L-2/T-2/BME Date : 25/09/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

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

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

The symbols have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Why is total lung less compliant than lung and chest wall individually? Emphysema is a pathological condition that changes lung compliance. Describe the physiological changes in emphysema with necessary diagrams. **(15)**

   (b) Observe the following ECG waves in Figure 2(a) and explain the underlying reason behind their difference from a normal ECG signal. **(15)**

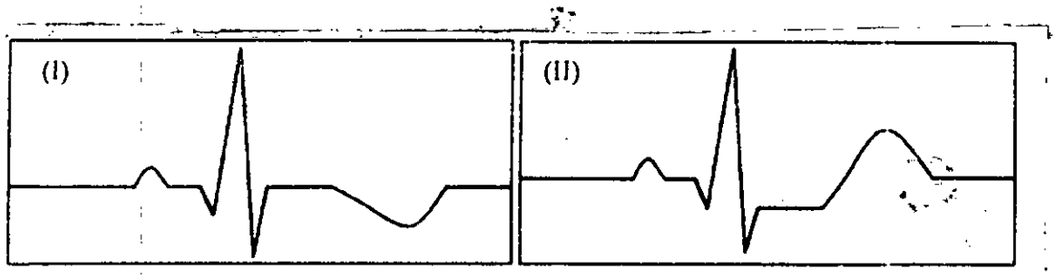

Figure for Question no. 2(a)

   (c) Write a short note on anatomical dead space. **(5)**

2. (a) Describe what happens to the mean arterial pressure in the following conditions: **(15)**
   (i) Decreasing of stroke volume
   (ii) Higher fluid intake
   (iii) Dilation of veins

   (b) You are given the following information on a patient. Blood volume = 5.2 liters; Hematocrit = 47%; Hemoglobin concentration = 12 g/dL whole blood; Total amount of oxygen carried in blood = 1015 mL; Arterial plasma = 100 mm Hg. **(10)**

   You know that when plasma P_{O_2} is 100 mm Hg, plasma contains 0.3 mL O_2/dL, and that hemoglobin is 98% saturated. Each hemoglobin molecule can bind to a maximum of four molecules of oxygen. Using this information, calculate the maximum oxygen carrying capacity of hemoglobin (100% saturated).

   (c) Which hormones are secreted from the pituitary gland? Briefly describe their functions. **(10)**

Contd P/2

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3. (a) Explain the following sentence using the concepts of homeostasis – "Hypertension represents a failure of homeostasis". **(13)**

(b) A person has a total blood volume of 5 L. Of this total, assume that 4 L is contained in the systemic circulation and 1 L is in the pulmonary circulation. If the person has a cardiac output of 5 L/min, how long will it take (i) for a drop of blood leaving the left ventricle to return to the left ventricle and (ii) for a drop of blood to go from the right ventricle to the left ventricle? **(10)**

(c) If the afferent arteriole of a nephron constricts, what happens to GFR in that nephron? If the efferent arteriole of a nephron constricts, what happens to GFR in that nephron? Assume that no autoregulation takes place. **(12)**

4. (a) Glucose concentration in our body is constantly being regulated. Mention the hormones that are involved in this process and write down their contributions. **(15)**

(b) You have been asked to study kidney function in a patient. You have isolated some nephrons and exposed them to inulin. Figure 4(b) shows the results of your studies. **(10)**

(i) How is the patient nephron handling inulin? Is inulin filtered? Is it excerted? Is there net inulin reabsorption? Is there net secretion? (ii) Draw a graph, accurately indicating net reabsorption or secretion.

