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GATE 2016

Detailed Solutions For
Electronics & Communication Engg

Date: 31-01-2016
Afternoon Session

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Q.1 – Q.5 Carry one mark each

01. An apple costs Rs. 10. An onion costs Rs. 8.

Select the most suitable sentence with respect to grammar and usage.

(A) The price of an apple is greater than an onion

(B)The price of an apple is more than onion

(C)The price of an apple is greater than that of an onion

(D)Apples are more costlier than onions

01. Ans: (C)

Sol: Based on the given sentences option 'C' is the correct sentence which is in the comparative degree. Option 'A' and 'B' convey the wrong comparison and 'D' has double comparative and so they are wrong.

02. The Buddha said, "Holding on to anger is like grasping a hot coal with the intent of throwing it at someone else; you are the one who gets burnt."

Select the word below which is closest in meaning to the work underlined above.

(A) Burning (B) igniting (C) clutching (D) flinging

02. Ans: (C)

Sol: The underlined word 'grasping' means clutching or holding something tightly.

03. M has a son Q and a daughter R. He has no other children. E is the mother of P and daughter-in law of M. How is P related to M?

(A) P is the son-in-law of M (B) P is the grandchild of M

(C) P is the daughter in law of M (D) P is the grandfather of M

03. Ans: (B)

Sol: Q and R are the son and Daughter of M, E is the mother of P and daughter-in-law of M means Q and E are married couples in the family

$\therefore$ P is the grandchild of M

04. The number that least fits this set: (324, 441, 97 and 64) is ____________.

(A) 324 (B) 441 (C) 97 (D) 64

04. Ans: (C)

Sol: In the given set of numbers, all are perfect squares but 97 is not

324 is square of 18 $\Rightarrow (18)^2 = 324$

441 is square of 21 $\Rightarrow (21)^2 = 441$

64 is square of 8 $\Rightarrow (8)^2 = 64$

97 is not the square of any number

$\therefore$ The number that least fits in given set is 97.

05. It takes 10s and 15s, respectively, for two trains traveling at different constant speeds to completely pass a telegraph post. The length of the first train is 120 m and that of the second train is150 m. The magnitude of the difference in the speeds of the two trains (in m/s) is ____________.

(A) 2.0 (B) 10.0 (C) 12.0 (D) 22.0

05. Ans: (A)

Sol: $\text{speed of the train (ST)} = \dfrac{\text{length of the train (LT)} + \text{Distance(D)}}{\text{Time (T)}}$

$$(ST) = \frac{LT + D}{T}$$

D = Distance (or) length of the plat form = 0

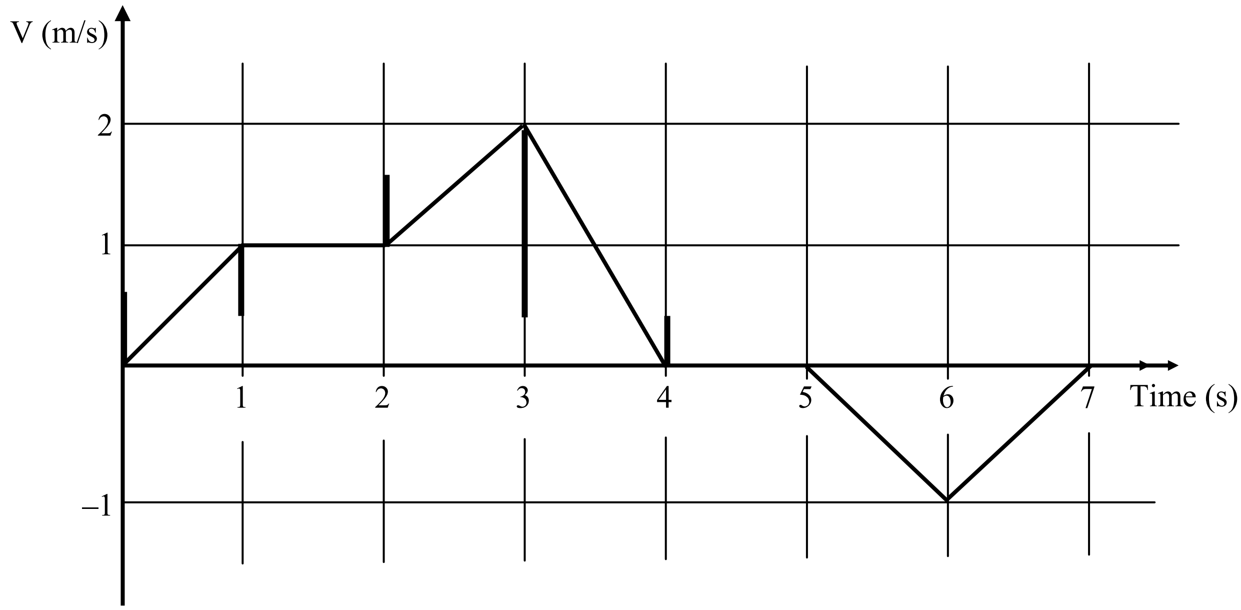
$\therefore$ Speed of the first train $(ST_1) = \dfrac{120}{10} = 12$ m/s

Speed of the second train $(ST_2 = \dfrac{150}{15} = 10$ m/s

$\therefore$ The magnitude of the difference in the speeds of the two trains (m/s) = 12 – 10 = 2

Q.6 – Q.10 carry Two marks each

06. The velocity V of a vehicle along a straight line is measured in m/s and plotted as shown with respect to time in seconds. At the end of the 7 seconds, how much will the odometer reading increase by (in m)?



(A) 0 (B) 3 (C) 4 (D) 5

06. Ans: (D)

Sol: The odometer reading increases from starting point to end point

Area of the given diagram = Odometer reading

Area of the velocity and time graph per second

1^{st} sec $\Rightarrow$ triangle = $\frac{1}{2}\times 1\times 1=\frac{1}{2}$

2^{nd} sec $\Rightarrow$ square = $1 \times 1 = 1$

3^{rd} sec $\Rightarrow$ square + triangle = $1 \times 1 + \frac{1}{2} \times 1 \times 1 = 1\frac{1}{2}$

4^{th} sec $\Rightarrow$ triangle = $\frac{1}{2}\times 1\times 2=1$

5^{th} sec $\Rightarrow$ straight line = 0

6^{th} sec $\Rightarrow$ triangle = $\frac{1}{2}\times 1\times 1=\frac{1}{2}$

7^{th} sec $\Rightarrow$ triangle = $\frac{1}{2}\times 1\times 1=\frac{1}{2}$

Total Odometer reading at 7 seconds

$= \frac{1}{2}+1+1\frac{1}{2}+1+0+\frac{1}{2}+\frac{1}{2}=5$

07. The overshelming number of people infected with rabies in India has been flagged by the World Health Organization as a source of concern. It is estimated that inoculating 70% of pets and stray dogs against rabies can lead to a significant reduction in the number of people infected with rabies.

Which of the following can be logically inferred from the above sentences?

(A) The number of people in India infected with rabies is high.

(B) The number of people in other parts f the world who are infected with rabies is low.

(C) Rabies can be eradicated in India by vaccinating 70% of stray dogs.

(D) Stray dogs are the main source of rabies worldwide.

07. Ans: (A)

Sol: Only option 'A' can be logically inferred from the information provided in the argument.

08. A flat is shared by four first year undergraduate students. They agreed to allow the oldest of them to enjoy some extra space in the flat. Manu is two months older than Sravan, who is three months younger than Trideep. Pavan is one month older than Sravan. Who should occupy the extra space in the falt?

(A) Manu (B) Sravan (C) Trideep (D) Pavan

08. Ans: (C)

Sol: Manu age = sravan age + 2 months

Manu age = Trideep age − 3 months

Pavan age = Sravan's age + 1 month

From this Trideep age > Man> Pavan > Sravan

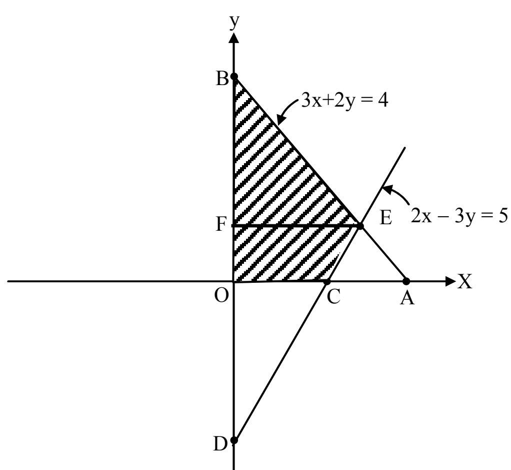
$\therefore$ Trideep can occupy the extra spane in the flat

09. Find the area bounded by the lines 3x+2y=14, 2x-3y=5 in the first quadrant.

(A) 14.95 (B) 15.25 (C) 15.70 (D) 20.23

09. Ans: (B)

Sol:



$A = \left[\frac{14}{3}, 0\right]$ $B = [0,7]$, $C = \left[\frac{5}{2}, 0\right]$ $D = \left[0, \frac{-5}{3}\right]$ E = [4,1], F = [0, 1]

Required area = Area of Δle OAB – Area of Δle CEA

$$= \left(\frac{1}{2} \times \frac{14}{3} \times 7\right) - \left[\frac{1}{2} \times \left(\frac{14}{3} - \frac{5}{2}\right) \times 1\right] = 15.25 \text{ sq.units}$$

Another method:

Required area = Area of Δ^{le} BFE + Area of FEOC

$$= \frac{1}{2}\times 4\times 6+\frac{1}{2}\times(4+2.5)\times 1 = 12 + 3.25 = 15.25 \text{ sq.units}$$

10. A straight line is fit to a data set (In x, y). This line intercepts the abscissa at In x = 0.1 and has a slope of –0.02. What is the value of y at x = 5 from the fit?

