GATE 2017
Instrumentation Engineering
(Afternoon Session: 12-02-2017)

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SECTION A: INSTRUMENTATION ENGINEERING

Q.1 The figure shows a phase locked loop. The output frequency is locked at $f_0 = 5$ kHz. The value of $f_i$ in kHz is ______.

Ans. (1)

In locked condition

\[
\frac{f_0}{5} = f_i
\]

\[
f_i = 1 \text{ kHz}
\]

Q.2 The pressure drop across an orifice plate for a particular flow rate is 5 kg/m². If the flow rate is doubled (within the operating range of the orifice), the corresponding pressure drop in kg/m² is

(a) 2.5 (b) 5.0 (c) 20.0 (d) 25.0

Ans. (c)

In orifice meter the relation between flowrate and differential pressure is

\[
Q \propto \sqrt{\Delta P} \quad [\text{’}Q\text{’ is volumetric flow rate, ‘}\Delta P\text{’ Differential pressure}]
\]

So,

\[
\frac{Q_2}{Q_1} = \sqrt{\frac{(\Delta P)_2}{(\Delta P)_1}}
\]

\[
\Rightarrow \left(\frac{Q_2}{Q_1}\right)^2 = \frac{\Delta P_2}{\Delta P_1}
\]

\[
\Rightarrow \Delta P_2 = \Delta P_1 \left[\frac{Q_2}{Q_1}\right]^2
\]

Given, $Q_2 = 2Q_1$

\[
\Rightarrow \Delta P_2 = \Delta P_1 \times \frac{2^2}{1} = 4 \times 5 \text{ kg/m}^2 = 20 \text{ kg/m}^2
\]
Q.3 If \( \mathbf{v} \) is a non-zero vector of dimension \( 3 \times 1 \), then the matrix \( A = \mathbf{vv}^T \) has rank = \( \_\_\_\_\_\_ \)

**Ans.** (1)

Since \( \mathbf{v} \) is non-zero vector of dimension \( 3 \times 1 \)
Therefore, \( \rho(A) \leq \min \{ \rho(\mathbf{v}), \rho(\mathbf{v}^T) \} \)
\( \leq \min \{ 1, 1 \} \)
\( \leq 1 \)
Since \( \mathbf{v} \) is non-zero. Hence \( \rho(A) = 1 \)

---

Q.4 If a continuous time signal \( x(t) = \cos(2\pi t) \) is sampled at 4 Hz, the value of the discrete time sequence \( x(n) \) is 5 is

(a) \(-0.707\)
(b) \(-1\)
(c) 0
(d) 1

**Ans.** (c)

\[
x(nT_s) = \cos 2\pi \cdot \frac{n}{4} = \cos \frac{\pi}{2} n = x(n)
\]

\[
x(n) \big|_{n=5} = \cos \frac{5\pi}{2} = 0
\]

---

Q.5 A system is described by the following differential equation:

\[
\frac{dy(t)}{dt} + 2y(t) = \frac{dx(t)}{dt} + x(t), x(0) = y(0) = 0
\]

where \( x(t) \) and \( y(t) \) are the input and output variables respectively. The transfer function of the inverse system is

(a) \( \frac{s+1}{s-2} \)
(b) \( \frac{s+2}{s+1} \)
(c) \( \frac{s+1}{s+2} \)
(d) \( \frac{s-1}{s-2} \)

**Ans.** (b)

\[
\frac{dy(t)}{dt} + 2y(t) = \frac{dx(t)}{dt} + x(t)
\]

So,

\[
H(s) = \frac{Y(s)}{X(s)} = \frac{s+1}{s+2}
\]

So, transfer function of inverse system.

\[
H^{-1}(s) = \frac{s+2}{s+1}
\]
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8. Ethics and values in Engineering profession.

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<tr>
<th>Venue</th>
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<td>Noida</td>
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<tr>
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<td>25th Feb, 2017</td>
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<td>20th Feb, 2017</td>
</tr>
</tbody>
</table>

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Q.6  The standard for long distance analog signal transmission in process control industry is 
(a) 4 - 20 mV  
(b) 0 - 20 mA  
(c) 4 - 20 mA  
(d) 0 - 5 V  

Ans.  (c)  
The standard for analog signal transmission in process control industry is 
(4 – 20) mA (or) (1 – 5) V

Q.7  A series R-L-C circuit is excited with a 50 V, 50 Hz sinusoidal source. The voltages across the resistance and the capacitance are shown in the figure. The voltage across the inductor (\(V_L\)) is ________ V. 

![Circuit diagram](image)

Ans.  (50)  
\[ V = \sqrt{V_R^2 + (V_L - V_C)^2} \]  
\[ 50 = \sqrt{50^2 + (V_L - 50)^2} \]  
\[ V_L = 50 \]

Q.8  The output \(V_o\) shown in the figure, in volt, is close to  
(a) –20  
(b) –15  
(c) –5  
(d) 0
Ans. (b)

\[ V_o = -\frac{R_F}{R_1} V_i = -\frac{2 \, \text{k} \Omega}{1 \, \text{k} \Omega} \times 10 = -20 \, \text{V} \]

- Not possible because \( V_o \) is saturated,
- \( V_o = -V_{\text{sat}} = -15 \, \text{V} \)

---

Q.9 The silicon diode, shown in the figure, has a barrier potential of 0.7 V. There will be no forward current flow through the diode if \( V_{\text{dc}} \), in volts, is greater than

\[ \frac{V_{\text{dc}}}{2} \]

(a) 0.7  
(b) 1.3  
(c) 1.8  
(d) 2.6

Ans. (d)

\[ I = \frac{2 - 0.7 - V_{\text{dc}}}{500} = 0 \]

\( V_{\text{dc}} = 2.6 \, \text{V} \)

- If \( V_{\text{dc}} > 2.6 \, \text{V} \) then diode will become off.
Q.10  The term hysteresis is associated with
(a) ON-OFF control  (b) P-I control
(c) Feed-forward control  (d) Ratio control

Ans. (a)
ON-OFF controller is designed to tolerate a range of error to avoid self sustained oscillations; known as hysteresis characteristics.

