L-2/T-2/BME **Date : 17/02/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2016-2017

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

Full Marks : 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

Symbols used have their usual meaning, reasonably assume any missing data.

1. (a) For an incompressible steady flow, using the system and volume of interest concept, prove that **(17)**

$$Q = \int_{area} \vec{v}.\vec{dA}$$

(b) Calculate the time rate of change of air density during expiration. Assume that the lung has a total volume of 6000 mL, the diameter of the trachea is 18 mm, the air flow velocity out of the trachea is 20 cm/s, and the density of air is 1.225 kg/m^3. Also assume that lung volume is decreasing at a rate of 100 mL/s. **(14)**

(c) Write down the mechanical aspects of atherosclerosis. **(4)**

2. (a) Draw schematic of stress relaxation of Newtonian fluid and viscoelastic fluid. Name and explain a common mathematical model to solve problem associated with viscoelastic material. **(11)**

(b) Determine the velocity of blood at cross-section 4 of the aortic arch schematized in Figure 2(b). Assume that the diameter of the blood vessel is 3 cm, 1.5cm, 0.8 cm, 1.1 cm, and 2.7 cm at cross-sections 1, 2, 3, 4, and 5, respectively. Branches 2, 3, and 4 make 75°, 85° and 70° angle with the horizontal direction, respectively. The velocity is 120, 85, 65, and 105 cm/s at 1, 2, 3, and 5 respectively. There is inflow at 1 and outflow at all of the remaining locations. Assume steady flow at this particular instant in time and that the volume of interest is non deformable. **(12)**

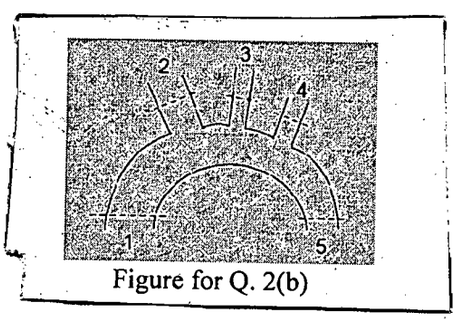

Figure for Q. 2(b)

Contd P/2

BME 205

Contd ... Q. No. 3

(c) The left common coronary artery has an axisymmetric constriction because of a plaque buildup (Figure 2(c)). Given the upstream conditions of a velocity of 20 cm/s (systole) and 12 cm/s (diastole), calculate the velocity at the stenosis throat and the pressure difference between the stanosis throat and the inlet during systole and diastole. Assume that the density of blood is 1050 kg/m^3. Assume other necessary conditions to solve this problem. **(12)**

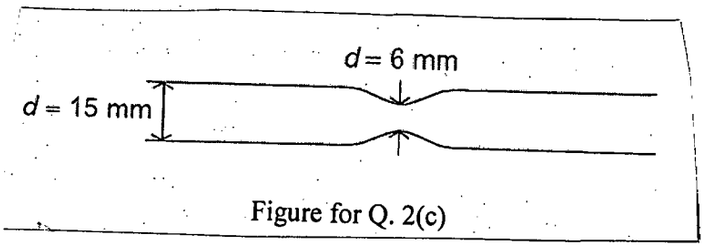

Figure for Q. 2(c)

3. (a) What are the factors affecting whole blood viscosity? **(10)**

(b) Name five rheological models of blood. Describe any two of them. **(13)**

(c) Figure 3(c) shows the relationship of a bifurcation of a mother blood vessel to two daughter vessels. Calculate the radius of one daughter branch knowing that the radius of the parent vessel is 175 μm and the radius of the other daughter branch is 125 μm. Draw the bifurcation with free hands showing the angles θ and φ of the daughter vessels to the horizontal axis. **(12)**

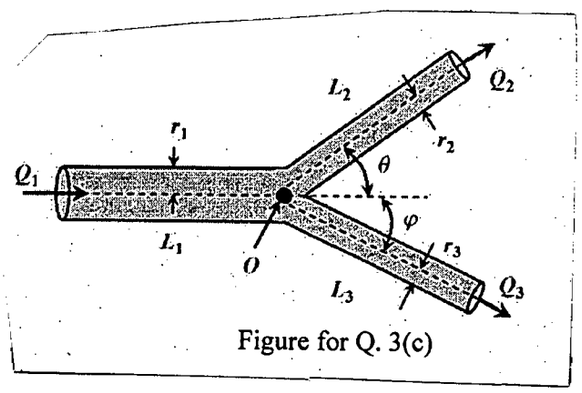

Figure for Q. 3(c)

4. (a) What is temperature homeostasis? How does our body adapt to hot or cold environment? **(12)**