(A) –0.030 (B) –0.014 (C) 0.014 (D) 0.030

10. Ans: (A)

Sol: Straight line equation y = mx + c

m = slope = –0.02

set (log x, y)

If log x = X, then set (x, y) → (0.1, 0)

$y = mX + C$

$o = -0.02 \times 0.1 + C$

$\therefore$ C = 0.002

$y = mX + C$

$y = -0.02 \times \log x + C$

@ x = 5

$y = -0.02 \times \log 5 + 0.002$

$= -0.030$

Q.1 – Q.25 Carry one mark each

01. Consider a 2×2 square matrix

$$A = \begin{bmatrix} \sigma & x \\ \omega & \sigma \end{bmatrix}$$

Where x is unknown. If the eigenvalues of the matrix A are $(\sigma + j\omega)$ and $(\sigma - j\omega)$, then x is equal to

(A) $+j\omega$ (B) $-j\omega$ (C) $+\omega$ (D) $-\omega$

01. Ans: (D)

Sol: $\det(A) = \sigma^2 - \omega x$

$= \sigma^2 + \omega^2 = \sigma^2 - \omega x$

$= \omega^2 = -\omega x$

$\omega^2 + \omega x = 0$

$\therefore x = -\omega$

02. For $f(z) = \frac{\sin(z)}{z^2}$, the residue of the pole at z = 0 is ______

02. Ans: 1

Sol: $\frac{\sin z}{z^2} = \frac{1}{z^2}\left\{z - \frac{z^3}{3!} + \frac{z^5}{5!} - \ldots\ldots\ldots\ldots\right\}$

$= \frac{1}{z} - \frac{z}{3!} + \frac{z^3}{5!} - \ldots\ldots.$

Res. f (z) = 1

z = 0

03. The probability of getting a "head" in a single toss of a biased coin is 0.3. The coin is tossed repeatedly till a "head" is obtained. If the tosses are independent, then the probability of getting "head" for the first time in the fifth toss is ______

03. Ans: 0.07203

Sol: $P = (0.7)^4\,(0.3)$

$= 0.07203$

04. The integral $\int_0^1 \frac{dx}{\sqrt{(1-x)}}$ is equal to _______

04. Ans: 2

Sol: $\int_0^1 \frac{dx}{\sqrt{1-x}} = \left\{-2\sqrt{1-x}\right\}_0^1$

$= -2\,[(0) - 1]$

$= 2$

05. Consider the first order initial value problem
$y' = y + 2x - x^2$, $y(0) = 1$, $(0 \le x < \infty)$
with exact solution $y(x) = x^2 + e^x$. For x = 0.1, the percentage difference between the exact solution and the solution obtained using a single iteration of the second-order Runge–Kutta method with step-size h = 0.1 is ________

05. Ans: 0.06%

Sol: $\frac{dy}{dx} = y + 2x - x^2$ $\quad y(0) = 1, \quad 0 \le x < \infty$

Given $f(x, y) = y + 2x - x^2$, $\quad x_o = 0,\ y_o = 1,\ h = 0.1$

$k_1 = hf(x_o, y_o) = 0.1\,(1 + 2(0) - 0^2) = 0.1$

$k_2 = hg\,(x_0 + h, y_0 + k_1) = 0.1\,((y_o + k_1) + 2(x_0 + h) - (x_0 + h)^2)$

$= 0.1\,((1+0.1) + 2(0.1) - (0.1)^2)$

$= 0.1\,(1.1 + 0.2 - 0.01)$

$= 0.129$

$\therefore y_1 = y_0 + \frac{1}{2}(k_1 + k_2)$

$= 1 + \frac{1}{2}(0.1 + 0.129)$

$= 1 + 0.1145 = 1.1145$

Exact solution, $\quad y(x) = x^2 + e^x$

$y(0.1) = (0.1)^2 + e^{0.1}$

$= 0.01 + 1.1052 = 1.1152$

ERROR = 1.1152 – 1.1145

= 0.00069

Relative error = $\frac{0.00069}{1.1152}$

= 0.00062

Percentage Error = 0.00062 × 100 = 0.06%

06. Consider the signal $x(t) = \cos(6\pi t) + \sin(8\pi t)$, where t is in seconds. The Nyquist sampling rate (in samples/second) for the signal $y(t) = x(2t + 5)$ is

(A) 8 (B) 12 (C) 16 (D) 32

06. Ans: (C)

Sol: $x(t) = \cos(6\pi t) + \sin(8\pi t)$

$y(t) = x(2t + 5)$

$y(t) = \cos(12\pi t + 30\pi) + \sin(16\pi t + 40\pi)$

$f_{m1} = 6,\ f_{m2} = 8$

$f_m = 8$ Hz

$(fs)_{min} = 2f_m = 16$ Hz

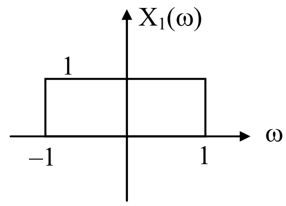
07. If the signal $x(t) = \frac{\sin(t)}{\pi t} * \frac{\sin(t)}{\pi t}$ with * denoting the convolution operation, then x(t) is equal to

(A) $\frac{\sin(t)}{\pi t}$ (B) $\frac{\sin(2t)}{\pi t}$ (C) $\frac{2\sin(t)}{\pi t}$ (D) $\left(\frac{\sin(t)}{\pi t}\right)^2$

07. Ans: (A)

Sol: convolution of two sinc pulses is sinc pulse.

$$x_1(t) = \frac{\sin t}{\pi t}$$



x(t) = $x_1(t) * x_1(t)$

$X(\omega) = X_1(\omega).\ X_1(\omega) = X_1(\omega)$

$$x(t) = x_1(t) = \frac{\sin t}{\pi t}$$

08. A discrete-time signal x[n] = δ[n – 3] + 2δ[n–5] has z-transform X(z). If Y(z) = X (–z) is the z-transform of another signal y[n], then

(A) y[n] = x[n] (B) y[n] = x[–n] (C) y[n] =–x[n] (D) y[n] = –x[–n]

08. Ans: (C)

Sol: $(a)^n x(n) \leftrightarrow X(z/a)$

a = –1

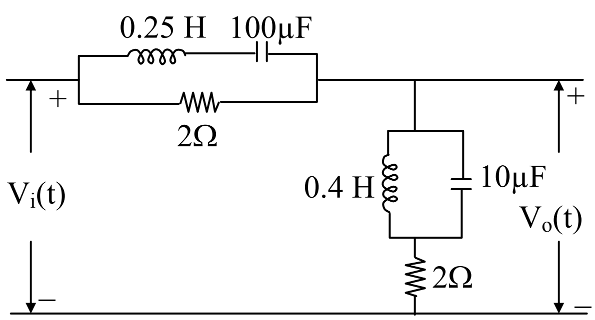
$(-1)^n\ x(n) \leftrightarrow X(-z)$

but x(n) = δ[n – 3] + 2δ[n – 5]

$y(n) = (-1)^n\ x(n) = (-1)^n\ [\delta(n-3) + 2\delta[n-5]$

y(n) = –δ(n – 3) –2δ(n – 5) = –x(n)

09. In the RLC circuit shown in the figure, the input voltage is given by $v_i(t)$ = 2 cos(200t)+4 sin(500t). The output voltage $v_0(t)$ is



(A) cos(200t) + 2 sin(500t) (B) 2cos(200t) + 4 sin(500t)

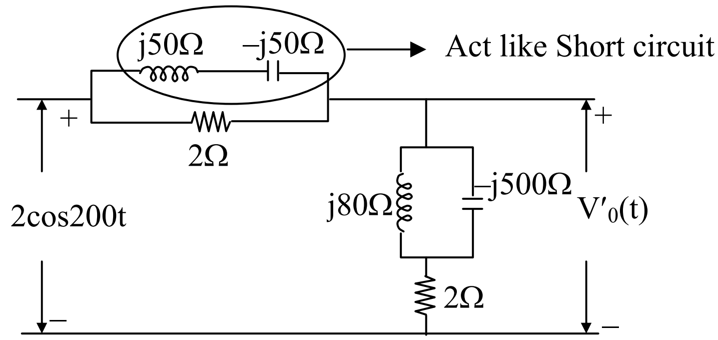
(C) sin(200t) + 2 cos(500t) (D) 2sin(200t) + 4 cos(500t)

09. Ans: (B)

Sol: Given

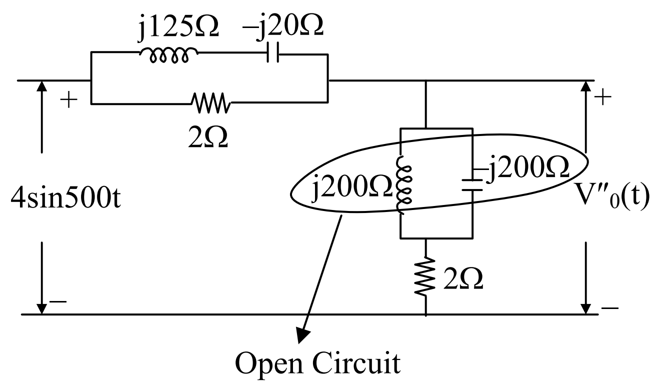
$V_i(t)$ = 2cos200t + 4sin500t

Let us apply SPT [Super Position Theorem] only consider 2cos200t, then circuit becomes



So, $V_0'(t) = 2\cos 200t$

Now only consider 4sin500t, then circuit becomes



So, again $V_0''(t) = 4\sin 500t$

finally according to SPT

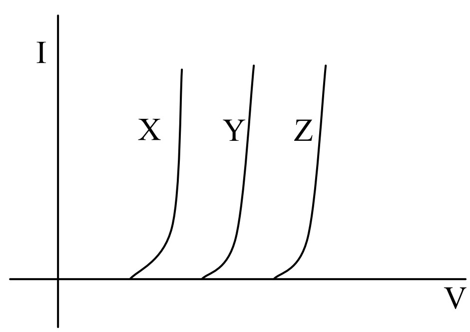
$V_0(t) = V_0'(t) + V_0''(t)$

$V_0(t) = 2\cos(200t) + 4\sin(500t)$

10. The I-V characteristics of three type of diodes at the room temperature, made of semiconductors X, Y and Z, are shown in the figure. Assume that the diodes are uniformly doped and identical in all respects except their materials. If E_{gX}, E_{gY} and E_{gZ} are the band gaps of X, Y and Z, respectively, then

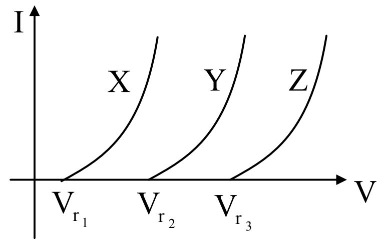
(A) $E_{gX} > E_{gY} > E_{gZ}$ (B) $E_{gX} = E_{gY} = E_{gZ}$

(C) $E_{gX} < E_{gY} < E_{gZ}$ (D) no relationship among these band gaps exists.



10. Ans: (C)

Sol:



Where V_r is cut in voltage.

