of 20 Hz. The frequency/frequencies present in the reconstructed signal is/are

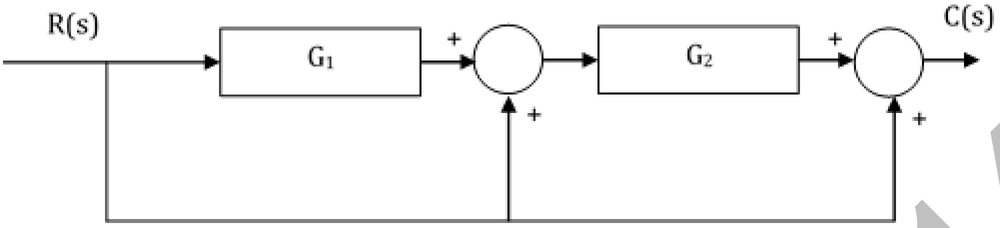
(A) 5 Hz and 15 Hz only
(B) 10 Hz and 15 Hz only
(C) 5 Hz, 10 Hz and 15 Hz only
(D) 5 Hz only

Q.18 For an all-pass system $H(z) = \frac{(z^{-1} - b)}{(1 - az^{-1})}$, where $\left|H(e^{-j\omega})\right| = 1$, for all ω.
If $\text{Re}(a) \neq 0,\ \text{Im}(a) \neq 0,$ then b equals

(A) a
(B) a^*
(C) $1/a^*$
(D) $1/a$

Q.19 A modulated signal is $y(t) = m(t)\cos(40000\pi t)$, where the baseband signal $m(t)$ has frequency components less than 5 kHz only. The minimum required rate (in kHz) at which $y(t)$ should be sampled to recover $m(t)$ is _______.

Q.20 Consider the following block diagram in the figure.



The transfer function $\frac{C(s)}{R(s)}$ is

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

Q.21 The input $-3e^{2t}u(t)$, where $u(t)$ is the unit step function, is applied to a system with transfer function $\frac{s-2}{s+3}$. If the initial value of the output is -2, then the value of the output at steady state is _______.

Q.22 The phase response of a passband waveform at the receiver is given by

$$\varphi(f) = -2\pi\alpha(f - f_c) - 2\pi\beta f_c$$

where f_c is the centre frequency, and α and β are positive constants. The actual signal propagation delay from the transmitter to receiver is

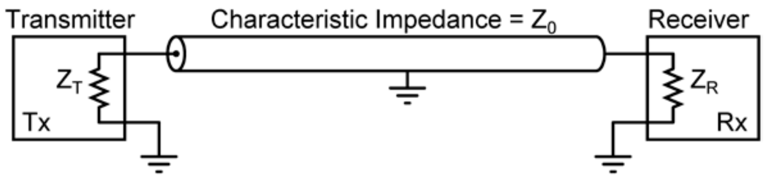
(A) $\frac{\alpha-\beta}{\alpha+\beta}$ (B) $\frac{\alpha\beta}{\alpha+\beta}$ (C) α (D) β

Q.23 Consider an FM signal $f(t) = \cos[2\pi f_c t + \beta_1 \sin 2\pi f_1 t + \beta_2 \sin 2\pi f_2 t]$. The maximum deviation of the instantaneous frequency from the carrier frequency f_c is

(A) $\beta_1 f_1 + \beta_2 f_2$ (B) $\beta_1 f_2 + \beta_2 f_1$
(C) $\beta_1 + \beta_2$ (D) $f_1 + f_2$

Q.24 Consider an air filled rectangular waveguide with a cross-section of 5 cm × 3 cm. For this waveguide, the cut-off frequency (in MHz) of TE_{21} mode is _________.

Q.25 In the following figure, the transmitter Tx sends a wideband modulated RF signal via a coaxial cable to the receiver Rx. The output impedance Z_T of Tx, the characteristic impedance Z_0 of the cable and the input impedance Z_R of Rx are all real.



Which one of the following statements is **TRUE** about the distortion of the received signal due to impedance mismatch?

(A) The signal gets distorted if $Z_R \neq Z_0$, irrespective of the value of Z_T
(B) The signal gets distorted if $Z_T \neq Z_0$, irrespective of the value of Z_R
(C) Signal distortion implies impedance mismatch at both ends: $Z_T \neq Z_0$ and $Z_R \neq Z_0$
(D) Impedance mismatches do NOT result in signal distortion but reduce power transfer efficiency

Q. 26 – Q. 55 carry two marks each.

Q.26 The maximum value of $f(x) = 2x^3 - 9x^2 + 12x - 3$ in the interval $0 \leq x \leq 3$ is _______.

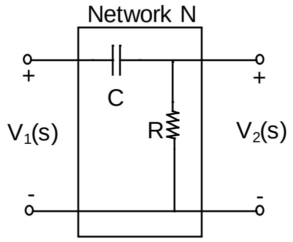
Q.27 Which one of the following statements is NOT true for a square matrix A?

(A) If A is upper triangular, the eigenvalues of A are the diagonal elements of it
(B) If A is real symmetric, the eigenvalues of A are always real and positive
(C) If A is real, the eigenvalues of A and A^T are always the same
(D) If all the principal minors of A are positive, all the eigenvalues of A are also positive

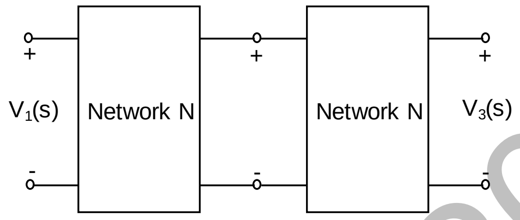
Q.28 A fair coin is tossed repeatedly till both head and tail appear at least once. The average number of tosses required is ______ .

Q.29 Let X_1, X_2, and X_3 be independent and identically distributed random variables with the uniform distribution on [0, 1]. The probability $P\{X_1 + X_2 \leq X_3\}$ is ________.

Q.30 Consider the building block called 'Network N' shown in the figure.
Let C = 100 μF and R = 10 kΩ.



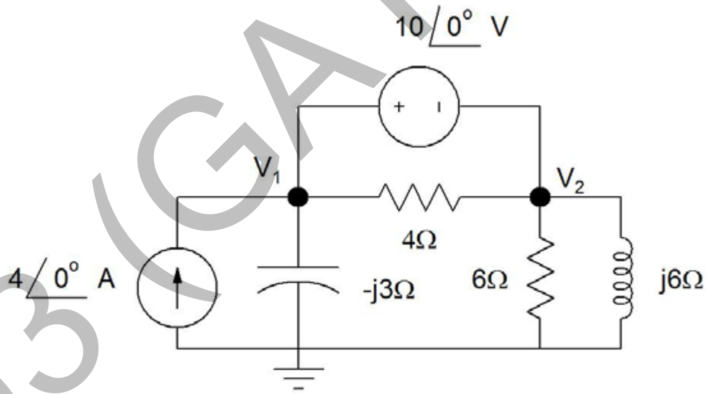
Two such blocks are connected in cascade, as shown in the figure.



The transfer function $\frac{V_3(s)}{V_1(s)}$ of the cascaded network is

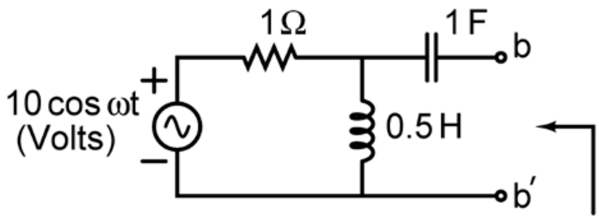
(A) $\frac{s}{1+s}$ (B) $\frac{s^2}{1+3s+s^2}$ (C) $\left(\frac{s}{1+s}\right)^2$ (D) $\frac{s}{2+s}$

Q.31 In the circuit shown in the figure, the value of node voltage V_2 is

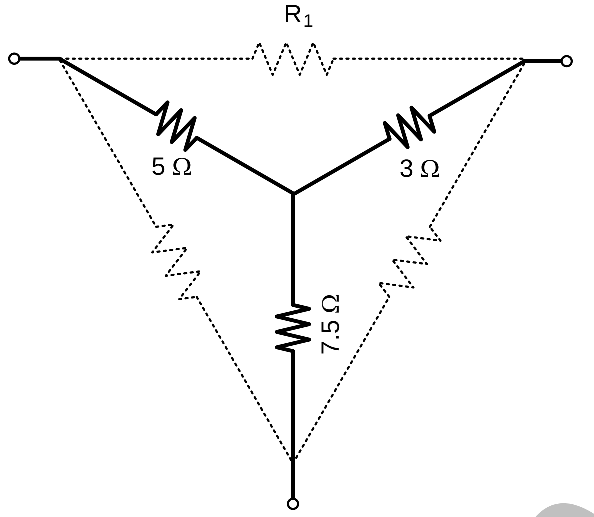


(A) 22 + j 2 V (B) 2 + j 22 V (C) 22 – j 2 V (D) 2 – j 22 V

Q.32 In the circuit shown in the figure, the angular frequency ω (in rad/s), at which the Norton equivalent impedance as seen from terminals b-b′ is purely resistive, is _________.



Q.33 For the Y-network shown in the figure, the value of R_1 (in Ω) in the equivalent Δ-network is ____.



