Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Examination, 2023
Department of Biomedical Engineering

BME 4151
Clinical Engineering and Hospital Management

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 clinical engineering? Write down the driving forces that have contributed to the emergence of clinical engineering discipline in hospitals. (10)

b) An ICU at home is the true replica of Hospital Intensive Care Unit with more personalized care provided by equally and efficiently trained healthcare professionals at home. Biomedical engineers at Apollo Home Care offers the required technical support, on-site installation, staff training, maintenance, and after sales services for developing home ICU. (15)
(i) As a CE in X hospital, how would you design Home ICU for a chronic asthma patient?
(ii) Which financial strategy will you consider to design Home ICU? Service contract or T&M contract? Why so?

c) Illustrate the administrative model in hospital. As a part of administrative model (CE), what questions will you ask in the viva board to recruit someone for the post of BMET? Why? (List at least 7 questions) (10)

2. a) Define healthcare technology management. Draw the bathtub curve and explain the probability of device failure at different time period. (10)

b) How does a human body conduct an electric current? Define electric shock. Explain macro shock and micro shock with neat sketch. Explain the body effect of men and women for direct current, 60 Hz ac and 10kHz ac. (15)

c) A hospital has 157 patient monitoring devices and the CE supervises the repair crews (BMET) who repair malfunctioning devices. The policy is to repair the broken down device and bring back in execution within 2 hours on the average. If average breakdown rate is 3.5 devices/hour and each repair crew can repair 0.25 device per hour on average, how many BMETs are required? (10)

3. a) For endoscopy, which gas is used to enlarge the body cavity? Write down the US color codes for different medical gases. (08)

b) Explain pressure swing adsorption principle. (10)

c) List the advantages of on-site gas generators. (07)

d) Illustrate the structure and functional block of mechanical ventilator and give brief description of each block. (10)

4. a) Define biosafety. What do you understand by CIA triad? Explain. (05)

b) Rabies is a rare disease seen in cats and dogs in Bangladesh. The affected animal loses its appetite and becomes very aggressive. If someone gets bitten by the affected animals, the chances of survival becomes a threat. Hence after laboratory approval of the suspected animal with rabies, red alert is issued for that particular area to aware the locality and the affected animal is taken care of. (10)
(i) What level of biosafety needs to be considered to study/test rabies virus?
(ii) Give brief description of the considered biosafety level in (i).

c) Tabulate different waste category and corresponding treatment-disposal. (20)

Section B

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

5. a) What is healthcare system? What are the functions of a hospital? Enumerate different types of hospital in details. (15)

b) Explain the services provided by inpatient, outpatient, and emergency departments. (15)

c) Briefly explain the characteristics of an effective healthcare marketing strategy. (05)

6. a) 'Hospital is a matrix organization'-explain with proper reasoning. (10)

b) Describe the principles of management. (10)

c) Define human resource management (HRM). What are the functions of HRM? What are the challenges of HRM practices in Bangladesh? Can you overcome these limitations? (15)

7. a) Depict the financial cycle of a hospital. (10)

b) The following table gives the annual demand and unit price of 3 items. Ordering cost is 5 Tk per order and holding cost is 10% of unit price. (15)

Items	Annual demand (units)	Unit price (Tk)
A	800	0.02
B	400	1.00
C	13,800	0.20

Determine the following:
(i) EOQ in units,
(ii) Minimum average cost,
(iii) EOQ in Tk,
(iv) EOQ in years of supply, and
(v) Number of orders per year.

c) Describe hospital information flow and handling with proper diagram. Give some examples of standard protocols in hospital information flow and handling. (10)

8. a) Show the data workflow within different departmental information systems including PACS, RIS, and HIS. (15)

b) Why does a hospital need both centralized and decentralized purchasing? Suppose a hospital purchases 1400 pairs (units) of surgical gloves each year at a unit price of Tk 25. The ordering cost is Tk 10 per order and the holding cost is 10% of unit price. Determine: (10)
(i) Economic order quantity,
(ii) Total annual cost, and
(iii) Number of orders per year.

