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.

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 <u>hierarchical</u> pie chart shows the population of animals in a reserve forest. The correct conclusions from <u>this</u> information are:
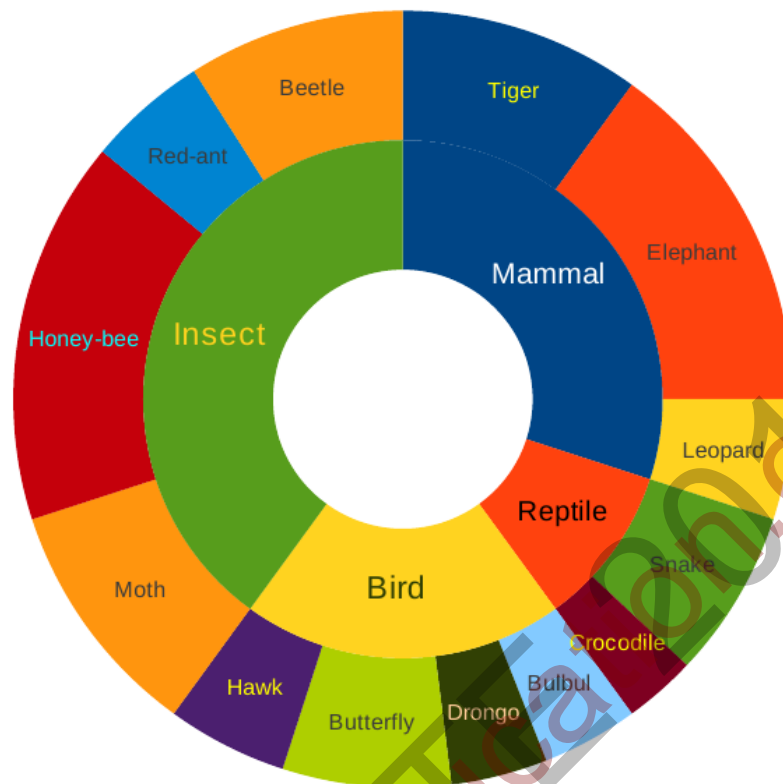
(i) Butterflies are birds
(ii) There are more tigers in this forest than red ants
(iii) All reptiles in this forest are either snakes or crocodiles
(iv) Elephants are the largest mammals in this forest

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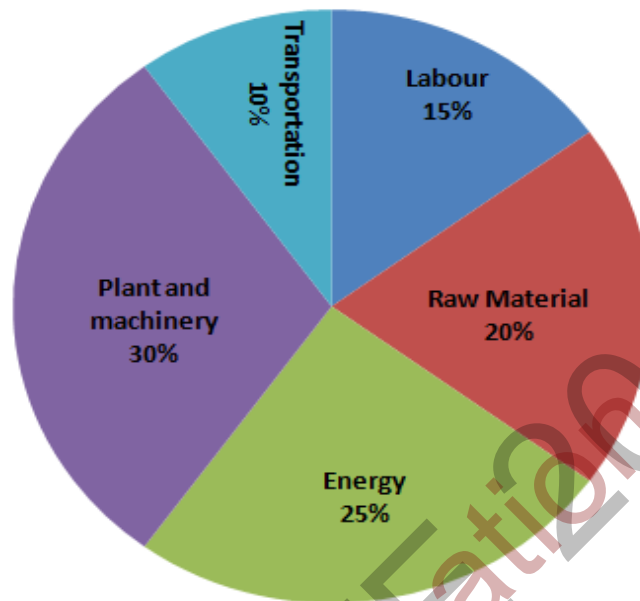
Q.10 A batch of one hundred bulbs is inspected by testing four randomly chosen bulbs. The batch is rejected if even one of the bulbs is defective. A batch typically has five defective bulbs. The probability that the current batch is accepted is _____

