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ESE-2017 : Prelims Exam

UPSC Engineering Services Examination

E & T ENGINEERING

Answer Key & Solutions

Test 7: Part Syllabus Technical

Signals & Systems + Microprocessors

1.	(b)	16.	(a)	31.	(c)	46.	(d)	61.	(b)
2.	(b)	17.	(b)	32.	(b)	47.	(b)	62.	(b)
3.	(c)	18.	(c)	33.	(a)	48.	(d)	63.	(c)
4.	(d)	19.	(c)	34.	(c)	49.	(d)	64.	(a)
5.	(b)	20.	(c)	35.	(c)	50.	(d)	65.	(c)
6.	(d)	21.	(b)	36.	(c)	51.	(c)	66.	(a)
7.	(c)	22.	(a)	37.	(c)	52.	(c)	67.	(c)
8.	(b)	23.	(d)	38.	(a)	53.	(d)	68.	(b)
9.	(d)	24.	(b)	39.	(d)	54.	(d)	69.	(c)
10.	(a)	25.	(b)	40.	(d)	55.	(d)	70.	(c)
11.	(b)	26.	(d)	41.	(d)	56.	(b)	71.	(d)
12.	(b)	27.	(d)	42.	(a)	57.	(c)	72.	(b)
13.	(c)	28.	(b)	43.	(d)	58.	(a)	73.	(d)
14.	(b)	29.	(b)	44.	(b)	59.	(b)	74.	(c)
15.	(c)	30.	(b)	45.	(c)	60.	(a)	75.	(c)

DETAILED EXPLANATIONS

1. (b)

$$\omega_0 = \frac{3\pi}{4}$$

$$\frac{\omega_0}{2\pi} = \frac{k}{N}$$

$$\Rightarrow \quad \frac{\frac{3\pi}{4}}{2\pi} = \frac{3}{8}$$

$$\Rightarrow \quad N = 8$$

2. (b)

$$y[n] = x[n+1] + x[n-1]$$

$$\text{DTFT}\{y[n]\} = Y(e^{j\omega})$$

$$\text{DTFT}\{x[n]\} = X(e^{j\omega})$$

$$\Rightarrow \quad Y(e^{j\omega}) = X(e^{j\omega})\,[e^{j\omega} + e^{-j\omega}]$$

$$\Rightarrow \quad \frac{Y(e^{j\omega})}{X(e^{j\omega})} = 2\cos\omega$$

3. (c)

$$|\sin(\omega)| = 0 \text{ at } \omega = 0, \pi$$

$$|\sin(\omega)| = 1 \text{ at } \omega = \frac{\pi}{2}$$

$\Rightarrow$ bandpass

5. (b)

$$E = \sum_{n=-\infty}^{\infty} x^2[n] = \sum_{n=-4}^{4} \cos^2 \pi n$$

$$= \frac{1}{2}\sum_{n=-4}^{4}[1+\cos 2\pi n] = \frac{1}{2}\sum_{n=-4}^{4}[1+1]$$

$$= 9$$

6. (d)

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]\,x[n-k]$$

$$y[2] = \sum_{k=-\infty}^{\infty} x[k]\,x[2-k]$$

$$= \sum_{k=0}^{2}\left(\frac{1}{2}\right)^k\left(\frac{1}{2}\right)^{2-k} \quad ; \text{for } 2-k \geq 0, \text{ i.e. } k \leq 2.$$

$$= \frac{3}{4}$$

7. (c)

$$\begin{aligned} h_1[n] * h_2[n] &= \delta[n-k_1] * \delta[n+k_2-k_1] \\ &= \delta[n-k_1] * \delta[n-(-k_2+k_1)] \\ &= \delta[n-(k_1-k_2+k_1)] \\ &= \delta[n+k_2-2k_1] \end{aligned}$$

9. (d)

$\left(\frac{1}{2}\right)^{-n} u[-n-1] = (2)^n u[-n-1] \Rightarrow$ ROC is $|z|<2$

