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GATE - 2021

Questions with Detailed Solutions

ELECTRONICS & COMMUNICATION ENGINEERING

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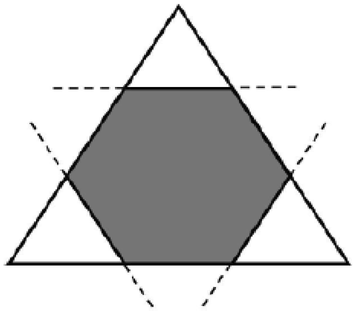
SUBJECTWISE WEIGHTAGE

S. No.	NAME OF THE SUBJECT	1 MARK QUESTIONS	2 MARKS QUESTIONS	Total Marks
1	Verbal Ability	2	1	4
2	Numerical Ability	3	4	11
3	Engineering Mathematics	4	3	10
4	Network Theory	2	4	10
5	Control Systems	2	2	6
6	Digital Circuits & Microprocessors	3	3	9
7	Signals & System	2	3	8
8	EDC & VLSI	2	2	6
9	Analog Circuits	3	3	9
10	EMT	2	4	10
11	Communication Systems	5	6	17
Total No. of Marks		**30**	**35**	**100**

Section : General Aptitude

01.



Corners are cut from an equilateral triangle to produce a regular convex hexagon as shown in the figure above.

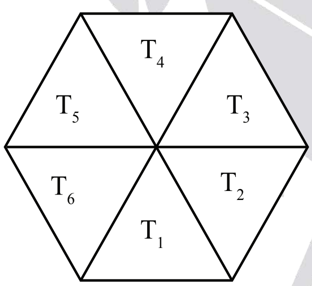
The ratio of the area of the regular convex hexagon to the area of the original equilateral triangle is

(a) 2 : 3 (b) 4 : 5

(c) 5 : 6 (d) 3 : 4

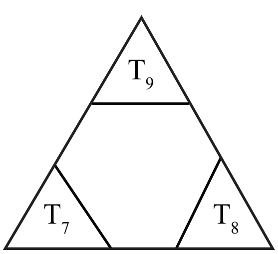
01. Ans: (a)

Sol:



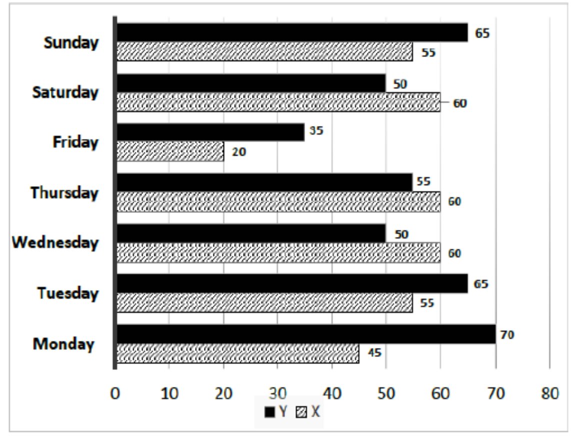
Area Hexagon = 6 Small Area Triangles

$T_7 = T_8 = T_9 = T_1 = T_2 = T_3 = T_4 = T_5 = T_6$ =Equal Areas



$$\frac{\text{Area of Hexagon}}{\text{Area of Original Triangle}} = \frac{6\text{ A}}{9\text{ A}} = \frac{2}{3}$$

02.



The number of minutes spent by two students, X and Y, exercising every day in a given week are shown in the bar chart above.

The number of days in the given week in which one of the students spent a minimum of 10% more than the other student, on a given day, is

(a) 5 (b) 6

(c) 4 (d) 7

02. Ans: (b)

Sol: Sunday 65 > 110 % (55) (Y > X)

Saturday 60 > 110 % (50) (X > Y)

Friday 35 > 110 % (20) (Y > X)

Wednesday 60 > 110 % (50) (X > Y)

Tuesday 65 > 110 % (55) (Y > X)

Monday 70 > 110 % (45) (Y > X)

Total 6 days, one student is 10% more than another student.

03. Nostalgia is to anticipation as ______ is to ______

Which one of the following options maintains a similar logical relation in the above sentence?

(a) Past, future

(b) Present, past

(c) Future, past

(d) Future, present

03. Ans: (a)

Sol: Nostalgia (means excessively sentimental yearning for return to or of some past period) is to anticipation (means visualization of a future event or state)

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04. The current population of a city is 11,02,500. If it has been increasing at the rate of 5% per annum, what was its population 2 years ago?

(a) 12,51,506 (b) 9,92,500

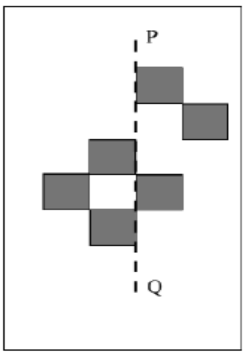
(c) 9,95,006 (d) 10,00,000

04. Ans: (d)

Sol: $P \times (105\%)^2 = 1102500$

$P = 1000000$

05.



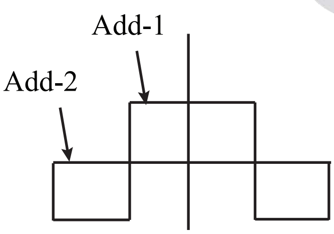
The least number of squares that must be added so that the line P-Q becomes the line of symmetry is ______

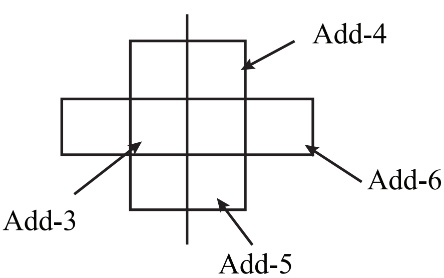
(a) 7 (b) 4

(c) 6 (d) 3

05. Ans: (c)

Sol:





6 squares to be added

06. Consider the following sentences:

(i) I woke up from sleep

(ii) I woked up from sleep

(iii) I was woken up from sleep

(iv) I was wokened up from sleep

Which of the above sentences are grammatically CORRECT ?

(a) (i) and (iv) (b) (i) and (ii)

(c) (ii) and (iii) (d) (i) and (iii)

06. Ans: (d)

Sol: Wake pastense is woke and third form is woken

So, the verb forms are

V1	V2	V3
wake	woke	woken

07. Given below are two statements and two conclusions.

Statement 1: All purple are green.

Statement 2: All black are green.

Conclusion I: Some black are purple.

Conclusion II: No black is purple.

Based on the above statements and conclusions, which one of the following options is logically CORRECT?

(a) Only conclusion II is correct.

(b) Both conclusion I and II are correct.

(c) Only conclusion I is correct.

(d) Either conclusion I or II is correct.

07. Ans: (d)

Sol:

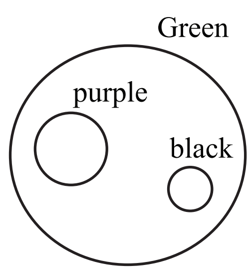


Diagram 1

No black is purple

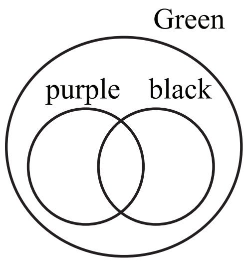


Diagram 2

Some black are purple

From above diagrams (1) & (2), it is clear that either conclusion I or II is correct.

08. Computers are ubiquitous. They are used to improve efficiency in almost all fields from agriculture to space exploration. Artificial intelligence (AI) is currently a hot topic. AI enables computers to learn, given enough training data. For humans, sitting in front of a computer for long hours can lead to health issues.

Which of the following can be deducted from the above passage?

(i) Nowadays, computers are present in almost all places.

(ii) Computers cannot be used for solving problems in engineering.

(iii) For humans, there are both positive and negative effects of using computers.

(iv) Artificial intelligence can be done without data.

(a) (ii) and (iv) (b) (ii) and (iii)

(c) (i) (iii) and (iv) (d) (i) and (iii)

08. Ans: (d)

Sol: The passage deduces that computers are present every where and they have both positive and negative effects on humans.

09. p and q are positive integers and $\frac{p}{q}+\frac{q}{p}=3$,

then, $\frac{p^2}{q^2}+\frac{q^2}{p^2}=$

(a) 3 (b) 7

(c) 9 (d) 11

09. Ans: (b)

Sol: $\frac{p}{q}+\frac{q}{p}=3$

$$\left(\frac{p}{q}+\frac{q}{p}\right)^2=3^2$$

$$\frac{p^2}{q^2}+\frac{q^2}{p^2}+2=9$$

$$\frac{p^2}{q^2}+\frac{q^2}{p^2}=7$$

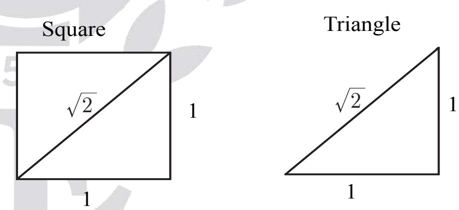
10. Consider a square sheet of side 1 unit. In the first step, it is cut along the main diagonal to get two triangles. In the next step, one of the cut triangles is revolved about its short edge to form a solid cone. The volume of the resulting cone, in cubic units, is ____

(a) $\frac{3\pi}{2}$ (b) 3π

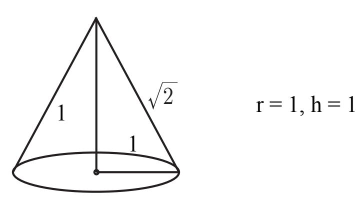
(c) $\frac{2\pi}{3}$ (d) $\frac{\pi}{3}$

10. Ans: (d)

Sol:



Solid core formed by revolving triangle abouts its short edge



Volume of solid cone $=\frac{1}{3}\times\pi\times1^2\times1=\frac{\pi}{3}$

Section : Electronics & Communication Engineering

01. In a high school having equal number is boy students and girl students, 75% of the students study Science and the remaining 25% students study Commerce. Commerce students are two times more likely to be a boy than are Science students. The amount of information gained in knowing that a randomly selected girl student studies Commerce (rounded off to three decimal places) is ________ bits.

01. Ans: 3.3219

Sol: $P(B)=\frac{1}{2},\ P(G)=\frac{1}{2}$

$$P(S)=\frac{3}{4},\ P(C)=\frac{1}{4}$$

$$P\left(\frac{B}{C}\right)=2P\left(\frac{B}{S}\right)$$

$$P(B)=P\left(\frac{B}{C}\right)P(C)+P\left(\frac{B}{S}\right)P(S)$$

$$\frac{1}{2}=P\left(\frac{B}{C}\right).\frac{1}{4}+P\left(\frac{B}{S}\right).\frac{3}{4}$$

$$2=P\left(\frac{B}{C}\right)+3P\left(\frac{B}{S}\right)=P\left(\frac{B}{C}\right)+\frac{3}{2}P\left(\frac{B}{C}\right)$$

$$P\left(\frac{B}{C}\right)=\frac{2}{2.5}=\frac{4}{5}$$

$$P\left(\frac{C}{B}\right)=\frac{P(B/C).P(C)}{P(B)}=\frac{\frac{4}{5}\times\frac{1}{4}}{\frac{1}{2}}=\frac{2}{5}$$

$$P(C)=P\left(\frac{C}{B}\right)P(B)+P\left(\frac{C}{G}\right)P(G)$$

$$\frac{1}{4}=\frac{2}{5}\times\frac{1}{2}+P\left(\frac{C}{G}\right)\frac{1}{2}$$

$$P\left(\frac{C}{G}\right)=\frac{\frac{1}{4}-\frac{1}{5}}{\frac{1}{2}}=\frac{\frac{1}{20}}{\frac{1}{2}}=\frac{1}{10}$$

$$I=-\log_2 P\left(\frac{C}{G}\right)=-\log_2\left(\frac{1}{10}\right)=\log_2 10$$

$$I=3.3219\text{ bits}$$

02. A sinusoidal message signal having root mean square value of 4V and frequency of 1 kHz is fed to a phase modulator with phase deviation constant 2 rad/volt. If the carrier signal is $c(t) = 2\cos(2\pi\, 10^6 t)$, the maximum instantaneous frequency of the phase modulated signal (rounded off to one decimal place) is ____ Hz.

02. Ans: 1011313.7

Sol: $V_{rms}=4=\frac{V_m}{\sqrt{2}}\Rightarrow V_m=4\sqrt{2}$

$$f_m=1\text{kHz}$$

$$K_p=2\text{ rad/volt}$$

$$c(t)=2\cos(2\pi.10^6t)$$

$$s_{PM}(t)=A_C\cos(2\pi f_c t+K_p m(t))$$

$$f_{i,max}=f_c+\frac{K_P}{2\pi}\frac{dm(t)}{dt}\Big|_{max}$$

$$m(t)=4\sqrt{2}\,\mathrm{Cos}(2\pi.10^3t)$$

$$\frac{dm(t)}{dt}=-4\sqrt{2}\times2\pi\times10^3\,\mathrm{Sin}(2\pi10^3t)$$

$$\frac{dm(t)}{dt}\Big|_{max}=|-8\sqrt{2}\pi10^3\,\mathrm{Sin}(2\pi10^3t)|_{max}=8\sqrt{2}\pi10^3$$

$$f_{i,max}=10^6+\frac{2}{2\pi}\times8\sqrt{2}\pi10^3$$

$$f_{i,max}=1011313.7\text{ Hz}$$

03. A speech signal, band limited to 4 kHz, is sampled at 1.25 times the Nyquist rate. The speech samples, assumed to be statistically independent and uniformly distributed in the range –5V to +5V, are subsequently quantized in an 8-bit uniform quantizer and then transmitted over a voice-grade AWGN telephone channel. If the ratio of transmitted signal power to channel noise power is 26 dB, the minimum channel bandwidth required to ensure reliable transmission of the signal with arbitrarily small probability of transmission error (rounded off to two decimal places) is _____ kHz.

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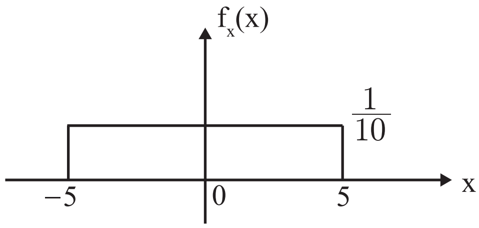
03. Ans: 9.26

Sol: $f_m = 4\text{kHz}$

$f_s = 1.25 \times NR = 1.25 \times 2 \times f_m = 1.25 \times 2 \times 4k$

$= 10k$ samples/sec



$$\text{Message signal power} = E(x^2) = \int_{-5}^{5} x^2 . \frac{1}{10} . dx$$

$$= \frac{1}{10} \cdot \frac{x^3}{3} \Big|_{-5}^{5}$$

$$= \frac{25}{3}$$

n = 8 (8-bit Uniform Quantizer)

$r_b = n.f_s = 8 \times 10k = 80\text{kbps}$

For reliable transmission, $R \le C$

$$R \le B \log\left(1 + \frac{S}{N}\right)$$

$$\frac{S}{N} = 10^{2.6} = 398.107$$

$80 \times 10^3 \le B \log_2 (1 + 398.107)$

$80 \times 10^3 \le B \times 8.64$

$$B \ge \frac{80 \times 10^3}{8.64}$$

$B \ge 9.259\text{kHz}$

$B \ge 9.26$ kHz

04. An antenna with a directive gain of 6 dB is radiating a total power of 16kW. The amplitude of the electric field in free space at a distance of 8 km from the antenna in the direction of 6 dB gain (rounded off to three decimal places) is _______ V/m.