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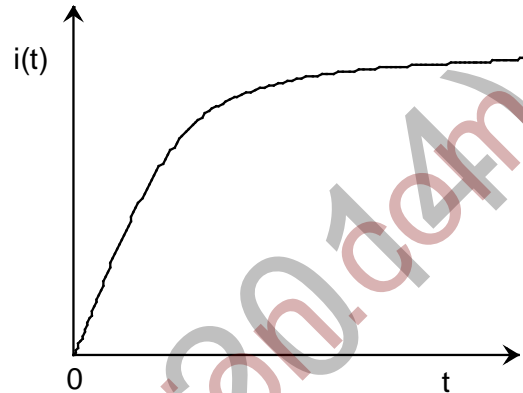
$$V_S = R\, i(t) + \frac{1}{C}\int_o^t i(u)\,du.$$

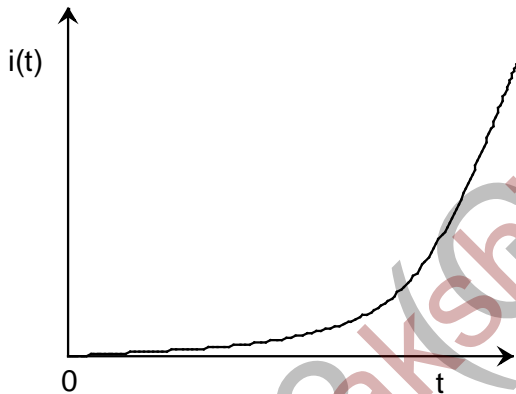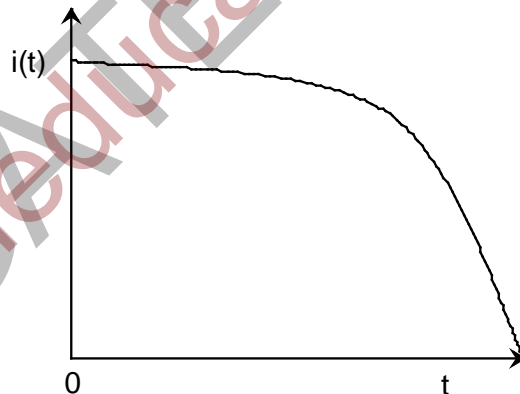Which one of the following represents the current $i(t)$?

(A)

i(t)

0   t

(B)

i(t)

0   t

(C)

i(t)

0   t

(D)

i(t)

0   t
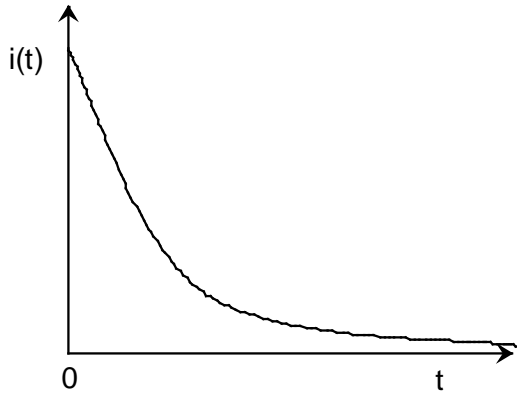
Q.7   In the figure shown, the value of the current I (in Amperes) is _____.
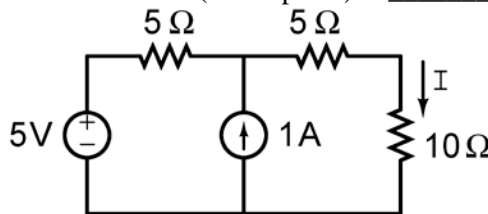
Q.8   In MOSFET fabrication, the channel length is defined during the process of

