Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Regular Examination, 2022
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) What is bio-optics? Explain the nature of interaction of light with biological molecules with necessary diagram. (10)
   b) List the various processes involved in electronic excitation created by light absorption. With the help of Jablonski diagram, describe the main radiative and non-radiative processes. Mention some applications of each type in spectroscopy. (12)
   c) List the various types of optical imaging methods, and explain the electronic luminescence spectroscopy illustrating it's spectra as an example. (13)

2. a) Define temporal and spatial coherence of light. When will the linearly polarized light be converted to elliptically polarized and circularly (left and right) polarized light? Explain with proper illustration of their electronic and magnetic field distributions. (13)
   b) Explain the effect of numerical aperture on the resolution of different types of microscopy with necessary sketch. (12)
   c) Briefly explain the principles of Raman spectroscopy. What are the advantages of Raman spectroscopies over its counterparts? (10)

3. a) Compare phase contrast microscopy with dark field microscopy. (12)
   b) Explain TIRF microscopy with required schematic diagrams. (13)
   c) Write short notes on various endogenous fluorophores with proper examples. (10)

4. a) Write the steps involved in laser operation. (07)
   b) Write the mechanism of non-linear optical processes. How would you design different light frequency converters by second order and third order non-linear optical processes? Explain with proper diagram. (14)
   c) What are the advantages of optical imaging compared to conventional imaging? (07)
   d) Calculate the electric field amplitude of an evanescent wave with electronic field value of 3.0 N/C at the surface of the prism, when a light wave (633 nm) is travelling from a prism (RI=1.52) to a cellular medium (1.37). Given the distance into the cellular medium is 90 nm and the angle of 65° from normal to prism-cell interface. (07)

Section B

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

5. a) What is optical biosensor? Illustrate the general scheme for optical biosensor and briefly explain its every parts. (12)

b) Write short notes on various light induced processes in tissue due to light-tissue interaction. (13)

c) Explain the process of optical biopsy with its several advantages. How the light can be delivered for in-vivo photo excitation? (10)

6. a) Explain the different optical geometries used for biosensing applications. What are the key features of planar waveguide biosensor? (10)

b) Explain the various optical transduction principles used for biosensing. (09)

c) Why the immobilization of biorecognition elements on biosensor is important? Briefly explain different immobilization methods. (10)

d) Mention several advantages of optical biosensor. (06)

7. a) With a neat sketch explain Mach-Zehnder interferometer biosensor. Also mention some advantages of surface Plasman resonance (SPR) biosensor. (12)

b) A prism was coated with a thin layer of silver (ε_m = -27.6 at λ = 800 nm), and placed in an aqueous environment (n_d = 1.33). Light from a focused LED was incident on the rear surface of the silver through the prism (n_p = 1.50), and scanned through a range of incident angles. Using the equations provided, calculate the Plasman resonance angle of the system, (10)

$$k_{sp} = kn_p \sin\theta_{sp}, \quad k_{sp} = k \times N_{sp}, \quad N_{sp} = \sqrt{\frac{\varepsilon_m \varepsilon_d}{\varepsilon_m + \varepsilon_d}}.$$

c) Describe the principle of operation of photo dynamic therapy (PDT) in cancer treatment. What advantage does this has over conventional chemotherapy? (13)

8. a) What is flow cytometer? Draw a schematic of a five-parameter flow cytometer showing identity of each component. (09)

b) Briefly explain the principle of laser tweezer action with necessary diagrams. (09)

c) What is tissue engineering? Give the role of femto second laser in tissue engineering. (08)

d) What are quantum dots? Explain how they can be used for bioimaging. What are their major advantages over organic dyes in this context? (09)

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B. Sc. Engineering 4th Year 1st Term Regular Examination, 2022
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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 conduction aphasia? Discuss Treisman's attenuation model in brief. (10)
   b) Draw and label the Broadman's cytoarchitectonic area of human brain. (12)
   c) Enumerate the functions of hippocampus. Describe the mechanism underlying learning and memory formation in the brain. (13)

2. a) Mention the key consequences of temporary refractoriness of neurons to stimuli during an action potential. Illustrate a typical block diagram of neuroprosthesis. (12)
   b) What is Jacksonian March? Discuss the mechanism behind epileptic seizure. (13)
   c) Define neurological disorders. Outline the current evidence-based treatment approaches for stroke. (10)

3. a) Examine the probable cause of Parkinson's disease. (08)
   b) What is 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)
   c) How is the integrity of information preserved in the nervous system? (10)

4. a) What type of PD patients typically benefit from DBS? Write down the challenges to future development of any modern neuroprosthesis devices. (11)
   b) What is brain-machine interface? Briefly describe the applications of BCI in the various fields of Neuroengineering. (12)
   c) What is neural computation? Mention some mathematical models of neural computation. Illustrate the topography of neural networks. (12)