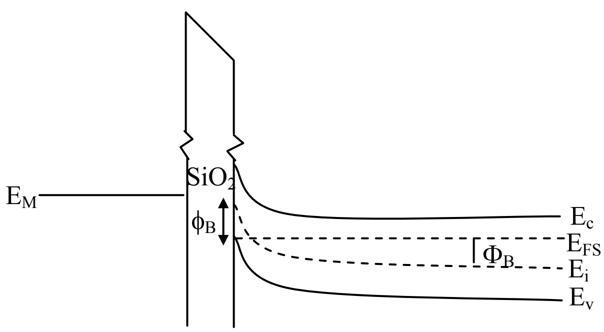
$V_{r_3} > V_{r_2} > V_{r_1}$

$V_r \propto E_g$

So, $E_{gZ} > E_{gy} > E_{gx}$

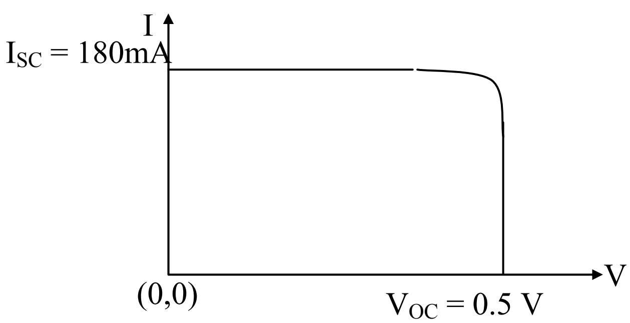
11. The figure shows the band diagram of a Metal Oxide Semiconductor (MOS). The surface region of this MOS is in

(A) inversion (B) accumulation (C) depletion (D) flat band



11. Ans: (A)

12. The figure shows the I-V characteristic of a solar cell illuminated uniformly with solar light of power 100 mW/cm^2. The solar cell has an area of 3 cm^2 and a fill factor of 0.7. The maximum efficiency (in%) of the device is ________



12. Ans: 21

Sol: Fill factor = $0.7 = \dfrac{P_{MAX}}{P_T} = \dfrac{P_{MAX}}{I_{SC}.V_{OC}}$

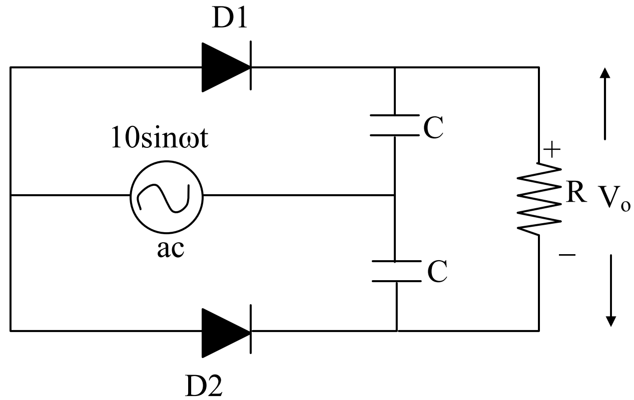
$\rightarrow P_{MAX} = 63\times10^{-3}$ W

($P_T \rightarrow$ Theoretical power)

$\eta_{MAX} = \dfrac{P_{MAX}}{P_{in}}$

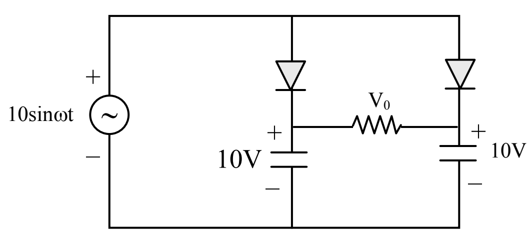
$$= \frac{63\times10^{-3}\,W}{100\times10^{-3}\,\frac{W}{cm^2}\times 3cm^2}\times 100 \quad = 21\%$$

13. The diodes D1 and D2 in the figure are ideal and the capacitors are identical. The product RC is very large compared to the time period of the ac voltage. Assuming that the diodes do not breakdown in the reverse bias, the output voltage V_O (in volt) at the steady state is ________



13. Ans: 0 V

Sol:

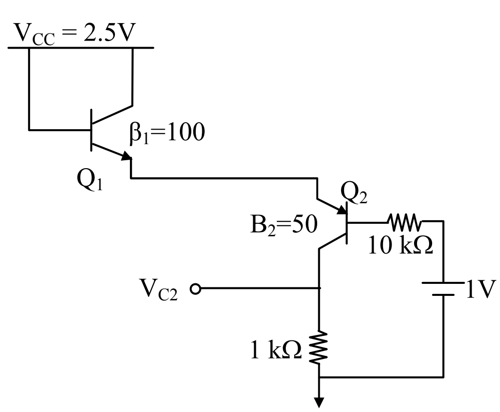


Diodes are ideal therefore during Positive cycle of input $V_0 = 10 - 10 = 0V$.

During Negative cycle, the diodes are Reverse biased $V_0 = 0V$

$\therefore V_0 = 0$ V(always)

14. Consider the circuit shown in the figure. Assuming $V_{BE1} = V_{EB2} = 0.7$ volt, value of the dc voltage V_{C2} (in volt) is _____



14. Ans: 0.5V

Sol: $V_{E1} = 2.5 - 0.7 = 1.8V$

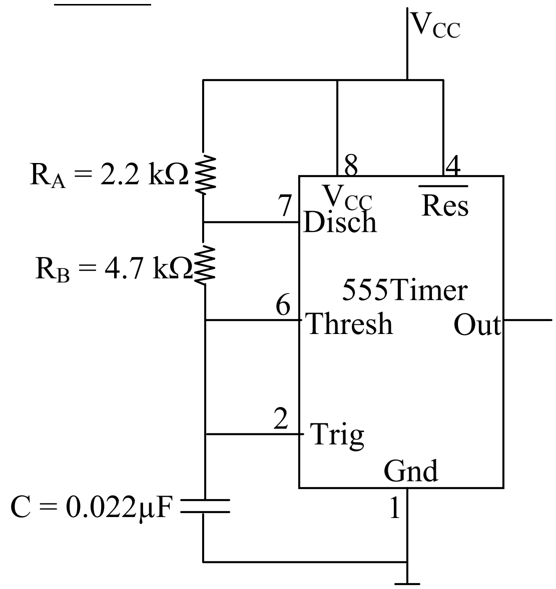
$V_{B2} = V_{E1} - V_{EB2} = 1.8 - 0.7 = 1.1V$

$$I_{B2} = \frac{V_{B2} - 1}{10k} = \frac{1.1 - 1}{10k} = \frac{0.1}{10k}$$

$$I_{C2} = \beta I_{B2} = 50\left[\frac{0.1}{10k}\right]$$

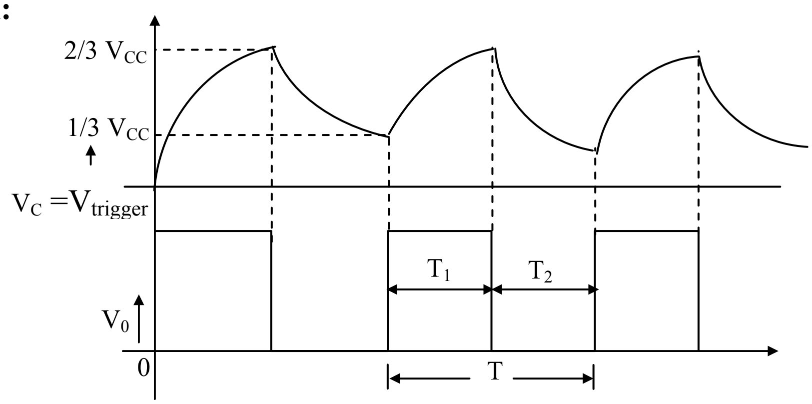
$$V_{C2} = I_{C2}\,(1K) = \frac{50(0.1)}{10k}(1k) = 0.5V$$

15. In the astable multivibrator circuit shown in the figure, the frequency of oscillation (in kHz) at the output pin 3 is ______



15. Ans: 5.65

Sol:



$T_1 = 0.693\,(R_A + R_B)\,C$

$= 0.693\,(2.2k + 4.7k)\,0.022\mu = 0.1052msec$

$T_2 = 0.693\ R_BC$

$= 0.693\ (4.7k)\ 0.022\mu = 0.0716562$msec

Total period $T = T_1 + T_2 = 0.1768562$msec

Frequency of oscillations (f) = 1/ T = 5.65kHz

16. In an 8085 microprocessor, the contents of the accumulator and the carry flag are A7 (in hex) and 0, respectively. If the instruction RLC is executed then the contents of the accumulator (in hex) and the carry flag, respectively, will be
(A) 4E and 0 (B) 4E and 1 (C) 4F and 0 (D) 4F and 1

16. Ans: (D)

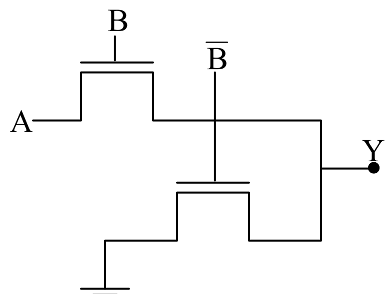
Sol:

Given $A = A7_H =$ | 1 0 1 0 0 1 1 1 | CY 0

After executing RLC $\Rightarrow$ A = | 0 1 0 0 1 1 1 1 | 1

$A = 4F_H$ and cy = 1

17. The logic functionality realized by the circuit shown below is



(A) OR (B) XOR (C) ANAD (D) AND

17. Ans: (D)

Sol: $\therefore$ It is a AND gate

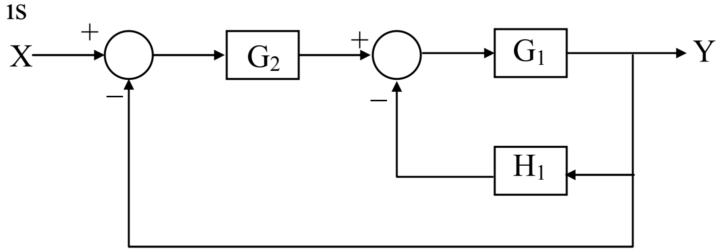
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

18. The minimum number of 2-input NAND gates required to implement a 2-input XOR gate is
(A) 4 (B) 5 (C) 6 (D) 7

18. Ans: (A)

Sol: Min no of NAND gates required for 2- input EX- OR gate = 4

19. The block diagram of a feedback control system is shown in the figure. The overall closed-loop gain G of the system is



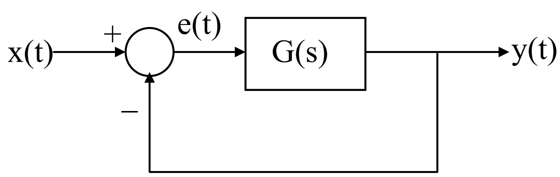
(A) $G = \dfrac{G_1G_2}{1+G_1H_1}$ (B) $G = \dfrac{G_1G_2}{1+G_1G_2+G_1H_1}$ (C) $G = \dfrac{G_1G_2}{1+G_1G_2H_1}$ (D) $G = \dfrac{G_1G_2}{1+G_1G_2+G_1G_2H_1}$

19. Ans: (B)

Sol: From block diagram

$$\frac{Y(s)}{X(s)} = G(s) = \frac{G_1G_2}{1+G_1H_1+G_1G_2}$$

20. For the unity feedback control system shown in the figure, the open-loop transfer function G(s) is given as $G(s) = \dfrac{2}{s(s+1)}$. The steady state error e_{ss} due to a unit step input is



(A) 0 (B) 0.5 (C) 1.0 (D) ∞

20. Ans: (A)

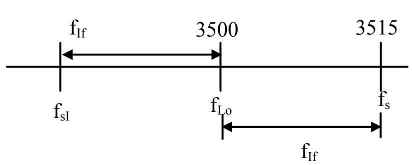
Sol: Given $G(s) = \dfrac{2}{s(s+1)}$, $H(s) = 1$

$\Rightarrow$ Type -1 System, to the unit step input the $e_{ss} = 0$

21. For a superheterodyne receiver, the intermediate frequency is 15 MHz and the local oscillator frequency is 3.5 GHz. If the frequency of the received signal is greater than the local oscillator frequency, then the image frequency (in MHz) is ________

21. Ans: 3485 MHz

Sol:



