Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Examination, 2021
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
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 neuroengineering? Enumerate the functions of right and left hemisphere. (10)
b) Distinguish between graded potential and action potential. Briefly describe the conduction of action potential along the neuron. (14)
c) Define cognition. Explain the process of auto-~~correction~~ regulation in the human brain. (11)

2. a) Write down the definition of epilepsy according to ILAE. What are the different types of epileptic seizures? (7)
b) What is transient ischemic attack? Discuss the mechanism behind endothelial cell dysfunction for ischemic stroke. (12)
c) How do plagues and tangles increase the propagation of Alzheimer's disease? Explain with appropriate schematics. (16)

3. a) Distinguish between normal tremor and Parkinson's tremor. Write down the clinical features of Parkinson's disease. (10)
b) Define neuroprosthesis. Briefly explain the applications of BCI in neuroengineering. (12)
c) How do neurons encode information? Describe the mechanisms behind error protection of information. (13)

4. a) What is neuromuscular system? Briefly explain the muscle synergy hypothesis. (11)
b) How does targeted muscle reinnervation (TNR) work? Write down the advantages of TMR over typical prosthetic implants. (12)
c) What is feedforward network? Briefly discuss the major learning paradigms of neural networks. (12)

Section B

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

5. a) Describe the distribution of ionic currents in the human brain. (10)
b) How to calculate the changes in concentration of main chromophores in brain tissue? Explain in brief using modified Beer-Lambert law. (13)
c) Describe the basis of the BOLD fMRI signal using schematic illustrations. (12)

6. a) Discuss the measurement principle of SRS-fNIRS system. (10)
b) How are activation maps formed in fMRI? (10)
c) Explain the block diagram of the MEG measurement system. (15)

7. a) What is Bipolar montage in EEG? Explain using schematic illustration. (12)
b) Why is the MR signal sensitive to changes in brain activity? (10)
c) Discuss the basic principle of Transcranial magnetic stimulation. (13)

8. a) Describe any two nerve regeneration techniques. (08)
b) What is the distance and in percentage distance separating F_3 from O_1? Explain it using 10-20 EEG electrode placement system. (07)
c) Describe the nature and origin of magnetic signals in the human brain. (10)
d) In fNIRS, briefly describe the absorption factor of main chromophores in tissues with the help of graphical representation. (10)

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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)	What is Biosensor according to IUPAC? Briefly describe the detection elements immobilization methods with necessary figures.	(15)
	b)	Justify "The specificity of a Biosensor can be improved using a semipermeable membrane in it." Give reasons discussing the general structure of a biosensor.	(11)
	c)	Write down the enzyme category with functions used in biosensors.	(09)
2.	a)	What are the factors that affect conductivity biosensing process? Write down the advantages and disadvantages of conductometric biosensor.	(10)
	b)	What is iso-potential point? How does Ion Selective Electrode perform in kcl solution?	(08)
	c)	Define Ion activity. Which law governs the potentiometric sensing mechanism? Derive it stating with appropriate half cell reactions.	(12)
	d)	What are the ideal features of a biosensor?	(05)
3.	a)	Describe different steps involved in macro-fabrication of a microsystem.	(08)
	b)	Briefly explain the sensing principle of resistors based on metal oxide semiconductors for the detection of CO gas.	(15)
	c)	Draw the energy band diagram of M-S structure semiconductors. How does an M-S structure semiconductor detect biological analytes? Explain it with its construction.	(12)
4.	a)	Define ISFET. Briefly discuss the construction and transduction procedure of a glucose oxidase based ISFET.	(12)
	b)	Briefly explain an application of a biosensor in obtaining information on cellular processes.	(08)
	c)	What is CRISPR-Cas system?	(05)
	d)	Write down the cleavage-based biosensing process of a Cas9-biosensor.	(10)

