Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 1st Term Regular Examination, 2022
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 biomedical signal processing? Briefly describe the difficulties encountered in biomedical signal acquisition and analysis. (13)

b) Draw the waveform corresponding to two cycles of a typical ECG signal and indicate the following waves and periods: (i) the P, QRS, and T waves, (ii) the RR interval, (iii) atrial contraction, (iv) atrial relaxation, (v) ventricular contraction, and (vi) ventricular relaxation. (12)

c) What is myopathy? Identify the EEG sub-bands and their associated frequency ranges, while briefly explaining the occurrences of these sub-bands. (10)

**2.** a) Propose a time-domain technique to remove random noise given the possibility of acquiring multiple realizations of the signal or event of interest. (13)

b) Illustrate PCG, ECG, and CP signals as a function of time and identify the beginning of $S_1$. (10)

c) Design a notch filter for removing powerline interference at 50 Hz of an ECG signal sampled at 1000 Hz. (12)

**3.** a) Write down an algorithmic description of synchronized averaging. Plot the impulse response of a Hann filter. (08)

b) How can you improve the performance of the basic first-order difference operator as a filter to remove low-frequency noise without distorting the QRS complex? (10)

c) Determine the transfer function of a $4^{th}$ order Butterworth low pass filter with 40 Hz cutoff frequency and 200 Hz sampling frequency in the Laplace Domain. Identify the poles of interest and show them in the s-plane. (17)

**4.** a) What is an epoch? Explain a basic peak-searching algorithm. (10)

b) Explain the problem addressed by the Pan-Tompkin's algorithm and provide a concise description of the algorithm, including relevant mathematical formulations. (15)

c) Distinguish between ensemble averages and temporal averages. Identify application of first order and second order averages of both types in EEG analysis. (10)

# Section B

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

5. a) Illustrate spectrum estimation. Why it is essential in biomedical signal processing? Briefly describe the pitfalls of nonparametric spectrum analysis. (15)

   b) List the names of different spectrum estimation techniques. Hence describe the auto regressive spectrum estimation technique. (13)

   c) What is windowing? Illustrate how it affects the estimation of spectrum with a suitable example. (07)

6. a) Define filter. Briefly describe the advantages and disadvantages of digital filters over analog filters. (10)

   b) What is the tolerance scheme of filter? Illustrate tolerance scheme of a band pass filter. (08)

   c) An FIR filter has impulse response, h(n), defined over the interval $0 \leq n \leq N-1$. Show that if N=8 and h(n) satisfies symmetry condition h(n) = h(N-n-1), the filter has a linear phase characteristics. (10)

   d) Briefly describe the attractive features of different co-efficient calculation methods of FIR filters. (07)

7. a) Show that the impulse response h(n) of an ideal low pass filter has a sinc shape with non-casual and infinite in duration. (10)

   b) What is finite word length effect? How does the finite word length impact the performance of FIR digital filters? Describe in brief. (10)

   c) Using the pole-zero placement method to calculate coefficients of a notch filter obtain, by pole-zero replacement method, the transfer function and the difference equation and structure of a simple digital notch filter that meets the following specifications: (15)

   Notch frequency: 50 Hz
   3 dB width of Notch: ±5 Hz
   Sampling frequency: 500 Hz.

8. a) Applying the impulse invariant method, design a digital filter to approximate the normalized analogue transfer function $H(s) = \frac{1}{s^2 + \sqrt{2}s + 1}$. (25)

   Obtain the transfer function, $H(z)$ and structure of the digital filter assuming a 3 dB cutoff frequency of 150 Hz and a sampling frequency of 1.28 kHz. In case of a complex conjugate pole pair.

   $$H(z) = \frac{2C_r - \left[C_r \cos(P_i T) + C_i \sin(P_i T)\right] 2e^{P_r T} z^{-1}}{1 - 2e^{P_r T} \cos(P_i T) z^{-1} + e^{P_r T} z^{-2}}$$, where $C_r$, $C_i$, $P_r$, and $P_i$ are real and imaginary parts of constant and poles, respectively.

   b) Starting from the following s-plane equation of a low pass resistance capacitance (RC) filter, determine using the BZT method, the transfer function of an equivalent discrete time high pass filter. Assume a sampling frequency of 150 Hz and cutoff frequency of 30 Hz. (10)

   $$H(s) = \frac{1}{s+1}.$$

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**BME 3103**
**Bioelectricity**