$f_{If} = 15$ MHz

$f_{Lo} = 3500$ MHz

$f_s - f_{Lo} = f_{If}$

$f_s = f_{Lo} + f_{If} = 3515$ MHz

f_{si} = image frequency = $f_s - 2\,f_{If}$
$= 3515 - 2\times 15$
$= 3485$ MHz

22. An analog baseband signal, band limited to 100 Hz, is sampled at the Nyquist rate. The samples are quantized into four message symbols that occur independently with probabilities $p_1 = p_4 = 0.125$ and $p_2 = p_3$. The information rate (bits/sec) of the message source is ______

22. Ans: 362.255

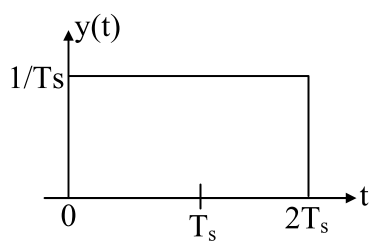
Sol: $P_1 = 0.125$
$P_4 = 0.125$
$P_2 = 0.375$
$P_3 = 0.375$

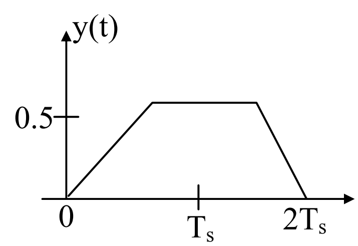
$$H = 0.125\log_2\frac{1}{0.125} + 0.125\log_2\frac{1}{0.125} + 0.375\log_2\frac{1}{0.375} + 0.375\times\log_2\frac{1}{0.375} = 1.811$$

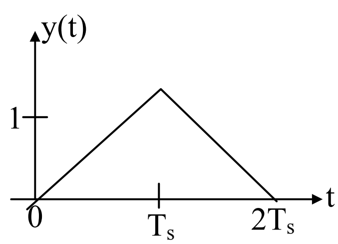
Information rate $= H \times 200$
$= 362.255$

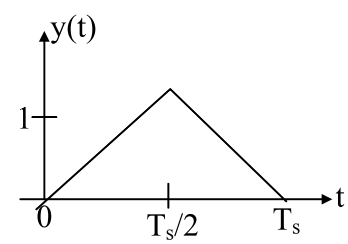
23. A binary baseband digital communication system employs the signal $p(t) = \begin{cases} \frac{1}{\sqrt{T_S}}, & 0 \le t \le T_S \\ 0, & \text{otherwise} \end{cases}$.

For transmission of bits. The graphical representation of the matched filter output y(t) for this signal will be

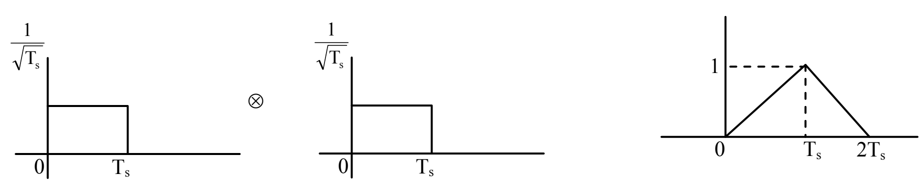
(A)


(B)


(C)


(D)


23. Ans: (C)

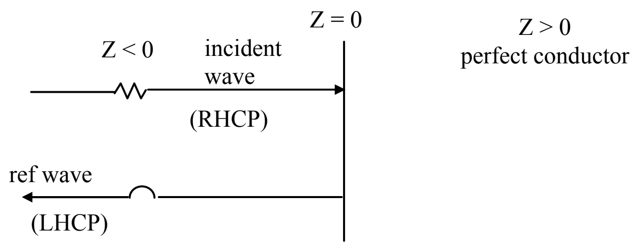
Sol:


24. If a right-handed circularly polarized wave is incident normally on a plane perfect conductor, then the reflected wave will be

(A) right-handed circularly polarized
(B) left-handed circularly polarized
(C) elliptically polarized with a tilt angle of 45°
(D) horizontally polarized

24. Ans: (B)

Sol:



If the wave is incident on perfect conductor then reflection coefficient is given by

$$\Gamma \equiv \frac{E_{r_0}}{E_{i_0}} = -1$$

$$E_{r_0} = E_{i_0} \angle 180^\circ$$

If incident wave is traveling along + Z direction then the reflected wave will be traveling along –Z direction.

∴ The reflected wave is left hand circularly polarized (LHCP)

25. Faraday's law of electromagnetic induction is mathematically described by which one of the following equations?

(A) $\nabla \bullet \vec{B} = 0$
(B) $\nabla \bullet \vec{D} = \rho_v$
(C) $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$
(D) $\nabla \times \vec{H} = \sigma \vec{E} + \frac{\partial \vec{D}}{\partial t}$

25. Ans: (C)

Sol: Differential from of Faraday's law in given by

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \text{(or)}$$

$$\nabla \times \vec{E} = -\mu \frac{\partial \vec{H}}{\partial t}$$

Q.26-Q.55 carry two marks each

26. The particular solution of the initial value problem given below is

$$\frac{d^2y}{dx^2}+12\frac{dy}{dx}+36y=0 \text{ with } y(0)=3 \text{ and } \left.\frac{dy}{dx}\right|_{x=0}=-36$$

(A) $(3-18x)e^{-6x}$ (B) $(3+25x)\,e^{-6x}$ (C) $(3+20x)\,e^{-6x}$ (D) $(3-12x)\,e^{-6x}$

26. Ans :(A)

Sol: $D^2+12D+36=0 \Rightarrow D=-6,-6$

The solution is $y = C_1\,e^{-6x} + C_2xe^{-6x} \rightarrow (1)$

$y(0) = 3 \Rightarrow 3 = C_1$

$(1) \Rightarrow y = 3\,e^{-6x} + C_2xe^{-6x}$

$$\frac{dy}{dx}=-18e^{-6x}+C_2\left\{-6xe^{-6x}+e^{-6x}\right\} \Rightarrow \left.\frac{dy}{dx}\right|_{x=0}=-18+C_2 \Rightarrow -36=-18+C_2$$

$\Rightarrow C_2 = -18$

$\therefore$ The solution is $y = 3\,e^{-6x} - 18\,x\,e^{-6x}$

27. If the vectors $e_1 = (1,0,2)$, $e_2 = (0,1,0)$ and $e_3 = (-2,0,1)$ form an orthogonal basis of the three dimensional real space R^3, then the vector $u = (4,3,-3) \in R^3$ can be expressed as

(A) $u=-\frac{2}{5}e_1-3e_2-\frac{11}{5}e_3$ (B) $u=-\frac{2}{5}e_1-3e_2+\frac{11}{5}e_3$

(C) $u=-\frac{2}{5}e_1+3e_2-\frac{11}{5}e_3$ (D) $u=-\frac{2}{5}e_1+3e_2-\frac{11}{5}e_3$

27. Ans: (D)

Sol: $u = x_1e_1 + x_2\,e_2 + x_3e_3$

$(4,3,-3) = x_1\,(1, 0, 2) + x_2\,(0,1,0) + x_3\,(-2, 0, 1)$

$x_1 - 2x_3 = 4 \rightarrow (1)$

$x_2 = 3 \rightarrow (2)$

$2x_1 + x_3 = -3 \rightarrow (3)$

on solving these equations, we get

$$x_1=-\frac{2}{5}, x_2=3, x_3=\frac{-11}{5}$$

$$\therefore\ u=-\frac{2e_1}{5}+3e_2-\frac{11}{5}e_3$$

28. A triangle in the xy-plane is bounded by the straight lines $2x = 3y$, $y = 0$ and $x = 3$. The volume above the triangle and under the plane $x + y + z = 6$ is ———.

28. Ans: 10

Sol: $$\text{Volume} = \iint z\,dx\,dy = \int_{x=0}^{3}\int_{y=0}^{\frac{2}{3}x}(6-x-y)\,dx\,dy = 10$$

29. The values of the integral $\frac{1}{2\pi j}\oint_c \frac{e^z}{z-2}dz$ along a closed contour c in anti-clockwise direction for

(i) the point $z_0 = 2$ inside the contour c, and
(ii) the point $z_0 = 2$ outside the contour c, respectively, are

(A) (i) 2.72, (ii)0 (B) (i) 7.39, (ii) 0
(C) (i) 0, (ii) 2.72 (D) (i) 0, (ii) 7.39

29. Ans: (B)

Sol: **i)** $\frac{1}{2\pi j}\oint_c \frac{e^z}{(z-2)}dz = \frac{1}{2\pi j}2\pi j f(2) \Rightarrow e^2 = 7.39$

ii) $\frac{1}{2\pi j}\oint_c \frac{e^z}{(z-2)}dz = 0$ ($\because z = 2$ lies out side c)

30. A signal $2\cos\left(\frac{2\pi}{3}t\right) - \cos(\pi t)$ is the input to an LTI system with the transfer function $H(s) = e^s + e^{-s}$ If C_k denotes the k^{th} coefficient in the exponential Fourier series of the output signal, then C_3 is equal to

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

30. Ans: (B)

Sol: $H(e^{j\omega}) = e^{j\omega} + e^{-j\omega} = 2\cos\omega$

It $x(t) = 2\cos\left(\frac{2\pi}{3}t\right)$

$\omega_0 = \frac{2\pi}{3}$

$H(j\omega_0) = 2\cos\left(\frac{2\pi}{3}\right) = 2\left(\frac{-1}{2}\right) = -1$

$y(t) = 2\cos\left(\frac{2\pi}{3}t + 180^0\right)$

$x(t) = \cos\pi t$

$\omega_0 = \pi$

$H(j\omega_0) = 2\cos(\pi) = -2$

$y(t) = 2\cos(\pi t + 180^o)$

$y(t) = 2\cos\left(\frac{2\pi}{3}t + \pi\right) - 2\cos(\pi t + \pi)$

$\omega_1 = \frac{2\pi}{3}$ $\omega_2 = \pi$

$T_1 = 3$ $T_2 = 2$

$T_0 = 6$

$$\omega_0 = \frac{2\pi}{T_0} = \frac{\pi}{3}$$

$y(t) = 2\cos(2\omega_0 t + \pi) - 2\cos(3\omega_0 t + \pi)$

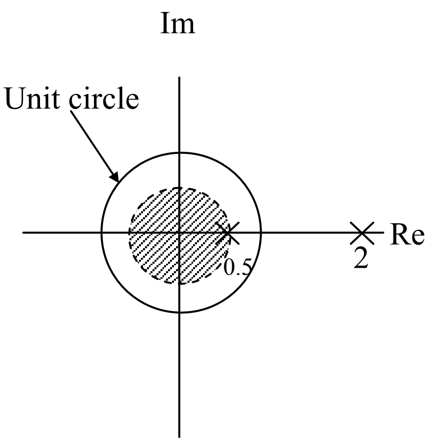
$y(t) = e^{j(2\omega_0 t+\pi)} + e^{-j(2\omega_0 t+\pi)} - e^{j(3\omega_0 t+\pi)} - e^{-j(3\omega_0 t+\pi)}$

