Q. 1 – Q. 5 carry one mark each.

Q.1 The strategies that the company _____ to sell its products _____ house-to-house marketing.

(A) use, includes
(B) uses, include
(C) used, includes
(D) uses, including

Q.2 The boat arrived _____ dawn.

(A) in
(B) at
(C) on
(D) under

Q.3 It would take one machine 4 hours to complete a production order and another machine 2 hours to complete the same order. If both machines work simultaneously at their respective constant rates, the time taken to complete the same order is _____ hours.

(A) 2/3
(B) 3/4
(C) 4/3
(D) 7/3

Q.4 Five different books (P, Q, R, S, T) are to be arranged on a shelf. The books R and S are to be arranged first and second, respectively from the right side of the shelf. The number of different orders in which P, Q and T may be arranged is ___.

(A) 2
(B) 6
(C) 12
(D) 120

Q.5 When he did not come home, she _____ him lying dead on the roadside somewhere.

(A) concluded
(B) looked
(C) notice
(D) pictured

Q. 6 – Q. 10 carry two marks each.

Q.6   Four people are standing in a line facing you. They are Rahul, Mathew, Seema and Lohit. One is an engineer, one is a doctor, one a teacher and another a dancer. You are told that:

1. Mathew is not standing next to Seema
2. There are two people standing between Lohit and the engineer
3. Rahul is not a doctor
4. The teacher and the dancer are standing next to each other
5. Seema is turning to her right to speak to the doctor standing next to her

Who among them is an engineer?

(A) Seema   (B) Lohit
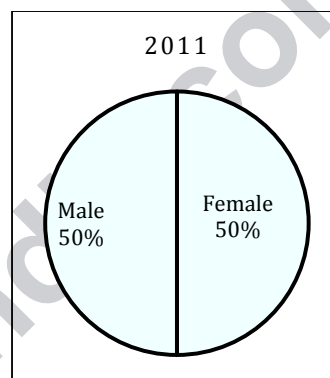(C) Rahul   (D) Mathew

Q.7   The bar graph in Panel (a) shows the proportion of male and female illiterates in 2001 and 2011. The proportions of males and females in 2001 and 2011 are given in Panel (b) and (c), respectively. The total population did not change during this period.
The percentage increase in the total number of literates from 2001 to 2011 is _____.

Proportion of illiterates (%)
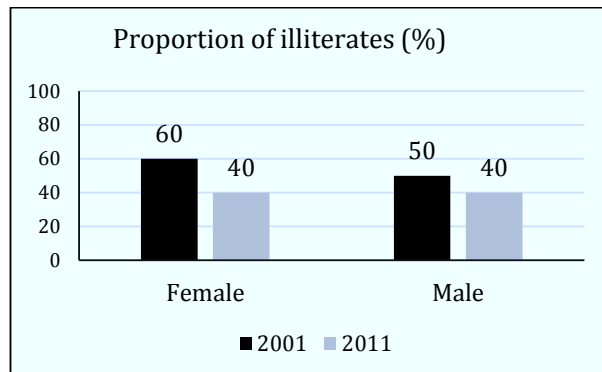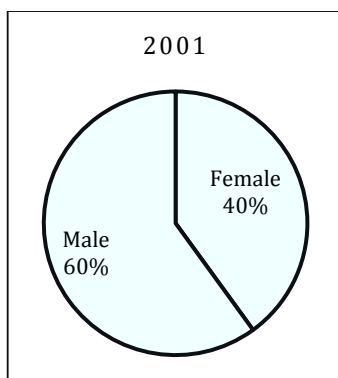
Panel (a)

Panel (b)

Panel (c)

(A) 30.43   (B) 33.43   (C) 34.43   (D) 35.43

Q.8 "Indian history was written by British historians – extremely well documented and researched, but not always impartial. History had to serve its purpose: Everything was made subservient to the glory of the Union Jack. Latter-day Indian scholars presented a contrary picture."

From the text above, we can infer that:

Indian history written by British historians _____

(A) was well documented and not researched but was always biased
(B) was not well documented and researched and was always biased
(C) was well documented and researched but was sometimes biased
(D) was not well documented and researched and was sometimes biased

Q.9 Two design consultants, P and Q, started working from 8 AM for a client. The client budgeted a total of USD 3000 for the consultants. P stopped working when the hour hand moved by 210 degrees on the clock. Q stopped working when the hour hand moved by 240 degrees. P took two tea breaks of 15 minutes each during her shift, but took no lunch break. Q took only one lunch break for 20 minutes, but no tea breaks. The market rate for consultants is USD 200 per hour and breaks are not paid. After paying the consultants, the client shall have USD _____ remaining in the budget.

(A) 000.00   (B) 166.67   (C) 300.00   (D) 433.33

Q.10 Five people P, Q, R, S and T work in a bank. P and Q don't like each other but have to share an office till T gets a promotion and moves to the big office next to the garden. R, who is currently sharing an office with T wants to move to the adjacent office with S, the handsome new intern. Given the floor plan, what is the current location of Q, R and T?
(O = Office, WR = Washroom)

(A)

WR	O 1 **P, Q**	O 2	O 3 **R**	O 4 **S**
Manager **T**			Teller 1	Teller 2
		Entry		
Garden				

(C)

WR	O 1 **P, Q**	O 2	O 3 **R, T**	O 4 **S**
Manager			Teller 1	Teller 2
		Entry		
Garden				

(B)

WR	O 1 **P, Q**	O 2	O 3 **T**	O 4 **R, S**
Manager			Teller 1	Teller 2
		Entry		
Garden				

(D)

WR	O 1 **P**	O 2 **Q**	O 3 **R**	O 4 **S**
Manager			Teller 1	Teller 2
		Entry		
Garden				

END OF THE QUESTION PAPER

Q. 1 – Q. 25 carry ONE mark each.

Q.1   Which one of the following functions is analytic over the entire complex plane?

(A) $\ln(z)$ (B) $e^{1/z}$ (C) $\dfrac{1}{1-z}$ (D) $\cos(z)$

Q.2   The families of curves represented by the solution of the equation

$$\frac{dy}{dx} = -\left(\frac{x}{y}\right)^n$$

for $n = -1$ and $n = +1$, respectively, are

(A) Parabolas and Circles   (B) Circles and Hyperbolas
(C) Hyperbolas and Circles   (D) Hyperbolas and Parabolas