**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 bioelectricity. Give some examples of bioelectric signals. Mention the comparison of bioelectricity and conventional electrical system. (06)
   b) Construct a simplified model to explain electrical behavior of biological tissue. What will be the effect if external ac electric field is applied to the tissue? (12)
   c) Write short notes on: (i) Isoelectric current and potential and (ii) Donnan equilibrium. (08)
   d) What does the Goldman equation predict? Calculate membrane potential for a neuron at 40° C with the following parameters. (09)

| Ion | Extracellular concentration (mM) | Intracellular concentration (mM) | Permeability |
|---|---|---|---|
| $K^+$ | 18 | 170 | 1 |
| $Na^+$ | 140 | 25 | 0.03 |
| $Cl^-$ | 115 | 15 | 0.47 |

2. a) Define postsynaptic potential. After a stimulus, the membrane potential has raised to -60 mV. Does it generate action potential? What will be its conduction process? Explain with neat sketch. (10)
   b) Describe the factors responsible for ion movement through the cell membrane. (06)
   c) What is extracellular recording? How can you perform a patch experiment? (07)
   d) Which model is used to describe the passive conduction process? Deduce the equation of that model with equivalent circuit. (12)

3. a) What will happen to the Inward current during depolarization if there is no concentration of $Na^+$ in ECM? (05)
   b) Mention the reasons behind (i) capacitive current, (ii) transient Inward current, and (iii) delayed Outward current in response stimulus. (12)
   c) Mention the significance of space constant and time constant with necessary equations. (06)
   d) On which properties does the conduction velocity of an axon depend? Compare continuous and saltatory conduction for an axon. (12)

4. a) How does the drug addiction affect the reward pathway of the brain? Discuss your answer based on the role of dopamine. (12)
   b) What causes Parkinson's diseases? Illustrate the effect of deep brain stimulation in Parkinson's disease with proper diagram. (10)
   c) How can you use bioelectricity to develop new bioelectronic medicine for cancer? Explain with necessary figure. (13)

## Section B

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

5. a) How to measure bioimpedance by the TPIM method? Explain the method with a proper diagram. Mention the advantages of TPIM. (11)

   b) What are the various electrodes used for bioelectric signal acquisition? Describe the effect of electrodes on impedance plethysmography. (11)

   c) Explain the relationship between the principles of impedance measurement and bioelectric signal measurement. (13)

6. a) Briefly explain 2-D 16 electrodes opposite method of EIT method for bioimpedance measurement with a neat sketch. Mention the advantages and disadvantages of EIT. (13)

   b) Describe the resistivity of blood as a function of hematocrit (Hct) with the help of graphical representation. (12)

   c) Explain the Culter principle for counting and sizing particles using impedance measurements. (10)

7. a) What is sensitivity field? 'To find the sensitivity for FIM, the sensitivity for the two individual tetrapolar impedance measurements is simply summed (or averages)'- Evaluate. (12)

   b) Describe the concentric spherical head model as a volume conductor. (11)

   c) Determine the stroke volume on the change in thoracic impedance. (12)

8. a) How to create a crude image in Pigeon Hole Imaging (PHI)? Explain in brief using the concept of FIM. (12)

   b) What is the forward and inverse problem in electrocardiography? Explain it with the help of schematic illustration. (10)

   c) Describe the most suitable method to illustrate the behavior of tissue impedance as a function of frequency. Explain the method briefly. (13)

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**BME 3141**
**X-ray and Ultrasound Imaging**

**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 are the differences between x-ray and γ-ray? Explain the radiation phenomenon behind the generation of x-rays using necessary diagram. (14)
   b) Illustrate the probability patterns of different interactions of x-rays with body tissues with respect to the x-ray energies and atomic numbers. (05)
   c) An incident x-ray beam penetrates through "fat + muscle + bone" layer with thickness of "1 cm + 0.5 cm + 0.7 cm" having linear attenuation co-efficient of "0.8 $cm^{-1}$ +1.2 $cm^{-1}$ + 6 $cm^{-1}$" respectively. Calculate the detected to incident x-ray ratio. (06)
   d) Briefly describe the working principle of flat panel x-ray detector. (10)