$y(t) = -e^{j(2\omega_0 t)} - e^{-j(2\omega_0 t)} + e^{j(3\omega_0 t)} + e^{-j(3\omega_0 t)}$

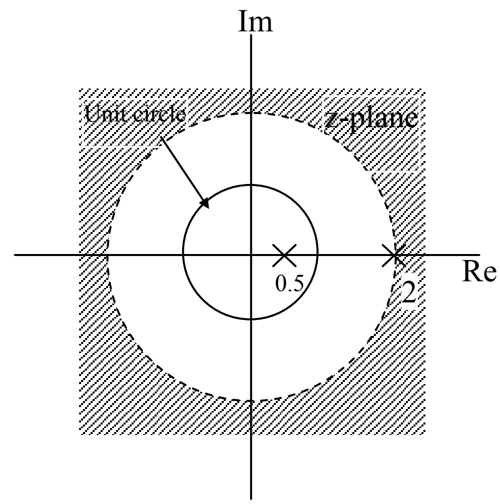
$C_3 = 1$

31. The ROC (region of convergence) of the z-transform of a discrete-time signal is represented by the shaded region in the z-plane. If the signal $x[n] = (2.0)^{|n|}$, $-\infty < n < +\infty$ then the ROC of its z-transform is represented by

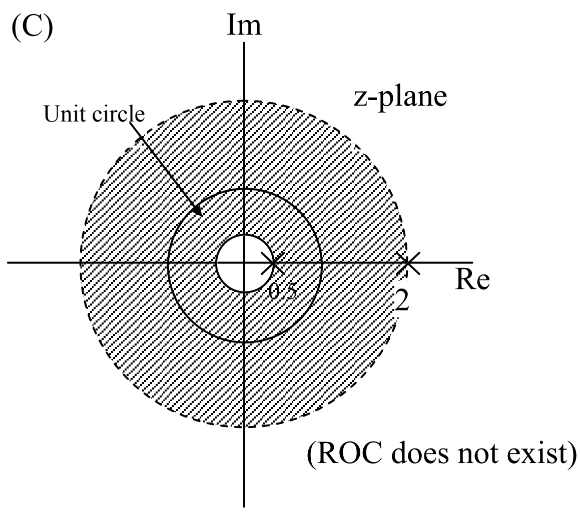
(A)



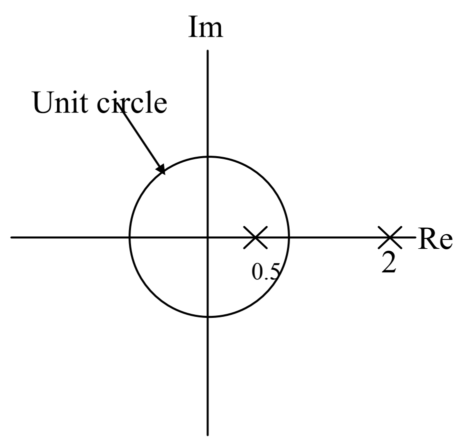
(B)



(C)



(D)



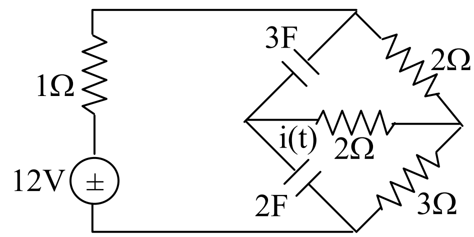
31. Ans: (D)

Sol: $x(y) = (2)^n u(n) + \left(\frac{1}{2}\right)^n u(-n-1)$

roc = $(|z| > 2) \cap (|z| < ½) = \phi$

No ROC

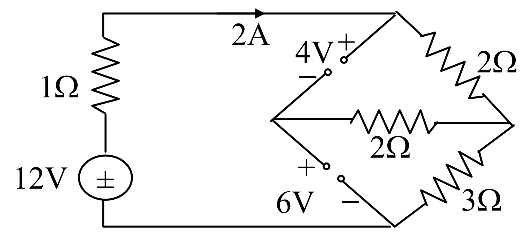
32. Assume that the circuit in the figure has reached the steady state before time t = 0 when the 3Ω resistor suddenly burns out, resulting in an open circuit. The current i(t) (in ampere) at $t = 0^+$ is ——



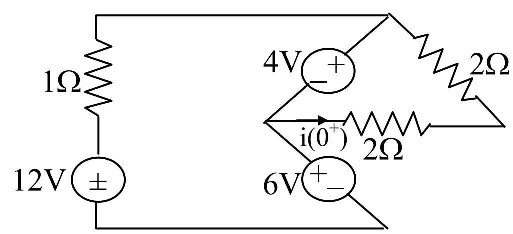
32. Ans: –1A

Sol: Here direction of current & correct component was not mentioned

Circuit at $t = 0^-$



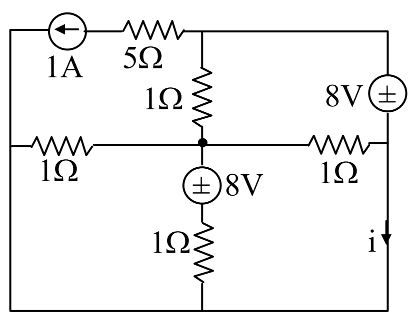
Now $t = 0^+$



So, $i(0+) = \frac{-4}{4} = -1A$

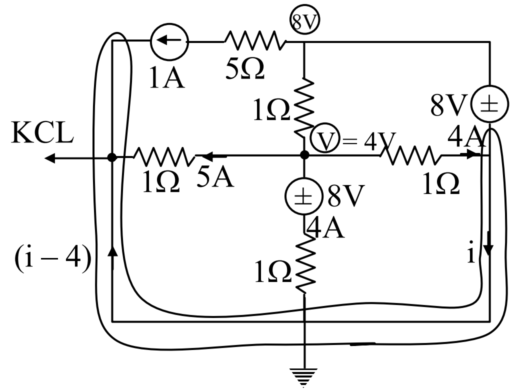
$\therefore$ The magnitude of the current is 1Amp

33. In the figure shown, the current i (in ampere) is ———.



33. Ans: i = –1A

Sol:



Nodal

$$\frac{(V-8)}{1}+\frac{V}{1}+\frac{(V-8)}{1}+\frac{V}{1}=0$$

$4V = 16$

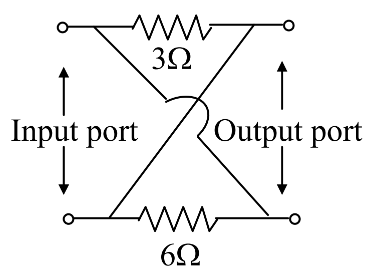
$V = 4$Volts

Now KCL

$i - 4 + 4 + 1 = 0$

$i = -1A$

34. The z-parameter matrix $\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}$ for the two-port network shown is



(A) $\begin{bmatrix} 2 & -2 \\ -2 & 2 \end{bmatrix}$ (B) $\begin{bmatrix} 2 & 2 \\ 2 & 2 \end{bmatrix}$ (C) $\begin{bmatrix} 9 & -3 \\ 6 & 9 \end{bmatrix}$ (D) $\begin{bmatrix} 9 & 3 \\ 6 & 9 \end{bmatrix}$

34. Ans: (A)

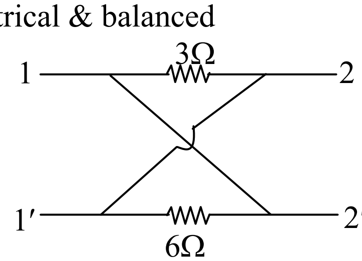
Sol: This is in Lattice form

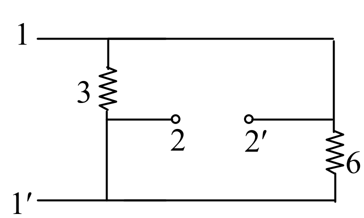
Where $Z_a = 3\Omega$ $Z_b = 0\Omega$

$Z_c = 0\Omega$ $Z_d = 6\Omega$

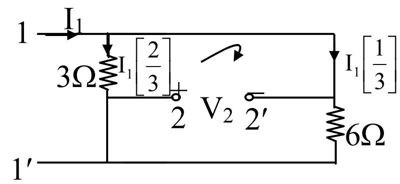
But it is not symmetrical & balanced

rewrite:





So, $Z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2=0} = 3 // 6 = 2\Omega$



$Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0}$

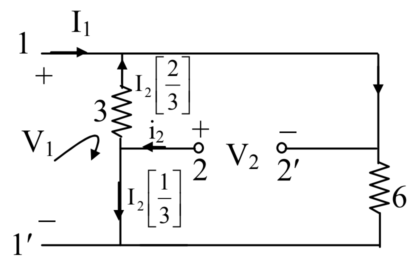
KVL

$-V_2 - 2I_1 + 0 = 0$

$V_2 = -2I_1 \Rightarrow Z_{21} = -2\Omega$

Also

$Z_{22} = \left.\frac{V_2}{I_2}\right|_{I_1=0} = 3 // 6 = 2\Omega$



$Z_{21} = \left.\frac{V_1}{I_2}\right|_{I_1=0}$

KVL

$-V_1 - 2I_2 = 0$

$V_1 = -2I_2$

$\Rightarrow Z_{12} = -2\Omega$

So, final answer

$$|Z| = \begin{bmatrix} 2 & -2 \\ -2 & 2 \end{bmatrix}\Omega$$

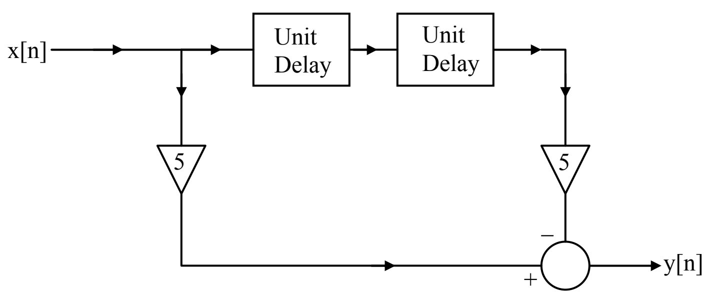
35. A continuous-time speech signal $x_a(t)$ is sampled at a rate of 8 kHz and the samples are subsequently grouped in blocks, each of size N. The DFT of each block is to be computed in real time using the radix-2 decimation-in-frequency FFT algorithm. If the processor performs all operations sequentially, and takes 20 μs for computing each complex multiplication (including multiplications by 1 and –1) and the time required for addition/subtraction is negligible, then the maximum value of N is ——.