Q.11  The differential amplifier, shown in the figure, has a differential gain of $A_d = 100$ and common mode gain of $A_c = 0.1$. If $V_1 = 5.01$ V and $V_2 = 5.00$ V, then $V_0$ in volt (up to one decimal place) is _______.

\[ V_0 = A_d(V_1 - V_2) + A_c \left( \frac{V_1 + V_2}{2} \right) \]
\[ = 100(5.01 - 5) + 0.1 \left( \frac{5.01 + 5}{2} \right) \]
\[ = 1.5005 \text{ V} \]

Ans. (1.5)

Q.12 Identify the instrument that does not exit:
(a) Dynamometer-type ammeter  (b) Dynamometer-type wattmeter
(c) Moving-iron voltmeter  (d) Moving-iron wattmeter

Ans. (d)

Q.13 The most suitable pressure gauge to measure pressure in the range of $10^{-4}$ to $10^{-3}$ torr is
(a) Bellows  (b) Barometer
(c) Strain gauge  (d) Pirani gauge

Ans. (d)
- Given pressure range is $10^{-4}$ to $10^{-3}$ torr this means it is low pressure range.
- Out of given choices “Pirani gauge” is the suitable pressure gauge which can measure the given range of pressure.
Q.14 The condition for oscillation in a feedback oscillator circuit is that at the frequency of oscillation, initially the loop gain is greater than unity while the total phase shift around the loop in degree is

(a) 0  (b) 90  (c) 180  (d) 270

Ans. (a)

Q.15 The eigenvalues of the matrix \( A = \begin{bmatrix} 1 & -1 & 5 \\ 0 & 5 & 6 \\ 0 & -6 & 5 \end{bmatrix} \) are

(a) -1, 5, 6  (b) 1, -5 ± j6  (c) 1, 5 ± j6  (d) 1, 5, 5

Ans. (c)

Characteristics equation is \( |A - \lambda I| = 0 \)

\[
\begin{vmatrix} 1-\lambda & -1 & 5 \\ 0 & 5-\lambda & 6 \\ 0 & -6 & 5-\lambda \end{vmatrix} = 0
\]

\[(1 - \lambda)((5 - \lambda)^2 + 36) + 1(0 - 0) + 5(0 - 0) = 0\]

\[(1 - \lambda)(\lambda^2 - 10\lambda + 61) = 0\]

\(\lambda = 1, \quad \lambda = \frac{10 \pm \sqrt{100 - 244}}{2} = \frac{10 \pm 12i}{2} = 5 \pm 6i\)

\(\lambda = 1, 5 \pm 6i\)

Q.16 A periodic signal \( x(t) \) shown in the figure. The fundamental frequency of the signal \( x(t) \) in Hz is ________.

![Periodic Signal](image)

Ans. (1)

\[ T = 1 \text{ sec} \]

So,

\[ f_0 = \frac{1}{T} = 1 \text{ Hz} \]
Q.17 A circuit consisting of dependent and independent source is shown in the figure. If the voltage at Node-1 is \(-1\) V, then the voltage at Node-2 is ______ V.

Ans. \(2\)

By KCL at node 2

\[ 2I_2 = \frac{V_2}{1/3} + \frac{V_2 + 4V_{R_1} - V_1}{0.5} \]

\[ V_{R_1} = -1 \]

Sub equation (ii) and (iii) in equation (i)

\[ V_2 = 2 \]

Q.18 Let \(z = x + jy\) where \(j = \sqrt{-1}\). Then \(\cos z =\)

(a) \(\cos z\) \hspace{1cm} (b) \(\cos^{-1} z\)

(c) \(\sin z\) \hspace{1cm} (d) \(\sin^{-1} z\)

Ans. (b)

\[
\cos z = \cos(x + iy) = \cos x \cos iy - \sin x \sin iy
\]

\[ = \cos x \cosh y - i \sin x \sinh y \]

\[ = \cos x \cosh y + i \sin x \sinh y \]

\[ = \cos x \cosh y + \sin x \sinh y = \cos(x - iy) = \cos z \]

Q.19 The Region of Convergence (ROC) of the Z-transform of a causal unit step discrete-time sequence is

(a) \(|z| < 1\) \hspace{1cm} (b) \(|z| \leq 1\)

(c) \(|z| > 1\) \hspace{1cm} (d) \(|z| \geq 1\)

Ans. (c)

\[ u[n] \xrightarrow{z} \frac{1}{1 - z^{-1}} : |z| > 1 \]
Q.20 For a first order lowpass filter with unity dc, gain and –3 dB corner frequency of \(2000\pi\) rad/s, the transfer function \(H(j\omega)\) is

(a) \(\frac{1}{1000 + j\omega}\) 
(b) \(\frac{1}{1 + j1000\omega}\) 
(c) \(\frac{2000\pi}{2000\pi + j\omega}\) 
(d) \(\frac{1000\omega}{1 + j1000\omega}\)

Ans. (c)

General transfer function of 1st order LPF is 
\[G(s) = \frac{1}{1 + s\tau}\]

Where \(\tau = RC = \frac{1}{\omega_C} = \frac{1}{2000\pi}\)

\[G(j\omega) = \frac{1}{1 + j\omega\left(\frac{1}{2000\pi}\right)} = \frac{2000\pi}{2000\pi + j\omega}\]

Q.21 The connection of two 2-port networks is shown in the figure. The ABCD parameters of \(N_1\) and \(N_2\) networks are given as

\[
\begin{bmatrix}
A & B \\
C & D
\end{bmatrix}_{N_1} = \begin{bmatrix} 1 & 5 \\ 0.2 & 1 \end{bmatrix}
\quad \text{and} \quad
\begin{bmatrix}
A & B \\
C & D
\end{bmatrix}_{N_2} = \begin{bmatrix} 1 & 0 \\ 0.2 & 1 \end{bmatrix}
\]

The ABCD parameters of the combined 2-port network are

(a) \(\begin{bmatrix} 2 & 5 \\ 0.2 & 1 \end{bmatrix}\) 
(b) \(\begin{bmatrix} 1 & 2 \\ 0.5 & 1 \end{bmatrix}\) 
(c) \(\begin{bmatrix} 5 & 2 \\ 0.5 & 1 \end{bmatrix}\) 
(d) \(\begin{bmatrix} 1 & 2 \\ 0.5 & 5 \end{bmatrix}\)

Ans. (a)

\[
\begin{bmatrix}
A & B \\
C & D
\end{bmatrix}_{N_1} = \begin{bmatrix} 1 & 5 \\ 0 & 1 \end{bmatrix}
\begin{bmatrix} 1 & 0 \\ 0.2 & 1 \end{bmatrix}
\]

\[
\begin{bmatrix}
A & B \\
C & D
\end{bmatrix} = \begin{bmatrix} 2 & 5 \\ 0.2 & 1 \end{bmatrix}
\]

End of Solution
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011-45124612, 9958995830  www.madeeasy.in
Q.22 A current waveform \( i(t) \), shown in the figure, is passed through a Permanent Magnet Moving Coil (PMMC) type ammeter. The reading of the ammeter up to two decimal place is