04. Ans: 0.244

Sol: Given: Directive gain

$10 \log D = 6$

$D = 10^{0.6} = 3.98$

$P_{rad} = 16\text{kW}$

$r = 8\text{km}$

Directivity (or) Directive gain is given by

$$D = 4\pi \frac{U_{max}}{P_{rad}}$$

$$D = 4\pi \frac{r^2 W_{rad}}{P_{rad}}$$

$$= \frac{4\pi r^2 \times \left(\frac{E^2}{2\eta}\right)}{P_{rad}}$$

$$E = \sqrt{\frac{P_{rad} \times D \times 2\eta}{4\pi r^2}}$$

$$= \sqrt{\frac{16 \times 10^3 \times 3.98 \times 2 \times 120\pi}{4\pi \times (8 \times 10^3)^2}}$$

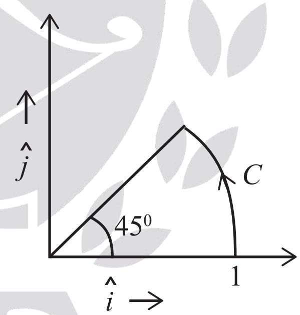
$$= \sqrt{5.97 \times 10^{-2}}$$

$= 0.244$ V/m

$\therefore$ Amplitude of electric field intensity

$E = 0.244$ V/m

05. The vector function $F(r) = -x\hat{i} + y\hat{j}$ is defined over a circular are C shown in the figure.



The line integral of $\int_C F(r).dr$ is

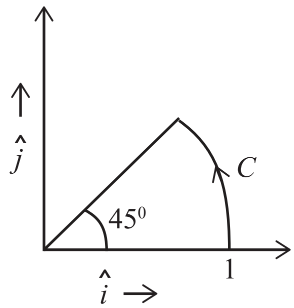
(a) $\frac{1}{2}$ (b) $\frac{1}{3}$

(c) $\frac{1}{4}$ (d) $\frac{1}{6}$

05. Ans: (a)

Sol: Let $I = \int_C \bar{f}(r).d\bar{r} = \int_C (f_1 dx + f_2 dy)$

Then $I = \int_C (-x\, dx + y\, dy)$



But x = r cosθ, Y = r sinθ

⇒ dx = –r sinθ dθ, dy = r cosθ dθ

Here, $\theta: 0$ to $\frac{\pi}{4}$

Now,

$$I = \int_{\theta=0}^{\pi/4} [(-r\cos\theta)(-r\sin\theta)d\theta + (r\sin\theta)(r\cos\theta)d\theta]$$

$$\Rightarrow I = \int_{\theta=0}^{\pi/4} [2r^2\cos\theta\sin\theta]d\theta$$

$$I = -\int_{\theta=0}^{\pi/4} \text{Sin}(2\theta)d\theta \quad (\because r = 1)$$

$$\therefore I = \left(\frac{-\text{Cos}(2\theta)}{2}\right)_0^{\pi/4} = \frac{1}{2}(1-0) = \frac{1}{2}$$

06. An 8-bit unipolar (all analog output values are positive) digital-to-analog converter (DAC) has a full-scale voltage range from 0V to 7.68V. If the digital input code is 10010110 (the leftmost bit is MSB), then the analog output voltage of the DAC (rounded off to one decimal place) is ____ V.

06. Ans: 4.5

Sol: FSO = 7.68V ⇒ $(2^8 - 1)$ stepsize = 7.68

$$\Rightarrow \text{Stepsize} = \frac{7.68}{255}\text{volts}$$

Digital Input = $10010110_2 = 96_{16} = 150_{10}$

Analog output $V_0 = 150_{10} \times \frac{7.68}{255} = 4.5\text{V}$

07. A bar of silicon is doped with boron concentration of 10^{16} cm^{-3} and assumed to be fully ionized. It is exposed to light such that electron-hole pairs are generated throughout the volume of the bar at the rate of 10^{20}cm^{-3}s^{-1}. If the recombination lifetime is 100µs, intrinsic carrier concentration of silicon is 10^{10}cm^{-3} and assuming 100% ionization of boron, then the approximate product of steady-state electron and hole concentrations due to this light exposure is

(a) 10^{32}cm^{-6} (b) 2×10^{20} cm^{-6}

(c) 2×10^{32} cm^{-6} (d) 10^{20} cm^{-6}

07. Ans: (c)

Sol: $N_A = 10^{16}/\text{cm}^3$

$G^1 = 10^{20}/\text{cm}^3$ -S

$\tau = 100$ µs

$n_i = 10^{10}/\text{cm}^3$

Steady state excess carriers

$\delta p = \delta n = \delta$

$\delta = G^1\tau = 10^{20} \times 100 \times 10^{-6}$

$\delta = 10^{16}/\text{cm}^3$

$p_P = p_{Po} + \delta = 2\times10^{16}/\text{cm}^3$

$n_p = n_{Po} + \delta \cong \delta = 10^{16}/\text{cm}^3$

$p_p\, n_p = 2 \times 10^{32}/\text{cm}^6$

08. The content of the registers are R_1 = 25H, R_2 = 30H and R_3 = 40H. The following machine instructions are executed.

PUSH {R_1}

PUSH {R_2}

PUSH {R_3}

POP{R_1}

POP{R_2}

POP{R_3}

After execution, the content of registers R_1, R_2, R_3 are

(a) R_1 = 25H, R_2 = 30H, R_3 = 40H

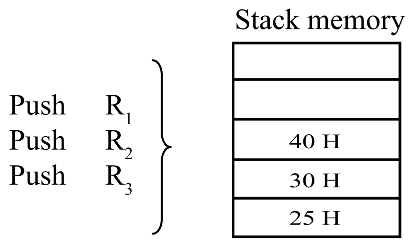
(b) R_1 = 40H, R_2 = 30H, R_3 = 25H

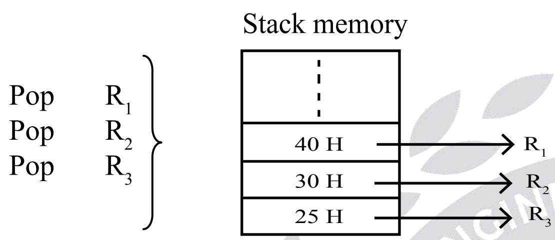
(c) R_1 = 30H, R_2 = 40H, R_3 = 25H

(d) R_1 = 40H, R_2 = 25H, R_3 = 30H

08. Ans: (b)

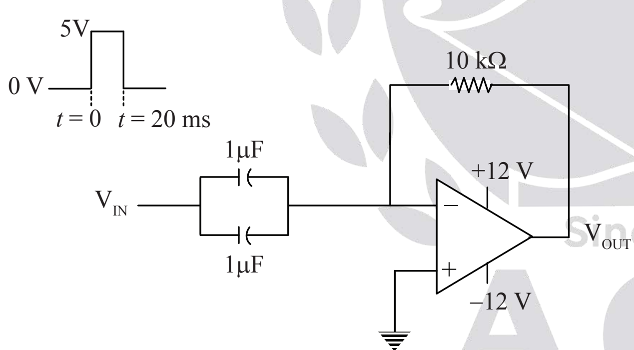
Sol: $R_1 = 25H, R_2 = 30H\ R_3 = 40H$





i.e., $R_1 = 40H, R_2 = 30H, R_3 = 25H.$

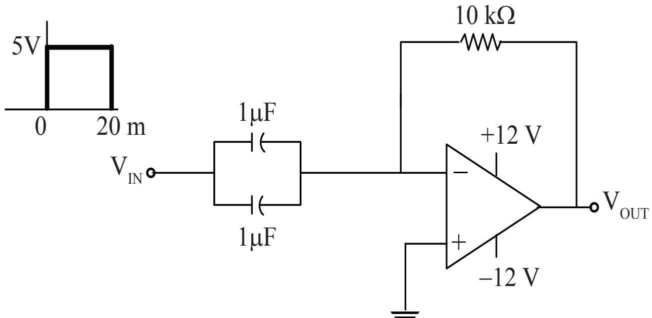
09. A circuit with an ideal OP-AMP is shown in the figure. A pulse V_{IN} of 20 ms duration is applied to the input. The capacitors are initially uncharged.

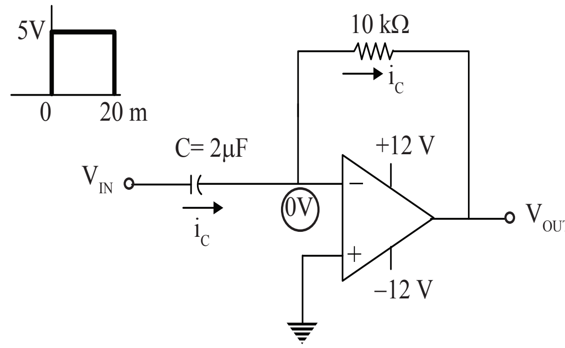


The output voltage V_{OUT} of this circuit at $t = 0^+$ (in integer) is _______ V.

09. Ans: –12

Sol:





$$i_C = \frac{0 - V_0}{R} = C\frac{dV_{in}}{dt}$$

$$V_0 = -RC\frac{d}{dt}V_{in}$$

$= -RC$ [Slope of input V_{in}]

$= -RC\,[\infty]$

$= -V_{sat}$

$= -12V$

10. Consider the integral

$$\oint_C \frac{\sin(x)}{x^2(x^2+4)}dx$$

where C is a counter-clockwise oriented circle defined as $|x - i| = 2$. The value of the integral is

(a) $-\frac{\pi}{8}\sin(2i)$

(b) $\frac{\pi}{4}\sin(2i)$

(c) $-\frac{\pi}{4}\sin(2i)$

(d) $\frac{\pi}{8}\sin(2i)$

10. Ans: no option

Sol: Let $f(x) = \dfrac{\sin(x)}{x^2(x^2+4)}$

$$f(x) = \frac{\sin(x)}{x^2(x+2i)(x-2i)}$$

$x = 0$ is a pole of order 1

$x = 2i, -2i$ are simple poles

UPCOMING BATCHES @ HYDERABAD

GATE + PSUs – 2022 (REGULAR BATCHES)

Batch Type	Timings	Batch Date	Duration	Venue & Streams
Regular	Daily 4 to 6 Hours	**2^{nd} & 17^{th} April 2021**	5 to 6 Months	Abids (CS&IT) Dilsukhnagar (EC, EE, IN) Kothapet (CE, ME, PI)
		1^{st} & 17^{th} May 2021		
		1^{st} & 17^{th} June 2021		

GATE + PSUs - 2022 (FLEXIBLE BATCHES)

Batch Type	Timings	Batch Date	Duration	Venue & Streams
Flexible Batches	Daily 6 to 8 Hours	**5^{th}, 20^{th} July 2021**	3 to 4 Months	Abids (CS&IT) Dilsukhnagar (EC, EE, IN) Kothapet (CE, ME, PI)
		4^{th}, 18^{th} August 2021		

GATE + PSUs – 2022 (SPARK BATCHES)

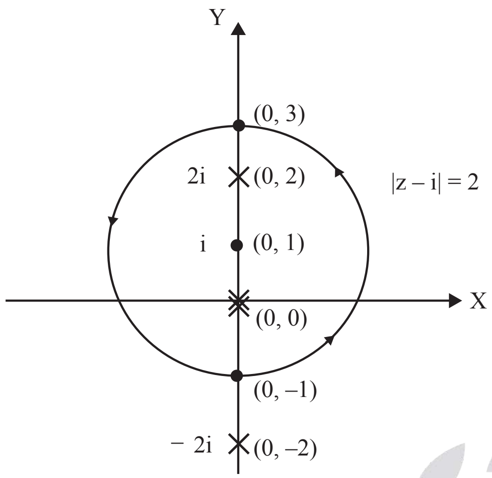
Batch Type	Timings	Batch Date	Duration	Venue & Streams
Spark	Daily 5 to 8 Hours	**17^{th} May 2021**	5 to 6 Months	Abids (CE, ME, CS) Kukatpally (EC, EE)
		1^{st} & 17^{th} June 2021		

ESE + GATE + PSUs – 2022 (REGULAR BATCHES)

Batch Type	Timings	Batch Date	Duration	Venue & Streams
Regular	Daily 6 to 8 Hours	**2^{nd} & 17^{th} April 2021**	9 to 10 Months	Kukatpally (EC, EE) Abids (CE, ME)
		1^{st} & 17^{th} May 2021		
		1^{st} & 17^{th} June 2021		

ESE + GATE + PSUs – 2022 (SPARK BATCHES)

Batch Type	Timings	Batch Date	Duration	Venue & Streams
Spark	Daily 6 to 8 Hours	**17^{th} May 2021**	9 to 10 Months	Kukatpally (EC, EE) Abids (CE, ME)
		1^{st} & 17^{th} June 2021		



$x = -2i$ lies outside $|z - i| = 2$

$$\underset{x=0}{\text{Res}}\, f(x) = \underset{x\to 0}{\text{Lt}}\, x\left\{\frac{\sin x}{x^2(x^2+4)}\right\}$$

$$= \underset{x\to 0}{\text{Lt}}\left\{\frac{\sin x}{(x^3+4x)}\right\}\left(\frac{0}{0}\right)$$

Applying L Hospital rule

$$\underset{x=0}{\text{Res}}\, f(x) = \underset{x\to 0}{\text{Lt}}\left\{\frac{\cos x}{3x^2+4}\right\} = \frac{1}{4} = 0.25$$

$$\underset{x=2i}{\text{Res}}\, f(x) = \underset{x\to 2i}{\text{Lt}}\left\{\frac{(x-2i)\sin x}{x^2(x+2i)(x-2i)}\right\}$$

$$= \underset{x\to 2i}{\text{Lt}}\left\{\frac{\sin x}{x^2(x+2i)}\right\} = \frac{\sin(2i)}{(2i)^2(2i+2i)}$$

$$= \frac{\sin(2i)}{-4(4i)} = \frac{-1}{16i}\sin(2i)$$

$$\text{Sum of residues} = \frac{1}{4} - \frac{1}{16i}\sin(2i)$$

$$\oint_C f(z)\,dz = 2\pi i\,(\text{sum of residues})$$

$$\oint_C f(z)\,dz = 2\pi i\left\{\frac{1}{4} - \frac{1}{16i}\sin(2i)\right\}$$

$$= \frac{\pi i}{2} - \frac{\pi}{8}\sin(2i)$$

11. For an n-channel silicon MOSFET with 10nm gate oxide thickness, the substrate sensitivity $(\partial V_T/\partial |V_{BS}|)$ is found to be 50 mV/V at a substrate Voltage $|V_{BS}| = 2V$, where V_T is the threshold voltage of the MOSFET. Assume that, $|V_{BS}| >> 2\phi_B$. where $q\phi_B$ is the separation between the Fermi energy level E_F and the intrinsic level E_i in the bulk. Parameters given are

Electron charge(q) = 1.6×10^{-19}C

Vacuum permittivity $(\varepsilon_0) = 8.85\times10^{-12}$F/m

Relative permittivity of silicon $(\varepsilon_{Si}) = 12$

Relative permittivity of oxide $(\varepsilon_{ox}) = 4$

The doping concentration of the substrate is

(a) $4.37\times10^{15}cm^{-3}$ (b) $7.37\times10^{15}cm^{-3}$

(c) $2.37\times10^{15}cm^{-3}$ (d) $9.37\times10^{15}cm^{-3}$

11. Ans: (b)

Sol: $t_{ox} = 10nm$, $\dfrac{\partial V_T}{\partial |V_{BS}|} = 50$ mV/V

$|V_{BS}| = 2V$, $|V_{BS}| >> 2\phi_B$

$$V_T = V_{TO} + \gamma\left[\sqrt{|V_{BS}| + 2\phi_B} - \sqrt{2\phi_B}\right]$$

$$V_{TO} = V_T|_{|V_{BS}|} = 0$$

$$\gamma = \frac{\sqrt{2qN_A\varepsilon_S}}{C_{OX}} - \text{Body effect parameter}$$

