

**SECTION – A**

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

1. (a) A patient is to be treated for a fracture from an accident. Lead shotgun pellets remain in the wound. The surgeon decides a bone plate should be used. What is your recommendation in choosing material for bone plate and why? (10)
- (b) Which characterization technique would you prefer for inspecting topographies of biological specimen? Describe its working principle. (12)
- (c) Classify hydrogel on the basis of physical structure, preparation method, and ionic charge. (13)
  
2. (a) What are beneficial features provided by the porous orthopedic implants over traditional orthopedic materials? (10)
- (b) What are the differences between the melting and glass transition temperature of a polymeric material? Explain the effects of high and low glass transition temperature on a polymer. (15)
- (c) Bone remodeling is triggered by "flexure" and not by principal stress - explain this statement. (10)
  
3. (a) Compare and contrast between agar diffusion and direct contact in vitro cell culture cytotoxicity assay methods. (12)
- (b) What is the role of diol or diamine chain extender in the formation of polyurethane elastomers? (13)
- (c) Which hydrogel do you use to manufacture contact lens? What are the advantages and preparation method of this hydrogel? (10)
  
4. (a) Illustrate the curing process of Poly methyl methacrylate (PMMA). (15)
- (b) In a 30 vol% glass fiber reinforced nylon matrix composite, the fibers are aligned parallel to the loading direction. What proportion of the load and stress are carried by the fibers? The modulus of elasticity for each component of the composite is  $E_{\text{glass}} = 72.4$  GPa and  $E_{\text{nylon}} = 2.8$  GPa. (12)
- (c) A silver amalgam filling has been in service for 15 years and has corroded. The filling surface has become black and the patient complains of tooth sensitivity. A gap has formed at the margin of the restoration, allowing leakage. Should the filling be drilled out and replaced by gold (8)

**MME 297**

**SECTION – B**

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

5. (a) Using suitable examples, discuss the structure-processing-properties relation of materials. (15)
- (b) Explain why metals are ductile and conductive while ceramics are brittle and nonconductive. (15)
- (c) Why is aluminium (bcc) more ductile than zinc (hcp)? (5)
6. (a) What are dislocations? Explain how dislocations influence properties of materials. (2+8=10)
- (b) What is the general strategy of strengthening materials? Using suitable examples, examine how materials can be strengthened by solid solution strengthening and work hardening methods? (5+20=25)
7. (a) Distinguish between the characteristics of ductile and brittle failure of materials. (10)
- (b) What is DBTT? Explain how this influences materials selection process while designing materials for cryogenic applications. (4+6=10)
- (c) What is fatigue failure of material? What are the factors that influence fatigue failure? How can you improve fatigue life of material? (3+4+8=15)
8. (a) Define and classify biomaterials. Using suitable examples, give a short account on different types of response-based biomaterials. (2+6+10=18)
- (b) What are the property requirements of an implant? List the factors that govern the success of a biomaterial as implant. How can you analyse the performance of an implant?(10+3+4=17)
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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **MATH 215** (Linear Algebra)

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) Solve the following system of linear equations by reducing the augmented matrix into its reduced row-echelon form: (17)

$$2u + v - 2w - 2x = -2$$

$$-u + 2v - 4w + x = 1$$

$$3u \qquad \qquad -3x = -3$$

- (b) State Cayley-Hamilton theorem. Find  $A^{-1}$  using this theorem, where (18)

$$A = \begin{bmatrix} 1 & 2 & 2 \\ 3 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

2. (a) What do you mean by an elementary matrix? Express the matrix A as a product of elementary matrices, where (15)

$$A = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 2 & 3 \\ 5 & 5 & 1 \end{bmatrix}$$

- (b) Define symmetric and skew-symmetric matrices. Show that the inverse of a non-singular matrix is unique. (10)

- (c) Define derogatory matrix. Find the minimal polynomial of the matrix (10)

$$A = \begin{bmatrix} 1 & -1 & 1 \\ 1 & 2 & 1 \\ 1 & 0 & 3 \end{bmatrix}$$

3. (a) Define a real quadratic form. Reduce the real quadratic form

$$Q = x_1^2 + 2x_2^2 - 2x_3^2 + 4x_1x_2 + 6x_1x_3$$

- to the canonical form and hence find the rank, index and signature of Q. Also, write down the corresponding equations of transformations. (20)

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**Contd...Q.3**

(b) Find an LU factorization of (15)

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 3 & 4 & 8 \\ 2 & 1 & 5 \end{bmatrix}$$

4. (a) Find all eigenvalues and corresponding eigenvectors of the matrix (20)

$$A = \begin{bmatrix} 1 & -3 & 3 \\ 3 & -5 & 3 \\ 6 & -6 & 4 \end{bmatrix}$$

Also, if possible, construct an eigenvector matrix S that diagonalize A and hence determine the corresponding eigen value matrix  $\Lambda$ .