Q.3   Let $H(z)$ be the z-transform of a real-valued discrete-time signal $h[n]$. If $P(z) = H(z)H\left(\frac{1}{z}\right)$ has a zero at $z = \frac{1}{2} + \frac{1}{2}j$, and $P(z)$ has a total of four zeros, which one of the following plots represents all the zeros correctly?
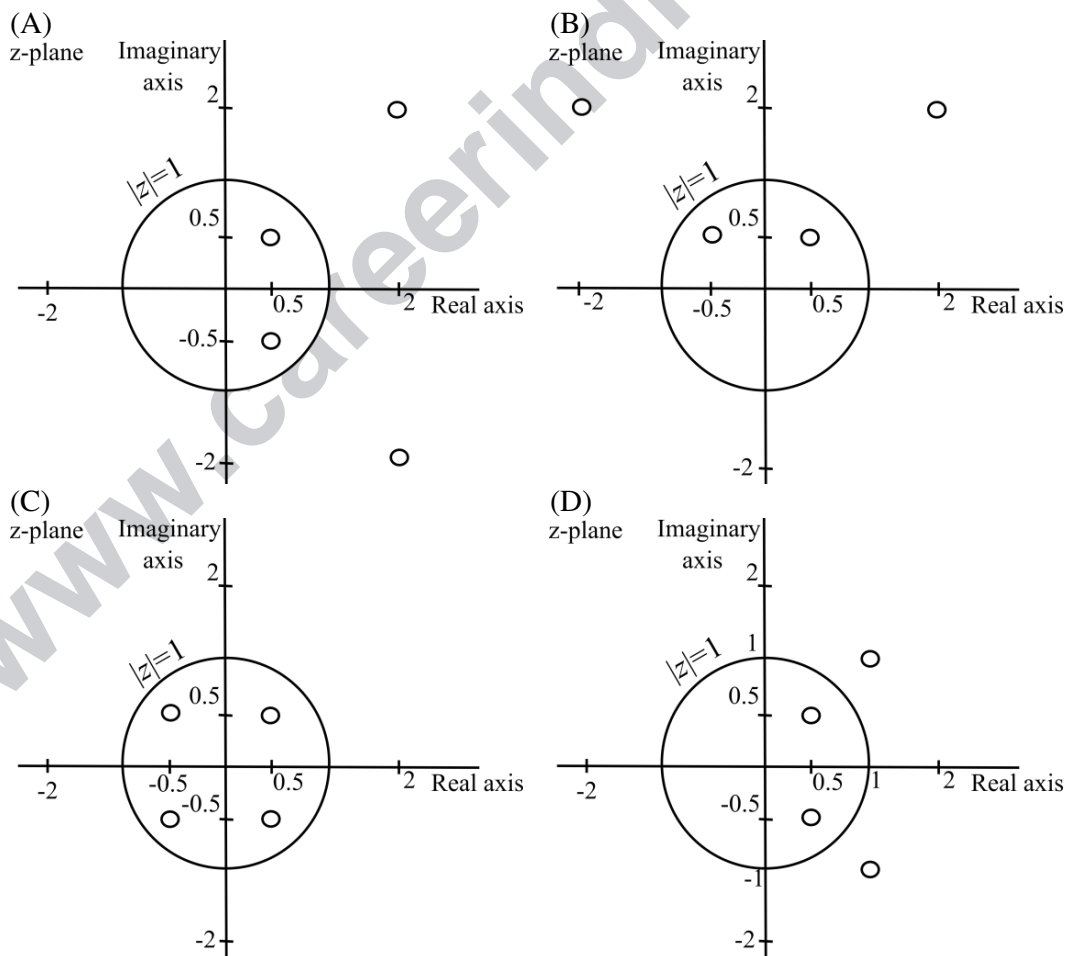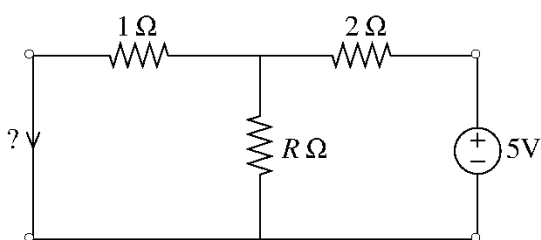
Q.4   Consider the two-port resistive network shown in the figure. When an excitation of
       5 V is applied across Port 1, and Port 2 is shorted, the current through the short circuit at
       Port 2 is measured to be 1 A (see (a) in the figure).
          Now, if an excitation of 5 V is applied across Port 2, and Port 1 is shorted (see (b) in the
       figure), what is the current through the short circuit at Port 1?
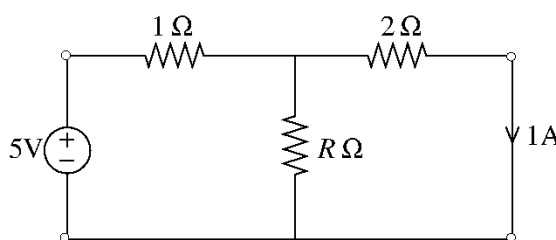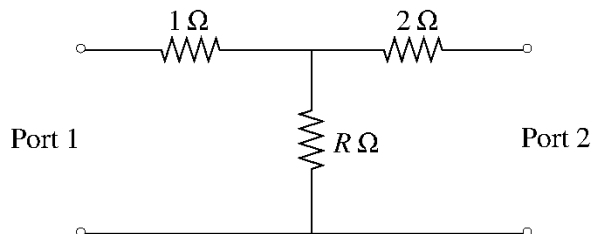
       (a)   (b)

       (A) 0.5 A   (B) 1 A   (C) 2 A   (D) 2.5 A

Q.5   Let $Y(s)$ be the unit-step response of a causal system having a transfer function

$$G(s) = \frac{3 - s}{(s + 1)(s + 3)}$$

       that is, $Y(s) = \frac{G(s)}{s}$. The forced response of the system is

       (A) $u(t) - 2e^{-t}u(t) + e^{-3t}u(t)$ (B) $2u(t) - 2e^{-t}u(t) + e^{-3t}u(t)$
       (C) $2u(t)$ (D) $u(t)$

Q.6   For an LTI system, the Bode plot for its gain is as illustrated in the figure shown. The number of system poles N_p and the number of system zeros N_z in the frequency range $1 \text{ Hz} \le f \le 10^7 \text{ Hz}$ is
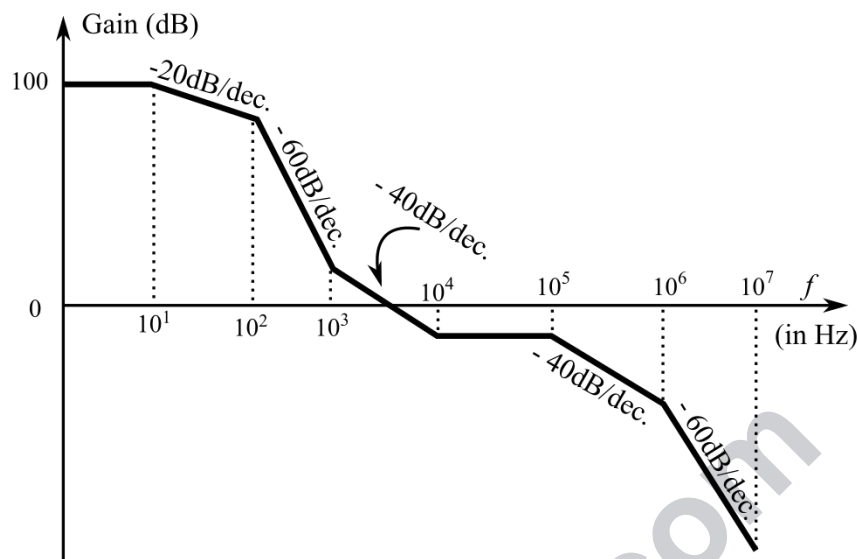
(A) $N_p = 5, N_z = 2$ (B) $N_p = 6, N_z = 3$ (C) $N_p = 7, N_z = 4$ (D) $N_p = 4, N_z = 2$

Q.7   A linear Hamming code is used to map 4-bit messages to 7-bit codewords. The encoder mapping is linear. If the message 0001 is mapped to the codeword 0000111, and the message 0011 is mapped to the codeword 1100110, then the message 0010 is mapped to

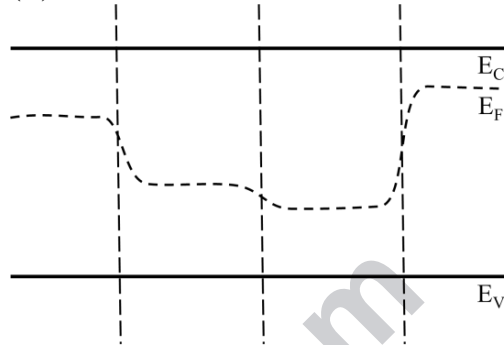(A) 0010011   (B) 1100001   (C) 1111000   (D) 1111111

Q.8   Which one of the following options describes correctly the equilibrium band diagram at T=300 K of a Silicon pnn$^+$p^{++} configuration shown in the figure?