c) How is hospital evaluation procedure performed? Mention the management tools in evaluating hospital services. (10)

Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Examination, 2023
Department of Biomedical Engineering

BME 4141
Brain and Neuroengineering

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 neuroengineering? Discuss Brodmann's cytoarchitectonic areas of the human brain with appropriate schematics. (12)

b) Enumerate the functions of the human brain. Explain the role of the limbic system in cognition and memory. (10)

c) What is autoregulation? Describe the complete pathway for memory retention in the human brain. (13)

2. a) What is brain-machine interface? Briefly describe the applications of BCI. (10)

b) Write down the definition of epilepsy according to ILAE. Examine the probable cause of Parkinson's disease. (08)

c) What is Jacksonian March? Explain the role of amyloid plaques and neurofibrillary tangles in the pathogenesis and progression of Alzheimer's disease. Support your explanation with appropriate schematic representations. (17)

3. a) Describe the division of nervous system along with their associated functions. (12)

b) What is Benzodiazepine? Describe the pathway for the formation of embolic stroke with relevant schematic representation. (13)

c) Classify BCI with example. Tabulate the neuroimaging approaches and the control signals used in typical BCI-based experimental protocols. (10)

4. a) What is graceful degradation? Discuss the mechanism behind neuronal stimulus encoding using examples of static and dynamic responses. (10)

b) Differentiate between stereotactic DBS and interventional image-guided DBS. Identify a few key drawbacks of current state-of-the-art neuroprosthesis and provide tangible solutions with proper explanation. (13)

c) What are neurological disorders? 'Seizures occur due to too much excitation or too little inhibition'-Evaluate. (12)

Section B

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

5. a) How can you describe the localization of focal discharge in EEG with referential montage? Explain with schematic illustration. (11)
   b) What is nerve regeneration? Describe any two nerve regeneration techniques. (10)
   c) Describe the fundamental principles underlying the BOLD fMRI signal using schematic representations. (14)

6. a) What is fNIRS? Describe the basic principle of fNIRS. (10)
   b) What is an artificial retina? Discuss the working principle of the artificial retina. (12)
   c) Explain the block diagram of the MEG measurement system. (13)

7. a) Illustrate the schematic structure of a helmet-shape liquid-He dewar in MEG system. (10)
   b) Why is the MR signal sensitive to changes in brain activity? (08)
   c) Derive the mathematical equation for calculating the absolute concentrations of Oxy-Hb and Deoxy-Hb in a FD-NIRS system. (10)
   d) Describe the generation of very small electrical fields by synaptic currents in pyramidal cells. (07)

8. a) Discuss the basic principle of rTMS. Mention the therapeutic uses of rTMS in psychiatric disorders. (10)
   b) Explain the principle of measuring MEG signal using SQUID. (10)
   c) Deduce the simplified Maxwell's equations for the low frequencies associated with neuronal activity. (10)
   d) What are the EEG electrodes? Sketch the equivalent circuit of the EEG electrode. (05)

Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Examination, 2023
Department of Biomedical Engineering

BME 4111
Biomedical Image Processing

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 digital image? Describe the key stages in digital image processing. (10)

b) Why relationship between pixels is necessary for a biomedical image? Define adjacency and paths between pixels. (10)

c) Illustrate neighborhood operation and geometric transformation. For a square with vertices $P_1 = (1, 1)$, $P_2 = (2, 1)$, $P_3 = (2, 2)$, and $P_4 = (1, 2)$, determine the new vertices of the square after applying a translation by (-2, 5) followed by a 60^0 clockwise rotation. (15)

2. a) What is dynamic range and contrast of an image? (05)

b) Illustrate smoothing spatial filters and sharpening spatial filters. How can you implement them on a digital image? (15)

c) Show the steps of histogram equalization for the image of size 5×5 given below. (15)

