Khulna University of Engineering & Technology
B. Sc. Engineering 4th Year 1st Term Examination, 2018
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 **Script A**)

1. a) What is digital image processing? Why the study of digital image processing is necessary for the students of Biomedical Engineering Department? (10)

b) Briefly explain simultaneous contrast and optical illusion. (10)

c) What are the general image acquisition methods? Briefly describe the image acquisition using single sensor. (10)

d) Define different neighbors of a pixel, $p(x, y)$. (05)

2. a) What is piecewise linear transformation? Briefly explain its basic principle with example for the following operations: (12)
i) Contrast stretching;
ii) Gray level slicing;
iii) Bit-plane slicing.

b) What is the purpose of sharpening spatial filters? How to sharpen an image using Laplacian? Derive simplified equation for sharpening an image using Laplacian. (08)

c) Write short notes on : (15)
i) Order Statistics filters;
ii) Unsharp masking and high-boost filtering;
iii) Smoothing linear filters.

3. a) Why do we need image transform? Define 2D-DFT and IDFT. (10)

b) What is meant by image compression? Explain how image compression is achieved. (08)

c) Define fidelity. Explain different types of fidelity criteria used in digital image processing. (10)

d) Briefly describe general image compression system model. (07)

4. a) How is information measured? Explain the entropy of a data source. (08)

b) What is JPEG? Write down the difference between JPEG and JPEG-2000 image compression standard. Briefly describe the steps of JPEG compression system. (15)

c) Write short notes on : (12)
(i) Huffman Coding;
(ii) LZW coding;
(iii) Runlength coding.

Section B

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

5. a) What is image segmentation? Why is image segmentation necessary? What are the main consideration points to segment an image? (12)

b) Write down the significance of 1st and 2nd derivatives in case of edge detection. (08)

c) Briefly explain the role of illumination in image segmentation. (10)

d) What is meant by region growing? (05)

6. a) Why color image processing is necessary? (06)

b) Write the purpose of using color model. Briefly explain RGB color model. (10)

c) What are the advantages of converting RGB color space to HSI color space? (07)

d) An RGB color image has the following color planes. Convert this from RGB to HSI: (12)

$$R = \begin{bmatrix} 70 & 82 \\ 10 & 40 \end{bmatrix}, \quad G = \begin{bmatrix} 102 & 170 \\ 114 & 160 \end{bmatrix}, \quad B = \begin{bmatrix} 50 & 42 \\ 48 & 43 \end{bmatrix}.$$

7. a) What is image reconstruction? Write down the application of image reconstruction. (10)

b) Describe Fourier Slice theorem and prove it. Write its application in CT scan images. (15)

c) Write down the Forward Back Projection algorithm. Also describe its applications in CT/MRI. (10)

8. a) Write down the drawbacks of Fourier Slice theorem. How this problem can be solved? (08)

b) 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 and reconstruct the original image. Showing each step separately. (12)

c) Write down the algorithm to select the basic global threshold value in image segmentation. (07)

d) How region splitting and merging can be used for image segmentation. (08)

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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 Bio-photonics? Briefly describe multidisciplinary scopes of bio-photonics in different applications (e.g. in healthcare). (09)

b) Define the terms: (08)
(i) Polarization of light.
(ii) Birefringence.
(iii) Group velocity.
(iv) Normal modes of vibration.

c) List various processes involved in electronic excitation created by light absorption. With the aid of Jablonsky (energy level) diagram, describe the main radiative and non-radiative processes. Mention some applications of each type in spectroscopy. (12)

d) In a particular fluorescent dye, an electronic transition occurs between the ground state (E=0 eV) and an excited state at E=5.00 eV. The electron then relaxes to an energy level of E=4.80 eV before emitting a photon and returning to the ground state. What is the wavelength (in nm) of the photon emitted and the photo absorbed? (06)

2. a) What is meant by spectroscopy? Write down the various spectroscopic methods in Bio-photonics. (08)

b) Distinguish between the essential features of Absorption and Fluorescence spectroscopy. Briefly describe the procedure for determining the concentration of an organic substance by absorption spectroscopy. (15)

c) What is meant by Circular Dichroism? What useful information can it provide? (06)

d) Describe the significance of both real and imaginary part of refractive index (η) of a medium. Also, find out the reflectance R when a light incident normally from air to a tissue of refractive index 1.56. (06)