(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 $\beta = 50$. Assume that $R_B = 100\ k\Omega$. For V$_0$ to be 5 V, the value of R_C (in $k\Omega$) is _____
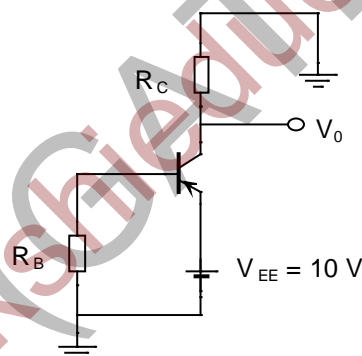
Q.13   The figure shows a half-wave rectifier. The diode D is ideal. The average steady-state current (in Amperes) through the diode is approximately _____.
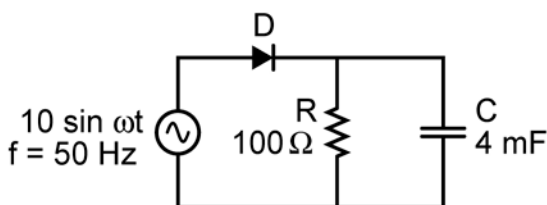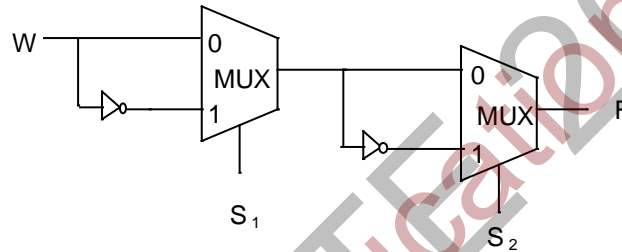

Q.14   An analog voltage in the range 0 to 8 V is divided in 16 equal intervals for conversion to 4-bit digital output. The maximum quantization error (in V) is _____

Q.15   The circuit shown in the figure is a
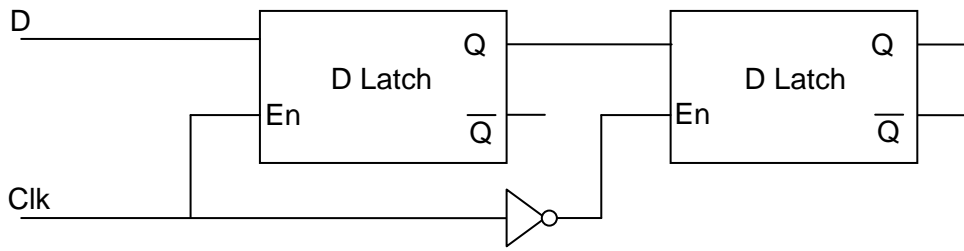
(A) Toggle Flip Flop
(B) JK Flip Flop
(C) SR Latch
(D) Master-Slave D Flip Flop

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 $H(z) = \dfrac{(z^{-1} - b)}{(1 - az^{-1})}$, where $\left|H\left(e^{-j\omega}\right)\right| = 1$, for all ω.

If $\mathrm{Re}(a) \neq 0,\ \mathrm{Im}(a) \neq 0,$ 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.
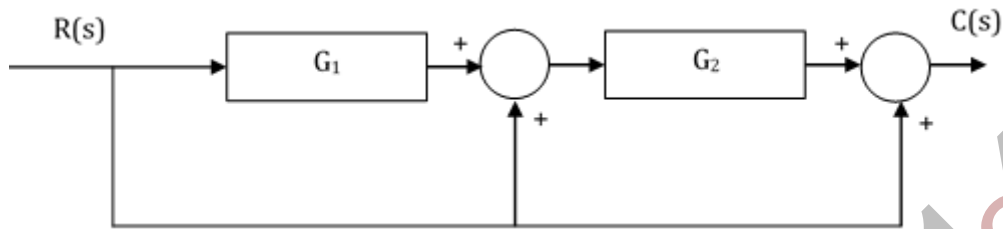
The transfer function $\frac{C(s)}{R(s)}$ is

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

(B) $G_1 G_2 + G_1 + 1$

(C) $G_1 G_2 + G_2 + 1$

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

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 $\times$ 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.
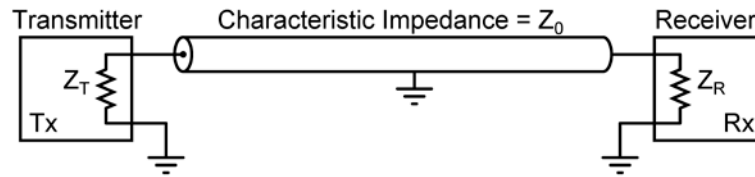

Which one of the following statements is **TRUE** about the distortion of the received signal due to impedance mismatch?