35. Ans: 8

Sol: The number of complex multiplications required for DIF- FFT = $\left(\frac{N}{2}\log_2 N\right)$

$$\therefore \left(\frac{N}{2}\log_2 N\right)(20\,\mu\text{sec}) = 125\ \mu\text{sec}$$

36. The direct form structure of an FIR (finite impulse response) filter is shown in the figure.



The filter can be used to approximate a

(A) low-pass filter
(B) high-pass filter
(C) band-pass filter
(D) band-stop filter

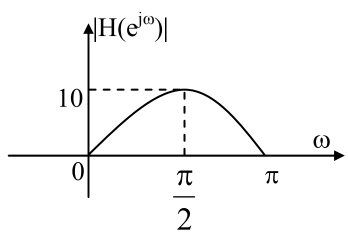
36. Ans: (C)

Sol: $y(n) = 5[x(n) - x(n-2)]$

$Y(e^{j\omega}) = 5[1 - e^{-2j\omega}]\, X(e^{j\omega})$

$H(e^{j\omega}) = 5[1 - e^{-2j\omega}]$

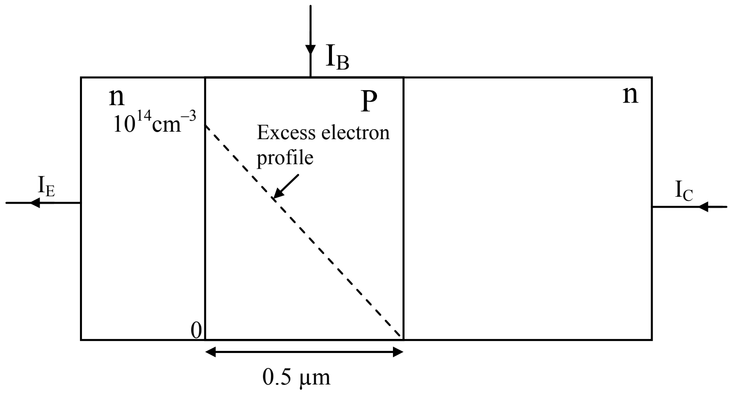
ω	$\lvert H(e^{j\omega})\rvert$
0	0
$\frac{\pi}{2}$	10
π	0



So it is a Band pass filter

37. The injected excess electron concentration profile in the base region of an npn BJT, biased in the active region, is linear, as shown in the figure. If the area of the emitter-base junction is0.001 cm^2, $\mu_n = 800\ cm^2/(V\text{-}s)$ in the base region and depletion layer widths are negligible, then the collector current I_c (in mA) at room temperature is ———.

(Given: thermal voltage V_T = 26mV at room temperature, electronic charge q = 1.6×10^{-19} C)



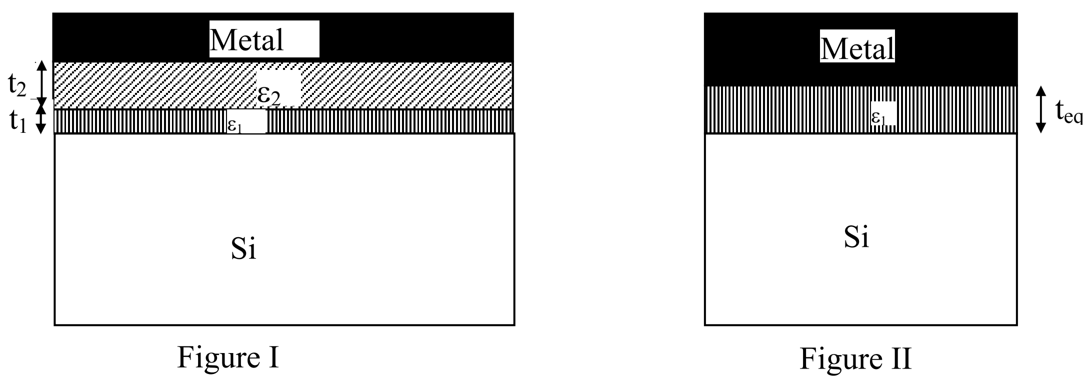
37. Ans: 6.656mA

Sol: $I_C = AeD_n \frac{dn}{dx} = Ae\mu_n V_T \frac{dn}{dx}$

$$I_C = 0.001 \times 1.6 \times 10^{-19} \times 800 \times 0.026$$
$$\times \left(\frac{10^4 - 0}{0.5 \times 10^{-4}}\right)$$

I_C = 6.656mA

38. Figures I and II show two MOS capacitors of unit area. The capacitor in Figure I has insulator materials X (of thickness t_1 = 1 nm and dielectric constant ε_1 = 4) and Y (of thickness t_2 = 3 nm and dielectric constant ε_2 = 20). The capacitor in Figure II has only insulator material X of thickness t_{Eq}. If the capacitors are of equal capacitance, then the value of t_{Eq} (in nm) is ———.



38. Ans: 0.375 nm

Sol: $C = \frac{\varepsilon A}{d}$

$$\frac{C}{A} = \frac{\varepsilon_1 \varepsilon_o}{t_1} + \frac{\varepsilon_2 \varepsilon_o}{t_2}$$

$$= \left[\frac{4}{1\times10^{-9}} + \frac{20}{3\times10^{-9}}\right]8.8521\times10^{-12}$$

$$= \left[4\times10^{9} + 6.667\times10^{9}\right]8.854\times10^{-12}$$

$$= 0.094446 \text{ F/m}^2$$

$$\frac{C}{A} = \frac{\varepsilon}{t_{eq}}$$

$$t_{eq} = \frac{\varepsilon_1\varepsilon_o}{0.094446} = \frac{4\times8.854\times10^{-12}}{0.094446}$$

$$= 0.375 \times 10^{-9} \text{ m}$$

$$= 0.375 \text{ nm}$$

39. The I-V characteristics of the zener diodes D1 and D2 are shown in Figure I. These diodes are used in the circuit given in Figure II. If the supply voltage is varied from 0 to 100V, then breakdown occurs in

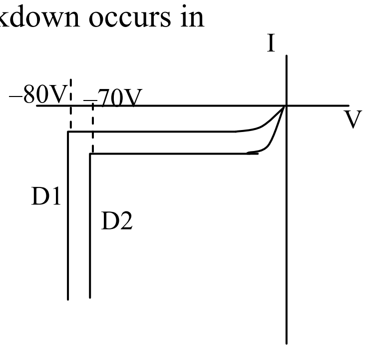


Figure I

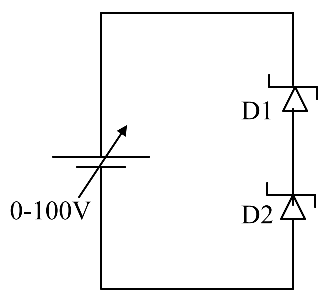
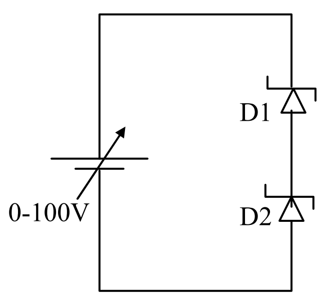


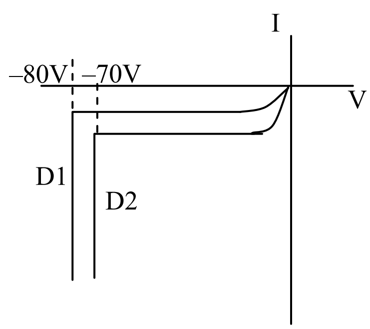
Figure II

(A) D1 only (B) D2 only (C) both D1 and D2 (D) none of D1 and D2

39. Ans: (A)

Sol:





Here both zener diodes are in RB.

$V_{BZ_1} = 80$ V

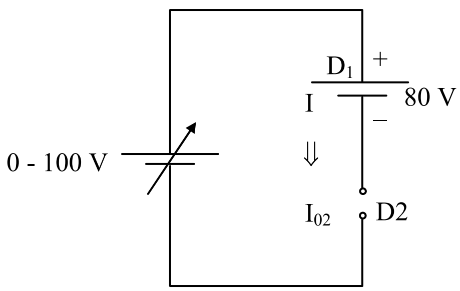
$V_{BZ_2} = 70$ V

D_1 have list saturation current.

When we will vary the voltage above 80V

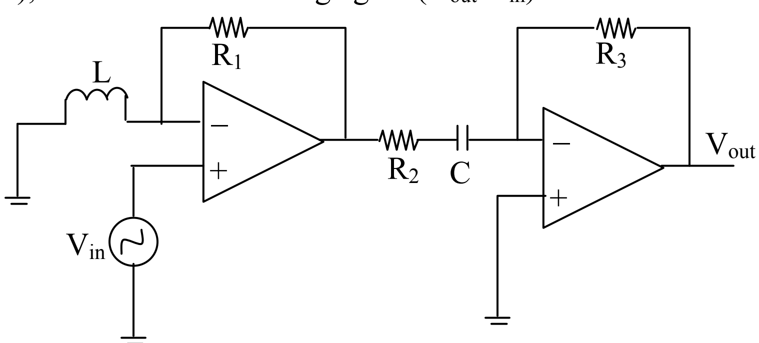
D_1 get breaks down & will replaced by 80V. & through it '∞' current can flow through it.

But because of D_2 we will take minimum current i.e. net current equals to reverse saturation current of D_2 as we know.



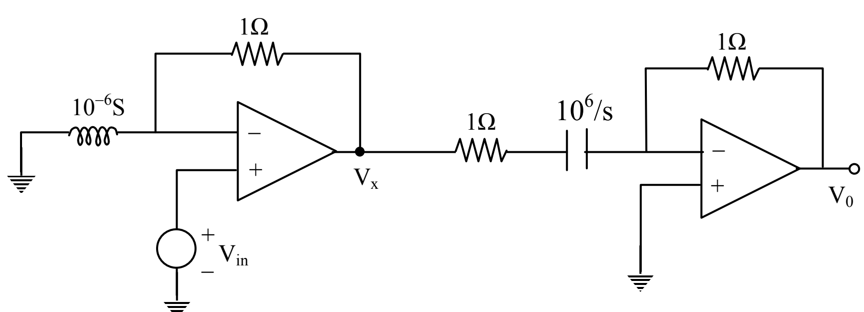
The diode have least saturation will break down first & it will replaced by its break down voltage & the net current equal upto other diode reverse saturation current.

40. For the circuit shown in the figure, $R_1 = R_2 = R_3 = 1\Omega$, $L = 1\ \mu H$ and $C = 1\ \mu F$. If the input $V_{in} = \cos(10^6 t)$, then the overall voltage gain (V_{out}/V_{in}) of the circuit is ———.