(b) Find adjoint of the matrix (15)

$$A = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \end{bmatrix}$$

Hence find P(A) when  $P(x) = x + 2x^{-1} - 4$

**SECTION - B**

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) Find the standard matrix for the transformation T on  $\mathbb{R}^3$ , where T is the composition of a counterclockwise rotation of  $\frac{\pi}{3}$  about y-axis, followed by a reflection about yz-plane, followed by contraction with factor  $\frac{1}{2}$ . Then find the image of the point (2, 0, 3) using the standard matrix. (15)

(b) Let  $W = \left\{ \begin{pmatrix} a \\ b \\ c \\ d \end{pmatrix} : a + b = 3c, b + c = 4d \right\}$ . Is W a subspace of  $\mathbb{R}^4$ ? (10)

(c) If the vectors  $\underline{u}_1 = (1,0,2)$ ,  $\underline{u}_2 = (-1,1,0)$ ,  $\underline{u}_3 = (0,2,3)$  form a basis of  $\mathbb{R}^3$ , find the co-ordinations of the vectors  $\underline{w} = (-1, 8, 11)$  relative to this basis. (10)

**MATH 215(BME)**

6. (a) Find the rank and a basis of the row space of  $A = \begin{bmatrix} 2 & 4 & -2 & 1 & 1 \\ 2 & 5 & 4 & -2 & 2 \\ 4 & 3 & 1 & 1 & 2 \\ 2 & -4 & 2 & -1 & 1 \\ 0 & 1 & 4 & 2 & -1 \end{bmatrix}$  (18)

Also find the nullspace of  $A$  and verify the dimension theorem for  $A$ .

(b) Let  $T: \mathbb{R}^4 \rightarrow \mathbb{R}^3$  be the linear transformation defined by

$T(w, x, y, z) = (2w + 4x + 6y + 5z, -w - 2x + 2y, 8y + 4z)$ . Find a basis for (i) the kernel of  $T$  and (ii) the range of  $T$ . (17)

7. (a) Let  $B = \{(1, 3), (-2, -2)\}$  and  $B' = \{(-12, 0), (-4, 4)\}$  be two bases for  $\mathbb{R}^2$  and let (20)

$A = \begin{bmatrix} 3 & 2 \\ 0 & 4 \end{bmatrix}$  be the matrix for  $T: \mathbb{R}^2 \rightarrow \mathbb{R}^2$  relative to  $B$ .

(i) Find the transition matrix  $P$  from  $B'$  to  $B$ .

(ii) Use the matrices  $A$  and  $P$  to find  $[\underline{v}]_B$  and  $[T(\underline{v})]_B$ , where  $[\underline{v}]_{B'} = \begin{bmatrix} -1 \\ 2 \end{bmatrix}$ .

(iii) Find  $A'$  (the matrix for  $T$  relative to  $B'$ ) and inverse of  $P$ .

(iv) Find  $[T(\underline{v})]_{B'}$ .

(b) Find a basis for the orthogonal complement of the subspace of  $\mathbb{R}^3$  spanned by the vectors (15)  
 $\underline{v}_1 = (1, -1, 3), \underline{v}_2 = (5, -4, -4), \underline{v}_3 = (7, -6, 2)$ .

8. (a) Use Gram-Schmidt process to transform the basis  $B = \{(4, -3, 0), (1, 2, 0), (0, 0, 4)\}$  into

an orthogonal basis for  $\mathbb{R}^3$ . Also find the  $QR$ -decomposition of  $A = \begin{bmatrix} 4 & 1 & 0 \\ -3 & 2 & 0 \\ 0 & 0 & 4 \end{bmatrix}$  (20)

(b) Describe briefly ten different fields of applications of Linear Algebra. (15)

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**SECTION – A**

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

1. (a) Design an efficient system, which will detect more than one occurrence of the bit pattern "01" in the input. For example, if the input is "1100000", the system will output 0 as there is no occurrence of bit pattern "01". Again, if the input is "0111000", as there is only one occurrence of the bit pattern "01", so the output will be 0. But, if the input is like "01001" or "0101011", then the system will output 1 as there is more than one occurrence of bit pattern "01". Use T flip-flops and basic gates to design the system. Note that, you do not have to consider about the unused state if there is any. (5+5+6+4=20)

- (i) Draw the state diagram of the system (the system will remain in the final state if it enters there once).
- (ii) Write down the state table.
- (iii) Write down the input equations of the T flip-flops.
- (iv) Draw the circuit diagram of the system.

(b) Consider a 2-bit register, which has a selection bit S. If S is 0, the register will perform a parallel load. On the other hand, if S is 1, the register will perform an exchange operation. In exchange operation, the present output of the flip-flops will exchange their values, i.e., output 00 will become 00, output 11 will become 11, output 10 will become 01, and output 01 will become 10. Now, draw the circuit diagram of this register using J-K flip-flops and basic gates. Also, describe the operations of the register in brief. (15)

2. (a) Consider the following state table. (14)

Present State	Next State		Output	
	Input = 0	Input = 1	Input = 0	Input = 1
A	D	A	0	0
B	F	A	0	0
C	H	F	0	1
D	A	D	1	0
E	D	H	0	1
F	A	D	1	0
G	C	B	0	0
H	A	F	1	0

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**Contd... Q. No. 2(a)**

Reduce as many states of the system as possible using implication table. Then, assign the reduced states using one-hot assignment. How many flip-flops do you need to implement the system using this one-hot assignment?