3	1	0	5	0
6	2	5	7	6
7	5	3	6	5
3	7	4	6	4
5	7	6	4	7

3. a) Define intensity transformation function. Explain the different approaches for performing intensity transformation on an image. (13)

b) Perform filtering on a noisy image using 2×2 average kernel, and compare the enhanced image with the original. The 8-bit grayscale original image, noisy image and the 2×2 average kernel are given below. (14)

4×4 original image:

$$\begin{bmatrix} 100 & 100 & 100 \\ 100 & 100 & 100 \\ 100 & 100 & 100 \\ 100 & 100 & 100 \end{bmatrix}$$

4×4 noisy image:

$$\begin{bmatrix} 99 & 107 & 113 \\ 92 & 116 & 84 \\ 103 & 93 & 86 \\ 87 & 109 & 106 \end{bmatrix}$$

2×2 average kernel:

$$\frac{1}{4}\begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$$

c) Write down the expression of DFT, IDFT, and Fourier spectrum for an image. (08)

4. a) Why do we need to transform an image in frequency domain? Describe the basic steps to filter an image in frequency domain. (08)

b) Explain digital image processing. Why the study of digital image processing is necessary for the students of biomedical engineering? (07)

c) A 2×2 image I and a frequency space filter H are given below. (20)

$$I = \begin{bmatrix} 100 & 50 \\ 100 & -10 \end{bmatrix} \qquad H = \frac{1}{4}\begin{bmatrix} 0 & 1 \\ 2 & 0 \end{bmatrix}$$

(i) Determine the 2D-DFT of the image I and show the output.
(ii) Filter the image with given frequency space filter H.
Show the filtered image in spatial domain.

Section B

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

5. a) What is morphological image processing? Explain opening and closing with suitable examples. (12)

b) How Hit or Miss transformation can be used to find the location of a small shape at a large image? (12)

c) Perform dilation operation of set A by set B given below. Set B is the structural element. (11)

		1	1		
				1	
		1	1		
	1			1	

Set A

Origin of B

1	1

Set B

6. a) What are the main consideration point to segment a biomedical image? Briefly explain global processing via Hough transform with necessary diagram. (13)

b) Explain how region splitting and merging can be used for image segmentation. (10)

c) What is pruning? Briefly describe the steps of pruning. (12)

7. a) Briefly explain the different approaches of segmentation. Compare the first order and second order derivative based edge detection methods. (12)

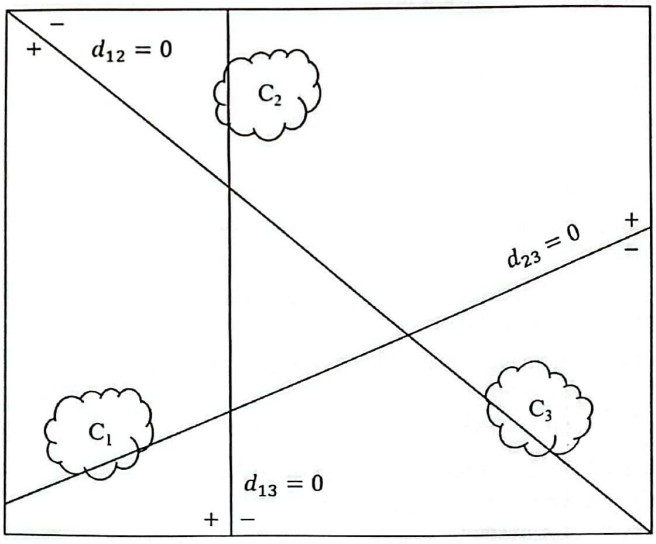
b) How is segmentation performed by morphological watersheds? Explain with proper illustration. (13)

c) What are the criteria of edge linking for local processing? Write down the algorithm to obtain basic global thresholding. (10)

8. a) Consider position of pattern classes C_1, C_2, and C_3 as shown below. Using concept of decision boundaries between class pairs, find out the decision regions. (15)

b) Explain the purpose of pseudo color image processing. Briefly explain gray level to color transformation method with necessary diagram. (10)

c) Draw the block diagram of a pattern recognition system. Why pattern recognition is important in biomedical image processing. (10)



Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Examination, 2023
Department of Biomedical Engineering

BME 4133
Biosensors and Biochips

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) Draw a schematic diagram of a biosensor illustrating its components. (07)

b) Mention the types of transduction of biosensors. Briefly explain the working mechanism of each type. (15)

c) What is antibody? How can the biomolecular interactions of antibodies be utilized to detect biological analytes? (08)

d) Write down some applications of ISE. (05)

2. a) Assume, a blood sample is given. Construct a biosensor using 0.3M $CuSO_4$ (aq) to determine the quantity of iron (Fe) in the blood in molar concentration. In the given ambience, the room temperature is 25°C and the constructed sensor generates +0.794V. (15)
Assumptions:
Only following half-cell reactions take place:
$Cu^{2+} + 2e^- \longrightarrow Cu\ (s), \quad E^o = +0.34V$
$Fe^{2+} + 2e^- \longrightarrow Fe\ (s), \quad E^o = -0.44V$
Derive the required equation and quantify the amount of iron (Fe) in blood sample.

b) What are the advantages of ion-selective electrodes? (08)

c) Briefly explain how a Clark oxygen sensor can be utilized to determine glucose concentration in a sample. (12)

3. a) Mention some attractive features of microsensors. (05)

b) Briefly explain the hydrogen gas (H_2) sensing mechanism with a schottky diode-based biosensor with its architecture. (13)

c) Discuss the construction and working mechanism of a calorimetric biosensor. (10)

d) Write a short note on an optical microsensor. (07)

4. a) Explain the working mechanism of a FET-based biosensor which is able to detect mutant type p53 gene. (10)

b) How does FET sense the presence of a biological target? Explain the process with a basic FET structure. (12)

c) How does the Cas13 effector-based CRISPR Cas system identify specific sequences of DNA or RNA fragments? (13)

Section B

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

5. a) How does a DNA microarray simultaneously identify thousands of distinct genes? (10)
   b) Describe the basic principle of dielectrophoresis (DEP) for biochip design. Mention some advantages and disadvantages of using biochips. (13)
   c) How many types of proteins microarrays? Discuss them in brief. (12)

6. a) How does cytokine antibody microarray work? Explain in brief with schematic illustrations. (10)
   b) Explain the basic principle of digital microfluidic biochips (DMB). (12)
   c) Describe Mask photolithography fabrication process for DNA microarray design. (13)

7. a) Draw and label a two-layer digital microfluidic biochip. (10)
   b) Write down the process of identification of proteins from a sample using the MALDI-TOF-MS technique. Give necessary figures. (10)
   c) Why is gold used as surface material for biochip design? Explain the surface chemistry of cDNA probes. (10)
   d) What are the limitations of analytical protein microarray? (05)

8. a) Discuss the general classification of proteomics. (10)
   b) What are the differences between Genotyping and Phenotyping? Discuss the gene expression process. (13)
   c) Explain the chemical strategies on silicon surfaces for generating protein biochip. (12)

Khulna University of Engineering & Technology
B. Sc. Engineering 4rt Year 1st Term Examination, 2023
Department of Biomedical Engineering

BME 4131
Bio-Optics

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) With proper example, prove that the total energy 'E' of a particle can never be zero when bound (or confined), even though its potential energy is zero. (12)

b) Show that the reflection coefficients r_x and r_y can be written in terms of only the incident angle θ_1 and the refractive index ratio $n_{21} = n_1/n_2$ as (10)

$$r_\perp = r_x = \frac{Cos\theta_1 - (n_{21}^2 - sin^2\theta_1)^{\frac{1}{2}}}{Cos\theta_1 + (n_{21}^2 - sin^2\theta_1)^{\frac{1}{2}}}$$

$$r_\parallel = r_y = \frac{n_{21}^2 Cos\theta_1 - (n_{21}^2 - sin^2\theta_1)^{\frac{1}{2}}}{n_{21}^2 Cos\theta_1 + (n_{21}^2 - sin^2\theta_1)^{\frac{1}{2}}}$$

c) Diffraction pattern is produced in the screen from the monochromatic source by the arrangement shown in Fig. 1(c). How this arrangement produces interference fringes on the screen? Explain with proper conditions. (06)