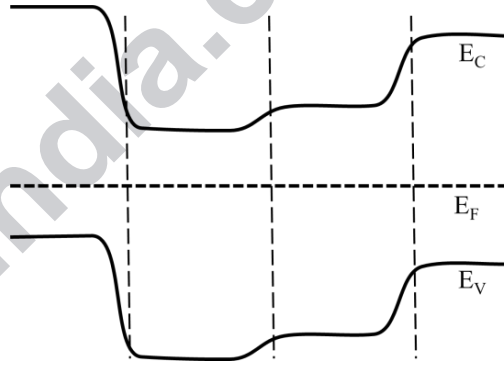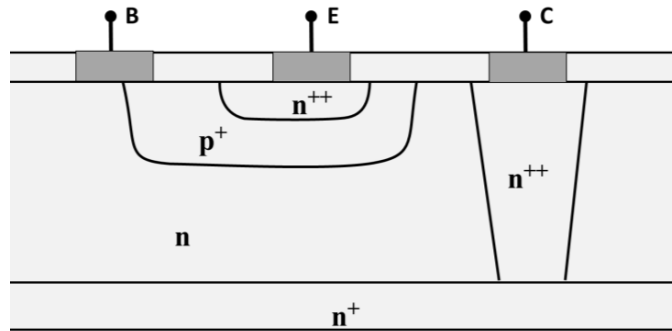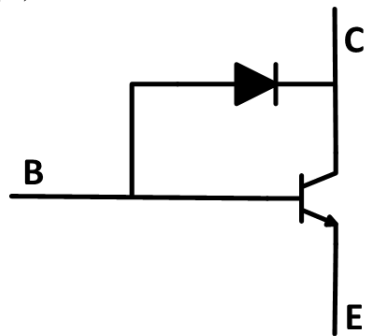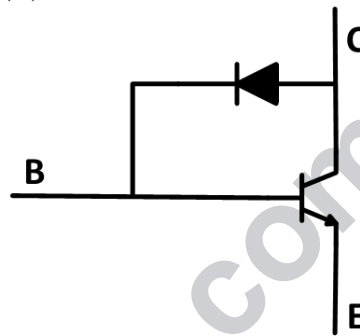| p	n	n^+	p^{++}

(A)
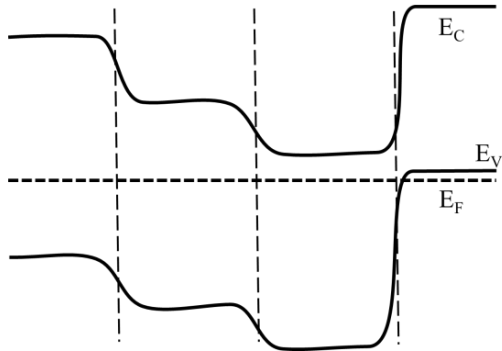
(B)

(C)
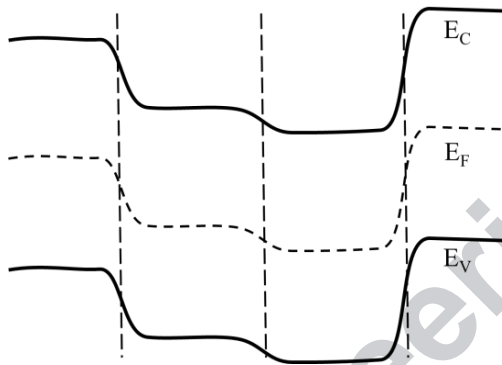
(D)

Q.9   The correct circuit representation of the structure shown in the figure is
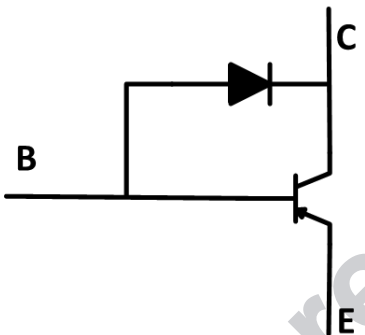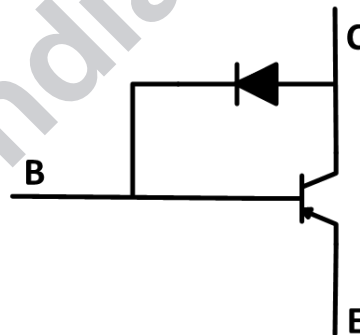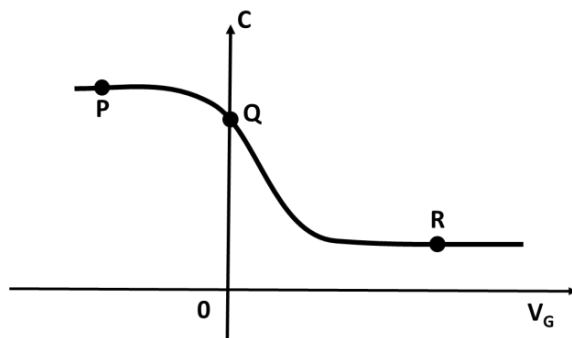

(A)

(B)

(C)

(D)

Q.10 The figure shows the high-frequency C-V curve of a MOS capacitor (at T = 300 K) with Φ_{ms} = 0 V and no oxide charges. The flat-band, inversion, and accumulation conditions are represented, respectively, by the points

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

Q.11 What is the electric flux ($\int \vec{E} \cdot d\hat{a}$) through a quarter-cylinder of height H (as shown in the figure) due to an infinitely long line charge along the axis of the cylinder with a charge density of Q ?
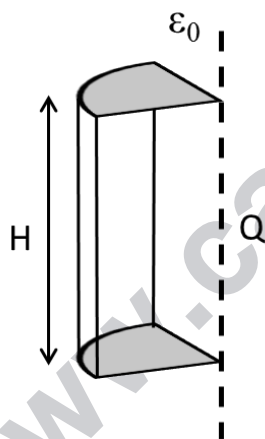

(A) $\dfrac{HQ}{\varepsilon_0}$

(B) $\dfrac{HQ}{4\varepsilon_0}$

(C) $\dfrac{H\varepsilon_0}{4Q}$

(D) $\dfrac{4H}{Q\varepsilon_0}$

Q.12   In the table shown, List I and List II, respectively, contain terms appearing on the left-hand side and the right-hand side of Maxwell's equations (in their standard form). Match the left-hand side with the corresponding right-hand side.

List I		List II	
1	$\nabla \cdot \mathbf{D}$	P	0
2	$\nabla \times \mathbf{E}$	Q	ρ
3	$\nabla \cdot \mathbf{B}$	R	$-\dfrac{\partial \mathbf{B}}{\partial t}$
4	$\nabla \times \mathbf{H}$	S	$\mathbf{J} + \dfrac{\partial \mathbf{D}}{\partial t}$

(A) 1 - P, 2 - R, 3 - Q, 4 - S   (B) 1 - Q, 2 - R, 3 - P, 4 - S
(C) 1 - Q, 2 - S, 3 - P, 4 - R   (D) 1 - R, 2 - Q, 3 - S, 4 - P

Q.13   A standard CMOS inverter is designed with equal rise and fall times ($\beta_n = \beta_p$). If the width of the pMOS transistor in the inverter is increased, what would be the effect on the LOW noise margin (NM_L) and the HIGH noise margin NM_H?