(a) \(-0.25\) A  
(b) \(-0.12\) A  
(c) \(0.37\) A  
(d) \(0.5\) A

Ans. (a)

The PMMC ammeter in this case measures the average value of the current

\[
I_{\text{average}} = \frac{A_1 + A_2}{T} = \frac{1}{2} \cdot \frac{1\times 1 + (-1\times 1)}{2} = \frac{0.5 - 1}{2} = -0.25 \text{ A}
\]

Q.23 A and B are the logical inputs and \( X \) is the logical shown in the figure. The output \( X \) is related to \( A \) and \( B \) by
(a) $X = \bar{A} \bar{B} + \bar{B} \bar{A}$  
(b) $X = A \bar{B} + \bar{B} A$
(c) $X = A B + \bar{A} \bar{B}$  
(d) $X = A \bar{B} + \bar{B} \bar{A}$

Ans. (c)

Q.24 The figure shows a shape $ABC$ and its mirror image $A_1, B_1, C_1$, across the horizontal axis (X-axis). The coordinate transformation matrix that maps $ABC$ to $A_1, B_1, C_1$ is

(a) $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$  
(b) $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$
(c) $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$  
(d) $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$

Ans. (a)

Coordinate transformation matrix

$\begin{bmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{bmatrix}$

Orthogonal

$\therefore \theta = 90^\circ$

$\begin{bmatrix} \cos 90^\circ & \sin 90^\circ \\ -\sin 90^\circ & \cos 90^\circ \end{bmatrix}$

$\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$

Q.25 An 8-bit microcontroller with 16 address lines has 3 fixed interrupts i.e. Int 1, Int2 and Int3 with corresponding interrupt vector addresses as 0008 H, 0010 H and 0018 H. To execute a 32-byte long interrupt service subroutine for Int1 starting at the address ISS1, the location 0008H onwards should ideally contain

(a) a CALL to ISS1  
(b) an unconditional JUMP to ISS1
(c) a conditional JUMP to ISS1  
(d) Only ISS1
Ans. (b)
As the service routine length is more than 8 bytes. It should not disturb vector locations of other interrupts.

Q.26 For the circuit, shown in the figure, the total real power delivered by the source to the loads is _____ kW.

Ans. (1.866)

\[ I = I_1 + I_2 = 5\angle0^\circ + 5\angle30^\circ \]
\[ I = 9.659 \angle 14.94^\circ \]
\[ P = VI\cos\theta = 200 \times 9.659 \times \cos(14.94^\circ) \]
\[ = 1.866 \text{ kW} \]

Q.27 The current response of a series R-L circuit to a unit step voltage is given in the table. The value of L is _____ H.

<table>
<thead>
<tr>
<th>t in s</th>
<th>0</th>
<th>0.25</th>
<th>0.5</th>
<th>0.75</th>
<th>1.0</th>
<th>...</th>
<th>( \infty )</th>
</tr>
</thead>
<tbody>
<tr>
<td>i(t) in A</td>
<td>0.197</td>
<td>0.316</td>
<td>0.388</td>
<td>0.432</td>
<td>...</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

Ans. (1)

\[ i(t) = \frac{V}{R} \left[ 1 - e^{-\frac{Rt}{L}} \right] \]

From given data at t = \( \infty \)

\[ \frac{V}{R} = 0.5 \]
\[ \therefore V = 1 \]
\[ R = 2 \Omega \]
\[ \text{at } t = 0.25 \]

\[ 0.197 = 0.5 \left[ 1 - e^{-2(0.25)} \right] \]

\[ L = 1 \text{ H} \]
Q.28 In the circuit, shown in the figure, the MOSFET is operating in the saturation zone. The characteristics of the MOSFET is given by \( I_D = \frac{1}{2}(V_{GS} - \eta)^2 \) mA, where \( V_{GS} \) is in V. If \( V_S = +5V \), then the value of \( R_s \) in kΩ is ______.

\[ V_G = \frac{15 \times 7M}{8M + 7M} = 7 \text{ V} \]

\[ V_{GS} = V_G - V_S = 7 - 5 = 2 \text{ V} \]

\[ I_D = \frac{1}{2}(V_{GS} - \eta)^2 \text{ mA} = 0.5 \text{ mA} \]

\[ V_S = I_D R_S \]

\[ \Rightarrow R_S = \frac{5}{0.5 \times 10^{-3}} = 10 \text{ kΩ} \]

Ans. (10)
Q.29 The hot junction of a bare thermocouple, initially at room temperature (30°C), is suddenly dipped in molten metal at \( t = 0 \) s. The cold junction is kept at room temperature. The thermocouple can be modeled as a first-order instrument with time constant of 1.0 s and a static sensitivity of 10 \( \mu \text{V/°C} \). If the voltage, measured across the thermocouple indicates 10.0 mV at \( t = 1.0 \) s, then the temperature of the molten metal in °C is ________.

Answer. (1612.28)

Initially \( (t < 0) \)

Hot junction temperature.

So, \( T_H(0^+) = 30°C \)

\( \forall t \geq 0 \)

A sudden step change is applied to the thermocouple hot junction and the amount of step change is equal to “Molten steel temperature”.

So, for thermocouple,

\[ T_H(0) = 30°C \]
\[ T_H(\infty) = T_m \text{ (Molten steel temperature)} \]

and \( T_H(t) = 30° \ (\forall \ t \geq 0) \)

where, \( T_C = \text{Cold junction temperature} \).

Given that time constant of thermocouple is 1 sec.

⇒ The step response of first order system is given as

\[ T_H(t) = T_H(\infty) + [T_H(0) - T_H(\infty)] e^{-t/T_C} \]

at \( t = 1 \) sec

\[ T_H(1) = T_m + (30 - T_m) e^{-1} \]

thermocouple output voltage at any time is

Given as

\[ e_H(t) = k \times (T_H(t) - T_C(t)) \ (\forall t \geq 0) \]

\[ k = 10 \ \mu \text{V/°C} \text{ (Static sensitivity)} \]

at \( t = 1 \) sec

\[ e_H(1) = k(T_H(1)) - T_C(1)) \]

\[ 10 \times 10^{-3} = 10 \times 10^{-6} \ [T_m - T_m e^{-1} + 11.036 - 30] \]

\[ 1000 = T_m (1 - e^{-1}) - 18.9631 \]

\[ \frac{1018.9636}{(1 - e^{-1})} = T_m \]

\[ T_m = \frac{1018.9636}{0.632} = 1612.2844°C \]

Q.30 Three DFT coefficients, out of the DFT coefficients of a five-point real sequence are given as: \( X(0) = 0 \), \( X(1) = 1 - j1 \) and \( X(3) = 2 + j2 \). The zeroth value of the sequence \( x(n) \).