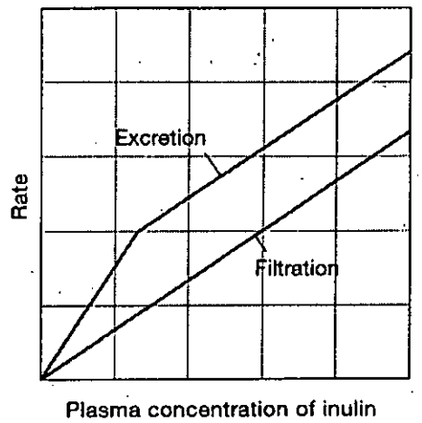

Figure for Question 4(b)

(c) How does kidney maintain the balance of sodium ions in the body? Describe the functions of aquaporins. **(10)**

Contd P/3

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SECTION – B

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

5. (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)**

   (b) With a neat schematic, show the events at the neuromuscular junction. Explain the roles of titin and nebulin in muscle contraction. **(10)**

   (c) Vestibulocochlear system is an important part of our sensing in terms of hearing and maintaining equilibrium. How does the vestibular system sense linear and rotational acceleration? Briefly explain. **(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 'amylin'. **(5)**

6. Jeremy is a special child. He mostly understands what others are saying but finds difficulty in speaking or writing. However, he loves to eat desserts. One fine morning, when he was enjoying the apple pie made by his mother; he suddenly saw a lizard. He got very scared and frantically ran from the table. While doing so, he fell down and got a deep cut on his knee which was bleeding constantly. His mother came, tended his wound and said, "Don't worry, dear. Soon, the coagulation cascade will activate to stop your bleeding."

   (a) Explain the type of aphasia that Jeremy has. **(4)**

   (b) When Jeremy started to run seeing the lizard, which nervous system got activated? What are the physiological effects due to the activation of this system? **(6)**

   (c) Illustrate and briefly describe the taste transduction pathway that was engaged while Jeremy was having the apple pie. How will the pie (rich in starch and sucrose) be processed in small intestine during digestion? **(10)**

   (d) With a neat schematic, show how the intrinsic, extrinsic, and common pathways of coagulation cascade works together to form the fibrin clot. Despite having the positive feedback loop activated, why do the platelets not adhere to the nearby intact epithelium? **(15)**

7. (a) Renee Zhao, an undergraduate student, was investigating the effect of saline solution's osmolarity on the shape of RBCs. She took 10 sets of data and got the following Fig, 7(a) that illustrates the relative volume of RBC in contact with different concentrations of saline solution (NaCl). She assumed the osmotic coefficient of NaCl to be **0.89** and calculated the osmolarity of the isotonic saline concentration to be **0.125 OsM**. **(10)**

Contd P/4

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Contd ... Q. No. 7(a)

(i) Determine the osmolarity of RBCs at the isotonic saline concentration using the plot given below. Was the calculation of Renee correct? Mark the hypotonic and hypertonic zones in the plot.

(ii) Explain the shape of RBCs at points A, B and C. How does normal RBCs maintain the unique biconcave shape and what are the advantages of it?

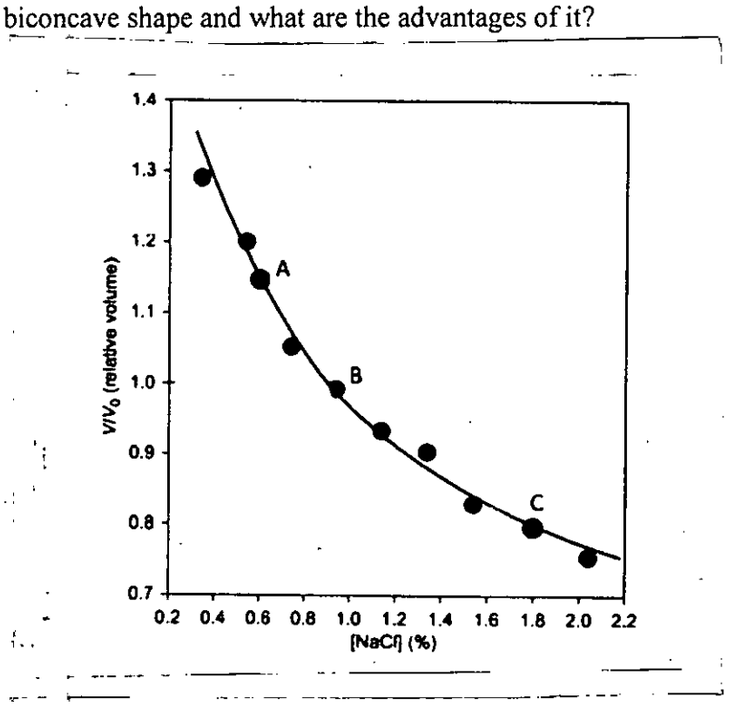

Fig. for 7(a)

