Reg. No.



MANIPAL INSTITUTE OF TECHNOLOGY

(A constituent unit of MAHE, Manipal 576104)

1st SEMESTER M. Tech. (BME) DEGREE END SEM EXAMINATIONS FEB/MAR 2021.

SUBJECT: ADVANCED BIOMEDICAL SIGNAL PROCESSING ANALYSIS AND MODELING (BME 5151) (REVISED CREDIT SYSTEM) Friday, 26th February 2021, 2 PM to 5 PM

Instructions to Candidates:

TIME: 3 HOURS

MAX. MARKS: 50

Answer ALL questions.
Draw labeled diagram wherever necessary

- 1. a) A biomedical signal is bandpass filtered to the range 0 150 Hz. Assume the filter to be (5M) ideal and assume any distribution of spectral energy over the bandwidth of the signal. (i) what is the minimum frequency at which the signal should be sampled to avoid aliasing error? (ii) A researcher samples the signal at 500 Hz. Draw a schematic representation of the spectrum of the sampled signal. (iii) Another researcher samples the signal at 200 Hz. Draw a schematic representation of the spectrum of the spe
 - b) Explain how one may apply ensemble averaging and temporal (time) averaging (5M) procedures to process ECG signals. Identify applications of both types in ECG.
- 2. a) Design an optimal filter to remove noise η(n) from a signal x(n) = d(n) + η(n), given (5M) that the desired signal d(n) and noise processes η(n) are independent, stationary random processes. You may assume that the "desired" characteristics of the uncorrupted signal are known. The noise characteristics may also be assumed to be known.
 - b) You have been hired to develop a software package for the analysis of 10-channel EEG (5M) signals to detect the spike-and-wave complexes of a prespecified shape in any channel. Design signal processing package to address this problem by providing the following details: (i) A schematic block diagram representing the various signal processing steps that you recommend. (ii) Explain each block with a reason or logic behind your recommendation.

- 3. a) Draw a block diagram representing various steps in the Pan-Tompkins method to detect (5M) QRS complexes in ECG signals. Explain the purpose and nature of each step in the procedure, including detection of the peaks in the output corresponding to the QRS complexes. (*No equations are required in your answer*)
 - b) Explain step-by-step to obtain an averaged periodogram when you are given only a single (5M) record of duration.
- 4. a) A model is described by the relationship y(n) = x(n) + 0.5x(n 1) + 0.25x(n 2), (5M) where x(n) is the input and y(n) is the output. (i) What is the type of this system among Autoregressive (AR), Moving Average (MA) and ARMA systems? Justify. (ii)What is the model order? (iii) What is the system function? (iv) Draw the pole-zero diagram of the system and comment on the stability of the system?
 - b) Given a noisy observation of the output of a linear system in response to a certain input, (5M) develop an iterative system identification-based method to estimate the numerator and denominator polynomials of the system function.
- 5. a) Describe the characteristics of PCG signals that would make them nonstationary. Propose (5M) signal processing strategy to break a PCG signal into quasi-stationary fixed segments.
 - b) Describe the characteristics of EEG signals that would make them nonstationary. Propose (5M) signal processing strategies to break a EEG signal into quasi-stationary segments of variable duration.