3. a) Explain autofluorescence. What does the Stokes shift of a fluorescent dye refer to, and explain its practical relevance to biosensor measurements? (08)

b) What is the main difference between Rayleigh and Raman scattering? Briefly describe the process of Raman spectroscopy. (11)

c) Describe the terms: (10)
(i) Second order non-linear process.
(ii) Fluorescence microscopy.

d) A laser produces 1×10^{19} photons in a 2 ms pulse. Each photon has an energy of 4.1 eV. Calculate the pulse power and wavelength of emission. (06)

4. a) What are the benefits offered by optical imaging? (07)

b) What is the smallest feature that can be resolved with an optical microscope using a 60x, 1.0 NA objectives? (06)

c) Describe in detail any two of the following bioimaging techniques (16)
(i) Confocal Microscopy.
(ii) Optical Coherence Tomography (OCT).
(iii) Near-field Optical Microscopy.

d) Differentiate between phase contrast and dark field-microscopy. (06)

Section B

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

5. a) List the various processes through which the light interact with the biological components. (07)

b) Briefly explain various light induced process in tissues. (09)

c) What is photo-process? Outline in detail one photo-processes in biopolymers. (12)

d) What are the available methods of Light delivery for in Vivo photoexcitation? Briefly describe the process of optical fiber delivery system. (07)

6. a) Describe the key components of a typical biosensor device. Mention several advantages of optical biosensor. (11)

b) List the various optical transduction principles used for biosensing. Explain the different optical geometries used for such applications. (11)

c) Give the basic principle of evanescent wave-biosensor. Also mention some advantages offered by it. (07)

d) As shown in figure bellow, a light ray impinges on the surface of a prism ($n_p = 1.50$) which has an air superstrate ($n_s = 1.00$). Calculate the wavelength of light required to produce an evanescent wave penetration depth of 150 nm for a system in which $\theta_i = 66.1°$. (06)

$$d_p = \frac{\lambda}{2\pi n_1 \sqrt{sin^2\theta_i - sin^2\theta_c}}$$

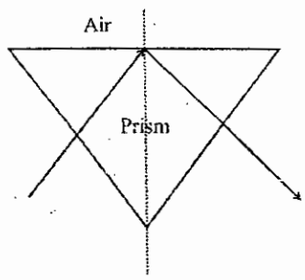

Figure Q.6(d)

7. a) With a neat sketch explain Mach-Zehnder interferometer biosensor. Also mention some advantages of Surface Plasmon Resonance (SPR) biosensor. (12)

b) What is flow cytometer? Explain the operation of a flow cytometer with the help of a block diagram. Also, mention two applications of it. (14)

c) Briefly explain the principle of Laser Tweezer action. (09)

8. a) Describe the operating principle of photodynamic therapy (PDI) in cancer treatment. What advantage does this have over conventional chemotherapy? (12)

b) Illustrate in detail how restructuring and contouring of tissues can be done using laser. Give the role of femtosecond laser in surgery. (13)

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

(i) Biosensing using nanoparticles and nanorodes.

(ii) Optical Biopsy.

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BME 4133
Biosensors & 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)	Define Biosensor according to IUPAC with examples.	(06)
	b)	Explain working steps of Biosensors with suitable diagram.	(08)
	c)	What is meant by photochemical transducer? Describe different transduction principles used in photochemical transducer with suitable examples.	(14)
	d)	Briefly describe piezoelectric transduction principle with advantages and disadvantages.	(07)
2.	a)	Briefly describe Clark Oxygen electrode.	(12)
	b)	What is meant by Bioreceptor? Briefly describe the different types of bioreceptors with suitable examples.	(15)
	c)	Define electrochemical biosensor. Classify it according to detection approaches.	(08)
3.	a)	Briefly describe the glucose (H_2O_2 based) biosensor.	(10)
	b)	How cell potential is measured? Derive Nernst equation and explain the effect of temperatures on measurement potential effects. Why normal range of analysis is far from isopotential points.	(15)
	c)	Write down the attractive features of ISE.	(05)
	d)	What are the factors resulting in conductivity changes in conductometric transducer?	(05)
4.	a)	Why microsensors are needed in modern application? Write down the key characteristic features of microsensors.	(08)
	b)	Briefly describe the working principles of DNA-based ISFET.	(10)
	c)	Write a short note on gas sensors based on suspended gate FETs.	(07)
	d)	Write short note on potentiometric biosensors.	(05)
	e)	Why is FET used in biosensor?	(05)