(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.
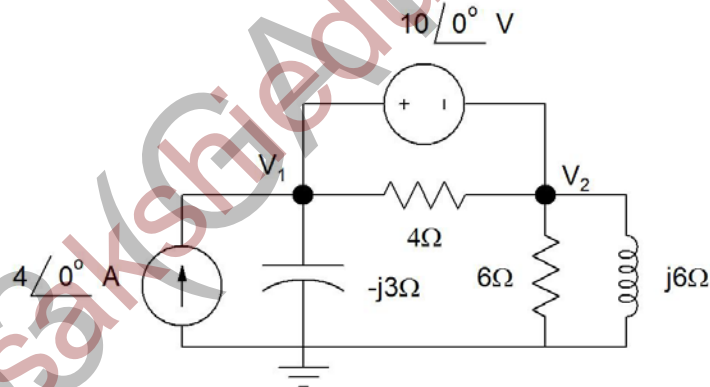Let C = 100 μF and R = 10 kΩ.
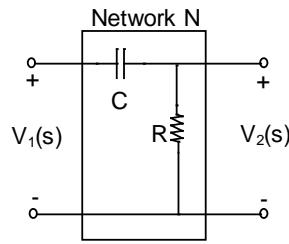
Two such blocks are connected in cascade, as shown in the figure.
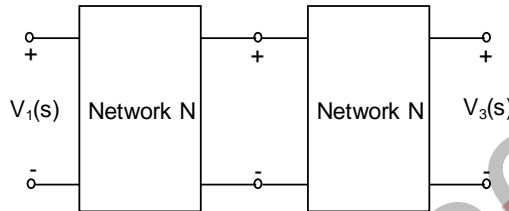
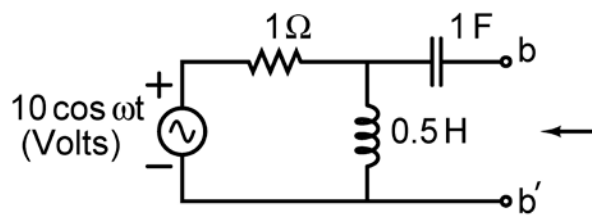The transfer function $\frac{V_3(s)}{V_1(s)}$ of the cascaded network is

(A) $\frac{s}{1+s}$

(B) $\frac{s^2}{1+3s+s^2}$

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

(D) $\frac{s}{2+s}$

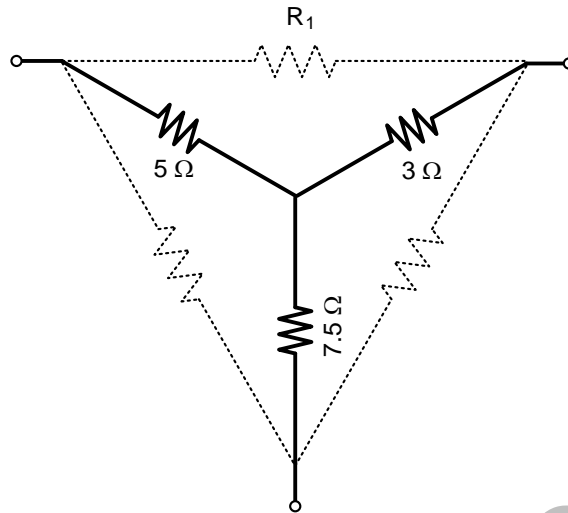Q.31   In the circuit shown in the figure, the value of node voltage V_2 is