(A) NM_L increases and NM_H decreases.
(B) NM_L decreases and NM_H increases.
(C) Both NM_L and NM_H increase.
(D) No change in the noise margins.

Q.14   In the circuit shown, what are the values of F for EN = 0 and EN = 1, respectively?
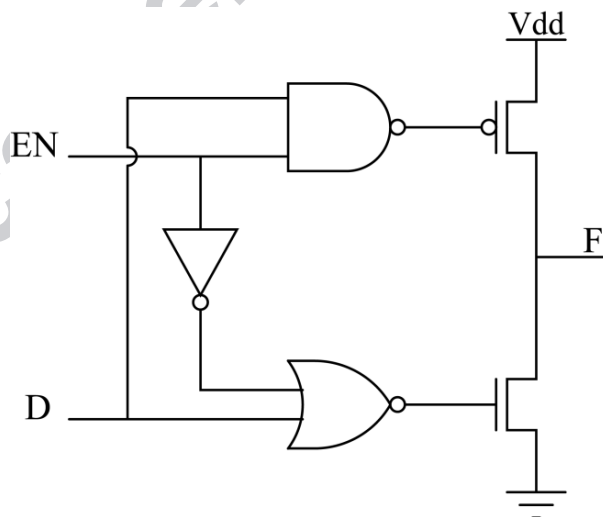
(A) 0 and D
(B) Hi-Z and D
(C) 0 and 1
(D) Hi-Z and $\overline{\text{D}}$

Q.15 In the circuit shown, A and B are the inputs and F is the output. What is the functionality of the circuit?
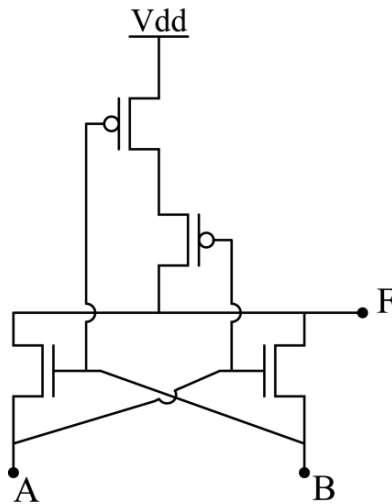
(A) Latch
(B) XNOR
(C) SRAM Cell
(D) XOR

Q.16 The value of the contour integral

$$\frac{1}{2\pi j} \oint \left(z + \frac{1}{z}\right)^2 dz$$

evaluated over the unit circle $|z| = 1$ is _____.

Q.17 The number of distinct eigenvalues of the matrix

$$A = \begin{bmatrix} 2 & 2 & 3 & 3 \\ 0 & 1 & 1 & 1 \\ 0 & 0 & 3 & 3 \\ 0 & 0 & 0 & 2 \end{bmatrix}$$

is equal to _____.

Q.18   If X and Y are random variables such that $E[2X + Y] = 0$ and $E[X + 2Y] = 33$, then
$E[X] + E[Y] =$ _____ .

Q.19   The value of the integral $\int_0^\pi \int_y^\pi \frac{\sin x}{x} dx\ dy$, is equal to _____ .

Q.20   Let Z be an exponential random variable with mean 1. That is, the cumulative distribution
function of Z is given by
$$F_Z(x) = \begin{cases} 1 - e^{-x} & \text{if } x \geq 0 \\ 0 & \text{if } x < 0 \end{cases}$$
Then $\Pr(Z > 2\ |Z > 1)$, rounded off to two decimal places, is equal to _____ .

Q.21   Consider the signal $f(t) = 1 + 2\cos(\pi t) + 3\sin\left(\frac{2\pi}{3}t\right) + 4\cos\left(\frac{\pi}{2}t + \frac{\pi}{4}\right)$, where t is in
seconds. Its fundamental time period, in seconds, is _____ .

Q.22   The baseband signal $m(t)$ shown in the figure is phase-modulated to generate the PM
signal $\varphi(t) = \cos(2\pi f_c t + k\ m(t))$. The time t on the x-axis in the figure is in
milliseconds. If the carrier frequency is $f_c = 50$ kHz and $k = 10\pi$, then the ratio of the
minimum instantaneous frequency (in kHz) to the maximum instantaneous frequency (in
kHz) is _____ (rounded off to 2 decimal places).
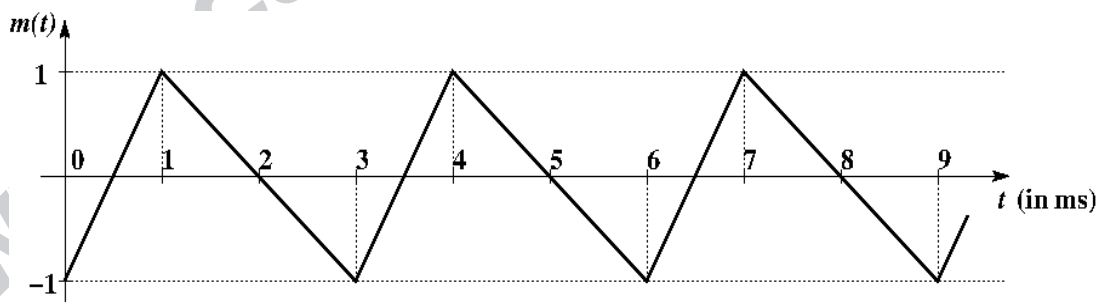
Q.23   Radiation resistance of a small dipole current element of length l at a frequency of 3 GHz is
       3 ohms. If the length is changed by 1%, then the percentage change in the radiation
       resistance, rounded off to two decimal places, is _____ %.

Q.24   In the circuit shown, V_s is a square wave of period T with maximum and minimum values
       of 8 V and -10 V, respectively. Assume that the diode is ideal and $R_1 = R_2 = 50\ \Omega$.
       The average value of V_L is _____ volts (rounded off to 1 decimal place).
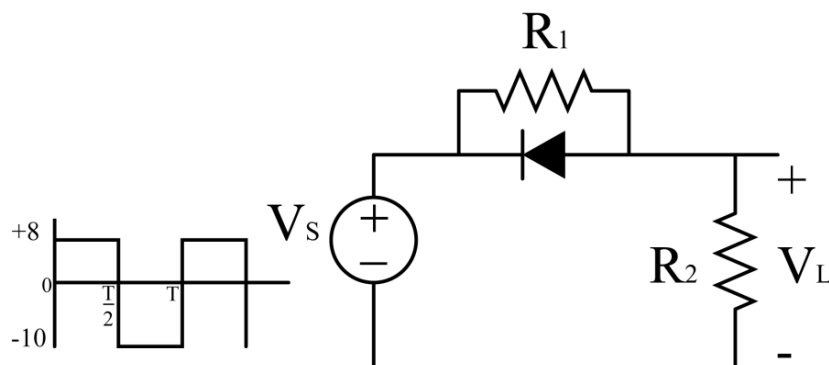
Q.25   In the circuit shown, the clock frequency, i.e., the frequency of the Clk signal, is 12 kHz.
       The frequency of the signal at Q_2 is _____ kHz.
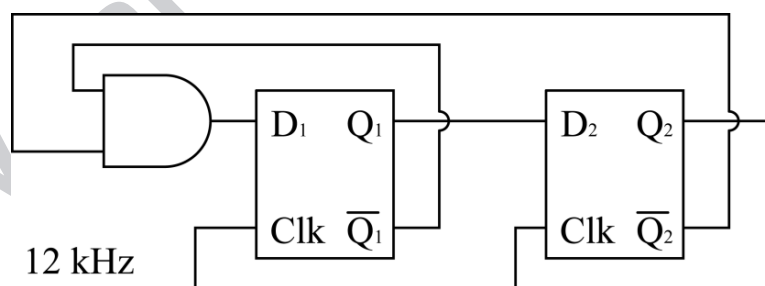
Q. 26 – Q. 55 carry TWO marks each.