(b) Describe Pennes' bioheat transfer equation. **(10)**

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Contd ... Q. No. 4

(c) Consider a person standing in a room at 20°C with an exposed surface area 1.7 m^2. The deep body temperature of the human body is 37°C, and the thermal conductivity of the human tissue near the skin is about 0.3 W/m.K. The body is losing heat at a rate of 150 W by natural convection and radiation to the surroundings. Taking the body temperature 0.5 cm beneath the skin to be 37°C, determine the skin temperature of the person. **(13)**

SECTION – B

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

5. (a) Describe Newton's law of viscosity. **(5)**

(b) Define compliance and inertance for blood flow in the cardiovascular system. **(6)**

(c) A concentric cylinder viscometer consists of two concentric cylinders with a gap between the cylinders. Whole blood (assume $\mu = 4$ cP) is placed in this gap. The gap width is 1 mm and the inner cylinder radius is 30 mm. Estimate the torque on the 10 cm long inner cylinder if the outer cylinder is rotated at 5 rpm. **(12)**

(d) In an experiment on an exposed abdominal aorta of a dog, the pulse wave speed was determined to be 1.5 m/s. The wall thickness of the artery was measured to be 5% of the diameter. Estimate the Young's modulus for the aorta. In another segment of the same artery, the pulse wave speed was double the previous value. What can you conclude from this? (Assume $\rho = 1045$ kg/m^3) **(12)**

6. (a) A balloon catheter has been placed within a femoral artery of a patient to be passed to the coronary artery. The location where the catheter is inserted into the femoral artery is 50 cm below the aortic arch. The coronary artery is 5 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. **(12)**

(b) Calculate the hydrostatic pressure in the cranium and in the feet at the end of systole and the end of diastole for a hypertensive patient (end systolic pressure is equal to 185 mmHg and end diastolic pressure is equal to 145 mmHg). Assume that blood density does not change significantly with height and that the cranium is 25 cm above the aortic valve and the feet are 140 cm below the aortic valve. Compare this with a normal patient. **(11)**

Contd P/3

BME 205

Contd ... Q. No. 6

(c) Considering surface tension effects only, how much energy is required to inflate all 300 million alveoli in the lungs? Assume that the total alveolar volume before inspiration is 2.5 liters, that the tidal volume is 500 ml, that all alveoli are identically sized spheres, and that the effective surface tension coefficient during inspiration is constant and equal to 0.035 N/m. **(6)**

7. (a) Discuss whether biological fluid flow is turbulent. **(6)**

(b) Flow through a 5 mm diameter venous valve carrying blood at a flow rate of 120 ml/min is to be studied. But in a model of the flow system, water will be used in place of blood which is more difficult to obtain and to work with. Take the viscosity of blood to be 4 cP and the viscosity of water to be 1 cP. Complete geometric similarity exists between the model and the prototype. Assume a model inlet of 5 cm in diameter. Determine the required flow velocity in the model that would be required for Reynolds number similarity. **(12)**

(c) Define Womersley number. Write down its physical significance. Compare the flows in arteries and capillaries in terms of Womersley number. **(10)**

(d) For a typical human aorta, the diameter of the lumen is 30 mm and the thickness of the wall is 4 mm. Assuming a blood viscosity of 3.5 cP, calculate the Womersley number if the heart rate is 72 bpm. **(7)**

8. (a) Find out radial velocity distribution for Poiseuille flow in a tube of radius R. From this find an expression for wall shear stress in terms of volume flow rate Q. **(15)**

(b) Give reasons why Poiseuille's law is not appropriate for arterial blood flow. **(5)**

(c) A normal human contains 5 liters of blood, approximately 2% of which is resident in the systemic (i.e., non-pulmonary) capillaries at any given time. **(15)**

(i) Assuming the capillaries are 8 μm in diameter, estimate the total length of capillaries in the body. (excluding the lungs).

(ii) If an average capillary length is 1 mm, how many capillaries are there in the body?

(iii) Cardiac output is about 5 liter/min. Assuming this is evenly distributed throughout a parallel network consisting of the capillaries found in (ii), estimate the pressure drop across the capillary bed. Assume Newtonian Laminar flow in the capillaries with μ of 3.5 cP. What percentage of the total 85 mmHg systemic pressure drop is this?

