POSTAL BOOK PACKAGE 2027

ELECTRONICS ENGINEERING

OBJECTIVE PRACTICE SETS VOLUME - II

CONTENTS

SIGNALS AND SYSTEMS

OBJECTIVE PRACTICE SETS

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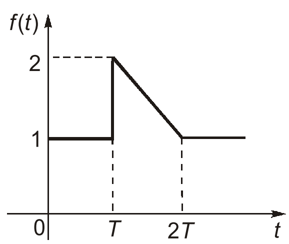
1 CHAPTER Basics of Signals and Systems

MCQ and NAT Questions

Q.1 If a continuous time signal $x(t)$ can take on any value in the continuous interval $(-\infty, \infty)$, it is called
(a) Deterministic signal
(b) Random signal
(c) Analog signal
(d) Digital signal

Q.2 The function $f(t)$ shown in the figure can be represented as



(a) $u(t)+u(t-T)-\frac{(t-T)}{T}u(t-T)+\frac{(t-2T)}{T}u(t-2T)$

(b) $u(t)-u(t-T)+\frac{(t-T)}{T}u(t-T)-\frac{(t-2T)}{T}u(t-2T)$

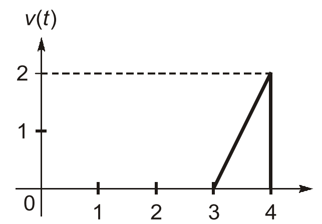
(c) $u(t)-u(t-T)-\frac{(t-T)}{T}u(t-T)-\frac{2(t-2T)}{T}u(t-2T)$

(d) $u(t)+u(t-T)+\frac{(t-T)}{T}u(t-T)-\frac{2(t-2T)}{T}u(t-2T)$

Q.3 Which of the following statements is/are true?
1. If $x(t)$ is a continuous time periodic signal with period T, then $y(t) = x(2t)$ will also be periodic with period $2T$.
2. Sum of two continuous time periodic signals may or may not be periodic.
3. Sum of two discrete time periodic signals may or may not be periodic.

(a) 2 and 3 only
(b) 1 and 3 only
(c) 1 and 2 only
(d) 2 only

Q.4 In the graph shown below, which one of the following express $v(t)$?



(a) $(2t+6)[u(t-3)+2u(t-4)]$
(b) $(-2t-6)[u(t-3)+u(t-4)]$
(c) $(-2t+6)[u(t-3)+u(t-4)]$
(d) $(2t-6)[u(t-3)-u(t-4)]$

Q.5 Match **List-I** with **List-II** and select the correct answer using the code given below the Lists:

List-I	List-II
A. Even signal	1. $x(n)=\left(\frac{1}{4}\right)^n u(n)$
B. Causal signal	2. $x(-n)=x(n)$
C. Periodic signal	3. $x(t)=u(t)$
D. Energy signal	4. $x(n)=x(n+N)$

Codes:

	A	B	C	D
(a)	2	3	4	1
(b)	1	3	4	2
(c)	2	4	3	1
(d)	1	4	3	2

Q.6 Which one of the following relation is not correct?
(a) $f(t)\delta(t) = f(0)\delta(t)$

(b) $\int_{-\infty}^{\infty} f(t)\delta(t-\tau)dt = f(\tau)$

(c) $f(t) * \delta(t-\tau) = f(t-\tau)$

(d) $\int_{-\infty}^{\infty} \delta(at)dt = 1$

Q.7 Which of the following signals are periodic?

1. $\cos\left(\frac{\pi}{3}n\right)+\sin\left(\frac{\pi}{3}n\right)$

2. $\cos\left(\frac{1}{2}n\right)+\cos\left(\frac{1}{3}n\right)$
3. Even $\{\cos(4\pi t)u(t)\}$
4. Even $\{\sin(4\pi t)u(t)\}$

(a) 1 and 4 only (b) 1, 2 and 3 only
(c) 1 and 3 only (d) 1, 3 and 4 only

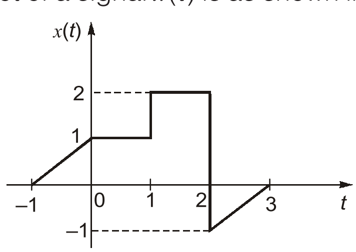
Q.8 The power in the signal

$s(t) = 8\cos\left(20\pi t - \frac{\pi}{2}\right) + 4\sin(15\pi t)$ is

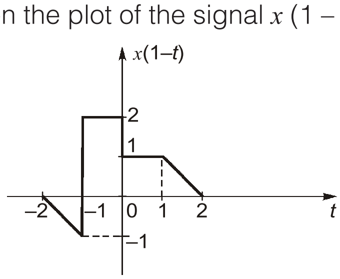
(a) 40 (b) 41
(c) 42 (d) 82

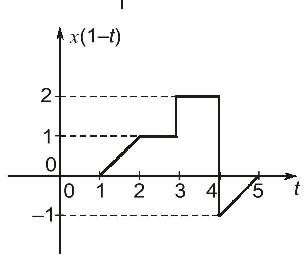
Q.9 **Statement (I):** The total energy of an energy signal falls between the limits 0 and ∞.
Statement (II): The average power of an energy signal is zero.
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is **NOT** the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

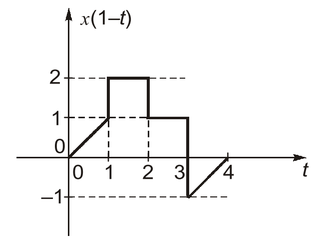
Q.10 If a plot of a signal $x(t)$ is as shown in the Figure.

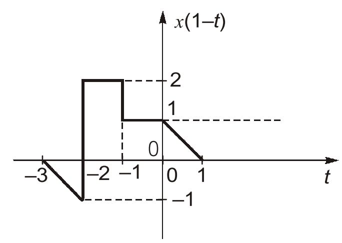


Then the plot of the signal $x(1-t)$ will be:

(a)


(b)


(c)


(d)


Q.11 The signal $x(t) = A\cos(\omega_0 t + \phi)$ is
(a) an energy signal
(b) a power signal
(c) an energy as well as a power signal
(d) neither an energy nor a power signal

Q.12 Double integration of a unit step function would lead to
(a) an impulse (b) a parabola
(c) a ramp (d) a doublet

Q.13 If $\int_{-\infty}^{\infty} e^{3\left(\frac{t}{2}-1\right)}.\sin\frac{\pi t}{8\beta}.\delta(2-t) = \frac{-1}{\sqrt{2}}$.

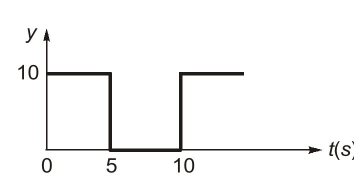
Then the maximum value of β is

(a) -1 (b) $\frac{1}{5}$

(c) $\frac{1}{13}$ (d) $\frac{1}{21}$

Q.14 For a periodic waveform to be halfwave symmetric, it must be represented by a function satisfying
(a) $f(t) = f(t + T/2)$ (b) $f(t) = -f(t + T/2)$
(c) $f(t) = f - (-t)$ (d) $f(t) = f(-t)$

Q.15 In the given figure, the effective value of the waveform is



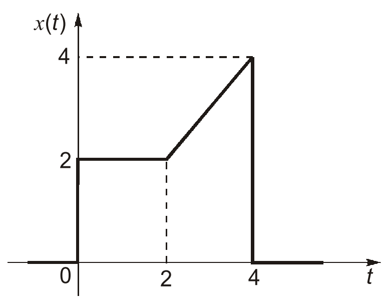
(a) 5.0 (b) 2.5
(c) $\sqrt{2.5}$ (d) $\sqrt{50}$

Q.24 For a power signal $f(n) = Au(n)$. The average power is given by 8 W, then the magnitude of A will be ______.

Q.25 The period of the signal

$$x[n] = \cos\frac{\pi}{4}n + \sin\left(\frac{\pi}{3}n + \frac{1}{2}\right) \text{ is } \_\_\_\_\_\_\_\_\_\_.$$

Q.26 Consider the following signal:

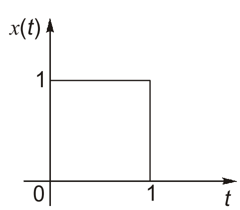


The signal $x(t)$ is expressed as,

$x(t) = 2u(t) + (t - 2)\,u(t - 2) - (t - t_0)\,u(t - 4)$

If $u(t)$ is a unit step function, then the value of t_0 will be __________.

Q.27 An LTI system has step response $(1 - e^{-t})\,u(t)$. The response of the system for following input $x(t)$ at $t = 2$ is________.



Multiple Select Questions (MSQs)

Q.28 For which of the following function(s) the time scaling operation will effect its original nature of the function:

(a) $\delta(t)$

(b) $u(t)$

(c) $r(t)$

(d) A rectangular pulse within finite duration.

Q.29 A discrete system with input $x[n]$ and output $y[n]$ are related by

$$y[n] = \sum_{n=-\infty}^{\infty} x[n]e^{-j\omega n}$$

The system is

(a) unstable (b) stable

(c) time variant (d) time invariant

Q.30 Consider a continuous time signal $x(t) = 2\cos\left(\frac{\pi t}{4}\right) * \delta\left(\frac{t}{2} - 1\right)$. Then for which value of 't', signal $x(t)$ is zero.

(a) $t = 0$ (b) $t = 2$

(c) $t = 1$ (d) $t = 4$

Q.31 Consider a discrete-time periodic signal $x[n] = \begin{cases} 1, & 0 \le n \le 7 \\ 0, & 8 \le n \le 9 \end{cases}$ with period of $N = 10$. A function $y[n]$ is defined as $y[n] = \xi[n] - \xi[n-1]$, then the correct options regarding $y[n]$ are

(a) period $N = 10$

(b) period $N = 8$

(c) $y[n] = \{1,0,0,0,0,0,0,0,-1,0\}$ for one time period

(d) $y[n] = \{1,0,0,0,0,0,-1,0\}$ for one time period

■■■■

Answers Basics of Signals and Systems

1.	(c)	2.	(a)	3.	(d)	4.	(d)	5.	(a)	6.	(d)	7.	(c)
8.	(a)	9.	(b)	10.	(a)	11.	(b)	12.	(b)	13.	(b)	14.	(b)
15.	(d)	16.	(a)	17.	(a)	18.	(c)	19.	(a)	20.	(–2)	21.	(8)
22.	(4)	23.	(2)	24.	(4)	25.	(24)	26.	(0)	27.	(0.232)	28.	(a, c, d)
29.	(b, c)	30.	(a, d)	31.	(a, c)								

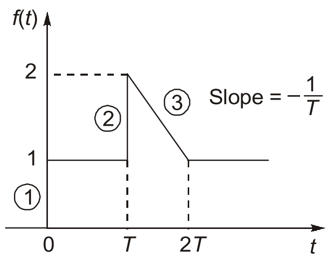
Explanations | Basics of Signals and Systems

1. (c)

If a continuous time signal can take on any value in the continuous interval $(-\infty, \infty)$ then this signal is known as analog signal.

