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Memory based Questions & Solutions

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SECTION - A GENERAL APTITUDE

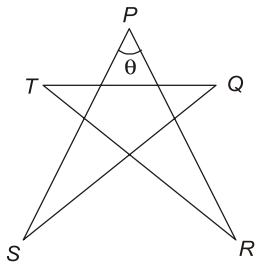
Q.1 Getting to the top is _____ than staying on top

(a) easier (b) easiest
(c) more easy (d) much easy

Ans. (a)
Easier

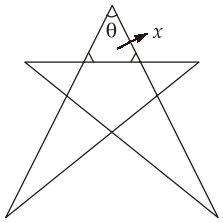
End of Solution

Q.2 In the given figure value of θ, when *PR*, *PS*, *QS*, *TR*, *TQ* are of equal length. θ = ?



(a) 36 (b) 108
(c) 72 (d) 45

Ans. 36



Sum of angle furmed at the pentagon = 540°

$$\text{Each angle of pentagon} = \frac{540}{6} = 108°$$

$$\angle x = 180 - 108 = 72°$$

Sum of angle of triangle = 180°

$$72° + 72° + \theta = 180°$$

$$\theta = 36°$$

End of Solution

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Q.3 $\oplus$ and $\odot$ are two operators on numbers p and q such that $p \oplus q = \frac{p^2 + q^2}{pq}$ and $p \odot q = \frac{p^2}{q}$, if $x \oplus y = 2 \odot 2$, then $x =$ _____.

(a) y (b) $2y$

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

Ans. (a)

$$x \oplus y = 2 \odot 2$$

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

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

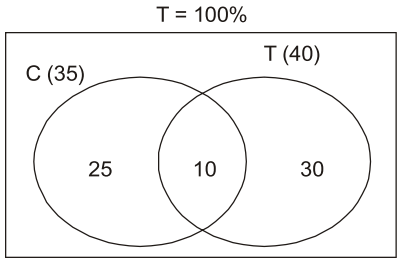
End of Solution

Q.4 In a company, 35% and the employees drink coffee, 40% drink tea and 10% drink both tea and coffee. What % of employees drink neither tea nor coffee?

(a) 25 (b) 35

(c) 40 (d) 15

Ans. (b)



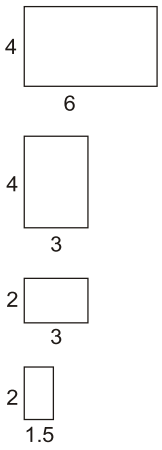
Percent of employees drink neither tea nor coffee = 100 – 25 – 10 – 35 = 35

End of Solution

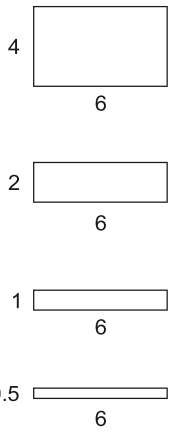
Q.5 Two paper M and N with same dimensions of 6 cm × 4 cm.
Operation 1: paper is folded exactly half by joining its shorter edges each time.
Operation 2: paper is folded half by joining its longer edges each time.
Now consider following:
Operation 1 done for M paper 3 times and Operation 2 done for N paper 3 times.
Find the ratio of perimeter of rectangle formed (N to M ratio).

Solution:

Operation 1 on M



Operation 2 on N



$(\text{Perimeter})_M = 2(2 + 1.5) = 7$

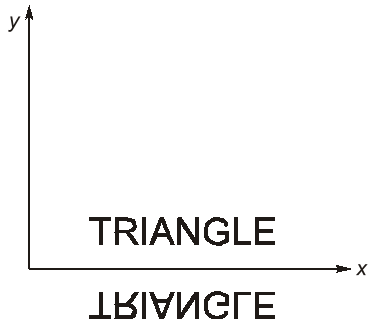
$(\text{Perimeter})_N = 2(0.5 + 6) = 13$

Required ratio $= \frac{13}{7}$

End of Solution

Q.6 Find mirror image about x-axis

Solution:



End of Solution

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Q.7 Either P marries Q or X marries Y. Among the option below, what is the absolute logical 'Negations' of this statement?

(a) Neither P marry Q nor X marry Y
(b) P does not marry Q and X marries Y
(c) P marries Q and X marries Y
(d) X does nor marry and P marries Q

Ans. (a)

End of Solution

Q.8 Four persons P, Q, R and S are to be seat in a row, all are facing the same direction, but not necessary in the same order.
P and R can not seat adjacent to each other and S could be seated to the right of Q. The number of distinct seating arrangement possible?

(a) 4 (b) 2
(c) 8 (d) 6

Ans. (b)
If S is seated immediately right of *Q* then number of possible distinct arrangements are 2.
Note: If S is seated right of *Q* then number of possible distinct arrangements are 6.

End of Solution

Q.9 $\lambda(p\,q)=\begin{cases}(p-q)^2 & p\geq q\\ p+q & p<q\end{cases}$

Calculate the value of $\dfrac{\lambda\{-(-3+2),(-2+3)\}}{\{-(-2+1)\}}$

Solution:

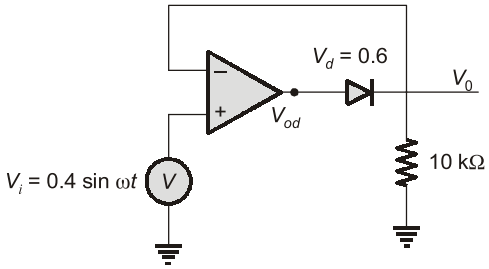
$$\frac{\lambda\{-(-3+2),(-2+3)\}}{\{-(-2+1)\}}=\lambda(1,1)=1^2-1^2=0$$

End of Solution

■■■■

SECTION - B TECHNICAL

Q.1 When V_i is at its peak, the value of V_0 is _____.



Ans. **($V_0 = 0.4$ V; $V_{od} = 1$ V)**

Given circuit is called precision diode.

$V_i = 0.4 \sin \omega t$

Let diode be OFF.

Then $V^- = V_0 = 0$ and $V^+ = V_i$;

If $V^+ < V^-$ i.e., $V_i < 0$ then $V_{od} = -V_{sat}$

and diode remains OFF $\Rightarrow V_0 = 0$

If $V^+ > V^-$ i.e., $V_i > 0$ then V_{od} becomes +ve

Now diode becomes ON and opamp will be closed-loop.