(a) 1  \hspace{2cm} (b) 2
(c) 3  \hspace{2cm} (d) 4
Ans. (b)
Since \( x[n] \) is real
So,
\[
X[k] = X^*[N - k] \\
X[2] = X^*[3] = 2 - j2 \\
X[4] = X^*[1] = 1 + j1
\]
So,
\[
X[0] = \frac{1}{N} \sum_{k=0}^{N} X[k] = \frac{4 + 1 + 2 + 2 + 1}{5} = 2
\]

---

**Q.31** The two inputs A and B are connected to an R-S latch via two AND gates as shown in the figure. If \( A = 1 \) and \( B = 0 \), the output \( Q\bar{Q} \) is

(a) 00  
(b) 10  
(c) 01  
(d) 11

Ans. (b)

From the figure shown above
\[
S = A\bar{Q} \\
R = BQ
\]
Since \( Q \) and \( \bar{Q} \) are complement of each other thus \( S \) and \( R \) can not be 1 at the same time but can be zero at the same time. Thus R-S latch have 1, 1 as a invalid state, which is the possible case only in S-R NOR latch but not in S-R NAND latch.

S-R NOR latch truth table

<table>
<thead>
<tr>
<th>S</th>
<th>R</th>
<th>( Q_{n+1} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>No change</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Invalid state</td>
</tr>
</tbody>
</table>

S-R NAND latch truth table

<table>
<thead>
<tr>
<th>S</th>
<th>R</th>
<th>( Q_{n+1} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>Invalid state</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>No change</td>
</tr>
</tbody>
</table>
Now For S-R NOR latch

\[ Q_{n+1} = S + \overline{\bar{R} \cdot Q_n} = Q_n + \bar{0} \cdot Q_n = Q_n + Q_n = 1 \]

When \( AB = 10 \), then irrespective of present state, the next state will be set state \( Q\bar{Q} = 10 \)

**Q.32** An angle modulated signal with carrier frequency \( \omega_c = 2\pi \times 10^6 \text{ rad/s} \) is given by \( \phi_m(t) = \cos(\omega_c t + 5 \sin(10000\pi t) + 10 \sin(2000\pi t)) \). The maximum deviation of the frequency in the angle modulated signal from that of the carrier is _______ kHz.

**Ans.** (12.5)

Given angle modulated signal

\[ \phi(t) = \frac{\cos(2\pi f_c t + 5\sin(10000\pi t) + 10\sin(2000\pi t))}{Q(t)} \]

\[ f_i = \frac{1}{2\pi} \frac{d}{dt} \phi_i(t) \]

\[ = f_c + 2500 \cos(10000\pi t) + 10000 \cos(2000\pi t) \]

\[ = f_c + Kp \cdot m(t) \]

Maximum frequency deviation

\[ \Delta f = \max [Kp \cdot m(t)] \]

\[ = \max [2500 \cos(10000\pi t) + 10000 \cos(2000\pi t)] \]

\[ = 2500 + 10000 = 12.5 \text{ kHz} \]

**Q.33** The magnetic flux density of an electromagnetic flowmeter is 100 mWb/m². The electrodes are wall-mounted inside the pipe having a diameter of 0.25 m. A voltage of 1 V is generated when a conducting fluid is passed through the flowmeter. The volumetric flowrate of the fluid in m³/s is _______.

**Ans.** (1.96)

Given that:

Magnetic flux density \( (B) = 100 \times 10^{-3} \text{ Wb/m}^2 \).

Diameter \( (D) = 0.25 \text{ m} \).

Generated voltage \( (e_o) = 1 \text{ V} \).

From the concept of “Electro magnetic flowmeter”.

We can write that,

\[ e_o = B \times D \times v \]

Where, \( v = \text{ Mean velocity of conductive fluid} \).
\[ v = \frac{e_0}{BD} \] ... (i)

But we know that
\[ Q = AV \] ... (ii)

From (i) and (ii)
\[
Q = A \times \frac{e_0}{BD} = \pi \frac{D^2}{4} \times \frac{e_0}{BD}
\]
\[
= \frac{\pi \cdot D \cdot e_0}{4B} = \frac{3.14 \times 0.23 \times 1}{4 \times 100 \times 10^{-3}} = 1.96 \text{ m}^3/\text{sec}
\]

Q.34 The following table lists an \( n \)th order polynomial \( f(x) = a_n x^n + a_{n-1} x^{n-1} + \ldots + a_1 x + a_0 \) and the forward difference evaluated at equally spaced values of \( x \). The order of the polynomial is

<table>
<thead>
<tr>
<th>( x )</th>
<th>( f(x) )</th>
<th>( \Delta f )</th>
<th>( \Delta^2 f )</th>
<th>( \Delta^3 f )</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.4</td>
<td>1.7648</td>
<td>-0.2965</td>
<td>0.089</td>
<td>-0.03</td>
</tr>
<tr>
<td>-0.3</td>
<td>1.4683</td>
<td>-0.2075</td>
<td>0.059</td>
<td>-0.0228</td>
</tr>
<tr>
<td>-0.2</td>
<td>1.2608</td>
<td>-0.1485</td>
<td>0.0362</td>
<td>-0.0156</td>
</tr>
<tr>
<td>-0.1</td>
<td>1.1123</td>
<td>-0.1123</td>
<td>0.0206</td>
<td>-0.0084</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>-0.0917</td>
<td>0.0122</td>
<td>-0.0012</td>
</tr>
<tr>
<td>0.1</td>
<td>0.9083</td>
<td>-0.0795</td>
<td>0.011</td>
<td>0.006</td>
</tr>
<tr>
<td>0.2</td>
<td>0.8286</td>
<td>-0.0685</td>
<td>0.017</td>
<td>0.0132</td>
</tr>
</tbody>
</table>

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

Ans. (d)
In the following table by calculating \( \Delta^4 f \) we get \( 7.2 \times 10^{-3} \) for all the differences. Which is constant for all values. Therefore the order of the polynomial is 4.

Q.35 The circuit of a Schmitt trigger is shown in the figure. The zener-diode combination maintains the output between \( \pm 7 \) V. The width of the hysteresis band is _______ V.