2. a) Draw the block diagram of a Digital Radiography (DR) system. What are the sources of blurring and noises in digital radiographs? (09)
   b) Explain the Fourier slice theorem for CT image formation. (10)
   c) Why is the filtering necessary during back-projection? Compare the performance of the common filters considering the SNR and resolution of the CT image. (06)
   d) Write down the procedural steps of equiangular fan beam CT reconstruction technique. Calculate the scan time for a 2G CT scanner having 18 detectors spaced 0.5° apart. (10)

3. a) Write short notes on the following resolutions in the context of CT: (i) Directional resolutions and (ii) low contrast resolution. (08)
   b) Why compression is necessary in mammography? Discuss on the design aspects of specialized x-ray tube required for mammography. (12)
   c) Briefly explain the working principle of Xeroradiography technique. (08)
   d) Why is contrast necessary in angiography? Write down the procedural steps of Digital Subtraction Angiography (DSA). (07)

4. a) Write down the name of the components of dental x-ray machine along with their functions. (06)
   b) Why is the x-ray based diagnosis harmful? Discuss on the maximum permissible dose and common protection measure against x-ray radiation. (12)
   c) Distinguish between Radiolucent and Radiopaque structures and comment on their appearance in x-ray image. (06)
   d) What are TACT and CBCT? Describe the working principle of CBCT and mention its applications in dentistry. (11)

# Section B

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

5. a) What is the typical frequency range of medical ultrasound? Write down the advantages and applications of ultrasound imaging. (07)

   b) Write short note on each factors that influence the ultrasound beam shape. (13)

   c) Make a comparison among conventional, polymer, and composite piezoelectric materials. (10)

   d) Write short note on non-specular reflection. (05)

6. a) Prove that for every 3 bB change, there is a change in intensity by a factor of 1. (07)

   b) Explain m-mode ultrasound imaging with necessary diagram, and write down its advantages over A, B-mode imaging. (13)

   c) "Two different reflected signals from two separate boundaries are just resolvable if the distance between them is one half of pulse length" prove the statement with proper illustration. (10)

   d) Write short note on C-mode imaging. (05)

7. a) Describe the basic principles of Doppler ultrasound for measuring blood velocity and flow direction through an artery. (13)

   b) What is contrast agent? How do contrast agents help in getting better quality ultrasound image? Explain briefly. (10)

   c) Write short notes on different types of artifacts involved in ultrasound imaging. Mention the steps for speckle noise reduction. (12)

8. a) Define ultrasound elastography and mention its applications. Write short notes on Strain imaging and shear wave elastography. (13)

   b) Consider a focused transducer with a radius of curvature of 10 cm and a diameter of 4 cm. This transducer operates at a frequency of 3.5 MHz, and transmits a pulse of duration 0.857 μs. What is the axial and lateral resolution at the focal point of the transducer? (07)

   c) Assume the simple case in Fig. 8(c) where the angle of insonation is 135° and the velocity of sound in blood is $1.5 \times 10^5$ cm/sec. The ratio of transmitted to received frequency is 0.9. (i) Determine the speed of RBC. (ii) If the velocity of blood particle, transmitted frequency are reduced to half of their original values, and θ is reduced to 60° then how will be the Doppler frequency changed? (10)

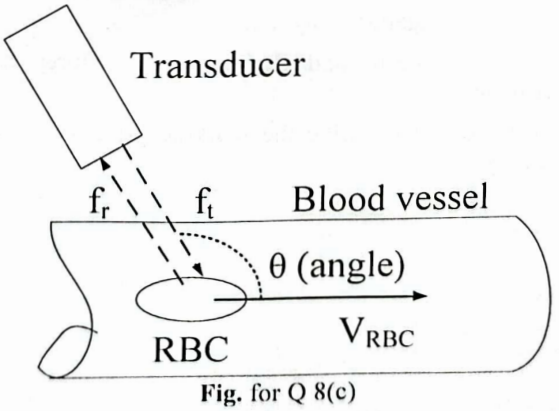


**Fig.** for Q 8(c)

   d) Make a comparison table for color Doppler and power Doppler ultrasounds. (05)

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**CSE 3115**
**Microprocessors and Microcontrollers**