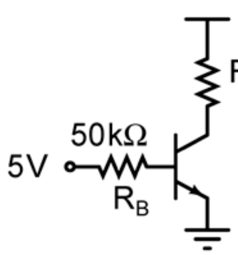
Q.34 The donor and accepter impurities in an abrupt junction silicon diode are 1 x 10^{16} cm^{-3} and 5 x 10^{18} cm^{-3}, respectively. Assume that the intrinsic carrier concentration in silicon n_i = 1.5 x 10^{10} cm^{-3} at 300 K, $\frac{kT}{q}$ = 26 mV and the permittivity of silicon $\epsilon_{si} = 1.04 \times 10^{-12}$F/cm. The built-in potential and the depletion width of the diode under thermal equilibrium conditions, respectively, are

(A) 0.7 V and 1 x 10^{-4} cm
(B) 0.86 V and 1 x 10^{-4} cm
(C) 0.7 V and 3.3 x 10^{-5} cm
(D) 0.86 V and 3.3 x 10^{-5} cm

Q.35 The slope of the I_D vs. V_{GS} curve of an n-channel MOSFET in linear regime is $10^{-3}\Omega^{-1}$ at $V_{DS} = 0.1$ V. For the same device, neglecting channel length modulation, the slope of the $\sqrt{I_D}$ vs. V_{GS} curve (in $\sqrt{\text{A}}$/V) under saturation regime is approximately _________.

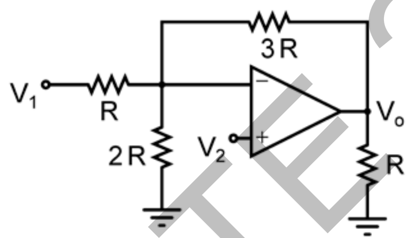
Q.36 An ideal MOS capacitor has boron doping-concentration of 10^{15} cm^{-3} in the substrate. When a gate voltage is applied, a depletion region of width 0.5 μm is formed with a surface (channel) potential of 0.2 V. Given that $\varepsilon_0 = 8.854 \times 10^{-14}$ F/cm and the relative permittivities of silicon and silicon dioxide are 12 and 4, respectively, the peak electric field (in V/μm) in the oxide region is _____________.

Q.37 In the circuit shown, the silicon BJT has $\beta = 50$. Assume $V_{BE} = 0.7$ V and $V_{CE(sat)} = 0.2$ V. Which one of the following statements is correct?



(A) For $R_C = 1$ kΩ, the BJT operates in the saturation region
(B) For $R_C = 3$ kΩ, the BJT operates in the saturation region
(C) For $R_C = 20$ kΩ, the BJT operates in the cut-off region
(D) For $R_C = 20$ kΩ, the BJT operates in the linear region

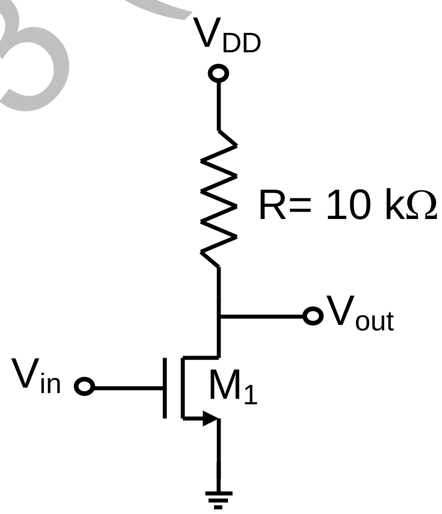
Q.38 Assuming that the Op-amp in the circuit shown is ideal, V_o is given by



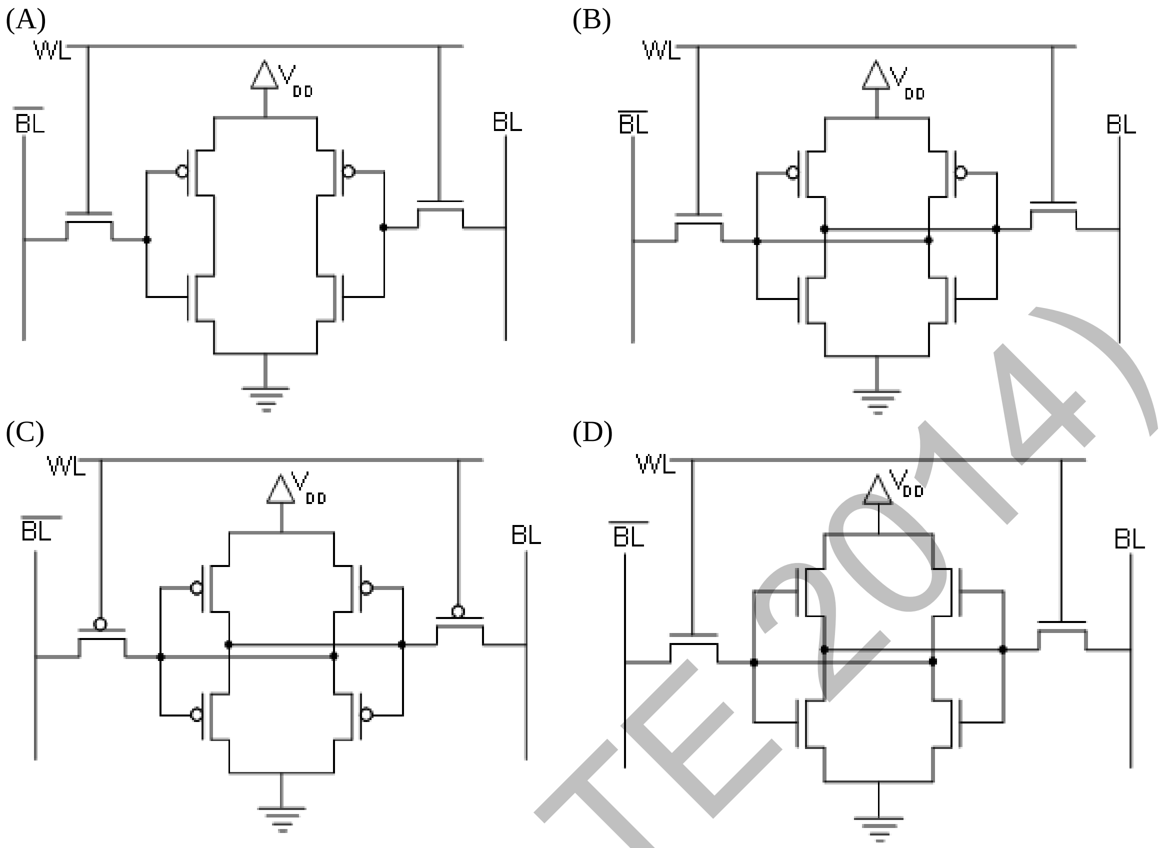
(A) $\frac{5}{2}V_1 - 3V_2$ (B) $2V_1 - \frac{5}{2}V_2$

(C) $-\frac{3}{2}V_1 + \frac{7}{2}V_2$ (D) $-3V_1 + \frac{11}{2}V_2$

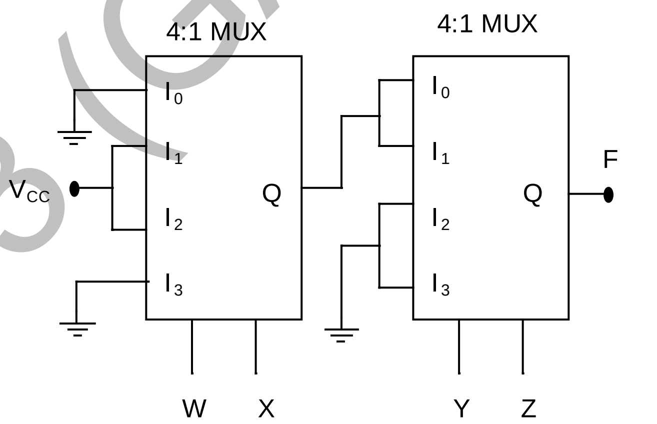
Q.39 For the MOSFET M_1 shown in the figure, assume W/L = 2, $V_{DD} = 2.0$ V, $\mu_n C_{ox} = 100\ \mu A/V^2$ and $V_{TH} = 0.5$ V. The transistor M_1 switches from saturation region to linear region when V_{in} (in Volts) is__________.



Q.40 If WL is the Word Line and BL the Bit Line, an SRAM cell is shown in



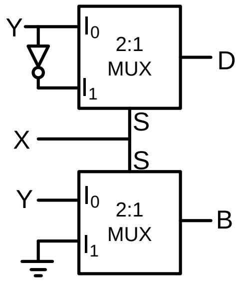
Q.41 In the circuit shown, W and Y are MSBs of the control inputs. The output F is given by



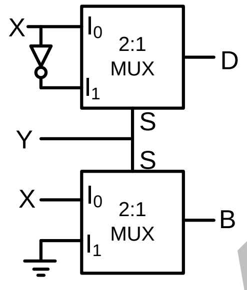
(A) $F = W\bar{X} + \bar{W}X + \bar{Y}\bar{Z}$
(B) $F = W\bar{X} + \bar{W}X + \bar{Y}Z$
(C) $F = W\bar{X}\bar{Y} + \bar{W}X\bar{Y}$
(D) $F = (\bar{W} + \bar{X})\bar{Y}\bar{Z}$

Q.42 If **X** and **Y** are inputs and the Difference (**D = X – Y**) and the Borrow (**B**) are the outputs, which one of the following diagrams implements a half-subtractor?