Q.26   Consider a differentiable function $f(x)$ on the set of real numbers such that $f(-1) = 0$ and $|f'(x)| \leq 2$. Given these conditions, which one of the following inequalities is necessarily true for all $x \in [-2, 2]$?

(A) $f(x) \leq \frac{1}{2}|x + 1|$
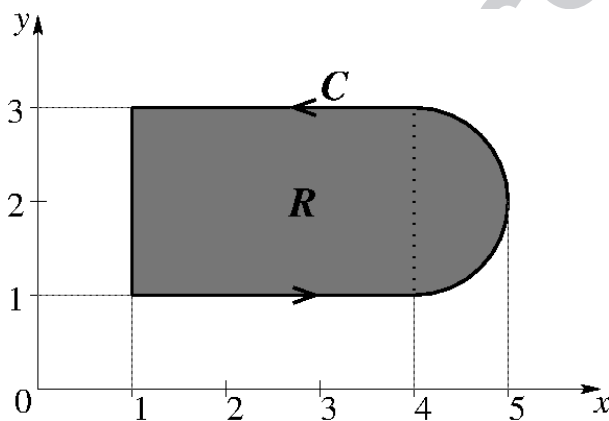
(B) $f(x) \leq 2|x + 1|$

(C) $f(x) \leq \frac{1}{2}|x|$

(D) $f(x) \leq 2|x|$

Q.27   Consider the line integral

$$\int_C (x\,dy - y\,dx)$$

the integral being taken in a counterclockwise direction over the closed curve C that forms the boundary of the region R shown in the figure below. The region R is the area enclosed by the union of a 2×3 rectangle and a semi-circle of radius 1. The line integral evaluates to
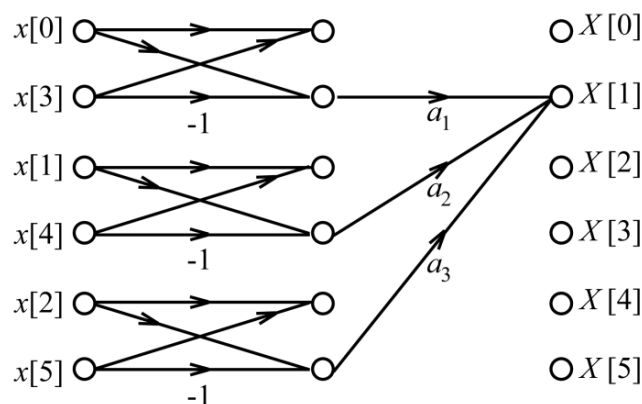

(A) $6 + \pi/2$ (B) $8 + \pi$ (C) $12 + \pi$ (D) $16 + 2\pi$

Q.28 Consider a six-point decimation-in-time Fast Fourier Transform (FFT) algorithm, for which the signal-flow graph corresponding to $X[1]$ is shown in the figure. Let $W_6 = \exp\left(-\frac{j2\pi}{6}\right)$. In the figure, what should be the values of the coefficients a_1, a_2, a_3 in terms of W_6 so that $X[1]$ is obtained correctly?

(A) $a_1 = -1, a_2 = W_6, a_3 = W_6^2$ (B) $a_1 = 1, a_2 = W_6^2, a_3 = W_6$
(C) $a_1 = 1, a_2 = W_6, a_3 = W_6^2$ (D) $a_1 = -1, a_2 = W_6^2, a_3 = W_6$

Q.29 It is desired to find a three-tap causal filter which gives zero signal as an output to an input of the form

$$x[n] = c_1 \exp\left(-\frac{j\pi n}{2}\right) + c_2 \exp\left(\frac{j\pi n}{2}\right),$$
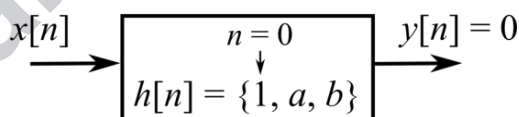
where c_1 and c_2 are arbitrary real numbers. The desired three-tap filter is given by
$$h[0] = 1, \qquad h[1] = a, \qquad h[2] = b$$
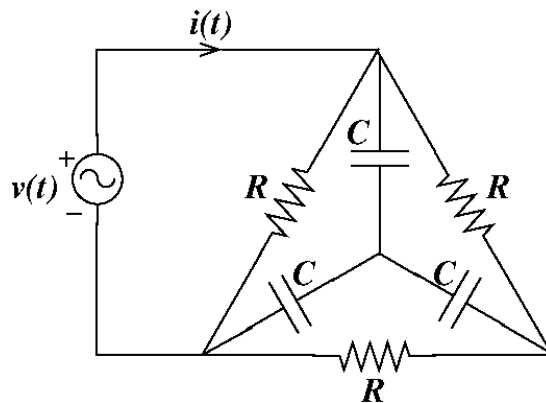and
$$h[n] = 0 \text{ for } n < 0 \text{ or } n > 2.$$
What are the values of the filter taps a and b if the output is $y[n] = 0$ for all n, when $x[n]$ is as given above?

(A) $a = 1, b = 1$ (B) $a = 0, b = -1$ (C) $a = -1, b = 1$ (D) $a = 0, b = 1$

Q.30 In the circuit shown, if $v(t) = 2\sin(1000\,t)$ volts, $R = 1\text{ k}\Omega$ and $C = 1\,\mu\text{F}$, then the steady-state current $i(t)$, in milliamperes (mA), is

(A) $\sin(1000\,t) + \cos(1000\,t)$ (B) $2\sin(1000\,t) + 2\cos(1000\,t)$
(C) $3\sin(1000\,t) + \cos(1000\,t)$ (D) $\sin(1000\,t) + 3\cos(1000\,t)$

Q.31 Consider a causal second-order system with the transfer function
$$G(s) = \frac{1}{1 + 2s + s^2}$$
with a unit-step $R(s) = \frac{1}{s}$ as an input. Let $C(s)$ be the corresponding output. The time taken by the system output $c(t)$ to reach 94% of its steady-state value $\lim_{t\to\infty} c(t)$, rounded off to two decimal places, is

(A) 5.25   (B) 4.50   (C) 3.89   (D) 2.81

Q.32 The block diagram of a system is illustrated in the figure shown, where $X(s)$ is the input and $Y(s)$ is the output. The transfer function $H(s) = \frac{Y(s)}{X(s)}$ is
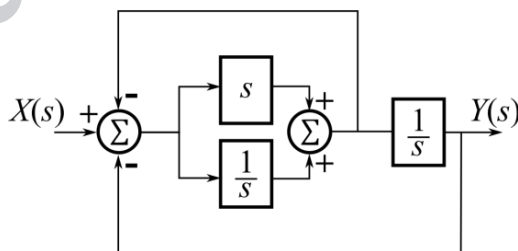
(A) $H(s) = \dfrac{s^2+1}{s^3+s^2+s+1}$