$\Rightarrow \quad V^- = V^+ \Rightarrow V_0 = V_i$

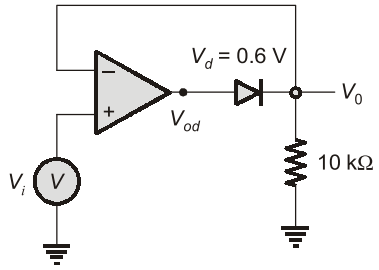
If V_i has peak value i.e. $V_i = 0.4$ V

$\Rightarrow \quad V_0 = 0.4$ V

Now $V_{od} - V_0 = V_d$

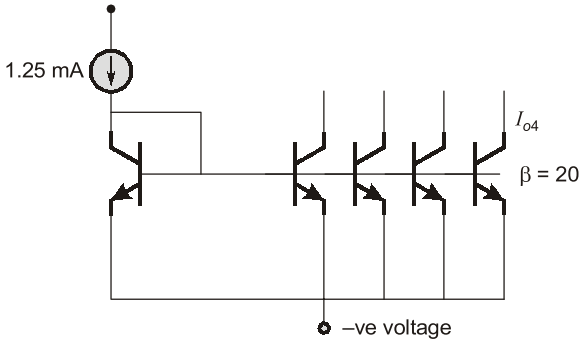
$\Rightarrow \quad V_{od} = V_d + V_0 = 0.6 + 0.4$

$\Rightarrow \quad V_{od} = 1$ V



End of Solution

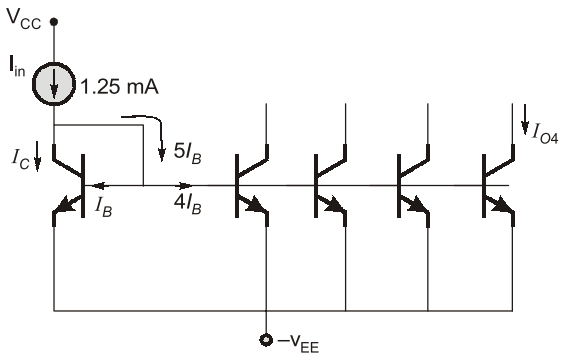
Q.2 Find value of I_{o4} = _____ mA.



Ans. (1)

$\beta = 20$

All transistors are identical and their V_{BE} values are perfectly equal. Hence, their currents will be equal.



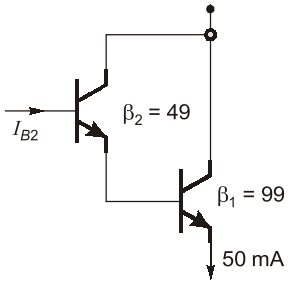
By KCL, $I_{In} = I_C + 5I_B = I_C + \dfrac{5I_C}{\beta}$

$$I_C = \frac{I_{in}}{1+\frac{5}{\beta}}$$

$$I_{o4} = \frac{I_{in}}{1+\frac{5}{\beta}} = \frac{1.25}{1+\frac{5}{20}} = 1\text{mA}$$

End of Solution

Q.3 The transistor Q_1 has gain $\beta_1 = 99$ and Q_2 has $\beta_2 = 49$, the current I_{B2} is _____ μA.



Ans. (10)

$\beta_1 = 99$

$\beta_2 = 49$

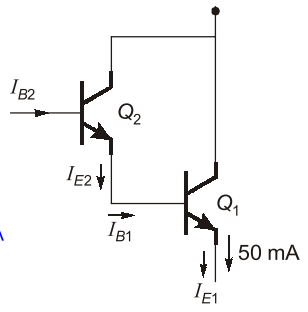
$I_{E1} = 50$ mA

$$I_{E2} = I_{B1} = \frac{I_{E1}}{1+\beta_1}$$

$$\Rightarrow \quad I_{E2} = \frac{50}{100} = 0.5\text{ mA} = 500\ \mu\text{A}$$

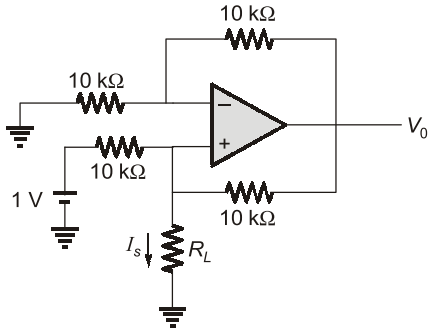
$$I_{B2} = \frac{I_{E2}}{1+\beta_2} = \frac{500}{50}$$

$$\Rightarrow \quad I_{B2} = 10\ \mu\text{A}$$



End of Solution

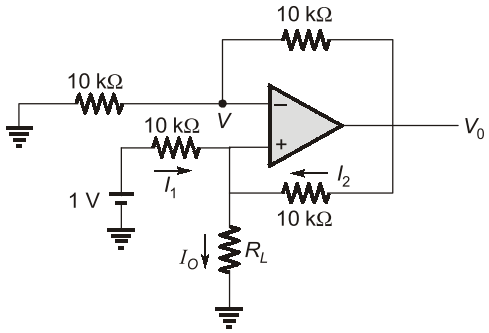
Q.4 The output V_0 of ideal Op. Amp used in circuit shown below is 5 V. Then the value of resistor R_L in kΩ is



