BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1   B. Sc. Engineering Examinations 2022-2023

Sub : **BME 401** (Molecular Biology for Engineers)

Full Marks : 210   Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

Question No. 1 is **MANDATORY**. Answer any **TWO** of the remaining **THREE** questions.

1. (a) How does glucose and lactose affect the lac operon?   **(15)**

   (b) Explain the mechanism of a rapidly amplifying selective nucleotide sequence in a test tube.   **(15)**

   (c) Elaborate on the process by which an action potential propagates along the length of an axon, detailing the molecular and physiological events involved in this complex phenomenon.   **(15)**

2. (a) Explain, with an example, how homologous recombination allows for the flawless repair of DNA double-strand breaks.   **(15)**

   (b) How do scientists detect a specific nucleotide sequence, and what methods do they use for this process.   **(15)**

3. (a) Why is it necessary to remove a membrane protein from the membrane to understand its function? Explain the process and key steps involved in isolating membrane proteins for analysis.   **(15)**

   (b) How do start and stop signals influence the positioning of a transmembrane protein in the lipid bilayer?   **(15)**

4. (a) Describe the distinct steps involved in protein synthesis from mRNA.   **(15)**

   (b) How could the deactivation of phospholipase C, resulting from a newly discovered drug that effectively controls high blood pressure, potentially lead to side effects? Consider the broader physiological consequences of this specific mechanism of action.   **(15)**

BME 401

SECTION – B

Question No. 5 is **MANDATORY**. Answer any **TWO** of the remaining **THREE** questions.

5. (a) How does the structures and chemical properties of antibodies and antigens impact their bindings with each other? Why is the presence of hinge in the F_{ab} region of antibody significant? **(15)**

   (b) IL-2 production is decreased in systemic lupus erythematosus (SLE) patients. Transcription factors regulating IL-2 production behave aberrantly in SLE T cells. Describe the complications that are associated in SLE patients. **(10)**

   (c) In humoral immune response, B lymphocytes display several effector functions. Explain the mechanism followed by B lymphocytes that contribute to pathogen elimination. **(20)**

6. (a) What proteins are responsible in recruiting leukocytes to vascular endothelial cells? Discuss the differences in their functions. **(10)**

   (b) Discuss different locations of Toll-like receptors (TLRs) and state its significance. How does TLR initiate acute inflammation? **(15)**

   (c) Discuss different properties of cytokines. **(5)**

7. (a) How does T lymphocytes mature and activate? Describe the role of thymus in selecting mature lymphocytes. **(15)**

   (b) Describe the effector functions of cell-mediated immunity. How does cytotoxic T lymphocyte destroy target cells? **(15)**

8. (a) What is the role of innate immunity in stimulating adaptive immune response? Describe the functions of mast cells in innate immunity. **(10)**

   (b) Explain the role of interferon gamma in modulating the overall immune response after a pathogen attack. **(10)**

   (c) Describe the functions of the complement system. Healthy cells in our body do not activate the complement system. Explain the reason behind it. **(10)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1   B. Sc. Engineering Examinations 2022-2023

Sub: **BME 403** (Medical Imaging)

Full Marks: 210   Time: 3 Hours

The figures in the margin indicate full marks

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Question No. 1 is **MANDATORY**.

Answer any **TWO** of the remaining **THREE** questions.

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1. (a) Let two 1-D LTI systems with PSFs $h_1(x)$ and $h_2(x)$ are given: 15

$$h_1(x) = e^{-\frac{x^2}{5}} \; ; \; h_2(x) = e^{-\frac{x^2}{10}}$$

   i.   Determine the MTF of System-1, System-2 and their cascade system, respectively.

   ii. Suppose an input signal $f(x,y) = 2 + \sin(\pi x)$ is passed through the three systems (system-1, system-2, and their cascade). Determine the output contrasts, respectively.

   (b) Explain A-mode, M-mode, and B-mode images in ultrasound imaging.   15
   Suppose, an ultrasound imaging system is operating in B-mode and requires 256 pulses to generate an image. Assume that the transducer is sensitive to at most 75 dB loss. If the tissue being imaged has a speed of sound, c =1,540 m/s and a = 1 dB.cm^{-1}MHz^{-1}, determine the working frequency to achieve a frame rate of 15 frames/second.

   (c) Suppose you are generating an MRI image of a sample with two different   15
   materials, A and B, having the same M_0= 1 A/m. However, the relaxation times of the materials are different. Determine the contrast of the image for TR= 3.6s and TE=59ms.