(B) $H(s) = \dfrac{s^2+1}{s^3+2s^2+s+1}$

(C) $H(s) = \dfrac{s+1}{s^2+s+1}$

(D) $H(s) = \dfrac{s^2+1}{2s^2+1}$

Q.33 Let the state-space representation of an LTI system be $\dot{\mathbf{x}}(t) = A\,\mathbf{x}(t) + B\,u(t)$,
$y(t) = C\,\mathbf{x}(t) + d\,u(t)$ where A, B, C are matrices, d is a scalar, $u(t)$ is the input to the
system, and $y(t)$ is its output. Let $B = [0 \quad 0 \quad 1]^T$ and $d = 0$. Which one of the following
options for A and C will ensure that the transfer function of this LTI system is

$$H(s) = \frac{1}{s^3 + 3s^2 + 2s + 1}?$$

(A) $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix}$ and $C = [1 \quad 0 \quad 0]$

(B) $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -2 & -1 \end{bmatrix}$ and $C = [1 \quad 0 \quad 0]$

(C) $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix}$ and $C = [0 \quad 0 \quad 1]$

(D) $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -2 & -1 \end{bmatrix}$ and $C = [0 \quad 0 \quad 1]$

Q.34 A single bit, equally likely to be 0 and 1, is to be sent across an additive white Gaussian
noise (AWGN) channel with power spectral density $N_0/2$. Binary signaling, with
$0 \mapsto p(t)$ and $1 \mapsto q(t)$, is used for the transmission, along with an optimal receiver that
minimizes the bit-error probability.

Let $\varphi_1(t), \varphi_2(t)$ form an orthonormal signal set.

If we choose $p(t) = \varphi_1(t)$ and $q(t) = -\varphi_1(t)$, we would obtain a certain bit-error
probability P_b.

If we keep $p(t) = \varphi_1(t)$, but take $q(t) = \sqrt{E}\,\varphi_2(t)$, for what value of E would we
obtain the **same** bit-error probability P_b?

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

Q.35 The quantum efficiency (η) and responsivity (R) at a wavelength λ (in μm) in a p-i-n
photodetector are related by

(A) $R = \dfrac{\eta \times \lambda}{1.24}$ (B) $R = \dfrac{\lambda}{\eta \times 1.24}$ (C) $R = \dfrac{1.24 \times \lambda}{\eta}$ (D) $R = \dfrac{1.24}{\eta \times \lambda}$

Q.36 Two identical copper wires W1 and W2, placed in parallel as shown in the figure, carry currents I and 2I, respectively, in opposite directions. If the two wires are separated by a distance of 4r, then the magnitude of the magnetic field $\vec{B}$ between the wires at a distance r from W1 is
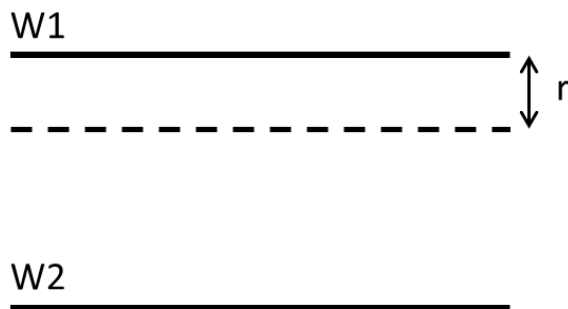
(A) $\dfrac{\mu_0 I}{6\pi r}$

(B) $\dfrac{6\mu_0 I}{5\pi r}$

(C) $\dfrac{5\mu_0 I}{6\pi r}$

(D) $\dfrac{\mu_0^2 I^2}{2\pi r^2}$

Q.37 The dispersion equation of a waveguide, which relates the wavenumber k to the frequency ω, is

$$k(\omega) = (1/c)\sqrt{\omega^2 - \omega_o^2}$$

where the speed of light $c = 3 \times 10^8$ m/s, and ω_o is a constant. If the group velocity is 2×10^8 m/s, then the phase velocity is
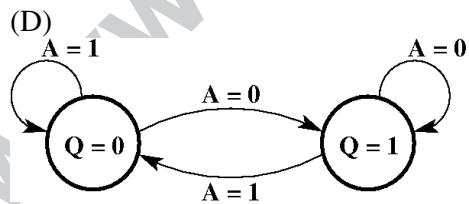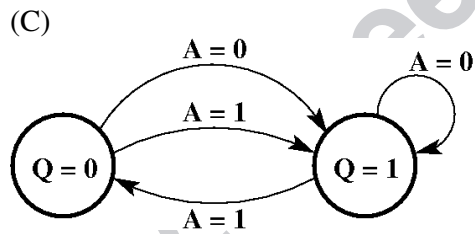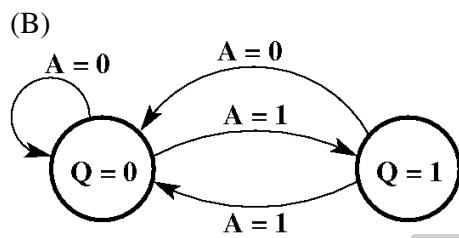
(A) 1.5×10^8 m/s   (B) 2×10^8 m/s   (C) 3×10^8 m/s   (D) 4.5×10^8 m/s

Q.38 In the circuit shown, the breakdown voltage and the maximum current of the Zener diode are 20 V and 60 mA, respectively. The values of R_1 and R_L are 200 Ω and 1 kΩ, respectively. What is the range of V_i that will maintain the Zener diode in the 'on' state?
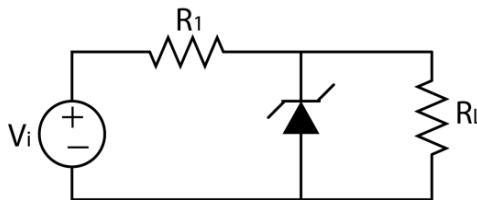
(A) 22 V to 34 V
(B) 24 V to 36 V
(C) 18 V to 24 V
(D) 20 V to 28 V

Q.39 The state transition diagram for the circuit shown is

D Q

Q̄

CLK

1

0

A

(A)

A = 0   A = 0

A = 1

Q = 0   Q = 1

A = 1

(B)

A = 0   A = 0

A = 1

Q = 0   Q = 1

A = 1

(C)

A = 0   A = 0

A = 1

Q = 0   Q = 1

A = 1

(D)