(a) 25 (b) 50
(c) 5 (d) 2.5

Ans. **(a)**

Given, $V_o = 5$ V



$$V = \frac{V_o \times 10}{10+10} = \frac{V_o}{2} = 2.5V$$

Using virtual section property,

$$V^+ = V^- = 2.5 \text{ V}$$

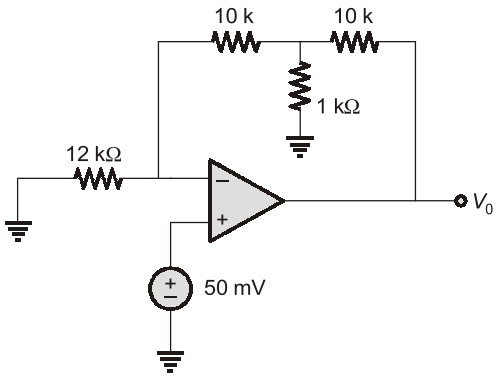
by KCL, $I_1 + I_2 = I_0$

$$\frac{1-2.5}{10} + \frac{5-2.5}{10} = \frac{2.5}{R_L}$$

$$\Rightarrow \quad R_L = 25 \text{ kΩ}$$

End of Solution

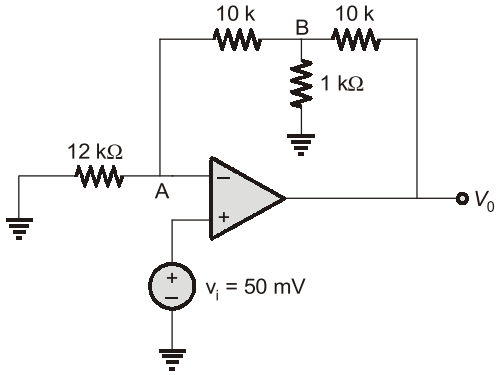
Q.5



Find V_0. (in volts)

Ans. (1.05)

Using vertual s/c property,



$$V^- = V^+$$

$$\Rightarrow \quad V_A = V_i = 50 \text{ mV}$$

by KCL at A: $\frac{0 - V_A}{12} + \frac{V_B - V_A}{10} = 0$

$$\Rightarrow \quad V_B = \frac{11V_A}{6} = \frac{11V_i}{6} \qquad \text{... (i)}$$

by KCL at B:

$$\frac{V_A - V_B}{10} + \frac{0 - V_B}{1} + \frac{V_o - V_B}{10} = 0$$

$$\Rightarrow V_A - V_A - 10V_A + V_0 - V_B = 0$$

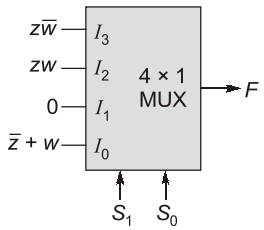
$$V_0 = 12V_B - V_A$$

$$= 12 \times \frac{11V_i}{6} - V_i$$

$$= 21V_i = 21 \times 50 \text{ mV} = 1050 \text{ mV or } 1.05 \text{ V}$$

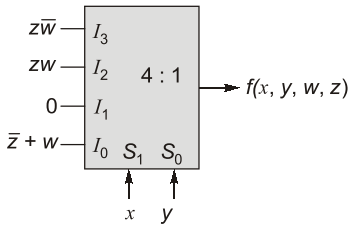
End of Solution

Q.6 4 × 1 MUX with two selection line is used to realize Boolean function F having four Boolean variable x, y, z, w as shown, S_0, S_1 denotes the LSB and MSB of selection lines of multiplexer. I_0, I_1, I_2, I_3 are input line. The canonical sum of product of F is



(a) $F(x, y, z, w) = \Sigma m(2, 5, 9, 11, 14)$
(b) $F(x, y, z, w) = \Sigma m(0, 1, 3, 11, 14)$
(c) $F(x, y, z, w) = \Sigma m(0, 1, 3, 14, 15)$
(d) None of the above

Ans. (b)



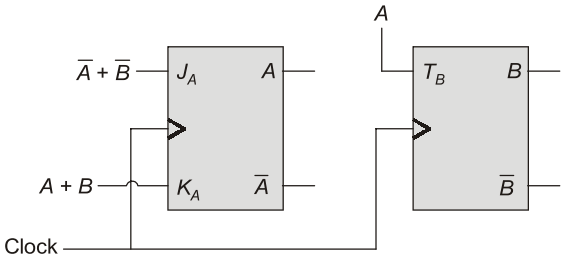
$$f = \bar{x}\bar{y}(\bar{z} + w) + \bar{x}y \cdot 0 + x\bar{y}(zw) + xy(z\bar{w})$$

$\bar{x}$	$\bar{y}$	$\bar{z}$	_	+	$\bar{x}$	$\bar{y}$	_	w	+	x	$\bar{y}$	z	w	+	x	y	z	$\bar{w}$
0	0	0	0		0	0	0	1		1	0	1	1		1	1	1	0
0	0	0	1		0	0	1	1										

$$f(x, y, z, w) = \Sigma m(0, 1, 3, 11, 14)$$

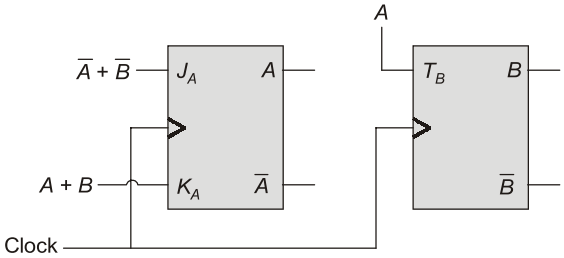
End of Solution

Q.7 Given block diagram of synchronous sequential circuit with one JK-flipflop and one T flipflop with their output denote as A and B respectively with $J_A = \bar{A} + \bar{B}$, $K_A = A + B$ and $T_B = A$, Starting from the initial state $AB = 00$, the sequence of states AB visited by the circuit.



(a) 00 → 10 → 11 → 01 → 00....
(b) 00 → 01 → 10 → 11 → 00....
(c) 00 → 10 → 01 → 11 → 00....
(d) None of the above

Ans. (c)



$A^+ = J\overline{A} + \overline{K}A$

$A^+ = (\overline{A}+\overline{B})\cdot\overline{A} + (\overline{A+B})\cdot A$

$A^+ = \overline{A}$

$B^+ = T_B \oplus B$

$B^+ = A \oplus B$

	$\overline{A}$	$A \oplus B$
$A\,B$	A^+	B^+
0 0	1	0
10	0	1
0 1	1	1
11	0	0

00 → 10 → 01 → 11 → 00....

End of Solution

Q.8 A 10 bit ADC has a full-scale of 10.230 V, when the digital output is $(1111111111)_2$. The quantization error of ADC in millivolts is _____.