   [Hint: X-Y plane Magnetization, $M_{XY}(t) = M_0 e^{-TE/T2}$; neglecting precision term, Contrast, $C = \frac{|I_A - I_B|}{I_B}$ and Intensity, I=Amplitude^2]

   Given, the relaxation times of material A and B are as follows:

   A: T_{1A} = 1.2s and T_{2A} = 80ms

   B: T_{1B} = 800ms and T_{2B} = 45ms

2. (a) Describe the basic spin echo imaging sequence with an illustration.   15

(b) Given the probability distributions of the test results for normal and disease **15**
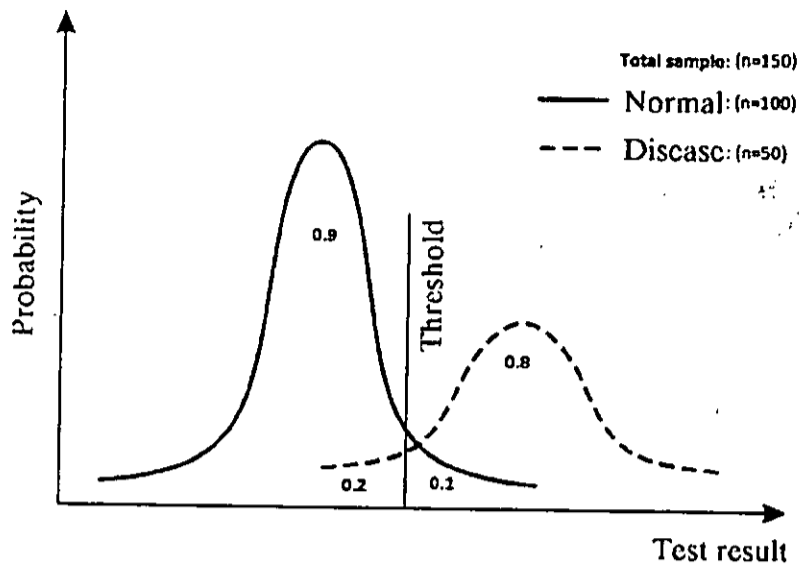subjects in Figure: Question 2(b)

Figure: Question 2(b)

i. Determine the Sensitivity, Specificity, Diagnostic Accuracy, Prevalence, Positive Predictive Value (PPV), Negative Predictive Value (NPV)

ii. Explain the effect of shifting the threshold to the right on sensitivity and specificity.

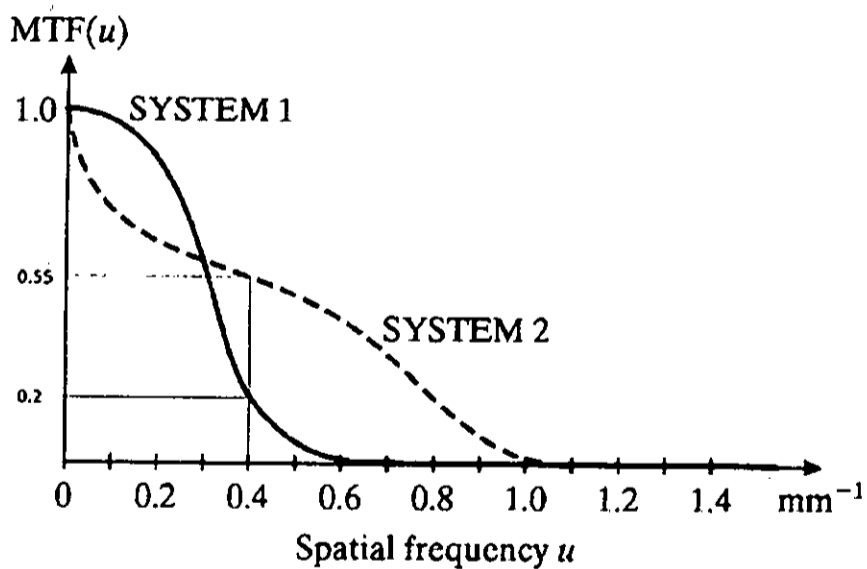3   (a) Given the modulation transfer function MTF(u) of two systems in Figure: **15**
Question 3(a)

Figure: Question 3(a)

i. Determine the resolutions of the two systems and comment on which system is better suited for what type of imaging.

ii. Determine the output contrast of a sinusoidal object $f(x) = 10\sin(2 * \pi * 0.4 * x) + 10$ on both systems.

(b) Consider a transducer placed at an angle (θ) with the blood stream. The **10**
transducer is operating in pulse echo mode and generating a plane wave of

frequency (f_s). Derive a relation between Doppler frequency (f_D), velocity of sound (c), transducer frequency (f_s) and velocity of blood stream (v).