2. (a)

For the given $f(t)$



Step (1) = $u(t)$ = $u(t)$ both steps are of unity magnitude

Step (2) = $u(t-T)$ = $u(t-T)$

Hence ramp (3) = $\dfrac{-1}{T}\{r(t-T)-r(t-2T)\}$

$$= \frac{-1}{T}\{(t-T)u(t-T)-(t-2T)u(t-2T)\}$$

Since, $\quad r(t) = tu(t)$

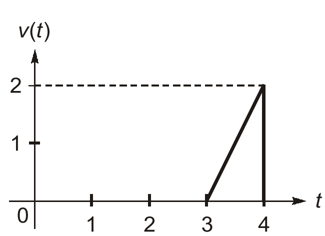
Hence,

$$f(t) = u(t)+u(t-T)-\frac{(t-T)}{T}u(t-T)+\frac{(t-2T)}{T}u(t-2T)$$

3. (d)

- If $x(t)$ is periodic with time period T, then $y(t) = x(2t)$ will be periodic with time period $T/2$.
- Sum of two discrete time periodic signals is always periodic.

4. (d)



v(t) consist 1 Ramp and 1 negative step,

Hence Ramp (1) having slope = 2

So $\quad$ Ramp (1) = $2\{r(t-3)-r(t-4)\}$

$\quad$ step (2) = $-2u(t-4)$

So, $\quad v(t) = 2r(t-3) - 2r(t-4) - 2u(t-4)$

$= 2(t-3)\,u(t-3) - 2(t-4)u(t-4) - 2u(t-4)$

$= 2(t-3)\,u(t-3) - 2(t-3)u(t-4)$

$= (2t-6)\,\{u(t-3) - u(t-4)\}$

5. (a)

- Even signal $x(n) = x(-n)$
- Causal system is one in which output at any time depends only on present and/or past values of input.
- Periodic signal is one which satisfies $x(n) = x(n+N)$; $N \to$ Fundamental period.
- Energy signal is absolutely summable i.e. $x(n)$

$$= \left|\left(\frac{1}{4}\right)^n u(n)\right| < \infty$$

6. (d)

$$\int_{-\infty}^{\infty} \delta(at)\,dt = \frac{1}{a}$$

Since, $\quad \delta(at) = \dfrac{1}{|a|}\delta(t)$

7. (c)

1. $\cos\left(\dfrac{\pi}{3}n\right)+\sin\left(\dfrac{\pi}{3}n\right) \Rightarrow$ periodic

   Period $= \dfrac{2\pi\times 3}{\pi} = 6$

2. $\cos\left(\dfrac{1}{2}n\right)+\cos\left(\dfrac{1}{3}n\right) \Rightarrow$ non-periodic

3. Even $\{\cos(4\pi t)u(t)\}$

   $= \dfrac{\cos(4\pi t)\,u(t)+\cos(-4\pi t)u(-t)}{2}$

   $= \dfrac{\cos 4\pi t}{2} \Rightarrow$ Periodic

4. Even $\{\sin(4\pi t)u(t)\}$

   $= \dfrac{\sin(4\pi t)u(t)+\sin(-4\pi t)u(-t)}{2} \Rightarrow$ non-periodic

8. (a)

Given: $s(t) = 8\cos\left(20\pi t - \dfrac{\pi}{2}\right) + 4\sin(15\pi t)$

$s(t) = 8\sin 20\pi t + 4\sin 15\pi t$

When both the sinusoidal signal having different frequency. Then overall power $(P) = P_1 + P_2$

$$P = \frac{8^2}{2}+\frac{4^2}{2} = 40$$

9. (b)

Energy of any signal is given by

$$E = \int_{-\infty}^{\infty} \left|x^2(t)\right| dt$$

and power of a signal is given by

$$P = \lim_{T\to\infty} \int_{-T/2}^{T/2} \frac{1}{T}\left|x^2(t)\,dt\right|$$

For energy signal, Energy is finite

$$\therefore \qquad P = \lim_{T\to\infty} \frac{E}{T}$$

$$P = \frac{E}{\infty} = 0$$

→ All the finite duration and bounded signals are energy signals.

Hence statements (I) and (II) are correct but statement (II) is not correct explanation of statement (I).

10. (a)

For given question $x(t)$ is defined for $-1 < t < 3$

Left shifted of $x(t)$ by 1: $-2 < t + 1 < 2$

Time reversal, $-2 < -t + 1 < 2$

Sorange of $x(1 - t)$ will be -2 to 2 by checking options.

11. (b)

$$x(t) = A\cos(\omega_0 t + q)$$

this is periodic signal and according to definition, all periodic signals are power signal.

Here, $\qquad \text{Power} = \left(\frac{A}{\sqrt{2}}\right)^2 = \frac{A^2}{2}$

12. (b)

$$\int_t u(\tau)d\tau = r(t) \quad \text{Ramp}$$

$$\int_t r(\tau)\,d\tau = p(t) \quad \text{Parabola}$$

13. (b)

$$\delta(2-t) = \delta(t-2)$$

$$f(t) = e^{3\left(\frac{2}{2}-1\right)}.\sin\frac{\pi(2)}{8\beta}$$

$$= e^{3(1-1)}\sin\frac{\pi}{4\beta} = \frac{-1}{\sqrt{2}}$$

$$\sin\frac{\pi}{4\beta} = \frac{-1}{\sqrt{2}}$$

$$\beta = \frac{1}{5}, \frac{1}{13} \qquad \text{and } \beta = -1$$

$$\beta_{max} = \frac{1}{5}$$

14. (b)

For half wave symmetry

$$f(t) = -f\left(t+\frac{T}{2}\right) = -f\left(t-\frac{T}{2}\right)$$

15. (d)

Effective value = rms value

$$\text{Here} = \sqrt{\frac{1}{10}\int_0^5 (10)^2\,dt} = \sqrt{50}$$

16. (a)

Given, $\qquad x[n] = [-4-5j \;\; \underset{\uparrow}{1+2j} \;\; 4]$

$$x^*[n] = [-4+5j \;\; \underset{\uparrow}{1-2j} \;\; 4]$$

$$x^*[-n] = [4 \;\; 1-2j \;\; -4+5j]$$

Now, $\qquad x_{oc} = \dfrac{x(n) - x^*(-n)}{2}$

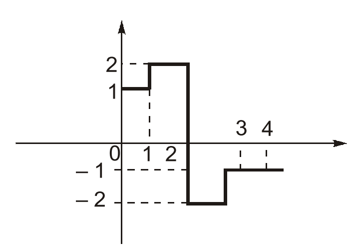
$$x_{oc} = \left[\frac{-4-5j-4}{2} \;\; \frac{(1+2j)-(1-2j)}{2}, \;\; \frac{4-(-4+5j)}{2}\right]$$

$$x_{oc} = [-4-2.5j \;\; \underset{\uparrow}{2j} \;\; 4-2.5j]$$

17. (a)

$$y(t) = \int_{-\infty}^{\infty} x(t).\delta'(t-2.5)dt$$

$$= -\left.\frac{dx(t)}{dt}\right|_{t=2.5}$$



$$y(t) = -(-2) = 2$$

COMMUNICATION SYSTEMS

OBJECTIVE PRACTICE SETS

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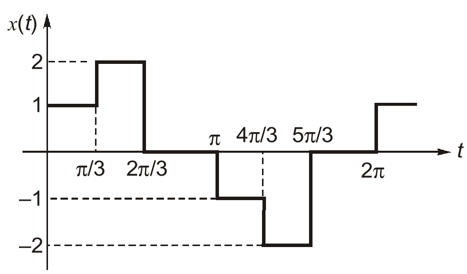
1
CHAPTER

Fourier Analysis of Signal Energy and Power Signals

MCQ and NAT Questions

Q.1 If $G(f)$ represents the Fourier transform of a signal $g(t)$ which is real and odd symmetric in time then
(a) $G(f)$ is complex
(b) $G(f)$ is imaginary
(c) $G(f)$ is real
(d) $G(f)$ is real and non-negative

Q.2 Compute the amplitude of the fundamental component of the waveform given in figure.



(a) 0 (b) 1.00
(c) 1.603 (d) 1.712

Q.3 Let $x(t)$ be a signal with its Fourier transform $X(j\omega)$ suppose we are given the following facts.
1. $x(t)$ is real.
2. $x(t) = 0$ for $t \le 0$.
3. $\frac{1}{2\pi}\int_{-\infty}^{\infty} \text{Re}\{X(j\omega)\}e^{j\omega t}d\omega = 2|t|e^{-|t|}$.

then a closed form expression for $x(t)$ is
(a) $2e^{-t}\,u(t)$ (b) $e^{-|t|}$
(c) $te^{-2t}\,u(t)$ (d) $2te^{-t}\,u(t)$

Q.4 **Assertion (A):** If two signals are orthogonal they will also be orthonormal.
Reason (R): If two signals are orthonormal they also will be orthogonal.
(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not a correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

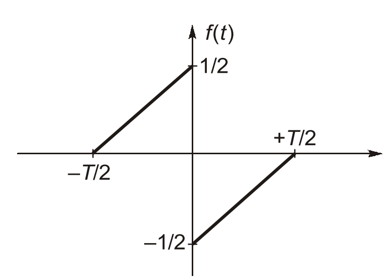
Q.5 Consider the following statements:
The normalized power, $S \equiv v^2(t)$ can be defined as the
1. instantaneous power divided by the maximum power in the circuit.
2. time average power that appears in a one ohm resistor.
3. Total power consumed by the circuit divided by the average power consumed in that circuit.
4. the mean square value of $v(t)$.

Which of the above statements is/are correct?
(a) 2 only (b) 1 and 2
(c) 2 and 3 (d) 2 and 4

Q.6 The auto correlation function of a rectangular pulse of duration T is
(a) A rectangular pulse of duration T
(b) A rectangular pulse of duration $2T$
(c) A triangular pulse of duration T
(d) A triangular pulse of duration $2T$

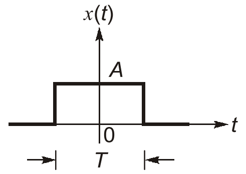
Q.7 The amplitude spectrum of Gaussian pulse is
(a) uniform (b) a sine function
(c) gaussian (d) an impulse function

Q.8 A function $f(t)$ is shown in figure.



The Fourier transform $F(\omega)$ of $f(t)$ is
(a) real and even function of ω
(b) real and odd function of ω
(c) imaginary and odd function of ω
(d) imaginary and even function of ω

Q.9 What is the total energy of the rectangular pulse shown in the figure below?

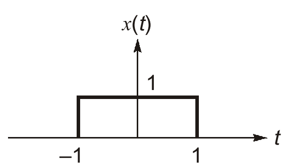


(a) AT (b) A^2T
(c) A^2T^2 (d) AT^2

Q.10 Which one of the following is not a property of auto correlation function ($R(\tau)$)?
(a) $R(0) \le R(\tau)$
(b) $R(\tau) = R(-\tau)$
(c) $R(0) = s$ = average power of the waveform
(d) Power spectral density is Fourier transform of auto correlation function for a periodic waveform

Q.11 $x(t)$ is a positive rectangular pulse from $t = -1$ to $t = +1$ with unit height as shown in figure.