[Diagram of a Schmitt trigger]
Ans. \(0.67\)

\[ V_i = 2 \beta V_z = \frac{2 \times 0.5k}{10k + 0.5k} \times 7 = \frac{2}{3} = 0.67 \text{ V} \]

Q.36 The loop transfer function of a closed-loop system is given by \(G(s)H(s) = \frac{K(s + 6)}{s(s + 2)}\). The breakaway point of the root-loci will be ________

Ans. \((-1, 10)\)

\[ G(s)H(s) = \frac{k(s + 6)}{s(s + 2)} \]

Breakaway point and Break in point can be obtained from the solutions of \(\frac{dk}{ds}\).

\[ k = \frac{-s(s + 2)}{s + 6} \]

\[ \frac{dk}{ds} = 0 \]

\[ \Rightarrow \quad s = -6 \pm 2\sqrt{6} \]

Breakaway point = \(-6 + 2\sqrt{6} = -1.1\)

Break in point = \(-6 - 2\sqrt{6} = -10.9\)

Q.37 In the AC bridge, shown in the figure, \(R = 10^9 \Omega\) and \(C = 10^{-7} \text{ F}\). If the bridge is balanced at a frequency \(\omega_0\), the value of \(\omega_0\) in rad/s is ________.
Ans.  (10000)

Under the balanced condition of the bridge,

\[ 2R \left( \frac{R}{1 + j\omega CR} \right) = R \left( R + \frac{1}{j\omega C} \right) \]

\[ \frac{2R}{1 + j\omega CR} = R + \frac{1}{j\omega C} \]

\[ 2R = R + j\omega CR^2 + \frac{1}{j\omega C} + R = 2R + j\omega CR^2 + \frac{1}{j\omega C} \]

\[ j\omega CR^2 = \frac{1}{\omega C} \]

\[ \omega_b^2 = \frac{1}{R^2C^2} \]

OR

\[ \omega_b = \frac{1}{RC} = \frac{1}{10^3 \times 10^{-7}} = 10000 \text{ rad/sec} \]

Q.38 The probability that a communication system will have high fidelity is 0.81. The probability that the system will have both high fidelity and high selectivity is 0.18. The probability that a given system with high fidelity will have high selectivity is

(a) 0.181 (b) 0.191 (c) 0.222 (d) 0.826

Ans.  (c)

\[ P(F) = 0.81 \]

\[ P(F \cap S) = 0.18 \]

By conditional probability

\[ P(S/F) = \frac{P(S \cap F)}{P(F)} = \frac{0.18}{0.81} = 0.22 \]

Q.39 The unbalanced voltage of the Wheatstone bridge, shown in the figure is measured using a digital voltmeter having infinite input impedance and a resolution of 0.1 mV. If \( R = 1000 \Omega \), then the minimum value of \( \Delta R \) in \( \Omega \) to create a detectable unbalanced voltage is ________.

[Diagram of Wheatstone bridge with resistances and voltmeter]
Ans. \((0.2)\)

**Method I**

Given bridge is the quarter bridge arrangement.

For quarter bridge arrangement

\[ V_o = \frac{V_S \Delta R}{4R} \]

\[ \Delta R = \frac{V_o \times 4 \times R}{V_S} = \frac{0.1 \times 10^{-3} \times 4 \times 1000}{2} = 0.2 \Omega \]

**Method II**

Redraw the bridge we have

Since the voltmeter is having an infinite input impedance \(I_D = 0\), and \(I_1 = I_3\) and \(I_2 = I_4\) the voltmeter ready \(E_o\) is given by

\[ E_o = E_3 - E_4 = I_3R_3 - I_4R_4 \]

But,

\[ I_2 = I_4 = \frac{E}{R_2 + R_4} \]

\[ I_1 = I_3 = \frac{E}{R_1 + R_3} \]

i.e.

\[ E_o = \frac{ER_3}{R_1 + R_3} - \frac{ER_4}{R_2 + R_4} = E \left[ \frac{R_3(R_2 + R_4) - R_4(R_1 + R_3)}{(R_1 + R_3)(R_2 + R_4)} \right] \]

\[ = E \left\{ \frac{R_2R_3 + R_3R_4 - R_4R_2 - R_4R_3}{(R_1 + R_3)(R_2 + R_4)} \right\} \]

\[ = E \left\{ \frac{R_2R_3 - R_4R_3}{(R_1 + R_3)(R_2 + R_4)} \right\} \]

But given, \(R_1 = R_2 = R_4 = R\) and \(R_3 = (R + \Delta R)\)

\[ \because \] Voltmeter reading \(E_o + \Delta E_o\)

and as \(E_0 = 0\)
\[
E_0 + \Delta E_0 = E \left\{ \frac{R(R + \Delta R) - R^2}{(R + R + \Delta R)2R} \right\}
\]
\[
\Delta E_0 = E \left\{ \frac{\Delta R}{4R + 2\Delta R} \right\} = E \left\{ \frac{\Delta R / R}{4 + 2\frac{\Delta R}{R}} \right\}
\]
\[
\therefore \quad 4 \ggg 2 \frac{\Delta R}{R}
\]
\[
\therefore \quad \Delta E_0 = \frac{E \cdot \Delta R}{4 \cdot R}
\]
Here,
\[
\Delta E_0 = 0.1 \times 10^{-3} \text{ V}
\]
\[
E = 2 \text{ V}
\]
and
\[
R = 1000 \ \Omega
\]
\[
\therefore \quad 0.1 \times 10^{-3} = \frac{2}{4} \times \frac{\Delta R}{1000}
\]
\[
\Delta R = \frac{4 \times 0.1 \times 10^{-3} \times 1000}{2} = 0.2 \ \Omega
\]

Q.40 Assuming the opamp shown in the figure to be ideal, the frequency at which the magnitude of \( V_o \) will be 95% of the magnitude of \( V_{in} \) is _______ kHz.

Ans. (2.95)

\[
A_v = \frac{|V_o|}{|V_i|} = \frac{A}{\sqrt{1 + \left( \frac{f_c}{f_o} \right)^2}}
\]

Where,
\[
A = 1 + \frac{R_F}{R_1} = 2
\]
\[
f_c = \frac{1}{2\pi RC} = \frac{1}{2\pi \times 10 \times 10^3 \times 10 \times 10^{-9}} = 10^4 \ \text{Hz}
\]

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At \( f = f_1 \)

\[ V_0 = 0.95 \, V_i \]

\[ A_y = 0.95 \]

\[ 0.95 = \frac{2}{\sqrt{1 + \left(\frac{f_1}{f_c}\right)^2}} \]

\[ \Rightarrow \quad f_1 = f_c \sqrt{\left(\frac{2}{0.95}\right)^2 - 1} = 2.95 \text{ kHz} \]

**Q.41** The two-input voltage multiplier, shown in the figure has a scaling factor of 1 and produces voltage output. If \( V_1 = +15 \text{ V} \) and \( V_2 = +3 \text{ V} \), the value of the \( V_0 \) in volt is _____.

