*Candidates are required to give their answers in their own words as far as practicable.*
*The figures in the margin indicate full marks.*

## Digital Signal Processing

### [Theory]

Answer *any two* of the following:  2×15=30

1. (a) What is meant by fundamental period? Show that the signal $x(n) = (-1)^n$ is periodic and hence find its fundamental period.  1+3

    (b) Find the convolution sum of

    $x(n) = \{4, 2, -1, 3\}$ for $M = 4$ and $h(n) = \{1, 3, 2\}$ for $N = 3$.  5

↑↑

(c) Suppose $x_{ev}^{(n)}$ and $x_{od}^{(n)}$ represent the even and odd parts of square-summable sequence $x(n)$, respectively. Then prove that

$$\sum_{n=-\infty}^{\infty} x^2(n) = \sum_{n=-\infty}^{\infty} x_{ev}^2(n) + \sum_{n=-\infty}^{\infty} x_{od}^2(n).$$

4

(d) What are conjugate-symmetric and conjugate-anti symmetric signals ? 2

2. (a) Find the convolution of the following two sequences : 4

i. $x(n) = e^{-n^2}$ for all $n$

ii. $x(n) = 2n$ for all $n$ .

(b) If $s(n)$ be the unit step response of a DTS, then show that the response $y(n)$ to the input $x(n)$ is given by.

$$y(n) = [x(n) - x(n-1)] * s(n)$$

$$= x(n) * [s(n) - s(n-1)]$$

4

(c) Prove the following properties of the DTFT : 6

(i) Time shifting

(ii) Convolution

(iii) Modulation

(d) What is unit Ramp signal? 1

3. (a) Find discrete Fourier transform of the signal $x(n) = \{1, 0, 1, 0\}$ using direct method.

4

(b) Explain the linearity theorem in discrete Fourier transform. 3

(c) Determine the z-transform of the anticausal signal $x(n) = -a^n u(-n-1)$ and also find the Region of Convergence (ROC). 5

(d) Find the inverse z-transform of $X(z) = z^2 + z + 3$ 3

4. (a) What do you mean by continuous and discrete signals ?                              2+2

   (b) Find the Fourier transform of the unit step function.                              2

   (c) Make a comparison between DIT (Decimation-in-Time) and DIF (Decimation-in-Frequency) algorithms.                                                                4

   (d) The frequency response of a digital differentiator is given by $H_d(e^{j\omega}) = j\omega$, where $-\pi \leq \omega \leq \pi$. Using a rectangular window of length $M = 9$, determine the frequency response of the designed FIR differentiator.                      5

<center>Answer <i><b>any one</b></i> of the following:                              1×10=10</center>

5. (a) What is low-pass IIR digital filter ?                                              3

   (b) If a system has output $y(n)$ for an input $x(n)$ related by $y(n) = \log_e[x(n)]$, then determine whether it is memory less or stable.                              4

   (c) Compute the energy of the following length-N-sequence

   $$x(n) = \cos\left(\frac{2\pi k n}{N}\right) \text{ for } 0 \leq n \leq N-1 .$$                      3

6. (a) What are the properties of Twiddle factor $W_N$ ?                                   2

   (b) Prove that the convolution sum operation is commutative and distributive.          4

   (c) Give the definition of Region of Convergence (ROC).                                2

   (d) Determine the z-transform of a unit impulse function.                              2

## [Practical]

Answer *any one* of the following: 1×20=20

1. a. Write a python program to generate and plot the real valued exponential sequence

   $x(n) = (1.5)^n u(n)$ for $0 \leq n \leq 50$. 10

   b. Write a python program to compute the convolution sum of a rectangle signal with itself for $N = 6$. The rectangle signal is given by 10

   $$x(n) = rect\left(\frac{n}{2N}\right) = \begin{cases} 1 & -N \leq n \leq N \\ 0 & \text{otherwise} \end{cases}$$

2. a. Write a python program to generate and plot the unit step sequence $u(n)$ for $0 \leq n \leq 50$. 10

   b. Let *x(n)* be a 4-point sequence :

   $$x(n) = \left\{ \begin{matrix} 1, 1, 1, 1 \\ \uparrow \end{matrix} \right\} = \begin{cases} 1 & 0 \leq n \leq 3 \\ 0 & \text{otherwise} \end{cases}$$

   Write a python program to compute and plot the 4-point DFT of *x(n)*. 10

3. a. Write a python program to generate and plot the ramp sequence *r(n)* for $0 \leq n \leq 50$. 10

   b. Write a python program to design a low pass filter with a pass band gain of unity and cut off frequency of 1 KHz using a rectangular window. The filter works at a sampling frequency of 5 KHz and the length of the impulse response is taken as *M = 17*. 10

   N.B. : Students are requested to write the python program and don't need to plot any figure.