(b) Describe the propagation of action potential in a myelinated axon. Why is it called saltatory conduction? Write a short note on myelin forming glial cells. **(12)**

(c) Which parts of the sarcomere shortens during muscle contraction? Why does too much or too little overlap of thick and thin filaments in resting muscle result in decreased tension? Explain with the plot of length-tension relationship. **(8)**

(d) Define active transport. Illustrate the postulated mechanism for pump-mediated cotransport of sodium and potassium. **(5)**

8. (a) The table 8(a) shows the ionic concentration of a squid axon at 17°C: **(7)**

Table for 8(a)

Nerve (squid axon)		
	Intracellular mM	Extracellular mM
K^+	397	20
Na^+	50	437
Cl^-	40	556

Contd P/5

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Contd ... Q. No. 8(a)

The relative permeability of the K^+, Na^+ and Cl^- channels of the squid axon are 0.94, 0.03 and 0.26, respectively. Calculate the ionic contribution to the total resting membrane potential using Goldman-Hodgkin-Katz equation.

(b) What are the three phases of digestion? "Short reflexes integrate in the enteric nervous system while long reflexes are integrated in CNS" – do you agree with the statement? Represent the integration of digestive reflexes in a schematic. **(13)**

(c) State the advantages of cerebral lateralization. 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? **(10)**

(d) What is the difference between mechanistic approach and teleological approach? Explain the approaches with a suitable example. **(5)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

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

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

The symbols have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

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

1. (a) Blood flowing through the descending aorta can become turbulent in some highly trained athletes. Does blood act as a Newtonian fluid in this case? Why or why not? **(8)**

(b) The heart rate of a 400-kg horse is approximately 36 bpm, while the heart rate of a 3-kg rabbit is approximately 210 bpm. Compare the Womersley number in the horse aorta to that in the rabbit aorta. Assume that the blood density is approximately the same across the species and the values of viscosity were 0.0052 Ns/m^2 for the horse and 0.0040 Ns/m^2 for the rabbit. The allometric relationship for the aorta size of various mammals to estimate the diameter of the aorta: **(12)**

$$D = 0.48W^{0.34}$$

where **D** is the aortic diameter, given in cm, and **W** is the animal weight, given in kg.

(c) Blood is flowing within a small hollow fiber module containing a total of 10,000 fibers. Each fiber has an internal diameter of 60 μm and a length of 20 cm. If the total blood flow rate is 10 mL min^{-1}, estimate the pressure drop in mmHg across the hollow fibers. Also, calculate the tube hematocrit, H_T. Assume the discharge hematocrit of the blood is 0.40 and that the Newtonian viscosity of blood in large tubes is 3 cP. The plasma viscosity is 1.2 cP. **(15)**

$$\frac{H_T}{0.40} = 0.40 + (1 - 0.40)(1 + 1.7e^{-0.415d} - 0.6e^{-0.011d})$$

$$C = (0.8 + e^{-0.075d})\left(-1 + \frac{1}{1 + 10^{-11}d^{12}}\right) + \frac{1}{1 + 10^{-11}d^{12}}$$

$$\eta^*_{0.45} = 220e^{-1.3d} + 3.2 - 2.44e^{-0.06d^{0.645}}$$

$$\frac{\mu_{apparent}}{\mu_{plasma}} = \left[1 + (\eta^*_{0.45} - 1)\frac{(1 - H_D)^C - 1}{(1 - 0.45)^C - 1}\left(\frac{d}{d - 1.1}\right)^2\right]\left(\frac{d}{d - 1.1}\right)^2$$

Where, **d** = diameter (μm), $\mathbf{H_D}$ = discharge hematocrit, $\eta^*_{0.45}$ = ratio of apparent viscosity of blood to plasma at a hematocrit of 0.45, **C** = curve fitting parameter, $\mathbf{H_T}$ = tube hematocrit.

