Khulna University of Engineering & Technology
B. Sc. Engineering 2nd Year 2nd Term Regular Examination, 2022
Department of Biomedical Engineering

BME 2231
Biomedical Instrumentation

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 instrumentation and bioinstrumentation. Briefly describe the design criteria and process for medical instrumentation. (15)

b) Discuss the development of instrumentation amplifier. What are the advantages of three op-amp instrumentation amplifiers? (10)

c) Define physiological variable. Explain how electrical physiology is measured. (10)

2. a) Show that the voltage in lead aVR is 50% greater than that in lead VR at the same instant. (15)

b) What are the problems associated with the ECG acquisition? Briefly describe them. (10)

c) Describe the working principle of a synchronized DC defibrillator. (10)

3. a) Describe the differences between leads and electrodes. Briefly describe ECG leads. (15)

b) Explain the relationship between electrical and mechanical events of heart during a cardiac cycle. (10)

c) A student attempts to measure his own ECG on an oscilloscope having a differential input. For Fig. 3(c), Z_{in} = 1 MΩ, Z_1 = 20 kΩ, Z_2 = 10 kΩ, Z_G = 30 kΩ, and i_{db} = 0.5 μA. Calculate the powerline interference the student observe. (10)

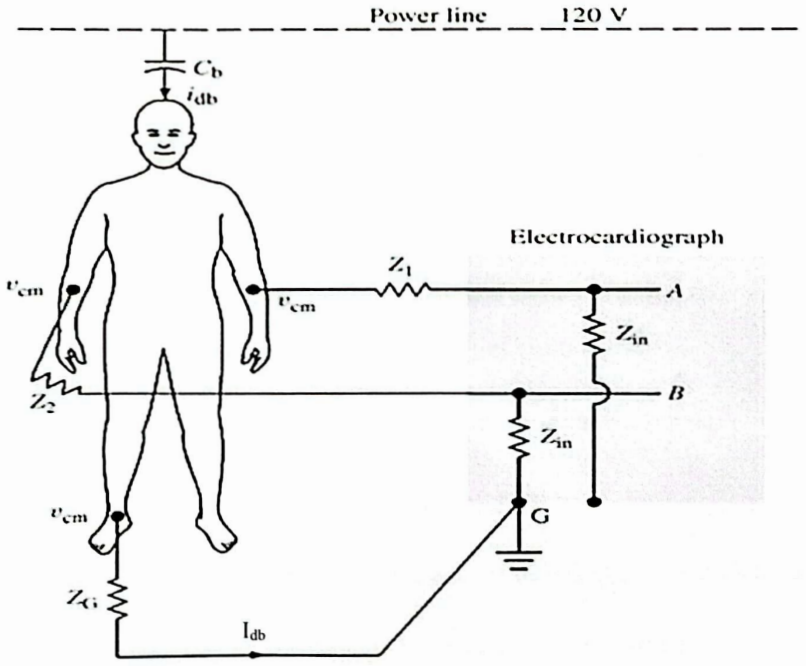

Fig. 3(c)

4. a) Describe the indicator-dilution method that can be used to measure cardiac output without requiring an arterial puncture. Give the equation for calculating cardiac output with definitions for all terms. (15)

b) What is meant by hemodialysis? Discuss the working principle of hemodialysis machine. (10)

c) Discuss the schemes of electric accident prevention in the hospital and hospital equipements. (10)

Section B

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

5. a) What is the most important concern of a biomedical engineer for a biomedical instrumentation system? How a biomedical engineer should take care of that? Explain with suitable examples. (15)

   b) Demonstrate different analogus devices corresponding to human senses with a brief comparison of their working principles. (10)

   c) What is meant by output impedance? What should we do to avoid loading effects for interfacing a sensor circuit with a transducer? (10)

6. a) Why the selection of a transducer in biomedical instrumentation is so important? Describe the important points that should be considered to determine a transducer suitable for a biomedical measurement system? (15)

   b) Describe the physical principles involved in the transduction of temperature with RTD. What are some of the characteristics of RTD that make it suitable for use in biomedical applications? (10)

   c) What are the main methods to calculate gas concentration in a gaseous or liquid solution? Explain briefly the working principle of infrared spectrophotometry. (10)