Ans. (5)

Given, 10 bit ADC, Full scale = 10.23 V

$$\text{Resolution} = \frac{V_{FS}}{2^n - 1} = \frac{10.23}{2^{10} - 1} = 10\text{ mV}$$

$$\text{Quantization error} = \frac{\text{Step size}}{2} = 5\text{ mV}$$ (Step size = resolution of ADC)

End of Solution

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Q.9 For a 4-bit flash type analog to digital convertor with full scale input voltage range 'V', which statement(s) is/are true?

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

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

(c) ADC requires on 4 to 2 priority encoder and 4 comparators.

(d) ADC require 15 comparators.

Ans. **(b, d)**

Given, 4 bit flash ADC, $n = 4$

$$\text{Resolution} = \frac{V_R}{2^n} = \frac{V_R}{2^4} = \frac{V_R}{16}$$

Any change $\frac{V_R}{16}$ changes LSB.

Example, Input : 0 V $\rightarrow$ 0000

$\frac{V_R}{16} \rightarrow 0001$

No. of comparators required for 4-bit flash type ADC $= 2^4 - 1 = 15$

End of Solution

Q.10 $\sqrt{2}\sin t\ u(t)$ is applied to system with *TF* $G(s) = \frac{1}{s+1}$. Amplitude of steady state output is _____.

Ans. **(1)**

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

$$r(t) = A \sin \omega t = \sqrt{2}\sin t$$

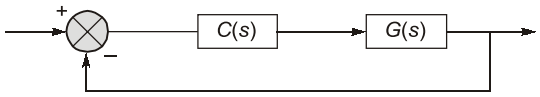
$$c(t) = B \sin(\omega t + \phi)$$

$$B = A|G(j\omega)|$$

$$= \sqrt{2}\left|\frac{1}{s+1}\right|_{s=j1} = 1$$

End of Solution

Q.11 A PID controller is incorporated in closed loop system as shown below. The transfer function of the system $G(s)$ and transfer function of $C(s)$ are given as below. Which of the following is true about the controller gain (K).



$G(s) = \dfrac{1}{(s+1)(s+3)}$ and $C(s) = \dfrac{k(s+3-j)(s+3+j)}{s}$ with k being scalar, the closed loop system is

(a) only stable at $k > 0$.
(b) only stable for k between -1 and $+1$.
(c) stable for all value of k.
(d) only stable for $k < 0$.

[2 marks]

Ans. **(a)**

$$q(s) = 1 + C(s)G(s) = 0$$
$$q(s) = s^3 + s^2(K+4) + s(6K+3) + 10K = 0$$

Necessary: $K > -4;\ K > -\dfrac{1}{2};\ K > 0$

Sufficient : $bc > ad$

$(K+4)(6K+3) > 10K$

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

$\Rightarrow \quad K > \dfrac{-4}{3}$ and $K > -\dfrac{3}{2}$ (or) $K < -\dfrac{4}{3}$ and $K < -3$

Finallly $K > 0$ and $K > \dfrac{-4}{3}$

$\therefore$ The closed loop system is stable only for $K > 0$.

End of Solution

Q.12 Consider a system with transfer function $G(s) = \dfrac{2}{s+1}$. A unit step function $u(t)$ is applied to the system, which result in an output $y(t)$ and $e(t) = y(t) - u(t)$, then $\lim\limits_{t\to\infty} e(t)$ is _____.

Ans. **(−1)**

$$\text{TF} = \frac{2}{s+1}$$
$$\text{OLTF} = \frac{2}{s-1}$$
$$\text{Type} = 0$$
$$e_{ss} = \frac{1}{1+k_p} \text{ for step input,}$$

$$k_p = \lim_{s\to 0} \frac{2}{s-1} = -2$$

$$\therefore \quad e_{ss} = \frac{1}{1-2} = -1$$

End of Solution

Q.13 A response of a system is oscillatory in nature and it is decaying to zero slowly then the system is

(a) First order system
(b) Second order system
(c) the system is under damped for pair of poles
(d) does not has real roots

Ans. **(*)**

If MSQ ans. (C)
If MSQ ans. B and C

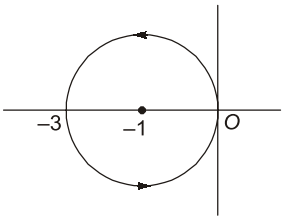
End of Solution

Q.14 Taking N as positive for CW encirclement otherwise negative, the number of encirclement of (–1, 0) in the Nyquist plot of $G(s) = \frac{3}{s-1}$ is _____.

Ans. **(–1)**

$$\text{OLTF} = \frac{3}{s-1}$$

Nyquist plot

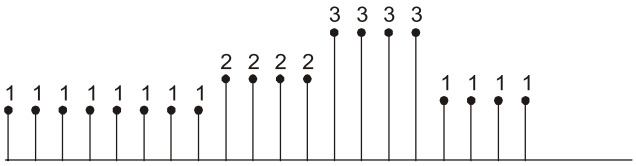


Since N is the in CW and –ve in ACW as in the question,

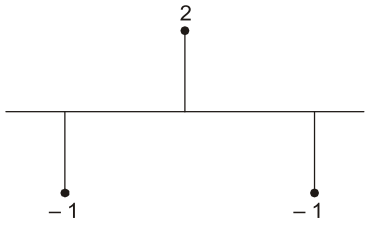
$$\therefore \quad N = -1$$

End of Solution

Q.15 The input signal is shown below:

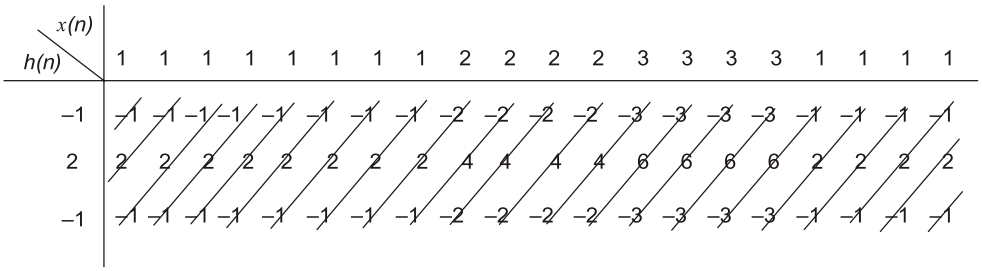


is passed through the filter with following taps.



No. of non zero samples in output is _____.