$\left(\frac{1}{2}\right)^{n} (2^{-n})u[n] = \left(2^{-n}\right)^2 u[n] = \left(\frac{1}{4}\right)^{n} u[n] \Rightarrow$ ROC is $|z|>\frac{1}{4}$

$\therefore$ ROC is $\frac{1}{4}<|z|<2$

10. (a)

$$\left(\frac{1}{8}\right)^{n} u[n] \xleftrightarrow{Z.T} \frac{z}{z-\frac{1}{8}}, |z|>\frac{1}{8}$$

$$\left(\frac{1}{8}\right)^{-n} u[-n] \xleftrightarrow{Z.T} \frac{1/z}{\frac{1}{z}-\frac{1}{8}}$$

$$\begin{aligned} X(z) &= \frac{1}{1-\frac{1}{8}z} \\ &= \frac{8}{8-z}, \quad |z|<8 \end{aligned}$$

11. (b)

$$C_k = \frac{1}{N}\sum_{n=0}^{N-1} x[n]e^{-jk\omega_0 n}$$

$$C_2 = \frac{1}{4}\sum_{n=0}^{3} x[n]e^{-j2\times\frac{2\pi}{4}\times n}$$

$$= \frac{1}{4}\sum_{n=0}^{3} x[n](-1)^n = \frac{1}{4}[0+(-1)+2-3]$$

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

13. (c)

to get poles of $H(z) \Rightarrow \left(z+\frac{1}{4}\right)(z-2)=0$; at $z=-\frac{1}{4},2$

$\Rightarrow$ as there is a pole outside the unit circle, the system is unstable

15. (c)

The most significant bit represents the sign of the number. Therefore, it is stored in the sign status flag.

16. (a)

Microprocessor operation is controlled by software it can perform many different functions.

17. (b)

$$\begin{aligned}\text{Number of multiplications} &= 2N\log_2 N \\ &= 2\times 16\times \log_2 16 \\ &= 32\times 4 = 128\end{aligned}$$

18. (c)

$$X(e^{j\omega}) = \sum_{n=0}^{4} e^{-j\omega n} = 1 + e^{-j\omega} + e^{-j2\omega} + e^{-j3\omega} + e^{-j4\omega}$$

$$= \left(\frac{1-e^{-j5\omega}}{1-e^{-j\omega}}\right) = e^{-j2\omega}\frac{\sin(2.5\omega)}{\sin(0.5\omega)}$$

19. (c)

$$y[n] = x_1[n] \otimes x_2[n]$$

$$= \sum_{k=0}^{3} x_1[k]\, x_2\left[n-k\right]_N \qquad N = 4$$

$$y[n] = \begin{bmatrix}1 & 1 & 3 & 2\\ 2 & 1 & 1 & 3\\ 3 & 2 & 1 & 1\\ 1 & 3 & 2 & 1\end{bmatrix}\times\begin{bmatrix}4\\3\\2\\2\end{bmatrix} = \begin{bmatrix}17\\19\\22\\19\end{bmatrix}$$

21. (b)

STAX address	:	7 T-states
SPHL	:	6 T-states
SIM	:	4 T-states
STA address	:	13 T-states

25. (b)

$$x[n] = [\underset{\uparrow}{0}, 0, 1, 1, 1, 1, 1, 0]$$

$$x[n+1] = [0, \underset{\uparrow}{0}, 1, 1, 1, 1, 1, 0]$$

$$x[3n+1] = [\underset{\uparrow}{0}, 1, 0]$$

so, option (b) is correct.

26. (d)

- average power of a periodic signal does not change with time shifting and scaling.
- so, the average power of $x\left(\frac{t-1}{2}\right)$ also equals to 2 W.

27. (d)

- linear ⇒ as only linear terms are preset
- time-variant ⇒ due to $ty(t)$, $t^2x(t)$ terms
- dynamic ⇒ any system described by a differential equation is dynamic.