7. a) What is Piezoelectric effect? Briefly describe the principle of Piezoelectric effect and principles of piezoelectric sensors. (15)

   b) Briefly describe the working principle of photodiode and photo resistor. (10)

   c) Explain the working principle of an amperometric O_2 sensor. (10)

8. a) Briefly describe different detection strategies and bioreceptor immobilization methods used in biosensors. (15)

   b) Explain the working principle of a glucose biosensor. (10)

   c) Sketch and briefly explain the working principle of a Pco_2 electrode. (10)

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BME 2201
Human Physiology

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 hemostasis? Describe different phases of hemostasis. (10)

b) What is membrane transport? Enumerate the transport process by which molecules in micro level cross the cell membrane. (10)

c) Discuss about the morphology and function of – Neutrophils, Eosinophils, Basophils, Monocytes, and Lymphocytes. (15)

2. a) What are neuroglia? List the principal types and their functions. (10)

b) Classify nerve fibers. Discuss about the properties of nerve fiber. (12)

c) Define and classify autonomic nervous system. Mention the differences between the sympathetic and parasympathetic division of autonomic nervous system. (13)

3. a) Draw and level the structural and functional components of skeletal muscles. Describe the role of Ca^{++} in muscle contraction. (10)

b) Define light reflex. Trace the pathway of light reflex and write the clinical importance of light reflex. (05)

c) What is action potential? Discuss about different phases of action potential. (10)

d) Write short notes on: (10)
(i) Excitatory Postsynaptic Potential (EPSP)
(ii) Cerebrospinal fluid (CSF)

4. a) Briefly discuss the modern concept regarding the mechanism of hearing. (12)

b) Classify muscles depending on control and situation. Mention the differences between skeletal and cardiac muscle. (12)

c) What is Landsteiner's law? Discuss about erythroblastosis fetalis. (11)

Section B

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

5. a) What is ejection fraction? Write down the significance of ejection fraction. (05)

b) Define cardiac cycle? Discuss about the ventricular events of cardiac cycle. (15)

c) What is cardiac output? Discuss about the factors maintaining cardiac output. (10)

d) What is ECG? Draw, level, and interpret a normal ECG. (05)

6. a) Define and classify dead space of respiratory tract. Discuss about physiological dead space with its significance. (10)

b) Discuss about the layers of respiratory membrane and the factors affecting diffusing capacity through the membrane. (15)

c) Describe in short the transport mechanism of O_2 from lung to tissue with proper diagram. (10)

7. a) Describe the mechanism of formation of hypertonic urine from isotonic filtrate. (15)

b) Define Glomerular filtration rate (GFR). Discuss about the factors regulating GFR. (10)

c) Calculate the clearance value, when the plasma concentration of a substance is 20 mg/dl, urine concentration is 12 mg/dl and urine volume is 1 ml/min. (05)

d) Discuss and show diagrammatically the reflex mechanism of micturation. (05)

8. a) Name the bile salts. How they are synthesized? Discuss the function of bile salts. (15)

b) Write down the composition of- (10)
(i) Pancreatic juice
(ii) Gastric juice.

c) Describe carbohydrate digestion and adsorption. (10)

Khulna University of Engineering & Technology
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Math 2215
Linear Algebra, Complex Variable and Vector Analysis

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) Discuss with an example, how arithmetic operations and rules in matrices differ significantly from those in real numbers, highlighting one notable case. (05)

b) Apply the partitioning rule of multiplication to partition the matrices A and B, ensuring they are conformable for multiplication while efficiently separating null entries. Then compute the product matrix obtained by applying the partitioning rule of multiplication; where (18)

$$A = \begin{bmatrix} 0 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 \\ 8 & 7 & 6 & 0 & 0 & 0 \end{bmatrix}, B = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 3 \\ 0 & 0 & 2 \\ 1 & 1 & 0 \end{bmatrix}$$

c) Define symmetric matrix, singular matrix, and rank of a matrix, including example for each. Highlight two important properties of each type of matrix. Additionally indicate one field of application for each of these matrices. (12)