(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 1×10^{16} cm^{-3} and 5×10^{18} cm^{-3}, respectively. Assume that the intrinsic carrier concentration in silicon $n_i = 1.5 \times 10^{10}$ 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 1×10^{-4} cm
(B) 0.86 V and 1×10^{-4} cm
(C) 0.7 V and 3.3×10^{-5} cm
(D) 0.86 V and 3.3×10^{-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 $\sqrt{A}$/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 $\epsilon_0 = 8.854 \times 10^{-14}$ 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?
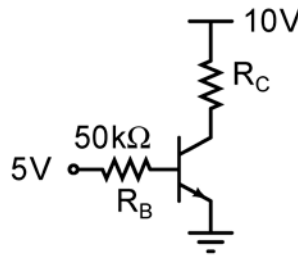
(A) For $R_C = 1$ kΩ, the BJT operates in the saturation region
(B) For $R_C = 3$ kΩ, the BJT operates in the saturation region
(C) For $R_C = 20$ kΩ, the BJT operates in the cut-off region
(D) For $R_C = 20$ kΩ, the BJT operates in the linear region

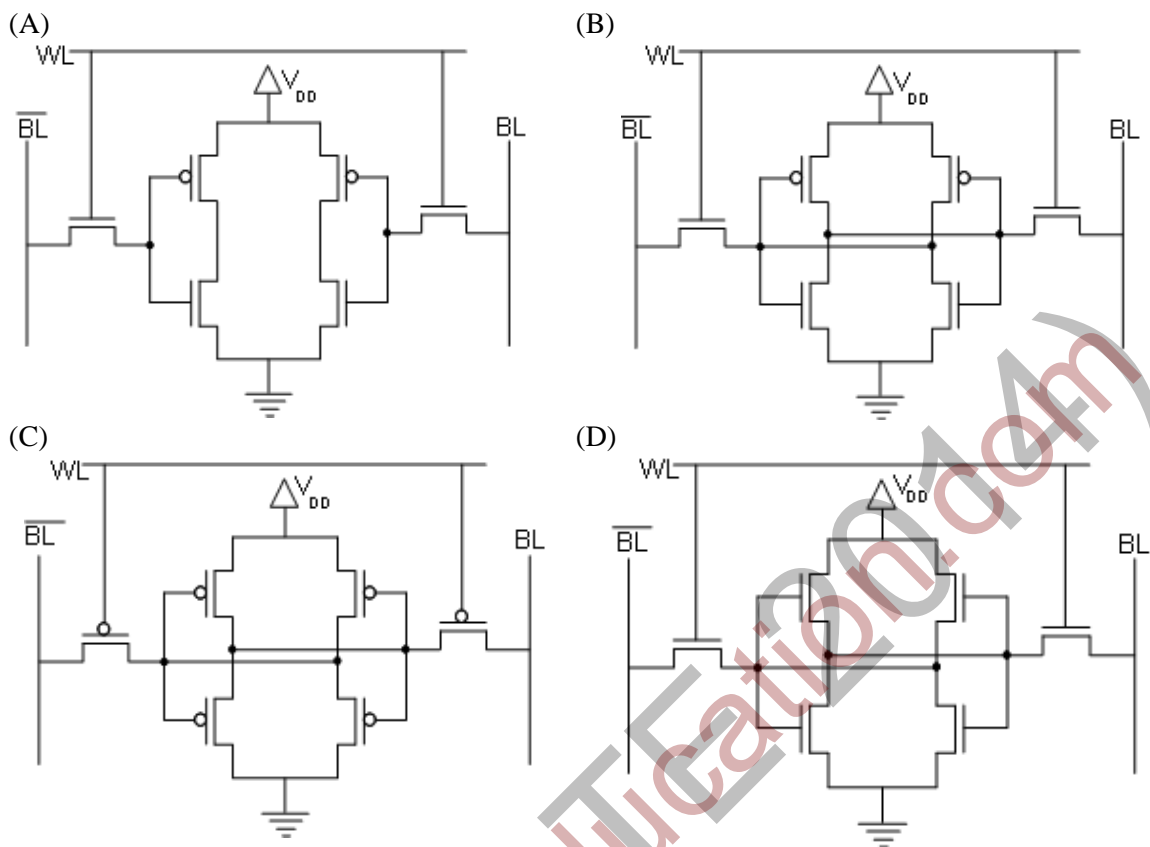Q.38   Assuming that the Op-amp in the circuit shown is ideal, V_o is given by
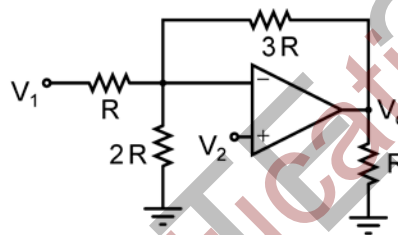
(A) $\frac{5}{2}V_1 - 3V_2$