Section B

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

5. a) What is EEG montage? What are the types of montages in EEG? Explain then in brief. (15)
   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)

6. a) Describe the fundamental principles underlying the BOLD fMRI signal using schematic representations. (14)
   b) Draw schematic structure of a helmet-shape liquid-He dewar in MEG system. (11)
   c) Discuss the working principle of electronic nose with a necessary diagram. (10)

7. a) Discuss the mathematical basis of fNIRS imaging. Why have we chosen NIR light in fNIRS? (15)
   b) What is cochlear implant? How does a cochlear implant work? (10)
   c) Briefly describe the EEG acquisition system with a necessary diagram. (10)

8. a) What is Functional Electrical Stimulation (FES)? How does FES work? (10)
   b) Draw the schematic diagram of hardware for CW-fNIRS system. Also explain the sensitivity distribution for source detector spacing in CW-fNIRS. (15)
   c) Derive the ARMA model for feature extraction of EEG. (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
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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.	(12)
	b)	How do optical biosensors transduce the solution concentration using photometry method? Explain the mechanism with proper figures.	(10)
	c)	Write down the enzyme category with functions used in biosensors.	(08)
	d)	What are the steps required to process cell mimetic bioreceptors?	(05)
2.	a)	Briefly discuss different types of ISE. Write down some applications of ISE.	(15)
	b)	Derive a mathematical formula with proper definition on which conductometric biosensing mechanism depends.	(11)
	c)	Briefly explain the working principle of Impedimetric biosensors.	(09)
3.	a)	Why do we need microsensors? What are the steps involved in microfabrication of micro-biosensors?	(11)
	b)	Define M-S junction diode. Write down the working mechanism of M-S junction based biosensors describing the V-I characteristics in both forward and reverse biases.	(13)
	c)	Give a detail outline on the construction and working mechanism of pollistor-type biosensors.	(11)
4.	a)	How are the solid electrolyte-based FET biosensors constructed? What measures should be taken to improve the sensitivity of it? Illustrate the sensor output response.	(11)
	b)	Write down some biosensing applications of CRISPR-Cas system.	(08)
	c)	How does the Cas13 effector based CRISPR-Cas system identify specific sequence of DNA or RNA fragments?	(11)
	d)	Mention a few applications of gas sensors.	(05)

Section B

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

5.	a)	How do DNA microarrays work? Describe with necessary diagrams.	(10)
	b)	What are the applications of digital microfluidic biochips?	(10)
	c)	What are the steps involved in analytical protein microarray for protein profling?	(10)
	d)	In what purposes, are the direct detection DNA microarrays used?	(05)
6.	a)	Draw and label a two-layer digital microfluidic biochip with integrated photodetector.	(10)
	b)	How do the reverse-phase protein microarrays work? Explain in brief with schematic illustration.	(10)
	c)	Describe the basic principle of electrowetting-on-dielectric (EWOD) method for biochip design.	(15)
7.	a)	How does Mass Spectrometry (MS) technique identify proteins from a sample? Explain.	(12)
	b)	Describe the surface chemistry of oligonucleotide probes.	(10)
	c)	Describe the basic principle of digital microfluidic biochips.	(13)
8.	a)	What are the main components of a biochips? Explain them briefly.	(10)
	b)	Explain the construction steps of CDNA libraries.	(15)
	c)	What is SNP genotyping? What is the importance of mutations in gene analysis?	(10)

Khulna University of Engineering & Technology
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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
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Section A

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

1. a) Briefly explain digital image processing. Why the study of digital image processing is necessary for the students of biomedical engineering? (10)

b) Describe the fundamental classes of digital image processing. (15)

c) Illustrate brightness adoption of human eye with the following effects (i) simultaneous contrast and (ii) optical illution. (10)

2. a) Illustrate and explain the process of acquisition of digital image from a typical scene. (12)

b) Define neighborhood and connectivity. What are the different types of pixel connectivity that may be present in a digital image? Illustrate them with suitable diagrams. (10)

c) Define spatial and gray level resolution. Explain the effect of changing these resolution of an image. (08)

d) Explain image interpolation with a suitable example. (05)

3. a) What is intensity transformation of an image? Explain following intensity transformation with suitable examples (i) Image negatives, (ii) Log transformations, and (iii) Gamma transformation. (12)

b) Show the steps of histogram equalization for the image of size 5x5 given in Fig. 3(b). (15)

8	3	5	4	3
9	2	4	8	5
0	3	0	9	6
3	2	5	4	8
7	3	7	2	4

Fig. for Q 3 (b)

c) Illustrate sharpening spatial filters. How can we implement them on a digital image? (08)