Ans. (10)

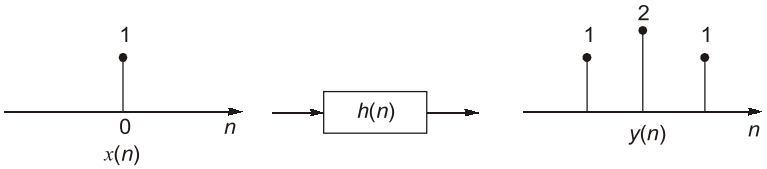


$y[n] = \{-1, 1, 0, 0, 0, 0, 0, 0, -1, 1, 0, 0, -1, 1, 0, 0, 2, -2, 0, 0, 1, -1\}$

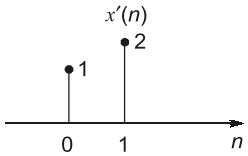
Number of non-zero samples in $y[n]$ = 10

End of Solution

Q.16 Input-output relationship of LTI system is shown below:



In input $x'(n)$ is



then the peak value of output when $x'(n)$ is passing through the given system $h(n)$ is

(a) 4 (b) 5

(c) 2 (d) 6

Ans. (b)

When $x[n] = \delta[n]$, then $y[n] = h[n]$

$$h[n] = \delta[n] + 2\delta[n-1] + \delta[n-2]$$
$$= \{1, 2, 3\}$$

Given, $x'[n] = \delta[n] + 2\delta[n-1]$

$$x'[n] = \{1, 2\}$$
$$y[n] = x'[n] * h[n]$$

Sum by column method:

$$\begin{array}{cccc} & 1 & 2 & \\ & 1 & 2 & 1 \\ \hline 1 & 2 & & \\ & 2 & 4 & \\ & & 1 & 2 \\ \hline \end{array}$$

$y[n] = \{1 \quad 4 \quad 5 \quad 2\}$

Peak value at the output is (5)

End of Solution

Q.17 The signal $\sin(\sqrt{2\pi t})$ is

(a) Periodic with period $T = 4\pi^2$

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

(c) Non periodic

(d) Periodic with period $T = 2\pi$

Ans. (c)

$$x(t) = \sin\left(\sqrt{2\pi t}\right)$$

- For negative values of 't', sine-function will apply on imaginary values.
- For positive values of 't', sine-function will apply on real-values.
- So, there will not be repetition in the waveform.

$\therefore$ We can draw waveform only in the RHS.

But we cannot draw waveform in the LHS.

- Therefore, $\sin\left(\sqrt{2\pi t}\right)$ is non-periodic.

End of Solution

Q.18 If $y(t) = e^{-3t}u(t) * u(t+3)$ where $*$ denotes convolution and $u(t)$ denotes the step function. The value of $y(t)$ at $t \to \infty$ is _____.

Ans. **(0.33)**

$$y(t) = e^{-3t}\, u(t) * u(t+3)$$

$$Y(s) = e^{3s}\left[\frac{1}{3}\left(\frac{1}{s} - \frac{1}{s+3}\right)\right]$$

$$Y(s) = e^{3s}\, F(s) \qquad \ldots (i)$$

where, $$F(s) = \frac{1}{3}\left(\frac{1}{s} - \frac{1}{s+3}\right)$$

$$f(t) = \frac{1}{3}\left[1 - e^{-3t}\right] \times u(t) \qquad \ldots (ii)$$

From (i), $Y(s) = e^{3s}\, F(s)$

$y(t) = f(t+3)$

$$y(t) = \frac{1}{3}\left[1 - e^{-3(t+3)}\right] u(t+3) \ldots. \text{ From (ii)}$$

Put $t = \infty$, $$y(\infty) = \frac{1}{3}[1-0] \times 1 = \frac{1}{3}$$

End of Solution

Q.19 Let $u(t)$ denotes the unit step function, the bilateral laplace transform of 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 $s < 1$.

Ans. **(d)**

$$f(t) = e^{t}u(-t)$$

As we know, $e^{-t}u(t) \Longleftrightarrow \frac{1}{s+1}, \sigma > -1$

By using time-reversal property of Laplace transform,

$$e^{t}u(-t) \Longleftrightarrow \frac{1}{-s+1}, \qquad -\sigma > -1$$

$$\therefore\ e^{t}u(-t) \Longleftrightarrow \frac{-1}{s-1}, \qquad \sigma < 1$$

End of Solution

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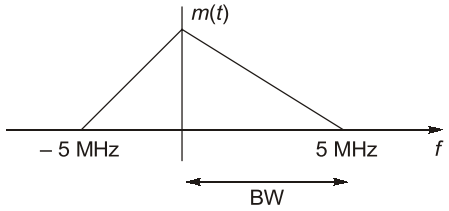
Q.20 Signal having bandwidth of 5 MHz is transmitted using the pulse code modulation. The signal is sampled at the rate 50% above the Nyquist rate and quantized in 256 level. The binary pulse rate of PCM signal in M bits per second is _____.

Ans. (120)



$f_m = 5$ MHz

N.R $= 2f_m = 2 \times$ BW

N.R = 10 MHz

$$f_s = 1.5 \times \text{N.R} = 1.5 \times 10 = 15 \text{ MHz} = \frac{1}{T_s}$$

$L = 256$

$L = 2^n$

So, $n = 8$ bit/sec

Bit rate, $R_b = \frac{n}{T_s} = 8 \times 15 = 120$

End of Solution

Q.21 An amplitude modulation scheme use the modulation with modulation index of 0.6. The power efficiency of the AM scheme is _____%.

Ans. (15.25)

Amplitude modulation, $\mu = 0.6$

Assuming sinusoidal message

$$\text{modulation efficiency, } \eta = \frac{\mu^2/2}{1+\frac{\mu^2}{2}} \times 100$$

$$\%\eta = \frac{(0.6)^2}{2+(0.6)^2} = \frac{0.36}{2+0.36} \times 100$$

$= 15.25\%$

End of Solution

Q.22 A single phase transformer has a magnetizing inductance of 250 mH and core loss resistance of 300 Ω referred to primary side, when excited with 230 V, 50 Hz sinusoidal supply at the primary. The power factor of the input current drawn with secondary on open circuit is _____ (Rounded to 2 decimal place).

