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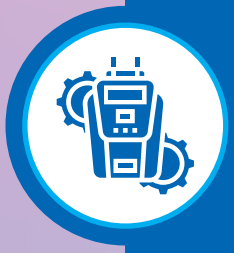

INSTRUMENTATION ENGINEERING

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GATE - 2021

Questions with Detailed Solutions

06/02/2021

Forenoon Session

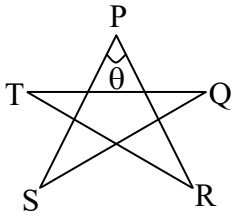
Instrumentation Engineering

SUBJECTWISE WEIGHTAGE

Name of the Subject	1Mark	2Marks	Total Marks
Electrical Circuits and Machine	1	4	9
Signals & Systems	3	2	7
Control System and Process Control	2	3	8
Analog Electronics	2	3	8
Digital Electronics	3	3	9
Measurements	2	5	12
Sensors & Industrial Instrumentation	4	2	8
Communication & Optical Instrumentation	2	3	8
General Aptitude	5	5	15
Engineering Mathematics	5	3	11
Electricity and Magnetism	1	2	5
Total	30	35	100

GENERAL APTITUDE

01.



Five line segments of equal lengths, PR, PS, QT and RT are used to form a star as shown in the figure above.

The value of θ, in degrees, is _____

(a) 108

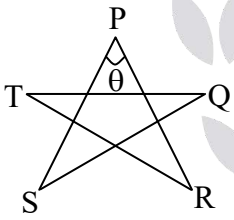
(b) 36

(c) 72

(d) 45

01. Ans: (b)

Sol:



Sum of the angles = 180°

Each angle $= \frac{180}{5} = 36^{\circ}$

02. Getting to the top is _____ than staying on top.

(a) much easy

(b) easier

(c) more easy

(d) easiest

02. Ans: (b)

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03. Four persons P, Q, R and S are to be seated in a row, all facing the same direction, but not necessarily in the same order. P and R cannot sit adjacent to each other. S should be seated to the right of Q. The number of distinct seating arrangements

(a) 6 (b) 8

(c) 4 (d) 2

03. Ans: (a)

Sol: P and R can not sit adjacent to each other 'S' is seated right of Q.

(i) PQSR

After interchanging 'P' and 'R', we get one more chance.

RQSP

(ii) Q _ S _ (here two chances)

(iii) _ Q _ S (here two chances)

So, total '6' chances

04.

The mirror image of the above text about the X-axis is

(a) ⊥ꓤIAИƆꓶE

(b) ⊥ꓤIAИƃꓶE

(c) ⊥ꓤIAИƆꓶE

(d) ⊥ꓤIAИƆꓶƎ

04. Ans: (a)

05. Statement: Either P marries Q or X marries Y

Among the options below, the logical NEGATION of the above statement is:

(a) X does not marry Y and P marries Q.

(b) Neither P marries Q nor X marries Y.

(c) P does not marry Q and X marries Y.

(d) P marries Q and X marries Y.

05. Ans: (b)

06. In a company, 35% of the employees drink coffee, 40% of the employees drink tea and 10% of the employees drink both tea and coffee. What % of employees drink neither tea nor coffee?

(a) 15 (b) 25

(c) 35 (d) 40

06. Ans: (c)

Sol: n[coffee] = 35%

n [Tea] = 40%

n [C∩T] = 10%

n [C∪T] = 35 + 40 – 10 = 65%

100 – 65 = 35%

Neither Tea or Coffee

07. Humans have the ability to construct worlds entirely in their minds, which don't exist in the physical world. So far as we know, no other species possesses this ability. This skill is so important that we have different words to refer to its different flavors, such as imagination, invention and innovation.

Based on the above passage, which one of the following is TRUE?

(a) No species possess the ability to construct worlds in their minds.

(b) We do not know of any species other than human who possess the ability to construct mental worlds.

(c) The terms imaginations invention and innovation refer to unrelated skills.

(d) Imagination, invention and innovation are unrelated to the ability to construct mental worlds.

07. Ans: (b)

08. A function λ, is defined by

$$\lambda(p,g)=\begin{cases}(p-g)^2, & \text{if } p\geq q,\\ p+q, & \text{if } p<q,\end{cases}$$

The value of the expression $\dfrac{\lambda(-(-3+2),(-2+3))}{(-(-2+1))}$ is:

(a) 0 (b) 16 (c) –1 (d) $\dfrac{16}{3}$

08. Ans: (a)

Sol: $\lambda(p,q)=\begin{cases}(p-q)^2 & \text{if } p\geq q\\ (p+q) & \text{if } p<q\end{cases}$

$$\frac{\lambda(-(3+2),(-2+3))}{(-(-2+1))}=\frac{\lambda(1,1)}{1}=\frac{(1-1)^2}{1}=0$$

09. Consider two rectangular sheets, Sheet M and Sheet N of dimensions 6 cm x 4 cm each.

Folding operation 1: The sheet is folded into half by joining the short edges of the current shape.

Folding operation 2: The sheet is folded into half by joining the long edges of the current shape.

Folding operation 1 is carried out on Sheet M three times.

Folding operation 2 is carried out on Sheet N three times.

The ratio of perimeters of the final folded shape of Sheet N to the final folded shape of Sheet M is_____,

(a) 3 : 2 (b) 7 : 5 (c) 13 : 7 (d) 5 : 13

09. Ans: (c)

Sol:

Shortest side folding

1st: 3 | 4

2nd: 3 | 2

3rd: 1.5 | 2

Perimeter = 2(2 + 1.5) =7

longest side folded

1st: 6 | 2

2nd: 6 | 1

3rd: 6 | 0.5

Perimeter = 2(6 + 0.5) =13

But requirement is N : M

13 : 7

10. $\oplus$ and $\odot$ are two operators on numbers p and q such that

$$p \oplus q = \frac{p^2 + q^2}{pq} \text{ and } p \odot q = \frac{p^2}{q};$$

If $x \oplus y = 2 \odot 2$, then x =

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

(b) 2y

(c) $\frac{3y}{2}$

(d) y

10. Ans: (d)

Sol: $p \oplus q = \frac{p+q}{pq}$ $p \odot q = \frac{p}{q}$

$x \oplus y = 2 \odot 2$

$$\frac{x^2 + y^2}{xy} = \frac{2^2}{2}$$

$x^2 + y^2 = 2xy$

$x^2 + y^2 - 2xy = 0$

$(x-y)^2 = 0$

$x - y = 0$

$x = y$

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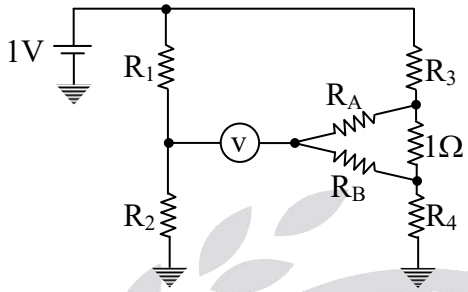
INSTRUMENTATION ENGINEERING

01. In the bridge circuit shown, the voltmeter V showed zero when the value of the resistors are: $R_1 = 100\ \Omega$, $R_2 = 110\ \Omega$, and $R_3 = 90\Omega$. If $(R_1/R_2) = (R_A/R_B)$, the value of R_4 in ohm is_____.



01. Ans: 99

Sol: The given circuit is a Kelvin double bridge under balanced conditions zero deflection in the voltmeter, the condition is

$$R_3 = \frac{R_1}{R_2}R_4 + \frac{R_A r}{R_A + R_B + 1}\left[\frac{R_1}{R_2} - \frac{R_A}{R_B}\right]$$

Here 'r' is the resistance between R_3 and R_4

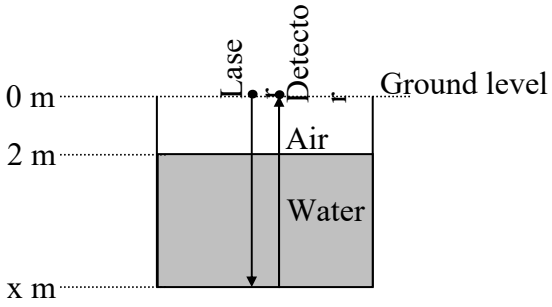
The given condition is $\frac{R_1}{R_2} = \frac{R_A}{R_B}$, then the above equation becomes

$$\Rightarrow R_3 = \frac{R_1}{R_2}R_4$$

$$\Rightarrow R_4 = R_3\frac{R_2}{R_1} = 90 \times \frac{110}{100} = 99\Omega$$

02. A laser pulse is sent from ground level to the bottom of a concrete water tank at normal incidence. The tank is filled with water up to 2 m below the ground level. The reflected pulse from the bottom of the tank travels back and hits the detector. The round-trip time elapsed between sending the laser pulse, the pulse hitting the bottom of the tank, reflecting back and sensed by the detector is 100 ns. The depth of the tank from ground level marked as x in metre is _____.

(Refractive index of water $n_{water} = 1.3$ and velocity of light in air $C_{air} = 3 \times 10^8$ m/s)

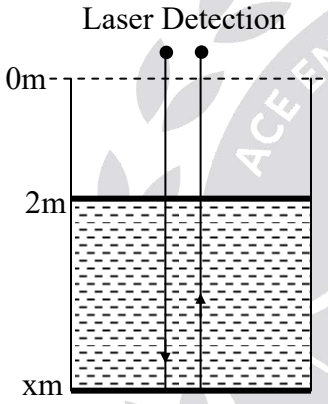


(a) 10 (b) 11

(c) 9 (d) 12

02. Ans: (d)

Sol:



Given $n_{water} = 1.3$

$C_{air} = 3\times10^8$ m/sec

$C_{water} = 2.307\times10^8$ m/sec

We, know, time = distance/velocity

$$\Rightarrow 100\times10^{-9} = \frac{2\times2}{C_{air}} + \frac{2(x-2)}{C_{water}}$$

$$\Rightarrow 100\times10^{-9} = \frac{4}{3\times10^8} + \frac{2x-4}{2.307\times10^8}$$

$$\Rightarrow 100\times10^{-9} = 1.333\times10^{-8} - 1.733\times10^{-8} + 0.87\times10^{-8}x$$

$$\Rightarrow 100\times10^{-1} = -0.4 + 0.87$$

$$\Rightarrow 10 + 0.4 = 0.87x$$

$$\Rightarrow x = 11.9540\text{m}$$

$$\cong 12\text{m}$$

03. Let u(t) denote the unit step function. The bilateral Laplace transform of the function $f(t) = e^{t}u(-t)$ is _____.