L-2/T-2/BME **Date : 22/02/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2016-2017

Sub : **BME 203** (Human Physiology)

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) Define homeostasis. **(3)**

   (b) "Most control systems of the body act by negative feedback" – explain with suitable examples. Why do essentially all control systems of the body operate by negative feedback rather than positive feedback? **(15+5)**

   (c) Explain the mechanisms of simple diffusion and facilitated diffusion. How does facilitated diffusion allow insulin to control the use of glucose in the body? **(8+4)**

2. (a) Describe the genesis of normal resting membrane potential. With suitable illustrations, explain how the action potential develops from the normal resting membrane potential. **(5+10)**

   (b) Explain, with suitable examples, how Karl Landsteiner's laws help in determination of blood groups. What is the limitation of Karl Landsteiner's laws? **(10+2)**

   (c) Explain the nature of the disease erythroblastosis fetalis. Why does the risk of the disease increase in subsequent pregnancies after the first child birth? **(5+3)**

3. (a) What are the events that lead to haemostasis? Describe and explain the tests that are commonly employed to detect bleeding disorders. **(9+6)**

   (b) What is the physiological cause of A-V nodal delay? How are 1st degree, 2nd degree and 3rd degree A-V blocks reflected in the ECG signal? **(6+6)**

   (c) With explanation of each of the terms, describe the relationships between heart rate, stroke volume, cardiac output, blood pressure and peripheral resistance. What are the different types of blood pressure? **(6+2)**

Contd P/2

BME 203

4. (a) What is the cardiac cycle? With suitable illustrations, describe and relate the events of the cardiac cycle to the ECG. **(2+13)**

   (b) Give the names and major functions of the hormones secreted by the following classical endocrine glands: **(3+3+3+3)**

   (i) Thyroid, (ii) Placenta, (iii) Pancreas, (iv) Parathyroid.

   (c) Describe a procedure for determining the percentage of each type of white blood cells present in the blood. What are the main functions of agranulocytes? **(4+4)**

SECTION – B

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

5. (a) Define respiration. Name the different phases of respiration. **(3+3)**

   (b) Explain the concepts of anatomical and physiological dead space air. **(3+3)**

   (c) Describe the gas transport mechanism from tissues to lung. **(11)**

   (d) Describe the functions of the different levels of the central nervous system. **(12)**

6. (a) What are the functions of lung? **(10)**

   (b) Explain the structure of the respiratory membrane. What are the factors that affect diffusion of gases through the respiratory membrane? **(5+5)**

   (c) What is glomerular filtration rate? What are the main factors that affect glomerular filtration rate? **(2+8)**

   (d) Define net filtration pressure. Calculate the net filtration pressure if the hydrostatic pressure is 60 mm Hg, Bowmen's capsule hydrostatic pressure is 18 mm Hg and the glomerular capillary colloid osmotic pressure is 32 mm Hg. **(2+3)**

7. (a) List the movements of GIT. **(8)**

   (b) What is the functional unit of a kidney? Describe, with suitable illustrations, the different parts of the functional unit. **(2+13)**

   (c) Define synapse. How does a nerve impulse cross the synapse? **(2+10)**

8. (a) Name the local hormones of GIT. Give the functions of any two of them. **(5+5)**

   (b) Describe the mechanisms that regulate the emptying of the stomach. **(10)**

   (c) What are the basic steps of urine formation in the kidney? How is dilute urine formed? **(5+10)**

L-2/T-2/BME **Date : 27/02/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2016-2017

Sub : **CSE 283** (Digital Techniques)

Full Marks: 210 Time : 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks.

SECTION – A

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

1. (a) Draw the logic diagram of the clocked RS flip-flop and JK flip-flop with characteristic table and characteristics equation. **(10)**

   (b) Design a serial adder that computes sum of two 3-bit binary numbers A and B stored in individual shift register. The result of the addition is stored in the shift register presenting A. Use sequential logic design procedure to design the serial adder. **(10)**

   (c) Briefly explain race and toggle condition with necessary logic diagram and example. **(10)**

   (d) What are the differences between characteristic table and excitation table? **(5)**

2. (a) If a flip-flop is sensitive to pulse duration, which problem may arise? Give a solution to that problem with a proper logic diagram. **(10)**

   (b) Design a synchronous counter with the sequence given in Figure 2(b) using T flip-flops. **(10)**

   (c) Design a counter that will count from 10 to 14 using the module given in Figure 2(c). **(10)**

   (d) If we want to convert a 3-bit binary up ripple counter (without the load option) into a mod-4 ripple counter, what feature(s) should the flip-flops have? **(5)**

3. (a) Design a T flip-flop using a D flip-flop and basic gates. Also design a D flip-flop using a T flip-flop and basic gates. **(10)**

   (b) How can you copy the value of one register into another register using serial in and serial out options? Draw a comprehensive block diagram. **(10)**