2. a) Transform the following matrix B into its echelon form, canonical form, and subsequently into normal form. Also find its rank. (18)

$$B = \begin{bmatrix} 0 & -4 & 1 & -2 \\ 1 & 2 & 1 & 1 \\ 2 & 0 & 1 & 0 \end{bmatrix}$$

Given that the first three columns of B form a coefficient matrix A and the last column of B is denoted as H, forming the equation $AX = H$, determine the solution of the system of equations from one of the obtained appropriate forms.

b) Given $2x - y + cz = 0$, $3x + 2y + z = 0$, $x - 4y + 5z = 0$, then determine the value of 'c' for which the given system of linear equations has (i) only trivial solution, and (ii) non-trivial solutions. If non-trivial solution exists for some values of c, find the corresponding solution by selecting an appropriate numerical value for 'c'. Find nullity on basis of the null space, if exist. Express this solution space in vector parametric form and illustrate the solution space through drawing. (17)

. a) Using elementary transform, find A^{-1}, where (10)

$$A = \begin{bmatrix} 2 & 1 & -1 \\ 1 & -1 & 2 \\ -1 & 2 & 1 \end{bmatrix}$$

Now given $AX = H$ where $H = [1 \quad 1 \quad 1]^t$, then find the value of X.

b) Find all eigenvalues and the eigenvector corresponding to the largest eigenvalues of the matrix (13)

$$A = \begin{bmatrix} 3 & 1 & 1 \\ 1 & 5 & 1 \\ 1 & 1 & 3 \end{bmatrix}$$

c) Define inner product space. Apply the Gram Schmidt orthogonalization process to find an orthogonal basis of $\mathbb{R}^4$ where, $v_1 = (1, 1, 1, 1)$, $v_2 = (1, 2, 3, 4)$, and $v_3 = (1, 3, -4, -2)$. (12)

. a) Discuss pure rotation and rotation plus translation with example. (12)

b) Find equations for the tangent plane and normal line to the surface $4z = x^2 - y^2$ at (3, 1, 2). (12)

c) Determine whether the vectors $\vec{A} = \hat{\imath} - 3\hat{\jmath} + 2\hat{k}$, $\vec{B} = 2\hat{\imath} - 4\hat{\jmath} - \hat{k}$, and $\vec{C} = 3\hat{\imath} + 2\hat{\jmath} - \hat{k}$ are linearly independent or not. (11)

Section B

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

5. a) Define Modulus and Argument of a complex number. Represent graphically the set of values of z for which $1 < |z + 2 - 3i| \leq 2$. (10)

b) State De Moivre's theorem. Find all the roots of $(2 + 2\sqrt{3}i)^{\frac{1}{3}}$ and locate them graphically in the complex plane. (12)

c) Define limit of a complex function. Evaluate (13)

(i) $\lim_{z \to e^{\frac{\pi i}{4}}} \frac{z^2}{z^4 + z + 1}$

(ii) $\lim_{z \to i} \frac{z^2 + 1}{z^6 + 1}$

6. a) Define analytical function with example. Show that the function $f(z) = x^2 + y^2 + 2ixy$ is not analytic at any point but is differentiable along the x axis. (12)

b) Check whether the function $u = e^{-2xy}\sin(x^2 - y^2)$ is harmonic or not. If so, find the conjugate harmonic function v and express $u + iv$ as an analytic function of z by using Milne-Thompson method. (13)

c) Evaluate $\int_C (x^2 - iy^3)\, dz$, where C is the lower half of the circle $|z| = 1$ from $z = -1$ to $z = 1$. (10)

7. a) Define branch point with example. Locate and classify all the singular points of the following functions: (12)

(i) $f(z) = \frac{\ln(z + 3i)}{(z^2 - 2z + 5)^2}$

(ii) $h(z) = cosec\left(\frac{1}{z^2}\right)$

b) Find the values of a, b, c such that the directional derivative of $f = ayz^2 + bz + cx^2y^3$ at the point (2, -1, 1) attains a maximum magnitude of 64 in the direction parallel to x-axis. Subsequently calculate the directional derivative of f along y-axis and determine the tangent plane at the point (2, -1, 1). (12)

c) Find the value of constant a, b, c, so that $\vec{V} = (x + 2y + az)\hat{i} + (bx - 3y - z)\hat{j} + (4x + cy + 2z)\hat{k}$ is irrotational. Also show that $\vec{V}$ can be expressed as the gradient of a scalar function. (11)