(c) An ultrasound imaging system has a transducer operating at 5-MHz with 100% bandwidth. What is the frequency range of the transducer?   **5**

4   (a) An ultrasound imaging system is equipped with two square transducers.   **10**
One operates at 5 MHz, and the other one operates at 12 MHz. The 5-MHz transducer is 2.0 cm by 2.0 cm and the 12-MHz one is 0.4 cm by 0.4 cm. The imaging system is tested in a medium having a speed of sound of 1560 m/s at both frequencies. What ranges are considered as near-field for each transducer?

(b) Describe different components of the instrumentation of MRI with proper illustration.   **15**

(c) Why T_1, and T_2 relaxation time constants for a sample are not same in MRI imaging?   **5**

SECTION – B

There are **FOUR** questions in this section. Question No. 5 is **MANDATORY**.

Answer any **TWO** of the remaining **THREE** questions.

5. (a) A doctor referred a patient to have a SPECT scan using a specific radiotracer. That **(5)** radiotracer was not available in the lab, but another radiotracer with the same emitted photon energy and half-life was available. Should the technician make the substitution? Explain.

(b) With appropriate diagrams, briefly describe the functions of compensation filters **(10)** and intensifying screen in X-ray imaging.

(c) Suppose you're designing a new CT scanner. It will be a fan-beam design, with **(10)** one source and D detectors. You want to use M angles, reconstruct images with N by N pixels, and strictly enforce the design rule of thumb $D = M = N$. The width of each detector d will be selected to be as large as possible in order to completely fill a 1-meter detector array with D detectors. The reconstruction ramp filter will be designed using a rectangular window with bandwidth $\varphi = 1/d$. A doctor requires that a lesion with contrast $C = 0.005$ embedded in water ($\bar{\mu} = 0.15$ cm^{-1}) will have a SNR of at least 20 dB. If $D = M = N = 300$, compute the minimum number of photons per projection at the detectors that is required in order to meet this SNR constraint. Make assumptions if necessary.

(d) A radioactive pellet containing a 140 keV gamma ray emitting substance with **(20)** activity A mCi is placed 1 m away from an Anger camera such that one-fourth of its total disintegrations hit the detector. Assume $t_{1/2}$ = 6 hours. Assume that the Z-pulse height, that is, the photopeak is equal to the energy of the incident photon.

    i.   What should be the acceptance window (in percentage) around the photopeak so that photons that are Compton-scattered more than 30° are rejected?

    ii.   Consider only the non-Compton-scattered photons now. Assume that the time response of the camera's Z-pulse to an absorbed photon hitting the camera at time $t = 0$ is given in Figure: Question 5(d). Assume that the response of camera is additive in nature so that its net response to multiple absorbed photons at different time instants is the shifted addition of their individual responses. Now plot and label the net response of camera's Z-pulse for two photons absorbed at time $t = 0$ ns and $t = 5$ ns.
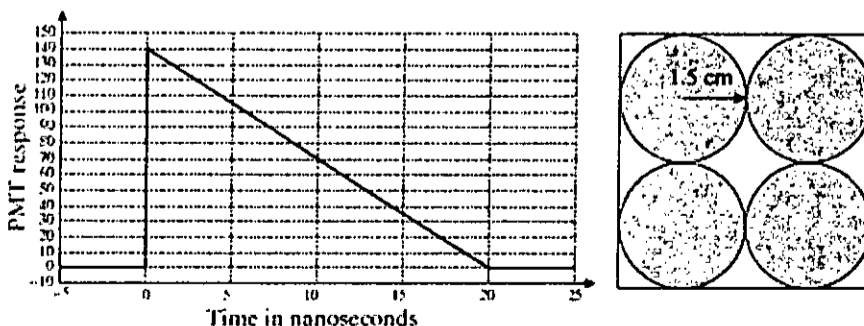

Figure: Question 5(d)

iii.   Consider the arrangement of PMT's shown in <u>Figure: Question 5(d)</u> where the origin is at the exact center of the square. Let the responses from the four PMT tubes to a detected photon be given by 80, 30, 20, and 5 (top-left, top-right, bottom-left, and bottom-right). Compute the height of the Z-pulse and the x and y location of the event.