   (c) Identify the logic operation for the given circuit diagram (Figure 3(c)). Find out the values of V_o for all input combinations (input A, B, and C). [Consider V(0) = 0.2V and V(1) = 5V]. **(5)**

   (d) If the transistor in Figure 3 (d) has a minimum value of h_{FE} of 10. Will it work as a proper NOT gate? What will happen if we decrease the values of R_3 in significant amount? Please consider the following values, if necessary. **(10)**

V(0) = 0.2V	V_{BE} (sat) = 0.8V	Diode (Conducting) = 0.7V
V(1) = 12V	V_{BE} (γ) = 0.5V	Diode(γ) = 0.6V
V_{cc} = 12V		

Contd P/2

CSE 283

4. (a) A sequential logic has one input. The state diagram is shown in Figure 4(a). Design the sequential logic diagram with JK flip-flop with state table. **(10)**

(b) Draw a logic diagram of 3-bit register with mode selection inputs S1 and S0 using D flip-flop. **(10)**

Mode Control		Register Operation
S1	S0	
0	0	No change
0	1	Shift left
1	x	Parallel Load

(c) Can we design the above mentioned register (Question: 4-b) using T flip-flops or RS flip-flops? Please give a explanation to support your answer. **(5)**

(d) Verify that the circuit of Figure 4(d) is a positive NAND gate. Will the circuit operate properly if D_2 is not used? Please consider the following values, if necessary. **(10)**

V(0) = 0.2V	V_{BE} (sat) = 0.8V	Diode (Conducting) = 0.7V
V(1) = 12V	V_{BE} (γ) = 0.5V	Diode(γ) = 0.6V

SECTION-B

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

5. (a) Express the Boolean function F = xy + x′z in a product of maxterm form. **(8)**

(b) Design a BCD-to-excess-3 code converter with SSI gates. Show an alternative design of a BCD-to-excess-3 code converter with a 4-bit full adder MSI circuit. **(12+8)**

(c) State and prove DeMorgan's Theorem. **(7)**

6. (a) Prove the following Boolean expression using Boolean algebra: **(10)**

$(x'y' + z)' + z + xy + wz = x + y + z$

(b) Show the operator precedence in Boolean algebra. **(5)**

(c) Simplify the following Boolean function: **(12)**

$F(w, x, y, z) = \Sigma (0, 2, 6, 7, 8, 10, 15)$

Which has the don't-care conditions:

$d(w, x, y, z) = \Sigma (4, 5, 12, 14)$

(d) Write down the truth table for a 1-bit comparator which gives a 1 if A>=B, where A and B are two 1-bit numbers. What will be the equation for the comparator output function in terms of A and B? Draw the circuit diagram. **(8)**

Contd P/3

CSE 283

7. (a) A majority circuit is a combinational circuit whose output is equal to 1 if more inputs have 1's than 0's. The output is 0 otherwise. Design a 3-input majority circuit by finding the circuit's truth table, simplifying the Boolean equation using K-map and showing the logic diagram. **(12)**

(b) What is an encoder? What is the limitation of an encoder? How can this limitation be overcomed? **(9)**

(c) Implement F(w, x, y, z) = w'x' + w'x'z + w'yz' using two-level forms of logic by using NOR gates only. Assume that complements of the variables are readily available. **(10)**

(d) F (A, B, C, D) = Π(3, 7, 12, 13, 14, 15) **(4)**

Express the complement of the above expression in both canonical sum of products and product of sums form. **(4)**

8. (a) Construct a 4 X 16 decoder with two 3 X 8 decoders. **(8)**

(b) Using four half-adders design a 4-bit combinational circuit incrementer (a circuit that adds 1 to a 4-bit binary number). **(8)**

(c) Determine the output functions *A* and *B* as sum minterms from Figure 1. **(12)**