Since $|V_{BS}| >> 2\phi_B$

$$V_T \simeq V_{TO} + \gamma\sqrt{|V_{BS}|}$$

$$\frac{\partial V_T}{\partial |V_{BS}|} = \gamma\frac{1}{2\sqrt{|V_{BS}|}}$$

$$50\times10^{-3} = \gamma\frac{1}{2\sqrt{2}}$$

$$\gamma = 2\sqrt{2}\times50\times10^{-3} = 141.42\times10^{-3}\sqrt{V}$$

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{4\times8.85\times10^{-14}}{10\times10^{-7}} = 3.54\times10^{-7}\ \text{F/cm}^2$$

$$\gamma = \frac{\sqrt{2qN_A\varepsilon_S}}{C_{ox}} \Rightarrow N_A = \frac{\gamma^2C_{ox}^2}{2q\,\varepsilon_S}$$

$$N_A = \frac{(141.42\times10^{-3})^2\times(3.54\times10^{-7})^2}{2\times1.6\times10^{-19}\times12\times8.85\times10^{-14}}$$

$= 7.37\times10^{15}/cm^3$

12. Consider the differential equation given below.

$$\frac{dy}{dx} + \frac{x}{1-x^2}\,y = x\sqrt{y}$$

The integrating factor of the differential equation is

(a) $(1-x^2)^{-3/4}$ (b) $(1-x^2)^{-1/4}$

(c) $(1-x^2)^{-1/2}$ (d) $(1-x^2)^{-3/2}$

12. Ans: (b)

Sol: Given $\frac{dy}{dx}+\left(\frac{x}{1-x^2}\right)y = x\sqrt{y}$........(1)

$$\left(\because \frac{dy}{dx}+P(n)y = Q(x).y^n\right)$$

Let $Y^{1/2}x = z$

Then $\frac{1}{2}Y^{\frac{1}{2}-1}\frac{dy}{dx} = \frac{dz}{dx}$ ......(4)

Using (3) & (4), (2) becomes

$$2\frac{dz}{dx}+\frac{x}{1-x^2}Z = x$$

$$\Rightarrow \frac{dz}{dx}+\frac{x}{2(1-x^2)}z - 2x \text{ ......(5)}$$

$$\text{I.F} = e^{\frac{1}{2}\int\frac{x}{1-x^2}dx} = e^{-\frac{1}{4}\int\frac{-2x}{1-x^2}dx} = e^{-\frac{1}{4}\log(1-x^2)}$$

$$\Rightarrow \text{I.F} = e^{\log(1-x^2)^{-\frac{1}{4}}} = (1-x^2)^{-\frac{1}{4}}$$

$$\therefore \text{ I.F} = \frac{1}{(1-x^2)^{\frac{1}{4}}}$$

13. Consider a superheterodyne receiver tuned to 600kHz. If the local oscillator feeds a 1000 kHz signal to the mixer, the image frequency (in integer) is _____ kHz.

13. Ans: 1400

Sol: $f_s = 600\text{kHz}$

$f_{LO} = 1000\text{kHz}$

$f_{SI} = \text{Image frequency} = f_S + 2\,f_{IF}$

$f_{IF} = f_{LO} - f_S = 1000\text{k} - 600\text{k} = 400\text{k}$

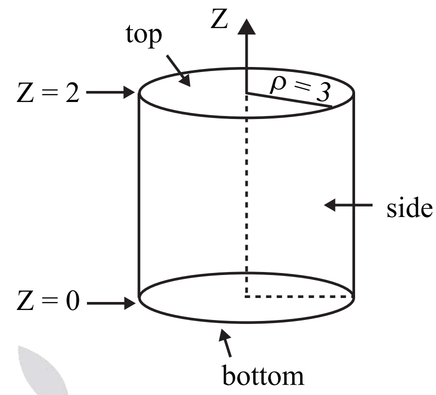
$f_{SI} = f_S + 2f_{IF} = 600\text{K} + (2\times 400\text{k})$

$f_{SI} = 1400\text{kHz}$

14. For a vector field $D = \rho\cos^2\varphi a_\rho + z^2\sin^2\varphi a_\varphi$ in a cylindrical coordinate system (ρ,φ,z) with unit vectors a_ρ, a_φ and a_z, the net flux of D leaving the closed surface of the cylinder (ρ = 3, $0 \le z \le 2$) (rounded off to two decimal places) is ____

14. Ans: 56.54

Sol: Given: $\vec{D} = \rho\cos^2\phi\hat{a}_\rho + z^2\sin^2\phi\hat{a}_\phi$



The net flux leaving the closed surface of the cylinder is

$$\psi_{net} = \psi_{bottom} + \psi_{top} + \psi_{side}$$

$$\psi_{net} = \int_S \underset{(Z=0)}{\vec{D}.d\vec{S}} + \int_S \underset{(Z=2)}{\vec{D}.d\vec{S}} + \int_S \underset{(\rho=3)}{\vec{D}.d\vec{S}}$$

As $d\vec{S} = \rho d\rho\, d\phi(\pm\hat{a}_z)$ for z = constant

and hence $\vec{D}.d\vec{S} = 0$ for both $z = 0$ & $z = 2$

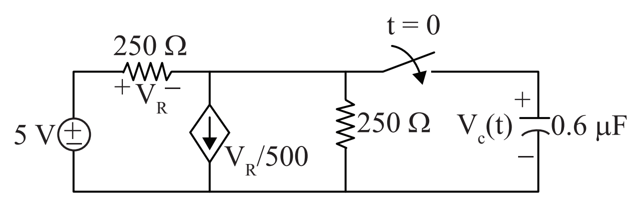
for $\rho = 3$: $\vec{D}.d\vec{S} = \left(\rho\cos^2\phi\hat{a}_\rho + z\sin^2\phi\hat{a}_\phi\right).\rho d\phi dz\hat{a}_\rho$

$$\psi_{net} = \int_{Z=0}^{2}\int_{\phi=0}^{2\pi} \underset{(\rho=3)}{\rho^2\cos^2\phi}\, d\phi\, dz$$

$$= (3)^2\times(2)\times\frac{1}{2}(2\pi)$$

$$\therefore \psi_{net} = 18\pi \text{ (or) } 56.54$$

15. In the circuit shown in the figure, the switch is closed at time $t = 0$, while the capacitor is initially charged to –5 V (i.e., $v_c(0) = -5\text{V}$).



The time after which the voltage across the capacitor becomes zero (rounded off to three decimal places) is ______ ms.

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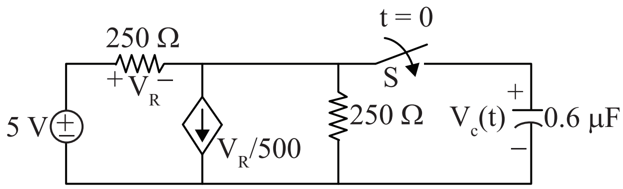
15. Ans: 0.1386

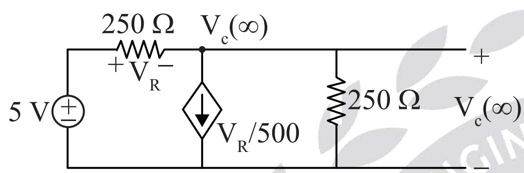
Sol: Given,



$V_C(0) = -5V = V_0$

For t > 0, S is closed

For Final value at $t = \infty$ (S.S), C → O.C.



By KCL at $V_C(\infty)$,

$$\frac{V_C(\infty)-5}{250}+\frac{V_R}{500}+\frac{V_C(\infty)}{250}=0$$

$$\frac{V_C(\infty)-5}{250}+\frac{5-V_C(\infty)}{500}+\frac{V_C(\infty)}{250}=0$$

$(V_R = 5 - V_C(\infty))$

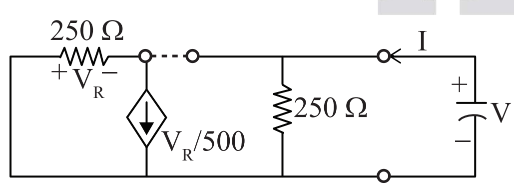
$$V_C(\infty)\left[\frac{1}{250}-\frac{1}{500}+\frac{1}{250}\right]=\frac{5}{250}-\frac{5}{500}$$

$V_C(\infty)\,[2-1+2] = 5(2-1)$

$$V_C(\infty)=\frac{5}{3}\text{volts}$$

For Time constant $\tau = R_{eq}C$

For R_{eq}(V→S.C) **V-I method:-**



By KCL at (V)

$$I+\frac{V_R}{250}=\frac{V_R}{500}+\frac{V}{250}$$

$$I=\frac{V_R}{500}-\frac{V_R}{250}+\frac{V}{250}$$

$$I=\frac{-V}{500}+\frac{V}{250}+\frac{V}{250} \qquad (V = -V_R)$$

$$I=V\left[\frac{2}{500}-\frac{1}{500}\right]=V\left[\frac{3}{500}\right]$$

$$\frac{V}{I}=\frac{500}{3}=R_{eq}$$

$$\tau = R_{eq}C=\frac{500}{3}\times 0.6\mu F=\frac{50\times 6}{3}H=10^{-4}\sec$$

$$V_C(t)=V_C(\infty)+\left(V_C(0)-V_C(\infty)\right)e^{-t/\tau}$$

$$=\frac{5}{3}+\left(-5-\frac{5}{3}\right)e^{-10^4t}$$

$$V_C(t)=\frac{5}{3}-5\left(\frac{4}{3}\right)e^{-10^4t}$$

$$V_C(t)=\left(\frac{5-20e^{-10^4t}}{3}\right)\text{volts} \quad t\geq 0$$

If $V_C(t) = 0$

$$5 = 20\,e^{-10^4t} \Rightarrow \frac{1}{4}=e^{-10^4t}$$

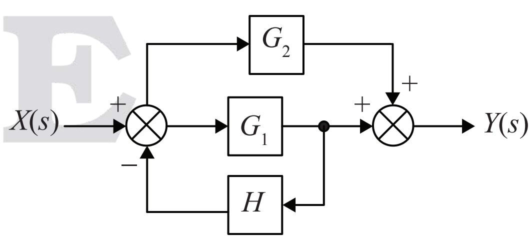
$$\ell n\frac{1}{4}=-10^4t$$

$+1.386 = +10^4t \Rightarrow t = 1.386\times10^{-4}$

$t = 0.1386\times10^{-3}$

$t = 0.1386$ msec

16. The block diagram of a feedback control system is shown in the figure.



The transfer function $\frac{Y(s)}{X(s)}$ of the system is

(a) $\frac{G_1+G_2}{1+G_1H}$

(b) $\frac{G_1+G_2+G_1G_2H}{1+G_1H}$

(c) $\frac{G_1+G_2+G_1G_2H}{1+G_1H+G_2H}$

(d) $\frac{G_1+G_2}{1+G_1H+G_2H}$

16. Ans: (a)

Sol: $\frac{Y(S)}{X(S)}=\frac{G_1+G_2}{1+G_1H}$ [By using mason's Gain formula]

College Goers Batch for GATE & ESE - 2022 / 2023 — @ Hyderabad

Batch Type	Timings	Batch Date	Duration	Venue
Morning, Evening Batches	**6am to 8am** & **6pm to 8:30pm**	20th March 2021	8 to 10 Months	Abids, Dilsukhnagar, Kukatpally.

GATE + PSUs – 2022 & ESE + GATE + PSUs – 2022 — @ DELHI

Regular Batches	Daily 5 to 6 Hours	5th March 2021	6 to 7 Months	ACE campus Saket
		7th April 2021		
		15th May 2021		
		5th June 2021		

GATE + PSUs – 2022 & ESE + GATE + PSUs – 2022 — @ PUNE

Regular / Weekend Batches	Daily 5 to 6 Hours	20th March 2021	6 to 7 Months	Pune Classroom

GATE + PSUs – 2022 & 2023 — @ VIZAG

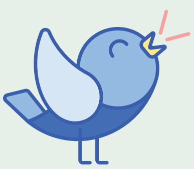
Weekend Batch	Saturday **2 pm to 8 pm** Sunday **9am to 6pm**	3rd April 2021	6 to 7 Months	Vizag Classroom

GATE + PSUs – 2022 & 2023 — @ VIJAYAWADA

Weekend Batch	Saturday **2 pm to 8 pm** Sunday **9am to 6pm**	3rd April 2021	6 to 7 Months	Vijayawada Classroom

GATE + PSUs – 2022 — @ TIRUPATI

Weekend Batch	Saturday **2 pm to 8 pm** Sunday **9am to 6pm**	20th March 2021	6 to 7 Months	Tirupati Classroom



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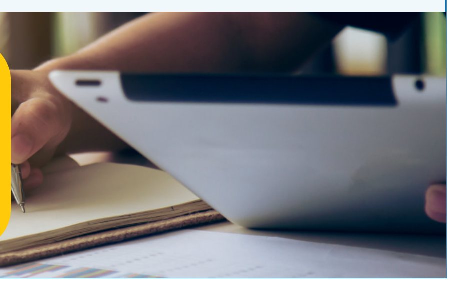
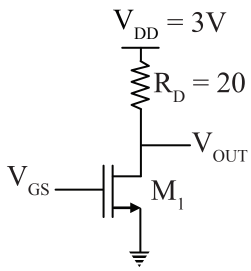


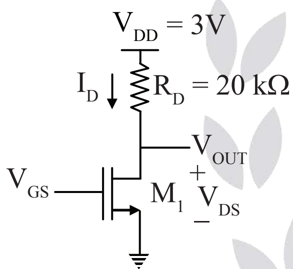
17. For the transistor M_1 in the circuit shown in the figure, $\mu_n C_{ox} = 100\mu A/V^2$ and $(W/L) = 10$, where μ_n is the mobility of electron. C_{ox} is the oxide capacitance per unit area. W is the width and L is the length.



The channel length modulation coefficient is ignored. If the gate-to-source voltage V_{GS} is 1 V to keep the transistor at the edge of saturation, then the threshold voltage of the transistor (rounded off to one decimal place) is ______ V.

17. Ans: 0.5

Sol:



$\mu_n C_{ox} = 100\mu A/V^2$

$\frac{W}{L} = 10$

$\lambda = 0$

$V_{GS} = 1V$

$V_T = ?$

Edge of saturation $V_{DS} = V_{GS} - V_T$

$V_{DS} = 1 - V_T$

$$I_D = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{GS} - V_T)^2$$

Applying KVL, we can write

$V_{DS} = V_{DD} - I_D R_D$

$$(1 - V_T) = 3 - \frac{1}{2} \times 100\mu \times 10(1 - V_T)^2 (20K)$$

$1 - V_T = 3 - 10(1 - V_T)^2$

$= 3 - 10 - 10V_T^2 + 20V_T$

$10V_T^2 - 21V_T + 8 = 0$

$V_T^2 - 2.1V_T + 0.8 = 0$

$(V_T - 1.6)(V_T - 0.5) = 0$

$V_T = 1.6V$ and $V_T = 0.5V$

To turn-on the transistor $V_{GS} > V_T$

So $V_T = 0.5V$

18. The exponential Fourier series representation of a continuous-time periodic signal x(t) is defined as

$$x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\omega_0 t}$$

where ω_0 is the fundamental angular frequency of x(t) and the coefficients of the series are a_k. The following information is given about x(t) and a_k.

I. x(t) is real and even, having a fundamental period of 6

II. The average value of x(t) is 2

III. $a_k = \begin{cases} k, & 1 \le k \le 3 \\ 0, & k > 3 \end{cases}$

The average power of the signal x(t) (rounded off to one decimal place) is ______

18. Ans: 32

Sol: From II, $a_0 = 2$

From III, $a_1 = 1$, $a_2 = 2$, $a_3 = 3$

From I, since x(t) is real & even $a_k = a_{-k}$

$a_1 = a_{-1} = 1$ and $a_2 = a_{-2} = 2$ and $a_3 = a_{-3} = 3$

From Parseval's theorem,

$$P_{av} = \frac{1}{T}\int_0^T |x(t)|^2 dt = \sum_{k=-\infty}^{+\infty} |a_k|^2$$

$$= \sum_{k=-3}^{3} |a_k|^2$$

$$= |a_0|^2 + 2\sum_{k=1}^{3} |a_k|^2$$

$$= (2)^2 + 2[(1)^2 + (2)^2 + (3)^2]$$

$= 4 + 28$

$= 32$ watts.

