

Khulna University of Engineering & Technology
 B. Sc. Engineering 4th Year 1st Term Examination, 2019
 Department of Biomedical Engineering
BME 4151
Clinical Engineering & 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 **Answer Script A**)

1. a) What is the ACCE definition of a Clinical Engineer? What are the functions of a clinical engineer on technology assessment, acquisition of technology, equipment control, preventive and corrective maintenance, safety and risk management? (15)
- b) What is the role of clinical engineering to support patient care? What is the role of clinical engineering within the hospital organization? Draw the organization chart of medical support services. (11)
- c) Mention the administrative, functional, and educational relationship among CE, CET, and BMET. (09)
2. a) Who is clinical engineering technologist? What are the responsibilities of CET? What knowledge should have a CET in a hospital? (07)
- b) Draw the medical technology life cycle. Classify healthcare delivery system based on: (i) level of care, (ii) by ownership, (iii) size, and (iv) specialization. (10)
- c) What are medical equipment services? What are the components of MES? Describe the benefits of each component of MES. (10)
- d) A factory has 200 machines and the maintenance engineer supervises the repair crews who repair malfunctioning machines. The maintenance policy is to repair the broken down machine and bring back in production within 2 hours on the average. If the average breakdown rate is 3.5 machines/hour and each repair crew can repair 0.25 machine per hour on the average. How many repair crews are required? (08)
3. a) What is the role of clinical engineering in the radiotherapy department? How the radiotherapy team is formed? Explain briefly. (06)
- b) Define the mean time between failure, repeated failure, repair time, downtime, and delinquent related to performance monitoring of equipment. (10)
- c) Medical equipment is needed to purchase in a hospital. The physicians requested the clinical engineer (CE) to procure the equipment. The CE wants to know the daily working schedule of the equipment. The physician informed the CE that they will use this equipment as per the following weekly schedule. The CE selects the equipment which can operate a maximum of 100 hours per week.

Schedule	Time Duration
Sunday to Thursday	8:30am-10:00am, 11:00am-13:00pm, 15:00pm-20:00pm
Friday & Saturday	9:00am-12:00pm, 15:00pm-20:00pm

Calculate the use co-efficient index for selecting this equipment in that hospital.

- d) Describe the inventory, methods, and resources of equipment planning. (10)
4. a) Mention different types of medical gases and their usage. What are the components of medical gas pipeline system? (10)
- b) Explain the role of a Clinical Engineer for biomedical waste management in hospitals. Describe the flow diagram for medical waste management process. (15)
- c) 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, 60Hz ac, and 10kHz ac. (10)

Section B

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

5. a) What is automation? Write down the advantages of automation in healthcare system. (10)
- b) Explain the design criteria of an inpatient service division. (10)
- c) Write down the role of procurement in hospital management. What are the advantages of direct purchase? (10)
- d) Write a short note on hospital record system. (05)

6. a) Define an information system. Write down the advantages of EHRs over paper-based records. (10)
- b) What is ANC? Write down the role of ANC in reducing the maternal mortality rate. (10)
- c) What is PACS? Enumerate the potential benefits of PACS. (05)
- d) Define human resource management (HRM). What are the functions of HRM? What are the limitations of HRM in Bangladesh? How can it overcome? (10)

7. a) Describe the design criteria of an ICU bed. (10)
- b) Classify budget. Write down the importance of zero-based budget system. (10)
- c) Explain the importance of auditing in health care system. (10)
- d) Write short note on Central Sterilization Unit. (05)

8. a) Enumerate the role of finance department in hospital management. (10)
- b) What are the functions of a hospital? Enumerate different types of hospitals in details. (10)
- c) Explain the design criteria of emergency medical unit in details. (10)
- d) Write short note on autoclaving. (05)

Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Examination, 2019
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.
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Section A

