Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 1st Term Examination, 2023
Department of Biomedical Engineering

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 is x-ray? Explain different radiation phenomena behind the production of x-ray. (11)

b) Mention the limitation of x-ray imaging with neat sketch. How to overcome this? Explain in brief. (07)

c) An incident x-ray beam penetrates through "fat + muscle + bone" layer with thickness of "0.3 cm + 4 cm + 1.5 cm" and the tissue's linear attenuation coefficients are "0.9 cm^{-1} + 1.2 cm^{-1} + 7 cm^{-1}" respectively. Calculate the detected to incident x-ray ratio. (07)

d) Briefly explain digital radiography system with necessary diagram. (10)

2. a) Explain the line focus principle and the effect of anode angle on field coverage. (07)

b) Is scatter radiation good for radiographic image contrast? How could you control the scatter radiation? Explain with proper diagram. (11)

c) What is Radon transform? Explain the importance of Radon transform in CT imaging. (07)

d) Why do we use filtered back-projection algorithm? Draw the flow-chart of filtered back-projection algorithm for CT image reconstruction. (10)

3. a) Briefly explain different resolution measures in CT. (10)

b) Briefly discuss on the noises and artifacts of CT. (10)

c) Write a short note on Angiography. (07)

d) Draw schematics of fluoroscopic image intensifier and mention the function of each part. (08)

4. a) Distinguish between Radiolucent and Radiopaque structures and comment on their appearance in x-ray image. (06)

b) Explain the effects of tube current, tube voltage, and 'Al' added filtration on x-ray spectra, with proper delineation. (12)

c) Briefly explain about the equipments used in modern mammography. Why is a specialized x-ray tube used in mammography? (12)

d) Why is the image contrast improved due to breast compression in mammographic examinations? (05)

Section B

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

5. a) What is ultrasound? Write down the properties of ultrasound. (07
   b) What do you understand by the negative role of gas? Briefly explain the three main factors that affect the ultrasound energy absorption in a medium. (10
   c) What problem will arise when two objects are situated closer than (1/2) SPL in the direction of ultrasound beam? How would you overcome the problem? Explain briefly. (10
   d) Illustrate the general shape of the ultrasound beam, with its pressure wave profile. How would the corresponding beam pattern for a transducer operating at double frequency look like? Note all the frequency dependent changes in the beam pattern. (08)

6. a) Show the required timing for simultaneous steering and dynamic focusing of a phased array with brief description. Also sketch the corresponding delays required for dynamic beam forming during signal reception. (12)
   b) Point out a brief comparison between segmental and sequential pulsing. (06)
   c) Calculate the end of the near field when using a 5 MHz, 0.375 inch diameter transducer to inspect human liver. The speed of sound in liver is 1570 m/s. (05)
   d) What are the primary requirements for the piezoelectric elements used in medical transducers? What extent of these requirements are fulfilled by the polymer and composite piezoelectric materials? (12)

7. a) How are the images formed in A, B, and M mode ultrasound imaging? Explain briefly with neat sketch. (15)
   b) Calculate the beam spread when using a 2.25 MHz, 0.475 inch diameter transducer to inspect kidney. The speed of sound in kidney is 1560 m/s. (05)
   c) Write short notes on (i) power Doppler ultrasound imaging, and (ii) effect of the angle of insonation in Doppler signal acquisition. (09)
   d) If the transmitted frequency and blood velocity are reduced by a factor ½ and incident angle increased twice as the initial angle, how would be the Doppler shift changed? (06)

8. a) What is ultrasound contrast agent? Briefly explain harmonic and pulse inversion imaging including their advantages and limitations. (10)
   b) Explain the ultrasound elastography imaging technique including strain imaging and shear wave imaging. (10)
   c) What is image artifact? Write short notes on the following artifacts and sketch the shapes of these artifacts produced from ultrasound scanning: (i) speckle and (ii) acoustic enhancement and shadowing. (09)
   d) "There is a trade-off between image resolution and the penetration depth of ultrasound which is governed by its frequency," explain the quotation and verify your answer. (06)

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BME 3101
Cell Biology

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

N.B. i) Answer **any THREE** questions from each section in separate scripts
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Section A

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

1. a) What is cell? Enumerate the functions of cell membrane protein. (07)

b) What is cell biology? How can you differentiate the bacterial cell from animal cell? (08)

c) Write a short note on pluripotent stem cell. Match the contents of A with corresponding contents of B mentioned in Table 1. (10)

Table 1

A	B
Lysosome	Packing Organelle
Endoplasmic Reticulum	Centriole
Mitochondria	Calcium Regulation
Golgi Apparatus	Protein Factory
Microtubules	Absent in RBC
Ribosome	Cellular Respiration

d) Write a short note on molecular scissor. How liposome can be used to deliver both hydrophilic and hydrophobic drug? Explain with appropriate diagram. (10)