6. (a) Muscle and bone are arranged as shown in <u>Figure: Question 6(a)</u>. The densities for muscle and bone are 1 gm/cm^3 and 1.8 gm/cm^3, respectively. The mass attenuation coefficients are given in Table for Question 6(a) in units of cm^{-1}. **(10)**
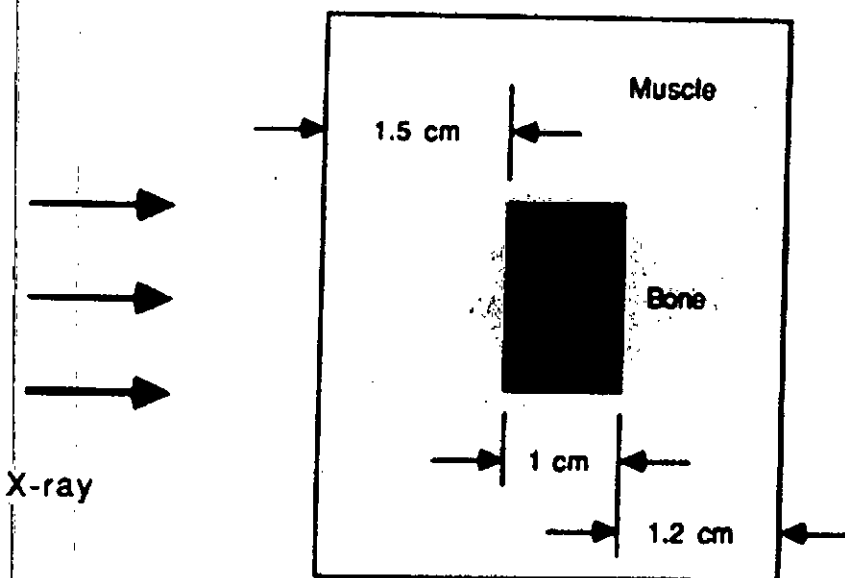

Figure: Question 6(a)

Compare the intensity of the attenuated X-ray beam that has passed through bone and muscle with just the muscle at the two energies.

Table for Question 6(a)

E	Muscle	Bone
60 keV	0.20	0.27
1 meV	0.07	0.07

(b) Explain how extended sources and detector thickness can blur objects even if they do not have a z extent, i.e., the objects do not have any thickness in the source-detector direction. Derive an imaging equation incorporating these two effects, and show that both of these processes can be modeled as convolutional effects that degrade image resolution. Include the geometrical effects in the imaging equation as well. **(20)**

7. (a) Suppose an acceptable chest radiograph was taken using 30 mAs at 80 kVp from 1.5 m. Suppose it was now requested that one be taken at 2 m at 80 kVp. What mAs setting should be used to yield the same exposure? **(10)**

(b) Mathematically show that back projection summation image is actually the original image convolved with a blurring function. **(20)**

8. (a) Consider an object comprising two small metal pellets located at $(x, y) = (2, 0)$ and $(2, 2)$ and a piece of wire stretched straight between $(0, -2)$ and $(0, 0)$. The object is shown in <u>Figure: Question 8(a)</u>. **(10)**
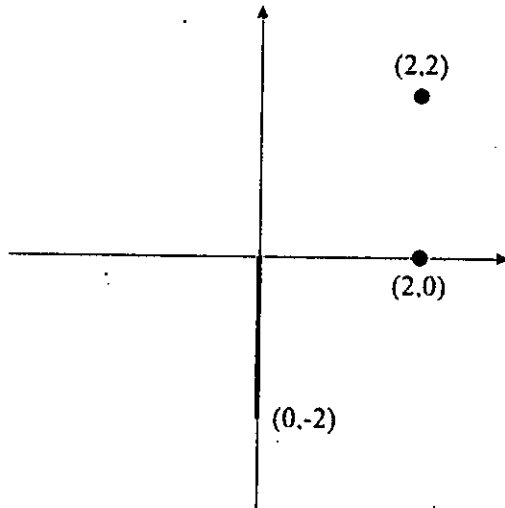
Figure: Question 8(a)

Assume that N photons are fired at each lateral position l in a parallel-ray configuration. For simplicity, assume that each metal object stops 1/2 the photons that are incident upon it no matter what angle it is hit. In your answer script, draw the projections you would see at $\theta = 0°$ and $\theta = 90°$.

(b) Briefly explain the two modes by which energetic electrons interact with matter, **(10)** and the outcomes of the interactions.

(c) State the projection slice theorem and derive its formation. **(10)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-1 B. Sc. Engineering Examinations 2022-2023

Sub: **BME 409** (Tissue Engineering)

Full Marks: 210   Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A`

There are **FOUR** questions in this section. Answer to **Question no. 1 (one) is Compulsory.**
Answer any **TWO** questions from Questions 2-4.