(b) What is the main difference between a latch and a flip-flop? Draw the circuit diagram of a D-latch using NAND gates. Then, draw the circuit diagram of a positive edge triggered master-slave T flip-flop using such D-latches and basic gates. **(3+3+6=12)**

(c) What is the main difference between a Mealy model and a Moore model? With a representative state diagram, show what problem can be caused by a counter with unused states? How can this problem be solved? **(3+3+3=9)**

3. (a) With respect to sequential circuit system, write short notes on the following topics:

- (i) Characteristic equation **(4+4+4=12)**
- (ii) Input equation
- (iii) Output equation

(b) Implement the function  $f(A, B, C) = \overline{A + (B.C)}$  using (i) RTL logic and (ii) CMOS logic. **(6+6=12)**

(c) Suppose, your system generates clock pulse at the speed of 60 MHz ( $60 \times 1024 \times 1024$  clock pulse per second). But the sub-systems you control are rather slower. You have 3 sub-systems each requires 10 MHz clock speed and 1 sub-system that requires 30 MHz clock speed. How can you control your sub-systems? **(11)**

4. (a) Briefly describe successive approximation method for Analog-to-Digital converter using appropriate figure(s). **(12)**

(b) Draw the circuit diagram of the ripple counter for the following repeating sequence of states, using D Flip-flops and other required gates. **(12)**

$$3 > 5 > 7 > 0 > 2 > 4 > 6 > 1 > 3 \dots$$

(c) What is the advantage and what is the disadvantage of a serial subtractor comparing to a parallel subtractor? Draw the circuit diagram of a serial subtractor using shift registers, full adder, D flip-flop, and other required gates. **(4+7=11)**

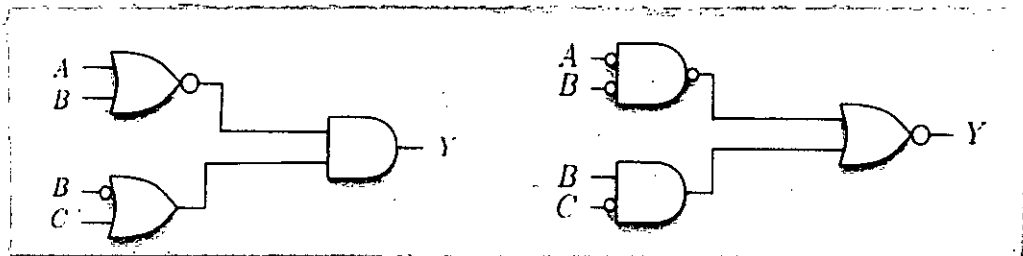
**CSE 283/BME**

**SECTION – B**

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

Please read carefully, some questions might have additional restrictions.

5. (a) Using Boolean algebra, show that the following two circuits are equivalent: (5)



- (b) Prove that the circuit below for F is equivalent to the given equation by converting the circuit to an equation and then using Boolean algebra theorems to manipulate it. Show each step and what theorem(s) or manipulation(s) you used. (5)

Circuit for F:	Desired form of equation for F
	$F = \bar{A} \cdot \bar{C} + \bar{B} \cdot \bar{C} + A \cdot B \cdot C$

- (c) We want to design a combinational circuit that computes the function  $f(X) = 3X + 1$  for a 2-bit  $X$ , where  $X$  is a number greater or equal to 0: (4+4+4=12)

- (i) What is the minimum number of bits required to represent all outputs from  $f(X)$ ?
- (ii) Show the truth table for this function.
- (iii) Implement the circuit using logic gates.

- (d) A combinational circuit produces the binary sum of two 2-bit numbers,  $x_1x_0$  and  $y_1y_0$ . The outputs are  $C, S_1, S_0$ . (10)

- (i) Provide a truth table for the circuit.
- (ii) Design the circuit using two full-adders.

- (e) What is the difference between ACTIVE LOW and ACTIVE HIGH outputs? Give examples of the outputs. (3)

6. (a) A comparator has two inputs  $A = a_1a_0$  and  $B = b_1b_0$  and one output  $F$ . Output  $F$  becomes one whenever the value of input  $A$  is greater than or equal to the value of input  $B$ . (12)

- (i) Show the truth table for output  $F$ .
- (ii) Simplify the function using K-map.
- (iii) Implement the circuit using logic gates.

- (b) Use a 3-to-8 decoder to design a majority function (three inputs, one output goes with the majority value of the inputs). Show truth table and the circuit. (12)



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**Contd... Q. No. 6**

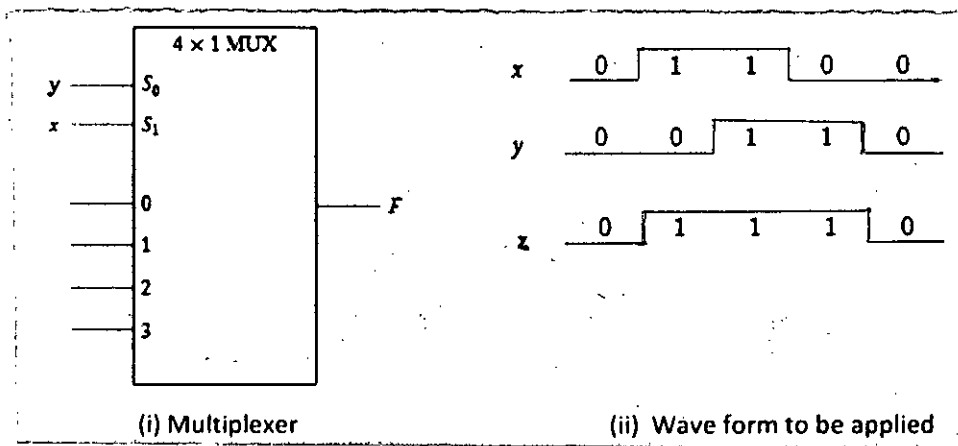
(c) For function  $F(x, y, z) = x'y'z + x'yz + x'yz' + xyz' + xy'z$ , we want to design a circuit to implement function  $F(x, y, z)$  using Multiplexer. (11)

- (i) Create the truth table for F
- (ii) Implement F by means of only 4-to-1 Mux and 2-to-1 Mux. [Hint: You may use multiple Muxes in a hierarchical method]

7. (a) Design and implement the following function of three variables with a four-to-one-line multiplexer shown in Figure 7(a)(i): (8)

$$F(x, y, z) = \sum(1, 2, 6, 7)$$

Note that  $x, y$  must be used as selection inputs of the multiplexer.