(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, $\mu_n C_{ox} = 100$ µA/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_____.
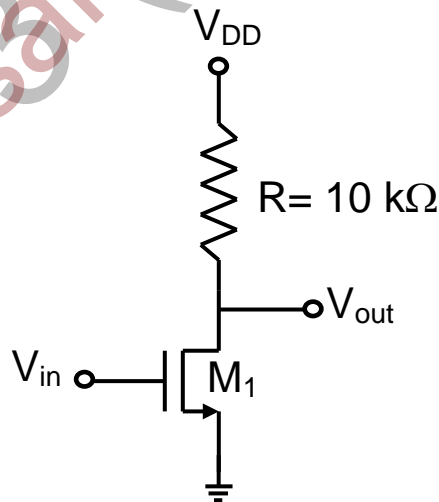
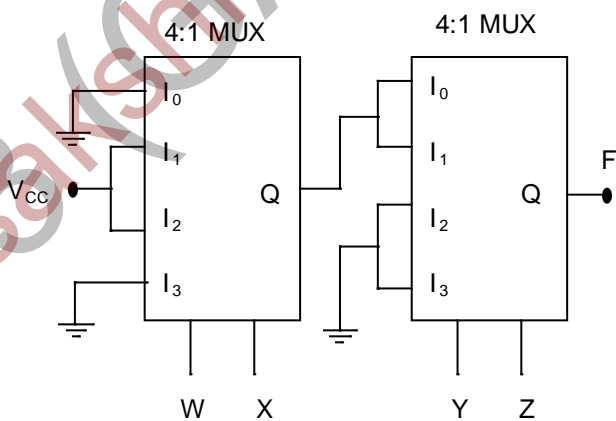Q.40   If WL is the Word Line and BL the Bit Line, an SRAM cell is shown in

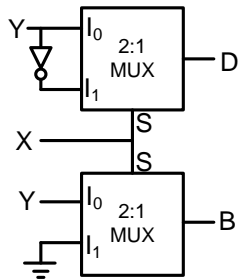(A)

(B)

(C)

(D)

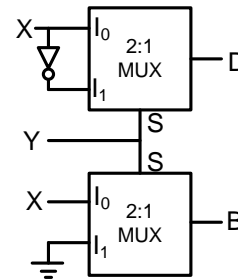Q.41   In the circuit shown, W and Y are MSBs of the control inputs. The output F is given by

(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?
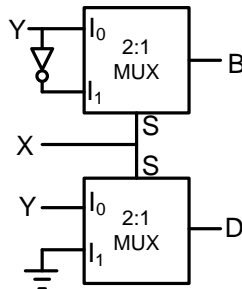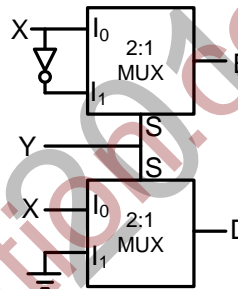
(A)