19. A box contains the following three coins.

I. A fair coin with head on one face and tail on the other face.

II. A coin with heads on both the faces.

III. A coin with tails on both the faces.

A coin is picked randomly from the box and tossed. Out of the two remaining coins in the box, one coin is then picked randomly and tossed. If the first toss results in a head, the probability of getting a head in the second toss is

(a) $\frac{2}{5}$

(b) $\frac{2}{3}$

(c) $\frac{1}{3}$

(d) $\frac{1}{2}$

19. Ans: (c)

Sol: Let A be the event of getting head in first toss and B be the event of getting head in second toss.

We need to find P(B/A)

$$P(B/A) = \frac{P(A\cap B)}{P(A)}$$

$$P(A) = P(\text{Selected coin is fair}) \times P\left(\frac{\text{Getting head}}{\text{Selected coin is fair}}\right)$$

$$+P(\text{Selected coin is double headed}) \times P\left(\frac{\text{Getting head}}{\text{Selected coin is double headed}}\right)$$

$$= \frac{1}{3}\times\frac{1}{2}+\frac{1}{3}.1 = \frac{1}{2}$$

Let us now find probability of getting heads in both the tosses.

Case-1: When the first tossed coin is a fair coin

$$\left(\frac{1}{3}.\frac{1}{2}\right)\left(\frac{1}{2}.1\right) = \frac{1}{12}$$

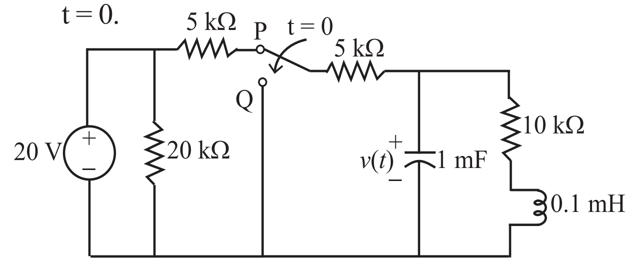
Casse-2: When the first tossed coin is a double headed coin

$$\left(\frac{1}{3}.1\right)\left(\frac{1}{2}.\frac{1}{2}\right) = \frac{1}{12}$$

$$\therefore\ P(A\cap B) = \frac{1}{12}+\frac{1}{12} = \frac{1}{6}$$

$$\text{Required probability} = \frac{P(A\cap B)}{P(A)} = \frac{1/6}{1/2} = \frac{1}{3}$$

20. The switch in the circuit in the figure is in position P for a long time and then moved to position Q at time t = 0.



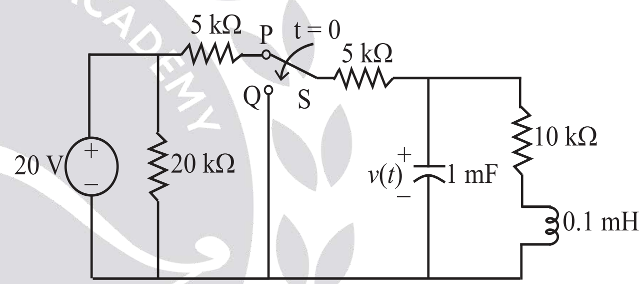
The value of $\frac{dv(t)}{dt}$ at $t = 0^+$ is

(a) –5 V/s (b) 3 V/s

(c) –3 V/s (d) 0 V/s

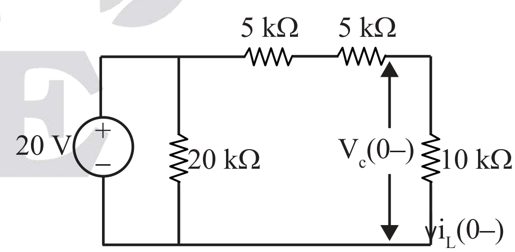
20. Ans: (c)

Sol: Given,



For t < 0, 'S' is in position (P)

At t = 0 – (S.S), L → S.C, C→ O.C



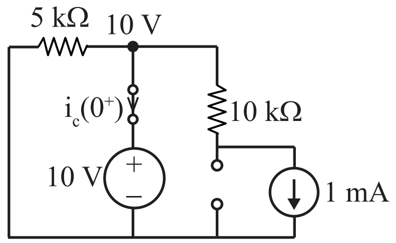
$$i_L(0-) = \frac{20}{20K} = 1mA = i_L(0+) = I_0$$

By VDR

$$V_C(0-) = \frac{20\times 10K}{(5+5+10)K} = 10V = V_C(0+) = V_0$$

At t = 0+, 'S' is in position(Q)

L → O.C. with I_0, C→S.C with V_0



By KCL at (10V)

$$\frac{10}{5K} + i_C(0+) + 1mA = 0$$

$i_C(0+) = -3mA$

$$c\frac{dV_C(0+)}{dt} = -3mA \Rightarrow \frac{dV_C(0+)}{dt} = \frac{-3m}{c} = \frac{-3m}{1m}$$

$$\frac{dV_C(0+)}{dt} = -3V/\sec$$

21. Two continuous random variables X and Y are related as

$$Y = 2X + 3$$

Let σ_X^2 and σ_Y^2 denote the variances of X and Y, respectively. The variances are related as

(a) $\sigma_Y^2 = 2\sigma_X^2$ (b) $\sigma_Y^2 = 4\sigma_X^2$

(c) $\sigma_Y^2 = 5\sigma_X^2$ (d) $\sigma_Y^2 = 25\sigma_X^2$

21. Ans: (b)

Sol: $Y = 2X + 3$

$$\text{Var}(Y) = \sigma_Y^2 = E[Y^2] - (E(Y))^2$$
$$= E((2X+3)^2) - (E(2X+3))^2$$
$$= E(4X^2 + 9 + 12X] - (2m_X + 3)^2$$
$$= 4E(X^2) + 9 + 12m_X - 4m_X^2 - 9 - 12m_X$$
$$= 4E(X^2) - 4m_x^2 = 4\sigma_X^2$$

$\Rightarrow \sigma_Y^2 = 4\sigma_X^2$

If $Y = aX + b$

$\sigma_Y^2 = a^2\sigma_X^2$

22. A standard air-filled rectangular waveguide with dimensions a = 8 cm, b = 4 cm, operates at 3.4 GHz. For the dominant mode of wave propagation, the phase velocity of the signal is v_p. The value (rounded off to two decimal places) of v_p/c, where c denotes the velocity of light, is _____

22. Ans: 1.19 (or) 1.20

Sol: Given: An air filled rectangular waveguide

a = 8cm, b = 4 cm

f = 3.4 GHz

Operating in dominant mode (TE_{10})

Phase velocity, v_p is given by

$$v_p = \frac{c}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

$$\frac{v_p}{c} = \frac{1}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

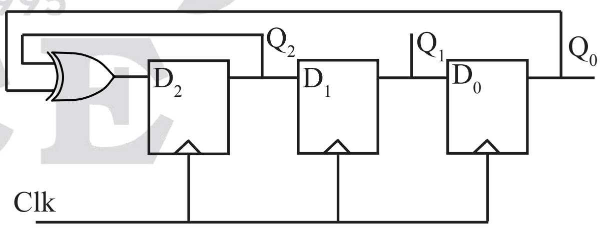
where

$$f_{C(TE_{10})} = \frac{c}{2a} = \frac{3\times10^{10}}{2\times8} = 1.875\text{ GHz}$$

$$\frac{v_p}{c} = \frac{1}{\sqrt{1-\left(\frac{1.875}{3.4}\right)^2}} = 1.198$$

$\therefore$ The factor $\frac{v_P}{c}$ is 1.198 (or) 1.20

23. The propagation delay of the exclusive-OR (XOR) gate in the circuit in the figure is 3 ns. The propagation delay of all the flip-flops is assumed to be zero. The clock (CLK) frequency provided to the circuit is 500 MHz.



Starting from the initial value of the flilp-flop outputs $Q_2Q_1Q_0$ = 111 with D_2 = 1, the minimum number of triggering clock edges after which the flip-flop outputs $Q_2Q_1Q_0$ becomes 1 0 0 (in integer) is _______

23. Ans: 5

Sol: Given t_{XOR} = 3ns, f = 500MHz

$$T = \frac{1}{f} = 2ns$$

Initially $Q_2Q_1Q_0$ = 111 and D_2 = 1

Clk	$D_2 = Q_2 \oplus Q_0$	Q_2 Q_1 Q_0
0	1	1 1 1
1 (at 0 ns)	1	1 1 1 (at 0 ns)
2 (at 2 ns)	1	1 1 1 (at 2 ns)
3 (at 4 ns)	0 (at 3 ns)	0 1 1 (at 4 ns)
4 (at 6 ns)	0 (at 5 ns)	0 0 1
5 (at 8 ns)	1 (at 7 ns)	$\boxed{1\ \ 0\ \ 0}$

24. A real 2 × 2 non-singular matrix A with repeated eigenvalue is given as

$$A = \begin{bmatrix} x & -3.0 \\ 3.0 & 4.0 \end{bmatrix}$$

where x is a real positive number. The value of x (rounded off to one decimal place) is _____

24. Ans: 10

Sol: Given $A = \begin{bmatrix} x & -3 \\ 3 & 4 \end{bmatrix}$

⇒ The characteristic equation of $A_{2\times2}$ is

$\lambda^2 - (x+4)\lambda + (4x+9) = 0$

$$\Rightarrow \lambda = \frac{(x+4) \pm \sqrt{(x+4)^2 - 4(1)(4x+9)}}{2(1)}$$

But given that the characteristic equation has repeated roots $b^2 - 4ac = 0$

So, consider $(x+4)^2 - 4(1)(4x+9) = 0$

$\Rightarrow x^2 + 16 + 8x - 16x - 36 = 0$

$\Rightarrow x^2 - 8x - 20 = 0$

$$\Rightarrow x = \frac{8 \pm \sqrt{64+80}}{2} = \frac{8 \pm \sqrt{144}}{2} = \frac{8 \pm 12}{2}$$

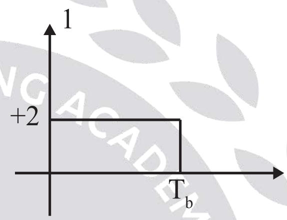
$\therefore x = 10$ (or) -2

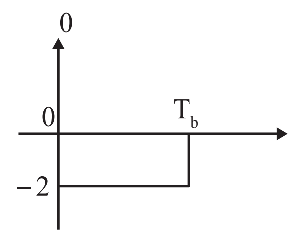
In given question where x is a real positive number x = 10

25. Consider a polar non-return to zero (NRZ) waveform, using +2V and –2V for representing binary '1' and '0' respectively, is transmitted in the presence of additive zero-mean white Gaussian noise with variance 0.4 V^2. If the a priori probability of transmission of a binary '1' is 0.4, the optimum threshold voltage for a maximum a posteriori (MAP) receiver (rounded off to two decimal places) is ______ V.

25. Ans: 0.04

Sol:





$$\text{Noise variance} = \frac{N_0}{2} = \sigma^2 = 0.4$$

$P(1) = 0.4, P(0) = 0.6$

$$\text{Optimum threshold} = \frac{S_0 + S_1}{2} + \frac{\sigma^2}{S_1 - S_0} \ell n \frac{P(0)}{P(1)}$$

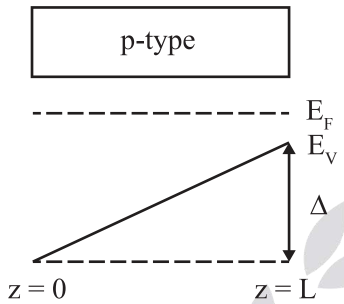
$$V_{Th} = \frac{-2+2}{2} + \frac{0.4}{2-(-2)} \ell n\left(\frac{0.6}{0.4}\right)$$

$$= \frac{0.4}{4} \ell n\, 1.5$$

$$= 0.0405$$

$V_{Th} = 0.04$ V

26. The energy band diagram of a p-type semiconductor bar of length L under equilibrium condition (i.e., the Fermi energy level E_F is constant) is shown in the figure. The valance band E_V is sloped since doping is non-uniform along the bar. The difference between the energy levels of the valence band at the two edges of the bar is Δ.



If the charge of an electron is q, then the magnitude of the electric field developed inside this semiconductor bar is

(a) $\frac{2\Delta}{qL}$ (b) $\frac{3\Delta}{2qL}$

(c) $\frac{\Delta}{2qL}$ (d) $\frac{\Delta}{qL}$

26. Ans: (d)

Sol: Relation between electric field and potential is given by

$$E' = -\frac{d\psi}{dx}$$

$$E' = -\frac{d}{dx}\left(-\frac{E}{q}\right) E - \text{Energy}$$

$$E' = \frac{1}{q}\frac{dE}{dx} = \frac{1}{q}\frac{\Delta}{L}$$

* Non-uniform doping in a semiconductor results in built-in electric field.

27. A message signal having peak-to-peak value of 2V, root mean square value of 0.1V and bandwidth of 5 kHz is sampled and fed to a pulse code modulation (PCM) system that uses a uniform quantizer. The PCM output is transmitted over a channel that can support a maximum transmission rate of 50 kbps. Assuming that the quantization error is uniformly distributed, the maximum signal to quantization noise ratio that can be obtained by the PCM system (rounded off to two decimal places) is ______

27. Ans: 30.72

Sol: Given that $V_{rms} = 0.1V$

$\Rightarrow$ Signal power $= V^2_{rms} = 0.01$

Bit rate $= n\, f_s = 50$ kbps

$$n \times 2 \times 5 \times 10^3 = 50 \times 10^3$$

$$\Rightarrow n = 5$$

$$\Delta = \frac{\text{Peak to Peak voltage}}{2^n} = \frac{2V}{2^5} = \frac{1}{2^4}$$

$$\text{Noise power} = \frac{\Delta^2}{12} = \frac{1}{12 \times (2^4)^2} = \frac{1}{12 \times 2^8}$$

$$\text{SNR} = \frac{\text{Signal power}}{\text{Noise power}} = 0.01 \times 12 \times 2^8$$

$$= 30.72$$

28. A 4 kHz sinusoidal message signal having amplitude 4 V is fed to a delta modulator (DM) operating at a sampling rate of 32 kHz. The minimum step size required to avoid slope overload noise in the DM (rounded off to two decimal places) is ______ V.

28. Ans: 3.14

Sol: $f_m = 4$kHz

$A_m = 4$ V

$f_S = 32$ kHz

Solpe overload distortion can be avoided,

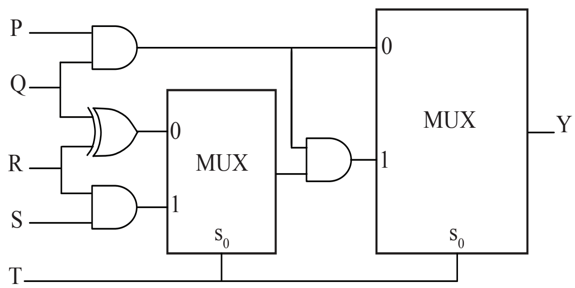
$$\left|\frac{dm(t)}{dt}\right|_{max} \le \frac{\Delta}{T_S}$$

$$\Delta \ge A_m\, 2\pi f_m / f_s$$

$$\Delta_{min} = \frac{4 \times 2\pi \times 4k}{32k}$$

$$\Delta_{min} = 3.14 \text{ V}$$

29. The propagation delays of the XOR gate, AND gate and multiplexer (MUX) in the circuit shown in the figure are 4ns, 2 ns and 1 ns, respectively.