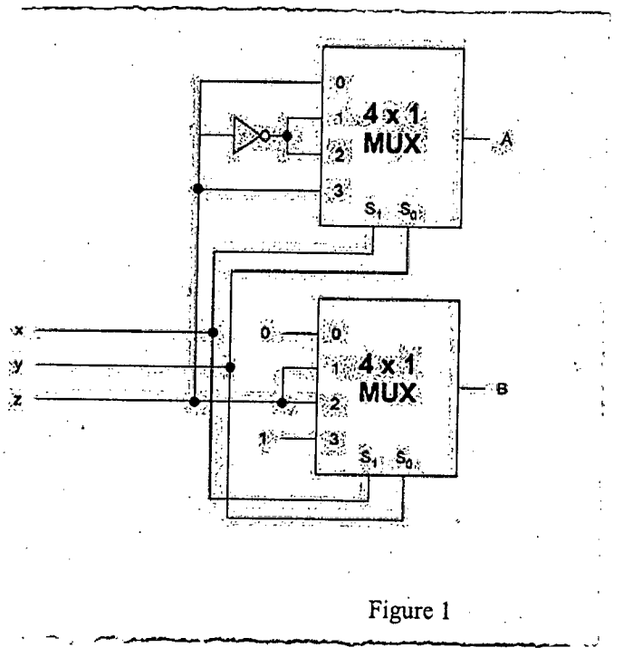

Figure 1

(d) Discuss the application of XOR gates in communication of data. **(7)**

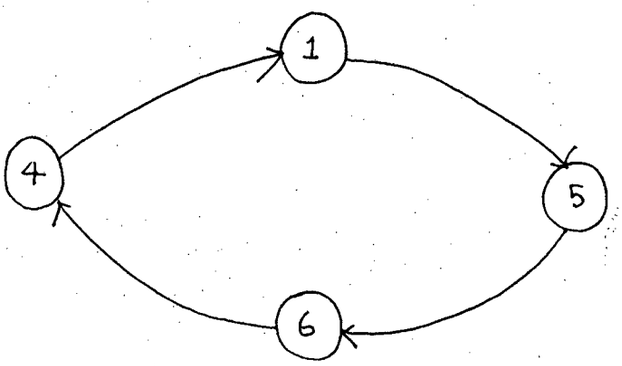

Figure 2(b)

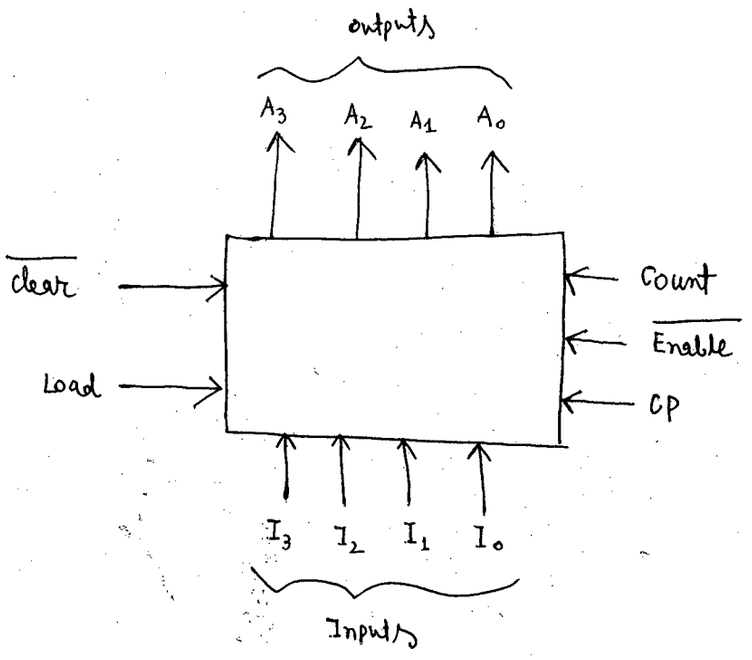

Figure 2(c)

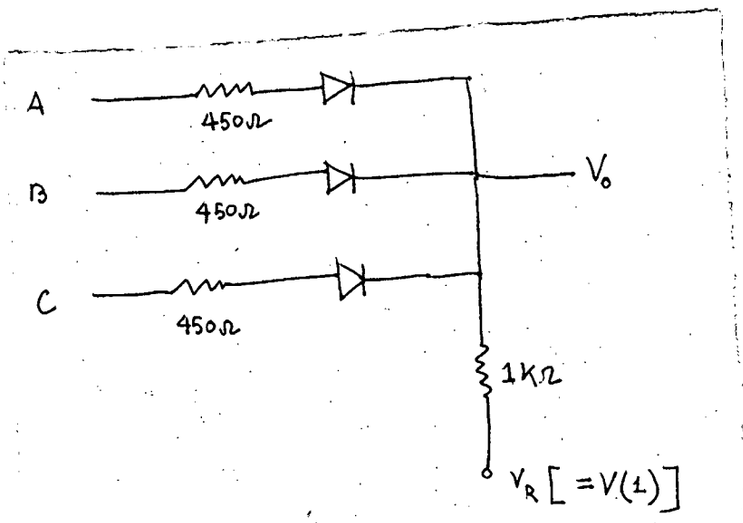

Figure 3(c)