40. Ans: –1

Sol:



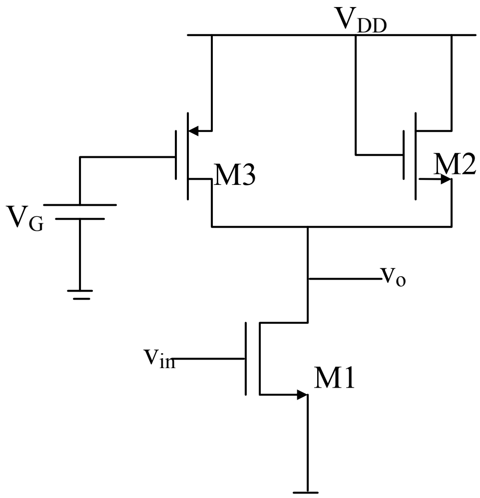
$$\frac{V_x}{V_{in}} = 1 + \frac{1}{10^{-6}s} = 1 + \frac{10^6}{s} = \frac{s + 10^6}{s}$$

$$V_0 = \left[\frac{-1}{1 + \frac{10^6}{s}}\right] V_x = \frac{V_0}{V_x} = \frac{-s}{s + 10^6}$$

$$\therefore \frac{V_0}{V_{in}} = \frac{V_0}{V_x}.\frac{V_x}{V_{in}} = \left[\frac{-s}{s+10^6}\right]\left[\frac{s+10^6}{s}\right] = -1$$

$$\therefore \frac{V_0}{V_{in}} = -1$$

41. In the circuit shown in figure, the channel length modulation of all transistor is non-zero ($\lambda \neq 0$). Also all transistor operate in saturation and have negligible body effect. The ac small signal voltage gain (V_0/V_{in}) of the circuit is



(A) $-g_{m1}\ (r_{01}//r_{02}//r_{03})$

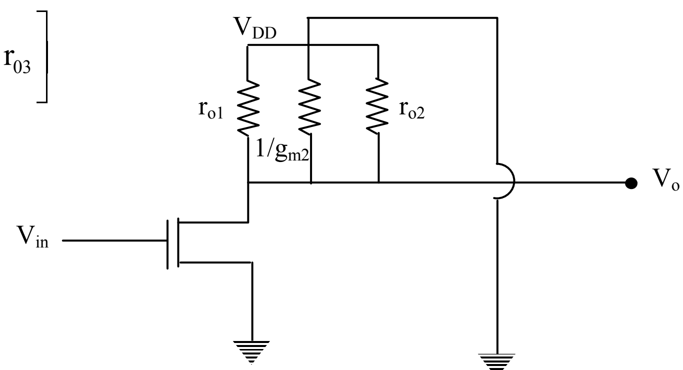
(B) $-g_{m1}(r_{01}//\frac{1}{g_{m3}}//r_{03}$

(C) $-g_{m1}\left(r_{01}//\left(\frac{1}{g_{m2}}//r_{02}\right)//r_{03}\right)$

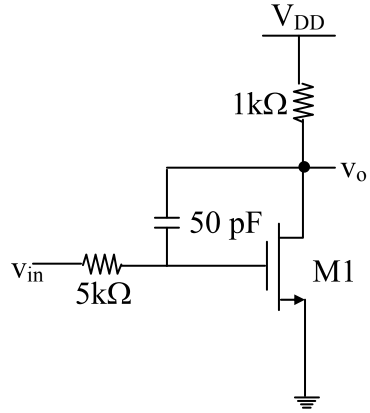
(D) $-g_{m1}\left(r_{01}//\left(\frac{1}{g_{m3}}//r_{03}\right)//r_{02}\right)$

41. Ans: (C)

Sol: $\frac{V_o}{V_{in}} = g_{m1}\left[r_{01} \| \left(\frac{1}{gm_2} \| r_{02}\right) \| r_{03}\right]$



42. In the circuit shown in the figure, transistor M1 is in saturation and has transconductance g_m = 0.01 siemens. Ignoring internal parasitic capacitances and assuming the channel length modulation λ to be zero, the small signal input pole frequency (in kHz) is ______



42. Ans: 57.8745 kHz

Sol: C_{M1} = 50 PF [1 – A_V]

$A_V = -g_m R_D$

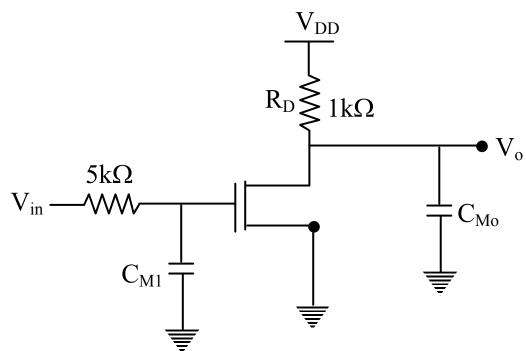
$= -0.01 \times 1$

$A_V = -10$

C_{Mi} = 50PF [1 + 10]

$= 0.55 \times 10^{-9}$F

= 0.55 nF



$$f_p = \frac{1}{2\pi R_i C_{mi}}$$

$$f_p = \frac{1}{2\pi \times 5K \times 0.55mF}$$

$$= \frac{1}{2\pi \times 5 \times 10^3 \times 0.55 \times 10^{-9}}$$

= 57.8745 kHz

43. Following is the K-map of a Boolean function of five variables P,Q,R,S and X. The minimum sum-of –product (SOP) expression for the function is

RS \ PQ	00	01	11	10
00	0	0	0	0
01	1	0	0	1
11	1	0	0	1
10	0	0	0	0

X= 0

RS \ PQ	00	01	11	10
00	0	1	1	0
01	0	0	0	0
11	0	0	0	0
10	0	1	1	0

X= 1

(A) $\overline{P}\,\overline{Q}\,S\,\overline{X} + P\,\overline{Q}\,S\,\overline{X} + Q\,\overline{R}\,\overline{S}\,X + Q\,R\,\overline{S}\,X$ (B) $\overline{Q}\,S\,\overline{X} + Q\,\overline{S}\,X$

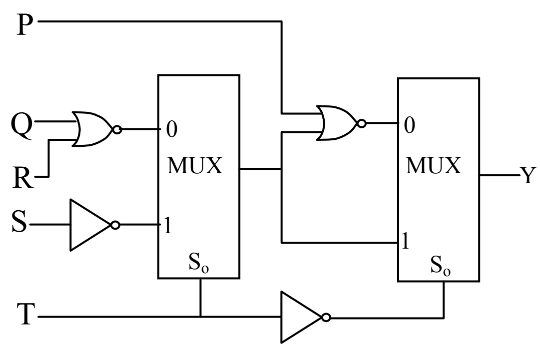
(C) $\overline{Q}\,S\,X + Q\,\overline{S}\,\overline{X}$ (D) $\overline{Q}\,S + Q\,\overline{S}$

43. Ans: (B)

Sol: It is a 5-variable K-map

$= \overline{Q}.S.\overline{X} + Q.\overline{S}.X$

44. For the circuit shown in figure, the delays of NOR gates, multiplexer and inverters are 2ns, 1.5ns and 1ns, respectively. If all the inputs P,Q,R,S and T are applied at the same time instant, the maximum propagation delay (in ns) of the circuit is _______



44. Ans: 7

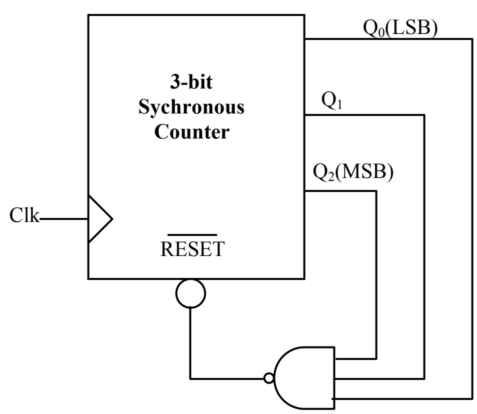
Sol: Max prop. Delay of the circuit is

$= t_{pd,\,NOR} + t_{pd,mux} + t_{pd,\,NOR} + t_{pd,mux}$

$= 2 + 1.5 + 2 + 1.5$

$= 7$ ns

45. For the circuit shown in the figure, the delay of the bubbled NAND gate is 2ns and that of the counter is assumed to be zero



If the clock (Clk) frequency is 1GHz, then the counter behaves as a

(A) mod-5 counter (B) mod-6 counter (C) mod-7 counter (D) mod-8 counter

45. Ans: (D)

Sol: At 6th Clk pulse (i.e. at 6ns) $\Rightarrow Q_2Q_1Q_0 = 110 \Rightarrow$ It makes NAND gate output '0' at 8ns due to its delay. By that time counter receives 7th, 8th Clk pulse and counts 111, 000. Thus it is a Mod – 8 counter

46. The first two rows in the Routh table for the characteristic equation of a certain closed-loop control system are given as

s^3	1	(2K+3)
s^2	2K	4

The range of K for which the system is stable is

(A) –2.0 < K < 0.5 (B) 0< K<0.5 (C) 0<K<∞ (D) 0.5< K <∞

46. Ans: (D)

Sol:

s^3	1	2k+3
s^2	2k	4
s^1	$\frac{2k(2k+3)-4}{2k} > 0$ for stability	
s^0	4	

$4k^2 + 6k - 4 > 0$

$k > -2, k > 0.5$

$0.5 < k < \infty$

47. A second-order linear time-invariant system is described by the following state equations

$$\frac{d}{dt}x_1(t) + 2x_1(t) = 3u(t)$$

$$\frac{d}{dt}x_2(t) + x_2(t) = u(t)$$

Where $x_1(t)$ and $x_2(t)$ are the two state variables and $u(t)$ denotes the input. If the output $c(t) = x_1(t)$, then the system is

(A) controllable but not observable

(B) observable but not controllable

(C) both controllable and observable

(D) neither controllable nor observable

47. Ans: (A)

Sol: $\dot{x}_1 = -2x_1 + 3U$

$\dot{x}_2 = -x_2 + U$

$c = x_1$

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

$$[c] = [1 \quad 0]\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

By applying Gilbert's test, the system is controllable but not observable.

48. The forward-path transfer function and the feedback-path transfer function of a single loop negative feedback control system are given as $G(s) = \frac{K(s+2)}{s^2+2s+2}$ and H(s) = 1 respectively. If the variable parameter K is real positive, then the location of the breakaway point on the root locus diagram of the system is ______

48. Ans: – 3.41

Sol: Given $G(s) = \frac{k(s+2)}{(s^2+2s+2)}$, H(s) = 1

Break away point $\Rightarrow \frac{dk}{ds} = 0$

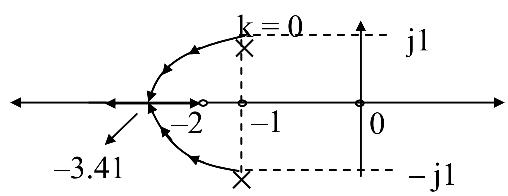
$$\frac{d}{ds}\left(\frac{s+2}{s^2+2s+2}\right) = 0$$

$$\Rightarrow \left[\frac{1(s^2+2s+2)-(s+2)(2s+2)}{(s^2+2s+2)^2}\right] = 0$$

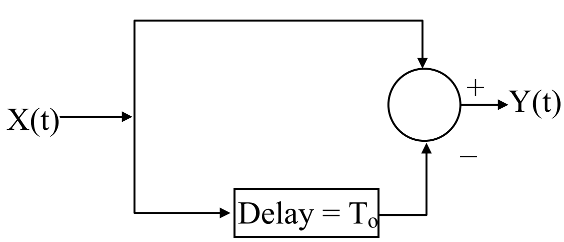
$\Rightarrow -s^2 - 4s - 2 = 0$

$\Rightarrow -0.58, -3.41$

Valid BAP is –3.41



49. A wide sense stationary random process X(t) passes through the LTI system shown in the figure. If the autocorrelation function of X(t) is $R_X(\tau)$, then the autocorrelation function $R_Y(\tau)$ of the output Y(t) is equal to