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2. (a) What are the major differences between SynCardia TAH and AbioCor TAH? Which one will you choose as a heart transplant and why? **(15)**

   (b) Explain which characteristics are important in selecting a pump for blood transportation and why? **(10)**

   (c) Describe the basic functions of a Constant Volume (CV) ventilator with a schematic. **(10)**

3. (a) Consider a person standing in a room at 20°C with an exposed surface area of 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.°C. 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. **(15)**

   (b) The carbon dioxide concentration in the gas at the inlet of a semipermeable oxygenator is 5 mmHg and that in the blood is 45 mmHg. Assume the radius of the channel is 4 cm and that the thickness of the boundary is 100 μm. Calculate the change in carbon dioxide concentration with distance if the diffusion coefficient is 2×10^{-4} cm^2/s, the gas velocity is 5 cm/s, and the blood velocity is 10 cm/s. **(15)**

   (c) Show that, according to Murray's function, if the radii of the daughter branches are equal, the bifurcation angles are equal. **(5)**

4. (a) When a person's foot touches the fire, a small amount of water evaporates from the skin and this layer of water vapor protects the skin from being burned. A schematic of the heat transfer during fire walking and the properties of the different layers are in the table given below. **(20)**

   (i) What will the temperature in the skin be at 1 mm from the skin-steam interface?

   (ii) If the steam layer is absent, what will the temperature be at the same location (at the skin-coal interface)?

   (iii) Did the steam layer make a significant difference?

	Sp. Heat (J/kgK)	Thermal conductivity (W/m.K)	Density (kg/m^3)
Skin	3600	0.43	1102
Steam	2060	0.026	0.5863
Coal	1800	0.16	300

Table for Question 4(a)

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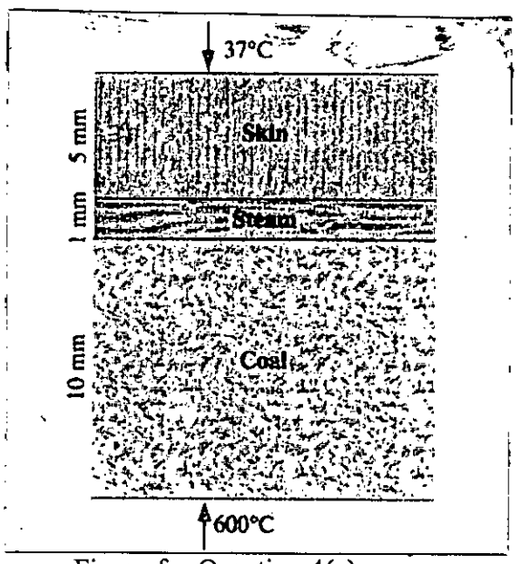

Figure for Question 4(a)

(b) Body temperatures of fish vary with the environment (water). Consider a fish that can be approximated as a slab whose total metabolic beat generation in W is given by $0.194\ m^{0.85}$ where m is the mass of the fish in kg. Its movement in water leads to a surface heat transfer coefficient of 50 $W/m^2.K$. The fish weighs 2 kg, the thickness of the fish (slab) is 5 cm, and its thermal conductivity is 0.5 W/m.K. The density of the fish can be assumed to be that of water, 1000 kg/m^3. At steady state, what is the temperature difference between – **(15)**

(i) The center (core) and the surface of this fish?

(ii) The center of the fish and the bulk water?

SECTION – B

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

5. (a) How does the flow develop in the case of laminar and turbulent conditions? Why is the velocity profile of turbulent flow flatter than laminar flow? **(12)**

(b) A plate is moving upwards through a channel filled with water in Figure 5(b). The plate velocity is 10 cm/s, and the spacing is 50 mm on each side of the plate. The force required to move the plate is equal to 5 N. Determine the surface area of the plate. If the distance on the right-hand side is increased to 100 mm and the fluid on the right side is changed to blood (μ = 3.5 cP), determine the viscosity of the fluid on the left side. **(15)**

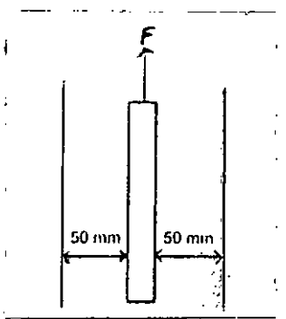

Figure for Question 5(b)