The value of $\int_{-\infty}^{\infty} |X(\omega)|^2 d\omega$ (where $X(\omega)$ is Fourier transform of $x(t)$) is



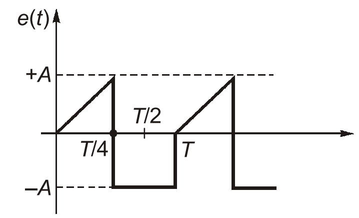
(a) 2 (b) 2π
(c) 4π (d) 4

Q.12 The Fourier transform of $x(t) = \dfrac{2a}{a^2 + t^2}$ is

(a) $2\pi e^{-a|\omega|}$ (b) $\pi e^{-2a|\omega|}$
(c) $\pi e^{-a\omega}$ (d) $\pi e^{-2a\omega}$

Q.13 Out of the four signal waveforms-sinusoid, rectangular, triangular and saw-tooth, all of them having the same periodicity, the minimum bandwidth corresponds to which one of the following?
(a) Sinusoidal (b) Rectangular
(c) Triangular (d) Saw-tooth

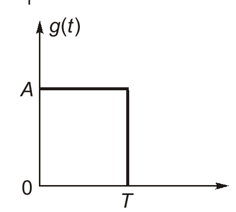
Q.14 The rms value of the periodic waveform $e(t)$ shown in figure is



(a) $\sqrt{\dfrac{3}{2}}A$ (b) $\sqrt{\dfrac{2}{3}}A$

(c) $\sqrt{\dfrac{1}{3}}A$ (d) $\sqrt{\dfrac{5}{6}}A$

Q.15 The energy density spectrum $|G(f)|^2$ of a rectangular pulse shown in the given figure is

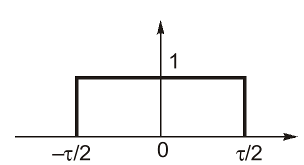


(a) $AT\left(\dfrac{\sin\pi fT}{\pi fT}\right)$ (b) $(AT)^2\left(\dfrac{\sin \pi fT}{\pi fT}\right)^2$

(c) $(AT)^2\left(\dfrac{\sin \pi fT}{\pi fT}\right)$ (d) $A^2\left(\dfrac{\sin\pi fT}{\pi fT}\right)$

Q.16 Fourier transform of the gate function as shown below is

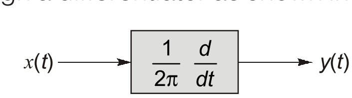
$f(t) = 1$ for $-\tau/2 \le t < \tau/2$
$= 0$ otherwise
(where τ is the width of the gate function).
The value of $F(\omega)$ is



(a) $\dfrac{\tau\sin(\omega\tau)}{\omega\tau}$ (b) $\dfrac{\tau\sin(2\omega\tau)}{2\omega\tau}$

(c) $\dfrac{\tau\sin(\omega\tau/2)}{(\omega\tau/2)}$ (d) $\dfrac{\tau}{2}\cdot\dfrac{\sin(\omega\tau/2)}{(\omega\tau/2)}$

Q.17 A deterministic signal $x(t) = \cos 2\pi t$ is passed through a differentiator as shown in figure.



what is its power spectral density $S_{yy}(f)$?

(a) $\frac{1}{4}[\delta(f-1)+\delta(f+1)]$ (b) $\frac{1}{2}[\delta(f-1)+\delta(f+1)]$

(c) $\frac{1}{4}[\delta(f)+\delta(f+1)]$ (d) None of the above

Q.18 A signal is represented by

$$x(t)=\begin{cases}1 & |t|<1\\ 0 & |t|>1\end{cases}$$

The Fourier transform of the convolved signal $y(t) = x(2t) * x(t/2)$.

(a) $\frac{4}{\omega^2}\sin\left(\frac{\omega}{2}\right)$ (b) $\frac{4}{\omega^2}\sin\left(\frac{\omega}{2}\right)\sin(2\omega)$

(c) $\frac{4}{\omega^2}\sin 2\omega$ (d) $\frac{4}{\omega^2}\sin^2\omega$

Q.19 A signal has Fourier series coefficients $C_n \Rightarrow C_{-1} = C_1 = 8,\ C_0 = 0,\ C_2 = C_{-2} = 2$ its power is

(a) 0 (b) 136

(c) 20 (d) 120

Q.20 Consider the signal defined by

$$x(t)\begin{cases}e^{j10t} & \text{for } |t|\le 1\\ 0 & \text{for } |t|>1\end{cases}$$

its Fourier transform is

(a) $\frac{2\sin(\omega-10)}{\omega-10}$ (b) $2e^{j10}\frac{\sin(\omega-10)}{\omega-10}$

(c) $\frac{2\sin\omega}{\omega-10}$ (d) $e^{j10\omega}\frac{2\sin\omega}{\omega}$

Q.21 Suppose we have given following information about a signal $x(t)$

1. $x(t)$ is real odd
2. $x(t)$ is periodic with $T = 2$
3. Fourier coefficients $C_n = 0,\ |n| > 1$
4. $\frac{1}{2}\int_0^2 |x(t)^2|\,dt = 1$

The signal that satisfy these conditions

(a) $\sqrt{2}\sin\pi t$ and unique

(b) $\sqrt{2}\sin\pi t$ but not unique

(c) $2\sin\pi t$ and unique

(d) $2\sin\pi t$ but not unique

Q.22 The Fourier series coefficients, of a periodic signal $x(t)$ expressed as $\sum_{k=-\infty}^{k=+\infty} a_k e^{j2\pi kt/T}$ are given by $a_{-2} = 2 - j1;\ a_{-1} = 0.5 + j0.2;\ a_0 = j2;\ a_1 = 0.5 - j0.2$ $a_2 = 2 + j1$; and $a_k = 0$; for $|k| > 2$

which of the following is true.

(a) $x(t)$ has finite energy because only finitely many coefficients are non-zero

(b) $x(t)$ has zero average value because it is periodic

(c) the imaginary part of $x(t)$ is constant

(d) the real part of $x(t)$ is even

Q.23 If the energy of a signal $X(t)$ is 9 unit, then the energy of signal $X(2t)$ will be ______ unit.

Q.24 If $x(t) = \frac{1}{t}$, then Hilbert transform of $x(t)$ will be $-K\delta(t)$. Then the value of K will be ______.

Q.25 What will be the value of following integral _____?

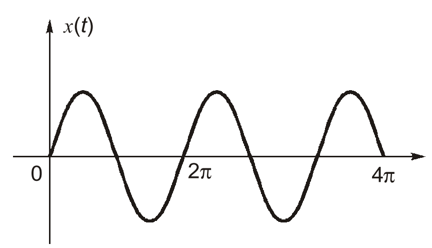
$$\int_{-\infty}^{\infty} S_a^2(2t)\,dt$$

where $S_a(t)$ = Sampling function $S_a(t) = \frac{\sin t}{t}$

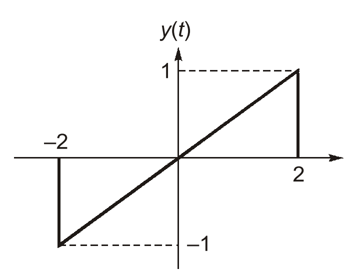
Multiple Select Questions (MSQs)

Q.26 Consider the real signals shown below:

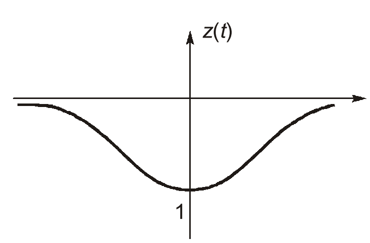
(i)



(ii)



(iii)



Which of the below statements are correct?

(a) The Fourier transform of $y(t)$ and $z(t)$ is real-valued.

(b) The Fourier transform of $x(t)$ is conjugate symmetric.

(c) $\int_{-\infty}^{\infty} X(j\omega)\cdot d\omega = 0$

(d) $\int_{-\infty}^{\infty} Z(j\omega)\cdot d\omega = 0$

Q.27 Consider a continuous-time ideal low pass filter having the frequency response

$$H(j\omega) = \begin{cases} 1, & |\omega| \le 80 \\ 0, & |\omega| > 80 \end{cases}$$

The input to this filter is a signal $x(t)$ with fundamental frequency $\omega_0 = 10$ rad/sec and Fourier series coefficients $X[k]$. If $y(t)$ represents the output of the filter and it is given that $Y[k] = X[k]$, then the values of k for which $X[k]$ is non-zero are:

(a) 3 (b) 7

(c) 10 (d) 12

Q.28 For a periodic signal $x(t)$, the Fourier series coefficients are given as below:

$$X[k] = \begin{cases} 5 & , \quad k = 0 \\ j\left(\frac{1}{2}\right)^{|k|} & , \quad \text{otherwise} \end{cases}$$

Which of the below statements are correct?

(a) $x(t)$ is real signal.

(b) $x(t)$ is an even signal.

(c) $\frac{dx(t)}{dt}$ is an odd signal.

(d) $x(t)$ is an energy signal.

■■■■

Answers — Fourier Analysis of Signal Energy and Power Signals

1. (b)	2. (a)	3. (d)	4. (d)	5. (d)	6. (d)	7. (c)
8. (c)	9. (b)	10. (a)	11. (c)	12. (a)	13. (a)	14. (d)
15. (b)	16. (c)	17. (b)	18. (b)	19. (b)	20. (a)	21. (b)
22. (a)	23. (4.5)	24. (3.14)	25. (1.57)	26. (b, c)	27. (a, b)	28. (b, c)

Explanations — Fourier Analysis of Signal Energy and Power Signals

1. (b)

Function, $g(t)$	Fourier Transform, $G(f)$
Real and odd	Imaginary and odd
Real and even	Real and even
Imaginary and odd	Real and odd
Imaginary and even	Imaginary and even

2. (a)

$$a_0 = \frac{1}{T}\cdot\int_0^T f(t)\,dt$$

$$a_0 = \frac{1}{2\pi}\int_0^{2\pi} f(t)\,dt = \frac{1}{2\pi}\times\left[\int_0^{2\pi/3} f(t)\,dt + \int_{\pi}^{5\pi/3} f(t)\,dt\right]$$

$$= \frac{2}{2\pi}\left[1\cdot\frac{\pi}{3} + 2\cdot\frac{\pi}{3} - 1\cdot\frac{\pi}{3} - 2\cdot\frac{\pi}{3}\right] = 0$$

3. (d)

$$x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(j\omega)e^{j\omega t}d\omega$$

$$\Rightarrow \quad \text{Real}\,(x(t)) = 2|t|e^{|t|}$$

Since, $x(t) = 0, \quad t \le 0$

$\Rightarrow \quad x(t) = 2te^{-t} \quad t > 0$

$\Rightarrow \quad x(t) = 2te^{-t}u(t)$

4. (d)

Orthogonal: Two vector are perpendicular i.e. their dot product is zero.

