Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 1st Term Examination, 2021
Department of Biomedical Engineering

BME 3111
Biomedical Signal Processing

Time: 3 Hours **Full Marks: 210**

N.B. i) Answer **any THREE** questions from each section in separate scripts
ii) Figures in the right margin indicate full marks.

Section A

(Answer **ANY THREE** questions from this section in Script A)

1. a) What is biosignal? Classify biosignals with example. Enumerate the objectives of biomedical signal analysis. (10)
   b) Illustrate the flow diagram of a modern computer-aided diagnosis system for biomedical signal analysis and briefly describe each step. (13)
   c) Explain why the P and T waves are low frequency signals whereas the QRS complex is a high frequency signal. Include diagrams of action potentials and ECG waveform in your reasoning. (12)
2. a) List four potential sources of instrumentation and physiological artifacts in recording ECG signal. Describe methods to prevent or remove each artifact. Identify the possible undesired effects of your procedures on the ECG signal. (12)
   b) What is temporal averaging? Write down the input-output relationship of a 8-point MA filter. Determine the impulse response, the transfer function, and the frequency response of a Hann filter and draw its signal-flow diagram. (13)
   c) What are the advantages and disadvantages of derivative-based operators? How can you improve the performance of the basic first-order difference operator as a filter? (10)
3. a) Enumerate the different specifications of a filter. In which cases are frequency-domain fixed filtering applicable? (10)
   b) Why is the Butterworth filter commonly used? A signal sampled at 1000 Hz contains periodic artifact with fundamental frequency at 60 Hz and odd harmonics at 180 Hz, 300 Hz, and 420 Hz. Design a comb filter to remove the periodic artifact. (14)
   c) Why event detection is important in biomedical signal analysis? Mention the typical values of nerve conduction velocity in different parts of the human body for recording ENG. (11)
4. a) What is neuropathy? Draw and label the PCG, ECG, and CP signals of a typical adult as a function of time. (10)
   b) Propose an algorithm to detect QRS complexes in an ongoing ECG signal. (15)
   c) What is the second derivative of $y_o(n) = |x(n) - x(n-2)|$? List a few events and transients that occur in the EEG signal. (10)

Section B

(Answer **ANY THREE** questions from this section in Script B)

5. a) What is digital filter? Describe the advantages and limitations of digital filters over analog filters. (12)
   b) Define FIR filter and IIR filter. What are the properties of FIR and IIR filters? Describe the criteria for choosing FIR and IIR filters. (13)
   c) An FIR low pass filter is to be designed to meet the following frequency response specification: (10)
   Cutoff frequency – 0.40 (normalized)
   Transition width – 0.03 (normalized)
   Stopband deviation – 0.001
   Passband deviation – 0.05
   (i) Sketch the tolerance scheme for the filter.
   (ii) Express the filter edge frequencies in standard unit of kilohertz assuming a sampling frequency of 12 kHz and the stopband and passband deviations in decibels.

6. a) Briefly discuss the conditions for a realizable digital filter to have a linear phase characteristics. An FIR digital filter has an impulse response, $h(n)$, defined over the interval $0 \leq n \leq N-1$. Show that if $N=7$ and $h(n)$ satisfies the symmetry condition $h(n) = h(N-n-1)$, the filter has a linear phase characteristics. (12)

b) What is finite word length effect? Describe the ways in which finite word length affect the performance of FIR digital filters. (10)

c) Obtain the coefficient of an FIR lowpass filter to meet the following specifications using window method: (13)
Passband edge frequency 1.5 kHz
Transition width 0.5 kHz
Stopband attenuation > 50 dB
Sampling frequency 8 kHz

7. a) A bandpass digital filter is required to meet the following specifications: (20)
(i) Complete signal rejection at dc and 250 Hz
(ii) A narrow passband centered at 125 Hz
(iii) A 3dB bandwidth of 10 Hz
Assuming a sampling frequency of 500 Hz, obtain the transfer function of the filter, by suitably placing z-plane poles and zeros; filter coefficients, its difference equation, and block diagram representation.

b) The normalized transfer function of an analog filter is given by (15)

$$H(s) = \frac{1}{s^2 + \sqrt{2}s + 1}$$

Obtain the transfer function $H(z)$, of an equivalent digital filter using the matched z-transform. Assume a 3dB cutoff frequency of 150 Hz and a sampling frequency of 1.28 kHz.
For a complex conjugate poles

$$(S - P_1)(S - P_2) \rightarrow 1 - 2e^{P_r T}\cos(P_i T)\, z^{-1} + e^{P_r T} z^{-2}$$

Where P_r, $P_i \rightarrow$ real and imaginary parts of poles.