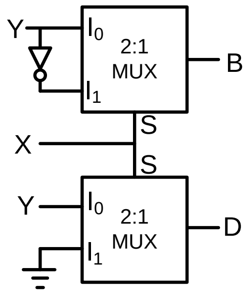
(A)



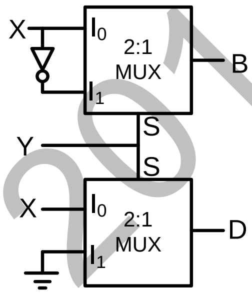
(B)



(C)



(D)



Q.43 Let $H_1(z) = (1 - pz^{-1})^{-1}, H_2(z) = (1 - qz^{-1})^{-1}, H(z) = H_1(z) + r\, H_2(z)$. The quantities p, q, r are real numbers. Consider $p = \frac{1}{2}, q = -\frac{1}{4}, |r| < 1$. If the zero of $H(z)$ lies on the unit circle, then $r =$ ________

Q.44 Let $h(t)$ denote the impulse response of a causal system with transfer function $\frac{1}{s+1}$. Consider the following three statements.

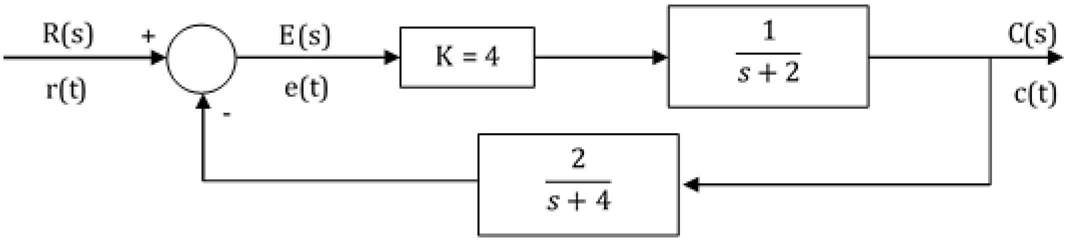
S1: The system is stable.
S2: $\frac{h\,(t+1)}{h(t)}$ is independent of t for $t > 0$.
S3: A non-causal system with the same transfer function is stable.

For the above system,

(A) only S1 and S2 are true
(B) only S2 and S3 are true
(C) only S1 and S3 are true
(D) S1, S2 and S3 are true

Q.45 The z-transform of the sequence $x[n]$ is given by $X(z) = \frac{1}{(1-2\,z^{-1})^2}$, with the region of convergence $|z| > 2$. Then, $x[2]$ is ________.

Q.46 The steady state error of the system shown in the figure for a unit step input is _______.



Q.47 The state equation of a second-order linear system is given by

$$\dot{\boldsymbol{x}}(t) = A\boldsymbol{x}(t), \quad \boldsymbol{x}(0) = \boldsymbol{x}_0$$

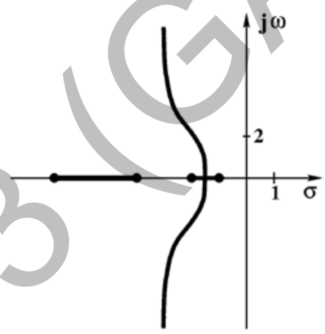
For $\boldsymbol{x}_0 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$, $\boldsymbol{x}(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$ and for $\boldsymbol{x}_0 = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, $\boldsymbol{x}(t) = \begin{bmatrix} e^{-t} - e^{-2t} \\ -e^{-t} + 2e^{-2t} \end{bmatrix}$.

When $\boldsymbol{x}_0 = \begin{bmatrix} 3 \\ 5 \end{bmatrix}$, $\boldsymbol{x}(t)$ is

(A) $\begin{bmatrix} -8e^{-t} + 11e^{-2t} \\ 8e^{-t} - 22e^{-2t} \end{bmatrix}$ (B) $\begin{bmatrix} 11e^{-t} - 8e^{-2t} \\ -11e^{-t} + 16e^{-2t} \end{bmatrix}$

(C) $\begin{bmatrix} 3e^{-t} - 5e^{-2t} \\ -3e^{-t} + 10e^{-2t} \end{bmatrix}$ (D) $\begin{bmatrix} 5e^{-t} - 3e^{-2t} \\ -5e^{-t} + 6e^{-2t} \end{bmatrix}$

Q.48 In the root locus plot shown in the figure, the pole/zero marks and the arrows have been removed. Which one of the following transfer functions has this root locus?



(A) $\frac{s+1}{(s+2)(s+4)(s+7)}$ (B) $\frac{s+4}{(s+1)(s+2)(s+7)}$

(C) $\frac{s+7}{(s+1)(s+2)(s+4)}$ (D) $\frac{(s+1)(s+2)}{(s+7)(s+4)}$

Q.49 Let $X(t)$ be a wide sense stationary (WSS) random process with power spectral density $S_X(f)$. If $Y(t)$ is the process defined as $Y(t) = X(2t-1)$, the power spectral density $S_Y(f)$ is

(A) $S_Y(f) = \frac{1}{2} S_X\left(\frac{f}{2}\right) e^{-j\pi f}$ (B) $S_Y(f) = \frac{1}{2} S_X\left(\frac{f}{2}\right) e^{-j\pi f/2}$

(C) $S_Y(f) = \frac{1}{2} S_X\left(\frac{f}{2}\right)$ (D) $S_Y(f) = \frac{1}{2} S_X\left(\frac{f}{2}\right) e^{-j2\pi f}$

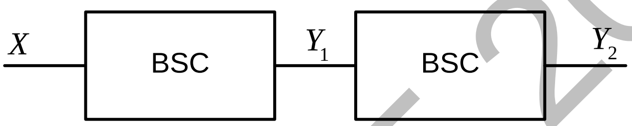
Q.50 A real band-limited random process $X(t)$ has two-sided power spectral density

$$S_X(f) = \begin{cases} 10^{-6}\,(3000 - |f|)\ \text{Watts/Hz} & \text{for } |f| \le 3\ \text{kHz} \\ 0 & \text{otherwise} \end{cases}$$

where f is the frequency expressed in Hz. The signal $X(t)$ modulates a carrier $\cos 16000\,\pi t$ and the resultant signal is passed through an ideal band-pass filter of unity gain with centre frequency of 8 kHz and band-width of 2 kHz. The output power (in Watts) is _______.

Q.51 In a PCM system, the signal $m(t) = \{\sin(100\pi t) + \cos(100\pi t)\}$ V is sampled at the Nyquist rate. The samples are processed by a uniform quantizer with step size 0.75 V. The minimum data rate of the PCM system in bits per second is _____.

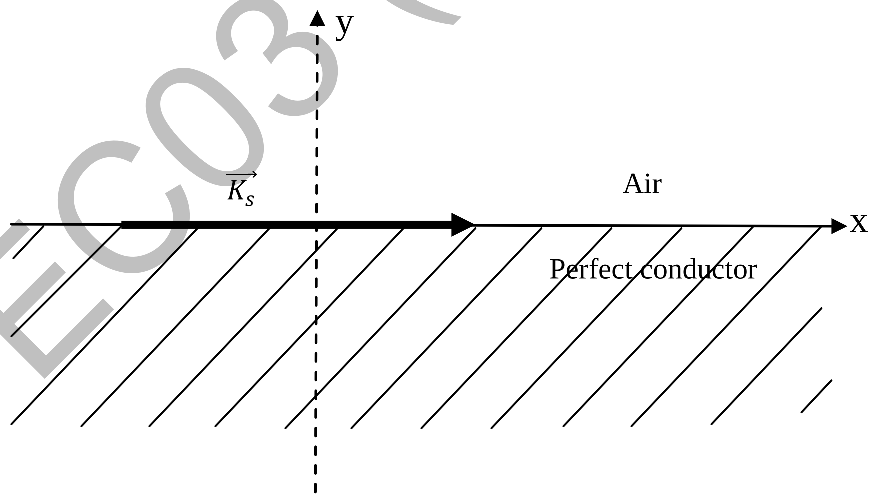
Q.52 A binary random variable X takes the value of 1 with probability $1/3$. X is input to a cascade of 2 independent identical binary symmetric channels (BSCs) each with crossover probability $1/2$. The output of BSCs are the random variables Y_1 and Y_2 as shown in the figure.



The value of $H(Y_1) + H(Y_2)$ in bits is _____.

Q.53 Given the vector $\boldsymbol{A} = (\cos x)(\sin y)\hat{a}_x + (\sin x)(\cos y)\hat{a}_y$, where $\hat{a}_x$, $\hat{a}_y$ denote unit vectors along x,y directions, respectively. The magnitude of curl of $\boldsymbol{A}$ is ________

Q.54 A region shown below contains a perfect conducting half-space and air. The surface current $\vec{K_s}$ on the surface of the perfect conductor is $\vec{K_s} = \hat{x}2$ amperes per meter. The tangential $\vec{H}$ field in the air just above the perfect conductor is



(A) $(\hat{x} + \hat{z})2$ amperes per meter
(B) $\hat{x}2$ amperes per meter
(C) $-\hat{z}2$ amperes per meter
(D) $\hat{z}2$ amperes per meter

Q.55 Assume that a plane wave in air with an electric field $\vec{E} = 10\cos\left(\omega t - 3x - \sqrt{3}z\right)\hat{a}_y$ V/m is incident on a non-magnetic dielectric slab of relative permittivity 3 which covers the region $z > 0$. The angle of transmission in the dielectric slab is ________ degrees.