If all the inputs P, Q, R S and T are applied simultaneously and held constant, the maximum propagation delay of the circuit is

(a) 6 ns (b) 3 ns (c) 7 ns (d) 5 ns

29. Ans: (a)

Sol: $t_{XOR} = 4ns$, $t_{AND} = 2ns$, $t_{MUX} = 1ns$

Case-(i): when T = 0

Propagation delay $= t_{AND1} + t_{MUX2}$

$= 2 + 1 = 3ns.$

Case-(ii): When T = 1

Propagation delay $= t_{AND2} + t_{MUX1} + t_{AND3} + t_{MUX2}$

$= 2 + 1 + 2 + 1 = 6ns$

Hence maximum propagation delay of the circuit is 6ns

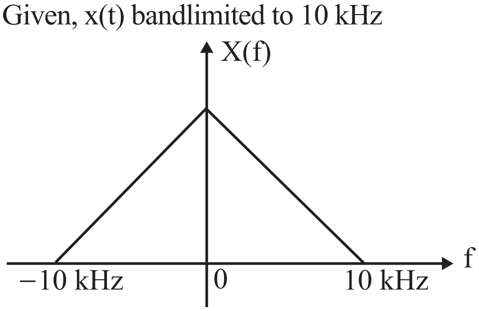
30. Consider a real-valued base-band signal x(t), band limited to 10kHz. The Nyquist rate for the signal $y(t) = x(t)x\left(1+\frac{t}{2}\right)$ is

(a) 20 kHz (b) 30 kHz

(c) 15 kHz (d) 60 kHz

30. Ans: (b)

Sol: Given, x(t) bandlimited to 10 kHz



Given, $y(t) = x(t)\ x\left(1+\frac{t}{2}\right)$

Assume $x_1(t) = x(t)$ and $x_2(t) = x\left(1+\frac{t}{2}\right)$

$y(t) = x_1(t)\ x_2(t)$

Apply Fourier Transform

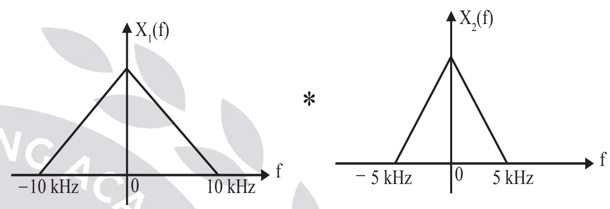
From convolution in frequency domain property

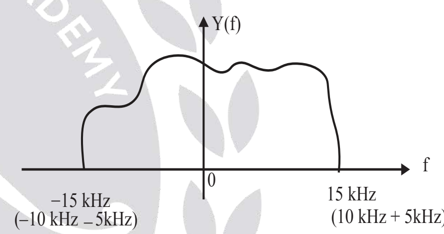
$Y(f) = X_1(f)*X_2(f)$

$X_1(f) = X(f)$

$x_2(t) = x\left(\frac{t}{2}+1\right)$

$X_2(f) = 2e^{j4\pi f}\ X(2f)$

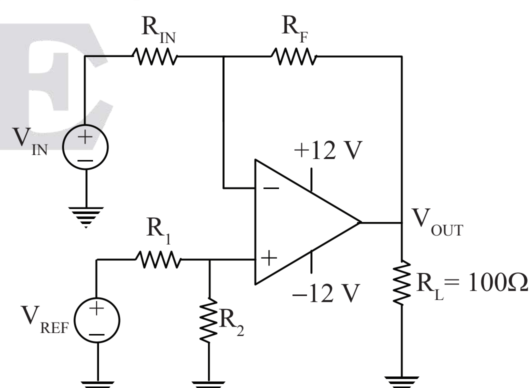




Maximum frequency of y(t) is $f_m = 15kHz$

Nyquist rate $= 2f_m = 30kHz$

31. For the circuit with an ideal OP-AMP shown in the figure, V_{REF} is fixed.

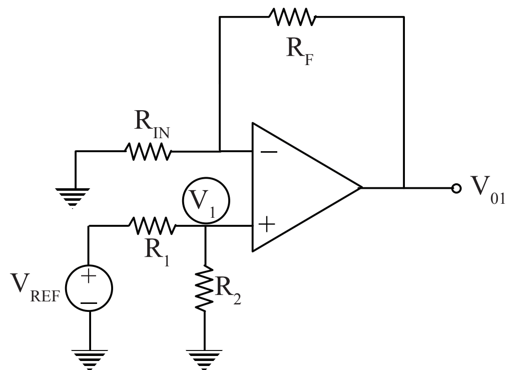


If $V_{OUT} = 1$ volt for $V_{IN} = 0.1$ volt and $V_{OUT} = 6$ volt for $V_{IN} = 1$ volt, where V_{OUT} is measured across R_L connected at the output of this OP-AMP, the value of R_F/R_{IN} is

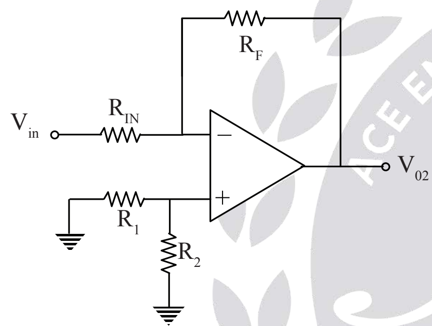
(a) 3.285 (b) 3.825 (c) 5.555 (d) 2.860

31. Ans: (c)

Sol:



$$V_{01}=\left(1+\frac{R_f}{R_{in}}\right)V_x=\left(1+\frac{R_f}{R_{in}}\right)\frac{V_{ref}R_2}{R_1+R_2}$$



$$V_{02}=\left(-\frac{R_f}{R_{in}}\right)V_{in}$$

Total $V_0=V_{01}+V_{02}$

$$V_0=\left(1+\frac{R_f}{R_{in}}\right)V_{ref}\frac{R_2}{R_1+R_2}-\frac{R_f}{R_{in}}V_{in}$$

$$\text{Given } 1=\left(1+\frac{R_f}{R_{in}}\right)V_{ref}\frac{R_2}{R_1+R_2}-\frac{R_f}{R_{in}}(0.1)\text{.....(1)}$$

$$6=\left(1+\frac{R_f}{R_{in}}\right)V_{ref}\frac{R_2}{R_1+R_2}-\frac{R_f}{R_{in}}(1)\text{.....(2)}$$

$$\text{(2)-(1)}\Rightarrow 6-1=-\frac{R_f}{R_{in}}(1-0.1)$$

$$\rightarrow\frac{R_f}{R_{in}}=\frac{-5}{0.9}=-5.555$$

$$\therefore\ \left|\frac{R_f}{R_{in}}\right|=5.555$$

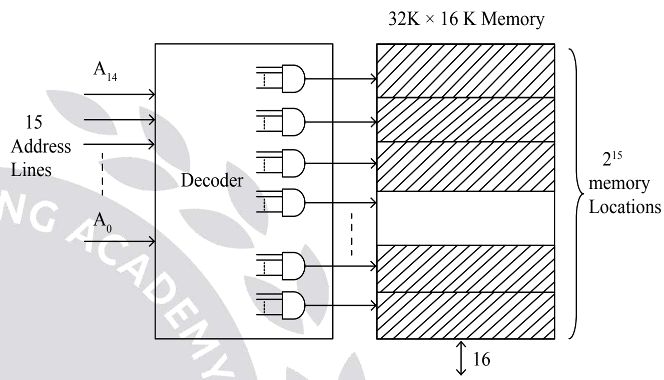
32. Addressing of a 32K × 16 memory is realized using a single decoder. The minimum number of AND gates required for the decoder is

(a) 2^8 (b) 2^{32}

(c) 2^{19} (d) 2^{15}

32. Ans: (d)

Sol: Memory size = 32K × 16 = $2^{15}\times 16$



So, Number of AND gates required = 2^{15}.

33. For a unit step input u[n], a discrete-time LTI system produces an output signal $(2\delta[n+1]+\delta[n]+\delta[n-1])$. Let y[n] be the output of the system for an input $\left(\left(\frac{1}{2}\right)^n u[n]\right)$. The value of y[0] is ________

33. Ans: 0

Sol: $x(n)=u(n)\Rightarrow X(z)=\dfrac{1}{1-z^{-1}}$

$y(n)=2\delta[n+1]+\delta[n]+\delta[n-1]$

$Y(z)=2z+1+z^{-1}$

$$\text{T.F.}H(z)=\frac{Y(z)}{X(z)}=\frac{2z+1+z^{-1}}{\frac{1}{1-z^{-1}}}=(2z+1+z^{-1})(1-z^{-1})$$

$$=2z+1+z^{-1}-2-z^{-1}-z^{-2}$$

$$H(z)=2z-1-z^{-2}$$

If $x(n)=\left(\frac{1}{2}\right)^n u(n)$ for this system with

$H(z)=2z-1-z^{-2}$ then

$\downarrow$ find y(n) I.Z.T

$h(n)=2\delta(n+1)-\delta(n)-\delta(n-2)$

$$Y(z) = X(z)\,H(z)$$

$$= \frac{2z - 1 - z^{-2}}{1 - \frac{1}{2}z^{-1}}$$

$$y(n) = x(n)*h(n)$$

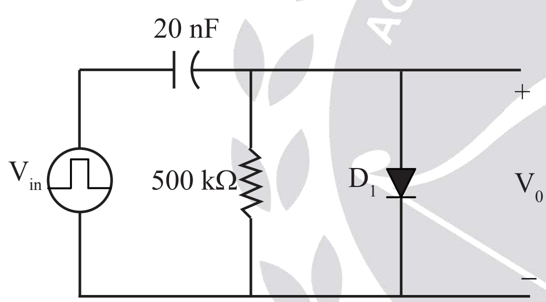
$$= 2\left(\frac{1}{2}\right)^{n+1} u(n+1) - \left(\frac{1}{2}\right)^{n} u(n) - \left(\frac{1}{2}\right)^{n-2} u(n-2)$$

As we want y(0), it is due to first 2 terms of y(n)

$$y(0) = 2\left(\frac{1}{2}\right)^{0+1} - \left(\frac{1}{2}\right)^{0}$$

$$= 1 - 1 = 0$$

34. An asymmetrical periodic pulse train v_{in} of 10V amplitude with on-time T_{ON} = 1 ms and off-time T_{OFF} = 1 μs is applied to the circuit shown in the figure. The diode D_1 is ideal.



The difference between the maximum voltage and minimum voltage of the output waveform v_0 (in integer) is _______ V.

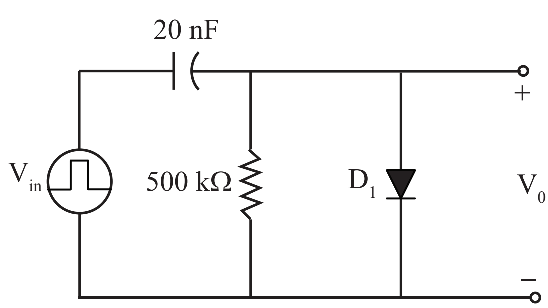
34. Ans: 10

Sol: Given: V_{in} = 10V

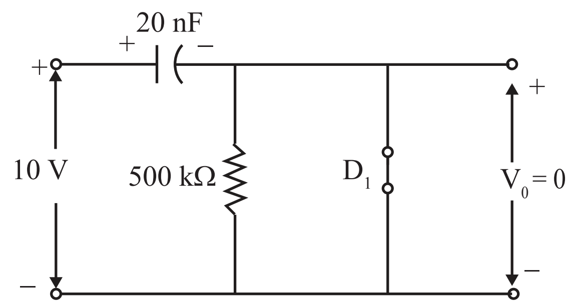
Asymmetrical periodic pulse train

T_{ON} = 1msec & T_{OFF} = 1μsec

Diode is ideal

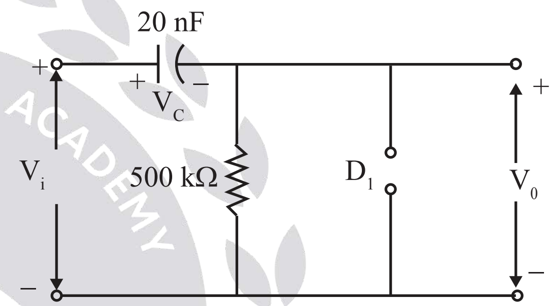


Case-(i):- If V_{in} = 10V ⇒ D_1 is ON



& V_C (Voltage across capacitor) = 10V.......(1)

Case-(ii):- If V_{in} = 0V ⇒ D_1 is OFF



The duration of input pulse with amplitude 0V is

T_{OFF} = 1μsec &

Discharging time for Capacitor,

$T_{Discharge}$ = 20nF × 500KΩ = 10msec

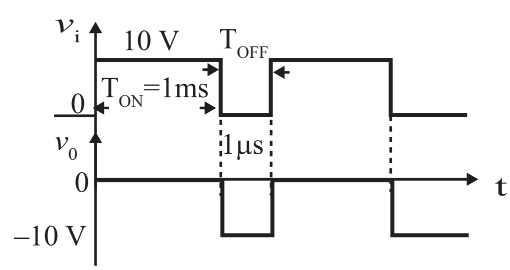
i.e., $T_{Discharge} >> T_{OFF}$

$\therefore\ V_0 = V_i - V_C = 0V - 10V = -10V$ ....(2)

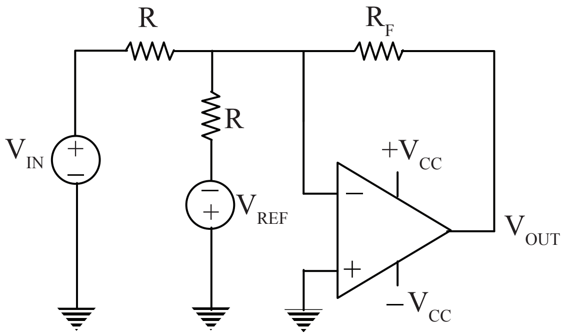
NOTE: The difference between maximum voltage & minimum voltage of the output waveform

$= 0 - (-10V)$

$= 10V$ ....(3)



35. Consider the circuit with an ideal OP-AMP shown in the figure.



Assuming $|V_{IN}| << |V_{CC}|$ and $|V_{REF}| << |V_{CC}|$, the condition at which V_{OUT} equals to zero is

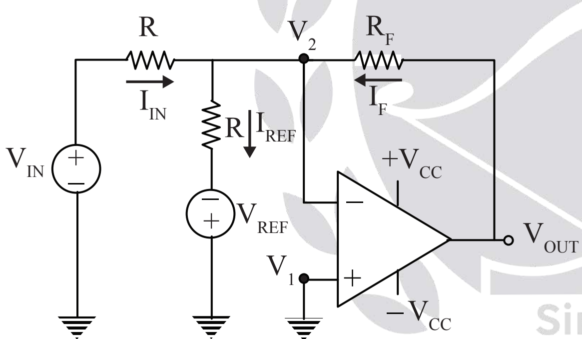
(a) $V_{IN} = 2 + V_{REF}$ (b) $V_{IN} = 2\,V_{REF}$

(c) $V_{IN} = V_{REF}$ (d) $V_{IN} = 0.5\,V_{REF}$

35. Ans: (c)

Sol: Given: $|V_{IN}| << V_{CC}$

$|V_{Ref}| << V_{CC}$



Step-1: KCL at V_2

$I_{IN} + I_F = I_{Ref}$.....(1)

$$\Rightarrow \frac{V_{IN}-V_2}{R} + \frac{V_{OUT}-V_2}{R_f} = \frac{V_2+V_{Ref}}{R} \text{.......(2)}$$

Step-2: $\because V_1 = 0 \Rightarrow V_2 = 0$

$$\Rightarrow \frac{V_{IN}}{R} + \frac{V_{OUT}}{R_f} = \frac{V_{Ref}}{R}$$

$$\Rightarrow \frac{V_{OUT}}{R_f} = \frac{V_{Ref}}{R} - \frac{V_{IN}}{R} = \frac{V_{Ref}-V_{IN}}{R}$$

$$\Rightarrow V_{OUT} = \frac{R_f}{R}\left(V_{Ref} - V_{IN}\right) \text{.......(3)}$$