Ans. \((-5)\)

Scaling factor

\[ V_R = 1 \]

KCL at Node A:

\[ \frac{0 - V}{R} + \frac{0 - V_{01}}{R} = 0 \]

\[ \Rightarrow \quad V_{01} = -V_1 = -15 \text{ V} \]

Also,

\[ V_{01} = \frac{V_0 \times V_1}{V_R} = \frac{V_0 \times 3}{1} \]

\[ \Rightarrow \quad V_0 = -\frac{V_{01}}{3} = -\frac{15}{3} = -5 \text{ V} \]
Q.42 The junction semiconductor temperature sensor shown in the figure is used to measure the temperature of hot air. The output voltage \( V_o \) is 2.1 V. The current output of the sensor is given by \( I = 10^{-3} T \) where \( T \) is the temperature in K. Assuming the opamp to be ideal, the temperature of the hot air in °C is approximately _____.

Ans. (77)

Given that the constant output of sensor \( I = T \times 10^{-3} \) (\( T \) is kelvin)

\[
V = 2.1 \times \frac{1}{1k + 2k} = 2.1 \times \frac{1}{3} = 0.7 \text{ V}
\]

And from ideal “Op-amp”

Configuration \( V = V_o = V_o = 0.7 \text{ V} \)

And the voltage across the 2 kΩ resistor (follow the sensor) is

\[
0.7 \text{ V} = I \times 2 \times 10^3
\]

\[
I = \frac{0.7 \text{ V}}{2 \times 10^{-3}} = 350 \text{ mA}
\]

\[
T \times 10^{-6} = 0.35 \times 10^{-3}
\]

\[
T = 350 \text{ kelvin}
\]

\[
T = 350 - 273 = 77 \text{ °C}
\]
Q.43  The angle between two vectors \( \vec{x}_1 = [2 6 14]^T \) and \( \vec{x}_2 = [-12 8 16]^T \) in radian is ________.

Ans.  (0.723)

\[
\vec{x}_1 = 2\vec{i} + 6\vec{j} + 14\vec{k}
\]

\[
\vec{x}_2 = -12\vec{i} + 8\vec{j} + 16\vec{k}
\]

\[
\cos \theta = \frac{\vec{a} \cdot \vec{b}}{||\vec{a}|| ||\vec{b}||} = \frac{(2\vec{i} + 6\vec{j} + 14\vec{k})(-12\vec{i} + 8\vec{j} + 16\vec{k})}{\sqrt{4 + 36 + 196} \sqrt{144 + 64 + 256}}
\]

\[
= \frac{-24 + 48 + 224}{15.36(21.54)} = \frac{248}{330.8544} = 0.7495
\]

\[
\theta = \cos^{-1}(0.7495) = 41.45^\circ
\]

\[
= 0.723 \text{ radians}
\]

Q.44  A resistance temperature detector (RTD) is connected to a circuit, as shown in the figure. Assume the opamp to be ideal. If \( V_0 = +2.0 \text{ V} \), then the value of \( x \) is ________.

Ans.  (0.2)

Given that:

\( V_0 = +2 \text{ V} \) and opamp is ideal.
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8800338066
KCL at node A
\[
\frac{12-0}{R(1+x)} + \frac{-12-0}{R} + \frac{V_0-0}{R} = 0
\]
\[
\frac{12}{1+x} - 12 + 2 = 0
\]
\[
\frac{12}{1+x} = 10
\]
\[
1 + x = 12
\]
\[
x = 0.2
\]

Q.45 In the circuit diagram, shown in the figure, S₁ was closed and S₂ was open for a very long time. At \( t = 0 \), S₁ is opened and S₂ is closed. The voltage across the capacitor, in volts, at \( t = 5 \mu s \) is ______.

Ans. \( 1.52 \)

at \( t = 0^- \)

\[
V_C(0^-) = 0
\]

at \( t = \infty \)
\[ V_c(\infty) = \frac{3}{2 + 1} = 2 \text{ V} \]

\[ V_c(t) = [V_c(0^+) - V_c(\infty)]e^{-\frac{t}{RC}} + V_c(\infty) = [1 - 2]e^{-\frac{t}{3 \times 10^8}} + 2 \]

at \( t = 5 \mu\text{sec} \)

\[ V_c = 1.52 \text{ Volts} \]

**Q.46** A series R-L-C circuit is excited with an A.C voltage source. The quality factor (Q) of the circuit is given as \( Q = 30 \). The amplitude of current in ampere at upper half-power frequency will be ________.

![Circuit Diagram](image)

**Ans.** (6.36)

\[ \omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{1 \times 10^{-3} \times 4 \times 10^{-6}}} = 5000 \text{ rad/sec} \]

\[ Q = \frac{\omega_0 L}{R} \]

\[ 30 = \frac{5000(10 \times 10^{-3})}{R} \]

\[ R = \frac{5}{3} \Omega \]

at \( \omega_0 \rightarrow \) \[ I = \frac{V}{R} = \frac{15}{5/3} = 9 \text{ V} \]

at \( \omega_2 \rightarrow \) \[ I = \frac{9}{\sqrt{2}} = 6.36 \text{ A} \]

**Q.47** A closed-loop system is shown in the figure. The system parameter \( \alpha \) is not known. The condition for asymptotic stability of the closed loop system is

\[ \frac{s + \alpha}{s^3 + 2\alpha s^2 + \alpha s + 1} \]

(a) \( \alpha < -0.5 \)  \hspace{1cm}  (b) \( -0.5 < \alpha < 0.5 \)

(c) \( 0 < \alpha < 0.5 \)  \hspace{1cm}  (d) \( \alpha > 0.5 \)
Ans.  \((d)\)

Characteristics equation

\[ q(s) = s^3 + 2\alpha s^2 + s(\alpha + 1) + (\alpha + 1) = 0 \]

By RH criteria,

\[
\begin{align*}
& s^3 \quad 1 \\
& s^2 \quad 2\alpha \\
& s^1 \quad \frac{2\alpha(\alpha + 1) - (\alpha + 1)}{2\alpha} \\
& s^0 \quad \alpha + 1
\end{align*}
\]

Necessary condition: \(\alpha > 0\)

Sufficient condition: \(\frac{2\alpha(\alpha + 1) - (\alpha + 1)}{2\alpha} > 0\)

\[ \therefore \alpha > 0.5 \]

---

Q.48
Consider two discrete-time signals:

\(x_1(n) = \{1, 1\} \) and \(x_2(n) = \{1, 2\} \), for \(n = 0, 1\).