Section B

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

5.	a)	What is Biochip? Describe the working principle of a Biochip.	(09)
	b)	Briefly Explain the basic fluidic operations on the digital microfluidic biochips.	(14)
	c)	How do you find specific proteins from a sample using 2-D gel electrophoresis technique? Explain in brief with necessary diagrams.	(12)
6.	a)	What are the processes involved in biochip design using Field Programmable Gate Array? Explain those.	(15)
	b)	How does cytokine antibody microarray work? Explain with schematic illustrations.	(12)
	c)	What are SNPs and why are they important?	(08)
7.	a)	Give a comparative discussion on active and passive measurements technique.	(10)
	b)	Describe Mask Photolithography Fabrication process for DNA microarray design.	(15)
	c)	What are the applications of digital microfluidic biochips?	(10)
8.	a)	Define QAM. Draw bit representation diagrams of 4-QAM, 8-QAM, and 16-QAM.	(10)
	b)	Describe Functional Protein Microarray with necessary diagram.	(11)
	c)	How many steps are involved in proteomic analysis? Explain them briefly.	(14)

Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Examination, 2021
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BME 4111
Biomedical Image 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) Explain digital image processing. Why the study of digital image processing is necessary for the students of biomedical engineering? (10)
   b) Describe the components of an image processing system. (10)
   c) What are the fundamental classes of digital image processing? Describe briefly. (15)

2. a) What are the parameters used to represent the quality of a digital image? Explain briefly. (12)
   b) Illustrate the process of image acquisition using a single sensor, a sensor strip, and a sensor array. (15)
   c) Explain the process of geometric transformation of an image with suitable example. (08)

3. a) What is image enhancement? Do you think that we can achieve a better quality image by such enhancement process? Verify your answer. (08)
   b) What is piecewise linear transformation? Briefly explain its basic principle with example for the following operations. (12)
   (i) Contrast stretching, (ii) Gray level slicing, and (iii) Bit-plane slicing.
   c) Table 3(c) shows the number of pixels at each of the gray levels in a 4-bit deep (i.e., 16 gray levels) image. Draw the gray-level histogram. Perform histogram equalization and draw the resulting histogram. (15)

Table 3(c)

Gray level	Number of pixel
0	20
1	40
2	60
3	75
4	80
5	75
6	65
7	55
8	50
9	45
10	40
11	35
12	30
13	25
14	20
15	30

4. a) What is the purpose of sharpening spatial filters? How to sharpen an image using Laplacian? Derive simplified equations and marks for sharpening an image using Laplacian. (10
   b) Starting from discrete representation of 1-D continuous signals, illustrate the 2-D sampling process. (10
   c) Explain unsharp masking and high boost filtering with a suitable example. (10
   d) Write down the expression for DFT, IDFT, and Fourier spectrum for an image. (05

Section B

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

5. a) Explain morphological image processing with the following operations. (
(i) Erosion and dilation
(ii) Opening and closing.

b) A 3×3 image is shown in Fig. 5(b). Compute central moments upto 3rd order and also calculate the centroid and radius of gyration. (1

$f(x,y)$	$y=1$	$y=2$	$y=3$
$x=1$	3	1	2
$x=2$	2	5	3
$x=3$	3	3	2

Fig. 5(b)

c) Derive the equation of threshold, T using optimal thresholding. (11)

6. a) Consider a mask operation whose sum of elements is equal to zero. What would be the effect of applying this mask on an image with constant elements? Show mathematically. (10)

b) Compare the first order and second order derivative based edge detection methods. (10)

c) Convert the following RGB image, I into YIQ and gray scale images. 15)

$$I=\begin{bmatrix} 11,21,35 & 35,121,25 & 25,25,25 \\ 0,1,0 & 100,25,200 & 82,62,92 \\ 210,90,120 & 123,100,210 & 16,34,82 \end{bmatrix}$$

7. a) An 8-bit 5×4 original gray scale image is given in the Fig. 7(a). Apply the following edge detectors to the image. (15)
(i) Sobel vertical edge detector,
(ii) Laplacian edge detector.