8. a) Explain how we can implement IIR filters. (10)

b) Illustrate spectral leakage and spectral smearing with suitable example. What is the reason behind these phenomena? How can we overcome these? (12)

c) Categorize spectrum estimation techniques. Hence describe the autoregressive spectrum estimation technique. (13)

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BME 3103
Bioelectricity

Time: 3 Hours **Full Marks: 210**

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Section A

(Answer **ANY THREE** questions from this section in Script A)

1. a What is bioelectricity? Write down some applications of bioelectricity and bioimpedance. (10)

b Distinguish between active and passive conduction. Briefly explain the process of saltatory conduction in neurons. (12)

c Deduce the Nernst equation for an ion traversing the cell membrane. Calculate the Nernst potential for Na^+, K^+, and Cl^- ions at room temperature from the following table: (13)

Ion	Concentration (mM)	
	Inside cell	Outside cell
Na^+	20	120
K^+	139	2.5
Cl^-	3.8	120

2. a) What is thresholding? Briefly explain different types of patch clamp methods. (10)

b) Briefly explain the excitability of neurons in response to various command voltages. (10)

c) Define voltage dependent ion channel. Classify it with examples. (10)

d) Write a short note on semipermeable membrane. (05)

3. a) Determine the equivalent circuit of the cell membrane using a graphical representation and explain it in brief. Also, write down the cable equation. (10)

b) What are the limitations removed by the Hodgkin-Huxley model? Draw the equivalent circuit and the mathematical equation of the Hodgkin-Huxley model. List the predictions made by this model. (12)

c) Define space clamp and classify it. Discuss the time constant for a cylindrical axon in brief. (08)

d) Write a short note on chronaxie. (05)

4. a) What are the limitations of commercial deep brain stimulator device? Propose the design of a device for epileptic patients that can overcome these limitations. (15)

b) What is addiction? Discuss the role of dopamine in addiction. (10)

c) Illustrate the effect of neurodegeneration in direct and indirect pathway of Parkinson's disease. (10)

Section B

(Answer **ANY THREE** questions from this section in Script B)

5. a) Describe the possible approaches to the solution of Inverse Problem in bioelectric modeling. (12)

b) What is sensitivity field? How many types of sensitivity fields are there for bioimpedance? Calculate the sensitivity field from FIM. (13)

c) Define electrode. Briefly describe the different types of electrodes for bioelectric signals acquisition. (10)

6. a) How can you measure bioimpedance using the TPIM method? Explain with appropriate diagram. Mention the advantages and disadvantages of TPIM. (12)

b) Describe two thorax models to investigate the origin of the impedance signal with the help of schematic illustrations. (12)

c) What are the purposes of modeling biological systems? How many ways can you model volume sources? (11)

2. a) Explain four different steps of 16 electrodes cross method of EIT for bioimpedance measurement with neat sketch. (12
   b) Derive the equation of numerical simulation of bioimpedance phenomenon. (10
   c) Define transfer impedance. Describe the advantages and disadvantages of different versions of FIM. (08
   d) Sketch an equivalent circuit for a pair of electrodes attached on skin for AC current. (05

3. a) Explain the behavior of skeletal muscle tissue impedance using cole-cole plot. (10
   b) Describe the effect of electrodes on impedance plethysmography. (07
   c) Mention clinical applications of EIT. (10
   d) Explain the relationship between specific conductivity and frequency for fat, blood, and bone marrow. (08

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BME 3101
Cell Biology

Time: 3 Hours **Full Marks: 210**

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Section A

(Answer **ANY THREE** questions from this section in Script A)

1.	a)	Define appendages. Mention the differences between the gram-positive and gram-negative bacteria.	(10)
	b)	Describe the fluid mosaic model of cell membrane. Write down the functions of cell membrane.	(15)
	c)	What is meant by cellular transport? Explain the mechanism of active transport with a neat sketch.	(10)
2.	a)	Write short notes on: (i) microtubules and (ii) intermediate filament.	(10)
	b)	Define and classify cell junction. Describe adherens junction and focal adhesion.	(15)
	c)	Write down the steps of collagen synthesis.	(10)
3.	a)	Define and classify receptors. Describe the structure of serpentine receptor.	(15)
	b)	Mention the differences between nuclear-receptor-dependent signal molecules and cell-surface-receptor-dependent signal molecules.	(10)
	c)	Write down the name of different intracellular signaling pathway. Describe cAMP pathway.	(10)
4.	a)	Draw and label the double helix DNA with short description.	(10)
	b)	Write short notes on: (i) electron transport chain, (ii) second messenger, and (iii) gene.	(15)
	c)	Write down cell cycle function of cyclins and cyclin dependent kinases. Calculate the total ATP production from one glucose molecule in cellular respiration process.	(10)

Section B

(Answer **ANY THREE** questions from this section in Script B)