(c) Describe the relationship between viscosity and shear rate of Newtonian, Dilatants, and Pseudoplastic fluids with suitable diagram. **(8)**

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BME 205

6. (a) Determine the force required to hold the brachial artery in place during peak systole in Figure 6(a). Assume the inlet the pressure is 100 mmHg and the outlet the pressure is 85 mmHg. The diameter of the brachial artery is 18 mm at the inflow and 16 mm at the outflow. The blood flow velocity at the inlet is 65 cm/s. For simplicity, neglect the weight of the blood vessel and the weight of the blood within the vessel. **(15)**

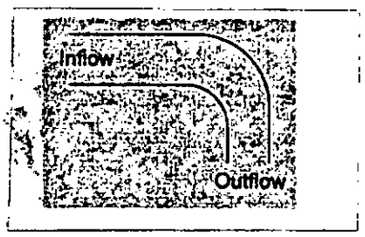

Figure for Question 6(a)

(b) What is center of pressure? Derive the equation to calculate the center of pressure on a vertical plane surface. **(12)**

(c) Describe the significance of Womersley number from biomedical engineering perspective. **(8)**

7. (a) The average gauge blood pressure is 80 mmHg as it enters an arteriole and is 20 mmHg as it leaves the arteriole. The viscosity of blood is 3e-03 Pa.s and the arteriole has a radius of 0.1 mm and a length of 950 micron. What is the resistance to blood flow and average flow rate in the arteriole? Now suppose plaque deposits in the arterioles decreased the radius from 0.1 mm to a new smaller radius r_{new}. If the resistance in the arterioles is doubled as a result of this constriction, find r_{new}. **(15)**

(b) Use the Reynolds Transport Theorem to prove how fluid mass is conserved in a system. **(15)**

(c) Write short notes on: (i) Steady flow; (ii) Differential manometers. **(5)**

8. (a) The left common coronary artery has an axisymmetric constriction because of a plaque buildup (Figure 8(a)). 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 stenosis throat and the inlet during systole and diastole. **(10)**

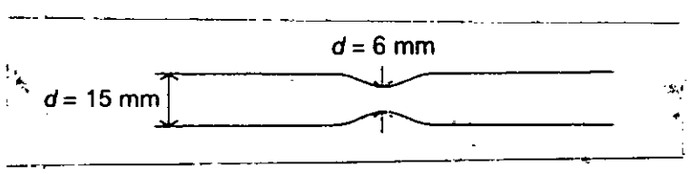

Figure for Question 8(a)

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Contd ... Q. No. 8

(b) Derive the Darcy-Weisbach equation to calculate friction loss in pipe flow. **(12)**

(c) Determine the blood velocity at cross-section 3 of the aortic arch in Figure 8(c). Assume that the diameter of the blood vessel is 3 cm, 1.5 cm, 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 a 75°, a 85°, and a 70° angle with the horizontal direction, respectively. The velocity is 120, 85, 65, and 105 cm/s at cross sections 1, 2, 4, and 5, respectively. There is inflow at 1 and outflows at all of the remaining locations. Assume steady flow at this particular instant in time and that the volume of interest is nondeformable. **(13)**

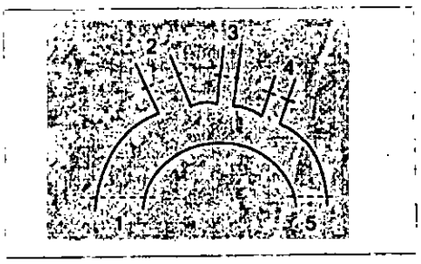

Figure for Question 8(c)

L-2/T-2/BME **Date: 26/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

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

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** questions.

Symbols have their usual meanings.