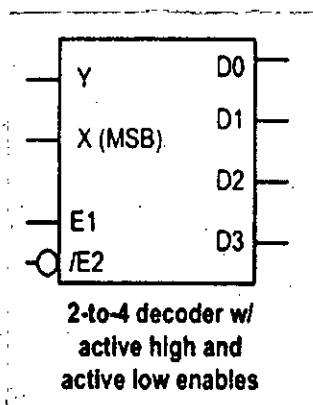


**Figure 7(a)**

(b) After you implementation assume that the waveforms shown in the Figure 7(a)(ii) have been applied in the multiplexer. Draw the output waveform. (6)

(c) Convert the following function, F to a canonical sum. Then implement F using only the decoders below and an appropriate OR gate. You can use more than one decoder if needed. (13)

$$F = \bar{A} \cdot \bar{C} + \bar{B} \cdot \bar{C} + A \cdot B \cdot C$$



**Figure 7(c)**

(d) Prove the following Boolean equation using Boolean algebra: (8)

$$xyz + xyz' + x'yz + xyz' + x'yz' = y$$

**CSE 283/BME**

8. (a) Design a four-input priority encoder with inputs  $D_0, D_1, D_2, D_3$ . Assume that input  $D_0$  has the highest priority and input  $D_3$  has the lowest priority, i.e., the priority order is as follows:

(11)

$$D_0 > D_1 > D_2 > D_3$$

Show the truth table and the circuit.

- (b) Find the following Boolean function  $F(w, x, y)$  and express it in the simplified SOP format.

(6)

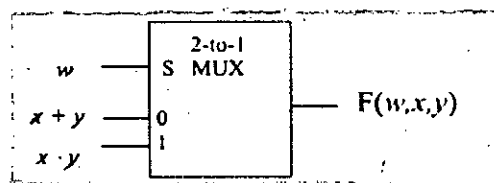


Figure 8(b)

- (c) Given  $Y = f(w, x, y, z) = \Pi(0, 1, 3, 5, 13)$  (3×6=18)

- (i) Write the complete truth table for  $Y$ .
- (ii) Write  $Y = f(w, x, y, z)$  in POS canonical form.
- (iii) Write  $Y = f(w, x, y, z)$  in **shorthand** SOP form. (i.e., using  $\Sigma$  or  $\Pi$  notation in your final answer)
- (iv) Write  $Y = f(w, x, y, z)$  in SOP canonical form. (Do not use  $\Sigma$  or  $\Pi$  notation in your final answer)
- (v) Using only K-map, derive a minimized POS expression for  $Y = f(w, x, y, z)$ .
- (vi) Using only K-map, derive a minimized SOP expression for  $Y = f(w, x, y, z)$ .

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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2017-2018

Sub : **BME 205** (Biofluid Mechanics and Heat Transfer)

Full Marks : 210

Time : 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meanings. Reasonably assume any missing data.

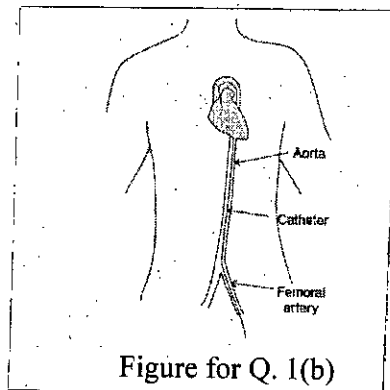
USE SEPARATE SCRIPTS FOR EACH SECTION

**SECTION – A**

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

1. (a) Define shear thickening fluid. What can be the possible biomedical application of shear thickening fluid? (9)

(b) A balloon catheter has been placed within a femoral artery of a patient of the coronary artery (Figure 1(b)). The location where the catheter is inserted into the femoral artery is 40 cm below the aortic arch. The coronary artery is 3 cm below the aortic arch. Assume that the catheter consists of two components: (i) a chamber to hold the balloon, which is 2 mm in diameter and 1 cm in length (a perfect cylinder), and (ii) a tube 0.5 mm in diameter and the total length needed to transport the balloon to the opening locations. Calculate the buoyancy force on this catheter. (14)



(c) Calculate the surface tension and the force associated with the surface tension for a red blood cell moving through blood. Assume that the radius of curvature for the red blood cell is 4 μm and the radius of curvature for the blood is 1 cm. The pressure difference across the cell and blood is 25 mmHg. Assume that a red blood cell is a perfect sphere when estimating contact area. (12)

2. (a) The specific gravity of human urine ranges from 1.001 – 1.035. What are the reasons for which specific gravity of urine can cross the lower or upper limit? (8)