Ans. (0.25)

$$L = 250 \times 10^{-3}; \quad R_0 = 300\ \Omega$$

$$B_L = \frac{1}{2\pi fL} = \frac{1}{2\pi(50)250\times10^{-3}} = 0.012732$$

$$G_0 = \frac{1}{300} = 3.33\times10^{-3}$$

$$\cos\theta = \frac{G_0}{\sqrt{G_0^2 + B_L^2}} = 0.253 \log$$

End of Solution

Q.23 A toroid mode of CRGO has an inner diameter of 10 cm and outer diameter of 14 cm. The thickness of the toroid is 2 cm. 200 turns of copper wire is wound on the core. If $\mu_0 = 4\pi \times 10^{-7}$ 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 millitesla is _____.

Ans. (10)

$$\phi = \frac{MMF}{s} = \frac{NI}{\frac{l}{a\mu_0\mu_0}} = \frac{NI}{l}(a\mu_0\mu_r)$$

$$B = \frac{d}{a} = \frac{\frac{NI}{l}(a\mu_0\mu_r)}{a}$$

$$B = \frac{NI\mu_0\mu_r}{l}$$

$$B = \frac{200(5\times10^{-3})(4\pi\times10^{-7})(3000)}{2\pi\left(\frac{12\times10^{-2}}{2}\right)}$$

$$B = 10 \text{ milli Tesla}$$

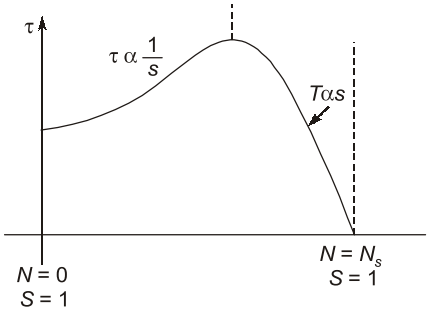
End of Solution

Q.24 The slipring induction motor is started by an external resistance so advantage of external resistance added is

(a) power factor at starting is lower (b) starting torque is high

(c) losses at starting is lower (d) starting current is higher

Ans. (b, c)



For power factor $\cos\theta_2 = \frac{R_2}{Z_2} = \frac{R_2}{R_2 + jsX_2}$

at starting $(\cos\theta_2)_{starting} = \frac{R_2}{R_2 + X_2}$

Order of R_2/phase = 0.1 to 0.2Ω

Order of X_2/phase = 1.5Ω to 2Ω

$$R_2^2 <<< X_2^2$$

So $R_2^2 \rightarrow$ neglected

$$\cos\theta_2 = \frac{R_2}{X_2}$$

As $R_2 \uparrow$ so power factor increases.

Hence option (a) is wrong.

$$T_s = \frac{180}{2\pi N_s} \times \frac{E_2^2 R_2}{R_2^2 + X_2^2}$$

So, R_2^2 term is neglected

$$T_s = \frac{180}{2\pi N_s} \frac{E_2^2 R_2}{X_2^2},$$

so, starting increases at it is directly proportional to rotor resistance.

Losses at time of starting.

Iron and mech. losses are low.

By inserting external resistance will reduce the starting current.

Hence option *B* and *C* are correct.

End of Solution

Q.25 Determinant of matrix

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

Ans. **(4)**

Expanding along R_1

$$|A| = +(1)\begin{vmatrix} 4 & 0 & 0 \\ 0 & 4 & 3 \\ 0 & 2 & 1 \end{vmatrix} - (2)\begin{vmatrix} 3 & 0 & 0 \\ 0 & 4 & 3 \\ 0 & 2 & 1 \end{vmatrix}$$

$$= (1)[4(4-6)] - 2[3(4-6)] = 4$$

End of Solution

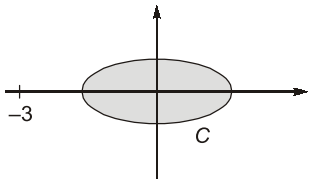
Q.26 Let $F(z) = \dfrac{1}{z^2+6z+9}$ defined in complex plane. The integral, $\oint_C F(z)$ over the contour of a circle C with center at the origin and having unit radius is _____.

Ans. **(0)**

$$f(z) = \frac{1}{z^2+6z+9} = \frac{1}{(z+3)^2}$$

Poles of $f(z)$, $(z+3)^2 = 0 \Rightarrow z = -3$ (Double pole)

$C : |z| = 1$



$\because$ Pole lies outside 'C' so by CIT, $\oint_c F(z)dz = 0$

End of Solution

Q.27 If $A = \begin{bmatrix} 2 & 5 \\ 0 & 3 \end{bmatrix}$. Then the determinant of $[A^4 - 5A^3 + 6A^2 + 2I]$ is

Ans. **(4)**

Characteristic Eq. of A is $|A - \lambda I| = 0 \Rightarrow (\lambda - 2)(\lambda - 3) = 0 \Rightarrow \lambda^2 + 5\lambda + 6 = 0$

By C.H theorem replace $\lambda \rightarrow A$ in Characteristic Eq.

$$A^2 - 5A + 6I = 0 \qquad \ldots(1)$$

Now $|A^4 - 5A^3 + 6A^2 + 2I| = |A^2(A^2 - 5A + 6I) + 2I|$

$$= |0 + 2I| = |2I| = 2^2|I| = 4|I| = 4 \times 1 = 4$$

End of Solution

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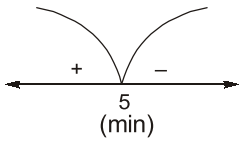
Q.28 Minimum value of $f(x)$ in range of [5, 10] where $f(x) = -x^2 + 10x + 100$ is given

Ans. (100)

$$f'(x) = -2x + 10$$
$$f'(5) = 0$$
$$f'(10) = -100$$

$\because$ $f'(x) \le 0$ in [5, 10] so $f(x)$ is decreasing function.

$$\text{Min } f(x) = f(10) = -(10)^2 + 10(10) + 100$$
$$= -100 + 100 + 100 = 100$$



End of Solution

Q.29 $U = [2 \quad 0]$ and $V = [1 \quad 0]$ both are row matrices.
The rank of $A = 2V^TV + 3U^TU$ is