29. (b)

Time domain	Frequency domain
Continuous	Aperiodic
Discrete	Periodic
Periodic	Discrete
Aperiodic	Continuous

31. (c)

- The signal has hidden halfwave symmetry and hidden odd symmetry.

hidden → DC value
odd symmetry → only sine terms
half wave symmetry → only odd harmonics
so, option (c) is correct.

32. (b)

$$\delta(t) \xleftrightarrow{\text{CTFT}} 1$$

$$1 \xleftrightarrow{\text{CTFT}} 2\pi\delta(\omega) \text{ or } \delta(f) \qquad \because \delta(at) = \frac{1}{|a|}\delta(t)$$

$$e^{j(2\pi f_0)t} \xleftrightarrow{\text{CTFT}} 2\pi\delta(\omega-\omega_0) \text{ or } \delta(f-f_0)$$

33. (a)

$$\text{sgn}(t) \xleftrightarrow{\text{CTFT}} \frac{2}{j\omega} = \frac{1}{j\pi f}$$

$$\frac{1}{j\pi t} \xleftrightarrow{\text{CTFT}} \text{sgn}(-f) = \text{sgn}(-\omega) = -\text{sgn}(\omega) \qquad \because \text{sgn}(\cdot) \text{ is an odd function}$$

$$\frac{1}{j\pi t} \xleftrightarrow{\text{CTFT}} -\text{sgn}(\omega)$$

$$\frac{j}{\pi t} \xleftrightarrow{\text{CTFT}} \text{sgn}(\omega)$$

34. (c)

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

$$x(0) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(\omega)\,d\omega$$

so, $$\int_{-\infty}^{\infty} X(\omega)\,d\omega = 2\pi x(0)$$

36. (c)

$$x(t) * \delta(-2t+1) = x(t) * \delta\left[-2\left(t-\frac{1}{2}\right)\right]$$

$$= x(t) * \frac{1}{2}\delta\left(t-\frac{1}{2}\right) \qquad \because \delta(at) = \frac{1}{|a|}\delta(t)$$

$$= \frac{1}{2}\left[x(t) * \delta\left(t-\frac{1}{2}\right)\right]$$

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

38. (a)

$$(\cos t)\, u(t) * u(t) = \int_{\tau=-\infty}^{\infty} \cos(\tau)u(\tau)\, u(t-\tau)\, d\tau$$

$u(\tau) = 1$ for $\tau > 0$
$u(t-\tau) = 1$ for $\tau < t$
} so, above integration exists for $0 < \tau < t$

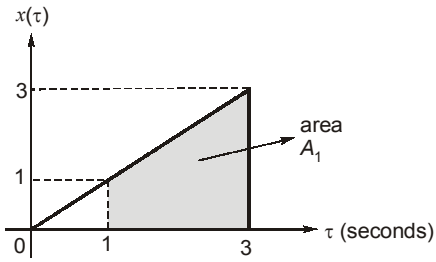
$$(\cos t)\, u(t) * u(t) = \int_0^t \cos(\tau) d\tau$$

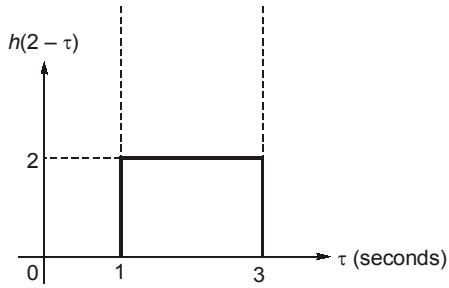
$$= \sin(\tau)\Big|_0^t = \sin(t); \text{ for } t > 0$$

so, $(\cos t)\, u(t) * u(t) = (\sin t)\, u(t)$

39. (d)

$$y(t) = x(t) * h(t) = \int_{-\infty}^{\infty} x(\tau)h(t-\tau)\, d\tau$$





$$y(t = 2s) = 2A_1$$

$$A_1 = \frac{1}{2}(3)(3) - \frac{1}{2}(1)(1) = \frac{1}{2}(9-1) = 4$$
$$y(t = 2s) = 2A_1 = 8$$

