

**VIT**

Vellore Institute of Technology

**Final Assessment Test (FAT) – May 2022**

Programme	B.Tech	Semester	Winter Semester 2021-22
Course Title	SIGNAL PROCESSING IN ROBOTICS	Course Code	ECE2036
Faculty Name	Prof. E. Sathish	Slot	B2+TB2
		Class Nbr	CH2021225000542
Time	3 Hours	Max. Marks	100

**Section A (5 X 10 Marks)****Answer All questions**

1. Recall about amplitude scaling, time shifting and time scaling operations on signal with a suitable example. (4 Marks)

**[10]**

Consider a discrete signals  $x[n] = [3, 2, 1, 0, 1, 2, 3]$  and  $y[n] = [-1, -1, -1, 0, 1, 1, 1]$ . With the neat sketches identify the following (6 Marks)

i.  $x[n-2] + y[n+2]$

ii.  $x[n-2] \cdot y[6-n]$

iii.  $x[-n] \cdot y[-n]$

2. 1) Figure 6 shows the input signal and a reconstructed signal, where N represents the order of Fourier series. Discuss the reasons for its overshoot at jump discontinuity and remedial measures to avoid it. (4 Marks)

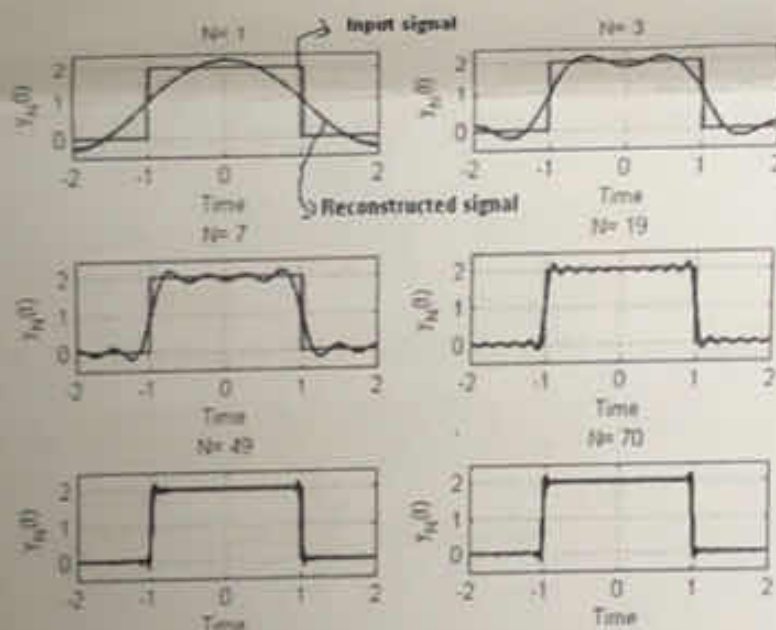
**[10]**

Figure 6

$$\frac{3}{e^{-4t}}$$

$$\frac{1}{6\tau a_0}$$

$$e^{-4t} \cdot 3e^{-4t} = 3e^{-8t}$$

$$x(t) = 3e^{-8t} - 3e^{-8t} = 0$$

- 2) Illustrate and Verify Parseval's theorem for  $x(t) = 3e^{-2t}u(t)$  (6 Marks)

3. Identify Laplace transform and possible ROC's of the  $x(t) = 6e^{2t}u(t) - 4e^{-2t}u(-t)$ . with a neat, comment on the nature of signal with respect to stability and causality.

**[10]**

4. Discuss in brief on encoding. Perform encoding on the signal shown in Figure 1, for which the discrete sample values are given in Table 1. Assume the amplitude values range from  $V_{min} = -8$  to  $V_{max} = 8$ . Assume each sample is represented using 5 bits.