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

1. a) Describe the transduction principles listed below with suitable diagram. (15)
(i) Pressure transduction; (ii) Strain transduction; (iii) Piezoelectric transduction
- b) Define Bioreceptors. How to make a biosensor biologically active? Explain with different way of them. (10)
- c) What are the steps to produce biomimetic receptors? (05)
- d) Draw a general architecture of biosensor. (05)
2. a) A biosensor uses 0.3M CuSO₄ (aq) as a biorecognition element to measure the concentration of iron (Fe²⁺) test solution using Daniell cell system at 273.15 k. This biosensor produces + 0.794V as voltage reading. Determine the concentration of iron (Fe²⁺). (10)
Assume, only given half reactions take place:
$$\text{Cu}^{2+} + 2\text{e}^{-} \longrightarrow \text{Cu(s)} \quad E^0 = + 0.34\text{V}$$
$$\text{Fe}^{2+} + 2\text{e}^{-} \longrightarrow \text{Fe(s)} \quad E^0 = - 0.44\text{V}$$
And entirely,
$$\text{Fe(s)} + \text{Cu}^{2+} \longrightarrow \text{Fe}^{2+} + \text{Cu(s)}.$$
- b) Explain conductometric transduction with suitable diagrams and mention its limitations. (13)
- c) Derive a relation between conductivity of an electrolyte solution and its ion concentration. (07)
- d) Show schematically how oxygen works as a mediator in Clark oxygen electrode while sensing glucose. (05)
3. a) Briefly explain the microsensing principle of resistor based metal oxide semiconductors. (14)
- b) How does a schottky diode-based sensor work in each possible bias? (13)
- c) What is NASICON? Write down the working principle of pellistor calorimetric biosensor. (08)
4. a) How does ISFET differ from MOSFET? (05)
- b) What are the working principles of DNA based ISFET? Discuss it in briefly. (10)
- c) Explain structural and functional properties of catalytic-gate FET: H₂ sensor. (10)
- d) Write some applications of biosensors in the following field: (10)
(i) Pathogens detection (ii) Biodefence biosensing application.

Section B

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

5. a) What is meant by biochips? What are they doing and why need them in Biomedical applications? (10)
- b) What are the basic principles of microfluidic chips? (07)
- c) What are the main issues to choose proper materials to fabricate microfluidic chips? (08)
- d) Describe the actuation methods of dielectrophoresis (DEP) for Biochip design. (10)
6. a) What is FPGA? Describe the FPGA architecture for Biochip design. (15)
- b) Show the flow diagram of FPGA design. (05)
- c) Describe the full custom design of Biochip. (10)
- d) What are the applications of digital microfluidic biochips (DMB)? (05)
7. a) Draw the block diagram of sensor detection system and explain with them in briefly. (10)
- b) Describe the invasive and non-invasive sensor measurement techniques. (08)
- c) Describe the wire and wireless sensor measurement techniques. (07)
- d) What are the steps of biomedical sensor design? (10)
8. a) What are the complexities of design processes for CAD analysis? (06)
- b) What is QAM? Draw bit representation diagram of 4-QAM, 8-QAM and 16-QAM. (12)
- c) Draw the waveform of bit sequence 110101 for ASK, BPSK, BFSK. (10)
- d) Sketch a mask layout for a CMOS 2-input NOR gate. (07)

Khulna University of Engineering & Technology
 B. Sc. Engineering 4th Year 1st Term Examination, 2019
 Department of Biomedical Engineering
BME 4131
Bio-optics

Time: 3 hours

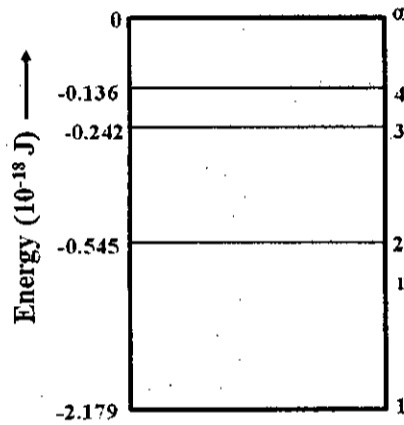
Full Marks: 210

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

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

1. a) What is coherence of light? Write down the features defining the complete coherence properties of light. (07)
- b) What is population inversion condition? Deduce the condition of population inversion from Einstein's model of absorption and emission. (12)
- c) How do you describe the interaction of light with biological samples with the viewpoint of electronic dipole moment? (05)
- d) Draw Jablonski diagram that describes the possible fates of excitations. Is a photon of light absorbed or emitted when an electron goes from the level $n=4$ to $n=3$? Give your reasoning. Also, find out the energy of that photon. Consider the diagram shown in Fig. 1(d) below. (11)



2. a) What is spectroscopy? List the various spectroscopic methods in bio-optics. (08)
- b) Define the terms: (i) Absorption Cross Section, (ii) Michelson interferometer (08)
- c) Mention some types of laser with their applications in bio-optics. (05)
- d) Explain autofluorescence. A fluorescent dye is said to have a large Stokes shift. What is meant by this and why is this useful in fluorescent measurements? (08)
- e) A laser produces 1×10^{19} photons in a 2ms pulse. Each photon has energy of 4.6 eV. Calculate the pulse power and wavelength of emission. (06)
3. a) A sample of saliva from a smoker is known to contain thiocyanate mixed with an unknown substance (compound X), and analysis using a spectrometer gives an absorbance of 0.25 at 530 nm and 0.47 at 620 nm in a 1 cm cuvette. The molar absorptivities ($M^{-1}cm^{-1}$) for the thiocyanate and compound X at the two wavelengths are summarized in the following table: (12)

	$\epsilon_{530} (M^{-1}cm^{-1})$	$\epsilon_{620} (M^{-1}cm^{-1})$
Thiocyanate	0.45	0.5
Compound X	0.15	0.27

Assuming negligible absorption from other compounds present in saliva, what is the concentration of Thiocyanate and compound X in the mixer?