A = 1   A = 0

A = 0

Q = 0   Q = 1

A = 1
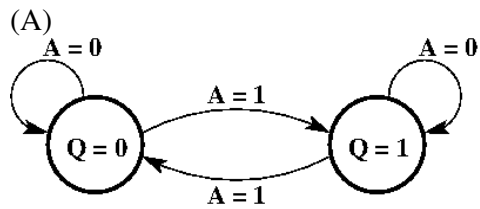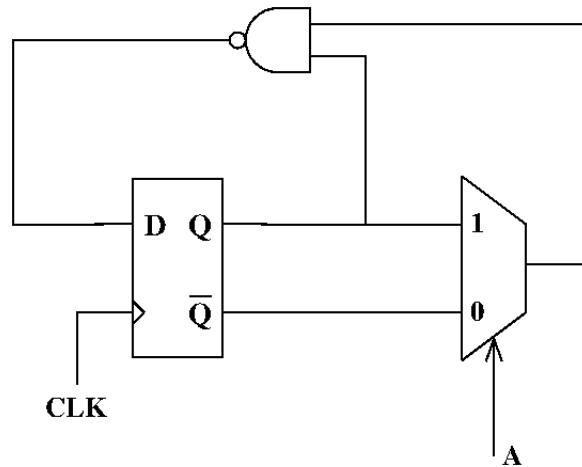
Q.40 In the circuits shown, the threshold voltage of each nMOS transistor is 0.6 V. Ignoring the effect of channel length modulation and body bias, the values of Vout1 and Vout2, respectively, in volts, are
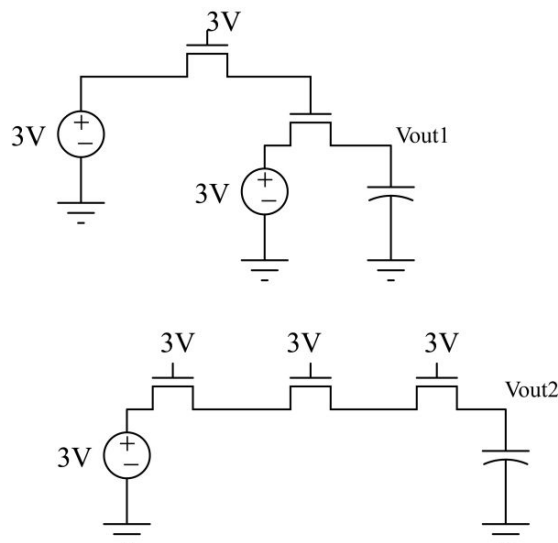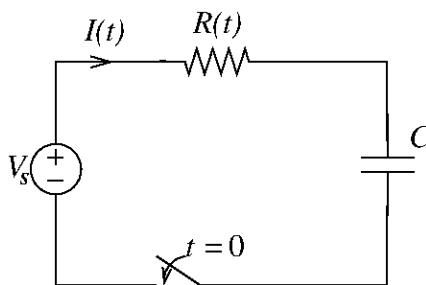

(A) 1.8 and 1.2   (B) 2.4 and 2.4   (C) 1.8 and 2.4   (D) 2.4 and 1.2

Q.41 The RC circuit shown below has a variable resistance $R(t)$ given by the following expression:

$$R(t) = R_0 \left(1 - \frac{t}{T}\right) \text{ for } 0 \le t < T$$

where $R_0 = 1\ \Omega$, and $C = 1$ F. We are also given that $T = 3\ R_0 C$ and the source voltage is $V_s = 1$ V. If the current at time $t = 0$ is 1 A, then the current $I(t)$, in amperes, at time $t = T/2$ is _____ (rounded off to 2 decimal places).

Q.42 Consider a unity feedback system, as in the figure shown, with an integral compensator $\frac{K}{s}$ and open-loop transfer function

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

where $K > 0$. The positive value of K for which there are exactly two poles of the unity feedback system on the $j\omega$ axis is equal to _____ (rounded off to two decimal places).
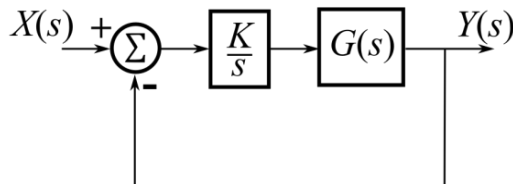
Q.43 Consider the homogeneous ordinary differential equation

$$x^2 \frac{d^2y}{dx^2} - 3x\frac{dy}{dx} + 3y = 0, \qquad x > 0$$

with $y(x)$ as a general solution. Given that
$$y(1) = 1 \quad \text{and} \quad y(2) = 14$$
the value of $y(1.5)$, rounded off to two decimal places, is _____.

Q.44 Let $h[n]$ be a length-7 discrete-time finite impulse response filter, given by

$$h[0] = 4, \qquad h[1] = 3, \qquad h[2] = 2, \qquad h[3] = 1,$$
$$h[-1] = -3, \quad h[-2] = -2, \quad h[-3] = -1,$$

and $h[n]$ is zero for $|n| \geq 4$. A length-3 finite impulse response approximation $g[n]$ of $h[n]$ has to be obtained such that

$$E(h, g) = \int_{-\pi}^{\pi} \left| H(e^{j\omega}) - G(e^{j\omega}) \right|^2 d\omega$$

is minimized, where $H(e^{j\omega})$ and $G(e^{j\omega})$ are the discrete-time Fourier transforms of $h[n]$ and $g[n]$, respectively. For the filter that minimizes $E(h, g)$, the value of $10g[-1] + g[1]$, rounded off to 2 decimal places, is _____ .

Q.45   Let a random process $Y(t)$ be described as $Y(t) = h(t) * X(t) + Z(t)$, where $X(t)$ is a
       white noise process with power spectral density $S_X(f) = 5$ W/Hz. The filter $h(t)$ has a
       magnitude response given by $|H(f)| = 0.5$ for $-5 \leq f \leq 5$, and zero elsewhere. $Z(t)$ is a
       stationary random process, uncorrelated with $X(t)$, with power spectral density as shown in
       the figure. The power in $Y(t)$, in watts, is equal to _____ W (rounded off to two
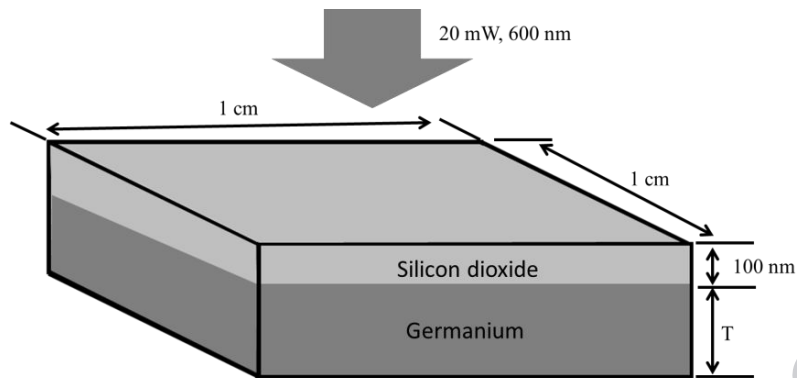   decimal places).
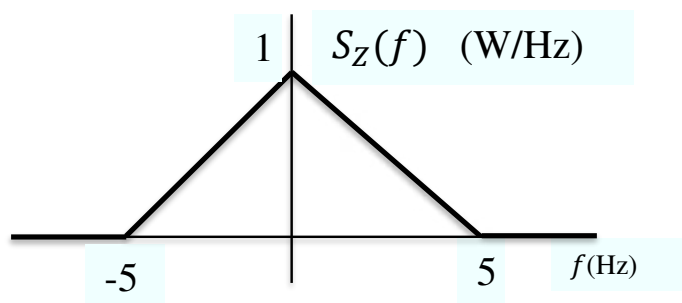
Q.46   A voice signal $m(t)$ is in the frequency range 5 kHz to 15 kHz. The signal is amplitude-
       modulated to generate an AM signal $f(t) = A(1 + m(t)) \cos 2\pi f_c t$, where $f_c = 600$ kHz.
       The AM signal $f(t)$ is to be digitized and archived. This is done by first sampling $f(t)$ at
       1.2 times the Nyquist frequency, and then quantizing each sample using a 256-level
       quantizer. Finally, each quantized sample is binary coded using K bits, where K is the
       minimum number of bits required for the encoding. The rate, in Megabits per second
       (rounded off to 2 decimal places), of the resulting stream of coded bits is _____ Mbps.