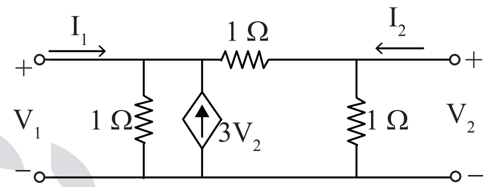
Step-3: For $V_{OUT} = 0$

$$\frac{R_f}{R}\left(V_{ref} - V_{IN}\right) = 0$$

$$\Rightarrow V_{Ref} - V_{IN} = 0$$

$$\therefore\ V_{IN} = V_{Ref} \text{..........(4)}$$

36. Consider the two-port network shown in the figure.



The admittance parameters, in siemens, are

(a) $y_{11} = 1, y_{12} = -2, y_{21} = -1, y_{22} = 3$

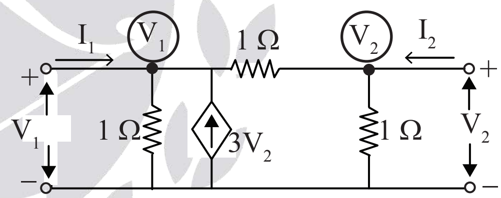
(b) $y_{11} = 2, y_{12} = -4, y_{21} = -4, y_{22} = 2$

(c) $y_{11} = 2, y_{12} = -4, y_{21} = -4, y_{22} = 3$

(d) $y_{11} = 2, y_{12} = -4, y_{21} = -1, y_{22} = 2$

36. Ans: (d)

Sol: Consider the two-port Network



For Y-Parameters

$I_1 = y_{11}V_1 + y_{12}V_2$

$I_2 = y_{21}V_1 + y_{22}V_2$

By KCL at (V_1)

$$I_1 + 3V_2 = \frac{V_1}{1} + \frac{V_1 - V_2}{1}$$

$I_1 = 2V_1 - 4V_2$ ....(1)

By KCL at (V_2)

$$I_2 = \frac{V_2}{1} + \frac{V_2 - V_1}{1}$$

$I_2 = -V_1 + 2V_2$ ....(2)

From (1) & (2)

$I_1 = 2V_1 - 4V_2$

$I_2 = -V_1 + 2V_2$

$$\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} = \begin{bmatrix} 2 & -4 \\ -1 & 2 \end{bmatrix}$$

37. Consider a carrier signal which is amplitude modulated by a single-tone sinusoidal message signal with a modulation index of 50%. If the carrier and one of the sidebands are suppressed in the modulated signal, the percentage of power saved (rounded off to one decimal place) is _____

37. Ans: 94.44

Sol: $\mu = 0.5$

Carrier and one side band suppressed

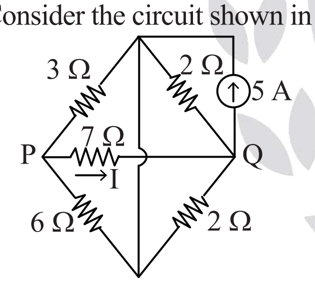
$$\% \text{ power saving} = \frac{\text{Power saved}}{\text{Total power}} \times 100$$

$$= \frac{P_C + P_{USB}}{P_T} \times 100$$

$$= \frac{P_C + P_C.\frac{\mu^2}{4}}{P_C\left[1 + \frac{\mu^2}{2}\right]} \times 100$$

$$= \frac{4 + 0.5^2}{2(2 + 0.5^2)} \times 100 = 94.44\%$$

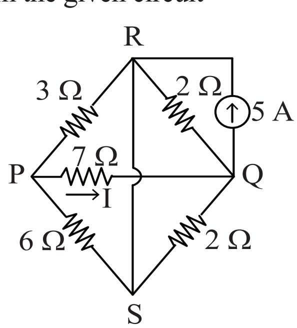
38. Consider the circuit shown in the figure.



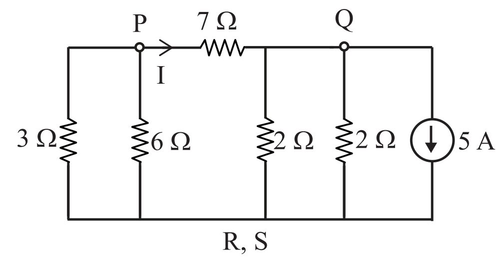
The current I flowing through the 7 Ω resistor between P and Q (rounded off to one decimal place) is ________A.

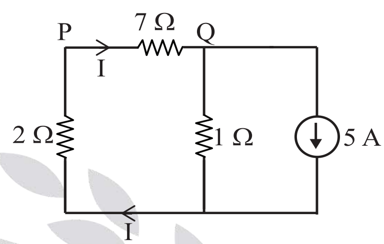
38. Ans: 0.5

Sol: From the given circuit



R, S points are same





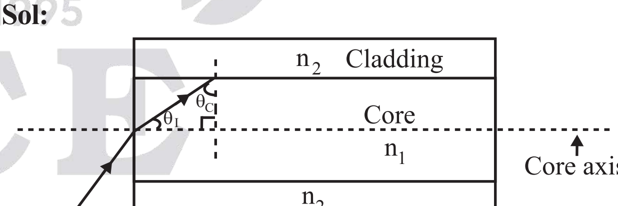
By CDR

$$I = \frac{5 \times 1}{1 + 2 + 7} = \frac{5}{10} = 0.5\text{Amps}$$

39. The refractive indices of the core and cladding of an optical fiber are 1.50 and 1.48, respectively. The critical propagation angle, which is defined as the maximum angle that the light beam makes with the axis of the optical fiber to achieve the total internal reflection, (rounded off to two decimal places) is ______ degree.

39. Ans: 9.39

Sol:



n_1 = Refractive index of core = 1.5

n_2 = Refractive index of cladding = 1.48

θ_C = Critical angle (or) minimum angle required for total internal reflection.

θ_I = angle w.r.t the axis of the core

If θ_C is minimum, θ_1 should be maximum

$$\theta_C = \sin^{-1}\left[\frac{n_2}{n_1}\right] = \sin^{-1}\left[\frac{1.48}{1.5}\right] = \sin^{-1}[0.9866] = 80.6$$

$$\theta_1 = 90 - \theta_C$$

$$\theta_1 = 9.39^\circ$$

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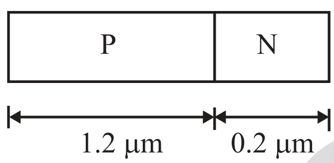
40. A silicon P-N junction is shown in the figure. The doping in the P region is 5×10^{16} cm^{-3} and doping in the N region is 10×10^{16} cm^{-3}. The parameters given are

Built-in voltage (ϕ_{bi}) = 0.8 V

Electron charge (q) = 1.6×10^{-19} C

Vacuum permittivity (ε_0) = 8.85×10^{-12} F/m

Relative permittivity of silicon (ε_{Si}) = 12



The magnitude of reverse bias voltage that would completely deplete one of the two regions (P or N) prior to the other (rounded off to one decimal place) is ______ V.

40. Ans: 8.2 V

Sol: $N_A = 5\times10^{16}/\text{cm}^3$, $N_D = 10\times10^{16}/\text{cm}^3$

$\phi_{bi} = 0.8\text{V}$

We know that $x_n N_D = x_p N_A \Rightarrow \dfrac{N_D}{N_A} = \dfrac{x_p}{x_n}$

$$\frac{N_D}{N_A} = 2 \Rightarrow x_p = 2x_n$$

As $x_n = 0.2\ \mu\text{m} \Rightarrow x_p = 0.4\ \mu\text{m}$

So, width of depletion region, W = 0.6 μm

$$W = \sqrt{\frac{2\varepsilon(V_0+V_R)}{q}\left(\frac{1}{N_A}+\frac{1}{N_D}\right)}$$

$$0.6\times10^{-4} = \sqrt{\frac{2\times12\times8.85\times10^{-14}(0.8+V_R)}{1.6\times10^{-19}}\left(\frac{1}{5\times10^{16}}+\frac{1}{10\times10^{16}}\right)}$$

$$\frac{0.36\times10^{-8}\times1.6\times10^{-19}\times5\times10^{16}}{2\times12\times8.85\times10^{-14}\times1.5} = (V_R+0.8)$$

$V_R = 8.2395$ Volts

41. Consider a rectangular coordinate system (x,y,z) with unit vectors $\mathbf{a}_x$, $\mathbf{a}_y$, and $\mathbf{a}_z$. A plane wave traveling in the region $z \geq 0$ with electric field vector $\mathbf{E} = 10\cos(2\times10^8 t + \beta z)\mathbf{a}_y$ is incident normally on the plane at z = 0, where β is the phase constant. The region $z \geq 0$ is in free space and the region $z < 0$ is filled with a lossless medium (permittivity $\varepsilon = \varepsilon_0$, permeability $\mu = 4\mu_0$, where $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m and $\mu_0 = 4\pi \times 10^{-7}$ H/m). The value of the reflection coefficient is

(a) $\frac{3}{5}$

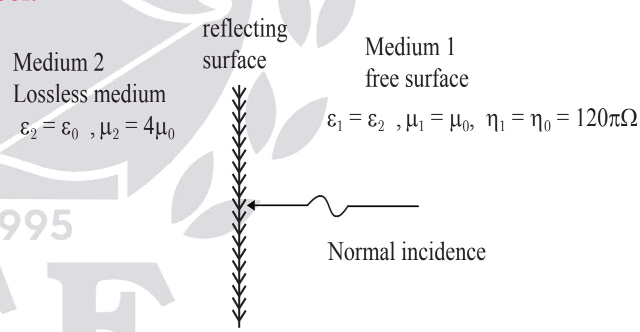
(b) $\frac{2}{3}$

(c) $\frac{2}{5}$

(d) $\frac{1}{3}$

41. Ans: (d)

Sol:



Z < 0   Z = 0   Z > 0

$$\eta_2 = 120\pi\sqrt{\frac{\mu_{r2}}{\varepsilon_{r2}}}$$

$$= 120\pi\sqrt{\frac{4}{1}}$$

$$\eta_2 = 2\times120\pi$$

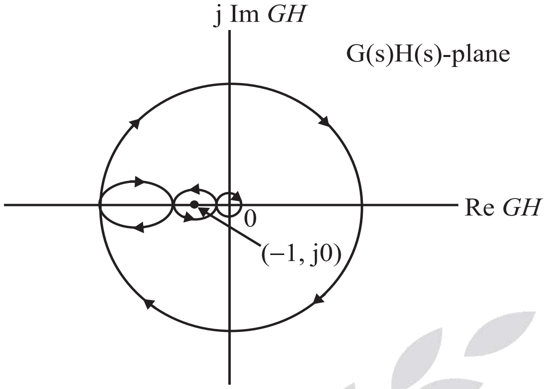
Reflection coefficient, Γ is given by

$$\Gamma = \frac{\eta_2-\eta_1}{\eta_2+\eta_1} = \frac{2\times120\pi-120\pi}{2\times120\pi+120\pi}$$

$$= \frac{(2-1)120\pi}{(2+1)120\pi}$$

$$\therefore \Gamma = \frac{1}{3}$$

42. The complete Nyquist plot of the open-loop transfer function G(s) H(s) of a feedback control system is shown in the figure.



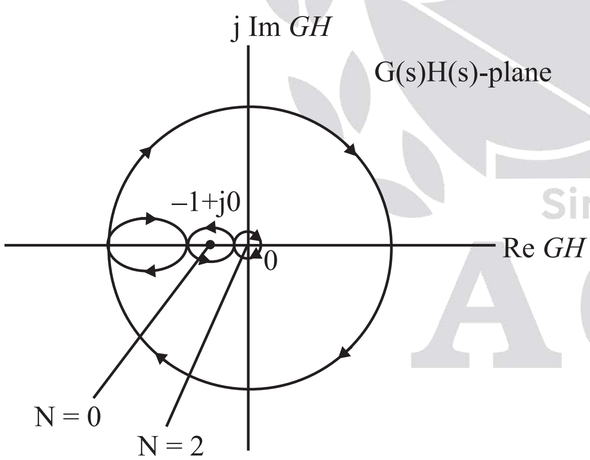
If G(s) H(s) has one zero in the right-half of the s-plane, the number of poles that the closed-loop system will have in the right-half of the s-plane is

(a) 1 (b) 3

(c) 4 (d) 0

42. Ans: (b)

Sol:



Open zeros in the RH Z = 1

$N_{(0,0)}$ = (OL Poles – OL Zeros)

2 = OL Poles – 1

OL Poles = 3 [3 OL Poles in the RHS]

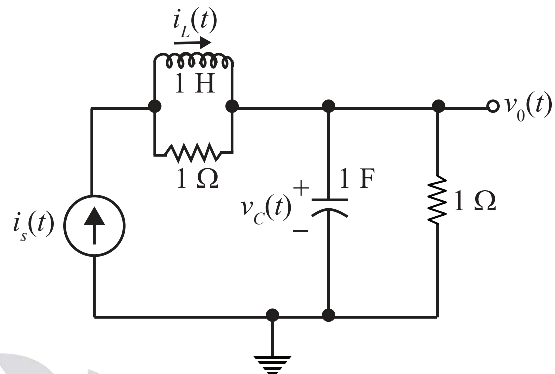
P = 3

$\Rightarrow N_{(-1,0)} = (P-Z)$

O = 3–Z

Z = 3 (3 CL Poles in the RH-S-Plane)

43. The electrical system shown in the figure converts input source current $i_s(t)$ to output voltage $v_0(t)$.



Current $i_L(t)$ in the inductor and voltage $v_c(t)$ across the capacitor are taken as the state variables, both assumed to be initially equal to zero, i.e., $i_L(0) = 0$ and $v_c(0) = 0$. The system is

(a) completely state controllable as well as completely observable

(b) neither state controllable nor observable

(c) completely state controllable but not observable

(d) completely observable but not state controllable

43. Ans: (b)

Sol: $i_S(t) = i_L(t) + i_R(t)$

$$= i_L(t) + \frac{V_R(t)}{1}$$

$$i_S(t) = i_L(t) + \frac{V_L(t)}{1}$$

But $V_L(t) = V_R(t) = 1 i_R(t) \Rightarrow i_R(t) = \frac{V_L(t)}{1} = L\frac{di_L(t)}{dt} = \frac{di_L(t)}{dt}$

$$i_S(t) = i_L(t) + \frac{di_L(t)}{dt} \Rightarrow \frac{di_L}{dt} = i_S(t) - i_L(t)$$

$\dot{i}_L(t) = i_S(t) - i_L(t)$........(1)

$\rightarrow i_S(t) = i_C(t) + i_R(t)$

$$i_S(t) = C\frac{dV_C(t)}{dt} + i_R(t) \Rightarrow i_S(t) = \frac{dV_C(t)}{dt} + \frac{V_R(t)}{1}$$

$$i_S(t) = \frac{dV_C(t)}{dt} + \frac{V_C(t)}{1} \Rightarrow \frac{dV_C(t)}{dt} = i_S(t) - V_C(t)$$

$\dot{V}_C(t) = i_S(t) - V_C(t)$ ....(2)

$\Rightarrow V_0(t) = V_C(t)$ ....(3)

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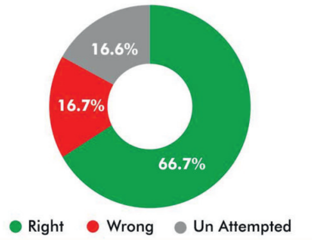

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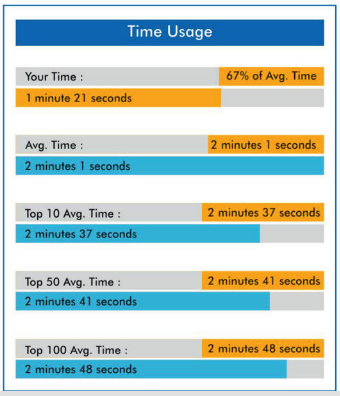