(a) $\frac{1}{s-1}$ with real part of $s < 1$

(b) $\frac{1}{s-1}$ with real part of $s > 1$

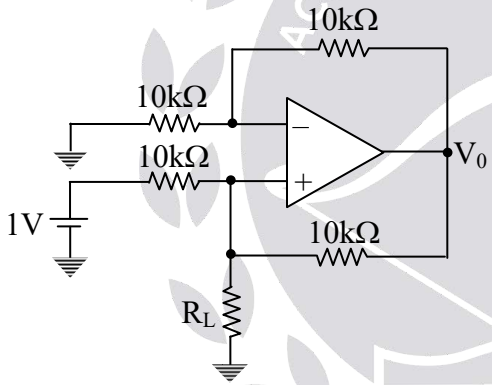
(c) $\frac{-1}{s-1}$ with real part of $s > 1$

(d) $\frac{-1}{s-1}$ with real part of $s < 1$

03. Ans: (d)

Sol: $e^{t}u(-t) \leftrightarrow \frac{-1}{S-1}$; $\mathrm{Re}\{S\} < 1$

04. The output V_o of the ideal OpAmp used in the circuit shown below is 5V. Then the value of resistor R_L in kilo ohm (kΩ) is



(a) 25

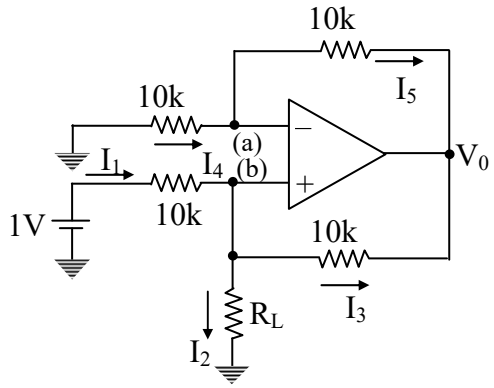
(b) 2.5

(c) 50

(d) 5

04. Ans: (a)

Sol:



Given that $V_0 = 5V$

Since $V_d = 0$, $V_a = V_b$

$$V_a = V_0\left(\frac{10}{20}\right) = 2.5V$$

Apply KCL at (b)

$I_1 = I_2 + I_3 \Rightarrow I_2 = I_1 - I_3$

$$\frac{V_b}{R_L} = \frac{1 - V_b}{10} - \frac{V_b - 5}{10} = \left(\frac{1 - V_b - V_b + 5}{10}\right)$$

$$\frac{2.5}{R_L} = \frac{6 - 5}{10} \Rightarrow R_L = 25K\Omega$$

05. A single-phase transformer has a magnetizing inductance of 250 mH and a core loss resistance of 300Ω, referred to primary side. When excited with a 230 V, 50 Hz sinusoidal supply at the primary, the power factor of the input current drawn, with secondary on open circuit, is _____ (rounded off to two decimal places).

05. Ans: 0.253

Sol: $L_0 = 250 \times 10^{-3}$ H, $R_0 = 300\Omega$

$X_{L0} = 2\pi f L_0 = 2\pi \times 50 \times 250 \times 10^{-3}$

$= 78.54\Omega$

$$B_{L0} = \frac{1}{X_{L0}} = \frac{1}{78.54} = 0.01273\,\text{℧}$$

$$G_0 = \frac{1}{300} = 3.33 \times 10^{-3}\,\text{℧}$$

$$Y_0 = \sqrt{G_0^2 + B_{L0}^2} = 0.01316\,\text{℧}$$

$$\cos\phi_0 = \frac{G_0}{Y_0} = 0.253 \quad (\text{lag})$$

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Spark	Daily 6 to 8 Hours	**17th May 2021**	9 to 10 Months	Kukatpally (EC, EE) Abids (CE, ME)
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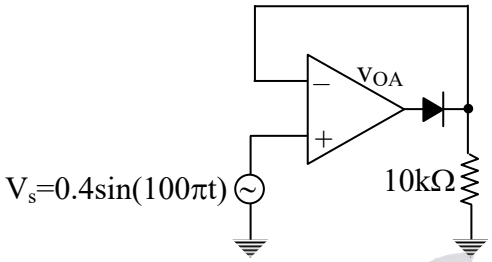
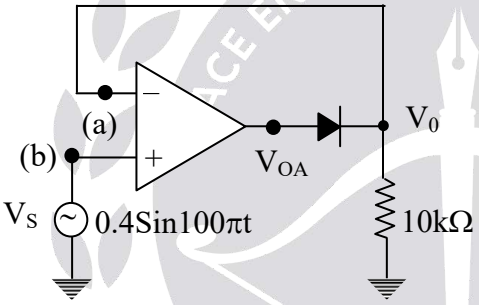
06. The diode used in the circuit has a fixed voltage drop of 0.6V when forward biased. A signal v_s is given to the ideal OpAmp as shown. When v_s is at its positive peak, the output (v_{OA}) of the OpAmp in volts is _____.



06. Ans: 1

Sol:



Given circuit is Precision Rectifier

Let initially D-OFF, $V_0 = 0 = V_a$

$V_b = V_i$

When $V_b > V_a \rightarrow$ Op-amp in +Ve saturation region

$V_b < V_a \rightarrow$ Op-amp in –Ve saturation region

When $V_i < 0 \Rightarrow$ D-OFF $\Rightarrow V_0 = 0$

When $V_i > 0 \Rightarrow$ D-ON (replaced by 0.6V) $\Rightarrow V_0 = V_s$

Then $V_{OA} - V_0 = 0.6 \Rightarrow V_{OA} = V_0 + 0.6$

$V_{OA} = V_0 + 0.6$

When V_S at its positive peak $V_S = 0.4V$

$\Rightarrow V_{OA} = 1V$

07. The signal $\sin\left(\sqrt{2\pi t}\right)$ is

(a) periodic with period T = 2π

(b) periodic with period T = $\sqrt{2\pi}$

(c) not periodic

(d) periodic with period T = $4\pi^2$

07. Ans: (c)

Sol: $\text{Sin}\left(\sqrt{2\pi t}\right)$ is not periodic

08. A 16-bit microprocessor has twenty address lines (A_0 to A_{19}) and 16 data lines. The higher eight significant lines of the data bus of the processor are tied to the 8-data lines of a 16 Kbyte memory that can store one byte in each of its 16K address locations. The memory chip should map onto contiguous memory locations and occupy only 16 Kbyte of memory space. Which of the following statement(s) is/are correct with respect to the above design?

(a) The above chip cannot be interfaced as the width of the data bus of the processor and the memory chip differs.

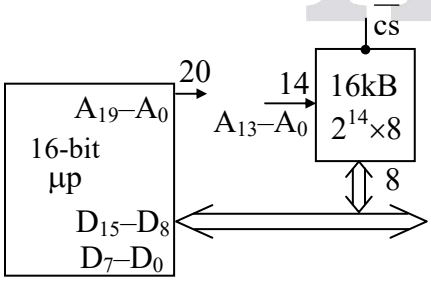
(b) The 16 Kbyte memory cannot be mapped with contiguous address locations with a starting address as 0F000H using only A_{19} to A_{14} for generating chip select.

(c) If the 16 Kbyte of memory chip is mapped with a starting address of 80000H, then the ending address will be 83FFFH.

(d) The active high chip-select needed to map the 16 Kbyte memory with a starting address at F0000H is given by the logic expression (A_{19} A_{18} A_{17} A_{16})

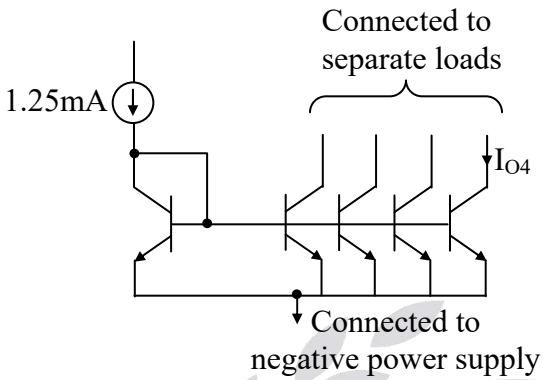
08. Ans: (b and c)

Sol: 20 address lines, data lines = 16



Correct option is b and c.

09. All the transistors used in the circuit are matched and have a current gain β of 20. Neglecting the Early effect, the current I_{O4} in milliampere is _____.