5.	a)	Who is Edward Jenner? What are the contribution of Edward Jenner in immunology?	(05)
	b)	Explain the Koch's postulates with its limitations in medical field.	(10)
	c)	List the first line defense of your body. Draw and label a macrophase with its function.	(10)
	d)	What is complement? How the compliments are activated in classical pathway? Describe with diagram.	(10)
6.	a)	What are the chemical nature of antigen? Draw and label the structure of an antibody.	(10)
	b)	Mention the differences between acute and chronic inflammation.	(10)
	c)	What is meant by graft? What are the types of graft?	(05)
	d)	Write down the applications of scanning electron microscope.	(10)
7.	a)	List the characteristic features of IgM with a diagram.	(07)
	b)	Write down the causes of immune deficiency. Describe the pathophysiology of immune deficiency.	(14)
	c)	Write down the mechanism of anaphylaxis with some example of anaphylactic diseases.	(14)
8.	a)	Draw the graph of IgG and IgM detection after dengue infection.	(10)
	b)	List the cell culture methods. How is cultured cell calculated in Neubauer counting chamber?	(10)
	c)	What is flow cytometry? Explain the optical system and fluidics system of flow cytometry with neat sketch.	(15)

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CSE 3115
Microprocessors and Microcontrollers

Time: 3 Hours **Full Marks: 210**

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Section A
(Answer **ANY THREE** questions from this section in Script A)

1. a) Explain the internal block diagram of the 8086 microprocessor with appropriate figure. (15)

b) Assume the following register status (all in hex): (15)
DS = 3000, SS = 2000, BX = 023B, BP = 012A, DI = 0020, SI = 0010
For each of the following memory location operand-
(i) [BP + 1A]
(ii) [BX] [DI] + 5
(iii) [DI + 9]
(iv) [BP] [SI]
(v) [SI + 7]
(vi) [BX - 5]
Compute its offset and absolute address.

c) Which feature does determine whether a microprocessor is considered as 16-bit or 32-bit device? (05)

2. a) Specify Macros. Explain how you can pass parameters to macros with necessary examples. (10)

b) What are the sources of 8086 interrupt? Show the 8086 interrupt response with appropriate figure. (10)

c) What is interrupt pointer table? At what address should vector, CS30, and IP30 (ISR information for INT 30) be stored in memory? Assume CS contains AABBH and IP contains 000CH then calculate the physical address. Draw necessary figure(s). (10)

d) What happens if two interrupts appear at the same time in 8259A? (05)

3. a) Give a comparison between CISC and RISC processes. A program with 80% of executed instructions being simple and 20% complex. For CISC, simple instructions take 4 cycles, complex take 6 cycles, cycle time = 80 ns. For RISC, simple instructions take 1 cycles, complex take 12 cycles, cycle time = 60 ns. How much time is required for a program with 1 million instructions? (12)

b) Illustrate pipelining and dual-pipelining to achieve instruction-level parallelism using necessary figures. (10)

c) What are Neural Implants? Describe the working principle of it with necessary figure(s). (13)

4. a) Where should you prefer RISC machine over CISC machine? Explain. (07)

b) Draw Bus action in memory read and write operations of 8086 with four states. (10)

c) Demonstrate the different advantages of bit-slice microprocessors. (08)

d) Differentiate between microprocessor and microcontroller with an appropriate block diagram. (10)

Section B

(Answer **ANY THREE** questions from this section in Script B)

5. a) Draw the block diagram showing how a DMA controller operates in a microcomputer system? Explain the operation of a DMA controller. (12)

   b) How do we solve limited memory problems in microprocessors? Explain the methods to solve the limited memory problems. (11)

   c) What is virtual memory? How the MMUs in the 80286 processor manage segment-based virtual memory? (12)

6. a) What is pull up register? How can you select register banks of 8051 microcontroller? (10)

   b) Explain the operations of Interrupt Enable Register and Interrupt Priority Register with appropriate figure(s). (08)

   c) Write short notes on: (10)
      (i) Virtual addresses
      (ii) Linear addresses
      (iii) Physical addresses.

   d) How does 8255A work in I/O mode? (07)

7. a) Illustrate the salient features of 8051 microcontroller. (05)

   b) Write down the 8051 CPU registers and describe the program status register of 8051. (10)

   c) Write down the differences between 80386DX and 80386SX. (10)

   d) Describe the memory management unit of 80386. (10)

8. a) Briefly explain the architectural block diagram of 8051 microcontroller. (10)

   b) Describe the general-purpose registers of 8089. (05)

   c) Calculate the data storage of RAM and ROM in a 8051 microcontroller. (10)

   d) Define scratch pad RAM. In RAM memory space allocation in the 8051, which term defines the collection of general-purpose registers? Explain with appropriate figures. (10)