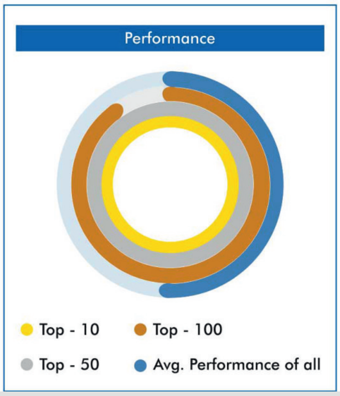

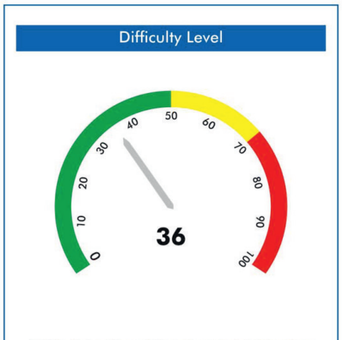

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$$\begin{bmatrix}\dot{i}_L(t)\\ \dot{V}_C(t)\end{bmatrix}=\begin{bmatrix}-1&0\\0&-1\end{bmatrix}\begin{bmatrix}i_L(t)\\V_C(t)\end{bmatrix}+\begin{bmatrix}1\\1\end{bmatrix}i_S(t)\ ,[\text{Volt}]=[0\ \ 1]\begin{bmatrix}i_L(t)\\V_C(t)\end{bmatrix}$$

Controllability:

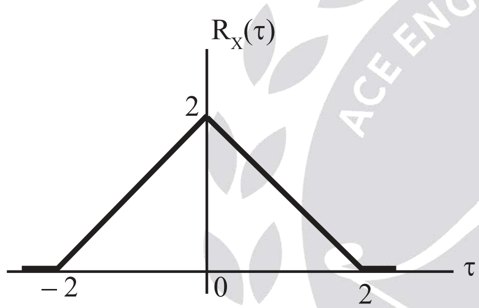
$$Q_C=[B\quad AB]=\begin{bmatrix}1&-1\\1&-1\end{bmatrix}\Rightarrow |Q_C|=0 \text{ Not Controllable}$$

Observability:

$$Q_0=\begin{bmatrix}C\\CA\end{bmatrix}=\begin{bmatrix}0&1\\0&-1\end{bmatrix}\Rightarrow |Q_0|=0 \text{ Not Observable}$$

Neither controllable Nor observable.

44. The autocorrelation function $R_x(\tau)$ of a wide-sense stationary random process X(t) is shown in the figure.

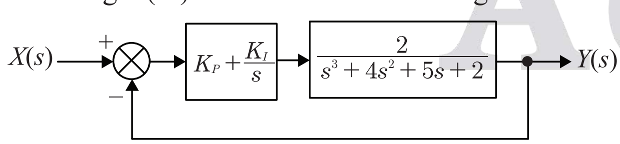


The average power of X(t) is ________

44. Ans: 2

Sol: Average power: $R_X(0) = 2$

45. A unity feedback system that uses proportional-integral(PI) control is shown in the figure.



The stability of the overall system is controlled by tuning the PI control parameters K_p and K_I. The maximum value of K_I that can be chosen so as to keep the overall system stable or, in the worst case, marginally stable (rounded off to three decimal places) is _______

45. Ans: 3.125

Sol: $$G(s)=\left[\frac{SK_P+K_I}{S}\right]\left[\frac{2}{S^3+4S^2+5S+2}\right]=\frac{2(SK_P+K_I)}{S(S^3+4S^2+5S+2)}$$

$$\xrightarrow{CE} 1+G(S)=0$$

$$\xrightarrow{CE} S^4+4S^3+5S^2+S(2+2K_P)+2K_I=0$$

From Necessary condition $\Rightarrow K_p>-1,\ K_I>0$

$$\begin{array}{c|ccc} s^4 & 1 & 5 & 2K_I \\ s^3 & 4 & 2+2K_p & \\ s^2 & \frac{[20-(2+2K_P)]}{4} & 2K_I & \\ s^1 & \frac{[(18-2K_P)(2+2K_P)]}{(18-2K_P)}-8K_I & & \\ s^0 & 2K_I & & \end{array}$$

For stability $\frac{20-2-2K_P}{4}>0\Rightarrow K_P<9$

$\Rightarrow -1<K_p<9$

For Stability:-

$$\Rightarrow\left[\frac{(18-2K_P)(2+2K_P)}{4}-8K_I\right]>0$$

$\Rightarrow (18-2K_p)\,[2+2K_p]-32K_I>0$

$\Rightarrow 36+36K_p-4K_p-4K_p^2-32K_I>0$

$$\Rightarrow (36+32K_P-4K_P^2)>32K_I\Rightarrow K_I<\left(\frac{36+32K_P-4K_P^2}{32}\right)$$

$$0<K_I<\left(\frac{36+32K_P-4K_P^2}{32}\right)$$

To get maximum value of $K_I\Rightarrow\frac{dK_I}{dK_P}=0$

$$\frac{dK_I}{dK_P}=0=[0+32-8K_P]=0$$

$K_p=4$

For $K_p=4$, $K_I=\frac{36+32(4)-4(4)^2}{32}=3.125$

$\Rightarrow K_{Imax}=3.125$

46. Consider two 16-point sequences x[n] and h[n]. Let the linear convolution of x[n] and h[n] be denoted by y[n], while z[n] denotes the 16-point inverse discrete Fourier transform (IDFT) of the product of the 16-point DFTs of x[n] and h[n]. The value(s) of k for which z[k] = y[k] is/are

(a) k = 15

(b) k = 0,1,2,.....,15

(c) k = 0

(d) k = 0 and k = 15

46. Ans: (a)

Sol: Given, y(n) = x(n)*h(n)

where '*' represents linear convolution

Given, z(n) = IDFT [X(k). H(k)]

$$z(n) = x(n) \textcircled{N} h(n)$$

Where $\textcircled{N}$ represents circular convolution

The length of linear convolution is $N_1 + N_2 - 1$

Given 16-point sequences. So, $N_1 + N_2 - 1 = 31$

y(n) length is 31.

The length of circular convolution is $\text{Max}(N_1, N_2)$

$= \text{Max}(16, 16)$

$= 16$

So, z(n) length is 16.

z(k) and y(k) are equal for k = 15 [16 – 1]

i.e., z(15) = y(15)

For your understanding purpose, consider two 4-point sequences as

x(n) = {1,2,3,4}, h(n) = {0,1,2,3}

$$y(n) = x(n) * h(n) = \begin{array}{c c} & \begin{array}{cccc} 0 & 1 & 2 & 3 \end{array} \\ \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \end{array} & \left[\begin{array}{cccc} 0 & 1 & 2 & 3 \\ 0 & 2 & 4 & 6 \\ 0 & 3 & 6 & 9 \\ 0 & 4 & 8 & 12 \end{array}\right] \end{array}$$

y(n) = {0,1,4, 10,16,17,12}

y(3) = 10.

$$z(n) = x(n) \textcircled{N} h(n) = \begin{bmatrix} 1 & 4 & 3 & 2 \\ 2 & 1 & 4 & 3 \\ 3 & 2 & 1 & 4 \\ 4 & 3 & 2 & 1 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \end{bmatrix}$$

z(n) = {16, 18, 16, 10}

z(3) = 10

Here y(n) and z(n) are equal for n = 3

[n = N–1 = 4 – 1]

where 'N' is length of the sequences.

47. If $(1235)_x = (3033)_y$, where x and y indicate the bases of the corresponding numbers, then

(a) x = 9 and y = 7

(b) x = 8 and y = 6

(c) x = 6 and y = 4

(d) x = 7 and y = 5

47. Ans: (b)

Sol: $(1235)_x = (3033)_y$

Convert LHS, RHS into Decimal

$$1 \times x^3 + 2 \times x^2 + 3 \times x^1 + 5 \times x^0 = 3 \times y^3 + 0 + 3 \times y^1 + 3 \times y^0$$

$$(x^3+2x^2+3x+5)_{10} = (3y^3 + 3y + 3)_{10}$$

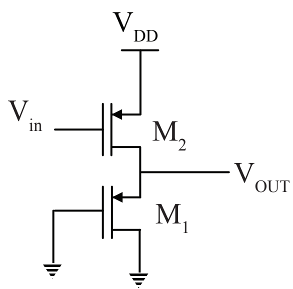
Substituting the given options, we find x = 8, y = 6

i.e., $8^3 + 2(8)^2 + 3(8) + 5 = 3(6^3) + 3(6) + 3$

LHS: $512 + 128 + 24 + 5 = 669_{10}$

RHS: $3(216) + 18 + 3 = 669_{10}$

48. In the circuit shown in the figure, the transistors M_1 and M_2 are operating in saturation. The channel length modulation coefficients of both the transistors are non-zero. The transconductance of the MOSFETs M_1 and M_2 are r_{01} and r_{02}, respectively.



Ignoring the body effect, the ac small signal voltage gain $(\partial V_{out}/\partial V_{in})$ of the circuit is

(a) $-g_{m1}\left(\frac{1}{g_{m2}} \| r_{01} \| r_{02}\right)$

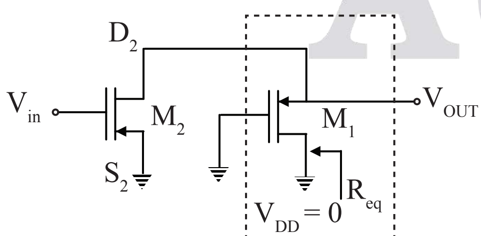
(b) $-g_{m2}(r_{01} \| r_{02})$

(c) $-g_{m2}\left(\frac{1}{g_{m1}} \| r_{01} \| r_{02}\right)$

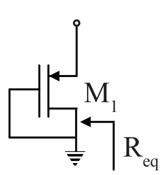
(d) $-g_{m2}\left(\frac{1}{g_{m1}} \| r_{02}\right)$

48. Ans: (c)

Sol: Step-1: AC model of the given circuit (All DC Sources = 0)

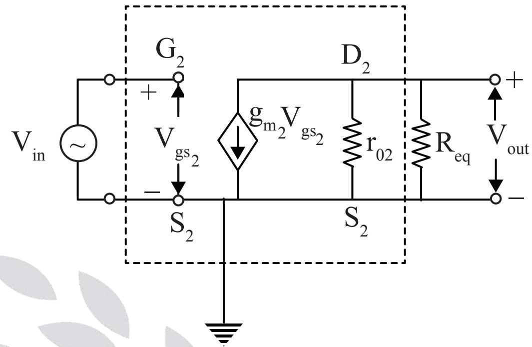


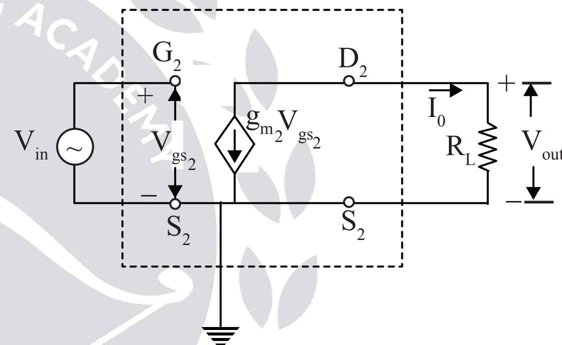
Consider the circuit w.r.t M_1



$$\Rightarrow R_{eq} = \frac{1}{g_{m_1}} \| r_{01} \quad \text{..........(1)}$$

Step-2: Small-Signal model of the given circuit





Where $R_L = r_{02} \| R_{eq}$ ....(2)

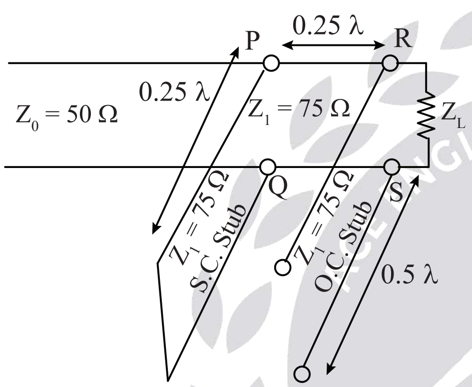
$V_{out} = I_0 R_L = -g_{m_2} V_{gs_2} R_L$ ....(3)

$$\Rightarrow \frac{V_{out}}{V_{gs_2}} = -g_{m_2} R_L \quad \text{........(4)}$$

But $V_{gs_2} = V_{in}$

$$\therefore \frac{V_{out}}{V_{in}} = A_V = -g_{m_2}[r_{02} // R_{eq}] = -g_{m_2}\left[r_{02} // \left(r_{01} // \frac{1}{g_{m_1}}\right)\right]$$

49. The impedance matching network shown in the figure is to match a lossless line having characteristic impedance $Z_0 = 50\Omega$ with a load impedance Z_L. A quarter-wave line having a characteristic impedance $Z_1 = 75\Omega$ is connected to Z_L. Two stubs having characteristic impedance of 75Ω each are connected to this quarter-wave line. One is a short-circuited (S.C.) stub of length 0.25λ connected across PQ and the other one is an open-circuit (O.C.) stub of length 0.5λ connected across RS.



The impedance matching is achieved when the real part of Z_L is

(a) 50.0 Ω

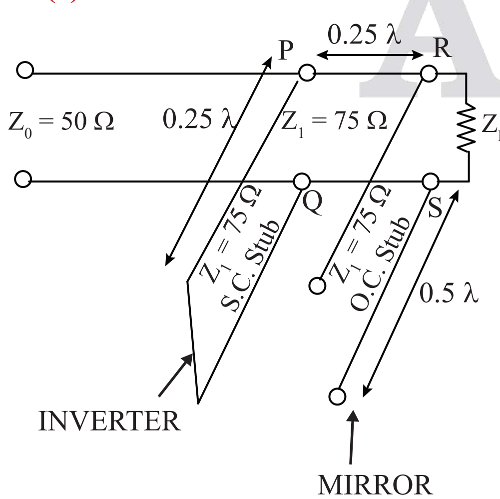
(b) 33.3 Ω

(c) 75.0 Ω

(d) 112.5 Ω

49. Ans: (d)

Sol:



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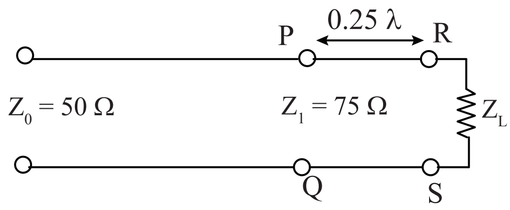

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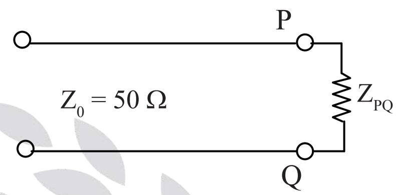


$$Z_{PQ} = \frac{75^2}{Z_L} = \frac{5625}{R_L} \qquad (Z_L = R_L)$$

$(Z_L = R_L)$

For the matching to take place there should not be any reflection

i.e., $\Gamma_L = 0$

$$\frac{Z_{PQ} - Z_0}{Z_{PQ} + Z_0} = 0$$

$\Rightarrow Z_{PQ} = Z_0$

$$\Rightarrow \frac{5625}{R_L} = Z_0 \Rightarrow R_L = \frac{5625}{50}$$

$R_L = 112.5\Omega$

50. A digital transmission system uses a (7,4) systematic linear Hamming code for transmitting data over a noisy channel. If three of the message-codeword pairs in this code $(m_i; c_i)$, where c_i is the codeword corresponding to the i^{th} message m_i, are known to be (1 1 0 0 ; 0 1 0 1 1 0 0), (1 1 1 0 ; 0 0 1 1 1 1 0) and (0 1 1 0 ; 1 0 0 0 1 1 0), then which of the following is valid codeword in this code?