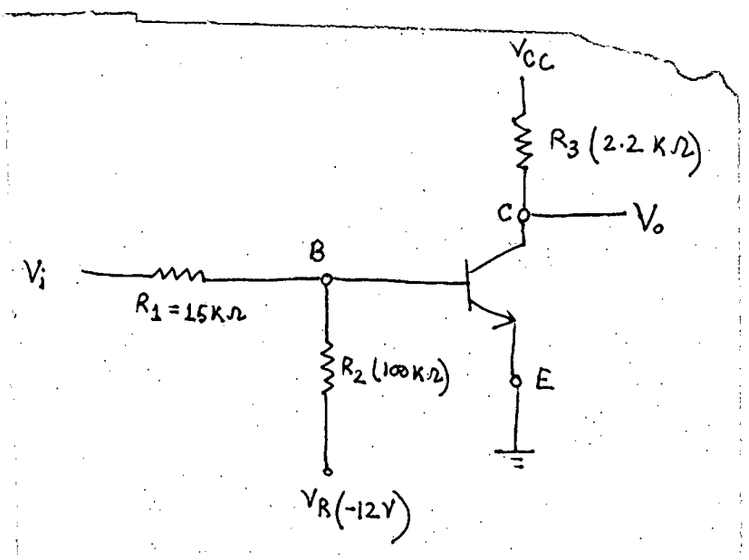

Figure 3(d)

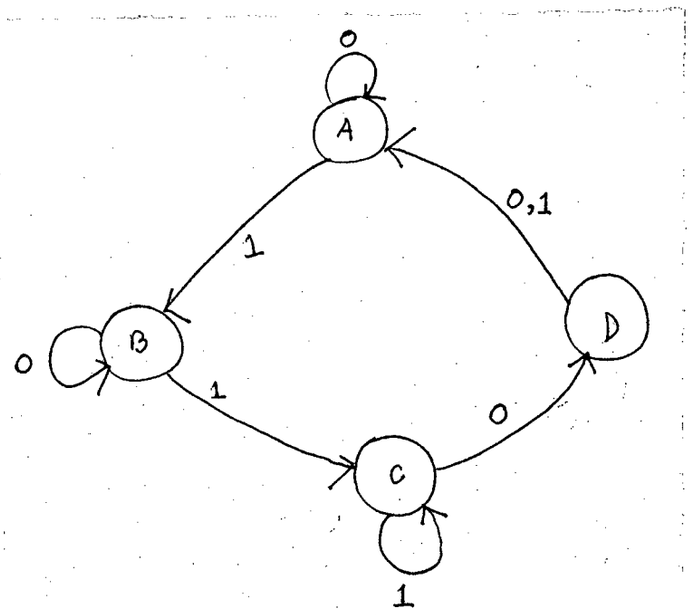

Figure 4(a)

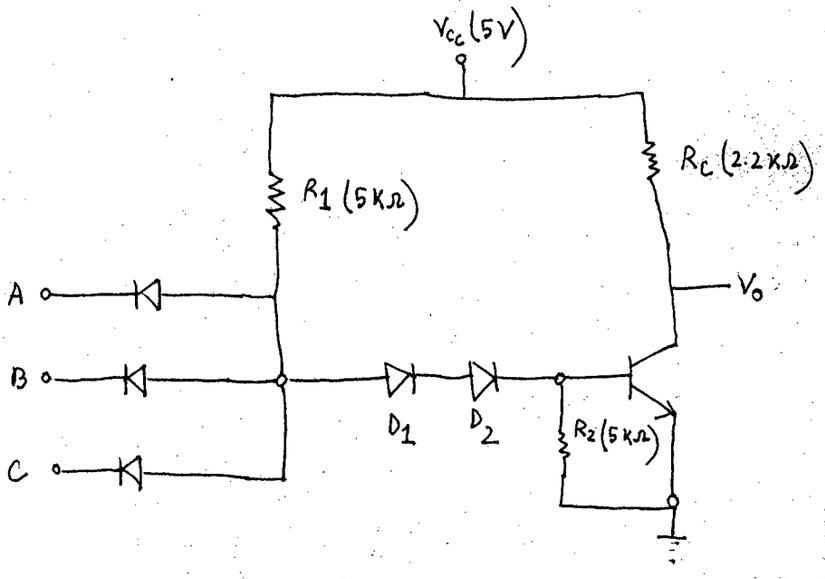

Figure 4(d)

L-2/T-2/BME **Date: 05/03/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2016-2017

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

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

Symbols used have their usual meaning.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) For the matrix $A=\begin{bmatrix}1 & 0 & 1\\ 2 & 1 & 2\\ 3 & 1 & 0\end{bmatrix}$ verify that $A(adjA)=|A|I_3$. Find the inverse of A as well. **(17)**