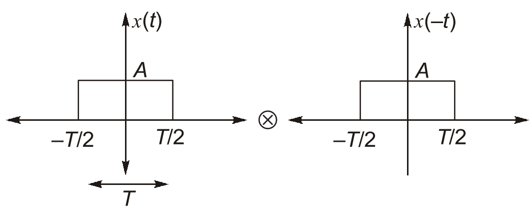
Orthonormal: Two vectors are perpendicular and are of unit length.

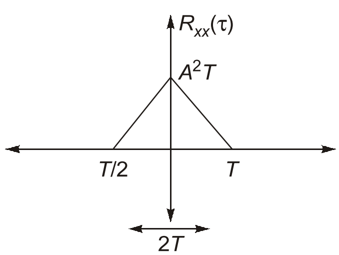
5. (d)

- Normalized power $\rightarrow$ Power in 1 Ω resistor
- $P_N = V^2(t)$, normalized power is average and mean of voltage required.
- $V_{rms} = \sqrt{P_N}$

6. (d)

ACF or Auto correlation function is nothing but convolution of $x(t)$ with time reversed form of $x(t)$, i.e. $x(t)$





ACF is a triangular pulse of duration 2T.

7. (c)

Amplitude spectrum of Gaussian pulse is Gaussian.

8. (c)

Signal is odd,

$$x(t) = -x(-t)$$

Signal is half symmetric

$$x(t) = x\left(t + \frac{T_0}{2}\right)$$

$\therefore$ contains odd harmonic.

Signal $f(t)$ is real and odd,

$\therefore$ $F(\omega)$ is imaginary and odd.

9. (b)

$$x(t) = A; \qquad -\frac{T}{2} \le t \le \frac{T}{2}$$

$$= 0; \qquad \text{for all other } t$$

$$E = \int_{-\infty}^{\infty} |x(t)|^2 \, dt$$

$$= \int_{-T/2}^{T/2} A^2 dt = \left[A^2 t\right]_{-T/2}^{T/2} = A^2 T$$

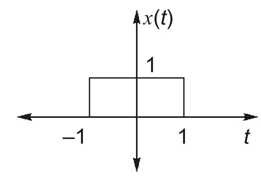
10. (a)

For autocorrelation function

$$R(0) \ge R(\tau)$$

$R(0) \rightarrow$ Maximum value of autocorrelation function.

11. (c)



From Parseval's theorem,

$$\int_{-\infty}^{\infty} |x(t)| dt = \frac{1}{2\pi} \int_{-\infty}^{\infty} |x(\omega)|^2 \, d\omega$$

$$\Rightarrow 2\pi \int_{-\infty}^{\infty} |x(t)|^2 \, dt = \int_{-\infty}^{\infty} |X(\omega)|^2 \, d\omega$$

$$= 2\pi \int_{-1}^{1} \cdot 1^2 dt = 2\pi \times 2 = 4\pi$$

$$\int_{-\infty}^{\infty} |X(\omega)|^2 \, d\omega = 4\pi$$

12. (a)

$$e^{-a|t|} \longleftrightarrow \frac{2a}{a^2 + \omega^2}$$

$$\frac{2a}{a^2 + t^2} \longleftrightarrow 2\pi e^{-a|-\omega|} = 2\pi e^{-a|\omega|}$$

As per duality property.

13. (a)

Fourier transform of a sinc wave is an impulse. So, it has infinitesimally narrow bandwidth and out of these, sinusoid have minimum BW.

14. (d)

$$V_{rms} = \sqrt{\frac{1}{T} \int_{-T/2}^{T/2} (f(t))^2 dt}$$

$$V_{rms}^2 = \frac{1}{T} \cdot \int_0^{T/4} \left(\frac{4A}{T} \cdot t\right)^2 dt + \int_{+T/4}^{T} (-A)^2 dt$$

$$V_{rms}^2 = \frac{1}{T} \cdot \left[\frac{3A^2 T}{4} + \frac{16A^2}{T^2} \cdot \frac{1}{3} \frac{T^3}{16 \times 4}\right]$$

$$V_{rms}^2 = A^2 \left[\frac{3}{4} + \frac{1}{12}\right] = A^2 \cdot \frac{10}{12}$$

$$V_{rms} = A\sqrt{\frac{5}{6}}$$

ELECTROMAGNETICS

OBJECTIVE PRACTICE SETS

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1 CHAPTER Vector Analysis

MCQ and NAT Questions

Q.1 For a given vector field $\vec{A} = 5x^2\left(\sin\frac{\pi x}{2}\right)\hat{a}_x$. The divergence $\vec{A}$ at $x = 2$ is ________.

Q.2 A field $\vec{A} = 3x^2yz\hat{a}_x + x^3z\hat{a}_y + (x^3y - 2z)\hat{a}_z$ can be termed as
(a) Irrotational (b) Divergence less
(c) Solenoidal (d) Rotational

Q.3 The angle θ_{AB} between the vectors

$A = 3a_x + 4a_y + a_z$ and $B = 2a_y - 5a_z$ is nearly
(a) 83.7° (b) 73.7°
(c) 63.7° (d) 53.7°

Q.4 The total length of the curve $\mu = \cos^2\theta$ (Cylindrical co-ordinates) from $\theta = 0$ to $\theta = \pi$ is
(a) 0.5π (b) 1.0
(c) 2.0 (d) π

Q.5 Laplacian of a scalar function V is
(a) Gradient of V
(b) Divergence of V
(c) Gradient of the gradient of V
(d) Divergence of the gradient of V

Q.6 For a solenoidal vector field

$$\vec{F} = (x + 3y)\hat{a}_x + (5y + 2z)\hat{a}_y + (x - Qz)\hat{a}_z,$$

the value of Q must be ________.

Q.7 Divergence of a vector div D in the cylindrical coordinate system is

(a) $\frac{1}{\rho}\frac{\partial}{\partial\rho}(D_\rho) + \frac{1}{\rho}\frac{\partial D_\phi}{\partial\phi} + \frac{\partial D_z}{\partial z}$

(b) $\frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho D_\rho) + \frac{1}{\rho}\frac{\partial(\phi D_\phi)}{\partial\phi} + \frac{1}{z}\frac{\partial(ZD_z)}{\partial z}$

(c) $\frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho D_\rho) + \frac{1}{\rho}\frac{\partial D_\phi}{\partial\phi} + \frac{\partial D_z}{\partial z}$

(d) $\frac{\partial D_\rho}{\partial\rho} + \frac{\partial D_\phi}{\partial\phi} + \frac{\partial D_z}{\partial z}$

Q.8 Given a vector $\vec{A}$ in spherical coordinates as $\vec{A} = 5\sin\theta\, a_\theta + 5\sin\phi\, a_\phi$. The divergence of $\vec{A}$ i.e. $\nabla\cdot\vec{A}$ at $\left(r = 1, \theta = \frac{\pi}{2}, \phi = \frac{\pi}{3}\right)$ is ______.

Q.9 The unit vector extending from origin toward the point $G(2, -2, -1)$ is

(a) $\frac{2}{3}\hat{a}_x + \frac{2}{3}\hat{a}_y + \frac{1}{3}\hat{a}_z$

(b) $-\frac{2}{3}\hat{a}_x + \frac{2}{3}\hat{a}_y + \frac{1}{3}\hat{a}_z$

(c) $\frac{2}{3}\hat{a}_x - \frac{2}{3}\hat{a}_y - \frac{1}{3}\hat{a}_z$

(d) $-\frac{2}{3}\hat{a}_x - \frac{2}{3}\hat{a}_y - \frac{1}{3}\hat{a}_z$

Q.10 For vector field $\vec{r} = x\hat{a}_x + y\hat{a}_y + z\hat{a}_z$,

1. $\nabla\cdot(\nabla\times\vec{r}) = 1$
2. $\nabla\times\vec{r} = 0$
3. $\nabla\cdot\vec{r} \neq 0$
4. $\nabla(\vec{r}\cdot\vec{r}) = \vec{r}$

Which of the above relations are true?
(a) 1 and 3 (b) 1 and 4
(c) 2, 3 and 4 (d) 2 and 3

Q.11 If $A = -\nabla f = (x + z)\hat{a}_x - 3z\,\hat{a}_y + (x - 3y - z)\hat{a}_z$.
Then the scalar field, f is

(a) $\frac{x^2}{2} + xz + \frac{z^2}{2}$

(b) $-\frac{x^2}{2} - 2xz + 6yz + \frac{z^2}{2}$

(c) $-xz + 3yz + \frac{z^2}{2}$

(d) $-\frac{x^2}{2} - xz + 3yz + \frac{z^2}{2}$

Q.12 If $V = \sinh x\cdot\cos ky\cdot e^{pz}$ is a solution of Laplace's equation, what will be the value of k?

(a) $\frac{1}{\sqrt{1+p^2}}$ (b) $\sqrt{1+p^2}$

(c) $\frac{1}{\sqrt{1-p^2}}$ (d) $\sqrt{1-p^2}$

Q.13 Laplace equation in cylindrical coordinates is given by

(a) $\nabla^2 V = \frac{1}{r}\frac{\partial}{\partial r}\left(\frac{r\partial V}{\partial r}\right) + \frac{1}{r^2}\left(\frac{\partial^2 V}{\partial \phi^2}\right) + \frac{\partial^2 V}{\partial z^2} = 0$

(b) $\nabla^2 V = \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2}$

(c) $\nabla^2 V = \frac{-\rho}{\varepsilon}$

(d) $\nabla^2 V = \frac{1}{r}\frac{\partial}{\partial r}\left(\frac{r^2\partial V}{\partial r}\right) + \left(-\frac{1}{r^2\sin\theta}\right)\frac{\partial}{\partial\theta}$

$\left(\sin\theta\frac{\partial V}{\partial\theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 V}{\partial\phi^2} = 0$

Q.14 The vector R_{AB} extends from $A(1, 2, 3)$ to B. If the length of R_{AB} is 10 units and its direction is given by

$$a = 0.6\hat{a}_x + 0.64\hat{a}_y + 0.48\hat{a}_z$$

the coordinates of B will be

(a) $7\hat{a}_x + 4.8\hat{a}_y + 4.8\hat{a}_z$

(b) $6\hat{a}_x + 6.4\hat{a}_y + 4.8\hat{a}_z$

(c) $7\hat{a}_x + 8.4\hat{a}_y + 7.8\hat{a}_z$

(d) $6\hat{a}_x + 8.4\hat{a}_y + 7.8\hat{a}_z$

Q.15 Consider the following statements:
Stokes' theorem is valid irrespective of
1. shape of closed curve C
2. type of vector A
3. type of coordinate system
4. whether the surface is closed or open

Which of the above statements are correct?