- b) What are the differences between Rayleigh and Raman scattering? Briefly describe the process of Raman Spectroscopy for Biological samples. (10)
- c) Classify optical methods of imaging for Bio-phobics. What are the factors that limit the resolution of a microscope? Find the resolution of a 1.0 NA objective with green light ($\lambda = 532$ nm). (13)

4. a) Why OCT is the most popular imaging technique in Bio-photonics? Describe the basic principle of OCT with a sketch of the experimental setup. (12)
- b) Describe different types of optical aberrations occurred in optical microscopy. (06)
- c) Describe spatial filtering method to separate the ballistic and snake photons from diffuse photons. (08)
- d) Briefly describe phase contrast microscopy method for optical imaging. (09)

Section B

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

5. a) Mention the various processes through which the light interacts with cells and tissues. (07)
- b) Briefly illustrate various light induced processes in tissues. (10)
- c) What is photo-process? Describe the methods of measurement of optical reflection, absorption, and scattering properties of a tissue. (09)
- d) What are the different methods of in-vivo light delivery? Explain the process of optical biopsy with its several advantages. (09)
6. a) Describe the key components of a typical biosensor device. Mention several advantages of optical biosensor. (10)
- b) List the various optical manifestation caused by the presence of an analyte in optical biosensor. Explain the principles that selectively recognize an analyte. (10)
- c) Briefly explain fiber optic biosensors. What are the key features of planar waveguide biosensors? (10)
- d) Green light ($\lambda = 540 \text{ nm}$) is coupled into a glass fiber ($n=1.50$) which is immersed in water ($n=1.33$) at an angle of 70° from normal to the fiber-water interface. What is the penetration depth of the evanescent wave? (05)
7. a) What is meant by surface plasmon? Describe the principle of operation of Surface Plasmon Resonance (SPR) biosensors. Also mention some advantages of it. (12)
- b) What is flow cytometer? Explain the operation of a flow cytometer with its some applications. (14)
- c) A prism was coated with a thin layer of silver ($\epsilon_m = -27.6$ at $\lambda = 800 \text{ nm}$), 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 Plasmon resonance angle of the system.
- $$k_{sp} = kn_p \sin \theta_{sp} \qquad k_{sp} = k \times N_{sp}$$
- $$N_{sp} = \sqrt{\frac{\epsilon_m \epsilon_d}{\epsilon_m + \epsilon_d}}$$
8. a) Describe the principle of operation of Photo Dynamic Therapy (PDT) in cancer treatment. What advantage does this have over conventional chemotherapy? (13)
- b) What are the various Laser-Tissue interaction mechanisms for ophthalmic applications? Give the role of femto second laser in surgery. (12)
- c) Write short note on any one: (10)
- (i) Optical Tweezer
- (ii) Quantum dots for bioimaging

Khulna University of Engineering & Technology
 B. Sc. Engineering 4th Year 1st Term Examination, 2019
 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.
 ii) Figures in the right margin indicate full marks.

Section A

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

1. a) What is biomedical image processing? Why the study of image processing is necessary for the students of Biomedical Engineering Department? (08)
- b) Illustrate analog image and digital image with suitable example. Why different imaging modalities are used in medical imaging? (08)
- c) Illustrate brightness adaption of human eye with the following effect: (12)
 - i) Mach band effect
 - ii) Simultaneous contrast
 - iii) Optical illusion.
- d) Why sensor is used in image processing? What are the basic parts of a photo sensor? (07)
2. a) Write short notes on: (12)
 - i) Log transformation
 - ii) Power-law transformation
 - iii) Image negatives.
- b) Show the steps of histogram equalization for the following image of size 5×5 given in Table 2(b) below: (10)

Table 2(b)

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

- c) Explain spatial filtering. Briefly describe the different methods of smoothing spatial filters with suitable applications. (13)
3. a) What is the purpose of sharpening spatial filters? How to sharpen an image using Laplacian function? (08)
- b) Schematically describe the basic filtering steps in frequency domain for a low quality image. (06)
- c) What is image compression? Briefly explain how image compression is achieved? (08)
- d) What is meant by psycho-visual redundancy? How can we eliminate psycho-visual redundancy? Determine the IGS code of the sequential pixels as shown in the Table 3(d). (13)

Table 3(d)

Pixel	Gray Level
$i - 1$	N/A
i	0110 1100
$i + 1$	1000 1011
$i + 2$	1000 0111
$i + 3$	1111 0100

Table 4(a)

Symbol	Probability
a_2	0.4
a_6	0.3
a_1	0.1
a_4	0.1
a_3	0.06
a_5	0.04

4. a) Briefly describe Huffman coding. Above Table 4(a) shows the source symbols with respective probability, determine the Huffman code for each symbols. Hence compare the average length of Huffman coding with binary coding. (15)
- b) Write down the steps in JPEG image compression standard. (06)
- c) Write down the differences between JPEG and JPEG- 2000 image compression standard. (06)
- d) Write short notes on: (08)
 - i) Run length coding
 - ii) Bit plane coding.