The Z-transform of the convoluted sequence \(x_1(n) \ast x_2(n)\) is

\[
\begin{align*}
(a) & \quad 1 + 2z^{-1} + 3z^{-2} \\
(b) & \quad z^2 + 3z + 2 \\
(c) & \quad 1 + 3z^{-1} + 2z^{-2} \\
(d) & \quad z^2 + 3z^3 + 2z^4
\end{align*}
\]

Ans. \((c)\)

\[ x_1[n] = \{1, 1,\} \times x_2[n] = \{1, 2\} \]

So,

\[ x[n] = x_1[n] \ast x_2[n] = \{1, 3, 2\} \]

\[ x(z) = 1 + 3z^{-1} + 2z^{-2} = -2 \]

---

Q.49
Quantum efficiency of a photodiode (ratio between the number of liberated electrons and the number of incident photons) is 0.75 at 830 nm. Given Plank’s constant \(h = 6.624 \times 10^{-34} \) J, the charge of an electron \(e = 1.6 \times 10^{-19} \) C and the velocity of light in the photodiode \(C_m = 2 \times 10^8 \) m/s. For an incident optical power of 100 \(\mu\)W at 830 nm, the photocurrent in \(\mu\)A is ________.

Ans. \((75.18)\)

Responsivity, \((R) = \frac{I}{P} = \frac{\eta e \lambda}{hC} \) A/W

\[ \therefore I = \frac{\eta e \lambda}{hC} P \]

\[ = \frac{0.75 \times 1.6 \times 10^{-19} \times 830 \times 10^{-9} \times 100 \times 10^{-6}}{6.624 \times 10^{-34} \times 2 \times 10^8} = 75.18 \text{ \(\mu\)A} \]

---

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Q.50 In sinusoidal amplitude modulation scheme (with carrier) the modulated signal is given by \( A_m(t) = 100 \cos(\omega_c t) + 50 \cos(\omega_m t) \cos(\omega_c t) \), where \( \omega_c \) is the carrier frequency and \( \omega_m \) is the modulation frequency. The power carried by the sidebands in % of total power is \( \text{_______} \) %.

Ans. (11.11)

Given an signal \( A_m(t) = 100 \cos(\omega_c t) + \frac{50}{2} \cos(\omega_m t) \)

\[ \text{% of side band power in total power} = \frac{P_{SB}}{P_1} = \frac{\frac{\mu^2}{2}}{2 + \mu^2} \]

\[ \frac{P_{SB}}{P_1} = 0.111111 = 11.11\% \]

Q.51 The power delivered to a single phase inductive load is measured with a dynamometer type wattmeter using a potential transformer (PT) of turns ratio 200:1 and the current transformer (CT) of turns ratio 1:5. Assume both the transformers to be ideal. The power factor of the load is 0.8. If the wattmeter reading is 200 W, then the apparent power of the load in kVA is _______.

Ans. (250)

As both the transformer are ideal the apparent power in KVA will be

\[ \frac{V}{200} \times \frac{I}{5} \times \cos \phi = 200 \text{ W} \]

\[ \frac{VI}{0.8} = 250 \text{ KVA} \]

Q.52 When the voltage across a battery is measured using a dc potentiometer, the reading shows 1.08 V. But when the same voltage is measured using a Permanent Magnet Moving Coil (PMMC) voltmeter, the voltmeter reading shows 0.99 V. If the resistance of the voltmeter is 1100 \( \Omega \), the internal resistance of the battery, in \( \Omega \) is _______.

Ans. (100)
Open circuit voltage, $V_s = 1.08 \text{ V}$
$R_m = 1100 \text{ } \Omega$

$V_o = V_s \frac{R_m}{R_m + R_s}$

$0.99 = (1.08) \frac{(1100)}{(1100) + R_s}$

$1089 + 0.99 R_s = 1188$

$R_s = \frac{1188 - 1089}{0.99} = 100 \text{ } \Omega$

---

**Q.53** The block diagram of a closed-loop control system is shown in the figure. The values of $k$ and $k_p$ are such that the system has a damping ratio of 0.8 and an undamped natural frequency $\omega_n$ of 4 rad/s respectively. The value of $k_p$ will be _______.

![Block Diagram](image)

**Ans.** (0.337)

$q(s) = 1 + \frac{k(1 + k_p s)}{s(s + 1)} = 0$

$q(s) = s^2 + s(1 + k k_p) + k = 0$

$\omega_n = \sqrt{k} = 4$

$k = 16$

$2\zeta\omega_n = 1 + kk_p = 2 (0.8)(4)$

$\therefore \quad k_p = 0.337$

---

**Q.54** The overall closed loop transfer function $\frac{C(s)}{R(s)}$, represented in the figure, will be

![Block Diagram](image)
\[ \frac{(G_1(s) + G_2(s))G_3(s)}{1 + (G_1(s) + G_2(s))(H_1(s) + G_3(s))} \quad (a) \]
\[ \frac{(G_1(s) + G_3(s))}{1 + G_1(s)H_1(s) + G_2(s)G_3(s)} \quad (b) \]
\[ \frac{(G_1(s) - G_2(s))H_1(s)}{1 + (G_1(s) + G_3(s))(H_1(s) + G_1(s))} \quad (c) \]
\[ \frac{G_1(s)G_2(s)H_1(s)}{1 + G_1(s)H_1(s) + G_1(s)G_3(s)} \quad (d) \]

Ans. \( (a) \)

Blocks \( G \) and \( G_2 \) are in parallel
\[ \therefore \quad G_1 + G_2 \]
To the above result \( H_1 \) is feedback
\[ \therefore \quad \frac{(G_1 + G_2)}{1 + (G_1 + G_2)H_1} \]
To the above result \( G_3 \) is in series
\[ \therefore \quad \frac{(G_1 + G_2)G_3}{1 + (G_1 + G_2)H_1} \]
To the above result feedback is ‘1’
\[ \therefore \quad \frac{C(s)}{R(s)} = \frac{(G_1 + G_2)G_3}{1 + (G_1 + G_2)[H_1 + G_3]} = \frac{(G_1(s) + G_2(s))G_3(s)}{1 + (G_1(s) + G_2(s))(H_1(s) + G_3(s))} \]

Q.55 The Laplace transform of a causal signal \( y(t) \) is \( Y(s) = \frac{s + 2}{s + 6} \). The value of the signal \( y(t) \) at \( t = 0.1s \) is _______ units.