END OF THE QUESTION PAPER

GATE 2014

Answer Keys for EC - Electronics and Communication Engineering

Section	Q. No.	SESSION - 0	
		Key / Range	Marks
GA	1	C	1
GA	2	B	1
GA	3	B	1
GA	4	16 to 16	1
GA	5	D	1
GA	6	B	2
GA	7	D	2
GA	8	4 to 4	2
GA	9	20000 to 20000	2
GA	10	0.80 to 0.82	2
EC	1	-0.01 to 0.01	1
EC	2	A	1
EC	3	B	1
EC	4	C	1
EC	5	C	1
EC	6	A	1
EC	7	0.49 to 0.51	1
EC	8	C	1
EC	9	D	1
EC	10	12.9 to 13.1	1
EC	11	A	1
EC	12	1.04 to 1.12	1
EC	13	0.08 to 0.12	1
EC	14	0.24 to 0.26	1
EC	15	D	1
EC	16	D	1
EC	17	A	1
EC	18	B	1
EC	19	9.5 to 10.5	1
EC	20	C	1
EC	21	-0.01 to 0.01	1
EC	22	C	1
EC	23	A	1

Section	Q. No.	SESSION - 0	
		Key / Range	Marks
EC	24	7750 to 7850	1
EC	25	C	1
EC	26	5.9 to 6.1	2
EC	27	B	2
EC	28	2.9 to 3.1	2
EC	29	0.15 to 0.18	2
EC	30	B	2
EC	31	D	2
EC	32	1.9 to 2.1	2
EC	33	9 to 11	2
EC	34	D	2
EC	35	0.06 to 0.08	2
EC	36	2.3 to 2.5	2
EC	37	B	2
EC	38	D	2
EC	39	1.4 to 1.6	2
EC	40	B	2
EC	41	C	2
EC	42	A	2
EC	43	-0.6 to -0.4	2
EC	44	A	2
EC	45	11.9 to 12.1	2
EC	46	0.49 to 0.51	2
EC	47	B	2
EC	48	B	2
EC	49	C	2
EC	50	2.4 to 2.6	2
EC	51	199 to 201	2
EC	52	1.9 to 2.1	2
EC	53	-0.01 to 0.01	2
EC	54	D	2
EC	55	29 to 31	2

SESSION - 4

GATE 2014: General Instructions during Examination

1. Total duration of the GATE examination is **180** minutes.
2. The clock will be set at the server. The countdown timer at the top right corner of screen will display the remaining time available for you to complete the examination. When the timer reaches zero, the examination will end by itself. You need not terminate the examination or submit your paper.
3. Any useful data required for your paper can be viewed by clicking on the **Useful Common Data** button that appears on the screen.
4. Use the scribble pad provided to you for any rough work. Submit the scribble pad at the end of the examination.
5. You are allowed to use a non-programmable type calculator, however, sharing of calculators is not allowed.
6. The Question Palette displayed on the right side of screen will show the status of each question using one of the following symbols:

You have not visited the question yet.

You have not answered the question.

You have answered the question.

You have NOT answered the question, but have marked the question for review.

You have answered the question, but marked it for review.

The **Marked for Review** status for a question simply indicates that you would like to look at that question again. *If a question is answered, but marked for review, then the answer will be considered for evaluation unless the status is modified by the candidate.*

<u>Navigating to a Question :</u>

7. To answer a question, do the following:
    a. Click on the question number in the Question Palette to go to that question directly.
    b. Select an answer for a multiple choice type question by clicking on the bubble placed before the 4 choices, namely A, B, C and D. Use the virtual numeric keypad to enter a number as answer for a numerical type question.
    c. Click on **Save & Next** to save your answer for the current question and then go to the next question.
    d. Click on **Mark for Review & Next** to save your answer for the current question and also mark it for review, and then go to the next question.

Caution: Note that your answer for the current question will not be saved, if you navigate to another question directly by clicking on a question number without saving the answer to the previous question.

You can view all the questions by clicking on the **Question Paper** button. This feature is provided, so that if you want you can just see the entire question paper at a glance.

Answering a Question :

8. Procedure for answering a multiple choice (MCQ) type question:
   a. Choose one answer from the 4 options (A,B,C,D) given below the question, click on the bubble placed before the chosen option.
   b. To deselect your chosen answer, click on the bubble of the chosen option again or click on the **Clear Response** button.
   c. To change your chosen answer, click on the bubble of another option.
   d. To save your answer, you MUST click on the **Save & Next** button.

9. Procedure for answering a numerical answer type question:
   a. To enter a number as your answer, use the virtual numerical keypad.
   b. A fraction (e.g. -0.3 or -.3) can be entered as an answer with or without '0' before the decimal point. As many as four decimal points, e.g. 12.5435 or 0.003 or -932.6711 or 12.82 can be entered.
   c. To clear your answer, click on the **Clear Response** button.
   d. To save your answer, you MUST click on the **Save & Next** button
10. To mark a question for review, click on the **Mark for Review & Next** button. *If an answer is selected (for MCQ) or entered (for numerical answer type) for a question that is* **Marked for Review***, that answer will be considered in the evaluation unless the status is modified by the candidate.*

11. To change your answer to a question that has already been answered, first select that question for answering and then follow the procedure for answering that type of question.
12. Note that ONLY Questions for which answers are ***saved*** or ***marked for review after answering*** will be considered for evaluation.

Choosing a Section :

13. Sections in this question paper are displayed on the top bar of the screen. Questions in a Section can be viewed by clicking on the name of that Section. The Section you are currently viewing will be highlighted.
14. A checkbox is displayed for every optional Section, if any, in the Question Paper. To select the optional Section for answering, click on the checkbox for that Section.
15. If the checkbox for an optional Section is not selected, the **Save & Next** button and the **Mark for Review & Next** button will NOT be enabled for that Section. You will

only be able to see questions in this Section, but you will not be able to answer questions in the Section.

16. After clicking the **Save & Next** button for the last question in a Section, you will automatically be taken to the first question of the next Section in sequence.
17. You can move the mouse cursor over the name of a Section to view the answering status for that Section.

Changing the Optional Section :

18. After answering the chosen optional Section, partially or completely, you can change the optional Section by selecting the checkbox for a new Section that you want to attempt. A warning message will appear along with a table showing the number of questions answered in each of the previously chosen optional Sections and a checkbox against each of these Sections. Click on a checkbox against a Section that you want to reset and then click on the **RESET** button. Note that RESETTING a Section will DELETE all the answers for questions in that Section. Hence, if you think that you may want to select this Section again later, you will have to note down your answers for questions in that Section. If you do not want to reset the Section and want to continue answering the previously chosen optional Section, then click on the **BACK** button.

19. If you deselect the checkbox for an optional Section in the top bar, the following warning message will appear: "Deselecting the checkbox will DELETE all the answers for questions in this Section. Do you want to deselect this Section?" If you want to deselect, click on the **RESET** button. If you do not want to deselect, click on the **BACK** button.

20. You can shuffle between different Sections or change the optional Sections any number of times.

GATE 2014 Examination

EC: Electronics & Communications Engineering

Duration: **180 minutes** *Maximum Marks*: **100**

Read the following instructions carefully.

1. To login, enter your Registration Number and password provided to you. Kindly go through the various symbols used in the test and understand their meaning before you start the examination.
2. Once you login and after the start of the examination, you can view all the questions in the question paper, by clicking on the **View All Questions** button in the screen.
3. This question paper consists of **2 sections**, General Aptitude (GA) for **15 marks** and the subject specific GATE paper for **85 marks**. Both these sections are compulsory.
   The GA section consists of **10** questions. Question numbers 1 to 5 are of 1-mark each, while question numbers 6 to 10 are of 2-mark each.
   The subject specific GATE paper section consists of **55** questions, out of which question numbers 1 to 25 are of 1-mark each, while question numbers 26 to 55 are of 2-mark each.
4. Depending upon the GATE paper, there may be useful common data that may be required for answering the questions. If the paper has such useful data, the same can be viewed by clicking on the **Useful Common Data** button that appears at the top, right hand side of the screen.
5. The computer allotted to you at the examination center runs specialized software that permits only one answer to be selected for multiple-choice questions using a mouse and to enter a suitable number for the numerical answer type questions using the virtual keyboard and mouse.
6. Your answers shall be updated and saved on a server periodically and also at the end of the examination. The examination will **stop automatically** at the end of **180 minutes**.
7. In each paper a candidate can answer a total of 65 questions carrying 100 marks.
8. The question paper may consist of questions of **multiple choice type** (MCQ) and **numerical answer type**.
9. Multiple choice type questions will have four choices against A, B, C, D, out of which only **ONE** is the correct answer. The candidate has to choose the correct answer by clicking on the bubble (○) placed before the choice.
10. For numerical answer type questions, each question will have a numerical answer and there will not be any choices**. For these questions, the answer should be entered**by using the virtual keyboard that appears on the monitor and the mouse.
11. All questions that are not attempted will result in zero marks. However, wrong answers for multiple choice type questions (MCQ) will result in **NEGATIVE** marks. For all MCQ questions a wrong answer will result in deduction of⅓ marks for a 1-mark question and ⅔ marks for a 2-mark question.
12. There is **NO NEGATIVE MARKING** for questions of **NUMERICAL ANSWER TYPE**.
13. Non-programmable type Calculator is allowed. Charts, graph sheets, and mathematical tables are **NOT** allowed in the Examination Hall. You must use the Scribble pad provided to you at the examination centre for all your rough work. The Scribble Pad has to be returned at the end of the examination.

Declaration by the candidate:

"I have read and understood all the above instructions. I have also read and understood clearly the instructions given on the admit card and shall follow the same. I also understand that in case I am found to violate any of these instructions, my candidature is liable to be cancelled. I also confirm that at the start of the examination all the computer hardware allotted to me are in proper working condition".

Q. 1 – Q. 5 carry one mark each.

Q.1 Which of the following options is the closest in meaning to the word underlined in the sentence below?

In a democracy, everybody has the freedom to disagree with the government.

(A) dissent (B) descent (C) decent (D) decadent

Q.2 After the discussion, Tom said to me, 'Please revert!'. He expects me to _________.