$$I=\begin{bmatrix} 110 & 110 & 110 & 110 \\ 110 & 100 & 100 & 110 \\ 110 & 100 & 100 & 110 \\ 110 & 110 & 110 & 110 \\ 110 & 110 & 110 & 110 \end{bmatrix}$$

Fig. 7(a)

b) Explain the watershed segmentation algorithm. (10)

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

8. a) Calculate the morphological thinning on the image F using P as the initial structuring element as shown in Fig. 8(a) and show the outcome at each step separately. (15)

0	0	0	0	0	0	1	1
1	1	0	0	0	0	1	1
1	1	1	1	1	0	0	0
1	1	1	1	0	1	1	0
1	1	1	1	1	1	0	0
1	1	1	0	1	1	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Image: F

0	0	0
X	(1)	X
1	1	1

Structuring Element: P

Fig. 8(a)

b) State and prove the duality between dialation and erosion. (10)

c) Draw the block diagram of a pattern recognition system. (05)

d) Write the basic formulations of region based segmentation. (05)

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BME 4131
Bio-Optics

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 diagnostic window? Why is it called so? Illustrate the major tissue components that have high light absorption coefficient with this window. (08)

   b) Explain the possible fates of electronic excitation through a Jablonski diagram. Is a photon of light absorbed or emitted when an electron goes from the level $n = 4$ to $n = 3$? Provide an appropriate reasoning. Also, find out the energy of that photon. Consider the diagram shown in Fig.1 (15)

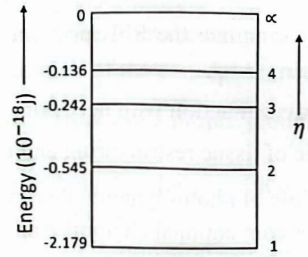

Fig.1

   c) Explain the terms in relevance of light wave: (i) Polarization (ii) Coherence (iii) Birefringence. (12)

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

   b) Briefly outline the principle of laser. Mention some types of laser with their applications in biophotonics. (10)

   c) List the various spectroscopic methods in bio-optics. Distinguish between the essential features of Absorption and Fluorescence spectroscopy. (10)

   d) Why phosphorescence is a slower process than fluorescence. (05)

3. a) Consider a plane wave that lies in the plane of incidence of an air-glass interface. (10)
      (i) Show that the values of reflection coefficients are $r_x = -0.303$ and $r_y = 0.092$; if this light wave is incident at 45° on the interface.
      (ii) Show that the values of the transmission coefficients are $t_x = 0.697$ and $t_y = 0.728$. Let $\eta_{air} = 1.00$ and $\eta_{glass} = 1.50$.

   b) Describe using an illustration, what is meant by a ballistic photon, a snake photon, and a diffuse photon. Explain the ways of eliminating ballistic photons from measurements. (10)

   c) Suppose you have an unpolarized light source, however for a biophotonic application you need a polarized light. How can you make the light polarized? Show necessary diagrams and/or equations to explain your answer. (10)

   d) Explain briefly the origin and significance of Green Fluorescent Protien (GFP) in bio-optics. (05)

4. a) Explain TIR fluorescence microscopy with necessary diagram and equations. (12)

   b) Why OCT is the most popular imaging technique in Bio-optics? Describe the basic principle of OCT with suitable sketch. (11)

   c) Describe in detail any one of the following bioimaging techniques: (12)
      (i) Confocal microscopy
      (ii) Near-field optical microscopy.

