Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

DEPARTMENT OF MECHATRONICS

FIRST SEMESTER M.TECH. (MECHATRONICS)

END SEMESTER EXAMINATIONS, JANUARY 2023

SUBJECT: SIGNAL PROCESSING AND APPLICATIONS [MTE 5008]

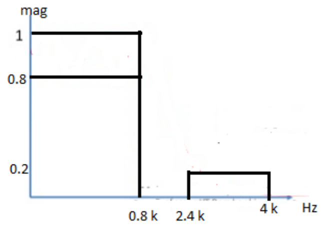
(03/01/2023)

Time: 3 Hours **MAX. MARKS: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- *Data not provided, may be suitably assumed*

Q. No		M	CO	PO	LO	BL
1A.	Determine whether the following signals are periodic. If they are periodic, find the fundamental period (a) $x_1[n] = cos(n)$ (b) $x_2[n] = \cos\left(\frac{1}{5}\pi n\right) \sin\left(\frac{1}{3}\pi n\right)$ (c) $x_3[n] = \sum_{k=-\infty}^{\infty} \delta[n-3k]$ (d) $x_4[n] = 2\sin(\pi^2\ n)$	4	1	1	1	3
1B.	Estimate the signal energy and signal power for the discrete-time signal (a) $y[n] = r\ [n]$ (b) $x[n] = \left(\frac{1}{2}\right)^n u[n]$	3	1	2	2	5
1C.	Compute 4 pt DFT of causal sequence given by $$x(n) = \begin{cases} \frac{1}{3}; 0 \le n \le 2 \\ 0; otherwise \end{cases}$$	3	2	2	2	5
2A.	Calculate $h_d(n)$ for a High Pass FIR filter with N=7, and $\omega_p = 2\, rad$.	3	3	3	5	5
2B.	Compute $H(z)$ using the impulse invariant technique for the analog system function $$H(s) = \frac{1}{(s+0.5)(s^2+0.5s+2)}$$ Assume $T = 1s$.	4	3	3	2	6

2C	For the given specifications of digital IIR filter, find the optimal order of the filter.  	**3**	**3**	**3**	**5**	**5**
3A.	Design a digital Butterworth filter that satisfies the following constraint using bilinear transformation. Assume $T = 1s$. $0.9 \leq \lvert H(e^{jw}) \rvert \leq 1, \quad 0 \leq w \leq \pi/2$ $\lvert H(e^{jw}) \rvert \leq 0.2, \quad 3\pi/4 \leq w \leq \pi$	**5**	**3**	**3**	**5**	**6**
3B.	Convert the analog filter with transfer function $H_a(s)$ to digital filter using bilinear transformation. $H_a(s) = \dfrac{(s+0.1)}{(s+0.1)^2+9}$	**3**	**3**	**2**	**2**	**3**
3C.	Draw the magnitude response of the filter for the given digital specifications Lower stopband edge = 200 Hz Lower passband edge = 100 Hz Upper stopband edge = 300 Hz Upper passband edge = 700 Hz Stopband attenuation = 35 dB Passband ripple = 0.3 dB Sampling frequency = 3kHz	**2**	**3**	**2**	**2**	**3**
4A.	A low frequency hum is getting interfered in a vocal recording, and as a sound engineer, you are asked to design a filter to remove those unwanted signals. The digital specifications of the required filter are given below. Stop band ripple $\leq 10\ dB$ Pass band edge = 150Hz Pass band attenuation > 2dB Stop band edge =100Hz Sampling frequency =1kHz	**5**	**3**	**3**	**5**	**5**
4B.	Consider an LTI system, initially at rest, described by the difference equation $y(n) = 0.25y(n-1) + 0.5y(n-2) + 2x(n) - 0.7x(n-1) + 0.2x(n-2)$ i) Determine the transfer function of the system. ii) Construct the direct form I and direct form II realization of this system and comment on the requirement of delay elements for the realization	**3**	**3**	**3**	**5**	**5**
4C.	Design the transfer function of 4^{th} order LPF using Butterworth approximation.	**2**	**3**	**2**	**5**	**5**

5A.	A linear phase digital filter is to be designed with 11 coefficients for the following specifications Passband cut off frequency = 0.50kHz Sampling Frequency = 2 kHz i) Identify whether it a low-pass or high-pass. Justify your answer ii) Determine the impulse response $h(n)$ for Hanning window. Comment of the responses.	**4**	**3**	**3**	**5**	**5**
5B.	With proper design steps compute the transfer function of an analog filter using Butterworth approximation method, for the given specifications. Use impulse invariant transformation. $0.8\,6 \leq \mid H(\omega) \mid \leq 1; \quad 0 \leq \mid \omega \mid \leq 0.25\pi$ $\mid H(\omega) \mid \leq 0.3; \quad 0.35\pi \leq \mid \omega \mid \leq \pi$	**3**	**3**	**3**	**5**	**6**
5C.	EEG (electroencephalogram) is a non-invasive technique used to measure the brain's electrical activity by detecting the voltage fluctuations on the scalp. Describe the various signal processing methods which could be adopted for analyzing such signals. Comment on the various applications for which those signal processing methods could be employed.	**3**	**4**	**2**	**2**	**6**