(b) A two-fluid manometer is used to measure the pressure difference for flowing blood in a laboratory experiment as shown in Figure 2 (b). Calculate the pressure difference between points A and B in the fluid. Assume that the density of blood is 1050 kg/m<sup>3</sup> and the density of water is 1000 kg/m<sup>3</sup>. (12)

**BME 205**

Contd ... Q. No. 2(b)

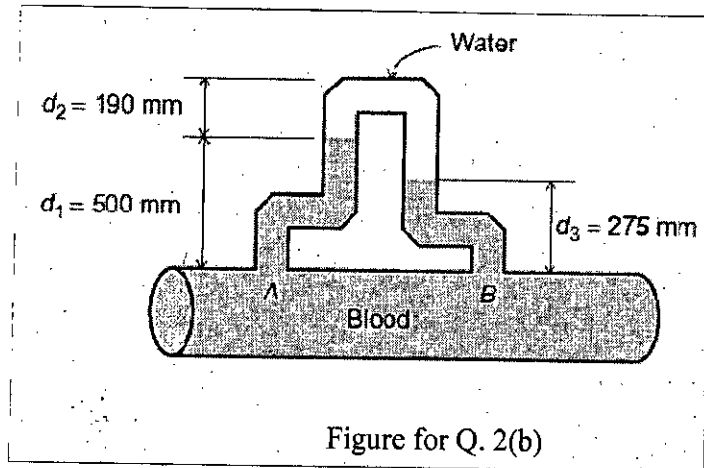


Figure for Q. 2(b)

(c) Why is the Womersley number larger for aorta compared to capillary? (7)

(d) Define inertance. What is the physical significance of inertance in cardiovascular system? (8)

3. (a) Calculate the total volumetric flow rate for the following blood vessel that is represented as an ellipse (Figure 3(a)). The blood vessel has known average velocity values and geometric values for laminae of fluid ( $r_L$  is the radius for the long axis and  $r_S$  the radius for the short axis).

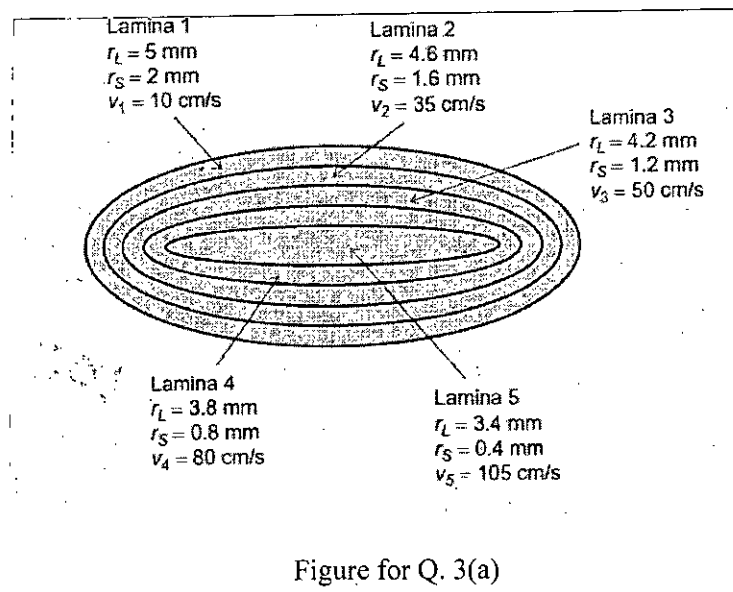


Figure for Q. 3(a)

(10)

(b) Using Reynolds Transport Theorem (RTT), derive that  $Q = \int_{area} v \cdot dA$ . (20)

(c) How does the venturi mask work? (5)

4. (a) A syringe with inside diameter of 15 mm horizontally ejects liquid with density of 1040 kg/m, through a needle with inside diameter of 1 mm at a velocity of 0.5 m/s. Determine the pressure in the syringe? (12)

(b) Describe the Casson's rheological model of blood. (7)

(c) Calculate the volumetric flow rate within an arteriole with a length of 100  $\mu$ m and a radius of 35  $\mu$ m. The pressure difference across the arteriole is 10 mmHg. Also, calculate the change in radius needed to reduce the volumetric flow rate 5%. In this vessel, the effective blood viscosity is 2.8 cP. Assume that when the radius changes there are no other changes in the other fluid parameters. (16)

**BME 205**

**SECTION – B**

There are **FOUR** questions in this Section. Answer any **THREE**.