**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 determines whether a microprocessor is considered as 8-bit, 16-bit, or 32-bit device? (07)

b) Define addressing modes. Use MOV instruction of 8086 microprocessor to illustrate different types of 8086 addressing mode. (08)

c) Let us consider that SS contains 7000 H and SP contains FFABH. Then (10)
(i) Determine the physical address.
(ii) Calculate the lower range and upper range of the segment.
(iii) Draw the physical address calculation mechanism.

d) Suppose that a 64 bit microprocessor is feeding with 3.4 GHz clock generator. On an average, 20 cycles are required to complete an instruction. (10)
(i) Determine processor speed in terms of instruction/sec.
(ii) How long it would take to execute 64 KB of code if average instruction size is 64 bit.

**2.** a) What is the significance of flag register? Show 8086 flag register format and determine contents of the flags (CF, PF, AF, ZF, SF, and OF) after the execution of the following code segment: (11)

```
MOV AL, 0FFH
ADD AL, 01H
```

b) Construct the binary code for each of the following 8086 instructions using Table Q2(b): (12)
(i) MOV 43H[SI], DH (ii) MOV CX, [437AH] (iii) MOV AX, OFFFEH.

Table Q2(b)

| MOD / R/M | 00 | 01 | 10 | 11 | |
|---|---|---|---|---|---|
| | | | | W = 0 | W = 1 |
| 000 | (BX) + (SI) | (BX) + (SI) + D8 | (BX) + (SI) + D16 | AL | AX |
| 001 | (BX) + (DI) | (BX) + (DI) + D8 | (BX) + (DI) + D16 | CL | CX |
| 010 | (BP) + (SI) | (BP) + (SI) + D8 | (BP) + (SI) + D16 | DL | DX |
| 011 | (BP) + (DI) | (BP) + (DI) + D8 | | BL | BX |
| 100 | (SI) | (SI) + D8 | (SI) + D16 | AH | SP |
| 101 | (DI) | (DI) + D8 | (DI) + D16 | CH | BP |
| 110 | D16 | (BP) + D8 | (BP) + D16 | DH | SI |
| 111 | (BX) | (BX) + D8 | (BX) + D16 | BH | DI |

c) Construct the binary code for the following 8086 instructions, (12)
(i) 1N AL, 05H, (ii) AND AL, 0FH, (iii) MOV [BX], CX.

**3.** a) Illustrate Reentrant procedure with figure. Explain how you can pass parameters to macros with examples. Also, discuss the main difference between procedure and macro. (13)

b) What is interrupt pointer table? If INT 03 is called then calculate physical address of vector 03:CS and IP. (10)

c) Explain priority of interrupt. How does 8086 handle responses for an interrupt call? Explain with proper steps and necessary figure. (12)

**4.** a) How can you reactivate the functionalities of a damaged area of human brain using implant device? (11)

b) Explain how superscalar architecture works for instruction level parallelism (ILP) with necessary figures. (09)

c) Multiply two numbers using the following approaches. (10)
(i) CISC approach
(ii) RISC approach

d) What is bit slice microprocessor and how it works? (05)

## Section B

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

5. a) What are the criteria for choosing a microcontroller? Write down the applications of microcontroller in the context of biomedical engineering. (12)

   b) How do 8087 and 8086 execute their respective instructions? (08)

   c) What are the conditions of stack 8087 after performing following operations sequentially? (10)
      (i) After reset.
      (ii) Performs 5 PUSH operations.
      (iii) Performs 2 POP operations
      (iv) Performs 3 PUSH operations

   d) What is the silent features of 8051 microcontroller? (05)

6. a) Write down the limitations of 80286. How does 80386 overcome this? (10)

   b) How 16,348 segments x 65,536 bytes/segment or about 1 Gbyte of logical or virtual address space can be achieved using memory management units (MMUs) in 80286 and 80386? Explain with necessary figures(s). (13)

   c) Explain the 8259A timer's hardware retrigger able one shot mode operation. (12)

7. a) What is DMA and how does it work? Explain with necessary figure. (12)

   b) Why memory must be specially managed in a multitasking operating system? Briefly describe Overlays and Bank switching method for memory management. (13)

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

8. a) Write down the functions of different I/O parts available in 8051 microcontroller. (12)

   b) Calculate the address range of 8051 microcontroller's 128 bytes at RAM. (07)

   c) Write short notes on the following terms of 8051 microcontroller. (08)
      (i) SBUF register
      (ii) SCON register

   d) Explain the interrupt structure of 8051 microcontroller. (08)

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**BME 3101**
**Cell Biology**

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

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ii) Figures in the right margin indicate full marks.