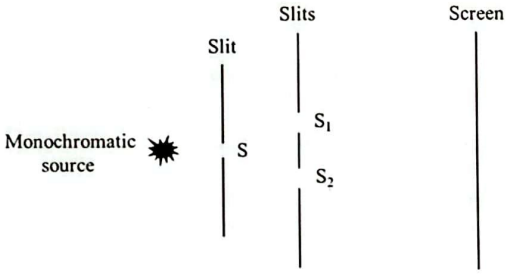


Fig. 1(c)

d) Where is the location of the biophotonics discipline in the electromagnetic spectrum? Illustrate the spectrum of absorption coefficients of major tissue components as a function of wavelength with example light source emission peaks. (07)

2. a) State Beer-Lambert law. Explain the basic principle of electronic absorption spectroscopy with neat sketch. (10)

b) Briefly explain Einstein's model of absorption and emission. Mention, why fluorescence measurements are considered more sophisticated than absorption and transmission experiments? (10)

c) Suppose you have an Nd:YAG laser. For treating jaundice you need UV light of about 355 nm. How would you convert the laser light into UV? Explain with necessary diagrams. (10)

d) Write a short note on the mechanism of nonlinear optical processes. (05)

3. a) Explain the principle of near-field microscopy with proper illustration of its different modes and instrumentation used for a near-field imaging setup. (13)

b) Compare phase contrast microscopy with dark field microscopy. (12)

c) Illustrate the setup of a fiber-based OCT. (05)

d) Mention some of the benefits offered by optical imaging. (05)

4. a) Describe the interaction of light with biological samples with necessary diagram and mathematical formulation. (10)

b) What is ex vivo? Write the conditions including required equations for linear, elliptical, and circular (left and right) polarization and illustrate their electromagnetic field representation. (10)

c) With the help of Jablonsky diagram, explain the possible fates of excitation. (10)

d) Why fluorescence is a faster process in comparison to phosphorescence? (05)

Section B

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

5. a) Define photosensitizer. Show different light scattering processes in tissue. (13)

   b) Draw the absorption and fluorescence spectra of Tryptophan, Collagen, and Falvins. Write short notes on: (12)
   (i) Coagulation
   (ii) Carbonization
   (iii) Articulated arm delivery with an aiming beam.

   c) What are the requirements to be considered to choose a PDT drug? (10)

6. a) What is laser contouring? Write short notes on: (07)
   (i) Tattoo removal using laser
   (ii) Hair removal using laser
   (iii) Laser angioplasty

   b) Briefly explain photodisruption. Why femto laser surgery is preferred for lamellar corneal transplantation? (08)

   c) Describe the laser tweezer action with necessary diagrams. (10)

   d) Explain the principle of fluorescence sensing scheme using a monomode planar waveguide with proper diagram. (10)

7. a) What is flow cytometry? Write two significant advantages of flow cytometer over traditional microscope. (05)

   b) What is the advantage of using elliptical beam over circular beam in flow cytometry? Briefly explain with diagram. (08)

   c) Describe the basic principle of photodynamic therapy in cancer treatment. What advantages does this have over conventional chemotherapy? (12)

   d) Draw a typical flow diagram and explain hydrodynamic focusing. (10)

8. a) What is the basic difference between extrinsic and intrinsic fiber optic biosensor? Tabulate different optical manifestations used for biosensing. (08)

   b) Draw a fiber optic glucose sensor utilizing a pH sensitive dye and explain it's mechanism. (07)

   c) What is plasmonic material? How would you utilize these materials for developing SPR based bio-sensor? Explain with necessary diagram. (12)

   d) Why dichroic mirror is used to separate different fluorescence wavelength in flow cytometry? Briefly explain. (08)