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

Q.16 Consider the vector field $\vec{A} = y\hat{a}_x + x\hat{a}_y$. The scalar line integral of this vector along the parabola $x = 2y^2$ from point (2, 1, –1) to (4, 2, –1) is

(a) 7 (b) 14
(c) 5 (d) 28

Multiple Select Questions (MSQs)

Q.17 $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ represents a position vector and $\| \vec{r} \|$ represents the normal of vector $\vec{r}$, then which of the below statements is/are true?

(a) Divergence of $\vec{r}$ is 3.

(b) Gradient of $\| \vec{r} \|^2$ is $3\vec{r}$

(c) Curl of $\vec{r}$ is 0

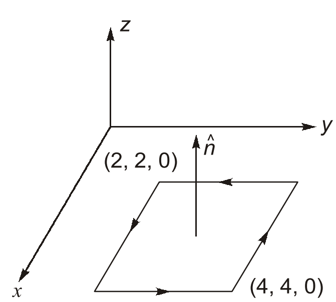
(d) Laplacian of $\| \vec{r} \|^2$ is 6.

Q.18 If $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ and $r = \sqrt{x^2+y^2+z^2}$, then which of the below relations are correct?

(a) $\nabla(\log r) = \frac{\vec{r}}{r}$ (b) $\nabla\left(\frac{1}{r}\right) = \frac{-\vec{r}}{r^3}$

(c) $\nabla\cdot\left(\frac{\vec{r}}{r^3}\right) = 1$ (d) $\nabla\cdot(3\vec{r}) = 9$

Q.19 Let $\vec{F} = xy^2\hat{a}_x + y^3\hat{a}_y + x^2y\hat{a}_z$ and the surface S consists of a square of length 2 lying in the xy plane as shown below:



Which of the following options is/are correct?

(a) $\iint_S \vec{F}\cdot\hat{n}\,ds = 80$

(b) $\iint_S (\vec{F}\times\hat{n})ds = 120\hat{a}_x - 112\hat{a}_y$

(c) $\nabla\times\vec{F} = x^2\hat{a}_x - 2xy\hat{a}_y - 2xy\,\hat{a}_z$

(d) $\iint_S (\nabla\times\vec{F})\cdot\hat{n}\,ds = -120$

Q.20 If $[\vec{a}, \vec{b}, \vec{c}]$ represents the scalar triple product of vectors $\vec{a}, \vec{b}$ and $\vec{c}$, then which of the below statements is/are true?

(a) $\left[\vec{a}, \vec{b}, \vec{c}\right] = \left[\vec{c}, \vec{b}, \vec{a}\right]$

(b) $\left[\vec{a}, \vec{b} + \vec{a}, \vec{c}\right] = 0$

(c) $\left[3\vec{b}, \vec{c}, \vec{a}\right] = 3\left[\vec{a}, \vec{b}, \vec{c}\right]$

(d) If $\left[\vec{a}, \vec{b}, \vec{c}\right] = 0$, the vectors $\vec{a}, \vec{b}$ and $\vec{c}$ are coplanar.

Q.21 The values of α for which the vectors $\vec{A} = \alpha\hat{a}_x + 2\hat{a}_y + 10\hat{a}_z$ and $\vec{B} = 4\alpha\hat{a}_x + 8\hat{a}_y - 2\alpha\hat{a}_z$ are perpendicular is/are

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

Q.22 Which of the below vector identities are true?

(a) $A \times (B \times C) = (A \times B) \times C$

(b) $A \times (B \times C) + C \times (A \times B) + B \times (C \times A) = 0$

(c) $(B \times C) \times (C \times A) = C(A \cdot B \times C)$

(d) $(A \times B) \cdot (C \times D) = (A \cdot C)(B \cdot D) - (A \cdot D)(B \cdot C)$

Q.23 For the scalar function, $\phi = x^2yz^3$, which of the below statements is/are correct?

(a) From the point (2, 1, –1) the directional derivative of ϕ is maximum in the direction represented by vector $-12\hat{i} - 4\hat{j} + 4\hat{k}$.

(b) The magnitude of greatest rate of change of ϕ from the point (2, 1, –1) is $4\sqrt{11}$.

(c) $(x - 2) + (y - 1) - 3(z + 1) = 0$ represents the tangent plane to the surface $\phi = 0$ at point (2, 1, –1).

(d) ϕ satisfies the Laplacian equation.

Answers Vector Analysis

1.	(–31.42)	2.	(a)	3.	(a)	4.	(a)	5.	(d)	6.	(6)	7.	(c)
8.	(2.5)	9.	(c)	10.	(d)	11.	(d)	12.	(b)	13.	(a)	14.	(c)
15.	(d)	16.	(b)	17.	(a, c, d)	18.	(b, d)	19.	(b, c)	20.	(c, d)	21.	(a, d)
22.	(b, c, d)	23.	(b, c)										

Explanations Vector Analysis

1. (–31.42)

$$\text{Div } \vec{A} = \frac{\partial}{\partial x}\left[5x^2\left(\sin\frac{\pi x}{2}\right)\right]$$

$$= 5x^2\left(\cos\frac{\pi x}{2}\right)\cdot\frac{\pi}{2} + 10x\sin\left(\frac{\pi x}{2}\right)$$

$$\text{Div } \vec{A}\Big|_{x=2} = \frac{\pi}{2}\times 5(2)^2\cos\pi + 10(2)\sin(\pi)$$

$$= -5\times 4\times\frac{\pi}{2}$$

$$= -10\pi$$

$$= -31.42$$

2. (a)

$$\vec{A} = 3x^2yz\hat{a}_x + x^3z\hat{a}_y + (x^3y - 2z)\hat{a}_z$$

$$\nabla\cdot\vec{A} = \frac{\partial}{\partial x}(3x^2yz) + \frac{\partial}{\partial y}(x^3z) + \frac{\partial}{\partial z}(x^3y - 2z)$$

$$= 6xyz - 2$$

$\nabla\cdot\vec{A} \neq 0 \Rightarrow \vec{A}$ is not a solenoidal.

$$\nabla\times\vec{A} = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 3x^2yz & x^3z & x^3y - 2z \end{vmatrix}$$

$$= (x^3 - x^3)\hat{a}_x - (3x^2y - 3x^2y)\hat{a}_y + (3x^2z - 3x^2z)\hat{a}_z$$

$$= 0$$

$\Rightarrow \vec{A}$ is irrotational.

3. (a)

$$\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta_{AB}$$

$$|\vec{A}| = \sqrt{3^2+4^2+1^2} = \sqrt{26}$$

$$|\vec{B}| = \sqrt{2^2+5^2} = \sqrt{29}$$

$$\vec{A}\cdot\vec{B} = (4\times 2)-(1\times 5) = 3$$

$$\cos\theta_{AB} = \frac{3}{\sqrt{26\times 29}}$$

$$\theta_{AB} = \cos^{-1}\left[\frac{3}{\sqrt{26\times 29}}\right] = 83.7°$$

4. (a)

$$\int_{\theta=0}^{\pi}\cos^2\theta d\theta = \int_{\theta=0}^{\pi}\left(\frac{1+\cos 2\theta}{2}\right)d\theta = \frac{\pi}{2}$$

5. (d)

$$\nabla^2 V = \vec{\nabla}\cdot(\vec{\nabla}V)$$

= divergence of gradient of V

6. (6)

The vector will be solenoidal if its divergence is zero

$$\vec{\nabla}\cdot\vec{F} = 0$$

$$\Rightarrow \frac{\partial}{\partial x}(x+3y)+\frac{\partial}{\partial y}(5y+2z)+\frac{\partial}{\partial z}(x-Qz)=0$$

$$\Rightarrow \quad 1+5-Q = 0$$

$$\Rightarrow \quad Q = 6$$

7. (c)

Divergence of vector $\vec{D}$ in different coordinates system is given by:

Cartesian coordinates:

$$\nabla\cdot\vec{D} = \frac{\partial D_x}{\partial x}+\frac{\partial D_y}{\partial y}+\frac{\partial D_z}{\partial z}$$

Cylindrical coordinates:

$$\nabla\cdot\vec{D} = \frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho D_\rho)+\frac{1}{\rho}\cdot\frac{\partial D_\phi}{\partial\phi}+\frac{\partial D_z}{\partial z}$$

Spherical coordinates:

$$\nabla\cdot\vec{D} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 D_r)+\frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(D_\theta\sin\theta)+\frac{1}{r\sin\theta}\cdot\frac{\partial D_\phi}{\partial\phi}$$

8. (2.5)

In spherical coordinates,

$$\nabla\cdot\vec{A} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2A_r)+\frac{1}{r\sin\theta}\cdot\frac{\partial}{\partial\theta}(A_\theta\cdot\sin\theta)+\frac{1}{r\sin\theta}\cdot\frac{\partial A_\phi}{\partial\phi}$$

$$\nabla\cdot\vec{A} = \frac{1}{r\sin\theta}\cdot\frac{\partial}{\partial\theta}(5\sin^2\theta)+\frac{1}{r\sin\theta}\frac{\partial}{\partial\phi}(5\sin\phi)$$

$$\nabla\cdot\vec{A} = \frac{10\cos\theta}{r}+\frac{5\cos\phi}{r\sin\theta}$$

$$= \frac{5}{1}\times\frac{1}{2}\times\frac{1}{1} = 2.5$$

9. (c)

$$\overline{OG} = 2\hat{a}_x-2\hat{a}_y-\hat{a}_z$$

$$\vec{a} = \frac{\overline{OG}}{|\overline{OG}|} = \frac{2\hat{a}_x-2\hat{a}_y-\hat{a}_z}{\sqrt{2^2+2^2+1^2}} = \frac{2}{3}\hat{a}_x-\frac{2}{3}\hat{a}_y-\frac{1}{3}\hat{a}_z$$

10. (d)

$$\nabla\times\vec{r} = \begin{vmatrix}\hat{a}_x & \hat{a}_y & \hat{a}_z\\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z}\\ x & y & z\end{vmatrix} = 0$$

$$\nabla\cdot\vec{r} = \frac{\partial}{\partial x}(x)+\frac{\partial}{\partial y}(y)+\frac{\partial}{\partial z}(z) = 3$$

$$\vec{r}\cdot\vec{r} = (x\hat{a}_x+y\hat{a}_y+z\hat{a}_z)\cdot(x\hat{a}_x+y\hat{a}_y+z\hat{a}_z)$$

$$= x^2+y^2+z^2$$

$$\nabla(\vec{r}\cdot\vec{r}) = \frac{\partial}{\partial x}(x^2+y^2+z^2)\hat{a}_x+\frac{\partial}{\partial y}(x^2+y^2+z^2)\hat{a}_y+\frac{\partial}{\partial z}(x^2+y^2+z^2)\hat{a}_z$$

$$= 2x\hat{a}_x+2y\hat{a}_y+2z\hat{a}_z = 2\vec{r}$$

11. (d)

$$A = -\nabla f$$

$$= -\frac{\partial f}{\partial x}\hat{a}_x-\frac{\partial f}{\partial y}\hat{a}_y-\frac{\partial f}{\partial z}\hat{a}_z$$