(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,

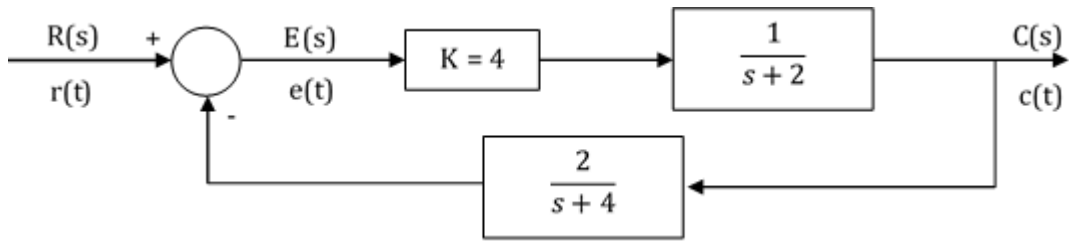(A) only S1 and S2 are true   (B) only S2 and S3 are true
(C) only S1 and S3 are true   (D) S1, S2 and S3 are true

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

$$\dot{x}(t) = Ax(t), \quad x(0) = x_0$$

For $x_0 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$, $x(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$ and for $x_0 = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, $x(t) = \begin{bmatrix} e^{-t} - e^{-2t} \\ -e^{-t} + 2e^{-2t} \end{bmatrix}$.

When $x_0 = \begin{bmatrix} 3 \\ 5 \end{bmatrix}$, $x(t)$ 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) $\dfrac{s+1}{(s+2)(s+4)(s+7)}$

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

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

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

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

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

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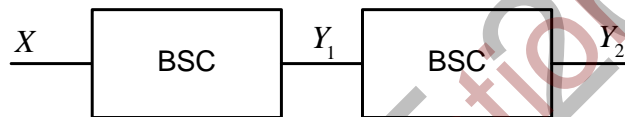
The value of $H(Y_1) + H(Y_2)$ in bits is _____.

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 $\overrightarrow{K_s}$ on the surface of the perfect conductor is $\overrightarrow{K_s} = \hat{x}2$ amperes per meter. The tangential $\vec{H}$ field in the air just above the perfect conductor is
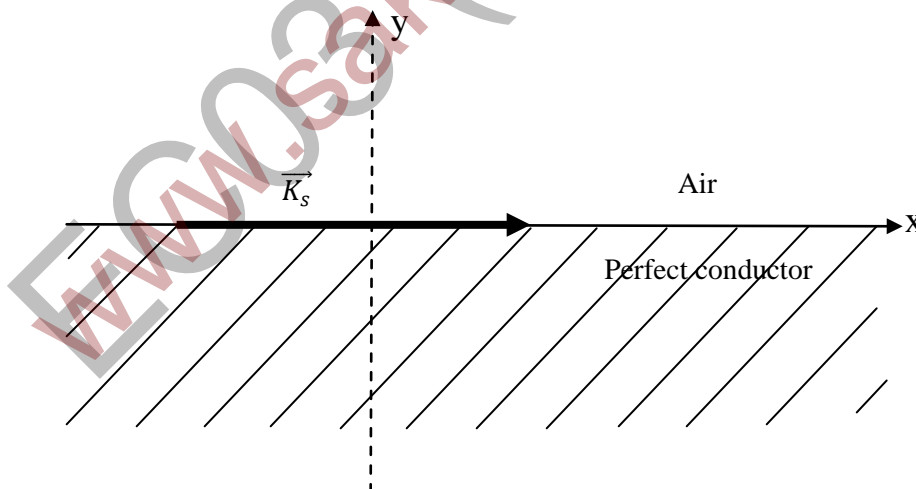
(A) $(\hat{x} + \hat{z})2$ amperes per meter
(B) $\hat{x}2$ amperes per meter
(C) $-\hat{z}2$ amperes per meter
(D) $\hat{z}2$ amperes per meter

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