Section B

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

5. a) What is image segmentation? Why segmentation is necessary for biomedical images? What are the main consideration points to segment a biomedical image? (12)
- b) Write down the significance of 1st and 2nd derivatives for edge detection of biomedical images. (08)
- c) Explain how region splitting and merging can be used for image segmentation. (10)
- d) Does noise play any role in biomedical image thresholding? Justify your answer. (05)
6. a) Why color image processing is necessary for biomedical images? Why R, G, B is considered as primary color? (10)
- b) What are the advantages of converting RGB color space to HIS color space? An RGB image has the following color planes. Convert this from RGB to HIS. (15)
- $$R = \begin{bmatrix} 70 & 82 \\ 10 & 40 \end{bmatrix}; \quad G = \begin{bmatrix} 110 & 170 \\ 111 & 160 \end{bmatrix}; \quad B = \begin{bmatrix} 50 & 42 \\ 48 & 43 \end{bmatrix}$$
- c) What is the purpose of pseudo color image processing? Briefly explain gray level to color transformation method with necessary block diagram. (10)
7. a) Explain image reconstruction and write some application of it. (10)
- b) Describe Fourier slice theorem and prove it. Mention the drawbacks of Fourier slice theorem. (15)
- c) Write down the steps used in Forward Back Projection algorithm. Also describe its application in CT/MRI. (10)
8. a) Derive the expression of optimal threshold used in biomedical image segmentation. (12)
- b) Explain the principle of Laplacian of Gaussian (LoG) filter for edge detection. (10)
- c) A CT image has four pixels. The attenuation of four projections are 5, 8, 3, 2. Use back projection in four directions 0° , 45° , 90° , 135° respectively. Construct the original image showing each step separately. (13)

Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Examination, 2019
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 **Answer Script A**)

1. a) Briefly explain that nerve as wires. List the various scope of neuroengineering. (08)
b) Which part of the brain is absent in Einstein's brain? Write down the main components of a typical brain neuron. (08)
c) How human brain is divided into two hemispheres? Enumerate the functions of right and left hemisphere. (10)
d) Write short notes on: (i) Broca's area; (ii) Wernicke's area; (iii) Cingulate gyrus (09)
2. a) Draw and label the Broadman's cytoarchitectonic area of human brain. (12)
b) What are the embryological developments of human brain? What is midbrain? (08)
c) How many ventricles are present in human brain? How they communicate with each other? (05)
d) What is choroid plexus? Describe how the CSF is formed? (10)
3. a) What is Epilepsy? Write down the cause and types of epilepsy. Classify seizure. (10)
b) How Epilepsy is diagnosed? Briefly explain the EEG activity? (10)
c) Sketch the schematic diagram of EEG machine. List the types of EEG electrode. (10)
d) What is the difference between neuronal and neural? (05)
4. a) What is Dopamine? Write down the cause and pathology of Parkinson's diseases. (10)
b) Describe the Hodgkin-Huxley model for Parkinson's diseases with proper diagram. (10)
c) Write short notes on: (i) LFP; (ii) Microelectrode arrays. (10)
d) What is Retinal prosthesis? Where and when the first electrical nose is developed? (05)

Section B

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

5. a) What is brain signal? Why EEG used in biomedical application? (08)
b) Derive the modified covariance method for used of EEG analysis. (12)
c) What is wavelet transform? Show the computational process of CWT for biomedical signal analysis. (10)
d) What is power spectral density? (05)
6. a) Why many classification algorithms do not perform efficiently for brain signal analysis? (10)
b) Show the summary of K-means algorithm for classification of brain signal. (13)
c) Define: i) Entropy; ii) Kolmogorov entropy; iii) Lyapunov Exponents; iv) Approximate entropy. (12)
7. a) What is hemodynamic response (HDR)? Describe the general linear model for fMRI data analysis. (10)
b) Derive the Beer-Lambert law and modified Beer-Lambert law. List the application area of fNIR. (10)
c) What is fNIR? Discuss about the working principle of fNIR. (10)
d) List the importance of fMRI. (05)
8. a) What is MEG? What are the principle features of MEG? (12)
b) What is SQUID? Why do we need MEG helmet? (08)
c) What are the differences of MEG and EEG? (05)
d) Briefly explain the BOLD fMRI signal with proper diagram. List the difference between MRI and fMRI. (10)