Q.47   A random variable X takes values -1 and $+1$ with probabilities 0.2 and 0.8, respectively.
       It is transmitted across a channel which adds noise N, so that the random variable at the
       channel output is $Y = X + N$. The noise N is independent of X, and is uniformly
       distributed over the interval $[-2, 2]$. The receiver makes a decision
       $$\hat{X} = \begin{cases} -1, & \text{if } Y \leq \theta \\ +1, & \text{if } Y > \theta \end{cases}$$
       where the threshold $\theta \in [-1,1]$ is chosen so as to minimize the probability of error
       $\Pr[\hat{X} \neq X]$. The minimum probability of error, rounded off to 1 decimal place, is
       _____.

Q.48   A Germanium sample of dimensions 1 cm × 1 cm is illuminated with a 20 mW,
       600 nm laser light source as shown in the figure. The illuminated sample surface has a
       100 nm of loss-less Silicon dioxide layer that reflects one-fourth of the incident light. From
       the remaining light, one-third of the power is reflected from the Silicon dioxide-
       Germanium interface, one-third is absorbed in the Germanium layer, and one-third is
       transmitted through the other side of the sample. If the absorption coefficient of
       Germanium at 600 nm is 3×10^4 cm^{-1} and the bandgap is 0.66 eV, the thickness of the
   Germanium layer, rounded off to 3 decimal places, is _____ µm.

Q.49   In an ideal pn junction with an ideality factor of 1 at T=300 K, the magnitude of the
       reverse-bias voltage required to reach 75% of its reverse saturation current, rounded off to
       2 decimal places, is ____mV.
       [$k = 1.38 \times 10^{-23}$ JK^{-1}, $h = 6.625 \times 10^{-34}$ J-s, $q = 1.602 \times 10^{-19}$C]

Q.50   Consider a long-channel MOSFET with a channel length 1 µm and width 10 µm. The
       device parameters are acceptor concentration $N_A = 5 \times 10^{16}$ cm^{-3}, electron mobility
       μ_n=800 cm^2/V-s, oxide capacitance/area C_{ox}= 3.45×10^{-7} F/cm^2, threshold voltage
       V_T=0.7 V. The drain saturation current (I_{Dsat}) for a gate voltage of 5 V is _____mA
       (rounded off to two decimal places). [$\varepsilon_0 = 8.854 \times 10^{-14}$F/cm, $\varepsilon_{Si} = 11.9$]

Q.51   A rectangular waveguide of width w and height h has cut-off frequencies for TE$_{10}$ and
       TE$_{11}$ modes in the ratio 1: 2. The aspect ratio w/h, rounded off to two decimal places, is
       _____.

Q.52   In the circuit shown, V_s is a 10 V square wave of period, T = 4 ms with R = 500 Ω and
       C = 10 μF. The capacitor is initially uncharged at t=0, and the diode is assumed to be ideal.
       The voltage across the capacitor (V_c) at 3 ms is equal to _____ volts (rounded off to one
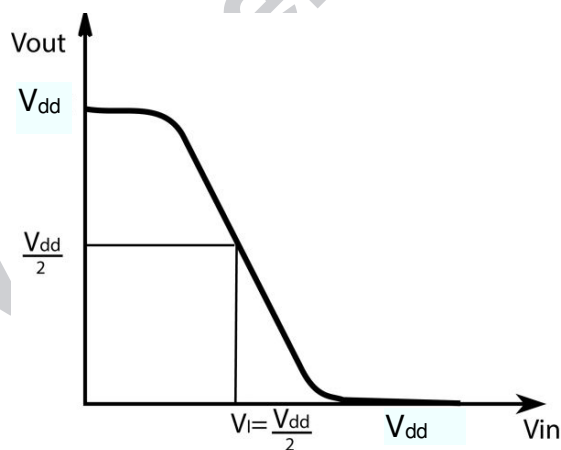   decimal place).
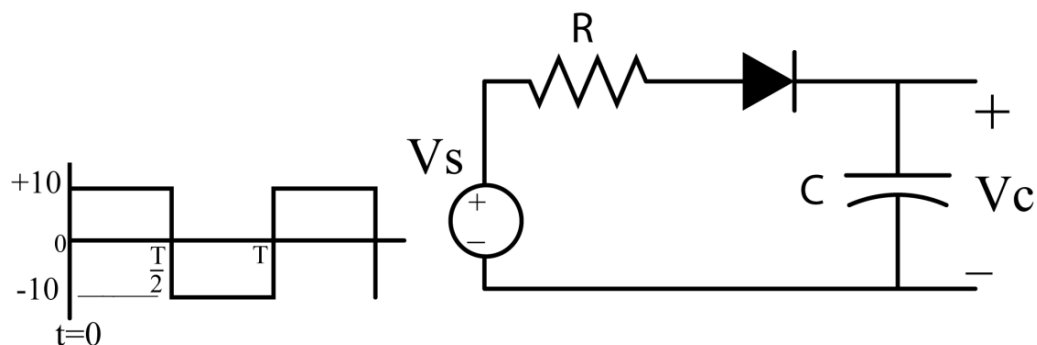
Q.53   A CMOS inverter, designed to have a mid-point voltage V_I equal to half of V_{dd}, as shown
       in the figure, has the following parameters:

       $V_{dd} = 3$ V
       $\mu_n C_{ox} = 100$ μA/V^2 ; $V_{tn} = 0.7$ V for nMOS
       $\mu_p C_{ox} = 40$ μA/V^2; $|V_{tp}| = 0.9$ V for pMOS

       The ratio of $\left(\frac{W}{L}\right)_n$ to $\left(\frac{W}{L}\right)_p$ is equal to _____ (rounded off to 3 decimal places).

Q.54   In the circuit shown, the threshold voltages of the pMOS ($|V_{tp}|$) and nMOS (V_{tn}) transistors are both equal to 1 V. All the transistors have the same output resistance r_{ds} of 6 MΩ. The other parameters are listed below:

$\mu_n C_{ox} = 60 \ \mu A/V^2$; $\left(\dfrac{W}{L}\right)_{nMOS} = 5$

$\mu_p C_{ox} = 30 \ \mu A/V^2$; $\left(\dfrac{W}{L}\right)_{pMOS} = 10$

μ_n and μ_p are the carrier mobilities, and C_{ox} is the oxide capacitance per unit area. Ignoring the effect of channel length modulation and body bias, the gain of the circuit is _____ (rounded off to 1 decimal place).
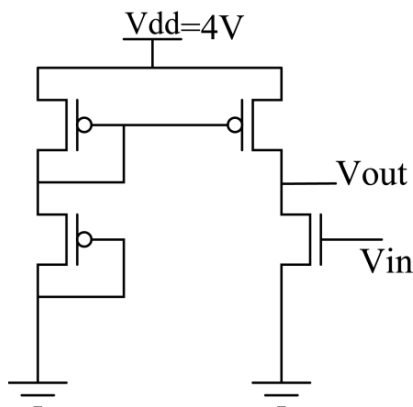
Q.55 In the circuit shown, $V_1 = 0$ and $V_2 = V_{dd}$. The other relevant parameters are mentioned in the figure. Ignoring the effect of channel length modulation and the body effect, the value of I_{out} is _____ mA   (rounded off to 1 decimal place).