———————

*Or*
## Experimental Techniques

### [Theory]

Answer *any two* of the following: 2×15=30

1. (a) Write down a short note on classification of errors in measurements on the basis of causes of error and magnitude of errors.

 (b) Count total number of significant figures in the following measurements:

 (i) 4.080 cm (ii) 0.079 m (iii) 9500 (iv) 10.00 cm (v) 4.07080 (vi) $7.090×10^5$.

 (c) Round off the following numbers to three significant figures:

 (i) 7.367 (ii) 8.3251 (iii) 9.4450 (iv) 9.4350 (v) 15.7500 (vi) 24572

 (3+6)+3+3) = 15

2. a) What do you mean by grounding and shielding of an electrical system? Discuss different methods of system level grounding. 2 + 4

 b) Give an analogy among RTD, Thermistor, and Thermocouples 6

 c) Define Q-meter and discuss its application. 3

3. (a) What do you mean by pumping speed of a rotary pump? Show that pumping speed of a rotary pump $S = \dfrac{v_o}{(t_2 - t_1)} \ln\left(\dfrac{p_1}{p_2}\right)$. Where, $v_o$ is the volume of the chamber, $p_1$ and $p_2$ are pressure of the chamber at time $t_1$ and $t_2$ respectively.

 (b) A rotary pump removes air from a 300-litre chamber at the rate of 0.5 litre/sec. What would be the pressure in the chamber after 20 sec if the initial pressure were 1 atm.

 (c) Explain with diagram the working principle of the rotary (mechanical)vacuum pump. What is the working pressure range of rotary pump ?

$$(2+4) + 2+ (5+2) = 15$$

4. (a) What do you mean Transducer? Give two examples of (i) Mechanical transducer (ii) Temperature transducer (iii) Electrical transducer.

   (b) Explain with diagram the working principle of Linear Variable Differential Transformer (LVDT) and show the variation of output voltage with core displacement of LVDT. Also write down advantages and disadvantages of LVDT.

$$(2+3) + (4+2+2+2) = 15$$

Answer *any one* of the following:                    1×10=10

5. a) Discuss frequency response analysis of a first order linear device.

   b) What do you mean by signal to noise ratio? Write a short note on Shot noise.

$$6+4$$

6. What is piezoelectric effect. How piezoelectricity works. Name two natural and two man made piezoelectric materials. Give four applications of piezoelectricity.

$$(2+2+2+4)=10$$

**[Practical]**

Answer *any one* of the following:                    1×20=20

1. Write down the working formula and methodology to measure the temperature of ambient using Platinum Resistance Temperature Device (RTD).

2. Write down the procedures to create vacuum in a small chamber using a mechanical (rotary) pump and determine the pumping speed of the rotary pump.

3. What is ultrasonic transducer? Describe the methodology to study the distance measurement using ultrasonic transducer.

———————

## *Or*
## Biological Physics

### [Theory]

Answer *any four* of the following: 4×15=60

1.  a)  Write down the roles of mitochondria.

    b)  Write down the differences between prokaryotic and eukaryotic cells with examples.

    c)  Write down and explain in a few sentences about the distinctive biological properties or processes exhibited by living organisms.

    d)  Write down the name of molecules which are known as molecules of life.

    e)  What is stem cell? 3+3+3+3+3

2.  a)  Discuss about the biological time scales associated with the various biological processes with necessary diagrams and examples.

    b)  Briefly discuss about the length scales associated with the biological systems.

    10+5

3.  a)  Compare Darwin model and Lamark theory of evolution.

    b)  Explain in the light of the above theory, why humans no more have a tail today.

    c)  Sex expression in mammals (including humans) is controlled by the X and Y chromosomes. Females are XX and males are XY. Since cells of the body contain 46 chromosomes, mom must give 23 to baby (1 sex+22 body) and dad must give 23 (1 sex +22 body) as well. Write down the relevant genotype and phenotype. If mom and dad have 8 kids, what are the expected number of boys and girls?

    5+5+5

4.  a)  Draw the complete flow chart, describing how a stem cell gives rise to various organs.

b) Explain in brief how it is determined that an unspecialized cell will divide itself into so many specialized cells in our body? 10+5

5. a) What do you understand by bacterial chemotaxis? Explain clearly with diagram.

b) Explain the mechanism of chemotaxis.

c) Explain the elasticity of polymer chains in the light of Random Walk model.

3+5+8

6. a) What do you mean by Operon?

b) What is CAP and Lac repressor?

c) Describe the working principle of the genetic circuit that controls the production of enzymes responsible for digesting sugar lactose. 3+4+8

7. Find out the probability of the RNA polymerase binding to the promoter sites by using a suitable statistical model. 15

8. a) Discuss the diffusive dynamics in a cell with some examples.

b) Explain how diffusion time is related to the distance with an example.

c) Establish the law of diffusion from Fick's law. 4+3+8

————————