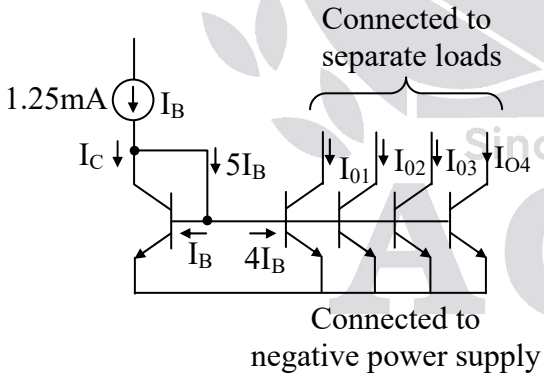


09. Ans: 1

Sol: As all transistor used in the circuit are matched and their V_{BE} are same and $I_C = I_{04}$

Then $I_S = I_C + 5\,I_B$

$$= I_C + 5\frac{I_C}{\beta}$$



$$I_S = I_C\left(1+\frac{5}{\beta}\right)$$

$$I_C = \frac{I_S}{1+\frac{5}{\beta}} \Rightarrow I_{04} = \frac{1.25\times10^{-3}}{1+\frac{5}{20}} = 1\text{mA}$$

10. Consider the sequence $x_n = 0.5x_{n-1} + 1$, n = 1,2, ……. with $x_0 = 0$. Then $\lim_{n\to\infty} x_n$ is

(a) 2 (b) ∞

(c) 1 (d) 0

10. Ans: (a)

Sol: Given: $x_n = 0.5x_{n-1} + 1$,

$n = 1,2,3,\ldots..$

$x_1 = 0.5\ x_0 + 1$

$x_1 = 1\ (\because\ x_0 = 0)$

$x_2 = 0.5\ x_1 + 1$

$x_2 = 0.5 + 1 = 1.5$

$x_3 = 0.5\ x_2 + 1$

$x_3 = (0.5)\ (1.5) + 1 = 1.75$

$x_4 = 0.5\ x_3 + 1 = 0.5\ (1.75) + 1$

$x_4 = 1.875$

$x_5 = 0.5\ x_4 + 1 = 0.5 \times 1.875 + 1$

$x_5 = 1.9375$

$\lim_{n\to\infty} x_n = 2$

(OR)

$x_n = 0.5\ x_{n-1} + 1$

Put $x_n = x_{n-1}$

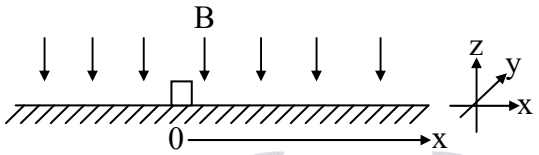
$x_n = 0.5x_n + 1$

$x_n - 0.5x_n = 1$

$0.5\ x_n = 1$

$x_n = 2$

11. The figure below shows an electrically conductive bar of square cross-section resting on a plane surface. The bar of mass of 1 kg has a depth of 0.5 m along the y direction. The coefficient of friction between the bar and the surface is 0.1. Assume the acceleration due to gravity to be 10 m/s^2. The system faces a uniform flux density $B = -1\ \hat{z}$ T. At time t = 0, a current of 10 A is switched onto the bar and is maintained.



When the bar has moved by 1m, its speed in metre per second is _____ (rounded off to one decimal place).

11. Ans: 2.82

Sol: The net force (F) on bar, which is subject to friction is equal to the sum of the applied force (F_{appl}) and the frictional force (F_{fr}).

$F = F_{appl} - F_{fr}$; (The negative sign is due to the frictional force opposes motion)

$ma = I \ell B - kmg$

where: m : mass of bar 1kg

I : current , I = 10A

ℓ : length of bar $\ell = 0.5m$

B = 1

k : Coefficient of friction k = 0.1

$g = 10 m/sec^2$

$$a = \frac{I\ell B}{m} - kg$$

$$= \frac{10 \times 0.5 \times 1}{1} - 0.1 \times 10$$

$a = 4 m/sec^2$

Acceleration, $a = 4 m/sec^2$

$v^2 - u^2 = 2as$; (From basics of Kinematics)

where 's' is the distance travelled by the bar

s = 1m

As bar is initially resting on the surface and hence its initial velocity u = 0

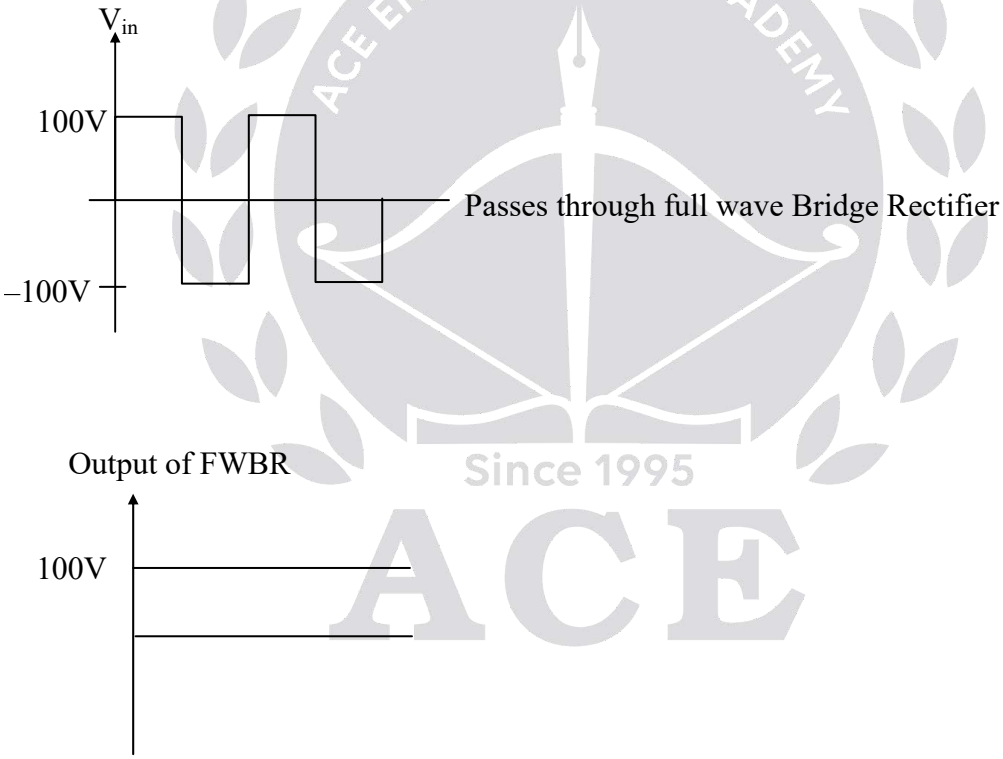
$V^2 = 2x\ (4)\ (1)$

$\therefore$ Speed, V = 2.82 m/sec

12. A $3\frac{1}{2}$ digit, rectifier type digital meter is set to read in its 2000 V range. A symmetrical square wave of frequency 50 Hz and amplitude ± 100 is measured using the meter. The meter will read_____.

12. Ans: 111

Sol:



Given to Dual slope integrating ADC which measures average value of output of FWBR

$\therefore$ Reading = 100 × 1.11 = 111 (Reading on 2000 Voltage range).

13. Taking N as positive for clockwise encirclement, otherwise negative, the number of encirclements N of (–1, 0) in the Nyquist plot of $G(s)=\frac{3}{s-1}$ is _____.

13. Ans: –1

Sol: $G(s)=\frac{3}{S-1}$

$G(j\omega)=\frac{3}{(j\omega-1)}$

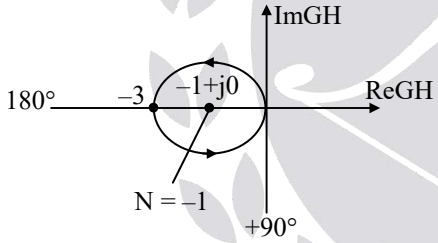
$M=\frac{3}{\sqrt{\omega^2+1}}$

$\theta = 180° - \tan^{-1}(\omega)$

$\omega = 0 \quad 3 \angle 180°$

$\omega = \infty \quad 0 \angle 90°$

$\rightarrow$ CW direction



14. The step response of a circuit is seen to have an oscillatory behaviour at the output with oscillations dying down after some time. The correct inference(s) regarding the transfer function from input to output is/are

(a) That it is of at least second order.

(b) That is does not have a real pole.

(c) That it has at least one pole-pair that is underdamped.

(d) That it is a first order system.

14. Ans: (a and c)

Sol: To get under damped oscillations, one pair of poles are complex conjugate.

15. When the movable arm of a Michelson interferometer in vacuum (n = 1) is moved by 325 μm, the number of fringe crossings is 1000. The wavelength of the laser used in nanometers is _____.

15. Ans: 650

Sol: For Michelson interferometer

$n\lambda = 2\ d$

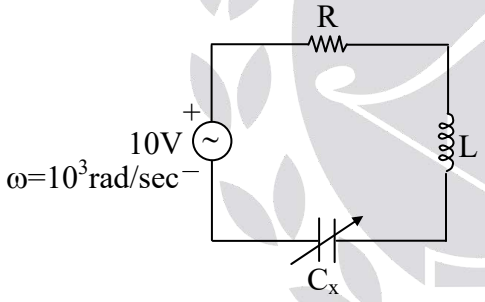
$\Rightarrow 1000 \times \lambda = 2 \times 325 \times 10^{-6}$

$\Rightarrow \lambda = 650\ nm$

16. A air cored coil having a winding resistance of 10 Ω is connected in series with a variable capacitor C_x. The series circuit is excited by a 10 V sinusoidal voltage source of angular frequency 1000 rad/s. As the value of the capacitor is varied, a maximum voltage of 30 V was observed across it. Neglecting skin-effect, the value of the inductance of the coil in millihenry is _____.

16. Ans: 30

Sol:



$|V_{C\max}| = QV$

$\Rightarrow 30 = Q\ 10$

$\Rightarrow Q = 3 =$ quality factor

$\Rightarrow Q$ – factor of a coil is $Q = \dfrac{\omega L}{R}$

$\Rightarrow 3 = \dfrac{10^3 \times L}{10}$

$\Rightarrow L = 30mH$

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17. A strain gage having nominal resistance of 1000 Ω has a gage factor of 2.5. If the strain applied to the gage is 100 μm/m, its resistance in ohm will change to _____ (rounded off to two decimal places).