(a) 2 (b) 1
(c) 4 (d) 3

Ans. (b)

$$A = 2\begin{bmatrix}1\\0\end{bmatrix}[1 \quad 0] + 3\begin{bmatrix}2\\0\end{bmatrix}[2 \quad 0]$$
$$= 2\begin{bmatrix}1 & 0\\0 & 0\end{bmatrix} + 3\begin{bmatrix}4 & 0\\0 & 0\end{bmatrix}$$
$$= \begin{bmatrix}2 & 0\\0 & 0\end{bmatrix} + \begin{bmatrix}12 & 0\\0 & 1\end{bmatrix} = \begin{bmatrix}14 & 0\\0 & 0\end{bmatrix}$$
$$\rho(A) = 1$$

End of Solution

Q.30 $f(z) = (z-1)^{-1} - 1 + (z-1) - (z-1)^2 + \ldots.$

Series expansions of

(a) $\dfrac{-1}{z(z-1)}$ for $|z-1|<1$ (b) $\dfrac{1}{z(z-1)}, |z-1|<1$

(c) $\dfrac{-1}{z-1}$ for $|z-1|<1$ (d) $\dfrac{1}{(z-1)^2}$, for $|z-1|<1$

Ans. (b)

$$f(z) = (z-1)^{-1}\left[1 - \frac{1}{(z-1)^{-1}} + \frac{(z-1)}{(z-1)^{-1}} - \frac{(z-1)^2}{(z-1)^{-1}} + \ldots\right]$$
$$= (z-1)^{-1}\left[1 - (z-1) + (z-1)^2 - (z-1)^3 + \ldots.\right]$$

We know that, $(1+x)^{-1} = 1 - x + x^2 - x^3 + \ldots$; for $|x| < 1$

$$= \frac{1}{(z-1)}[1+(z-1)]^{-1}; \text{ for } |z-1| < 1$$

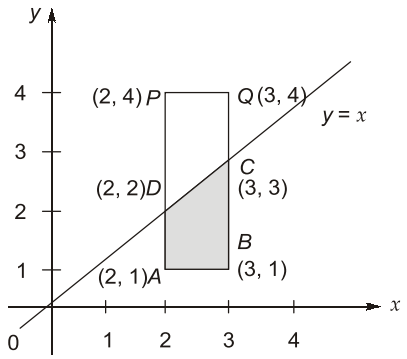
$$= \frac{1}{(z-1)}\left[z^{-1}\right]; \text{ for } |z-1| < 1$$

$$= \frac{1}{z(z-1)}; \text{ for } |z-1| < 1$$

End of Solution

Q.31 Consider x and y are independent continuous valued random variables with uniform PDF given by $x \in U(2, 3)$ and $y \in U(1, 4)$. Then $P(y \le x)$ is

Ans. (0.5)



Total area = $AB \times AP$

$= 1 \times 3 = 3$

Favourable Area (F_{av}) = Area of $ABCD$ (i.e., Trapezium)

$$= \frac{1}{2}(\text{sum of parallel sides}) \times (\text{Distance between them})$$

$$= \frac{1}{2}(AD + BC) \times (AB) = \frac{1}{2}(1+2) \times 1 = \frac{3}{2}$$

$$P(y \le n) = \frac{F_{av.} \text{ area}}{\text{Total area}} = \frac{3/2}{3} = \frac{3}{6} = 0.5$$

End of Solution

Q.32 A infinitely long line, with uniform positive charge density, lies along the z-axis. In cylindrical coordinates (r. ϕ, z), at any point not on the z-axis, the direction of the electric field is

(a) $\hat{r}$

(b) $\frac{\hat{r}+\hat{z}}{\sqrt{2}}$

(c) $\hat{\phi}$

(d) $\hat{z}$

Ans. (a)

End of Solution

Q.33 Consider the sequence $x_n = 0.5x_{n-1} + 1$

$n = 1, 2, 3.....$, if $x_0 = 0$ then the value of $\lim_{n\to\infty} x_n$ is

(a) ∞ (b) 0

(c) 2 (d) 1

Ans. (c)

$$x_n = \frac{x_{n-1}}{2} + 1 \Rightarrow x_1 = 1, x_2 = \frac{3}{2}, x_3 = \frac{7}{4}, x_4 = \frac{15}{8}, x_5 = \frac{31}{16}$$

Sequence is $1, \frac{3}{2}, \frac{7}{2^2}, \frac{15}{2^3}, \frac{31}{2^4}, \ldots \frac{2^n-1}{2^{n-1}}, \ldots\ldots$

i.e., $$x_n = \frac{2^n-1}{2^{n-1}} = \frac{2^n-1}{2^n/2} = 2\left[1-\frac{1}{2^n}\right]$$

$$\lim_{n\to\infty} x_n = \lim_{n\to\infty} 2\left(1-\frac{1}{2^n}\right) = 2\left(1-\frac{1}{\infty}\right) = 2$$

End of Solution

Q.34 In AC mains circuit $V_{ac} = 100 \pm 1\%$, rms current $I_{ac} = 1A \pm 1\%$ and power $W_{ac} = 50W \pm 2\%$. Percentage error in calculating the power factor using these readings is _____.

Ans. (4)

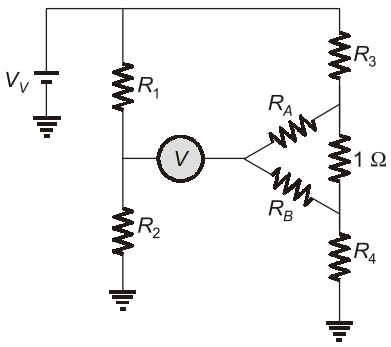
$$V_{GC} = 100 \pm 1\%,\ I_{GC} = \pm 1\%,\ W_{GC} = 50W \pm 2\%$$

$$P = VI\cos(\phi) \Rightarrow pf = \cos(\phi) = \frac{P}{VI} = \frac{50}{100\times 1} = 0.5$$

$$\%\text{Error} = \pm\left[\frac{\delta P}{P} + \frac{\delta V}{V} + \frac{\delta I}{I}\right] = \pm[2\% + 1\% + 1\%] = \pm 4\%$$

End of Solution

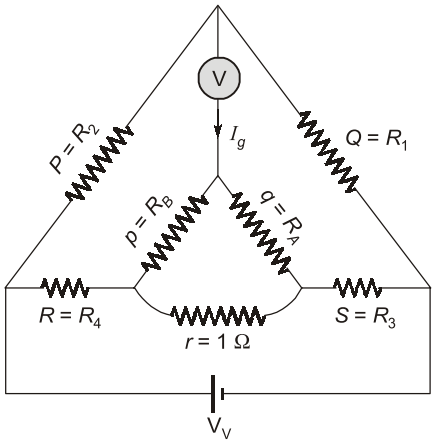
Q.35 In the bridge circuit shown, the voltmeter V showed zero when the values of the resistors are $R_1 = 100\ \Omega$, $R_2 = 110\ \Omega$ and $R_3 = 90\ \Omega$. If $\frac{R_1}{R_2} = \frac{R_A}{R_B}$, the value of R_4 in ohm is _____.