2. a) Illustrate active transport through cell membrane with appropriate diagram. (06)

b) Why gap junction is known as communication junction? Draw and label the shortest unit of gap junction. (07)

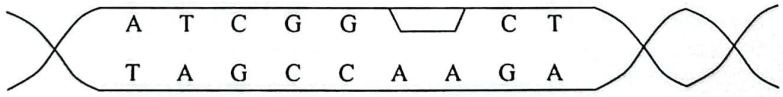
c) Define stem cell. Enumerate the characteristics of stem cell. (12)

d) Draw and label intracellular receptor. Show that different cells show different responses when same ligand is received. (10)

3. a) What is Chargaff's rule? Draw and label the chemical structure of riboneucleotide. (06)

b) Where and how cellular respiration takes place in plant cell? Explain with neat sketch. (08)

c) Does the following DNA sequence need to be repaired? If so, repair the sequence and then replicate it. (15)



d) What is mutation? Illustrate different types of chromosomal mutations. (06)

4. a) What is meant by cellular transport? Explain the mechanism of active transport with neat sketch. (06)

b) What are the phases of bacterial cell growth? Give graphical representation. (08)

c) Show that daughter cells contain half the original genetic information in meiosis cell division. (15)

d) Write short notes on: (06)
i) Malignant tumor
ii) Apoptosis
iii) Tetrad

Section B

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

5. a) Define immunity. Write down the principal functions of the cells in immune response. (10)

b) What is HLA? Write down the features of MHC I and MHC II. (08)

c) What is cell viability? How is cell viability measured in hemocytometer? (07)

d) What are the distinctive features of mono-clonal antibodies compared to serum antibodies? Mention some potential uses of monoclonal antibodies. (10)

6. a) Classify antigens. Explain the immunological role of haptens with examples. (12)

b) What is blotting? Write down the applications of western blotting in scientific fields. (06)

c) Define complement system. What are the major regulatory proteins of the complement system? (07)

d) When a 12 years old boy is treated with bone marrow transplantation, what types of reactions occur in his body and why? (10)

7. a) List the cell culture methods. How is cultured cell calculated in Neubauer counting chamber? (10)

b) What is induced tolerance? Describe the pathogenesis of autoimmunity with proper diagram. (07)

c) How does the body respond to a first covid-19 infection one month after receiving the vaccine? Explain in terms of clonal selection, clonal expansion, and immunological memory with necessary figures. (13)

d) Write a short note on "Toll-like Receptors". (05)

8. a) List the first line defense of your body. Draw and label a macrophase with its function. (10)

b) Which cell-membrane molecules are responsible for antigen recognition? Describe their unique role in the recognition with neat sketch. (13)

c) What is flow cytometry? Describe the main components of a flow cytometer with proper diagram. (12)

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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
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Section A

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

1. a) Define bioelectricity. Briefly explain the applications of bioelectricity. (10)

b) Derive the Nernst equation for an ion traversing the cell membrane. Calculate the Nernst potentials at room temperature from the following tabulated information. (13)

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

c) Differentiate between agonist and antagonist. Discuss the characteristics of some common neurotransmitters used for signaling in the human body. (12)

2. a) What is thresholding? Briefly explain different types of patch clamp methods. (12)

b) What is saltatory conduction? Explain the excitability of neurons in response to various command voltages. How can you confirm the presence of two distinct mechanisms responsible for generating TIC and DOC? (13)

c) Define myelination. State the Ohm's law and show that $\vec{J} = \sigma\vec{E}$. Here, $\vec{J}$ = electric current density, σ = conductivity of the material, and $\vec{E}$ = applied electric field. (10)

3. a) What is the limitation of the core conductor model? How did the cable model address this limitation? Mathematically derive the neuronal cable theory for the propagation and interaction of electrical signals in spatially extended nerve cells. (17)

b) Draw the equivalent circuit and write the mathematical equation of the Hodgkin-Huxley model. Discuss the predictions made by this model with appropriate schematics. (18)

4. a) What is deep brain stimulation? Identify the limitations of commercial deep brain stimulation device and propose design modifications that can improve the quality of life of patients with neurological disorders. (17)

b) What is the role of dopamine in addiction? Discuss the pathways in which different types of drugs act in the human brain. (10)

c) What is epilepsy? Illustrate the direct pathway for Parkinson's disease. (08)

Section B

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

5. a) Define isocurrent line and isopotential line. (05)

b) Describe the simplified admittance model of FIM-8. (10)

c) What is meant by current conduction? Give an explanation of the conduction phenomena at the electrode-tissue interface. (11)

d) How good is the correspondence between the model and the actual physiology? (09)