**[10]**

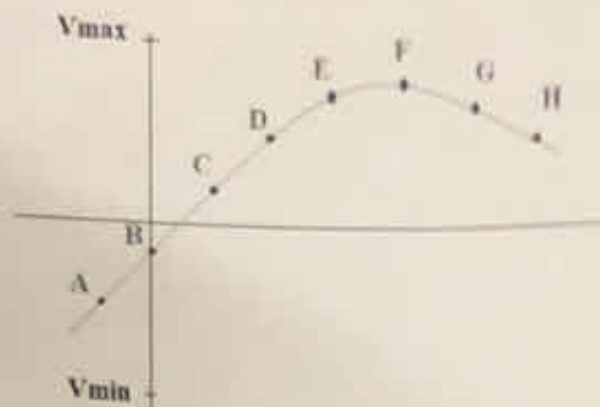


Figure 1. Signal for encoding

Table 1: Discrete sample values for waveform in Figure 1

A	B	C	D	E	F	G	H
-3.7	-1.4	1.9	3.2	4.6	4.8	4.3	3.4

Discuss in detail about spatial filters with box filter, weighted average, median, minimum and maximum. Consider an image with  $5 \times 5$  pixels has the intensity distribution as shown below. If smoothing is done for  $3 \times 3$  neighbourhood, calculate the output of pixel  $2 \times 2$ .

$$\text{Image} = \begin{bmatrix} 1 & 8 & 8 & 0 & 7 \\ 4 & 7 & 9 & 5 & 7 \\ 5 & 4 & 6 & 8 & 6 \\ 4 & 2 & 0 & 1 & 5 \\ 0 & 1 & 0 & 2 & 0 \end{bmatrix}$$

#### Section B (3 X 15 Marks)

##### Answer All questions

- 1) Discuss in brief about the robotics in space and underwater applications and its future. (10 Marks) [15]
- 2) Point out the social issues arising due to robotic automation in industrial applications (5 Marks)
7. Interpret the necessary sensors and actuators on marked spots of the humanoid robot in Figure 5. Explain them in detail. [15]

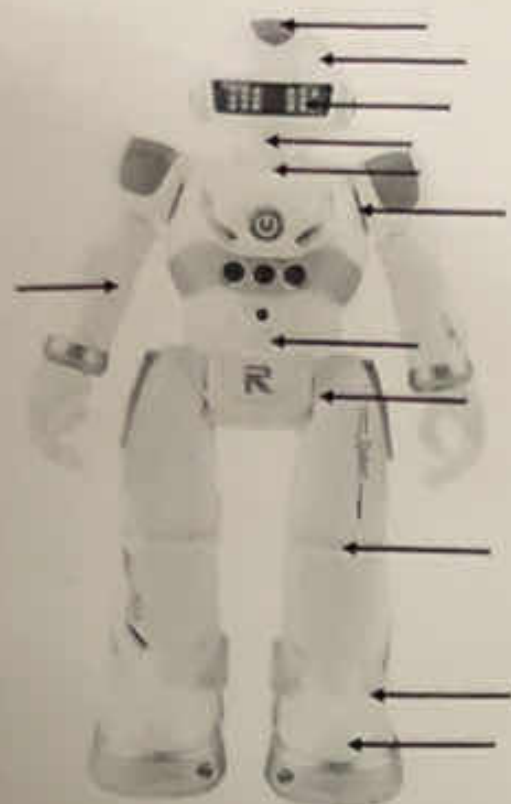


Figure 5 Humanoid robots marked for choice of sensors and actuators

- ✗ A 80 RPM motor is connected to a 100-tooth gear that couples in turn to an 80-tooth gear that directly drives a 40-tooth gear. The 50-tooth gear drives a 150-tooth gear. If the latter is connected by a shaft to a final drive, Calculate the speed in RPM? (5 Marks) [15]