17. Ans: 1000.25

Sol: R = 1000Ω

GF = 2.5

ε = 100 μm/m

$$\frac{\Delta R}{R} = GF\varepsilon$$

$\Delta R = GF\ \varepsilon R$

$= 2.5 \times 100 \times 10^{-6} \times 1000$

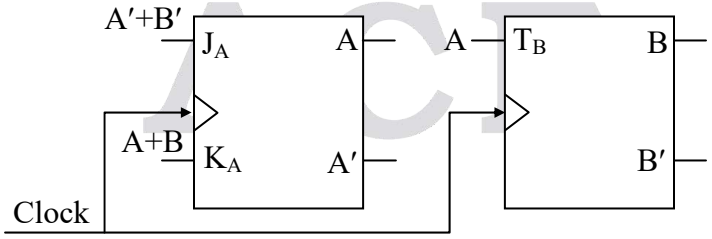
$\Delta R = 0.25\Omega$

So the resistance of the strain gauge changes to = R + ΔR

= 1000 + 0.25

= 1000.25Ω

18. Given below the diagram of a synchronous sequential circuit with one J-K flip-flop and one T flip-flop with their outputs denoted as A and B respectively, with $J_A = (A' + B')$, $K_A = (A + B)$, and $T_B = A$.



Starting from the initial state (AB = 00), the sequence of states (AB) visited by the circuit is

(a) 00 → 10 → 11 → 01 → 00 ….

(b) 00 → 01 → 10 → 11 → 00…

(c) 00 → 01 → 11 → 00 ….

(d) 00 → 10 → 01 → 11→ 00 …

18. Ans: (d)

Sol: $J_A = \overline{A} + \overline{B} = \overline{AB}; K_A = A + B; T_B = A$

Initial state AB = 00

	Present state		FF-input J_A	K_A	T_B	Next state		
	A	B	J_A	K_A	T_B	A	B	
⓪	0	0	1	0	0	1	0	②
①	1	0	1	1	1	0	1	①
②	0	1	1	1	0	1	1	③
③	1	1	0	1	1	0	0	⓪

Sequence of state AB = 00, 10, 01, 11

19. A single-phase transformer has maximum efficiency of 98%. The core losses are 80 W and the equivalent winding resistance as seen from the primary side is 0.5 Ω. The rated current on the primary side is 25 A. The percentage of the rated input current at which the maximum efficiency occurs is

(a) 50.6% (b) 80.5%

(c) 100% (d) 35.7%

19. Ans: (a)

Sol: $\eta_{max} = 98\%$

$W_{iron} = 80W$

$R_{01} = 0.5\Omega$

$I_1 = 25A$

At maximum efficiency,

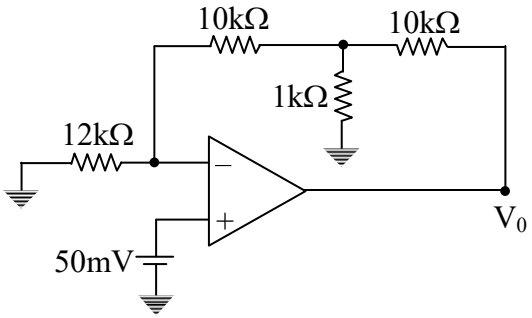
$x^2 I_1^2 R_{01} = W_i$

$x^2(25)^2\ (0.5) = 80$

$x = 50.59\%$

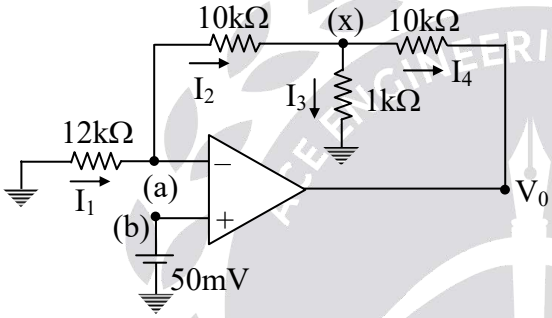
At 50.59% of load max efficiency occurs.

20. The circuit shown below uses an ideal OpAmp. Output V_o in volt is _____ (rounded off to one decimal place).



20. Ans: 1.05

Sol:



Since $V_d = 0$, $V_a = V_b = 50mV$

Apply KCL at (a)

$I_1 = I_2$

$$-\frac{V_a}{12K} = \frac{V_a - V_x}{10K} \Rightarrow \frac{-10V_a}{12} = V_a - V_x$$

$$V_x = V_a\left(1+\frac{10}{12}\right) = 91.6666mV$$

Apply KCL at (x)

$I_2 = I_3 + I_4$

$$\frac{V_a - V_x}{10K} = \frac{V_x}{1K} + \frac{V_x - V_0}{10K}$$

$$\frac{V_a - V_x}{10} = \frac{10V_x + V_x - V_0}{10}$$

$\Rightarrow V_0 = 12V_x - V_a = 12\,(91.6666) - 50$

$= 1050\ mV$

$V_0 = 1.05V$

21. A toroid made of CRGO has an inner diameter of 10 cm and an outer diameter of 14 cm. The thickness of the toroid is 2cm. 200 turns of copper wire is wound on the core. $\mu_0 = 4\pi \times 10^{-7}$ H/m and μ_R of CRGO is 3000. When a current of 5 mA flows through the winding, the flux density in the core in militesla is _____.

21. Ans: 10

Sol: Given: Toroid is made of CRGO with

$\mu_r = 3000$

$\mu_0 = 4\pi \times 10^{-7}$ H/m

$I = 5$ mA

$N = 200$

Inner diameter, $D_1 = 10$cm

Outer diameter, $D_2 = 14$cm

Mean diameter, $D = \left(\frac{10+14}{2}\right) = 12$cm

Mean radius, $R = 6$cm

Magnetic flux density in the core is given by

$$B = \frac{\mu NI}{\ell}$$

where, ℓ is mean length of toroid , $\ell = 2\pi R$

$$B = \frac{\mu_0 \mu_r NI}{2\pi R}$$

$$= \frac{4\pi \times 10^{-7} \times 3000 \times 200 \times 5 \times 10^{-3}}{2\pi \times 6 \times 10^{-2}}$$

$$= \frac{2 \times 10^{-7} \times 3 \times 10^{3} \times 2 \times 10^{2} \times 5 \times 10^{-3}}{6 \times 10^{-2}}$$

$\therefore B = 10$mT

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22. The determinant of the matrix M shown below is _____.

$$M = \begin{bmatrix} 1 & 2 & 0 & 0 \\ 3 & 4 & 0 & 0 \\ 0 & 0 & 4 & 3 \\ 0 & 0 & 2 & 1 \end{bmatrix}$$

22. Ans: 4

Sol: $|M| = \begin{vmatrix} 1 & 2 & 0 & 0 \\ 3 & 4 & 0 & 0 \\ 0 & 0 & 4 & 3 \\ 0 & 0 & 2 & 1 \end{vmatrix}$

$C_2 \rightarrow C_2 - 2C_1$

$$|M| = \begin{vmatrix} 1 & 0 & 0 & 0 \\ 3 & -2 & 0 & 0 \\ 0 & 0 & 4 & 3 \\ 0 & 0 & 2 & 1 \end{vmatrix}$$

$$|M| = \begin{vmatrix} -2 & 0 & 0 \\ 0 & 4 & 3 \\ 0 & 2 & 1 \end{vmatrix} = 4$$

23. Given $A = \begin{pmatrix} 2 & 5 \\ 0 & 3 \end{pmatrix}$. The value of the determinant $|A^4 - 5A^3 + 6A^2 + 2I| =$ _____.

23. Ans: 4

Sol: $A = \begin{pmatrix} 2 & 5 \\ 0 & 3 \end{pmatrix}$

C.E $|A - \lambda I| = 0$

$$|A - \lambda I| = \begin{vmatrix} 2-\lambda & 5 \\ 0 & 3-\lambda \end{vmatrix} = 0$$

$\lambda^2 - (5)\lambda + 6 = 0$

By, Cayley – Hamilton theorem

$A^2 - 5A + 6 = 0$

$A^2 (A^2 - 5A + 6) = 0$

$A^4 - 5A^3 + 6A^2 = 0$

In the given question

$= \left|A^4 - 5A^3 + 6A^2 + 2I\right|$

$= |0 + 2I|$

$= |2I|$

$= \begin{vmatrix} 2 & 0 \\ 0 & 2 \end{vmatrix} = 4$

24. A Boolean function F of three variable X, Y, and Z is given as

F (X, Y, Z) = (X′ + Y + Z).(X + Y′ + Z′).(X′ + Y + Z′).(X′ Y′ Z′ +X′ Y Z′ + X Y Z′)

Which one of the following is true?