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1. (a) Show that every square matrix can be expressed in one and only one way as the sum of a symmetric and a skew-symmetric matrix. **(8)**

(b) Prove that $adjAB = (adjB)\,(adjA)$ **(7)**

(c) Find the adjoint matrix of $A = \begin{bmatrix} 3 & -1 & 1 & 2 \\ 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 2 \\ 1 & 0 & 0 & 1 \end{bmatrix}$. **(20)**

2. (a) Find the canonical matrix of $A = \begin{bmatrix} 2 & 7 & 3 & 5 \\ 1 & 2 & 3 & 4 \\ 3 & 8 & 1 & -2 \\ 4 & 13 & 1 & -1 \end{bmatrix}$ and hence find its rank. **(18)**

(b) Use Gauss-Jordan method to solve the following system of linear equations: **(17)**

$$x_1 + 2x_2 - x_3 = 2$$
$$3x_1 + x_2 + 2x_3 = 11$$
$$4x_1 + 4x_2 - 3x_3 = 3$$
$$2x_1 - x_2 + 3x_3 = 9$$

3. (a) Reduce the quadratic form **(17)**

$q = x_1^2 + 2x_2^2 - 2x_3^2 + 4x_1x_2 + 6x_1x_3$ to the canonical form and find rank, index and signature of the form.

(b) Find a non-singular matrix P such that $P^{-1}AP$ is a diagonal matrix, where **(18)**

$$A = \begin{bmatrix} 6 & -2 & 2 \\ -2 & 3 & -1 \\ 2 & -1 & 3 \end{bmatrix}$$

Contd P/2

MATH 215/BME

4. (a) State Cayley -Hamilton theorem and use this theorem to find the inverse of the matrix $A = \begin{bmatrix} 2 & 0 & 1 \\ -2 & 1 & 0 \\ -1 & 1 & 1 \end{bmatrix}$. **(17)**

(b) Using matrix method find the currents $i_1(t)$ and $i_2(t)$ in an electrical network containing resistances R_1 = 8 ohms, R_2 = 3 ohms, inductors L_1 = 1 henry, L_2 = 1 henry and electromotive force (e.m.f) $E(t)$ = 100 sin$t$ volts. The currents $i_1(t)$ and $i_2(t)$ are initially zero. **(18)**

SECTION – B

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

5. (a) Find the standard matrix for the transformation T on $\mathbf{R}^3$, where T is the composition of a rotation of 45° about y-axis, followed by a reflection about the zx-plane, followed by a dilation with factor k = $\sqrt{2}$. Then find T(2, –5, 7) using the standard matrix. **(18)**

(b) Determine whether the set of all vectors of the form (i) (a, b, c), where a + b = c (ii) a + b = 1 are subspaces of $\mathbf{R}^3$. **(17)**

6. (a) Express the following polynomial $\mathbf{p} = 6 + 11x + 6x^2$ as a linear combination of $\mathbf{p}_1 = 2 + x + 4x^2$, $\mathbf{p}_2 = 1 - x + 3x^2$ and $\mathbf{p}_3 = 3 + 2x + 5x^2$. **(15)**

(b) Test whether the set S = $\{\underline{v}_1, \underline{v}_2, \underline{v}_3\}$ is a basis for $\mathbf{R}^3$, where $\underline{v}_1$ = (1, 2, 1), $\underline{v}_2$ = (2,9,0), $\underline{v}_3$ = (3, 3, 4). If so, then find the coordinate vector of $\underline{v}$ = (5, –1, 9) with respect to S. **(20)**

7. (a) Let T be a linear transformation defined by T(x, y, z) = (x+3y+4z, 3x+4y+7z, –2x+2y). Find (i) a basis and the dimension of Range(T). (ii) a basis and the dimension of Kernel(T). Then verify the dimension theorem. **(18)**

(b) (i) Find a subset of vectors $\underline{v}_1$ = (1, –2, 0, 3), $\underline{v}_2$ = (2, –5, –3, 6), $\underline{v}_3$ = (2, 0, 7, –7), $\underline{v}_4$ = (2, –1, 4, –7) and $\underline{v}_5$ = (– 4, 7, 2, 1) that forms a basis for the space spanned by these vectors. (ii) Express each vector not in the basis as a linear combination of the basis vectors. **(17)**