40. (d)

$$x(t) \xleftrightarrow{\text{CTFT}} X(\omega)$$
$$x(t-4) \xleftrightarrow{\text{CTFT}} X(\omega)\, e^{-j4\omega}$$
$$x(2t-4) \longleftrightarrow \frac{1}{2}X\left(\frac{\omega}{2}\right)e^{-j4\omega/2} = \frac{1}{2}X\left(\frac{\omega}{2}\right)e^{-j2\omega}$$

42. (a)

Order of numerator of $X(s)$ = order of denominator of $X(s)$
it means, there is an impulse at $t = 0$.

so, $$X(s) = 1 + \frac{2s+4}{s^2+2s+2}$$

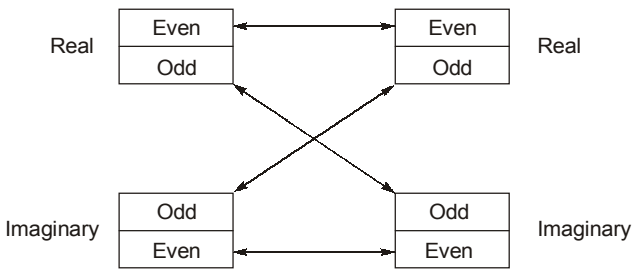
the term "1" in $X(s)$ produces an impulse at $t = 0$
at $t = 0^+$, $\delta(t) = 0$

so, $$x(0^+) = \lim_{s\to\infty} s\frac{2s+4}{s^2+2s+2} = 2$$

43. (d)

$$X(s) = \frac{1}{s}(1-e^{-s})\left[1+e^{-2s}+e^{-4s}+e^{-6s}+.....\right]$$
$$= \frac{\frac{1}{s}(1-e^{-s})}{(1-e^{-2s})} = \frac{\frac{1}{s}(1-e^{-s})}{(1+e^{-s})(1-e^{-s})}$$
$$= \frac{1}{s(1+e^{-s})}$$

44. (b)

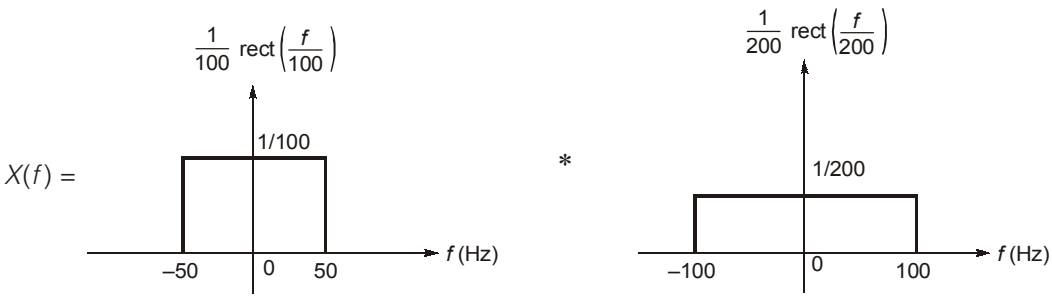


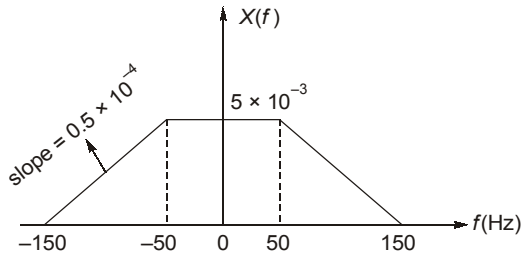
45. (c)

$$\text{sinc}(t) \xleftrightarrow{CTFT} \text{rect}(f)$$

$$\text{sinc}(100t) \xleftrightarrow{CTFT} \frac{1}{100}\text{rect}\left(\frac{f}{100}\right)$$

$$\text{sinc}(200t) \xleftrightarrow{} \frac{1}{200}\text{rect}\left(\frac{f}{200}\right)$$





f_{max} = 150 Hz

Nyquist sampling rate = 300 Hz

47. (b)

- In 8051 microcontroller, the relative address used with SJMP is of 8-bits.
- Using 8-bits, with 2's compliment form of representation, the numbers can be represented are "–128 to +127".