(a) F (X, Y, Z) = X′ Z′ + Y Z′

(b) F (X, Y, Z) = (X′ + Y).(X + Y′ + Z′)

(c) F (X, Y, Z) = X′ Y′ Z + X Y Z

(d) F (X, Y, Z) = (X + Y + Z′).(X′ + Y′ + Z′)

24. Ans: (a)

Sol: F (X, Y, Z) = (X′ + Y + Z).(X + Y′ + Z′).(X′ + Y + Z′).(X′ Y′ Z′ +X′ Y Z′ + X Y Z′)

Distributive law

= (X′ + Y) (X + Y′ + Z′) (X′ Y′ + X′ Y + X Y) Z′

= (X′ + Y) (X + Y′ + Z′).(X′ + X Y)Z′

= (X′ + Y) (X + Y′ + Z′) (X′ + Y) Z′

= (X′ + Y) (X + Y′ + Z′) Z′

= (X′ + Y) (X Z′ + Y′ Z′ + Z′)

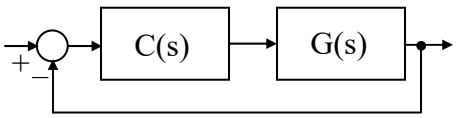
= (X′ + Y) (X + Y′ + 1) Z′

= (X′ + Y) Z′

F = X′ Z′ + Y Z′

25. Consider a unity feedback configuration with a plant and a PID controller as shown in figure.

$$G(s)=\frac{1}{(s+1)(s+3)} \text{ and } C(s)=K\frac{(s+3-j)(s+3+j)}{s} \text{ with}$$



(a) Only stable for K > 0

(b) Only stable for K between –1 and +1

(c) Stable for all values of K

(d) Only stable for K < 0

25. Ans: (a)

Sol: Method-1:-

$$\Rightarrow C(s)G(S)=\frac{K(S^2+6S+10)}{S(S+1)(S+3)},\ H(s)=1$$

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

$$\xrightarrow{CE} S^3+4S^2+3S+KS^2+6KS+10K=0$$

$$\xrightarrow{CE} S^3+S^2(K+4)+S(6K+3)+10K=0$$

S^3	1	6k+3
S^2	k + 4	10k
S^1	$\frac{(k+4)(6k+3)-10k}{(k+4)}$	
S^0	10k	

For stability: K > 0 [K should be positive]

$K + 4 > 0 \Rightarrow K > -4$ [Invalid]

$[(K+4)(6K+3)-10K) > 0$

$\Rightarrow 6K^2 + 3K + 24K + 12 - 10K > 0$

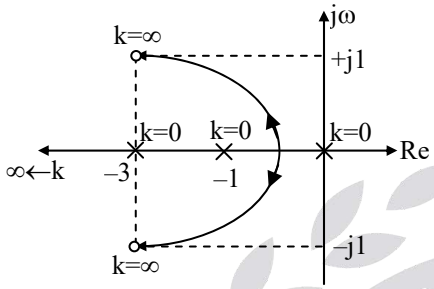
$\Rightarrow 6K^2 + 17K + 12 > 0$

$K = \frac{-4}{3}, \frac{-3}{2}$ [Invalid]

Method-2:-

Root Locus method:-

$$C(s)G(s)=\frac{K(S^2+6S+10)}{S(S+1)(S+3)},\ H(s)=1$$



K > 0 system is stable.

26. A piezo resistive pressure sensor has a sensitivity of 1 (mV/V)/kPa. The sensor is excited with a dc supply of 10 V and the output is read using a $3\frac{1}{2}$ digit 200 mV full-scale digital multimeter. The resolution of the measurement set-up, in pascal is _____.

26. Ans: 10

Sol: Piezo resistive pressure sensor sensitivity = 1(mV/V)/kPa

$3\frac{1}{2}$ digit in 200mV full scale gives minimum reading of 0.1mV

Resolution of the measurement set up $=\frac{0.1\text{mV}/10\text{V}}{1(\text{mV}/\text{V})/\text{kPa}}=10(\text{Pa})$

27. Consider a system with transfer-function $G(s)=\frac{2}{s+1}$. A unit step function μ(t) is applied to the system, which results in an output y(t). If e(t) = y(t) – μ(t), then $\lim_{t\to\infty} e(t)$ is _____.

27. Ans: 1

Sol. $Y(s) = G(s).\ \mu(s)$

$$= \frac{2}{S+1}.\frac{1}{S}$$

$$Y(s)=\frac{2}{S(S+1)}=\frac{2}{S}-\frac{2}{S+1}$$

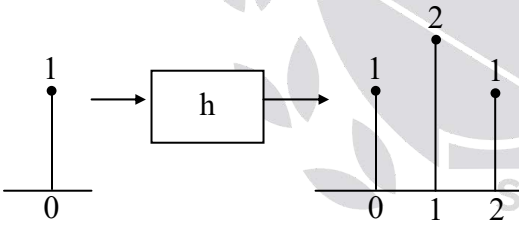
$$y(t) = (2 - 2e^{-t})\ \mu(t)$$

$$\lim_{t\to\infty}\left[y(t)-\mu(t)\right]$$

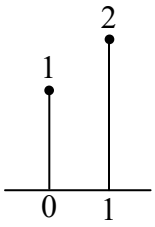
$$\lim_{t\to\infty}\left[\left[2-2e^{-t}\right]\mu(t)-1\mu(t)\right]$$

$$\Rightarrow 1$$

28. The input-output relationship of an LTI system is given below.



For an input x[n] shown below



The peak value of the output when x[n] passes through h is _____.

(a) 6 (b) 4

(c) 2 (d) 5

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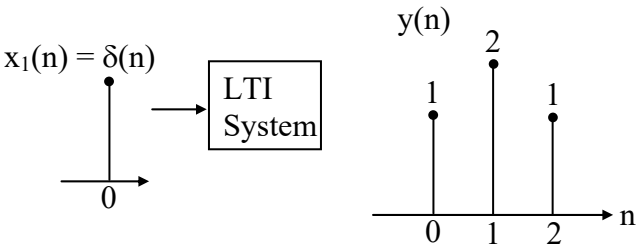
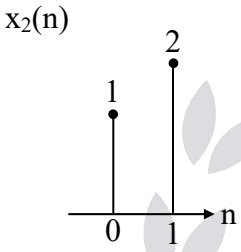
28. Ans: (d)

Sol: $x(n) = \delta(n)$

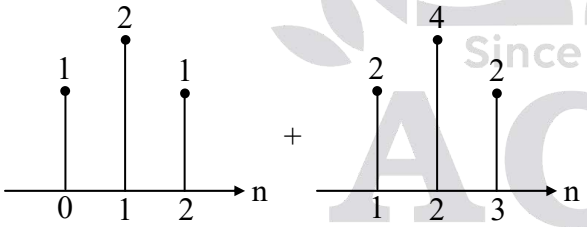




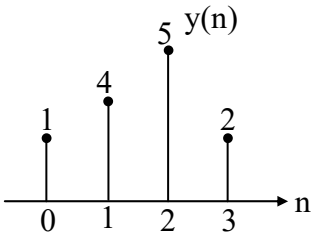
$x_2(n) = \delta(n) + 2\delta(n-1)$

$= x_1(n) + 2x_1(n-1)$

$y_2(n) = y_1(n) + 2y_1(n-1)$



Peak value of Output when x(n) passes through h is 5.

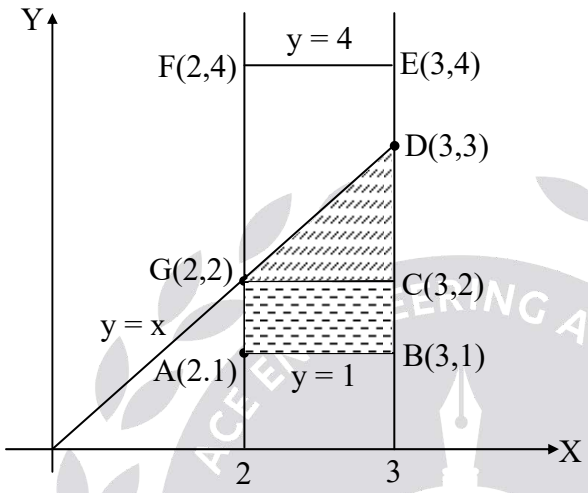


So, the correct option is (d)

29. Consider that X and Y are independent continuous valued random variables with uniform PDF given by X ~U(2, 3) and Y ~ U(1, 4). Then P(Y ≤ X) is equal to _____ (rounded off to two decimal places).

29. Ans: 0.5

Sol:



$$P(Y \le X) = \frac{\text{Area of shaded region}}{\text{Area of ABCDEFG}}$$

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

$$P(Y \le X) = \frac{\frac{3}{2}}{3} = \frac{1}{2} = 0.5$$

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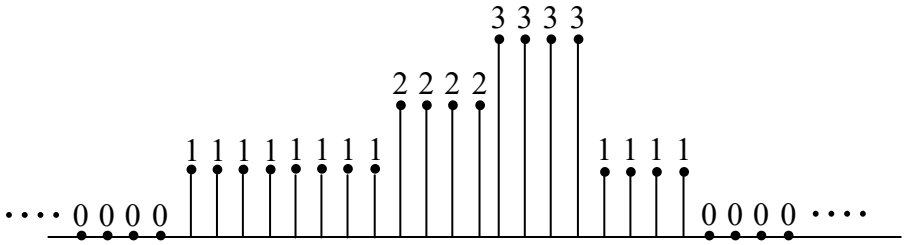
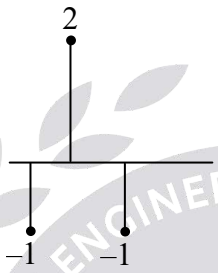
30. The input signal shown below



is passed through the filter with the following taps



The number of non-zero output samples is _____.

30. Ans: 10

Sol: x(t) → 1 1 1 1 1 1 1 1 2 2 2 2 3 3 3 3 1 1 1 1

h(n) → –1 2 –1

–1	–1	–1	–1	–1	–1	–1	–1	–2	–2	–2	–2	–3	–3	–3	–3	–1	–1	–1	–1	
	2	2	2	2	2	2	2	2	4	4	4	4	6	6	6	6	2	2	2	2
		–1	–1	–1	–1	–1	–1	–1	–1	–2	–2	–2	–2	–3	–3	–3	–3	–1	–1	–1	–1
–1	1	0	0	0	0	0	0	–1	1	0	0	–1	1	0	0	2	–2	0	0	1	–1

The number of non-zero output samples is 10

31. Input-output characteristic of a temperature sensor is exponential for a

(a) Thermistor

(b) Resistive Temperature Device (RTD)

(c) Thermocouple

(d) Mercury thermometer

31. Ans: (a)

Sol: The input output characteristics of a thermistor is exponential and it is negative temperature coefficient.

32. A 10-bit ADC has a full-scale of 10.230 V, when the digital output is $(11\ 1111\ 1111)_2$. The quantization error of the ADC in millivolt is _____.