(A) retract (B) get back to him (C) move in reverse (D) retreat

Q.3 While receiving the award, the scientist said, "I feel vindicated". Which of the following is closest in meaning to the word 'vindicated'?

(A) punished (B) substantiated (C) appreciated (D) chastened

Q.4 Let $f(x,y) = x^n y^m = P$. If x is doubled and y is halved, the new value of f is

(A) $2^{n-m}P$ (B) $2^{m-n}P$ (C) $2(n-m)P$ (D) $2(m-n)P$

Q.5 In a sequence of 12 consecutive odd numbers, the sum of the first 5 numbers is 425. What is the sum of the last 5 numbers in the sequence?

Q. 6 – Q. 10 carry two marks each.

Q.6 Find the next term in the sequence: 13M, 17Q, 19S, __

(A) 21W (B) 21V (C) 23W (D) 23V

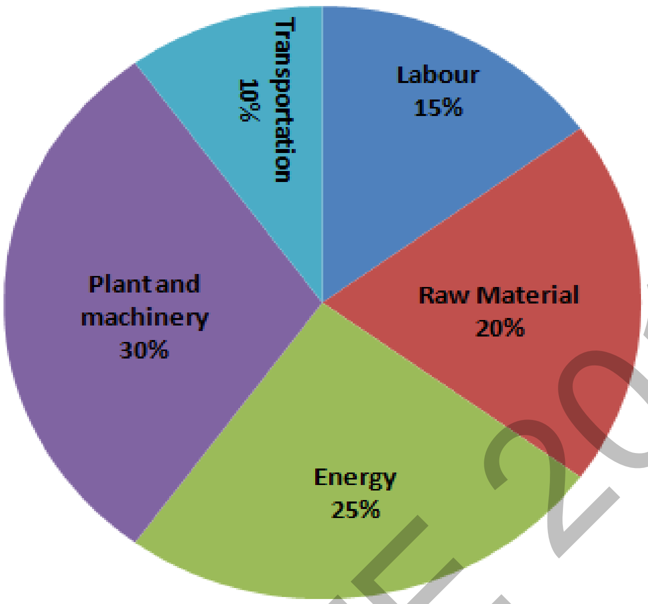
Q.7 If 'KCLFTSB' stands for 'best of luck' and 'SHSWDG' stands for 'good wishes', which of the following indicates 'ace the exam'?

(A) MCHTX (B) MXHTC (C) XMHCT (D) XMHTC

Q.8 Industrial consumption of power doubled from 2000-2001 to 2010-2011. Find the annual rate of increase in percent assuming it to be uniform over the years.

(A) 5.6 (B) 7.2 (C) 10.0 (D) 12.2

Q.9 A firm producing air purifiers sold 200 units in 2012. The following pie chart presents the share of raw material, labour, energy, plant & machinery, and transportation costs in the total manufacturing cost of the firm in 2012. The expenditure on labour in 2012 is Rs. 4,50,000. In 2013, the raw material expenses increased by 30% and all other expenses increased by 20%. What is the percentage increase in total cost for the company in 2013?



Q.10 A five digit number is formed using the digits 1,3,5,7 and 9 without repeating any of them. What is the sum of all such possible five digit numbers?

(A) 6666660 (B) 6666600 (C) 6666666 (D) 6666606

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry one mark each.

Q.1 The series $\sum_{n=0}^{\infty}\frac{1}{n!}$ converges to

(A) $2\ \ln 2$ (B) $\sqrt{2}$ (C) 2 (D) e

Q.2 The magnitude of the gradient for the function $f(x,y,z) = x^2 + 3y^2 + z^3$ at the point (1,1,1) is _________.

Q.3 Let X be a zero mean unit variance Gaussian random variable. $E[|X|]$ is equal to _____

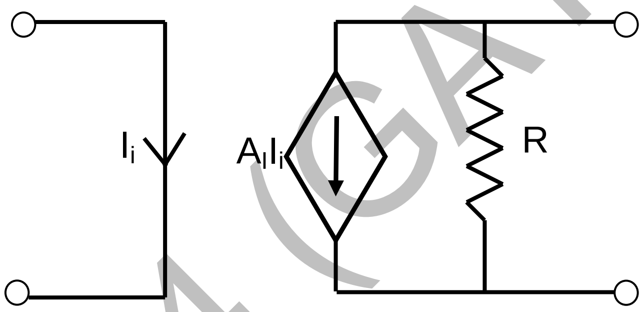
Q.4 If a and b are constants, the most general solution of the differential equation

$$\frac{d^2x}{dt^2} + 2\frac{dx}{dt} + x = 0 \quad \text{is}$$

(A) ae^{-t} (B) $ae^{-t} + bte^{-t}$ (C) $ae^{t} + bte^{-t}$ (D) ae^{-2t}

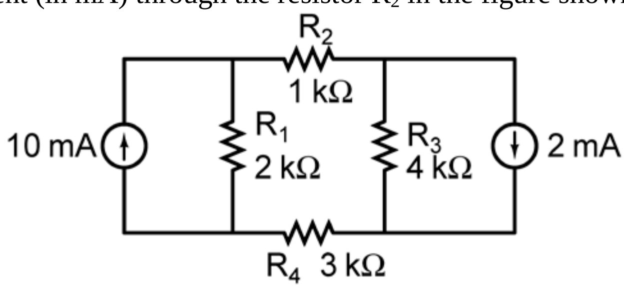
Q.5 The directional derivative of $f(x,y) = \frac{xy}{\sqrt{2}}(x+y)$ at (1, 1) in the direction of the unit vector at an angle of $\frac{\pi}{4}$ with y-axis, is given by ______ .

Q.6 The circuit shown in the figure represents a



(A) voltage controlled voltage source
(B) voltage controlled current source
(C) current controlled current source
(D) current controlled voltage source

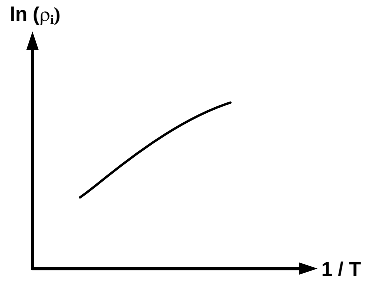
Q.7 The magnitude of current (in mA) through the resistor R_2 in the figure shown is_______.



Q.8 At T = 300 K, the band gap and the intrinsic carrier concentration of GaAs are 1.42 eV and 10^6 cm^{-3}, respectively. In order to generate electron hole pairs in GaAs, which one of the wavelength (λ_C) ranges of incident radiation, is most suitable? (Given that: Plank's constant is 6.62×10^{-34} J-s, velocity of light is 3×10^{10} cm/s and charge of electron is 1.6×10^{-19} C)

(A) 0.42 μm < λ_C < 0.87 μm
(B) 0.87 μm < λ_C < 1.42 μm
(C) 1.42 μm < λ_C < 1.62 μm
(D) 1.62 μm < λ_C < 6.62 μm

Q.9 In the figure, ln (ρ_i) is plotted as a function of 1/T, where ρ_i is the intrinsic resistivity of silicon, T is the temperature, and the plot is almost linear.



The slope of the line can be used to estimate

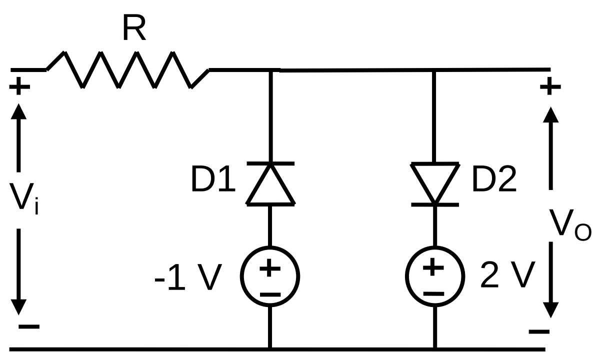
(A) band gap energy of silicon (E_g)
(B) sum of electron and hole mobility in silicon ($\mu_n + \mu_p$)
(C) reciprocal of the sum of electron and hole mobility in silicon $(\mu_n + \mu_p)^{-1}$
(D) intrinsic carrier concentration of silicon (n_i)

Q.10 The cut-off wavelength (in μm) of light that can be used for intrinsic excitation of a semiconductor material of bandgap E_g= 1.1 eV is ________

Q.11 If the emitter resistance in a common-emitter voltage amplifier is not bypassed, it will

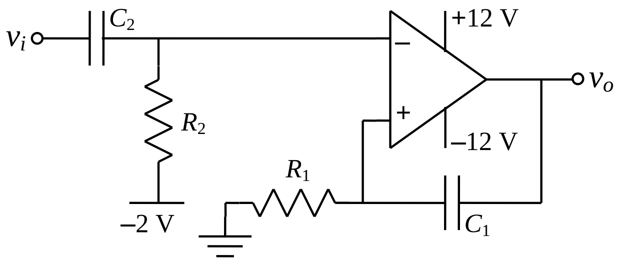
(A) reduce both the voltage gain and the input impedance
(B) reduce the voltage gain and increase the input impedance
(C) increase the voltage gain and reduce the input impedance
(D) increase both the voltage gain and the input impedance

Q.12 Two silicon diodes, with a forward voltage drop of 0.7 V, are used in the circuit shown in the figure. The range of input voltage V_i for which the output voltage $V_o = V_i$, is



(A) $-0.3\,V < V_i < 1.3\,V$
(B) $-0.3\,V < V_i < 2\,V$
(C) $-1.0\,V < V_i < 2.0\,V$
(D) $-1.7\,V < V_i < 2.7\,V$