Comparing it with given vector,

$$\frac{\partial f}{\partial x} = -(x+z)$$

$$\Rightarrow \quad f = -\frac{x^2}{2}-xz+f_1(y,z)$$

$$\frac{\partial f}{\partial y} = 3z \Rightarrow f = 3yz + f_2(x, z)$$

$$\frac{\partial f}{\partial z} = -(x - 3y - z)$$

$$\Rightarrow \quad f = -xz + 3yz + \frac{z^2}{2} + f_3(x, y)$$

$$\therefore \quad f = -\frac{x^2}{2} - xz + 3yz + \frac{z^2}{2}$$

12. (b)

$$V = \sinh x \cdot \cos ky \cdot e^{pz}$$

Laplace equation

$$\nabla^2 V = 0$$

$$\frac{\partial^2}{\partial x^2}(V) + \frac{\partial^2}{\partial y^2}(V) + \frac{\partial^2}{\partial z^2}(V) = 0$$

$\sinh x \cdot \cos ky \cdot e^{pz} - k^2 \sinh x \cdot \cos ky \cdot e^{pz}$
$+ p^2 \sinh x \cdot \cos ky \cdot e^{pz} = 0$

$\sinh x \cdot \cos ky \cdot e^{pz}(1 - k^2 + p^2) = 0$

$$k^2 = 1 + p^2$$

$$k = \sqrt{1 + p^2}$$

13. (a)

Laplace equation

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = 0 \quad \text{(Cartesian coordinates)}$$

$$\frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\rho \frac{\partial V}{\partial \rho}\right) + \frac{1}{\rho^2}\frac{\partial^2 V}{\partial \phi^2} + \frac{\partial^2 V}{\partial z^2} = 0$$

(Cylindrical coordinates)

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 \frac{\partial V}{\partial r}\right) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta \frac{\partial V}{\partial \theta}\right) + \frac{1}{r^2 \sin\theta}\frac{\partial^2 V}{\partial \phi^2} = 0$$

(Spherical coordinates)

14. (c)

As R_{AB} length is 10 units

$$\vec{R}_{AB} = \left|\vec{R}_{AB}\right| \vec{a}$$

$$\vec{R}_{AB} = 10\vec{a} = 6\hat{a}_x + 6.4\hat{a}_y + 4.8\hat{a}_z$$

$$\vec{A} \text{ radial vector} = \hat{a}_x + 2\hat{a}_y + 3\hat{a}_z$$

$$\vec{R}_{AB} = \vec{B} - \vec{A}$$

$$\vec{B} = \vec{R}_{AB} + \vec{A}$$

$$\therefore \quad \vec{B} = 10\vec{a} + \vec{A} = 7\hat{a}_x + 8.4\hat{a}_y + 7.8\hat{a}_z$$

15. (d)

According to Stokes theorem

$$\oint \vec{A} \cdot \vec{dl} = \iint (\vec{\nabla} \times \vec{A}) \cdot \vec{dS}$$

Stokes theorem is defined for any vector $\vec{A}$, for closed line [closed curve], open surface inside a closed line, for any coordinate system. It is not defined for closed surface.

16. (b)

Along the parabola $x = 2y^2$

$$\therefore \quad dx = 4ydy$$

$$\int \vec{A} \cdot \vec{dl} = \int (ydx + xdy)$$

$$= \int (y \cdot 4ydy + 2y^2 dy)$$

$$= \int 4y^2 dy + 2y^2 dy$$

$$= \int_1^2 6y^2 dy = \left(\frac{6y^3}{3}\right)_1^2$$

$$= 2(8 - 1) = 14$$

17. (a, c, d)

$$\nabla \cdot \vec{r} = \frac{\partial}{\partial x}(x) + \frac{\partial}{\partial y}(y) + \frac{\partial}{\partial z}(z) = 3$$

$$\nabla \times \vec{r} = \begin{vmatrix} \hat{i} & \hat{j} & k \\ \partial/\partial x & \partial/\partial y & \partial/\partial z \\ x & y & z \end{vmatrix}$$

$$= \hat{i}(0 - 0) + \hat{j}(0 - 0) + \hat{k}(0 - 0) = 0$$

We have,

$\|\vec{r}\|^2 = \vec{r} \cdot \vec{r} = x^2 + y^2 + z^2$. Therefore,

$$\nabla \|\vec{r}\|^2 = \frac{\partial}{\partial x}(x^2 + y^2 + z^2)\hat{i} + \frac{\partial}{\partial y}(x^2 + y^2 + z^2)\hat{j} + \frac{\partial}{\partial z}(x^2 + y^2 + z^2)\hat{k}$$

$$= 2x\hat{i} + 2y\hat{j} + 2z\hat{k}$$

$$= 2\vec{r}$$

$$\nabla \cdot (\nabla \|\vec{r}\|^2) = \frac{\partial^2}{\partial x^2}(x^2 + y^2 + z^2) + \frac{\partial^2}{\partial y^2}(x^2 + y^2 + z^2)$$

$$= \frac{\partial^2}{\partial z^2}(x^2 + y^2 + z^2)$$

$$= 2 + 2 + 2 = 6$$

DIGITAL CIRCUITS

OBJECTIVE PRACTICE SETS

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1 CHAPTER

Number Systems and Codes

MCQ and NAT Questions

Q.1 "BAD" is the hexadecimal representation of a binary number. If the number represents only the magnitude, its decimal equivalent is

(a) 2749 (b) 2989
(c) 1213 (d) 111013

Q.2 Which of the following is a self-complementary code?

(a) 8421 code (b) Excess 3 code
(c) Pure binary code (d) Gray code

Q.3 A Gray code is a/an:

(a) Binary weight code
(b) Arithmetic code
(c) Code which exhibits a single bit change between two successive codes
(d) Alphanumeric code

Q.4 If $(211)_x = (152)_8$, then the value of base 'x' is

(a) 3 (b) 5
(c) 7 (d) 9

Q.5 The decimal number 4097 is represented in four forms as shown below. Match **List-I (Type of Representation)** with **List-II (Number)** and select the correct answer:

	List I		List II
A.	Binary	**1.**	0000 0000 0000 1001
B.	BCD	**2.**	0000 0000 0001 0001
C.	Octal	**3.**	0001 0000 0000 0001
D.	Hexadecimal	**4.**	0100 0000 1001 0111

Codes:

	A	B	C	D
(a)	3	1	2	4
(b)	2	4	3	1
(c)	3	4	2	1
(d)	2	1	3	4

Q.6 The range of numbers that can be represented in two's complement mode with four binary digits is

(a) – 15 to +15 (b) – 8 to +8
(c) – 8 to +7 (d) – 7 to +7

Q.7 $(24)_8$ is expressed in Gray code as which one of the following?

(a) 11000 (b) 10100
(c) 11110 (d) 11111

Q.8 The 2's complement representation of –17 is

(a) 101110 (b) 101111
(c) 111110 (d) 110001

Q.9 A number is expressed as 1023 with radix x. Given that the number uses all the symbols of the number system, which of the following is correct?

(a) x = 3 and its decimal value is 37
(b) x = 2 and its decimal value is 14
(c) x = 4 and its decimal value is 15
(d) x = 4 and its decimal value is 75

Q.10 **Statement 1:** The range of unsigned decimal values that can be represented (using binary system) in a byte is 256.

Statement 2: The range of signed decimal values that can be represented (by signed binary using 2's complement) in a byte is 256.

(a) Statement 1 is TRUE
(b) Statement 2 is TRUE
(c) Statement 1 and Statement 2 both are TRUE
(d) Both are FALSE

Q.11 **Statement 1:** 256 different signed decimal values can be represented in a byte.

Statement 2: In 2's complement system.

$1\,1\,1\,1\,0\,1\,0\,0_2 = -12_{10}$

(a) statement 1 is TRUE
(b) statement 2 is TRUE
(c) both statements are TRUE
(d) both statements are FALSE

Q.12 For the given Grey code 10110 what will be the binary equivalent code?

(a) 10110 (b) 11101
(c) 11011 (d) None of these

Q.13 Which of the following represents seven bit code?
1. ASCII 2. BCD
3. EBCDIC 4. Selectric

Select the correct answer using the codes given below :
(a) 1 and 4 (b) 1 and 2
(c) 1 and 3 (d) 2 and 3

Q.14 With 2's complement representation, the range of values that can be represented on the data bus of an 8 bit microprocessor is given by
(a) –128 to +127 (b) –128 to +128
(c) –127 to +128 (d) –256 to +256

Q.15 The binary number 00001011 when represented in BCD format, is given by
(a) 00001011 (b) 10111011
(c) 00010001 (d) 10001000

Q.16 Hamming codes are used for error detection and correction. If the minimum Hamming distance is m, then the number of errors correctable is
(a) equal to m (b) less than m/2
(c) equal to 2 m (d) greater than m

Q.17 In signed magnitude representation, the binary equivalent of 22.5625 is (the bit before comma represents the sign)
(a) 0, 10110.1011 (b) 0, 10110.1001
(c) 1, 10101.1001 (d) 1, 10110.1001

Q.18 **Assertion (A):** A 16-bit data contained in a certain location of a computer memory can be expressed in terms of four hexadecimal digits only.

Reason (R): The hexadecimal number system has a base that is four times the base of binary number system.
(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not a correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Q.19 What will be the excess-3 code representation of the number $(64)_{10}$?
(a) 01000011 (b) 01110011
(c) 01000000 (d) 10010111

Q.20 The addition of two number $(–64)_{10}$ and $(80)_{16}$ is
(a) $(–16)_{10}$ (b) $(16)_{10}$
(c) $(1100000)_2$ (d) $(01000000)_2$

Q.21 Given that the largest *n*-bit binary number requires d digits in decimal representation. Which one of the following relations between n and d is approximately correct?
(a) $d = 2^n$ (b) $n = 2^d$
(c) $d < n \log_{10}2$ (d) $d > n \log_{10}2$

Q.22 A signed integer has been stored in a byte using the 2's complement format. We wish to store the same integer in a 16 bit word. We should
(a) copy the original byte to the less significant byte of the word and fill the more significant byte with zeros.
(b) copy the original byte to the more significant byte of the word and fill the less significant byte with zeros.
(c) copy the original byte to the less significant byte of the word and make each bit of the more significant byte equal to the most significant bit of the original byte.
(d) copy the original byte to the less significant bytes well as the more significant byte of the word.

Q.23 Consider the following operation

$$(23)_x + (21)_x = (y)_x$$

What is the minimum value of '*y*' that is possible?
(a) $(17)_{10}$ (b) $(20)_{10}$
(c) $(44)_{10}$ (d) $(110)_{10}$

Q.24 Consider the following statements:
1. When two unsigned numbers are added, an overflow is detected from the carry into the most significant position.
2. An overflow does not occur if the two numbers added are both negative.
3. If the carry into the sign bit position and carry out of the sign bit position are not equal, an overflow condition is produced.