32. Ans: 5

Sol: N = 10, FS = 10.23

$$\text{Step size} = \frac{FS}{2^N - 1} = \frac{10.23}{2^{10} - 1} = \frac{10.23}{1023} = 0.01$$

$$\text{Quantization error} = \pm\frac{\text{stepsize}}{2} = \pm\frac{0.01}{2} = \pm 5\text{mV}$$

33. In an ac main, the rms voltage V_{ac}, rms current I_{ac} and power W_{ac} are measured as: V_{ac} = 100 V ± 1%, I_{ac} = 1A ± 1% and W_{ac} = 50 W ± 2% (errors are with respect to readings). The percentage error in calculating the power factor using these reading is

(a) 1%

(b) 2%

(c) 4%

(d) 3%

33. Ans: (c)

Sol: $V_{ac} = 100 \pm 1\%$

$I_{ac} = 1 \pm 1\%$

$W_{ac} = 50 \pm 2\%$

Error in PF is ?

$$\cos\phi = \frac{W_{ac}}{V_{ac}\ I_{ac}}$$

$$\text{Error in } \cos\phi = \frac{\pm 2\%}{(\pm 1\%)(\pm 1\%)}$$

$$= \pm 4\%$$

34. Consider the row vectors $v = (1, 0)$ and $w = (2, 0)$. The rank of the matrix $M = 2v^T v + 3w^T w$, where the superscript T denotes the transpose, is

(a) 4 (b) 1

(c) 2 (d) 3

34. Ans: (b)

Sol: $V = (1, 0)$ & $W = (2, 0)$

$$V^T V = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \begin{bmatrix} 1 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$$

$$2V^T V = \begin{bmatrix} 2 & 0 \\ 0 & 0 \end{bmatrix}$$

$$W^T W = \begin{bmatrix} 2 \\ 0 \end{bmatrix} \begin{bmatrix} 2 & 0 \end{bmatrix} = \begin{bmatrix} 4 & 0 \\ 0 & 0 \end{bmatrix}$$

$$3W^T W = \begin{bmatrix} 12 & 0 \\ 0 & 0 \end{bmatrix}$$

$$M = 2V^T V + 3W^T W$$

$$M = \begin{bmatrix} 14 & 0 \\ 0 & 0 \end{bmatrix}$$

$\therefore$ Rank of M = 1

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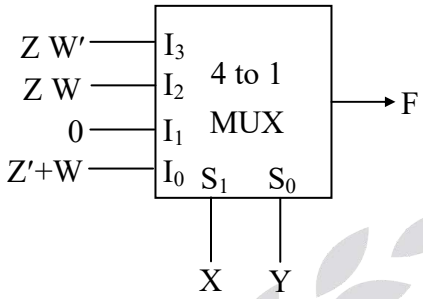
35. A 4 × 1 multiplexer with two selector lines is used to realize a Boolean function F having four Boolean variables X, Y, Z and W as shown below, S_0 and s_1 denote the least significant bit (LSB) and most significant bit (MSB) of the selector lines of the multiplexer respectively. I_0, I_1, I_2, I_3 are the input lines of the multiplexer.



The canonical sum of product representation of F is

(a) F (X, Y, Z, W) = ∑(0, 1, 3, 11, 14)

(b) F (X, Y, Z, W) = ∑ m(0, 1, 3, 14, 15)

(c) F (X, Y, Z, W) = ∑ m(2, 5, 9, 11, 14)

(d) F (X, Y, Z, W) = ∑ m(1, 3, 7, 9, 15)

35. Ans: (a)

Sol: $F = \overline{S}_1\overline{S}_0I_0 + \overline{S}_1S_0I_1 + S_1\overline{S}_0I_2 + S_1S_0I_3$

$$F = \overline{X}\,\overline{Y}\left(\overline{Z} + W\right) + \overline{X}Y.0 + X\overline{Y}Z.W + XY.Z\overline{W}$$

$$= \overline{X}\,\overline{Y}\,\overline{Z} + \overline{X}\,\overline{Y}W + X\overline{Y}ZW + XYZ\overline{W}$$

$$= \overline{X}\,\overline{Y}\,\overline{Z}\,\overline{W} + \overline{X}\,\overline{Y}\,\overline{Z}W + \overline{X}\,\overline{Y}ZW + X\overline{Y}ZW + XYZ\overline{W}$$

$$F = m_0 + m_1 + m_3 + m_{11} + m_{14}$$

$$= \sum m\,(0, 1, 3, 11, 14)$$

36. An amplitude modulation (AM) scheme uses tone modulation, with modulation index of 0.6. The power efficiency of the AM scheme is _____% (rounded off to one decimal place).

36. Ans: 15.2

Sol: $\mu = 0.6$

$$\text{Power efficiency} = \eta = \frac{\mu^2}{2+\mu^2} = \frac{(0.6)^2}{2+(0.6)^2}$$

$$= \frac{0.36}{2.36} = 0.152 = 15.2\%$$

37. For a 4-bit Flash type Analog to Digital Convertor (ADC) with full scale input voltage range "V", which of the following statement(s) is/are true?

(a) The ADC requires 15 comparators.

(b) The ADC requires one 4 to 2 priority encoder and 4 comparators.

(c) A change in the input voltage by $\frac{V}{16}$ will always flip MSB of the output.

(d) A change in the input voltage by $\frac{V}{16}$ will always flip the LSB of the output.

37. Ans: (a and d)

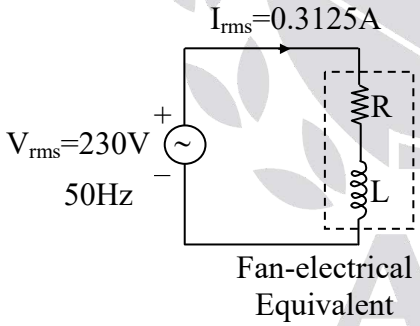
Sol: 4-Bit flash ADC,

Full scale input voltage range = V

38. A household fan consumes 60 W and draws a current of 0.3125 A (rms) when connected to a 230 V (rms) ac, 50 Hz single phase mains. The reactive power drawn by the fan in V_{Ar} is _____ (rounded off to the nearest integer).

38. Ans: 39.53

Sol:



Active power consumed = P = VI cosϕ (W)

$\Rightarrow 60 = 230 \times 0.3125 \times \cos\phi$

$\Rightarrow \cos\phi = 0.834$

$\Rightarrow \phi = \cos^{-1}(0.834) = 33.4°$

So, $\sin\phi = \sin 33.4° = 0.55$

Reactive power drawn by the fan

$\Rightarrow Q = VI \sin\phi$ (VAR) $= V_{rms} I_{rms} \sin\phi$ (VAR) $= 230 \times 0.3125 \times 0.55$

$= 39.53$ VAR

39. $f(z) = (z-1)^{-1} - 1 + (z-1) - (z-1)^2 + \ldots$ is the series expansion of

(a) $\frac{1}{(z-1)^2}$ for $|z-1|<1$

(b) $\frac{1}{z(z-1)}$ for $|z-1|<1$

(c) $\frac{-1}{z(z-1)}$ for $|z-1|<1$

(d) $\frac{-1}{(z-1)}$ for $|z-1|<1$

39. Ans: (b)

Sol: Let $f(z) = \frac{1}{Z(Z-1)}$

$$= \frac{1}{Z-1} - \frac{1}{Z}$$

$$= \frac{1}{(Z-1)} - \frac{1}{[(Z-1)+1]}$$

$$= \frac{1}{(Z-1)} - [1+(Z-1)]^{-1}$$

$$= (Z-1)^{-1} - \{1 - (Z+1) + (Z-1)^2 + \ldots..\}$$

The above series valid for

$|Z-1|<|$. Since $(1+x)^{-1} = 1 - x + x^2 +$

……. Valid $|x| < 1$

Option (b) is correct.

40. A sinusoid $(\sqrt{2}\sin t)\mu(t)$, where $\mu(t)$ is the step input, is applied to a system with transfer-function $G(s) = \frac{1}{s+1}$. The amplitude of the steady state output is_____.

40. Ans: 1

Sol: $r(t) = \sqrt{2}\sin(t)\mu(t)$

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

$$G(j\omega) = \frac{1}{(j\omega+1)}$$

$\omega = 1$

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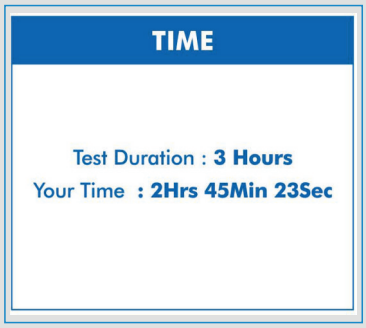

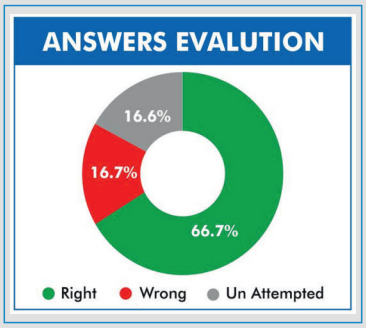

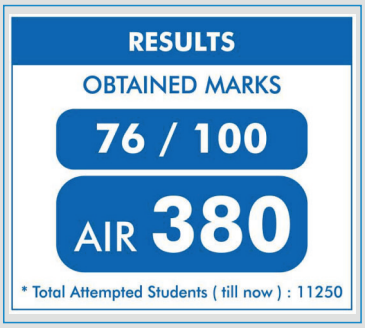

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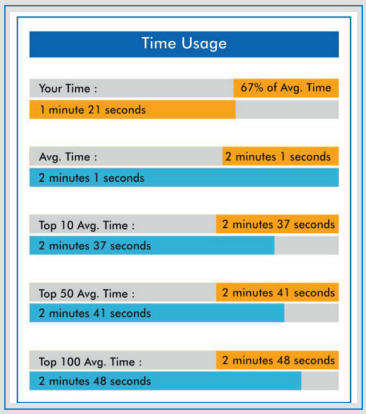

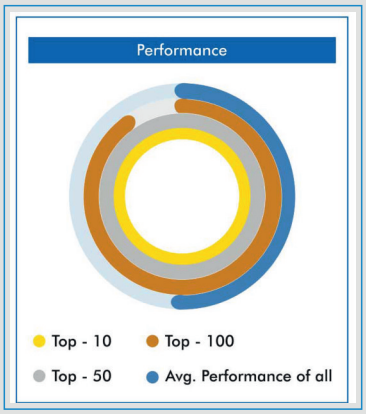

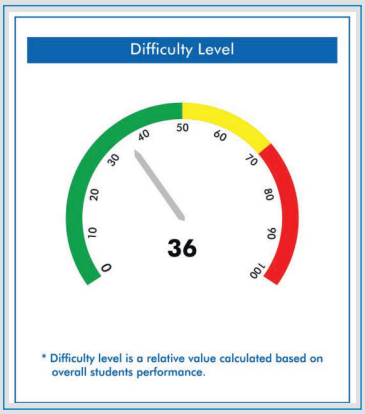

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$$G(j1)=\frac{1}{(j1+1)}$$

$$m=\frac{1}{\sqrt{2}}$$

Output amplitude $\sqrt{2}\times\frac{1}{\sqrt{2}}=1$

41. A 300 V. 5 A, LPF wattmeter has a full scale of 300 W. The wattmeter can be used for loads supplied by 300 V ac mains with a maximum power factor of _____ (rounded off to one decimal place).