6. a) What are the purposes of modeling biological systems? Describe the models used for representing the volume source. (12)

b) Enumerate the advantages and disadvantages of EIT. Describe the 2D 16 electrodes opposite method of EIT for the measurement of bioimpedance with a neat sketch. (13)

c) Identify the forward and reverse problem in electrocardiography and describe it with neat sketch. (10)

7. a) What is thoracic impedance? How does it relate to blood volume in the thorax? (10)

b) What is sensitivity field? Evaluate the following statement – 'To find the sensitivity for FIM, the sensitivity for the two individual tetrapolar impedance measurements is simply summed (or averaged). (10)

c) How did the Kinnen thorax model help in understanding the origin of the impedance signal in impedance cardiography? Explain briefly (07)

d) Describe the relationship between conductivity and frequency for the following specific tissues: bone marrow, muscle, fat, and blood. (08)

8. a) What is meant by contact impedance? Explain the relationship between contact impedance and frequency. (08)

b) Describe the instrumentation for FIM-6. (10)

c) Mention some clinical applications of bio-impedance. (10)

d) Explain where the band electrodes should be placed in order to measure the longitudinal thoracic impedance. (07)

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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) Show that the ECG and carotid pulse signals can be used to break a PCG signal into its systolic and diastolic parts. (10)

c) Identify the difficulties of biomedical signal acquisition and analysis and describe them in brief. (15)

2. a) Discuss some statistical methodologies for eliminating random noise in biomedical signal processing. Provide appropriate mathematical formulations to support your discussion. (15)

b) What is a comb filter? An ECG signal sampled at 1000 Hz contains powerline interference at 50 Hz. Design a notch filter to remove the interference. Illustrate pole-zero plot and magnitude and phase responses of the designed filter. (15)

c) Write a short note on event related potential (ERP) (05)

3. a) Explain why the P and T waves are low frequency signals whereas the QRS complex is a high frequency signal. Include diagrams of action potential and ECG waveform in your reasoning. (10)

b) Develop a time domain filtering technique to remove baseline drift in an ECG signal. How can you improve the performance of the filter without distorting the QRS complex? (13)

c) Why the Butterworth filter is commonly used? Write the input-output relationship of an 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. (12)

4. a) Elucidate the mechanism underlying a basic peak-searching algorithm. Discuss the events and transients that occur in EEG signals with appropriate illustrations. (15)

b) Propose an algorithm to detect QRS complexes in an ongoing ECG signal. (20)

Section B

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

5. a) What is filter? Enumerate the purpose for preferring digital filters over analogue filters. (10)

b) Briefly describe the types of linear phase FIR filters. Why does FIR filter coefficient calculation using window method require approximation via truncation? (15)

c) Discuss the conditions necessary for a realizable digital filter to have a linear phase characteristic. Mention the advantages of filters with such a characteristic. (10)

6. a) Describe the specifications of filters in frequency domain including tolerance scheme. (10)

b) An FIR bandpass filter is to be designed to meet the following frequency response sspecifications: (15)

Passband: 0.18 - 0.33 (normalized)
Transition width: 0.04 (normalized)
Stopband deviation: 0.001
Passband deviation: 0.05

(i) Sketch the tolerance scheme for the filter.
(ii) Express the filter band edge frequencies in the standard units of kHz, assuming a sampling frequency of 10 kHz and stopband and passband deviations in decibles.

c) Write the input-output relationship of a realizable IIR digital filter. Enumerate a summary of the impulse invariant method. (10)

7. a) Applying the impulse invariant method, design a digital filter to approximate the normalized analogue transfer function, (20

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

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 the case of a complex conjugate pole pair, consider

$$H(z) = \frac{2C_r - [C_r \cos(P_i T) + C_i sin(P_i T)]2e^{P_r T} z^{-1}}{1 - 2e^{P_r T}\cos(P_i T)z^{-1} + e^{P_r T} z^{-2}}$$

where C_r, C_i, P_r, and P_i are real and imaginary parts of constant and poles, respectively.

b) List the IIR filter coefficient calculation methods. Use the pole-zero placement method to determine the transfer function, the difference equation as well as coefficient of a 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) What is spectrum? Why spectrum estimating is essential in biomedical signal processing? Explain the pitfalls of nonparametric spectrum analysis. (15)

b) Compare the power spectral density estimation methods with proper reasoning. (10)

c) What is windowing? Illustrate the effects of windowing in spectrum estimation with a suitable example. (10)

Khulna University of Engineering & Technology
B. Sc. Engineering 3rd Year 1st Term Examination, 2023
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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) Explain the following addressing modes with examples: (15)
(i) Immediate Addressing Mode
(ii) Direct Addressing Mode
For each modes, describe a real-life scenario in a medical device context where this addressing mode would be particularly useful. For instance, consider a patient monitoring system that reads and processes sensor data, stores patient information, and executes control commands.