Q.13 The circuit shown represents

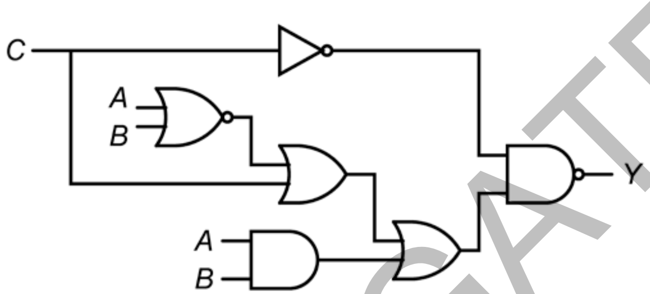


(A) a bandpass filter
(B) a voltage controlled oscillator
(C) an amplitude modulator
(D) a monostable multivibrator

Q.14 For a given sample-and-hold circuit, if the value of the hold capacitor is increased, then

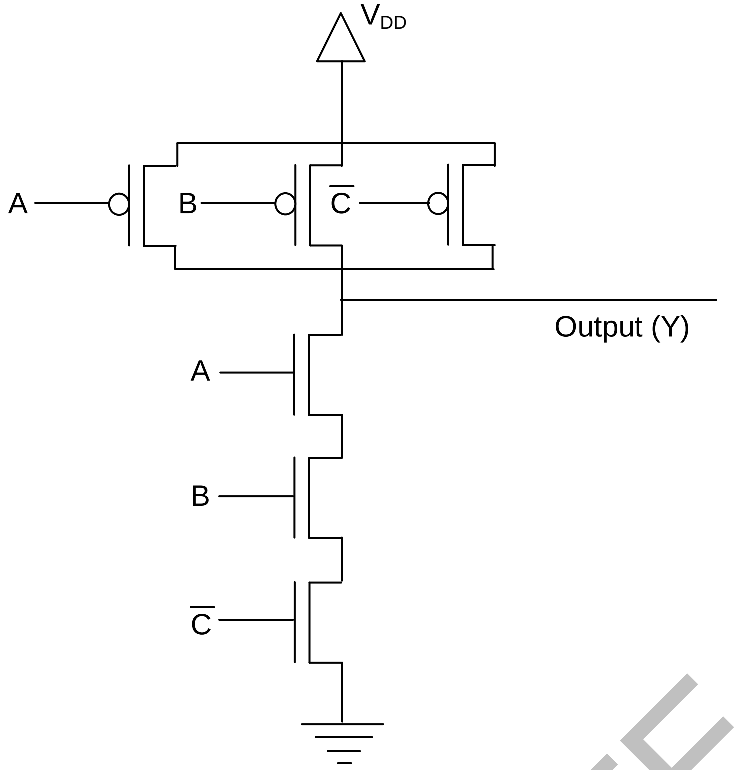
(A) droop rate decreases and acquisition time decreases
(B) droop rate decreases and acquisition time increases
(C) droop rate increases and acquisition time decreases
(D) droop rate increases and acquisition time increases

Q.15 In the circuit shown in the figure, if $C = 0$, the expression for Y is



(A) $Y = A\,\bar{B} + \bar{A}\,B$
(B) $Y = A + B$
(C) $Y = \bar{A} + \bar{B}$
(D) $Y = A\,B$

Q.16 The output (Y) of the circuit shown in the figure is



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

Q.17 A Fourier transform pair is given by

$$\left(\frac{2}{3}\right)^n u[n+3] \stackrel{FT}{\Leftrightarrow} \frac{A\, e^{-j6\pi f}}{1 - \left(\frac{2}{3}\right) e^{-j2\pi f}}$$

where $u[n]$ denotes the unit step sequence. The values of A is _________.

Q.18 A real-valued signal $x(t)$ limited to the frequency band $|f| \leq \frac{W}{2}$ is passed through a linear time invariant system whose frequency response is

$$H(f) = \begin{cases} e^{-j4\pi f}, & |f| \leq \frac{W}{2} \\ 0, & |f| > \frac{W}{2} \end{cases}.$$

The output of the system is

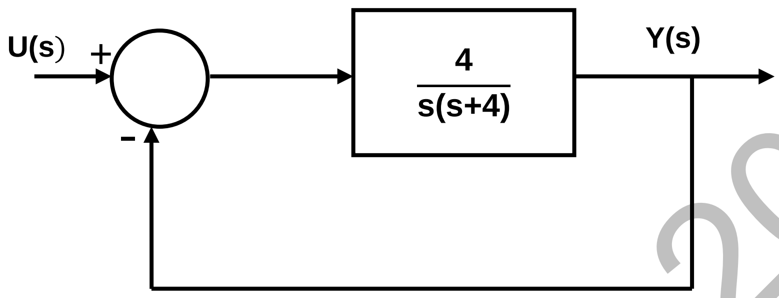
(A) $x(t+4)$ (B) $x(t-4)$ (C) $x(t+2)$ (D) $x(t-2)$

Q.19 The sequence $x[n] = 0.5^n \, u[n]$, where $u[n]$ is the unit step sequence, is convolved with itself to obtain $y[n]$. Then $\sum_{n=-\infty}^{+\infty} y[n]$ is _______.

Q.20 In a Bode magnitude plot, which one of the following slopes would be exhibited at high frequencies by a 4th order all-pole system?

(A) – 80 dB/decade (B) – 40 dB/decade (C) +40 dB/decade (D) +80 dB/decade

Q.21 For the second order closed-loop system shown in the figure, the natural frequency (in rad/s) is



(A) 16 (B) 4 (C) 2 (D) 1

Q.22 If calls arrive at a telephone exchange such that the time of arrival of any call is independent of the time of arrival of earlier or future calls, the probability distribution function of the total number of calls in a fixed time interval will be

(A) Poisson (B) Gaussian (C) Exponential (D) Gamma

Q.23 In a double side-band (DSB) full carrier AM transmission system, if the modulation index is doubled, then the ratio of total sideband power to the carrier power increases by a factor of ______.

Q.24 For an antenna radiating in free space, the electric field at a distance of 1 km is found to be 12 mV/m. Given that intrinsic impedance of the free space is $120\pi \ \Omega$, the magnitude of average power density due to this antenna at a distance of 2 km from the antenna (in nW/m^2) is ____.

Q.25 Match column A with column B.

Column A	**Column B**
1. Point electromagnetic source	P. Highly directional
2. Dish antenna	Q. End fire
3. Yagi-Uda antenna	R. Isotropic

(A)	(B)	(C)	(D)
$1 \rightarrow P$	$1 \rightarrow R$	$1 \rightarrow Q$	$1 \rightarrow R$
$2 \rightarrow Q$	$2 \rightarrow P$	$2 \rightarrow P$	$2 \rightarrow Q$
$3 \rightarrow R$	$3 \rightarrow Q$	$3 \rightarrow R$	$3 \rightarrow P$

Q. 26 – Q. 55 carry two marks each.

Q.26 With initial values $y(0) = y'(0) = 1$, the solution of the differential equation

$$\frac{d^2y}{dx^2} + 4\frac{dy}{dx} + 4y = 0$$

at $x = 1$ is _____.

Q.27 Parcels from sender S to receiver R pass sequentially through two post-offices. Each post-office has a probability $\frac{1}{5}$ of losing an incoming parcel, independently of all other parcels. Given that a parcel is lost, the probability that it was lost by the second post-office is_________.

Q.28 The unilateral Laplace transform of $f(t)$ is $\frac{1}{s^2+s+1}$. Which one of the following is the unilateral Laplace transform of $g(t) = t \cdot f(t)$?

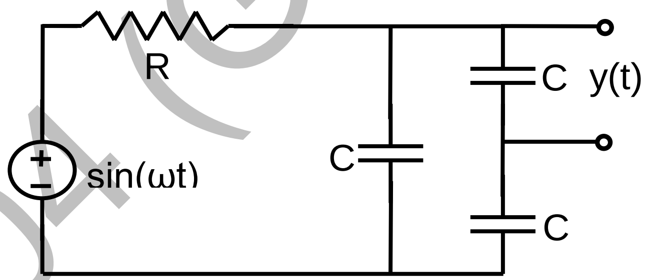
(A) $\frac{-s}{(s^2+s+1)^2}$ (B) $\frac{-(2s+1)}{(s^2+s+1)^2}$

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

Q.29 For a right angled triangle, if the sum of the lengths of the hypotenuse and a side is kept constant, in order to have maximum area of the triangle, the angle between the hypotenuse and the side is

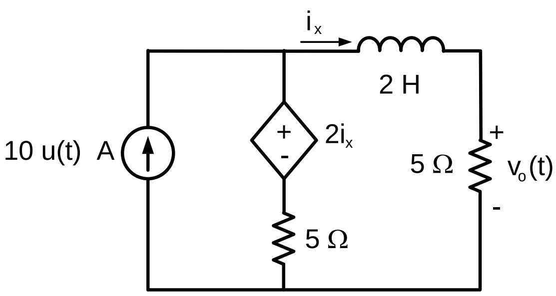
(A) 12^o (B) 36^o (C) 60^o (D) 45^o

Q.30 The steady state output of the circuit shown in the figure is given by $y(t) = A(\omega)\sin(\omega t + \phi(\omega))$. If the amplitude $|A(\omega)| = 0.25$, then the frequency ω is

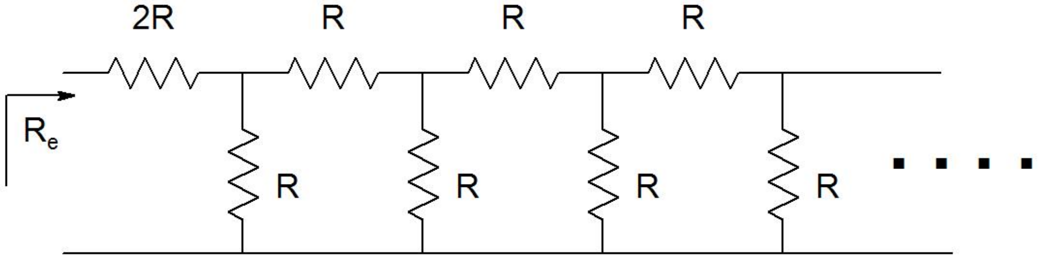


(A) $\frac{1}{\sqrt{3}\,R\,C}$ (B) $\frac{2}{\sqrt{3}\,R\,C}$ (C) $\frac{1}{R\,C}$ (D) $\frac{2}{R\,C}$

Q.31 In the circuit shown in the figure, the value of $v_0(t)$ (in Volts) for $t \to \infty$ is ______.