Ans. (99)

By redrawing CKT, we can get, "KELVIN DOUBLE BRIDGE"

Given that, $R_1 = 100\ \Omega$, $R_2 = 110\ \Omega$, $R_3 = 90\ \Omega$



Balance condition, $R = \frac{P}{Q} \times S + \frac{qr}{p+q+r}\left[\frac{P}{Q} - \frac{p}{q}\right]$

By comparing, $\frac{R_1}{R_2} = \frac{R_A}{R_B} \Rightarrow \frac{P}{Q} = \frac{P}{q} \Rightarrow R = \frac{P}{Q} \times S$

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

End of Solution

Q.36 The input and output characteristics appear to be exponential in the following:

(a) Thermocouple (b) RTD

(c) Thermistor (d) Strain gauge

Ans. (c)

End of Solution

Q.37 A metallic strain gauge, which has initial resistance of 1000 ohm and gauge factor of 2.5 is subjected to strain of 100 micron. The resistance of the strain gauge changes to _____. (upto two decimal points)

Ans. (1000.25)

For strain gauge $= \frac{\delta R}{R} = G.f \times \epsilon$ (ϵ = strain)

$\delta R = 1000 \times 2.5 \times 100 \times 10^{-6} = 0.25\Omega$

Resistance of the strain gauge changes to $1000 + 0.25 = 1000.25\Omega$

End of Solution

Q.38 The movable arm (mirror) of michelson interferometer is displaced by 325 micrometers. If 1000 fringes are passed in field of view then the wave length of source in nanometer is _____.

[1 mark]

Ans. (650)

Given, $d = 325$ mm

path difference, $= 2d = 2 \times 325$ mm

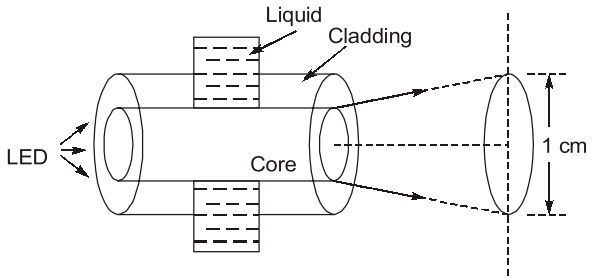
path difference $= n\lambda$

$$\therefore \quad 2d = n\lambda \quad \Rightarrow \quad n = \frac{2d}{\lambda} = \frac{2 \times 325\mu m}{1000}$$

$$\therefore \quad n = 650 \text{ nm}$$

End of Solution

Q.38 A multimodel optical fiber is made up of a core of refractive index (n_{core}) = 1.5 and cladding of refractive index ($n_{cladding}$) = 1.2 is used as shown below. LED is used to pump the light ray from one end of the fiber and at other end of the fiber a paper is placed as shown below. The diameter of the spot observed on the paper is 1 cm.
If some portion of the cladding is removed by water and passed as shown then the refractive index of water (n_{core}) is _____.



[2 marks]

Ans. (1.15)

Numerical Apeture, $NA = \sqrt{n_{core}^2 - n_{clad}^2}$

$$= \sqrt{(1.5)^2 - (1.2)^2}$$

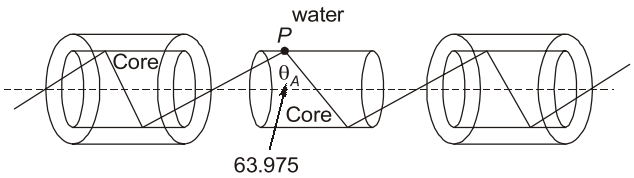
$$NA = 0.9$$

at starting of fiber,

$$n_0 \sin \theta_A = NA$$

$$\sin \theta_A = \frac{NA}{n_0} = \frac{0.9}{1} = 0.95$$

$$\therefore \quad \theta_A = \sin^{-1}(0.95) = 63.975°$$



$\therefore$ Apply Snells law at point P,

$$n_{core} \times \sin\theta'_A = n_W \sin \theta_C$$

where $\theta_C = 90 - 63.975 = 26.025$

$\therefore$ $15 \times \sin(26.025) = n_W$

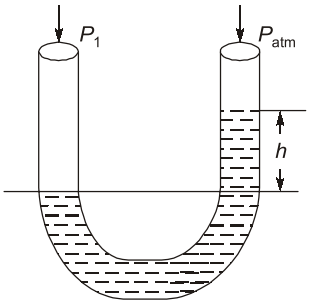
$\therefore$ refractive index of water,

$$n_W = 1.15$$

End of Solution

Q.38 An U-tube manometer is used for the measurement of pressure and it is uses Mano metric fluid of density 13,600 kg/m^3. If the atmospheric pressure is 101 KPa and acceleration due to gravity is 9.81 m/sec^2 and height indicated in one of the leg is 1 cm then the differential pressure in pascals is _____.

Ans. (1334.16)



Density of monometric fluid (ρ) = 13,600 kg/m^3

Acceleration due to gravity is (g) = 9.81 m/s^2

Height indicated (h) = 1 cm

$$P_1 = P_{atm} + \rho gh$$

$$P_1 - P_{atm} = \rho gh$$

Differential pressure

$$\Delta P = P_1 - P_{atm} = \rho gh$$

$$\Delta P = 13600 \times 9.81 \times 10 \times 10^{-2} = 1334.16 \text{ Pa}$$

End of Solution

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