48. (d)

(a) We can move date between the accumulator (A) and Rn (for n = 0 to 7) but movement of data between Rn registers is not allowed.

(b) Size of R2 is 8-bits and size of DPTR is 16-bits.

(c) Size of A is 8-bits and size of DPTR is 16-bits.

(d) Size of DPTR is 16-bits and 1616 H is a data of 16-bits.

For proper transfer of data source and destination registers should have same size.

49. (d)

- bit addressable registers of 8051 microcontroller are,

A, B, PSW, IP, IE, SCON, TCON and all ports.

55. (d)

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
EA	–	ET2	DS	ET1	EX1	ET0	EX0

- When EA = 0 ⇒ All the interrupts are disabled
  When EA = 1 ⇒ Interrupts can be enabled or disabled by programming the bits D_6 - D_0.
- Programming table when EA = 1

Interrupt source	To enable	To Desable
External INT 0	$D_0 = 1$	$D_0 = 0$
Timer 0	$D_1 = 1$	$D_1 = 0$
External INT 1	$D_2 = 1$	$D_2 = 0$
Timer 1	$D_3 = 1$	$D_3 = 0$
Serial port	$D_4 = 1$	$D_4 = 0$

- D5 of IE register is used only in 8052 microcontroller.
- given that (IE) = 88 H

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
EA	–	ET2	DS	ET1	DX1	ET0	EX0
1	0	0	0	1	0	0	0

- So, only timer 1 is enable.

56. (b)

LXI H, E000 H ⇒ Load HL pair with immediate data

T-states consumed = 10

$$\text{One T-state} = \frac{1}{f} = \frac{1}{2\,\text{MHz}} = 0.5\ \mu\text{sec}$$

so instruction cycle = 10 T states

$= 10 \times 0.5\ \mu\text{sec} = 5\ \mu\text{sec}$

57. (c)

In AND operation CY = 0 and AC = 1 By default

```
0 1 = 0 0 0 0 0 0 0 1
8 0 = 1 0 0 0 0 0 0 0
AND = 0 0 0 0 0 0 0 0
So → S Z   AC   P   CY
     0 1   1   1   0
```

58. (a)

Assembler → Convert source code into object code i.e. a program that translate symbolic code into binary code.

Mnemonic → A combination of letters symbols and numerals.

Program counter → Used to indicate the memory location of next instruction to be executed.

Monitor program → Is an operating system.

59. (b)

CMP B will not affect the contents of accumulator. In this instruction contents of A is compared with that of B by checking (A – B),

if A > B → Z = 0, CY = 0

A < B → Z = 0, CY = 1

A = B → Z = 1 CY = 0

But contents of A remains same.

62. (b)

SHLD 1080 H

When this instruction is executed then H - L pair content is stored into 2 memory locations

(1080 H) ← (L)

(1081 H) ← (H)

63. (c)

A ⊕ A = 00 H and defaulty CY = 0, AC = 0 after XRA operation.

∴ It can be used to set the zero flag, Reset the carry flag, clear the accumulator.

65. (c)

XRI byte → 7 T-states

STA address → 13 T-states

CALL address → 18 T-states

JMP address → 10 T-states

67. (c)

Order of priorities of interrupts is TRAP (RST 4.5) > RST 7.5 > RST 6.5 > RST 5.5 > INTR.

68. (b)

8085 resets program counter to 0000H.

69. (c)

Effective address = 20000 H + 5000 H = 25000 H

71. (d)

All flags get affected by SUB B.

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