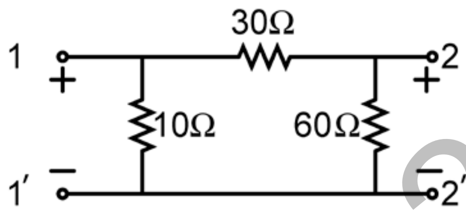


Q.32 The equivalent resistance in the infinite ladder network shown in the figure, is R_e.



The value of R_e/R is ________

Q.33 For the two-port network shown in the figure, the impedance (Z) matrix (in Ω) is

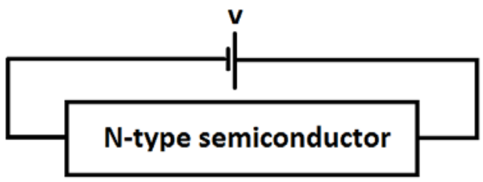


(A) $\begin{bmatrix} 6 & 24 \\ 42 & 9 \end{bmatrix}$ (B) $\begin{bmatrix} 9 & 8 \\ 8 & 24 \end{bmatrix}$ (C) $\begin{bmatrix} 9 & 6 \\ 6 & 24 \end{bmatrix}$ (D) $\begin{bmatrix} 42 & 6 \\ 6 & 60 \end{bmatrix}$

Q.34 Consider a silicon sample doped with $N_D = 1\times10^{15}/cm^3$ donor atoms. Assume that the intrinsic carrier concentration $n_i = 1.5\times10^{10}/cm^3$. If the sample is additionally doped with $N_A = 1\times10^{18}/cm^3$ acceptor atoms, the approximate number of electrons/cm^3 in the sample, at T=300 K, will be ______.

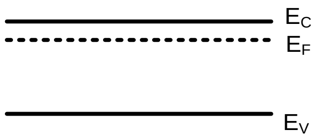
Q.35 Consider two BJTs biased at the same collector current with area A_1 = 0.2 µm × 0.2 µm and A_2 = 300 µm × 300 µm. Assuming that all other device parameters are identical, kT/q = 26 mV, the intrinsic carrier concentration is 1×10^{10} cm^{-3}, and q = 1.6×10^{-19} C, the difference between the base-emitter voltages (in mV) of the two BJTs (i.e., $V_{BE1} - V_{BE2}$) is _____.

Q.36 An N-type semiconductor having uniform doping is biased as shown in the figure.

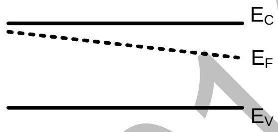


If E_C is the lowest energy level of the conduction band, E_V is the highest energy level of the valance band and E_F is the Fermi level, which one of the following represents the energy band diagram for the biased N-type semiconductor?

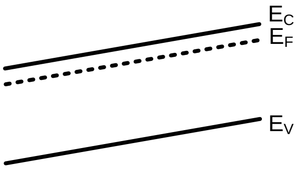
(A)



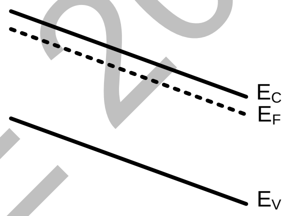
(B)



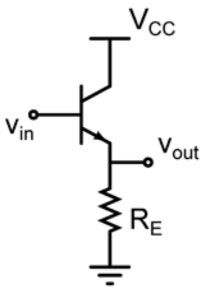
(C)



(D)



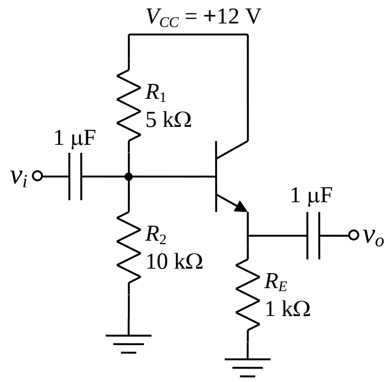
Q.37 Consider the common-collector amplifier in the figure (bias circuitry ensures that the transistor operates in forward active region, but has been omitted for simplicity). Let I_C be the collector current, V_{BE} be the base-emitter voltage and V_T be the thermal voltage. Also, g_m and r_o are the small-signal transconductance and output resistance of the transistor, respectively. Which one of the following conditions ensures a nearly constant small signal voltage gain for a wide range of values of R_E?



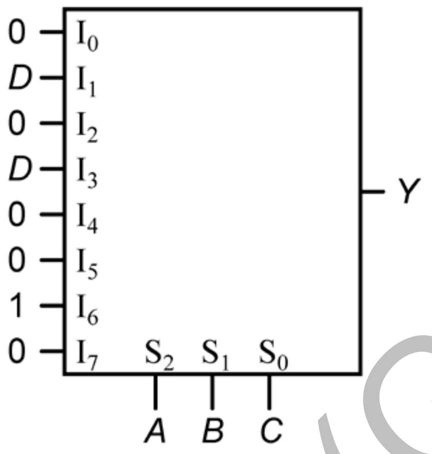
(A) $g_m R_E \ll 1$ (B) $I_C R_E \gg V_T$ (C) $g_m r_o \gg 1$ (D) $V_{BE} \gg V_T$

Q.38 A BJT in a common-base configuration is used to amplify a signal received by a 50 Ω antenna. Assume kT/q = 25 mV. The value of the collector bias current (in mA) required to match the input impedance of the amplifier to the impedance of the antenna is________.

Q.39 For the common collector amplifier shown in the figure, the BJT has high β, negligible $V_{CE(sat)}$, and $V_{BE} = 0.7$ V. The maximum undistorted peak-to-peak output voltage v_o (in Volts) is _______.

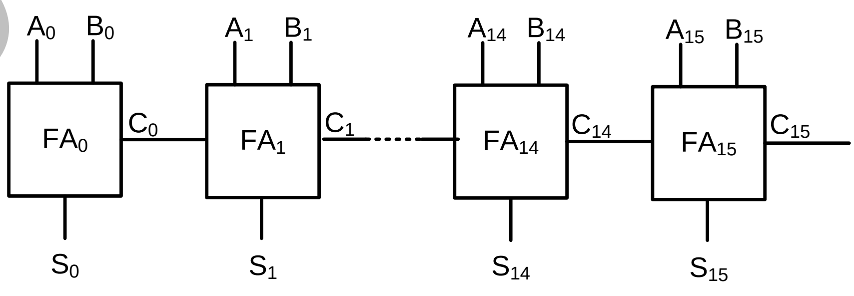


Q.40 An 8-to-1 multiplexer is used to implement a logical function Y as shown in the figure. The output Y is given by



(A) $Y = A\bar{B}C + A\bar{C}D$ (B) $Y = \bar{A}BC + A\bar{B}D$
(C) $Y = AB\bar{C} + \bar{A}CD$ (D) $Y = \bar{A}\bar{B}D + A\bar{B}C$

Q.41 A 16-bit ripple carry adder is realized using 16 identical full adders (FA) as shown in the figure. The carry-propagation delay of each FA is 12 ns and the sum-propagation delay of each FA is 15 ns. The worst case delay (in ns) of this 16-bit adder will be __________.



Q.42 An 8085 microprocessor executes "STA 1234H" with starting address location 1FFEH (STA copies the contents of the Accumulator to the 16-bit address location). While the instruction is fetched and executed, the sequence of values written at the address pins $A_{15} - A_8$ is

(A) 1FH, 1FH, 20H, 12H (B) 1FH, FEH, 1FH, FFH, 12H
(C) 1FH, 1FH, 12H, 12H (D) 1FH, 1FH, 12H, 20H, 12H

Q.43 A stable linear time invariant (LTI) system has a transfer function $H(s) = \frac{1}{s^2+s-6}$. To make this system causal it needs to be cascaded with another LTI system having a transfer function $H_1(s)$. A correct choice for $H_1(s)$ among the following options is

(A) $s+3$ (B) $s-2$ (C) $s-6$ (D) $s+1$

Q.44 A causal LTI system has zero initial conditions and impulse response $h(t)$. Its input $x(t)$ and output $y(t)$ are related through the linear constant-coefficient differential equation

$$\frac{d^2y(t)}{dt^2} + \alpha\frac{dy(t)}{dt} + \alpha^2 y(t) = x(t).$$

Let another signal $g(t)$ be defined as

$$g(t) = \alpha^2 \int_0^t h(\tau)d\tau + \frac{dh(t)}{dt} + \alpha h(t).$$

If $G(s)$ is the Laplace transform of $g(t)$, then the number of poles of $G(s)$ is _____.