41. Ans: 0.2

Sol: 300V, LPF w.m, 5A

FSU = 300W

$P = VI\cos\theta$

$300 = 300 \times 5 \times \cos\theta$

$\therefore \cos\theta = \frac{1}{5} = 0.2$

42. A $10\frac{1}{2}$ digit Counter-timer is set in the 'frequency mode' of operation (with T_s = 1 s). For a specific input, the reading obtained is 1000. Without disconnecting this input, the Counter-timer is changed to operate in the 'Period mode' and the range selected is microseconds (μs, with f_s = 1 MHz). The counter will then display

(a) 1000 (b) 10

(c) 0 (d) 100

42. Ans: (a)

Sol. (I) Frequency mode [as counter]

Gate is open for known time of 1sec

Specific input is pulse train that passes through opened GATE.

Reading = Gate open time × frequency of pulses

$\Rightarrow$ 1000 = 1sec × f

$$\Rightarrow f = 1000\,\frac{\text{Cycles}}{\text{sec}}$$

$$\Rightarrow f = 1000\ \text{Hz}$$

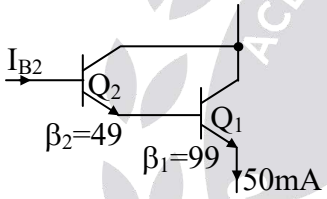
(II) Period mode [as Timer]

Specific input is used now to open the GATE where frequency is pulses passing through GATE is 1MHz

Reading = Gate open time × frequency of pulses

$$\Rightarrow \text{Reading} = \frac{1}{1000\text{Hz}} \times 1\text{MHz} = 1000$$

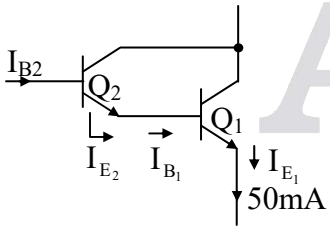
43. The transistor Q_1 has a current gain $\beta_1 = 99$ and the transistor Q_2 has a current gain $\beta_2 = 49$. The current I_{B2} in microampere is _____.



43. Ans: 10

Sol: From the given circuit

$I_{E1} = 50\text{mA}$ & $I_{B1} = I_{E2}$



$$I_{B1} = \frac{I_{E1}}{1+\beta_1} = \frac{50\times10^{-3}}{100}$$

$$= 500\mu\text{A}$$

$I_{E2} = I_{B1} = 500\mu\text{A}$

$$I_{B2} = \frac{I_{E2}}{1+\beta_2} = \frac{500\times10^{-6}}{1+49} = 10\mu\text{A}$$

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44. A signal having a bandwidth of 5 MHz is transmitted using the Pulse code modulation (PCM) scheme as follows. The signal is sampled at a rate of 50% above the Nyquist rate and quantized into 256 levels. The binary pulse rate of the PCM signal in Mbits per second is _____.

44. Ans: 120

Sol: $\omega = 5MHz$ Nyquist rate = 10MHz

$$\text{Sampling rate} = \frac{1}{T_s} = 1.5 \times 10MHz = 15MHz$$

$L = 256 = 2^m$

$m = 8$

$$\text{So the bit rate} = \frac{1}{T_s} \times m = 15 \times 8Mbits/sec$$

$R_b = 120Mbps$

45. Let $f(z) = \frac{1}{z^2 + 6z + 9}$ defined in the complex plane. The integral $\oint_c f(z)dz$ over the contour of a circle 0 with center at the origin and unit radius is _____.

45. Ans: 0

Sol: $$f(z) = \frac{1}{(Z^2 + 6Z + 9)}$$

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

$Z = -3$ is a singular point lies outside the circle with centre at (0,0) and unit radius

$\therefore$ By Cauchy's integral theorem

$$\oint_C f(z)dz = 0$$

46. Given $y(t) = e^{-3t}\,u(t) * u(t+3)$, where * denotes convolution operation. The value of $y(t)$ as $t \to \infty$ is _____ (rounded off to two decimal place)

46. Ans: 0.333

Sol: $y(t) = e^{-3t}u(t)*u(t+3)$

$$e^{-3t}u(t)*u(t) = \frac{1}{3}\left[1 - e^{-3t}\right]u(t)$$

$$\text{So, } y(t) = \frac{1}{3}\left[1 - e^{-3(t+3)}\right]u(t+3)$$

$$y(t)\big|_{t\to\infty} = \frac{1}{3} = 0.333$$

Hint: Assume

$$g(t) = e^{-at}u(t)*u(t)$$

$$\downarrow \text{L.T}$$

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

$$= \frac{1/a}{s} - \frac{1/a}{s+a}$$

$$g(t) = \frac{1}{a}\left[u(t) - e^{-at}u(t)\right]$$

47. An infinitely long line, with uniform positive charge density, lies along the z-axis. In cylindrical coordinates (r, ∅, z), at any point $\vec{p}$ not on the z-axis, the direction of the electric field is

(a) $\hat{z}$ (b) $\hat{r}$

(c) $\left(\frac{\hat{r}+\hat{z}}{\sqrt{2}}\right)$ (d) $\hat{\phi}$

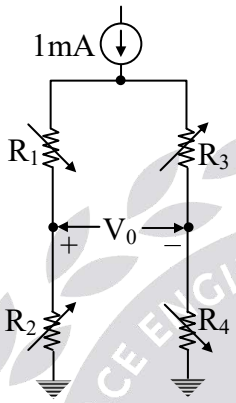
47. Ans: (b)

Sol: If an infinite line, lies along Z-axis, carrying uniform charge density ρ_ℓ C/m, then the electric field intensity in cylindrical coordinate system (r, ϕ, z) is given by

$$\vec{E} = \frac{\rho_\ell}{2\pi\varepsilon r}\hat{a}_r \text{ (or) } \frac{\rho_\ell}{2\pi\varepsilon r}\hat{r} \text{ V/m}$$

Therefore electric field intensity will be along $\hat{r}$ direction only.

48. For the full bridge made of linear strain gages with gage factor 2 as shown in the diagram, $R_1 = R_2 = R_3 = R_4 = 100\ \Omega$ at 0°C and strain is 0. The temperature coefficient of resistance of the strain gages used is 0.005 per °C. All strain gages are made of same material and exposed to same temperature. While measuring a strain of 0.01 at a temperature of 50 °C, the output V_o is millivolt is _____ (rounded off to two decimal places.)



48. Ans: 2

Sol: $R_1 = R_2 = R_3 = R_4 = 100\Omega$ at 0°C and 0 strain (given)

$\alpha = 0.005$ per °C

$R = R_0 (1 + \alpha \Delta T)$

at 50°C

$R = 100 (1 + 0.005 \times 50)$

$= 100 \times 1.25 = 125\Omega$

Due to strain $\Delta R_1 = GF\ \varepsilon \times R_1$

$= 2 \times 0.01 \times 100$

$= 2\Omega$

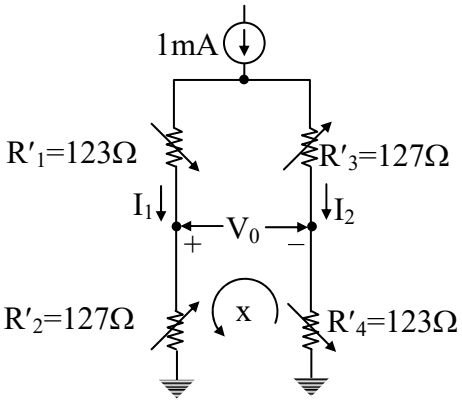
$R_1' = R_4' = 125 - 2 = 123\ \Omega$

Due to strain $\Delta R_2 = GF\ \varepsilon\ R_2$

$= 2 \times 0.01 \times 100 = 2\Omega$

$R_2' = R_2 + \Delta R_2 = 125 + 2 = 127\Omega$

$R_2' = R_3' = 127\ \Omega$



$$I_1 = I_2 = \frac{1mA}{2} = 0.5mA$$

Apply KVL in loop x

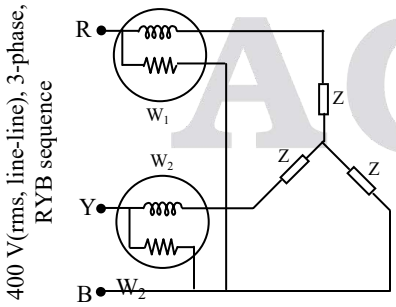
$(-I_2 \times 123) - V_0 + (I_1 \times 127) = 0$

$V_0 = 0.5mA\ (127 - 123)$

$= 0.5mA \times 4$

$V_0 = 2mV$

49. The power in a 400V (rms, line-line) three-phase, three-wire RYB sequence system is measured using the two wattmeters, as shown. The R-line current is $5\ \angle 60°A$. Wattmeter W_1 in the R-line will read (in watt) _____.