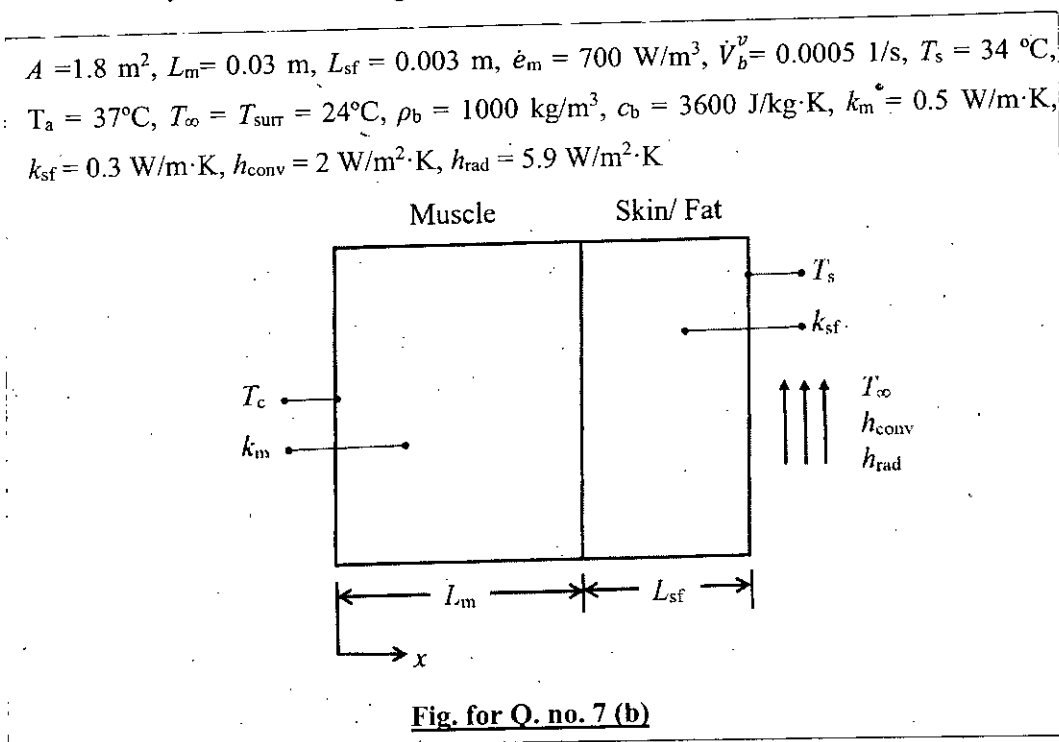
5. (a) An experimental model for blood flow through an artery is to be constructed. The diameter of the artery is 5 mm. the inlet velocity is 16 mm/sec and the heart beat is 72 bpm. However, you can only use water as the fluid flowing through the model artery. **(12+6)**
- (i) Derive the parameters to achieve dynamic similarity between the real artery and the model.
  - (ii) If the diameter of the model of the blood vessel is 1 cm, calculate the angular frequency of the pulsatile waveform and the initial inlet velocity for the model. (Blood viscosity = 3.5 cP, water viscosity =1 cP)
- (b) Describe how the blood flow through the aortic arch might be different from the flow in the abdominal aorta. **(7)**
- (c) A particular artery has an internal diameter of 1 cm and a wall thickness of 0.75 mm at an end diastolic pressure of 85 mm Hg. An 8% increase in the diameter was measured for a systolic pressure of 130 mm Hg. Compute the circumferential stress in the wall of the artery as well as the elastic modulus of the vessel assuming that the arterial wall is thin and made of linear isotropic elastic material. **(10)**
6. (a) For a bifurcating blood vessel, the flow is to be divided 60% - 40% through the two branches. Find the bifurcation angle and indicate on a figure of the bifurcation. **(9)**
- (b) Consider application of a medication to the surface of skin, maintaining a concentration of 10 µg/cc of the medication at the skin surface. The inner surface of the stratum corneum is assumed to be maintained at essentially zero concentration since the molecules are removed as soon as they reach the microcirculation by a sufficiently high peripheral blood flow through skin. The thickness of stratum corneum is 1 micron. The diffusivity of the medication through the stratum corneum is  $10^{-10}$  cm<sup>2</sup>/s. **(10)**
- (i) Calculate the flux of medication through the skin at steady state.
  - (ii) Calculate the total amount of medication in µg/cm<sup>2</sup> of skin that resides in the stratum corneum at steady state.
- (c) Assume that whole blood with a hematocrit of 45% flows through a small diameter tube. The total flow rate is 16 cc/sec, although in the core region it is 12 cc/sec and in the peripheral region it is 4 cc/sec. The blood cells accumulate in the core region having a volume of 10 mm<sup>3</sup> and there are no blood cells present in the cell-free peripheral region which has a volume of 6 mm<sup>3</sup>. By performing a mass balance on the red blood cells, determine the hematocrit in the core region and the peripheral region and the average hematocrit in the whole tube. **(10)**
- (b) Why does the apparent viscosity of blood decrease in small vessels? **(6)**

**BME 205**

7. (a) Derive the three dimensional unsteady form of the Pennes bio heat transfer equation. (14)

(b) Consider a region of muscle with a skin/fat layer over it under steady state conditions as shown in Fig. for Q. No. 7(b). For simplicity, approximate this region as a one-dimensional plane wall with surface area  $A$ . The muscle thickness is  $L_m$  covered by a layer of skin/fat

with a thickness  $L_{sf}$ . The metabolic heat generation rate,  $\dot{e}_m$  and perfusion rate,  $\dot{V}_b$  are both constant throughout the muscle but negligible in skin/fat layer. The arterial blood temperature ( $T_a$ ) and the skin temperature  $T_s$  are also assumed to be constant. The body is subjected to an air environment with a temperature of  $T_\infty$ , a convection heat transfer coefficient of  $h_{conv}$  and a radiation heat transfer coefficient of  $h_{rad}$ . Assuming blood properties and thermal conductivities are all constant, determine the core temperature  $T_c$  and the rate of heat from the body for the following conditions. (15)



(c) A person is found dead at 5 pm in a room whose temperature is 20°C. The temperature of the body is measured to be 25°C when found, and the heat transfer coefficient is estimated to be 8 W/m<sup>2</sup>·k. Modeling the body as a 30 cm diameter, 1.70-m-long cylinder and using the lumped system analysis as a rough approximation, estimate the time of death of that person. ( $\rho = 985 \text{ kg/m}^3, c_p = 3.4 \text{ kJ/kg}\cdot\text{K}$ ) (6)