Q.45 The N-point DFT X of a sequence $x[n]$, $0 \le n \le N-1$ is given by

$$X[k] = \frac{1}{\sqrt{N}}\sum_{n=0}^{N-1} x[n]e^{-j\frac{2\pi}{N}nk}, \qquad 0 \le k \le N-1.$$

Denote this relation as $X = DFT(x)$. For $N = 4$, which one of the following sequences satisfies $DFT(DFT(x)) = x$?

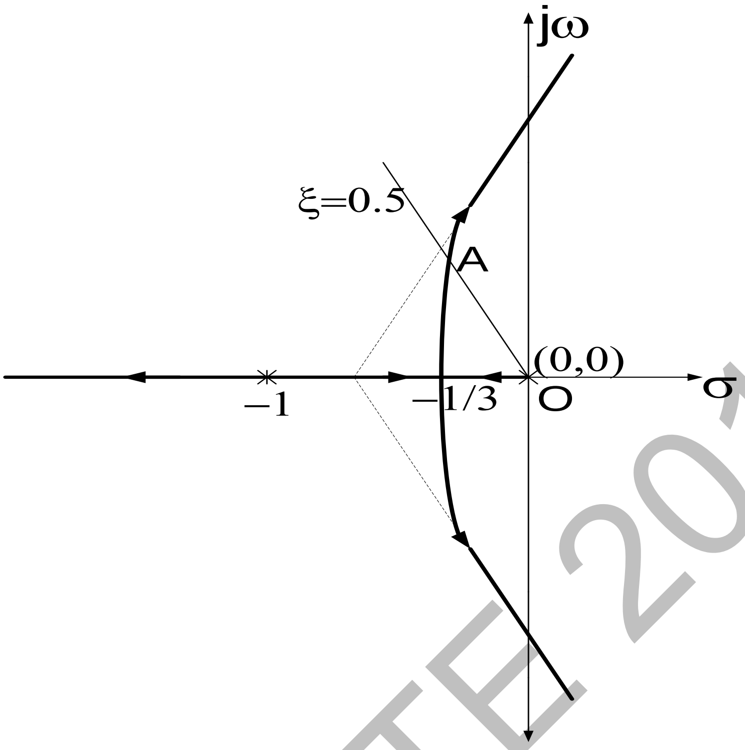
(A) $x = [1\ \ 2\ \ 3\ \ 4]$ (B) $x = [1\ \ 2\ \ 3\ \ 2]$
(C) $x = [1\ \ 3\ \ 2\ \ 2]$ (D) $x = [1\ \ 2\ \ 2\ \ 3]$

Q.46 The state transition matrix $\boldsymbol{\phi}$(t) of a system $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix} = \begin{bmatrix}0 & 1\\ 0 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$ is

(A) $\begin{bmatrix}t & 1\\ 1 & 0\end{bmatrix}$ (B) $\begin{bmatrix}1 & 0\\ t & 1\end{bmatrix}$ (C) $\begin{bmatrix}0 & 1\\ 1 & t\end{bmatrix}$ (D) $\begin{bmatrix}1 & t\\ 0 & 1\end{bmatrix}$

Q.47 Consider a transfer function $G_p(s) = \frac{ps^2+3ps-2}{s^2+(3+p)s+(2-p)}$ with p a positive real parameter. The maximum value of p until which G_p remains stable is ________.

Q.48 The characteristic equation of a unity negative feedback system is $1 + KG(s) = 0$. The open loop transfer function $G(s)$ has one pole at 0 and two poles at -1. The root locus of the system for varying K is shown in the figure.



The constant damping ratio line, for ξ=0.5, intersects the root locus at point A. The distance from the origin to point A is given as 0.5. The value of K at point A is ________ .

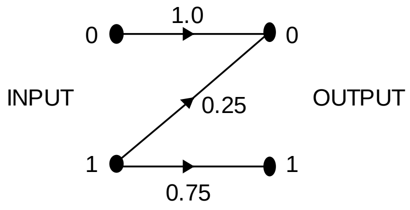
Q.49 Consider a communication scheme where the binary valued signal X satisfies $P\{X = +1\} = 0.75$ and $P\{X = -1\} = 0.25$. The received signal $Y = X + Z$, where Z is a Gaussian random variable with zero mean and variance σ^2. The received signal Y is fed to the threshold detector. The output of the threshold detector $\hat{X}$ is:

$$\hat{X} = \begin{cases} +1, & Y > \tau \\ -1, & Y \leq \tau. \end{cases}$$

To achieve a minimum probability of error $P\{\hat{X} \neq X\}$, the threshold τ should be

(A) strictly positive
(B) zero
(C) strictly negative
(D) strictly positive, zero, or strictly negative depending on the nonzero value of σ^2

Q.50 Consider the Z-channel given in the figure. The input is 0 or 1 with equal probability.



If the output is 0, the probability that the input is also 0 equals ______________

Q.51 An M-level PSK modulation scheme is used to transmit independent binary digits over a band-pass channel with bandwidth 100 kHz. The bit rate is 200 kbps and the system characteristic is a raised-cosine spectrum with 100% excess bandwidth. The minimum value of M is ________.

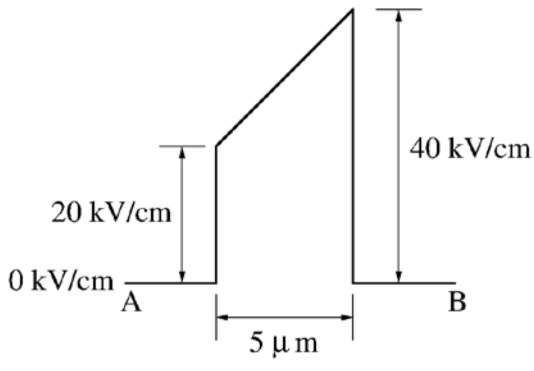
Q.52 Consider a discrete-time channel $Y = X + Z$, where the additive noise Z is signal-dependent. In particular, given the transmitted symbol $X \in \{-a, +a\}$ at any instant, the noise sample Z is chosen independently from a Gaussian distribution with mean βX and unit variance. Assume a threshold detector with zero threshold at the receiver.

When $\beta = 0$, the BER was found to be $Q(a) = 1 \times 10^{-8}$.
$\left(Q(v) = \frac{1}{\sqrt{2\pi}} \int_v^\infty e^{-u^2/2}\, du\right.$, and for $v > 1$, use $\left.Q(v) \approx e^{-v^2/2}\right)$

When $\beta = -0.3$, the BER is closest to

(A) 10^{-7} (B) 10^{-6} (C) 10^{-4} (D) 10^{-2}

Q.53 The electric field (assumed to be one-dimensional) between two points A and B is shown. Let ψ_A and ψ_B be the electrostatic potentials at A and B, respectively. The value of $\psi_B - \psi_A$ in Volts is ________.



Q.54 Given $\vec{F} = z\hat{a}_x + x\hat{a}_y + y\hat{a}_z$. If S represents the portion of the sphere $x^2 + y^2 + z^2 = 1$ for $z \geq 0$, then $\int_s \nabla \times \vec{F} \cdot \vec{ds}$ is______________.

Q.55 If $\vec{E} = -(2y^3 - 3yz^2)\hat{x} - (6xy^2 - 3xz^2)\hat{y} + (6xyz)\hat{z}$ is the electric field in a source free region, a valid expression for the electrostatic potential is

(A) $xy^3 - yz^2$ (B) $2xy^3 - xyz^2$ (C) $y^3 + xyz^2$ (D) $2xy^3 - 3xyz^2$

END OF THE QUESTION PAPER

GATE 2014

Answer Keys for EC - Electronics and Communication Engineering

Section	Q. No.	SECTION - 4	
		Key / Range	Marks
GA	1	A	1
GA	2	B	1
GA	3	B	1
GA	4	A	1
GA	5	495 to 495	1
GA	6	C	2
GA	7	B	2
GA	8	B	2
GA	9	22 to 22	2
GA	10	B	2
EC	1	D	1
EC	2	6.8 to 7.2	1
EC	3	0.79 to 0.81	1
EC	4	B	1
EC	5	2.99 to 3.01	1
EC	6	C	1
EC	7	2.79 to 2.81	1
EC	8	A	1
EC	9	A	1
EC	10	1.12 to 1.14	1
EC	11	B	1
EC	12	D	1
EC	13	D	1
EC	14	B	1
EC	15	A	1
EC	16	A	1
EC	17	3.36 to 3.39	1
EC	18	D	1
EC	19	3.9 to 4.1	1
EC	20	A	1
EC	21	C	1
EC	22	A	1
EC	23	3.95 to 4.05	1
EC	24	47.6 to 47.8	1
EC	25	B	1
EC	26	0.53 to 0.55	2
EC	27	0.43 to 0.45	2
EC	28	D	2
EC	29	C	2
EC	30	B	2
EC	31	31.24 to 31.26	2
EC	32	2.60 to 2.64	2
EC	33	C	2
EC	34	224.9 to 225.1	2
EC	35	378 to 381	2
EC	36	D	2
EC	37	B	2
EC	38	0.49 to 0.51	2
EC	39	9.39 to 9.41	2
EC	40	C	2
EC	41	194.9 to 195.1	2
EC	42	A	2
EC	43	B	2
EC	44	0.99 to 1.01	2
EC	45	B	2
EC	46	D	2
EC	47	1.9 to 2.1	2
EC	48	0.32 to 0.41	2
EC	49	C	2
EC	50	0.79 to 0.81	2
EC	51	15.9 to 16.1	2
EC	52	C	2
EC	53	-15.1 to -14.9	2
EC	54	3.13 to 3.15	2
EC	55	D	2