1. (a) What is the triad of tissue engineering? Explain. **(12)**

    (b) What are the comparative advantages and disadvantages of 2D monolayer and 3D biomaterials based cell culture? **(12)**

    (c) What defines a stem cell? Can all the stem cells become any kind of cell? Explain. **(15)**

    (d) Can adult cell be converted to iPSC in laboratory? If yes, how? **(6)**

2. (a) Different types of detergents are being used in chemical decellularization. With example mention different types of detergents, and analyze their comparative advantage and disadvantage. **(15)**

    (b) How scar tissue is being formed? **(9)**

    (c) Write down the functions of ECM. **(6)**

3. (a) What is biocompatibility? **(7)**

    (b) Give an example of a temperature responsive polymer. How can it be useful for cell-sheet technology? **(13)**

    (c) Compare the mechanisms between polymer degradation and erosion. **(10)**

4. (a) Can micro contact printing be useful for localized cell culture? If yes, how? **(15)**

    (b) Assume you are working on a bone degeneration research project for astronauts. If you need to choose a bioreactor for your research which one will you choose? Describe the working principle of this bioreactor. **(15)**

BME 409

<u>SECTION – B</u>

There are **FOUR** questions in this section. Answer to **Question no. 5 (five) is Compulsory**.
Answer any **TWO** questions from Questions 6-8.

5. (a) You are tasked with studying the effects of a new drug on asthma treatment. For this you have decided to use a lung-on-a-chip. Recent approaches to fabricate such devices include 3D bioprinting. Through this technique, researchers can design unique organ-on-a-chip. Now analyze the design considerations necessary to print such a device with suitable channels. Additionally, elaborate on the formulation and chemical properties of bioink required to achieve a successful 3D bioprinted lung-on-a-chip. **(25)**

(b) Assess the patterning techniques that can be employed to control cellular behavior on the surface of the 3D printed lung-on-a-chip. Also, describe the chemical modification methods that affects cell behavior. **(20)**

6. (a) Suppose you have fabricated a novel tissue engineered product that can precisely target basal cell carcinoma in skin. Your product has passed all the hurdles of preclinical phase and will be undergoing clinical phase. What are the challenges that are expected from this phase? How can you overcome these challenges? **(15)**

(b) Categorize the extracellular matrix proteins based on their interactions. What are the cell morphological hallmarks of integrin binding? **(15)**

7. (a) Describe the roadblocks that you may face in fabricating a microfluidic device. Mention the steps required to overcome them. Explain the role of different developers in preparing such a device. **(18)**

(b) In chronic inflammation macrophages continue to be at the site of infection. However, such presence can cause chronic fatigue, pain, and insomnia. Describe a tissue engineering approach that can reduce macrophage presence and decrease the time of inflammation. **(12)**

8. (a) Describe different modalities of 3D bioprinting. Why is it necessary to integrate cytokines in a bioink for regenerative purposes? **(15)**

(b) Explain the tissue engineering-based factors that dictate host immune response. How does blood proteins react when a biomaterial is implanted inside the body? **(15)**

25/5/2024

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA
L-4/T-1 B. Sc. Engineering Examinations 2022-2023
Sub: HUM 415 (Professional Ethics)

Full Marks: 210   Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are FOUR questions in this section. Answer any THREE.

1. (a) What is meant by professional code? **(10)**

    (b) What information should professional ethical codes contain? Explain in detail. **(25)**

2. (a) Analyze the concepts of bribery, extortion, grease payment and gifts. **(20)**

    (b) Why is it forbidden for professional to give and receive brides? Give reasons. **(15)**

3. (a) Discuss the features of utilitarian theory and deontological theory. Make a comparison between these two ethical standards and offer your comments. **(15)**

    (b) Explain the principle of double effect. What are the conditions of this principles? What connections does this principles have with medical science? Explain with examples. **(20)**

4. (a) Discuss in detail the fundamental canon's of NSPE. **(15)**

    (b) What was the cause of river blindness disease? Why did Merck and Co. Inc. assist patients suffering from the illness known as river blindness? Provide your arguments. **(20)**

SECTION – B

There are FOUR questions in this section. Answer any THREE.

5. (a) What are the intentional and adnintentional discriminations in job sectors. Explain with examples. **(10)**

    (b) Compare and contrast the three main kinds of arguments against the racial and sexual job discriminations. Which one of them is the strongest argument? Justify your position. **(25)**

6. (a) What is whistle-blowing? What are the justifications of whistle-blowing? **(15)**

    (b) Do you think that professionals should be encouraged to blow the whistle? Give reasons for your answer. **(20)**

7. (a) What is euthanasia? What are the arguments for and against euthanasia? **(15)**

    (b) Do you think that animals should have rights? Give reasons for your answer. **(20)**

8. (a) What is anthropocentrism? How is it different from nonanthropocentrism? **(15)**

    (b) Should engineers have environmental obligations? Justify your positions. **(20)**