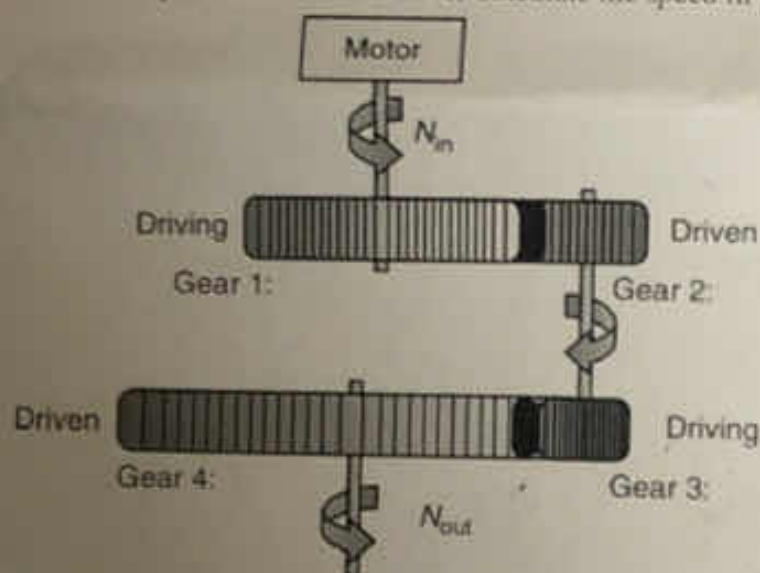
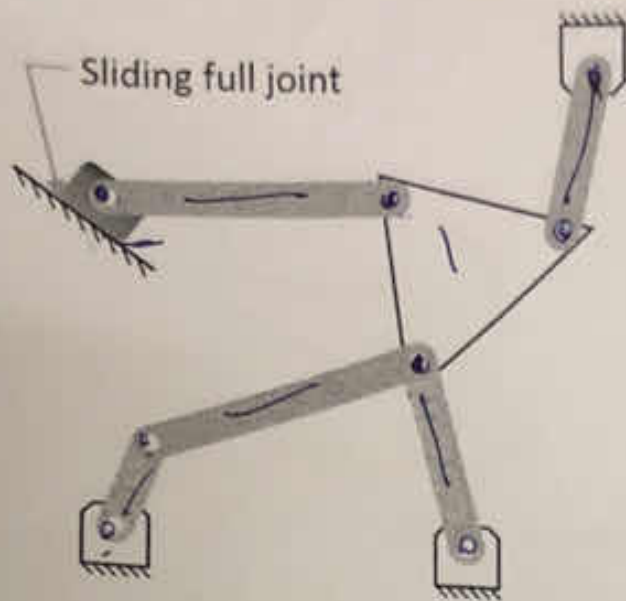


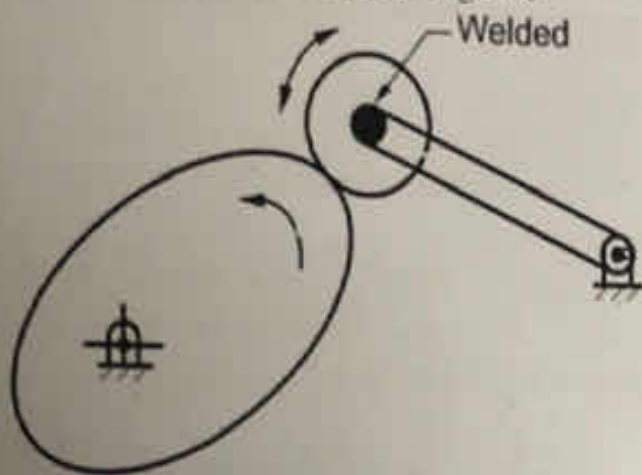
Figure 2: Gear arrangements

- ✗ Calculate the Degrees of Freedom (DoF) of the mechanism shown in Figure 3 and 4 using Kutzbach's Criteria (10 Marks)



$$3(7) + 18$$

Figure 3. Structure for calculating DoF



$$4 - 3(3) - 2(3) - 1$$

Figure 4. Structure for calculating DoF

Section c (1 X 5 Marks)

Answer All questions

9. A quartz crystal with young's modulus of  $9 \times 10^{10} \text{ N/m}^2$  with piezo-electric properties has a diameter of 10 mm and thickness of 2 mm. Its voltage sensitivity constant is 4500 V/m. If the voltage output is 127.3 V, Calculate the applied load.

[5]

$$m \cdot \frac{d^2 x}{dt^2} + \frac{1}{2} \frac{d^2 x}{dt^2}$$

$$d \cdot \frac{d^2 x}{dt^2}$$

$$Y \times \pi r^2 x$$