8. (a) Describe how the SynCrdia total artificial heart works. Will you recommend this device to a patient having and stage heart failure? (10)

(b) During Cardiopulmonary bypass surgery, cardiac activity is ceased by delivering cardioplegia solution. Describe how the circulation of blood and the Oxygen content of the patient's body can be maintained during the surgery. (7)

(c) Human body can maintain its core temperature despite changes in the environment. Describe the mechanisms behind this control. (8)

**BME 205**

**Contd ... Q. No. 8**

(d) Compare the total heat loss from a person dressed summer clothes to the heat loss from a person dressed in winter clothing under the same ambient conditions. The insulating effect of the layer or layers of air trapped between the layers of clothing and between the clothing and the body is reflected in the resistance values of the clothing ensembles. Average temperature of skin is 33°C, ambient temperature is 20°C, total surface area of body is 1.7 m<sup>2</sup>, area of body covered by summer clothing is 1 m<sup>2</sup>, area of body covered by winter clothing is 1.6 m<sup>2</sup> heat transfer coefficient of bare skin is 27.3 W/m<sup>2</sup>.K, overall heat transfer coefficient of winter clothing is 18.4 W/m<sup>2</sup>.K and overall heat transfer coefficient of winter clothing is 4.3 W/m<sup>2</sup>.K.

**(10)**

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**SECTION – A**

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

Symbols and abbreviation have their usual meanings.

1. (a) (i) Define homeostasis. Name some regulated variables that are maintained through homeostasis. Explain how Diabetes (Mellitus) disrupts homeostasis. **(5+5)**  
(ii) What is the internal environment of the human body? Explain its role in maintaining homeostasis.  
(b) How are the two branches of the autonomic nervous system related to maintaining homeostasis? What are the importance of these two branches? **(7)**  
(c) What does it mean to be a "morning" vs "night" person? Explain this phenomenon using the concepts of physiology and mention if the hormones are involved. **(8)**  
(d) With a neat diagram, explain the steps involved in peptide hormone synthesis. By which process are peptide hormones released into the blood stream and why? **(10)**
  
2. (a) Explain the differences between positive and negative feedback mechanisms. Under what circumstances would each be advantageous? Explain long-loop negative feedback. **(10)**  
(b) Why is the control of hormone release important? With the help of a flow-diagram, explain how insulin secretion is controlled in the body through multiple pathways. **(10)**  
(c) Draw a diagram of the anterior pituitary gland showing its internal veins. List the six hormones it releases and give an action of each. Indicate the trophic hormones. **(10)**  
(d) Researchers found that "amylin", a chemical in the pancreas, reduced rats' food intake. Discuss a translational research experiment that will validate the hypothesis that this chemical as a drug may be beneficial in controlling food intake of humans. Name a disease that can be treated using a drug developed using the chemical. **(5)**
  
3. (a) Explain the difference between graded potential and action potential. How do they affect each other? Discuss the concepts of sub-threshold and supra-threshold graded potential, and all-or-none phenomenon in this context. **(10)**



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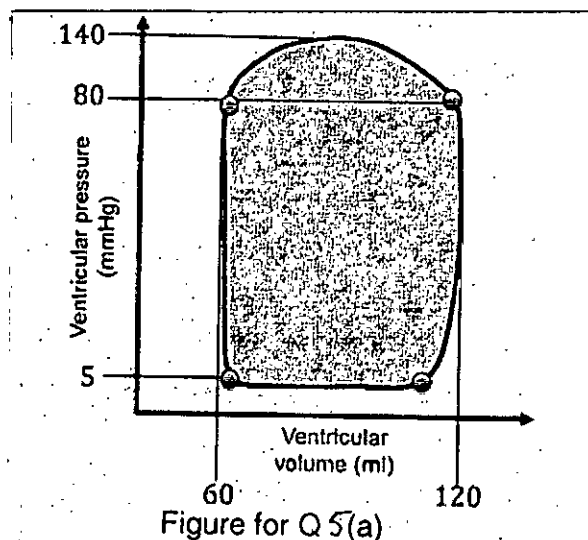
**Contd... Q. No. 3**

- (b) Explain the difference among the terms nerve, neurons and interneurons. How do humans distinguish between a sharp object (e.g., a pin) and a blunt object (e.g., the back-side of a pen) when pressed against the skin? (8)
  - (c) Why does an action potential only travel in one direction? Explain the mechanism that prevents its backward propagation through the axon towards the neuron cell body. (8)
  - (d) With neat diagrams, show how specific regions of central nervous system are activated when speaking a written word vs speaking a heard word. Explain how two types of aphasia are related with two different regions of the brain responsible for speech and language processing. (9)
4. (a) With a neat diagram show the functional areas of the cerebral cortex. Label the four lobes and summarize the functions they perform. (10)
- (b) If human babies' muscles and neurons are fully developed and functional at birth, why can't they focus their eyes, sit up, or learn to crawl within hours of being born? (7)
- (c) Explain why an unmyelinated axon has a much greater requirement for ATP than a myelinated axon of the same diameter and length. (8)
- (d) How many semicircular canals are there in the vestibular system and why? How does this system sense linear and rotational acceleration? (10)