(A) $2R_X(\tau)+R_X(\tau-T_0)+R_X(\tau+T_0)$
(B) $2R_X(\tau)-R_X(\tau-T_0)-R_X(\tau+T_0)$
(C) $2R_X(\tau)+2R_X(\tau-2T_0)$
(D) $2R_X(\tau)-2R_X(\tau-2T_0)$

49. Ans: (B)

Sol: $Y(t) = X(t) - X(t - T_o)$

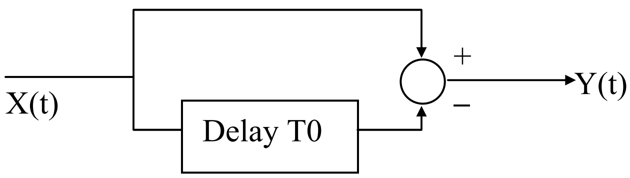
ACf of o/p = $R_y(\tau) = E[y(t)\, Y(t + \tau)]$

$R_y(\tau) = E[(X(t) - X(t - T_o)]\,[X(t + \tau) - X(t + \tau - T_o)]$

$R_y(\tau) = E[(X(t)\, X(t + \tau) - X(t)\, X(t + \tau - T_o) - X(t - T_o)\, X(t + \tau) + X(t - T_o)\, X(t + \tau - T_o)]$

$R_y(\tau) = [R_x(\tau) - R_x(\tau - T_o) - R_x(\tau + T_o) + R_x(\tau)]$

$R_y(\tau) = 2\, R_x(\tau) - R_x(\tau - T_o) - R_x(\tau + T_o)$



50. A voice-grade AWGN (additive white Gaussian noise) telephone channel has a bandwidth of 4.0 kHz and two-sided noise power spectral density $\frac{\eta}{2} = 2.5\times10^{-5}$ Watt per Hz. If information at the rate of 52 kbps is to be transmitted over this channel with arbitrarily small bit error rate, then the minimum bit energy E_b (in mJ/bit) necessary is _______

50. Ans: 31.503

Sol: C = 52 kbps B = 4 kHz $\frac{No}{2} = 2.5\times10^{-5}$

$N = 4 \times 10^3 \times 2.5 \times 10^{-5} \times 2$

$$C = B\log_2\left[1 + \frac{S}{N}\right]$$

S = 1638.2

$$E_b = \frac{S}{R_b} = \frac{J/sec}{bits/sec} = 31.503$$

$$\frac{C}{B} = \log_1(1 + S/N)$$

$$\Rightarrow \log_2(1 + S/N) = \frac{C}{B}$$

$$\Rightarrow (1 + S/N) = 2^{C/B} = 2^{13} = 8192$$

$\Rightarrow$ S/N = 8191

$$\Rightarrow S = 8191\times4\times10^3\times2.5\times10^{-5}\times2$$

$$= 819.1 \times 2$$

$$E_b = \frac{819.1\times2}{R_b} = 31.503$$

51. The bit error probability of a memoryless binary symmetric channel is 10^{-5}. If 10^5 bits are sent over this channel, then the probability that not more than one bit will be in error is _____

51. Ans: 0.735

Sol: $P = 10^{-5}$ $N = 10^5$

Method 1:

Binomial Method: $n_{C_x} p^x q^{n-x}$

$$P[x=0]+P[x=1] = 10^5{}_{c_0}(10^{-5})^o(1-10^{-5})^{10^5} + 10^5{}_{c_1}(10^{-5})^1(1-10^{-5})^{10^5-1}$$

$$= (1)\,(1) \times 0.367 + 0.367 = 0.735$$

Method 2:

Poisson method $= \dfrac{e^{-\lambda}\lambda^x}{x!}$

$$\lambda = np = 10^{-5}\times 10^5 = 1$$

$$= \frac{e^{-1}(1)^1}{1!} + e^{-1} \Rightarrow 2\times e^{-1} = 0.735$$

52. Consider an air-filled rectangular waveguide with dimensions a = 2.286cm and b = 1.016cm. At 10GHz operating frequency, the value of the propagation constant (per meter) of the corresponding propagation mode is _______

52. Ans: 158.07

Sol: Given

Air filled RWG,

a = 2.286 cm

b = 1.016 cm

f = 10 GHz

Assume dominant mode (TE_{10}) is propagating in the waveguide,

cut-off frequency of TE_{10} mode in given by

$$f_c(TE_{10}) = \frac{c}{2a}$$

$$= \frac{3\times 10^{10}}{2\times 2.286}$$

$f_c = 6.56$ GHz

propagation constant $\bar{\gamma}$ is given by

$$\bar{\gamma} = j\vec{\beta}$$

$$= i\omega\sqrt{\mu_0 \in_0}\sqrt{1-\left(\frac{f_c}{f}\right)^2} \qquad = j2\pi\times 10\times 10^9 \times \frac{1}{3\times 10^8}\sqrt{1-\left(\frac{6.56}{10}\right)^2}$$

$\bar{\gamma} = j158.07\,m^{-1}$

Therefore the value of propagation constant is given by

$|\bar{\gamma}| = 158.07\,m^{-1}$

53. Consider an air-filled rectangular waveguide with dimensions a = 2.286 cm and b = 1.016 cm. The increasing order of the cut-off frequencies for different modes is
(A) $TE_{01} < TE_{10} < TE_{11} < TE_{20}$ (B) $TE_{20} < TE_{11} < TE_{10} < TE_{01}$
(B) $TE_{10} < TE_{20} < TE_{01} < TE_{11}$ (D) $TE_{10} < TE_{11} < TE_{20} < TE_{01}$

53. Ans: (C)

Sol: a = 2.286 cm
b = 1.016 cm
air filled RWG

$$f_{c(TE_{11})} = \frac{c}{2}\sqrt{\frac{1}{a^2}+\frac{1}{b^2}} \quad (\because m = 1, n = 1)$$

$$= \frac{3\times10^{10}}{2}\sqrt{\left(\frac{1}{(2.216)^2}+\frac{1}{1.016^2}\right)}$$

$$f_{c(TE_{11})} = 16.15\,\text{GHz}$$

$$f_{c(TE_{01})} = \frac{c}{2b} = \frac{3\times10^{10}}{201.016} = 14.76\,\text{GHz}$$

$$f_{c(TE_{20})} = \frac{c}{a} = \frac{3\times10^{10}}{2.286} = 13.12\,\text{GHz}$$

$$f_{c(TE_{10})} = \frac{c}{2a} = \frac{3\times10^{10}}{2\times2.286} = 6.56\,\text{GHz}$$

∴ Increasing order of the cut-off frequency is given by
$TE_{10} < TE_{20} < TE_{01} < TE_{11}$

54. A radar operating at 5GHz uses a common antenna for transmission and reception. The antenna has again of 150 and is aligned for maximum directional radiation and reception to a regret 1km away having radar cross-section of $3m^2$. If it transmit 100kW, then the received power (in μW) is ________

54. Ans: 0.0122

Sol: Given
frequency, f = 5 GHz = 5×10^9 Hz

wave length, $\lambda = \frac{c}{f} = \frac{3\times10^8}{5\times10^9} = 0.06\,\text{m}$

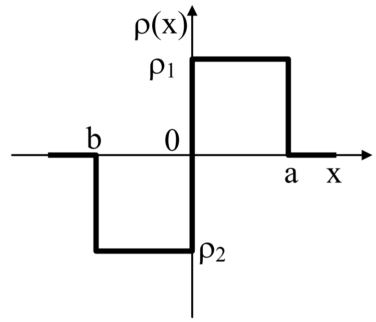
gain of antenna, G = 150
Range of target, R_{max} = 1 km = 10^3 m,
radar cross-section, $\sigma = 3m^2$,
transmitted power, P_t = 100 kW
The RADAR range equation is given by

$$R_{max} = \left[\frac{P_t \times G \times \frac{\lambda^2}{4\pi} \times G \times \sigma}{(4\pi)^2 \times P_R}\right]^{\frac{1}{4}} \quad \left(\because A_e = \frac{\lambda^2}{4\pi}G\right)$$

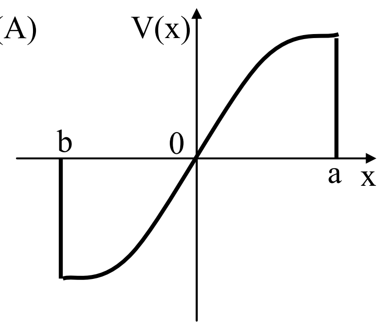
The received power, P_R is given by

$$P_R = \frac{100\times10^3\times150\times150\times(0.06)^2\times3}{(4\pi)^3\times(10^3)^4} = 1.22\times10^{-8} = 0.0122\ \mu W$$

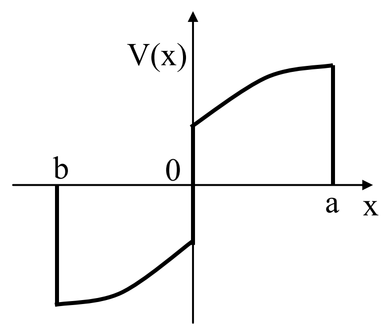
55. Consider the charge profile shown in figure. The resultant potential distribution is best described by



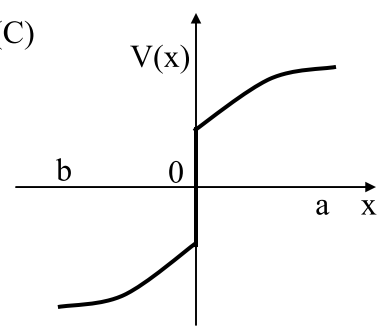
(A)



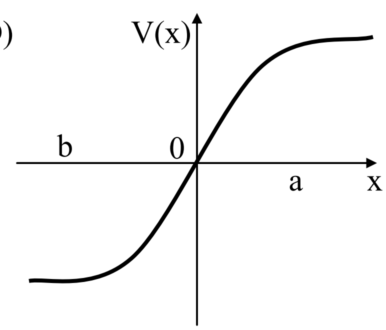
(B)



(C)



(D)



55. Ans: (C)

Sol: Let us consider b = –1 and a = 1.

For line (1):

Here (–1,0) to (0, –1) the line equation is

$$y - 0 = \frac{-1}{1}(t+1)$$

$y = -t-1$

$$\int_{-1}^{t} -(t+1)\,dt = \frac{-(t+1)^2}{2} \quad -1 < t < 0$$

For line (2)

Here (0 , –1) to (1, 0) the line equation is

$y = t - 1$

$\int_0^t (t-1)\,dt = \frac{(t-1)^2}{2}\; 0 < t < 1$

At $t = 0^-$:

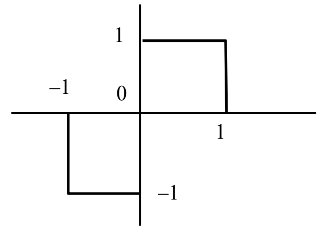
$y = \frac{-(t+1)^2}{2}$

$y = \frac{-1}{2}$

At $t = 0^+$:

$y = \frac{(t-1)^2}{2}$

$y = \frac{1}{2}$



After Ist integration