Which of the above statement(s) is/are correct?
(a) 1, 2 and 3 (b) 1 only
(c) 2 only (d) 3 only

Q.25 2's complement representation of a 16-bit signed number is FFFFH. Its magnitude in decimal representation is
(a) 0 (b) 1
(c) 32767 (d) 65535

Q.26 If a particular number system having base B, such that

$$\left(\sqrt{21}\right)_B = 3_{10}$$

Then the value of 'B' is ___________ .

Q.27 4-bit 2's complement representation of a decimal number is 1000. The number will be ______?

Q.28 If $(11 \times 1Y)_8 = (12C9)_{16}$, then the value of $X - Y$ will be ________.

Q.29 The number 1's present in the binary representation of $15 \times 256 + 5 \times 16 + 3$ are _______.

Q.30 The number of bytes required to represent the decimal number 1856357 in packed BCD (Binary Coded Decimal) form is _________.

Q.31 In a particular number system the cubic equation $x^3 + bx^2 + Cx - 190 = 0$ has roots $x = 5$, $x = 8$ and $x = 9$. Then the base of the number system is ____________.

Multiple Select Questions (MSQs)

Q.32 $(1010.011)_2$ is equal to

(a) $(10.75)_{10}$ (b) $(22.12)_4$

(c) $(12.3)_8$ (d) $(A.C)_{16}$

Q.33 If $(23)_x = (47)_y$, then the possible values of radix x and y could be

(a) $x = 2$, $y = 1$ (b) $x = 3$, $y = 1$

(c) $x = 4$, $y = 1$ (d) $x = 6$, $y = 2$

Q.34 $(-64)_{10} + (80)_{16}$ is equal to

(a) 0100 0000 in binary number system.

(b) 0110 0100 in BCD code.

(c) 80 in octal number system.

(d) 64 in hexadecimal number system.

Q.35 Which of the following are the self-complementing codes?

(a) BCD codes

(b) Excess-3 code

(c) 2-4-2-1 binary weighted code

(d) 4-2-2-1 binary weighted code

Q.36 Consider the signed binary number A = 0100 0110 and B = 1101 0011, where B is in 2's complement and MSB is the sign bit. Which of the below statement(s) is/are correct?

(a) $A + B$ = 1000 1001

(b) $A - B$ = 0111 0011

(c) $B - A$ = 0100 1101

(d) $-A - B$ = 1110 0111

Q.37 Which of the following represents $(AB)_{16}$?

(a) $(0110\,0010)_2 + (0100\,0001)_2$

(b) $(1100\,0011)_2 - (0001\,1000)_2$

(c) $(96)_{16} + (15)_{16}$

(d) $(D3)_{16} - (28)_{16}$

Q.38 If in a particular number system, the cubic equation $x^3 - ax^2 + bx - 190 = 0$ has roots $x = 5$, $x = 8$ and $x = 9$, then

(a) The base of the number system is 13.

(b) $a = 19$ in the given number system.

(c) $b = A7$ in the given number system.

(d) The equivalent equation in the hexadecimal system is $x^3 - 16x^2 + 9Dx - 168 = 0$.

■■■■

Answers Number Systems and Codes

1. (b)	2. (b)	3. (c)	4. (c)	5. (c)	6. (c)	7. (c)
8. (b)	9. (d)	10. (c)	11. (c)	12. (c)	13. (a)	14. (a)
15. (c)	16. (b)	17. (b)	18. (c)	19. (d)	20. (d)	21. (d)
22. (c)	23. (b)	24. (d)	25. (b)	26. (4)	27. (–8)	28. (2)
29. (8)	30. (4)	31. (15)	32. (b, c)	33. (c, d)	34. (a, b, c)	35. (b, c, d)
36. (b, d)	37. (b, c, d)	38. (c, d)				

Explanations Number Systems and Codes

1. (b)

$$\begin{aligned}(BAD)_{16} &= B \times 16^2 + A \times 16^1 + D \times 16^0\\ &= 11 \times 256 + 10 \times 16 + 13\\ &= (2989)_{10}\end{aligned}$$

2. (b)

Self complementing code:
Excess – 3 code, 2421, 3221, 4311, 5211
It is one that 9's complement in decimal is the 1's complement in binary.

3. (c)

A Gray code is a code which exhibits a single bit change between two successive codes.

4. (c)

$$(211)_x = (152)_8$$

Converting to decimal

$$2x^2 + x + 1 = 8^2 \times 1 + 8 \times 5 + 2 = 106$$

on solving, $x = 7, -15/2$

5. (c)

Binary: 0001 0000 0000 0001

$$2^{12} + 2^0 = 4097$$

BCD: $\underset{4}{\underline{0100}}\ \underset{0}{\underline{0000}}\ \underset{9}{\underline{1001}}\ \underset{7}{\underline{0111}}$

Octal: 0000 0000 0001 0001

$\rightarrow 1 \times 8^4 + 1 \times 8^0$

$\rightarrow 4097$

Hexadecimal: 0000 0000 0000 $\underline{1001}$

$$\begin{aligned}&= 1 \times 16^3 + 1 \times 16^0\\ &= 4097\end{aligned}$$

6. (c)

Range of signed magnitude and 1's complement representation for n-bit is $= -(2^{n-1} - 1)$ to $(2^{n-1} - 1)$
for 2's complement : -2^{n-1} to $(2^{n-1} - 1)$

7. (c)

$$(24)_8 \equiv (10100)_2 = (20)_{10}$$

Binary 1 0 1 0 0
$\oplus$ $\oplus$ $\oplus$ $\oplus$
Gray code 1 1 1 1 0

8. (b)

2's complement of a number = 1's complement + 1

$$(17)_{10} = 010001$$

1's complement of $(17)_{10}$ =	1 0 1 1 1 0
	+ 1
2's complement	1 0 1 1 1 1

9. (d)

Given $(1023)_x$
We know that radix x is always greater than any number inside it.
Hence, $x \geq 4$
Now by options check $x = 4$

So, $(1023)_4 = 1 \times 4^3 + 0 \times 4^2 + 2 \times 4^1 + 3 \times 4^0$
$= 64 + 0 + 8 + 3 = (75)_{10}$

10. (c)

In unsigned, range with n bit is 0 to $2^n - 1$
Here, 1 byte = 8 bit

$\therefore$ $0 \rightarrow 2^8 - 1$
$= 0 - 255$

for 2's complement $-(2^{n-1})$ to $(2^{n-1} - 1)$

11. (c)

2's complement of $(11110100)_2$

$$
\begin{array}{rr}
= & 00001011 \\
 & 1 \\
\hline
 & 00001100 = 12 \\
\hline
\end{array}
$$

But in 2's complement representation, MSB is '1' i.e. number is negative.

12. (c)

Given Gray code 1 0 1 1 0

Binary code will be 1 1 0 1 1

13. (a)

Seven bit code : ASCII, selectric

EBCDIC : 8-bit code

BCD : 4-bit code

14. (a)

For 8-bit 2's complement : – 128 to 127

15. (c)

Convert binary into decimal

$00001011 \rightarrow 2^3 \cdot 1 + 2^1 \cdot 1 + 2^0 \cdot 1 = 11$

$(11)_{10} = (0\,0\,0\,1 \quad 0\,0\,0\,1)_2$

16. (b)

No. of errors correctable in hamming code for m hamming distance < $m/2$.

17. (b)

$\because$ + 22.5625

$+ \rightarrow 0$

$- \rightarrow 1$

$$
\begin{array}{c|c|c}
2 & 22 & \\
2 & 11 & 0 \\
2 & 5 & 1 \\
2 & 2 & 1 \\
 & 1 & 0
\end{array}
\qquad \therefore \quad 22 = (10110)_2
$$

$0.5625 \times 2 = 1.1250 \rightarrow 1$

$0.1250 \times 2 = 0.2500 \rightarrow 0$

$0.2500 \times 2 = 0.5 \rightarrow 0$

$0.5 \times 2 = 1 \rightarrow 1$

$\therefore (1001)_2$

$\therefore \quad (22.5625) = (10110.1001)_2$

18. (c)

Hexadecimal, decimal, binary number system has a base 16, 10, 2 respectively.

19. (d)

Given, $(64)_{10} = (01000000)_2$

To convert into excess 3, first convert into BCD code.

$(64)_{10} \xrightarrow{BCD} \overset{6}{0110}\ \overset{4}{0100}$

Now add $(3)_{10}$ = 0011 into each Nibble.

$$
\text{So, } (64)_{10} \xrightarrow{\text{Excess 3}} \begin{array}{r} 0110\ 0100 \\ +\ 0011\ 0011 \\ \hline 1001\ 0111 \end{array}
$$

20. (d)

$$
\begin{aligned}
(80)_{16} &= (128)_{10} \\
(128)_{10} + (-64)_{10} &= (64)_{10} \\
(64)_{10} &= (01000\,000)_2
\end{aligned}
$$

21. (d)

For n-bit number

$$d > n \log_{10} 2$$

For $n = 1, 2, 3 \quad d = 1$

For $n = 4, 5, 6 \quad d = 2$

For $n = 7, 8, 9 \quad d = 3$

For $n = 10, 11, 12, 13 \quad d = 4$

For any n, $d > n \log_{10} 2$ is correct.

22. (c)

The MSB of the integer in 8 bit format should be repeated to expand the representation of 2's complement form to 16 bit.

23. (b)

For minimum value of 'y' the value of 'x' should be minimum

$\therefore$ minimum value of $x = 4$

$\therefore (23)_4 + (21)_4 = (110)_4 = (4^2 + 4 + 0)_{10} = (20)_{10}$

24. (d)

1. When two unsigned numbers are added, an overflow is detected from the carry out of most significant bit. (not into most significant bit)
2. Overflow does not occur if the numbers are of opposite sign otherwise it may occur.
3. In signed operation, if carry into sign bit and carryout of the sign bit are not equal, overflow occurs else overflow does not occur.

COMPUTER ORGANIZATION

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1 CHAPTER

Machine Instructions and Addressing Modes

MCQ and NAT Questions

Q.1 The most appropriate matching of the following pairs is

Column 1	Column 2
X: Indirect addressing	1. Loops
Y: Immediate addressing	2. Pointers
Z: Auto-decrement address	3. Constant

(a) X-2, Y-3, Z-1 (b) X-3, Y-2, Z-1
(c) X-1, Y-3, Z-2 (d) X-3, Y-1, Z-2

Q.2 A processor can support a maximum memory of 4 GB where memory is word addressable and word is 2 bytes. What will be the size of the address bus of the processor?
(a) At least 2 bytes (b) At least 28 bits
(c) At least 31 bits (d) Minimum 4 bytes

Q.3 A digital computer has memory unit with 24 bits word. The instruction set consists of 150 different operations. All instructions have an operation code part and an address part. Each instruction is stored in one word of memory. How many bits are needed for the OPCODE and how many bits are left for the address of the instruction.
(a) 8, 16 (b) 16, 64
(c) 4, 8 (d) 8, 64

Q.4 An instruction is stored at location 300 with its address field. At location 301 the address field has value 400. A processor register R1 contains the number 200. Evaluate the effective address matching the following addressing modes to their respective addresses.