8. a) Find the workdone in a moving particle along a circular path c in the xy plane. If the circle has the centre at the origin and radius is 3, and if the circle field is given by $\vec{F}$ where $\vec{F} = (2x - y + z)\hat{i} + (x + y - z^2)\hat{j} + (3x - 2y + 4z)\hat{k}$ (12)

b) Evaluate $\iint_S \vec{F}.\hat{n}\, dS$ where $\vec{F} = 4x\hat{i} - 2y^2\hat{j} + z^2\hat{k}$ and S is the surface bounded by the plane $x = 0, y = 0, z = 0, x = 4, y = 4$, and $z = 4$. (Using Gauss's theorem) (10)

c) Evaluate $\iint_S \nabla \times \vec{F}.\hat{n}\, dS$, where S is the surface of the sphere $x^2 + y^2 + z^2 = 4$ above the xy plane. (13)

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BME 2211
Signals and Systems

ime: 3 Hours **Full Marks: 210**

.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)

a) Define signal with an example. Explain the basic operations performed on signals with expressions. (13)

b) Find the signal energy or power of $x(t) = Acos(2\pi f_0 t + \theta)$. (10)

c) Write short notes on: (i) Exponential signal and (ii) A/D conversion. (12)

. a) Define system with an example. Express the operator that describes the input-output relationship (10)

$$y[n] = \frac{1}{3}(x[n+1] + x[n] + x[n-1])$$

in terms of the time-shift operator *S*. Show both the parallel and cascaded form of implementation.

b) Suppose the input $x(t)$ and the impulse response $h(t)$ of a LTI system are described by (12)

$$x(t) = u(t) - u(t-2)$$
$$h(t) = u(t) - u(t-1)$$

Find the output of this system.

c) Consider the *RC* circuit shown in Figure 2(c). Find the relationship between the input $x(t)$ and the output $y(t)$. (13)
(i) If $x(t) = v_s(t)$ and $y(t) = v_c(t)$
(ii) If $x(t) = v_s(t)$ and $y(t) = i(t)$

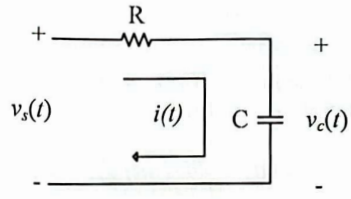

Figure 2(c)

3. a) Find the current through the *RL* circuit depicted in Figure 3(a) for an applied voltage $x(t) = \cos(t)\,V$ assuming normalized values R = 1 Ω and L = 1 H and that the initial condition is y(0) = 2 A. (18)

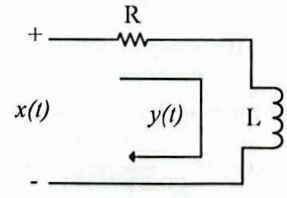

Figure 3(a)

b) Define Laplace transform and the Region of Convergence. Find the Laplace transform, ROC, and pole-zero plot of the signal $x(t) = e^{at}u(-t)$. Assume that a is real. (10)

c) Determine the initial and final values of a signal $x(t)$ whose Laplace transform is (07)

$$X(s) = \frac{7s + 10}{s(s+2)}$$

4. a) Use the Laplace transform to determine the output of a system represented by the differential equation (12)

$$\frac{d^2}{dt^2}y(t) + 5\frac{d}{dt}y(t) + 6y(t) = 2\frac{d}{dt}x(t) + x(t)$$

in response to the input $x(t) = u(t)$. Assume that the initial conditions on the system are $y(0^+) = 1$ and $\left[\frac{d}{dt}y(t)\right]_{t=0^+} = 2$. Identify the forced response of the system, $y^{(f)}(t)$ and the natural response, $y^{(n)}(t)$.