**SECTION – B**

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

5. (a) Pressure volume curve of the left ventricle during a cardiac cycle is shown below. Calculate the cardiac output and work done by the heart during the cardiac cycle if heart rate is 70 beats/min. (15)



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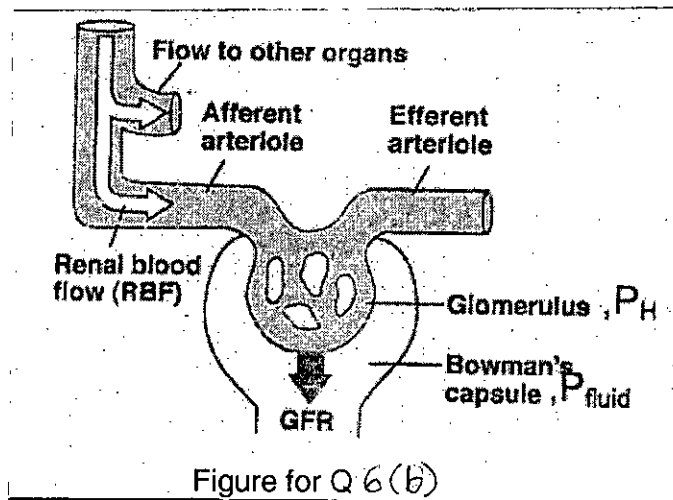
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(b) Each day, 180 liters of filtered fluid pass from the glomerular capillaries into the tubules, yet only about 1.5 liters are excreted in the urine. Thus, more than 99% of the fluid entering the tubules must be reabsorbed into the blood as filtrate moves through the nephrons. Why do nephrons filter 180 L/day and then reabsorb 99% of it rather than simply filter and excrete the 1% that needs to be eliminated? (10)

(c) How can an isometric contraction create force if the length of the muscle does not change significantly? (10)

6. (a) The sympathetic and parasympathetic branches of the autonomic division influence heart rate through antagonistic control. Describe how autonomic division control heart rate. (15)

(b) Given the following diagram of globular filtration, calculate the change in driving force for filtration under the following pathological conditions: (i) net colloid osmotic pressure decreases from 30 mm Hg to 25 mm Hg due to severe malnutrition, (ii) blood pressure in the glomerular capillaries decreases from 55 mm Hg to 40 mm Hg due to hemorrhage. In which of the situations will production of urine stop? At normal condition,  $P_H = 55$  mm Hg,  $P_{fluid} = 15$  mm Hg, and  $\pi_{coll} = 30$  mm Hg. (15)



(c) What is the advantage of the biconcave shape of the red blood cell? (5)

7. (a) An atherosclerotic plaque detected by coronary computed tomography angiography (CCTA) is found to occupy 70% of the total cross-sectional area of the carotid artery lumen. If blood flow into the upstream carotid is 90 mL/min, calculate the average velocity in (i) the normal artery, and (ii) the stenosed (narrowed) section.  $D_1 = 0.5$  cm, is the diameter of the normal artery. (12)

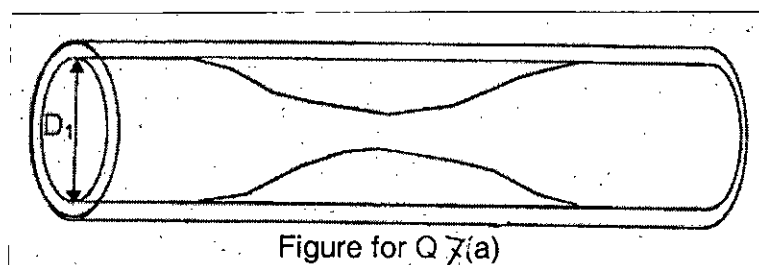


Figure for Q 7(a)

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**Contd... Q. No. 7**

- (b) Carbon dioxide homeostasis is an important function of lung. Higher  $P_{CO_2}$  level can cause pH disturbance and at extreme cases can depress central nervous system function, causing coma and even death. So, it is very important to make sure that  $CO_2$  is transferred properly from the cells to the lungs. Describe the different mechanisms of  $CO_2$  transport in the blood? (15)
- (c) How iron from our diet helps to produce hemoglobin (Hb)? How Hb is cleared from our body? (8)
8. (a) A spirometer with a volume of 1 litre ( $V_1$ ) is filled with a mixture of oxygen and helium, with the helium concentration being 4 g/L. Helium does not move from the lungs into the blood or from the blood into the lungs. A subject is told to blow out all the air he possibly can. Once he finishes that exhalation, he then puts the spirometer tube in his mouth and breathes quietly for several breaths. At the end of that time, the helium is evenly dispersed in the spirometer and the subject's lungs. A measurement shows the new concentration of helium is 1.9 g/L. What was the subject's lung volume at the start of the experiment? (12)
- (b) Urea is freely filtered at the nephron. If  $GFR = 125$  mL/min and urea clearance = 70 mL/min, calculate the fraction of urea which is reabsorbed. (15)
- (c) The muscle fiber's use of ATP is a key feature of muscle physiology. Muscles require energy constantly: during contraction for cross-bridge movement and release, during relaxation to pump  $Ca^{++}$  back into the sarcoplasmic reticulum, and after excitation-contraction coupling to restore  $Na^+$  and  $K^+$  to the extracellular and intracellular compartments, respectively. Where do muscles get the ATP they need for this work? (8)
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