b) If a code segment starts at address 1610h, then what will be the value of the IP register to point at the middle address of the code segment? What will be the value of the middle address? Consider the memory space as 32 MB. (12)

c) Determine the number of bits needed to address an "N" MB memory. (Use N = 8, if your roll number is odd, otherwise use N = 16) (08)

2. a) A hospital monitoring system uses the 8086 microprocessor to continuously monitor vital signs. The system needs to handle a timer interrupt to record vital signs every second which is invoked by NMI pin. (15)
(i) Calculate the IVT address number for timer interrupt.
(ii) Design an interrupt handling system by interrupt controller with another two interrupts; an external interrupt for nurse call button inputs and sensor interrupts for abnormal readings such as high heart rate or low oxygen levels.

b) Write down the corresponding machine codes for 8086 of the following instructions using Table 1 and Table 2. (10)
(i) MOV 43H[SI], DH
(ii) MOV CX, [437AH]

Table 1: Instruction code for 8086 registers.

Register		CODE
CL	CX	001
DL	DX	010
CH	BP	101
DH	SI	110

Table 2: Instruction code for MOD and RM registers.

MOD / RM	00	01	10
100	[SI]	[SI] + d8	[SI] + d16
101	[DI]	[DI] + d8	[DI] + d16
110	d16	[BP] + d8	[BP] + d16
111	[BX]	[BX] + d8	[BX] + d16

c) Write an assembly code to compare two strings using "CMPSB" instruction where the string have (10)
(i) Equal length
(ii) Different length

3. a) How 8086 and 8087 execute their respective instructions? (07)

b) Construct the binary code for the following (18)
(i) MOV CS: [BX], DL
(ii) IN AL, DX
(iii) ADD BX, 59H [DI]

c) Explain program development algorithm with flowchart. (10)

4. a) How would the choice between a microprocessor and a microcontroller impact the design and functionality of a portable ECG monitor? (10)

b) Consider a stack which starts at location 5000h and has a size of 80 bytes. Now draw the stack by showing SP register for each of the following consecutive operations: (13)
(i) push 6,
(ii) push 17,
(iii) pop,
(iv) push 5483,
(v) push 456,
(vi) pop.

c) Write an assembly code to design a stack with 100 bytes space and then determine the value of "Top of the stack (TOS)" while SS register is located at 7000h. (12)

Section B

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

5. a) When do you prefer to use a microcontroller over a microprocessor? Write down the unique attributes of a microcontroller. (10)

b) Write a program in assembly language to multiply 2*3*4*5. You need to write the program in a way so that (17)
(i) The top of the stack (TOS) always contains the intermediate multiplication value such as 2*3 = 6 at TOS, then 6*4 = 24 at TOS and so on.
(ii) Only one memory cell of stack in use.
(iii)Try to simulate the PC when debugging your assembly code. Also simulate the whole process.

c) Can you decode the data written in PSW of 8051 "11_××1_1"? "××" means you need to determine which bits will be suitable if you want to use 1C location of the memory. (08)

6. a) Suppose you want to use 8051 timers (started as software instruction) as 16-bit timer mode for delay generator. Explain the necessary value in TMOD register. (08)

b) The operating system of 8051 takes 4046 bytes of memory. However, you also need to install an application 'ABC' that requires 1KB of memory. In this case, (17)
(i) How can you make space for 'ABC'?
(ii) How can you access the memory location used by 'ABC'?
(iii)What are some register specific tasks to make your idea work?

c) Explain the block diagram of DMA. What are the advantages of DMA? (10)

7. a) Why is a math coprocessor necessary? Explain the co-ordinated interaction between 8086 and 8087 in a system. (11)

b) Suppose the status register of 8087 holds '1000H' and the tag register contains '000Fh'. Now, show the conditions of its stack after performing the following operations sequentially. (12)
(i) After 3 PUSH operations.
(ii) After 1 POP operations.

c) Describe the operation of 8254 PIT with necessary diagrams after programming in the following way. (12)
(i) $A_1, A_0 = 11$; CW = 14H; $\overline{WR} = 0$; $D_0 - D_7$ =02h
(ii) $A_1, A_0 = 11$; CW = C2H

8. a) Suppose you are using an advanced microprocessor where memory management facility is available. All the locations of memory can be addressed using 7 bits. It has other 5 bits for selector if the memory is needed to be expanded. (12)
(i) What is the actual size of RAM?
(ii) What is the expanded size of the memory? Explain with figure.

b) In the previous example (Q8(a)), suppose the segment 21 is present in the RAM. Then MMU receives the logical address 100100101110. What will happen? Translate the logical address as your own. (13)
NB: You can select the selector base address as your own.

c) Describe overlay methods. What are the problems associated with it? Do you have any idea to solve it? (10)