## Section A

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

| | | | |
|---|---|---|---|
| **1.** | a) | Define cell biology. How can you differentiate animal cell from plant cell? | (10) |
| | b) | Why cellular transport is important? Briefly describe the types of cellular transport. | (15) |
| | c) | Write down the functions of the following cell membrane components: (i) Phospholipid, (ii) Glycolipid, and (iii) Carbolydrate | (10) |
| **2.** | a) | Draw and label the structure of mitochondria. Write down the function of golgi complex and lysosomes. | (12) |
| | b) | Describe the steps of collagen synthesis. | (10) |
| | c) | Write down the function of cadherin. Discuss about the steps involved in the cell-cell interaction between leucocytes and endothelial cells during an inflammatory condition. | (13) |
| **3.** | a) | What is cell signaling? Discuss about different types of cell signaling. | (10) |
| | b) | What is DNA replication? Write down the process of DNA replication. | (15) |
| | c) | Draw and label the double helix DNA with short description. | (10) |
| **4.** | a) | Define apoptosis and necrosis. Mention the differences between apoptosis and necrosis. | (10) |
| | b) | What is meant by gene, codons, and anticodon. Write down the characteristics of genetic code. | (08) |
| | c) | Write down the function of different type of RNA. Discuss about post transcriptional modification. | (07) |
| | d) | What is Cancer? Mention the differences between benign and malignant type of neoplasm. Discuss about nanotechnology-based cancer treatment. | (10) |

## Section B

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

**5.** a) What are the immunocompetent cells? Write down the differences between T-lymphocyte and B- lymphocyte. (10)

b) How does the specificity work in adaptive immunity? Draw the schematic of primary and secondary immune responses. (08)

c) Describe the structure of antibody. What are the types of antibody? Also mention the significance of monoclonal antibody. (12)

d) Why haptens are not Immunogen? (05)

**6.** a) What is meant by immunological tolerance? Does the immune system mount response to anything that is "non-self"? Justify your answer. (07)

b) Define complement system. How does our body regulate the complement system? (10)

c) What is major histocompatibility complex? Briefly explain the immune mechanisms of graft rejection. (10)

d) What is erythroblastosis fetalis? Write short note on Type III and Type IV hypersensitivities. (08)

**7.** a) Define transplantation. Briefly explain direct and indirect alloantigen recognition with neat sketch. (08)

b) What is the difference between cell line and cell strain? How do you perform the cell culture in a laboratory? (12)

c) Write down the potential application of cell culturing. (07)

d) A 10 mL sample was diluted using 20 mL trypan blue. Calculate the following parameters from hemocytometer output shown in Fig. 7(d). (08)

(i) Line cell concentration (cell/mL)

(ii) Cell viability (%)

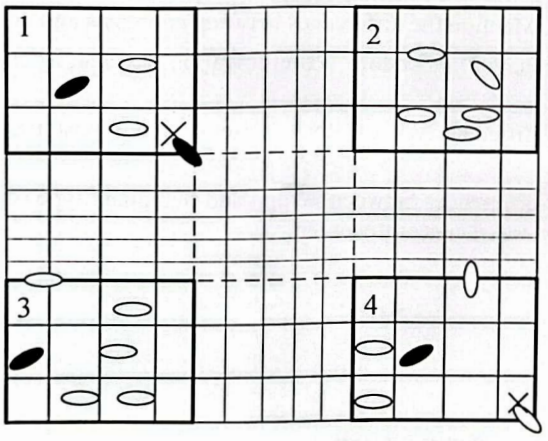


**Fig.** for Q 7(d)

**8.** a) Why do we use a western blot? Explain the procedure of the western blotting technique with figure. (15)

b) Define inflammation. Discuss about the vascular events during an acute inflammatory reaction. (10)

c) Define flow cytometry and mention its clinical application. Also draw the schematic of a five-parameter flow cytometer. (10)