(b) Define Hermitian and Nilpotent matrices with example. Solve the system of equations:

$$\begin{aligned} x_1+x_2+x_3+x_4&=4\\ 7x_1-5x_2+7x_3+x_4&=46\\ 3x_1+4x_2-5x_3+6x_4&=-11\\ 2x_1-x_2-x_3+3x_4&=6 \end{aligned}$$ **(18)**

2. (a) Factorize the matrix $A=\begin{bmatrix}1 & 2 & 2\\ 1 & 3 & 2\\ 1 & 2 & 3\end{bmatrix}$ into elementary matrices. **(17)**

(b) Write the condition for positive and negative definite quadratic forms. Reduce the quadratic form $q=4x_1^2+3x_2^2-x_3^2+2x_2x_3-4x_3x_1+4x_1x_2$ to the canonical form. Hence find rank, index and signature of q. Write down the corresponding equations of transformation. **(18)**

3. (a) State and verify Cayley-Hamilton theorem for the matrix $A=\begin{bmatrix}4 & -1 & 1\\ -1 & 4 & -1\\ 1 & -1 & 3\end{bmatrix}$. Hence find A^{-1}. **(17)**

(b) Check whether the matrix $B=\begin{bmatrix}6 & 2 & -2\\ 2 & 3 & -1\\ -2 & -1 & 3\end{bmatrix}$ is derogatory or not. If possible then express characteristic polynomial as the product of minimal polynomial and a certain monic factor of it. **(18)**

Contd P/2

4. (a) Find the characteristic polynomial, characteristic equation, eigen values, eigen vectors and eigen space for the matrix $B=\begin{bmatrix} 5 & -1 & 1 \\ -1 & 2 & -4 \\ 1 & -4 & 2 \end{bmatrix}$. **(17)**

(b) Diagonalise the matrix $A=\begin{bmatrix} 1 & -1 & 1 \\ 1 & 2 & 1 \\ 1 & 0 & 3 \end{bmatrix}$, if possible. **(18)**

SECTION – B

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

5. (a) Find the standard matrix for the transformation T on $\mathfrak{R}^3$, where T is the composition of a rotation of 45° about the y-axis, followed by a reflection about the yz-plane, followed by a dilation with factor $k=\sqrt{2}$. Then find $T(2,-1,4)$. **(18)**

(b) Consider the set P_2 of all polynomials of degree 2 and the set $S=\{p_2,p_2,p_3\}$ where $p_1=1+x$, $p_2=1+x^2$, $p_3=x+x^2$. Is the set S a basis for P_2? If so, find the coordinate vector of the polynomial $p(x)=2-x+x^2$ relative to the basis S. **(17)**

6. (a) Determine whether the following subsets are subspaces of $\mathfrak{R}^4$. If so, then find a basis in each case and their dimensions. **(18)**

   (i) all vectors of the form (a, b, c, d), where $d = a + b$ and $c = a - b$,

   (ii) all vectors of the form (a, b, c, d), where $d = 2a + 7c$ and $3c = 2a - 5b$,

   (iii) all vectors of the form (a, b, c, d), where $a = b = c = d$.

(b) Given $A=\begin{bmatrix} 1 & 4 & 5 & 6 & 9 \\ 3 & -2 & 1 & 4 & -1 \\ -1 & 0 & -1 & -2 & -1 \\ 2 & 3 & 5 & 7 & 8 \end{bmatrix}$. Find bases for the row space and null space of A. **(17)**

Hence verify the dimension theorem for A.

7. (a) Find a subset of the vectors **(15)**

$\underline{u_1}=(1,-1,5,2)$, $\underline{u_2}=(-2,3,1,0)$, $\underline{u_3}=(4,-5,9,4)$, $\underline{u_4}=(0,4,2,-3)$, $\underline{u_5}=(-7,18,2,-8)$

that forms a basis for the space spanned by these vectors; then express each vector that is not in the basis as a linear combination of the basis vectors.

Contd P/3

(b) Let W be the subspace of $\mathcal{R}^4$ spanned by the vectors $v_1 = (1,4,5,2)$, $v_2 = (2,1,3,0)$ and $v_3 = (-1,3,2,2)$. Find a basis for the orthogonal complement of W. **(10)**

(c) Consider the basis $S = \{u, v, w\}$ for $\mathcal{R}^3$, where $u = (1,1,1)$, $v = (1,1,0)$, $w = (1,0,0)$ and let T: $\mathcal{R}^3 \rightarrow \mathcal{R}^3$ be the linear operator such that $T(u) = (2,-1,4)$, $T(v) = (3,0,1)$ and $T(w) = (-1,5,1)$. Find a formula for $T(x, y, z)$ and use it to find $T(2,-3,5)$. **(10)**