A. Direct	1. 702
B. Immediate	2. 200
C. Relative	3. 400
D. Register indirect	4. 600
E. Index (R1 is index)	5. 301

(a) A3 B5 D2 E4 C1 (b) A3 B4 C1 D1 E5
(c) A5 B3 C2 D1 E4 (d) A4 B3 C1 D5 E2

Q.5 What is the most appropriate match for the items in the first column with the items in the second column:

Column 1:
X. Indirect addressing
Y. Indexed addressing
Z. Base register addressing

Column 2:
1. Array implementation
2. Writing relocatable code
3. Passing array as parameter

(a) X-3, Y-1, Z-2 (b) X-2, Y-3, Z-1
(c) X-3, Y-2, Z-1 (d) X-1, Y-3, Z-2

Q.6 In which of the following address mode, the content of the program counter is added to the address part of the instruction to get the effective address?
(a) Indexed addressing mode
(b) Implied addressing mode
(c) Relative addressing mode
(d) Register addressing mode

Q.7 In a certain processor, a 2 byte Jump instruction is encountered at memory address 3010H, the Jump instruction is in PC relative mode. The instruction is JMP – 7 where – 7 is signed byte. Determine the Branch Target Address
(a) 300B H (b) 3009 H
(c) 3003 H (d) 3007 H

Q.8 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I	List-II
A. $A[1] = B[J]$;	1. Indirect addressing
B. while [$*A$++];	2. Indexed addressing
C. int temp = $*x$;	3. Auto-increment

Codes:

	A	B	C
(a)	3	2	1
(b)	1	3	2
(c)	2	3	1
(d)	1	2	3

Q.9 In immediate addressing mode, where is the operand placed?
(a) In memory
(b) In stack
(c) In CPU register
(d) In instruction after opcode

Q.10 A 4-byte long PC-relative branch instruction is fetched from memory address $(512)_{10}$ and while its execution, the branch is made to location $(885)_{10}$. What is unsigned displacement present in the instruction? (relative value) _______?

Q.11 A machine has a 32-bit architecture, with 1-word long instructions. It has 64 registers, each of which is 32 bits long. It needs to support 45 instructions, which have an immediate operand in addition to two register operands. Assuming that the immediate operand is an unsigned integer, the maximum value of the immediate operand is _________.

Q.12 The register which contains the data to be written into or read out of the addressed location is known as
(a) Memory address register
(b) Memory data register
(c) Program computer
(d) Index register

Q.13 In four-address instruction format, the number of bytes required to encode an instruction is (assume each address requires 24 bits and 1 byte is required for operation code)
(a) 9 (b) 13
(c) 14 (d) 12

Q.14 The memory locations 1000, 1001 and 1020 have data values 18, 1 and 16 respectively before the following program is executed.

MOVI Rs, 1;	Move immediate
LOAD Rd, 1000(Rs);	Load from memory
ADDI Rd, 1000;	Add immediate
STOREI 0(Rd), 20;	Store immediate

Which of the statements below is TRUE after the program is executed?
(a) memory location 1000 has value 20
(b) memory location 1020 has value 20
(c) memory location 1021 has value 20
(d) memory location 1001 has value 20

Q.15 A CPU has 24-bit instructions. A program starts at address 300 (in decimal). Which one of the following is a legal program counter (all values in decimal)?
(a) 400 (b) 500
(c) 600 (d) 700

Q.16 Consider the following program segment:

	Instruction	Meaning	Size (words)
I_1	LOAD r_0, 500	r_0 – [500]	2
I_2	MOV r_1, r_0	$r_0 - r_0$	1
I_3	Add r_0, r_1	$r_0 - r_0 + r_1$	1
I_4	Inc r_0	$r_0 - r_0 + 1$	1
I_5	Inc r_1	$r_1 - r_1 + 1$	1
I_6	Add r_0, r_1	$r_0 - r_0 + r_1$	1
I_7	Store r_1, r_0	M[$(r_1)r_0$]	2
I_8	Halt	Stop	1

Assume that memory is word addressable with word size 32 bits. Program is loaded into memory location 3000 onwards. The value of PC at the end of execution of above program is _________.

Q.17 A computer has 32 bit instruction and 9-bit address. If there are 400 two address instructions then how many one address instructions can be formulated?
(a) 2^{14} (b) $2^{32} - 200$
(c) $2^{14} - 400$ (d) $(2^{14} - 400) \times 2^9$

Q.18 In which addressing mode, the effective address of the operand is generated by adding a constant value to the content of a register?
(a) Absolute mode (b) Indirect mode
(c) Immediate mode (d) Index mode

Q.19 Consider a 16-bit processor in which the following one address Instruction appeals in main memory starting at location 200.

200	Opcode
201	500
202	Next Instruction
⋮	
500	999

There is also a base register that contains the value 100.
Match **List-I** (Mode) with **List-II** (Effective Address) and select the correct answer using the codes given below the lists:

Multiple Select Questions (MSQs)

Q.57 A certain architecture supports indirect, direct and register addressing modes for use in identifying operands for arithmetic instructions. Which of the following can be achieved with a single instruction?

(a) Specifying a register number in the instruction such that the register contains the value of an operand that will be used by the operation.

(b) Specifying a register number in the instruction such that the register will serve as the destination for the operands output.

(c) Specifying an operand value in the instruction such that the value will be used by the operation.

(d) Specifying a memory location in the instruction such that the memory location contains the value of an operand that will be used by the operation.

Q.58 A machine has 24 bit instruction format. It has 32 registers and each of which is 32 bit long. It needs to support 49 instructions. Each instruction has two register operands and one immediate operand. Which of the following are correct?

(a) Total 5 bits are needed for opcode.

(b) The minimum value of immediate operand is –256 if operand is signed integer.

(c) The minimum value of immediate operand is –128 if operand is signed integer.

(d) The maximum value of immediate operand is 255 if operand is signed integer.

Q.59 Consider the following statements. Which of the following is correct for the computers that uses memory mapped I/O?

(a) The computer provides special instruction for manipulating I/O port.

(b) I/O ports are placed at address on bus and as accessed just like other memory location.

(c) To perform an I/O operation, it is sufficient to place the data in an address and call the channel to perform the operation.

(d) Ports are referenced only by memory mapped instruction of the computer and are located at hardwired memory location.

■■■■

Answers Machine Instructions and Addressing Modes

1. (a)	2. (c)	3. (a)	4. (a)	5. (a)	6. (c)	7. (a)
8. (c)	9. (d)	10. (369)	11. (16383)	12. (b)	13. (b)	14. (d)
15. (c)	16. (3009)	17. (d)	18. (d)	19. (c)	20. (c)	21. (d)
22. (c)	23. (b)	24. (c)	25. (d)	26. (b)	27. (c)	28. (b)
29. (c)	30. (c)	31. (c)	32. (369)	33. (a)	34. (c)	35. (b)
36. (a)	37. (–128)	38. (a)	39. (a)	40. (d)	41. (a)	42. (d)
43. (16)	44. (b)	45. (c)	46. (a)	47. (92)	48. (2032)	49. (c)
50. (a)	51. (b)	52. (c)	53. (c)	54. (2048)	55. (d)	56. (a)
57. (a, b, d)	58. (c)	59. (b)				

Explanations Machine Instructions and Addressing Modes

2. (c)

$$\text{Memory size} = 4\text{ GB} = 2^{32}\text{ B}$$
$$\text{Word size} = 2\text{ B}$$

$$\text{So, unique address} = \frac{2^{32}}{2^1} = 2^{31}$$

Hence, atleast 31 bits are required.

3. (a)

Each instruction is stored in one word of memory.

Memory is word addressable and 1 word = 24 bits $\Rightarrow$ 3 bytes.

Total number bits = 24

The instruction set consists of 150 different operations. To generate 150 different operations we need minimum 8 bits are required.

OP code	Address
8	16

So, option (a) is correct.

4. (a)

For direct, EA = address field value in IR (instruction register) = 400

For immediate, actually no meaning of effective address. So, EA here will be just the address of the operand field which is otherwise address field = 301.

For relative addressing, we have EA = PC value (current) + Address field value

EA = 302 + 400 = 702

For register indirect, the EA is the content of the register, the register name being present in the address field of instruction.

So, EA = content of R1 = 200

For indexed mode = Base address + index register content

= 400 + 200 = 600

So, option (a) is correct.

6. (c)

In relative addressing mode content of the program counter is added to the address part of the instruction to get the effective address.

So, option (c) is correct.

7. (a)

The Jump instruction is at address 3010 H and instruction is 2 bytes. Therefore, PC points to 3012 H on execution of this instruction.

Now Branch Target PC = PC + (–7)

= 3012 H – 7 H = 300 BH

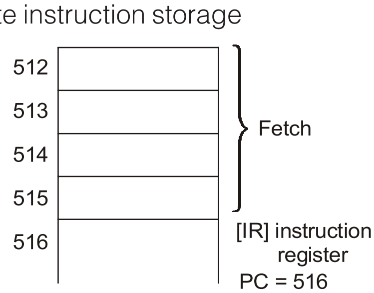
9. (d)

In immediate addressing mode, the operand is specified in the instruction itself.

For example: MOV R1, 12H is the immediate AM with 12 is operand.

10. (369)

4 byte instruction storage



Effective address = PC + Relative value

Relative value = EA – PC

= 885 – 516 = (369)10

So, answer is 369.

11. (16383)

(6)	(6)	(6)	
Opcode	R_1	R_2	Immediate

32 – (6 + 6 + 6) = 14 bits for immediate field

$\Rightarrow$ $2^{14} - 1$ = 16383 maximum possible value of immediate operand.

12. (b)

MDR register needed to read or written data into or onto memory location.

13. (b)

Four address instruction format:

Opcode	A_1	A_2	A_3	A_4
8 bits	24 bits	24 bits	24 bits	24 bits

So total bits needed = (24 bits × 4) + 8 bits

= 96 + 8 bits = 104 bits

So number of bytes = $\frac{104}{8}$ byte = 13 bytes

14. (d)

$M[1000] = 18$, $M[1001] = 1$, $M[1020] = 16$

MOV I R_S, 1	$R_S = 1$
LOAD R_D, 1000 (R_S)	$R_D \leftarrow M[1000+[R_S]]$
	$R_D \leftarrow M[1000+1] = M[1001]$
	$R_D \leftarrow 1$
ADD I R_d, 1000	$R_d \leftarrow R_d + 1000 = 1+1000 = 1001$
STORE I 0(R_d), 20	$M[0+R_d] = 20$
	$M[R_d] = 20$
	$M[1001] = 20$

15. (c)

As the instruction are 24 bit or 3 bytes, the value of program counter at any time should be multiple of 3 starting from 300 like 300, 303, 306 ... from options, '600' is multiple of 3 or is included in above series.

16. (3009)

Word addressable storage

3000 – 3001

3002

3003

3004

3005

3006

3007-3008

3009

Valid program counter value after program is 3009.