4. a) Explain unsharp masking and high boost filtering with a suitable example. (10)

b) Why do we need image transformation in frequency domain? Define 2D-DFT and IDFT. How can we perform smoothing and edge detection of an image in frequency domain? (15)

c) Describe the basic filtering steps in frequency domain for an image. (10)

Section B

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

5. a) What is morphological image processing? Illustrate erosion and dilation with suitable examples. (12)

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

c) Calculate the erosion of image A using P as the structuring element as shown in Fig. 5(c) and show the outcome at each step separately. (11)

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

A

1
1
1

P

Fig. for Q5(c)

6. a) What problems normally arise during boundary separating of individual classes using linear decision functions? Mention the probable solutions with proper mathematical explanations. (15)

b) Based on which properties the image segmentation algorithms are developed? Briefly explain global processing via Hough transform with necessary diagram. (10)

c) What is thresholding? Explain role of different types of thresholding in image processing. (10)

7. a) Illustrate the automated hole filling algorithm stepwise for binary image based on morphological reconstruction. (13)

b) Write short notes on: (i) Basic concept of morphological watersheds segmentation and (ii) Dam construction. (12)

c) How would you design different color filters using CMYR color model? Explain with suitable example. (10)

8. a) Convert the RGB image, I as shown in Fig. 8(a) into XYZ and gray scale images. (15)

$$I = \begin{bmatrix} 15,25,35 & 35,121,25 & 82,62,95 \\ 100,25,200 & 25,25,25 & 0,1,0 \\ 123,100,210 & 210,90,120 & 16,34,82 \end{bmatrix}$$

Fig. for Q 8(a)

b) Write short note on region splitting and merging. (08)

c) Write short notes on: (i) Pseudo color imaging, (ii) Color complement, and (iii) color slicing. (12)

Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Regular Examination, 2022
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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 contribute to the emergence of clinical engineering discipline in hospitals. (08)
   b) What are the functions of a clinical engineer? Discuss service contract management and development of new technology with proper examples. (15)
   c) What is healthcare technology management? Illustrate the HTM cycle and describe it in brief. (12)

2. a) What is maintenance? Briefly describe the significance of preventive maintenance using the bathtub curve. (10)
   b) Define overhaul. Explain the process of maintenance management using key the components of characteristics of maintenance. (15)
   c) Write down the minimum requirements and skills that a clinical engineering technolojist should have. A hospital has 200 machines and the CE supervises the BMETs who repair malfunctioning machines. The maintenance policy is to repair the broken down machine and bring them back in service within 2 hours (on average). If the average breakdown rate is 3.5 machines/hour and each BMET can repair 0.25 machine/hour (on average), how many BMETs are required? (10)

3. a) Define leakage current and classify it. Analyze a practical scenario where the significance of grounding is highlighted, emphasizing its essential role in a hospital setting. (12)
   b) What is nonrepudiation? How does it assist organizations in proving accountability? (08)
   c) Explain the laboratory practices of different biosafety levels. (15)

4. a) Why on-site gas generators are required? Write down the guidelines for gas pipeline. (11)
   b) What is CPAP? Describe a few methods of ventilatory support in brief. (12)
   c) Draw a typical schematic of a centralized air conditioning system and describe each cycle. (12)

Section B

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

5. a) What is hospital? Discuss the functions of different departments in a typical hospital. (10)

b) What is meant by hospital management? List the managerial activities of a hospital. (10)

c) Is there a single line of authority present in the hospital organization? Justify your answer. (10)

d) What are the levels of care? Give examples. (05)

6. a) List the guiding principles for hospital planning and design. Briefly describe the steps involved in hospital planning. (13)

b) Is it suitable to build a hospital in a crowded and noisy area? Enumerate the site selection criteria for hospital construction project. (12)

c) Draw a typical electrical distribution system for hospitals. Why is it necessary to have an essential electrical system in hospitals? (10)

7. a) What are the functions of healthcare financial management? Why budget is important for financial management? Conventional or zero-based budget which one is preferable? (12)

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 100 per order and the holding cost is 10% of unit price. Determine the following: (10)

(i) Economic order quantity,
(ii) Total annual cost, and
(iii) Number of orders per year.

c) What is HRM? Discuss the operational function of HRM in brief. (08)

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

8. a) What is hospital information flow and handling? Give some examples of standards used for hospital information flow and handling. (08)

b) Describe the steps of Quality Improvement Project (QIP) and write down the purposes of quality assurance of hospital services. (07)

c) Write short notes on (i) PACS and (ii) HIS. (10)

d) Define standards and regulation policies. List the key regulatory bodies of hospital related services in Bangladesh. (10)