8. (a) Consider the vector space $\mathcal{R}^3$. Apply Gram-Schmidt process to transform the basis vectors $u_1 = (0,1,2)$, $u_2 = (-1,0,1)$ and $u_3 = (-1,1,3)$ into an orthogonal basis $\{v_1, v_2, v_3\}$; then normalize the orthogonal basis vectors to obtain the orthonormal basis $\{q_1, q_2, q_3\}$. Finally, write the QR-decomposition of $A = \begin{bmatrix} 0 & -1 & -1 \\ 1 & 0 & 1 \\ 2 & 1 & 3 \end{bmatrix}$. **(17)**

(b) Let $T : P_2 \rightarrow P_3$ be the linear transformation defined by $T(p(x)) = xp(x-3)$; that is, **(18)**

$$T(a + bx + cx^2) = x(a + b(x-3) + c(x-3)^2)$$

Find the matrix for T with respect to the standard bases $E = \{1, x, x^2\}$ and $E' = \{1, x, x^2, x^3\}$. Finally, for any $x \in P_2$, verify the relation $A[x]_E = [T(x)]_{E'}$, where A is the matrix for T with respect to the bases E and E'.

L-2/T-2/BME **Date: 11/03/2018**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2016-2017

Sub: **MME 297** (Structure and Properties of Biomaterials)

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) Indicate the functions of chromium, molybdenum and nickel in stainless steel. **(9)**

   (b) Discuss the structure, properties and applications of Ti and Ti alloys used as biomaterials. **(6+8+2=16)**

   (c) Calculate the number of Co atoms released during a year from 28 mm diameter femoral head of a hip-joint prosthesis made of CoCrMo alloy. Assume that half of the area of femoral head is in contact with the socket portion of the joint and that the wear rate is 0.12 mm/yr and that all the atoms become ionized. The density and atomic weight of Co are 8.83 g/cc and 58.93 g/cc respectively. **(10)**

2. (a) Using ZrO_2-CaO phase diagram, indicate how CaO stabilizes the structure of zirconia. **(10)**

   (b) Explain how the partially stabilized zirconia ceramics can be toughened by phase transformation. **(10)**

   (c) Discuss the structure and properties of hydroxyapatite. **(10+5=15)**

3. (a) Analyse the effect of molecular weight and composition, cross-linking and branching, and temperature on properties of polymeric materials. **(10+10+5=25)**

   (b) Inspect the suitability of using nylons and PMMA as biomaterials with respect to their structures and properties. **(5+5=10)**

4. (a) Classify composites with examples based on matrix and reinforcing materials. List the factors that control the properties of composite materials. **(6+4=10)**

   (b) Examine the usefulness of porous composite implants. Write a short note on the manufacturing process of porous implants. **(2+8=10)**

   (c) Using a schematic organisation of a typical bone, discuss the composition, structure and properties of bone. **(15)**

Contd P/2

SECTION – B

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

5. (a) Briefly discuss the four factors that govern biocompatibility of a material. **(15)**

(b) Differentiate between biomaterials and biological materials. **(5)**

(c) Discuss the working principle of XPS. If you want to know the chemical composition of a thin surface layer (~5 nm) using XPS, you must be able to detect sufficient signal from the surface. How can you increase the signal that is obtained from the surface? Justify your answer. **(15)**

6. (a) Cr has BCC crystal structure and an atomic radius of 0.125 nm. Its atomic weight is 52. What is its theoretical bulk density? **(11)**

(b) Define atomic packing factor in simple terms. Prove that it is 0.68 for BCC. **(12)**

(c) Draw the FCC and HCP unit cells and determine the number of atoms per unit cell in both cases. **(12)**

7. (a) Schematically show different types of point defects in a non-ionic crystal. **(8)**

(b) At 500 K how much Cu (in kg) would contain 10^{20} vacancies? For Cu, vacancy formation energy is 0.9 eV per atom, atomic weight is 63.5 and density is 8.4 g/cm^3. **(15)**

(c) Illustrate an edge dislocation and show that its burger's vector is perpendicular to the dislocation line. **(12)**

8. (a) What is the primary driving force behind diffusion and what two conditions must be met for diffusion to occur? **(8)**

(b) Schematically show vacancy diffusion and interstitial diffusion. Give examples and explain why interstitial diffusion is usually much more rapid than vacancy diffusion. **(12)**

(c) "When loaded in tension, a single crystal usually begins to slip in a plane that is 45° to the direction of the applied stress" — derive the necessary equation and prove this statement. **(15)**