Ans. \(-2.195\)

\[ y(s) = \frac{s + 2}{s + 6} \] is proper converting to strictly proper
\[ y(s) = 1 - \frac{4}{s + 6} \]
\[ y(t) = \delta(t) - 4e^{-6t} u(t) \]
\[ y(0.1) = 0 - 4e^{-0.6} u(t) = -2.195 \]
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SECTION B : GENERAL APTITUDE

Q.1 Two dice are thrown simultaneously. The probability that the product of the numbers appearing on the top faces of the dice is a perfect square is

(a) $\frac{1}{9}$  
(b) $\frac{2}{9}$  
(c) $\frac{1}{3}$  
(d) $\frac{4}{9}$

Ans. (b)

Sample space = $6 \times 6 = 36$ events = Total chances  
Product of numbers on 2 dice have to perfect square = Favourable chances  
$(1, 1)$ $(2, 2)$ $(3, 3)$ $(4, 4)$ $(5, 5)$ $(6, 6)$ $(1, 4)$ $(4, 1) \Rightarrow 8$ events

$$\text{Probability} = \frac{\text{Favourable chances}}{\text{Total chances}} = \frac{8}{36} = \frac{2}{9}$$

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Q.2 Four cards lie on a table. Each card has a number printed on one side and a colour on the other. The faces visible on the cards are 2, 3, red and blue.

**Proposition:** If a card has an even value on one side, then its opposite face is red.

The cards which MUST be turned over to verify the above proposition are  
(a) 2, red  
(b) 2, 3, red  
(c) 2, blue  
(d) 2, red, blue

Ans. (c)

In order to verify proposition we have to turn to card 2 and blue from given four cards as proposition says it has even an one side opposite is red. Vice-verse might or might not be true so, ans. (c) as all other options are eliminated.

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Q.3 The event would have been successful if you ________ able to come.  
(a) are  
(b) had been  
(c) have been  
(d) would have been

Ans. (b)

Use of conditional sentence based on past perfect structure. Conditional clause uses $(\text{had} + V_{p})$, main clause is based on would / should / could + have + $V_{s}$.

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Q.4 There was no doubt that their work was thorough.  
Which of the words below is closest in meaning to the underlined word above?  
(a) pretty  
(b) complete  
(c) sloppy  
(d) haphazard

Ans. (b)

Use of context clue and understanding of sentence meaning.
Ans. (b)

Thorough refers to somethings that is exhaustively complete, accurate, careful or absolute.

Q.5  What is the value of $x$ when $81 \left( \frac{16}{25} \right)^{x+2} + \left( \frac{3}{5} \right)^{2x+4} = 144$?

(a) 1  
(b) -1  
(c) -2  
(d) Cannot be determined

Ans. (b)

\[
81 \left( \frac{16}{25} \right)^{x+2} + \left( \frac{3}{5} \right)^{2x+4} = 144
\]

Put \( x = -1 \)

\[
\left( \frac{16}{25} \right)^{x+2} = \left( \frac{3}{5} \right)^{2x+4}
\]

\[
\left( \frac{16}{25} \right)^{-1} = \left( \frac{3}{5} \right)^{-2}
\]

\[
\frac{25}{16} = \frac{9}{25}
\]

\[
5^2 = 3^2
\]

On putting \( x = -1 \)

\[
\text{LHS} = \text{RHS}
\]

Hence option (b) is correct.

Q.6  Bhaichung was observing the pattern of people entering and leaving a car service centre. There was a single window where customers were being served. He saw that people inevitably came out of the centre in the order that they went in. However, the time they spent inside seemed to vary a lot: Some people came out in a matter of minutes while for others it took much longer.

From this, what can one conclude?

(a) The centre operates on a first-come-first-served basis, but with variable service times, depending on specific customer needs.

(b) Customers were served in an arbitrary order, since they took varying amounts of time for service completion in the centre.

(c) Since some people came out within a few minutes of entering the centre, the system is likely to operate on a last-come-first-served basis.

(d) Entering the centre early ensured that one would have shorter service times and most people attempted to do this.

Ans. (a)

People coming out in the same order in which they enter indicates that the centre operates on a first-come-first-serve basis.
Q.7  The points in the graph below represent the halts of a lift for durations of 1 minute, over a period of 1 hour.

Which of the following statements are correct?
(i) The elevator never moves directly from any non-ground floor to another non-ground floor over the one hour period.
(ii) The elevator stays on the fourth floor for the longest duration over the one hour period.
(a) Only (i)  
(b) Only (ii)  
(c) Both (i) and (ii)  
(d) Neither (i) nor (ii)

Ans.  (d)
(i) is incorrect as it has move directly.
(ii) is incorrect as it stayed for maximum duration on ground floor.

Q.8  Budhan covers a distance of 19 km in 2 hours by cycling one fourth of the time and walking the rest. The next day he cycles (at the same speed as before) for half the time and walks the rest (at the same speed as before) and covers 26 km in 2 hours. The speed in km/h at which Budhan walks is
(a) 1  
(b) 4  
(c) 5  
(d) 6

Ans.  (d)
Let cycling speed = \( C \)
and walking speed = \( W \)

\[
C \left( \frac{1}{2} \right) + W \left( \frac{3}{2} \right) = 19 \quad \text{(i)}
\]

\[
C + W = 26 \quad \text{(ii)}
\]

On Solving eq. (i) and (ii) We get,
\[
W = 6 \text{ km/hr}
\]
Q.9  A map shows the elevations of Darjeeling, Gangtok, Kalimpong, Pelling and Siliguri. Kalimpong is at a lower elevation than Gangtok. Pelling is at a higher elevation than Gangtok. Pelling is at a higher elevation than Siliguri. Darjeeling is at a higher elevation than Gangtok.

Which of the following statements can be inferred from the paragraph above?

(i) Pelling is at a higher elevation than Kalimpong.
(ii) Kalimpong is at a lower elevation than Darjeeling.
(iii) Kalimpong is at a higher elevation than Siliguri.
(iv) Siliguri is at a lower elevation than Gangtok.

(a) Only (ii)  (b) Only (ii) and (iii)
(c) Only (ii) and (iv)  (d) Only (iii) and (iv)

Ans.  (c)

Following information is given

\[ K < G, \ P < G, \ S < P \text{ and } G < D \]

From these it can be inferred

\[ S < P < G < D \text{ and also } (K < G) \]

So, \( K < D \) as well but no comparison between \( K & S \) or \( K & P \) is given

So (ii) and (iv) follows.

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Q.10  P, Q, R, S, T and U are seated around a circular table. R is seated two places to the right of Q, P is seated three places to the left of R. S is seated opposite U. If P and U now switch seats, which of the following must necessarily be true?

(a) P is immediately to the right of R
(b) T is immediately to the left of P
(c) T is immediately to the left of P or P is immediately to the right of Q
(d) U is immediately to the right of R or P is immediately to the left of T

Ans.  (c)

Following two possibilities can be drawn

![Circular table diagram]

Given in question P & U interchange then new diagram can be drawn.

![Updated circular table diagram]

Now verify (c) only follows.