(a) 1 0 1 1 0 1 0 (b) 0 1 1 0 1 0 0

(c) 0 0 0 1 0 1 1 (d) 1 1 0 1 0 0 1

50. Ans: (c)

Sol: $P_0\ P_1\ P_2\ d_0\ d_1\ d_2\ d_3$

0 1 0 1 1 0 0 ....C_1

0 0 1 1 1 1 0 ....C_2

1 0 0 0 1 1 0 ....C_3

$P_0 = d_0 \oplus d_1 \oplus d_3$

$P_1 = d_1 \oplus d_2 \oplus d_3$

$P_2 = d_0 \oplus d_1 \oplus d_2$

$P_0\ P_1\ P_2\ d_0\ d_1\ d_2\ d_3$

1 1 0 1 0 1 0 - Option a

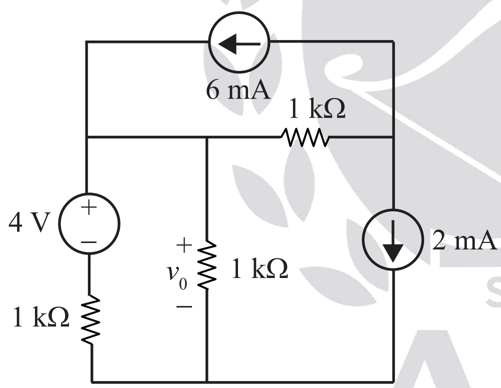
1 1 1 0 1 0 0 - Option b

0 0 0 1 0 1 1 - Option c

0 1 1 1 0 0 1 - Option d

So, Option c is a valid code word

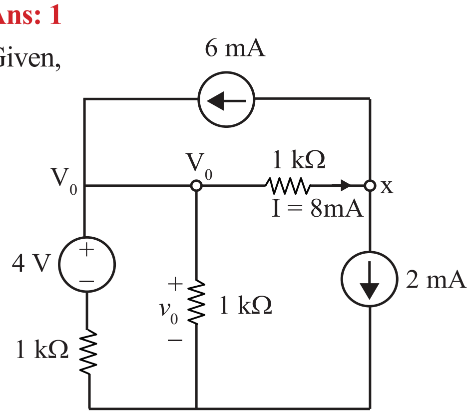
51. Consider the circuit shown in the figure.



The value of v_0 (rounded off to one decimal place) is _____ V.

51. Ans: 1

Sol: Given,



By KCL at (x) I = (6 + 2) = 8mA

By KCL at V_0

$$\frac{V_0}{1K} + \frac{V_0 - 4}{1K} + 8mA = 6mA$$

$$\frac{2V_0}{1K} - 4mA + 8mA = 6mA$$

$$\frac{2V_0}{1K} = 2mA \Rightarrow V_0 = 1 \text{ volt}$$

52. Consider the vector field $\mathbf{F} = \mathbf{a}_x(4y - c_1 z) + \mathbf{a}_y(4x + 2z) + \mathbf{a}_z(2y + z)$ in a rectangular coordinate system (x,y,z) with unit vectors a_x, a_y and a_z. If the field **F** is irrotational (conservative), then the constant c_1 (in integer) is _____

52. Ans: 0

Sol: Given that

$F = F_1\hat{a}_x + F_2\hat{a}_y + F_3\hat{a}_z$ is an irrotational

$\Rightarrow \nabla \times F = \bar{0}$ (or) Curl $F = \bar{0}$

$$\Rightarrow \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \dfrac{\partial}{\partial x} & \dfrac{\partial}{\partial y} & \dfrac{\partial}{\partial z} \\ (4y - C_1 z) & (4x - 2z) & (2y - z) \end{vmatrix} = \bar{0}$$

$$\Rightarrow (2-2)\hat{a}_x - [0 - (0 - C_1)]\hat{a}_y + (4-4)\hat{a}_z = \bar{0}$$

$$\Rightarrow (0)\hat{a}_x - (C_1)\hat{a}_y + (0)\hat{a}_z = (0)\hat{a}_x + (0)\hat{a}_y + (0)\hat{a}_z$$

$$\Rightarrow -C_1 = 0$$

$$\therefore C_1 = 0$$

53. Consider the signals $x[n] = 2^{n-1}u[-n+2]$ and $y[n] = 2^{-n+2}u[n+1]$, where u[n] is the unit step sequence. Let $X(e^{j\omega})$ and $Y(e^{j\omega})$ be the discrete-time Fourier transform of x[n] and y[n], respectively. The value of the integral

$$\frac{1}{2\pi}\int_0^{2\pi} X(e^{j\omega})Y(e^{-j\omega})d\omega$$

(rounded off to one decimal place) is _____

Hearty Congratulations to our

GATE - 2020 TOP RANKERS

EC

KALPIT AGRAWAL	PAVAN KUMAR REDDY A	D SURENDRA KUMAR	K MUKHESH	GHANENDRA SINGH	KV PAVAN KUMAR REDDY	VELURU APARANJINI	JYOTSNA PRIYA RAGU	NISHANT DHULL
AIR – 1	AIR – 1	AIR – 3	AIR – 4	AIR – 6	AIR – 7	AIR – 9	AIR – 10	AIR – 10

EE

ABHASH RAI	RUPAM RAJ	ALIN ANTO	AYUSH RAJ	NEERAJ KUSHWAHA	JATIN TIWARI	HIMANSHU KUMAR	NIKHIL KUMAR	YUVRAJ SINGH RATHORE
AIR – 1	AIR – 2	AIR – 4	AIR – 4	AIR – 6	AIR – 8	AIR – 9	AIR – 9	AIR – 9

CE

AJAY SINGHAL	SUMIT DEWDA	ASHISH CHOUDHARY	ADITYA SHARMA	TARUN GUPTA	SANAT DUTTA	SATISH RAI
AIR – 1	AIR – 1	AIR – 3	AIR – 4	AIR – 8	AIR – 9	AIR – 10

ME

VIKASH KUMAR	SHREYASH AGARWAL	MAYANK GUPTA	AKSHAY KUTE	V. V. ATCHUTA SRAVAN KUMAR	AVINASH VERMA	VIVEK KUMAR KASHYAP	NIKHIL GAIKWAD	APURVA KRISHNA YADAV	SHASHI BHUSHAN	SANKET BHATT
AIR – 1	AIR – 3	AIR – 5	AIR – 6	AIR – 6	AIR – 9	AIR – 9	AIR – 4 (XE)	AIR – 7 (XE)	AIR – 7 (XE)	AIR – 10 (XE)

CS

HITESH POPLY	HIMANSHU JAIN	AVINASH KRISHNA	ARAVIND G	PHANI MADHUSUDHAN	ASHISH KUMAR	KARAN GUPTA
AIR – 1	AIR – 3	AIR – 5	AIR – 6	AIR – 7	AIR – 8	AIR – 9

IN

KRISHNA SINGH RAJPUT	SHAKTI PATHAK	SIDDHARTHA SINHA ROY	AKASH CHOTIA	SUSHANTHIKA J	RIYA ARON
AIR – 1	AIR – 3	AIR – 5	AIR – 6	AIR – 7	AIR – 10

PI

SURYANSH GARG	MOHIT JEENA	PRAVEEN KUMAR	ROHIT AGARWAL	ANKIT YADAV	GOWTHAM GUDIMELLA	SUBHANSHU RANJAN TIWARI	GANESH ADIGAUR	DEEPESH SHARMA
AIR – 1	AIR – 2	AIR – 2	AIR – 4	AIR – 6	AIR – 6	AIR – 8	AIR – 9	AIR – 10

and many more...

Total Selections in Top 10 58

EE : 9	EC : 9	ME:7	CE : 7	CS : 7	IN : 6	PI : 9	XE : 4

53. Ans: 8

Sol: Given

$$x(n) = 2^{n-1}u(-n+2) \xleftrightarrow{F.T} X(e^{j\omega})$$
$$y(n) = 2^{-n+2}u(n+1) \xleftrightarrow{F.T} Y(e^{j\omega})$$

For any real signal $X(e^{j\omega}) = X^*(e^{-j\omega})$

$$X^*(e^{j\omega}) = X(e^{-j\omega})$$

Value of $\frac{1}{2\pi}\int_0^{2\pi} X(e^{j\omega})Y(e^{-j\omega})d\omega$

$$= \frac{1}{2\pi}\int_0^{2\pi} X(e^{j\omega})Y^*(e^{j\omega})d\omega$$

From Plancherel's theorem

$$= \sum_{n=-\infty}^{+\infty} x(n)y^*(n)$$

Overlap of the signals x(n) and y(n) in the range –1 to +2

$$x(n) = 2^{n-1};\quad n \le 2$$
$$y(n) = 2^{-n+2};\quad n \ge -1$$

$$= \sum_{n=-1}^{2} 2^{n-1}.2^{-n+2}$$
$$= \sum_{n=-1}^{2} 2$$
$$= 2[1+1+1+1]$$
$$= 8$$

54. If the vectors (1.0, –1.0, 2.0), (7.0, 3.0, x) and (2.0, 3.0, 1.0) in R^3 are linearly dependent, the value of x is ________

54. Ans: 8

Sol: Given that the vectors (1, –1, 2), (7, 3, x) and (2, 3, 1) are linearly dependent

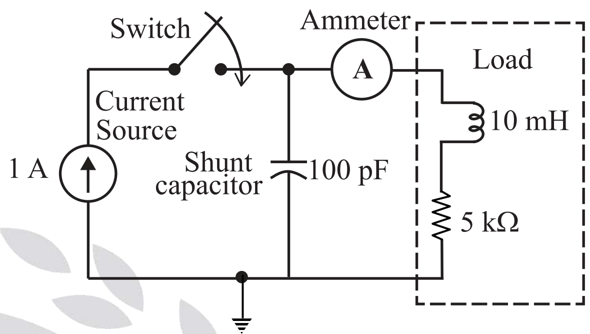
$$\Rightarrow \begin{vmatrix} 1 & -1 & 2 \\ 7 & 3 & x \\ 2 & 3 & 1 \end{vmatrix} = 0$$

$\Rightarrow$ (3–3x) – (7–2x) + 2(21–6) = 0

$\Rightarrow$ –5x + 10 + 30 = 0

$\therefore$ x = 8

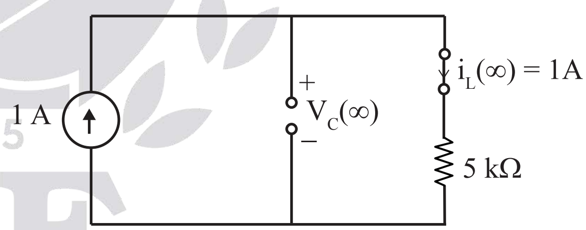
55. The circuit in the figure contains a current source driving a load having an inductor and a resistor in series, with a shunt capacitor across the load. The ammeter is assumed to have zero resistance. The switch is closed at time t = 0.



Initially, when the switch is open, the capacitor is discharged and the ammeter reads zero ampere. After the switch is closed, the ammeter reading keeps fluctuating for some time till it settles to a final steady value. The maximum ammeter reading that one will observe after the switch is closed (rounded off to two decimal places) is ________ A.

55. Ans: 1.44

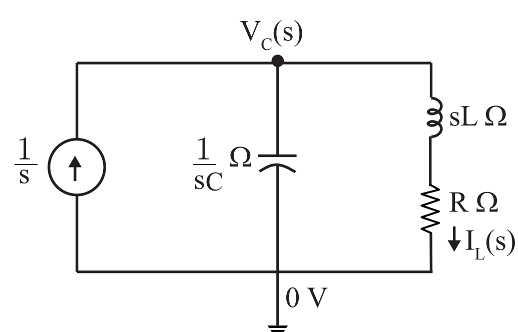
Sol: In steady state the circuit is



$\Rightarrow i_L(\infty) = 1A$ = Ammeter current in steady state

$\Rightarrow V_C(\infty) = 5K.\ 1A = 5KV$

During the transient period the Laplace domain transformed circuit with zero initial conditions



Nodal equation in S-Domain

$$\Rightarrow -\frac{1}{s}+\frac{V_C(s)}{1/sC}+\frac{V_C(s)}{R+sL}=0$$

$$\Rightarrow V_C(s)=\frac{1}{s}\cdot\frac{R+sL}{s^2LC+RCs+1}$$

$$\Rightarrow I_L(s)=\frac{V_C(s)}{R+sL}=\frac{1/LC}{s\left(s^2+\frac{R}{L}s+\frac{1}{LC}\right)}$$

$$\Rightarrow \omega_n^2=\frac{1}{LC}\ \ \&\ 2\xi\omega_n=\frac{R}{L}\Rightarrow \xi=\frac{R}{2}\sqrt{\frac{C}{L}}$$

$$\Rightarrow \xi=\frac{5\times10^3}{2}\sqrt{\frac{100\times10^{-12}}{10\times10^{-3}}}=2.5\times10^{+3}\sqrt{10^{-8}}$$

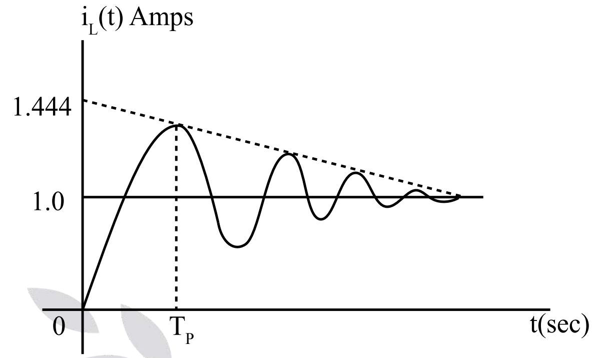
$$=2.5\times10^3\times10^{-4}$$

$$=0.25$$

$\rightarrow$ Peak over shoot (or) First maxima $= e^{-\xi\pi/\sqrt{1-\xi^2}}$

$$= e^{-\frac{0.25\times3.14}{\sqrt{1-(0.25)^2}}}$$

$$= 0.4443$$



So, the maximum ammeter reading just after the switch closed is $i_L(t)|_{max} = 1 + 0.444 = 1.444$A

Hearty Congratulations to our

ESE - 2019 TOP RANKERS

ELECTRICAL ENGINEERING

- AIR 1 KARTIKEYA SINGH
- AIR 2 SHAMBHAVI T
- AIR 3 ABHISHEK ANAND
- AIR 4 ANKIT TAYAL
- AIR 5 KUMAR MAYANK
- AIR 6 RITESH LALWANI
- AIR 7 KARTIKEY SINGH
- AIR 9 DEEPITA ROY
- AIR 10 ANKITA SHARMA

ELECTRONICS & TELECOMMUNICATION ENGINEERING

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- AIR 2 ANKUSH MANGLA
- AIR 3 ROHIT KUMAR
- AIR 4 AMIR KHAN
- AIR 7 RAHUL JAIN
- AIR 8 KULDEEP KUMAR
- AIR 9 SHUBHAM KARNANI
- AIR 10 GAURAV SRIVASTAVA

MECHANICAL ENGINEERING

- AIR 1 HARSHAL BHOSALE
- AIR 2 SAHIL GOYAL
- AIR 3 KUMAR CHANDAN
- AIR 4 SAURAV
- AIR 6 PUSHPAK
- AIR 7 MANISH RAJPUT
- AIR 8 HEMANT KUMAR SINGH
- AIR 9 DWEEP SABAPARA
- AIR 10 SUMIT BHAMBOO

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- AIR 3 AMARJEET
- AIR 4 AMAN GULIA
- AIR 5 AYUSH CHANDRA
- AIR 6 KABIL BHARGAVA
- AIR 8 YOGESH KUMAR
- AIR 9 ANKIT KUMAR

and many more...

Total Selections in Top 10 33

EE : 9	E&T : 8	ME : 9	CE : 7