Section B

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

5.	a)	What is Biochips? What are they doing and why need them in Biomedical applications?	(10)
	b)	Describe different phase of design methodology for Digital Microfluidic Biochips (DMB).	(15)
	c)	What are the main issues to choose proper materials to fabricate microfluidic chips?	(10)
6.	a)	What is FPGA? Describe the FPGA architecture for Biochip design.	(15)
	b)	What are the characteristics of cells for standard based cell design in Biochip?	(10)
	c)	Draw the flow diagram of physical design cycle of Biochip/VLSI.	(10)
7.	a)	Draw block diagram of sensor detection system and briefly explain them.	(15)
	b)	Describe the steps of biomedical sensor design.	(10)
	c)	Describe the active and passive sensor measurement techniques.	(10)
8.	a)	Write down the working principles of magneto-electric induction sensor.	(10)
	b)	What are the difference between ultrasonic sensors and IR sensors?	(10)
	c)	Describe the blood pressure sensor measurement system.	(10)
	d)	What is optical proximity sensor? How many type of it?	(05)

Khulna University of Engineering & Technology
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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.
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Section A

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

1. a) Define clinical engineering. What are the mission and vision of clinical engineering? What is technology planning? What is the function of a clinical engineer on technology planning, 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 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) Draw the control structure of healthcare technology management (HTM). (06)

   b) Draw a diagram illustrating the range of interactions in which a clinical engineer might be required to engage in a hospital setting. (09)

   c) What are the different types of maintenance? Mention the difference between preventive maintenance and predictive maintenance. What are the disadvantages of corrective maintenance and advantages of predictive maintenance? (12)

   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 two hours on the average. If average breakdown rate is 3.5 machine/hour and each repair crew can repair 0.25 machine/hour on the average. How many repair crews are required? (08)

3. a) What is the role of a clinical engineer in radiotherapy department? (06)

   b) Why is equipment maintenance essential? What are the objectives of equipment maintenance? Explain the scope of equipment maintenance. Mention the components of equipment management system. (10)

   c) A 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 following weekly schedule. The CE selects the equipment which can operate maximum 12 hours in a day. (09)

Schedule	Time Duration
Sunday to Thursday	8:30am-10:00am; 11:00am-13:00pm; 15:00pm-18:00pm
Friday and Saturday	9:00am-12:00pm; 15:00pm-19:00pm

   Calculate the use coefficient 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 physiological effects of electricity. Describe the physiological effect of electric current in humans. (10)

   c) Draw the graph that shows the perception of thresholds and let go current for man and woman. Explain macro shock and micro shock with neat sketch. (10)

   d) Explain the need for Biomedical waste management in hospitals. (05)

Section B

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

5.	a)	What is EPI? What are the goals of EPI? Enumerate different vaccine schedule.	(10)
	b)	What are the components of primary health care service? Explain the role of family planning in health care management.	(10)
	c)	What is ANC? Explain the role of ANC in health care system.	(10)
	d)	Write a short note on zero based budgeting.	(05)
6.	a)	Classify hospital based on administration. Enumerate the function of hospital.	(10)
	b)	Write down the standard criteria for ICU design. Enumerate the function of a standard ICU bed.	(10)
	c)	What is HIS? What are the advantages of HIS? Explain the importance of EHRs over paper based record.	(10)
	d)	Write a short note on RIS.	(05)
7.	a)	What is PACS? What are the typical components of PACS? Enumerate the potential benefits of PACS.	(10)
	b)	Explain the design criteria of emergency medical unit in details.	(10)
	c)	Enumerate the architectural characteristics of central sterilization unit.	(10)
	d)	Write a short note on Autoclaving.	(05)
8.	a)	Define sterilization. Enumerate different methods of sterilization in details.	(15)
	b)	What is HRM? Write down the role and responsibilities of HRM division.	(10)
	c)	Write short notes on: (i) Radiology department; (ii) Inpatient service.	(10)