b) What is transfer function? Check the stability of the system with characteristic equation (14)

$$s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$$

c) When a system will be stable in accordance with the location of pole-zero? Sketch the magnitude response of the system having the transfer function (09)

$$H(s) = \frac{(s - 0.5)}{(s + 0.1 - 5j)(s + 0.1 + 5j)}$$

Section B

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

5. a) What is a linear system? The discrete-time system given below is at rest $[y(-1) = 0]$. Check if the system is BIBO stable. (10)

$$y(n) = ny(n-1) + x(n), \quad n \geq 0$$

b) Compute the convolution of $y(n) = x(n) * h(n)$ of the following pair of signals. (13)

$$x(n) = \begin{cases} 1, & n = -2, 0, 1 \\ 2, & n = -1 \\ 0, & elsewhere \end{cases}$$

$$h(n) = \delta(n) - \delta(n-1) + \delta(n-4) + \delta(n-5)$$

c) Determine the output $y(n)$ of a relaxed LTI system with impulse response (12)

$$h(n) = a^n u(n), \quad |a| < 1$$

when the input is a unit step sequence, i.e. $x(n) = u(n)$.

6. a) Determine the z-transform of the signal (10)

$$x(n) = -\alpha^n u(-n-1)$$

b) What is sampling? State and describe Shannon's sampling theorem with necessary diagram. (10)

c) Calculate the DFT of the data sequence {0, 1, 1, 0} using the decimation-in-time (Cooley-Tukey) FFT algorithm and plot the amplitude and phase spectra. (15)

7. a) Compute DFT of the sequence $x(n) = cos(n\pi/2)$, where N = 4 using Cooley-Tukey FFT algorithm. (10)

b) Find out the cross correlation of the two sequences $x_1(n)$ and $x_2(n)$ by applying fast correlation theorem (20)

$$x_1(n) = \{1, 0, 0, 1\}$$
$$x_2(n) = \{0.5, 1, 1, 0.5\}$$

c) Define causal and noncausal systems. (05)

8. a) Define z-transform. Write down the computational advantages of FFT over conventional DFT. (10)

b) Determine the causal signal $x(n)$ having the z-transform (12)

$$X(z) = \frac{1}{(1 + z^{-1})(1 - z^{-1})^2}$$

c) Determine the unit sample response of the system characterized by the difference equation (13)

$$y(n) = 2.5y(n-1) - y(n-2) + x(n) - 5x(n-1) + 6x(n-2)$$

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B. Sc. Engineering 2nd Year 2nd Term Regular Examination, 2022
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HUM 2251
Economics and Sociology

ime: 3 Hours **Full Marks: 210**

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)

a) Define economics. Distinguish between micro and macro economics. (15)
b) Define supply schedule. How does market disequilibrium create inefficiency in an economy? (15)
c) Market research has revealed the following market demand and supply functions of chocolate; $Q_d = 1600\text{-}30P$, $Q_s = 1400+70P$. Calculate the equilibrium price and quantity demand in the market. (05)

a) What is price elasticity of supply? Explain the types of price elasticity of supply. (15)
b) Suppose the income of people has increased over the month. Now use an equilibrium diagram to show the effect of increasing income and show what happens to the consumer surplus and producer surplus. (20)

. a) Distinguish between perfect competition market and monopoly market. (15)
b) Suppose the cost of production of bundle of goods has increased over several months. What kind of inflation it will cause in an economy and what are the measures that need to be taken to reduce this kind of inflation. (20)

4. a) Why average cost curve is "U" shaped? (10)
b) What are the yardsticks that can be applied for project appraisal? (10)
c) Consider a project which has the following cash flow stream: (15)

Year	Cash flow (in taka)
0	10,00,000
1	25,000
2	40,000
3	40,000
4	50,000

The cost of capital for the firm is 10%. According to the Net Present value method, evaluate if the firm should invest in the project or not.

Section B

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

5. a) Define sociology. (05)
b) Differentiate between society and community. (13)
c) Explain the features of the social structure of rural Bangladesh. (17)

6. a) What is urbanization? Discuss the social impacts of the urbanization. (18)
b) Politics is the prime dominant factor in changing social life- do you agree or disagree? Give your opinion with acceptable evidence. (17)

7. a) Distinguish between culture and civilization. (08)
b) Analyze cultural lag and its' impacts on society. (15)
c) Discuss the merits and demerits of capitalism. (12)

8. a) Characterize the concept of crime and deviance. (10)
b) Demonstrate the relationship between population and resources. (10)
c) How does technology affect the social life in modern society? (15)