Section B

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

5. a) Outline the main processes that light undergoes in tissue, and explain how these processes contribute to the measurement of a signal in finger probe pulse oximeter. (08)

b) What are the available methods of light delivery for in-vivo photoexcitation? Briefly describe the process of optical fiber delivery system. (08)

c) Explain the process of optical biopsy with its several advantages. (08)

d) List the various optical manifestation caused by the presence of an analyte in optical biosensor. Explain the principles that selectively recognize an analyte. (11)

6. a) Describe the key components of a typical optical biosensor device. Mention several advantages of optical biosensor. (12)

b) Explain the term evanescent wave. What is meant by the 'penetration depth' of the evanescent wave? Estimate the value of the penetration depth of 500nm radiation incident within glass at a 65° angle on a glass water interface. (09)

c) What is flow cytometer? Explain the hydrodynamic focusing and five parameter detection of it. (14)

7. a) What is SPR? How would you utilize the SPR principle in developing a glucose sensor? Explain with necessary diagram. (12)

b) Write the principle of laser tweezer action with necessary equations. (11)

c) Clearly illustrate the principle of tissue restructuring and contouring femto second laser. (12)

8. a) Describe the operating principle of photo-dynamic therapy (PDT) in cancer treatment. What advantage does this have over conventional chemotherapy? (13)

b) What are quantum dots? Explain how they can be used for bioimaging. What are their major advantages over organic dyes in this context? (12)

c) Write short notes on any one: (10)

(i) Biomaterials for photonics.

(ii) Interferometric biosensor.

Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Regular Examination, 2021
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.	(08)
	b)	Enumerate the functions of clinical engineering. Draw the administrative, functional, and educational models of CE, CET, and BMET.	(12)
	c)	Illustrate the range of interactions that a CET must encounter in a hospital setting.	(10)
	d)	Mention the minimum requirements and skills that a clinical engineer should have.	(05)
2.	a)	Define maintenance. Write down the philosophies of maintenance. Briefly describe the significance of preventive maintenance using the bathtub curve.	(10)
	b)	Sketch a flow diagram of the maintenance process in a healthcare organization and briefly describe the characteristics of maintenance from the diagram.	(15)
	c)	What is ventilator? Discuss the evolution of the concept of mechanical ventilation.	(10)
3.	a)	Define macroshock and microshock? How can a proper grounding system protect patients in a hospital setting?	(10)
	b)	What is meant by biosafety? Classify biosafety levels with examples. Which biosafety level is required for studying the SARS-CoV-2 virus?	(10)
	c)	Briefly describe the guiding principles of information safety in modern hospitals.	(10)
	d)	Write a short note on the physiological effects of electricity in the human body.	(05)
4.	a)	What is central medical gas system? Describe the pressure swing adsorption principle used in hospitals.	(10)
	b)	What is an HVAC system? Write down the treatment and disposal techniques of hospital wastes based on waste category?	(15)
	c)	What is the permissible limits of pH for effluents generated from the hospital? Draw a typical schematic of a centralized air conditioning system and describe each cycle.	(10)

Section B

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

5.	a)	Define hospital. Discuss about the factors responsible for development of hospital.	(15)
	b)	Classify hospital according to (i) Type of services and (ii) Duration of hospital stay.	(10)
	c)	What is meant by Bed capacity (BC)? In a hospital, Average Bed occupancy (ABO) is 600 and Average bed Availability is 800. Calculate Bed occupancy rate (BoR).	(10)
6.	a)	Discuss in brief about different functions of a hospital.	(10)
	b)	Define management. Discuss about the financial management system of a modern hospital.	(15)
	c)	What is meant by hospital utilization? Discuss about different factors influencing hospital utilization.	(10)
7.	a)	Define Nosocomial infection. Discuss the sterilization process using different type of chemical agents.	(10)
	b)	Define and classify planning. What are the significances of planning?	(15)
	c)	Discuss about the role of outpatient department (OPD) of a hospital in case of emergency patient management.	(10)
8.	a)	What is meant by General Duty Assistant (GDA)? Discuss about the duties and responsibilities of GDA.	(15)
	b)	What is meant by hospital administration? Mention the criteria of a good administrator in case of hospital management.	(10)
	c)	Discuss about different laboratories with their functions in case of a modern hospital management system.	(10)