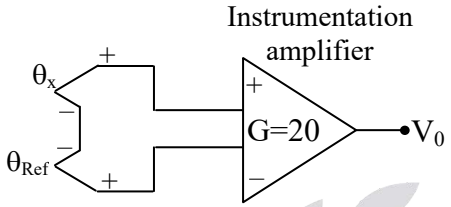
49. Ans: 0

Sol: $W = V_L I_L \cos(30 + \phi)$

$= 400 \times 5 \times \cos(30 + 60)$

$= 0W$

50. A J-type thermocouple has an output voltage $V_0 = (13650 + 50\ \theta_x)\ \mu V$, where θ_x is the junction temperature in Celsius (°C). The thermocouple is used with reference junction compensation, as shown in the figure. The Instrumentation amplifier used has a gain G = 20. If θ_{Ref} is 1 °C, for an input $\theta_x = 100°C$ the output V_0 of the instrumentation amplifier in millivolt is.



(a) 100 mV

(b) 99 mV

(c) 98 mV

(d) 101 mV

50. Ans: (b)

Sol: $V_\theta = (13650 + 50\ \theta_x)\ \mu V$

$V_0 = G\left(V_{\theta_x} - V_{\theta_{ref}}\right)$ (from given figure)

V_{θ_x} is voltage generated by θ_x junction

V_{ref} is the voltage generated by θ_{ref} junction

$$V_{\theta_{ref}}\Big|_{\theta_{ref}=1^\circ C} = (13650+50)\mu V = 13700\mu V$$

$$V_{\theta_x}\Big|_{\theta_x=100^\circ C} = (13650+(50\times100))\mu V = 18650\mu V$$

$V_0 = 20\ (18650 - 13700)\ \mu V$

$V_0 = 99mV$

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VIKASH KUMAR
AIR – 1


SHREYASH AGARWAL
AIR – 3


MAYANK GUPTA
AIR – 5


AKSHAY KUTE
AIR – 6


V. V. ATCHUTA SRAVAN KUMAR
AIR – 6


AVINASH VERMA
AIR – 9


VIVEK KUMAR KASHYAP
AIR – 9


NIKHIL GAIKWAD
AIR – 4 (XE)


APURVA KRISHNA YADAV
AIR – 7 (XE)


SHASHI BHUSHAN
AIR – 7 (XE)


SANKET BHATT
AIR – 10 (XE)

CS


HITESH POPLY
AIR – 1


HIMANSHU JAIN
AIR – 3


AVINASH KRISHNA
AIR – 5


ARAVIND G
AIR – 6

PHANI MADHUSUDHAN
AIR – 7

ASHISH KUMAR
AIR – 8

KARAN GUPTA
AIR – 9

IN

KRISHNA SINGH RAJPUT
AIR – 1

SHAKTI PATHAK
AIR – 3

SIDDHARTHA SINHA ROY
AIR – 5

AKASH CHOTIA
AIR – 6

SUSHANTHIKA J
AIR – 7

RIYA ARON
AIR – 10

PI

SURYANSH GARG
AIR – 1

MOHIT JEENA
AIR – 2

PRAVEEN KUMAR
AIR – 2

ROHIT AGARWAL
AIR – 4

ANKIT YADAV
AIR – 6

GOWTHAM GUDIMELLA
AIR – 6

SUBHANSHU RANJAN TIWARI
AIR – 8

GANESH ADIGAUR
AIR – 9

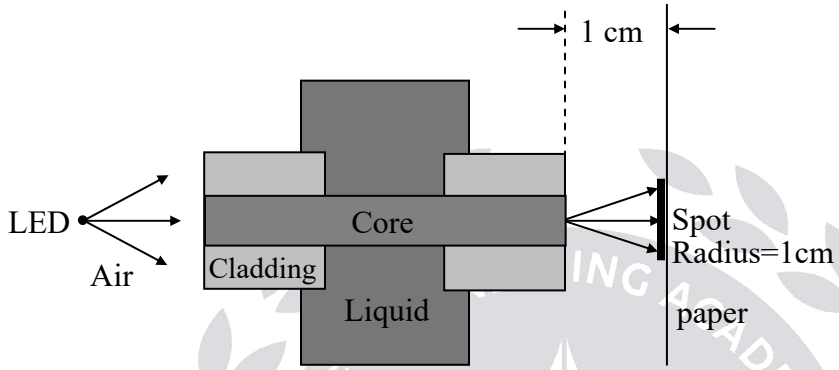
DEEPESH SHARMA
AIR – 10

and many more...

Total Selections in Top 10 58

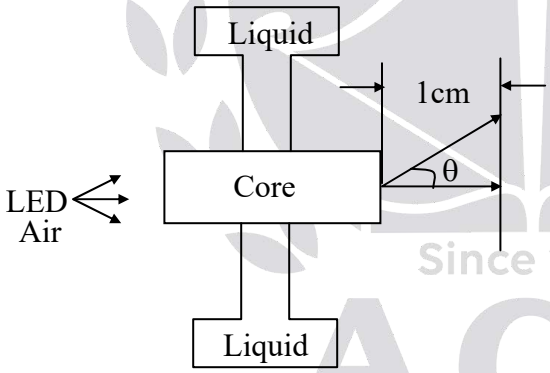
EE : 9	EC : 9	ME:7	CE : 7	CS : 7	IN : 6	PI : 9	XE : 4

51. In the figure shown, a large multimode fiber with $n_{core} = 1.5$ and $n_{clad} = 1.2$ is used for sensing. A portion with the cladding removed passes through a liquid with refractive index n_{liquid}. An LED is used to illuminate the fiber from one end and a paper is placed on the other end, 1 cm from the end of the fiber. The paper shows a spot with radius 1cm . The refractive index $n_{liquied}$ of the liquid (rounded off to two decimal places) is _____.



51. Ans: 1.322

Sol:



Angle of Acceptance = $\tan^{-1}(1) = 45$

Launching medium is air (n_0) = 1

We, know, $A.A = \text{Sin}^{-1}\left(\sqrt{n_{core}^2 - n_{liquid}^2}\right)$, For this question

$\Rightarrow 0.707 = \sqrt{n_{core}^2 - n_{liquid}^2}$

$\Rightarrow 0.4998 = 2.25 - n_{liquid}^2$

$\Rightarrow$ Liquid = 1.322

52. A slip-ring induction motor is expected to be started by adding extra resistance in the rotor circuit. The benefit that is derived by adding extra resistance in the rotor circuit in comparison to the rotor being shorted is

(a) The starting torque would be higher.

(b) The losses at starting would be lower.

(c) The starting current is higher.

(d) The power factor at start will be lower.

52. Ans: (a)

Sol: By adding external resistance in slip ring induction motor, the starting torque is increased.

53. Consider the function $f(x) = -x^2 + 10x + 100$. The minimum value of the function in the interval [5, 10] is _____.

53. Ans: 100

Sol: Given that

$f(x) = -x^2 + 10x + 100$

$f'(x) = -2x + 10$

Critical values: $f'(x) = 0$

$-2x + 10 = 0$

$x = 5$

$f''(x) = -2 < 0 \therefore$ maximum value

at $x = 5$ gives maximum value.

$f(5) = -5^2 + 10(5) + 100 = 125$ (maximum value)

$f(10) = -(10^2) + 10(10) + 100 = 100$ (minimum value)

54. A bar primary current transformer of rating 1000/1 A, 5VA, UPF has 995 secondary turns. It exhibits zero ratio error and phase error of 30 minutes at 1000 A with rated burden. The watt loss component of the primary excitation current in ampere is _____ (rounded off to one decimal place).

54. Ans: 5

Sol: 1000/1 A CT 5VA, UPF.

$N_s = 995$, Ratio error = 0

phase error = 30 minutes

$$I = 1000A, n = \frac{1000}{1} = 1000$$

$\Rightarrow$ as ratio error is zero, we can write $R = k_n = \frac{1000}{1} = 1000$

$\Rightarrow \theta = 30\text{min} = 0.5$ degree

UPF = resistive burden

$(\delta = 0)$

$$\theta = \frac{180}{\pi}\frac{I_m}{I_s}$$

$$0.5 = \frac{180}{\pi}\frac{I_m}{1000 \times 1} \Rightarrow I_m = 8.68A$$

$$\Rightarrow R = N_s + \frac{I_c}{I_s} \Rightarrow 1000 = 995 + \frac{I_c}{1}$$

$\therefore I_c = 5A$

55. Given: Density of mercury is 13,600 kg/m^3 and acceleration due to gravity is 9.81 m/s^2. Atmospheric pressure is 101kPa. In a mercury U-tube manometer, the difference between the heights of the liquid in the U-tube is 1 cm. The differential pressure being measured in pascal is _____ (rounded off to the nearest integer).

55. Ans: 1334.16

Sol: $\rho = 13600$ (kg/m^3)

$g = 9.81$ (m/sec^2)

$P_{atm} = 101$ kPa

$h = 1\text{cm} = 0.01$ m

$\Delta P = \rho gh$

$P_m - P_{atm} = \rho gh$

$\Delta p = 13600 \times 9.81 \times 0.01$

$= 1334.16$ (Pa)

Hearty Congratulations to our
ESE - 2019 TOP RANKERS

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AIR 3 ABHISHEK ANAND

AIR 4 ANKIT TAYAL

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AIR 6 RITESH LALWANI

AIR 7 KARTIKEY SINGH

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AIR 10 ANKITA SHARMA

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AIR 9 ANKIT KUMAR

and many more...

Total Selections in Top 10 — 33

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