8. (a) Consider the vector space $\mathbf{R}^3$ with the Euclidean inner product. Apply *Gram-Schmidt* process to transform the basis vectors u_1 = (1, 1, 1), u_2 = (0, 1, 1) and u_3 = (0, 0, 1) into a orthogonal basis {v_1, v_2, v_3} taking $v_1 = u_1$; then normalize the orthogonal basis vectors to obtain the orthogonal basis {q_1, q_2, q_3}. Also find the QR-decomposition of the matrix A = [u_1|u_2|u_3]. **(20)**

(b) Let T: $P_1 \rightarrow P_2$ be the linear transformation defined by T($p(x)$) = $x\,p(x)$. Find the matrix for T with respect to the standard bases B = {u_1, u_2} and B' {v_1, v_2, v_3}, where, $u_1 = 1$, $u_2 = x$; $v_1 = 1$, $v_2 = x$, $v_3 = x^2$. If X = $p(x)$ a + bx is any vector in P_1, then verify that $[T]_{B'}, {}_B\,[X]_B = [T(X)]_{B'}$. **(15)**

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L-2/T-2/BME **Date: 20/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

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** questions.

1. (a) Design a gated SR Latch (i.e., SR latch with control/enable) using only NOR gates. The SR latch should store the input data when control signal is high. **(6)**

(b) Using three T flip-flops A, B, C, and basic gates, design a 3-bit synchronous counter with the following repeated binary sequence: 1, 3, 5, 7. The counter has four unused states: 0, 2, 4, 6. Don't treat the unused states as don't cares; instead design the counter so that from any unused state, the counter moves to the valid state 1 (i.e., binary state 001). Assume that counter state is labelled as $Q_AQ_BQ_C$ in terms of the flip-flop outputs (i.e., Q_A is the MSB). Show the state transition table, minimized Boolean expressions for the flip flop inputs, and the final circuit diagram. **(5+6+4=15)**

(c) A sequential circuit has two JK flip flops A and B and one input x. The circuit is described by the following flip flop input equations: $J_A = x$, K_A = B, $J_B = x$, K_B = A'. **(4+5+5=14)**

i. Draw the circuit diagram.

ii. Derive the next-state equations $A(t + 1)$ and $B(t + 1)$.

iii. Show the transition table.

2. (a) Consider the state diagram of a state machine shown in Fig. 2 and answer the following questions. **(6+4+10+10=30)**

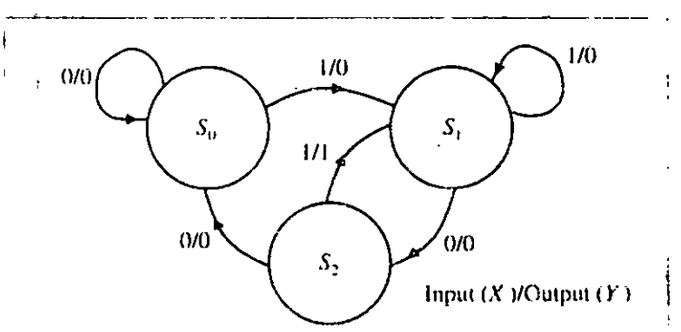

Fig. 2: A state diagram

i. Assuming that the machine starts in state S_0 and that the input data sequence at input (X) is appropriately synchronized with clock, determine the next-state and output sequences for the input sequence 01010100.

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CSE 283/BME
Contd... Q. No. 2(a)

ii. What operation does the machine perform?

iii. For an implementation based on two D-type flip-flops (labelled *A* and *B*), determine simplified Boolean expressions for flip flop inputs and machine output (Y), assuming the state assignment $S_0 = 00$, $S_1 = 01$, and $S_2 = 10$ is used, where a state is labelled Q_AQ_B in terms of the flip-flop outputs (i.e., Q_A is the MSB). Any unused states should be treated as don't care conditions.

iv. For the previous question 2(a) (iii), determine simplified Boolean expressions for flip flop inputs when JK flip-flops are used instead of D flip flops.

(b) Show how you can construct a JK flip flop using a D flip flop (having both Q and Q' outputs) and a 4-to-1 line multiplexer. **(5)**

3. (a) Design a 3-bit asynchronous up-counter using T flip flops. The counter should operate (i.e., count up) on the positive edge of the input clock pulse. **(5)**

(b) Suppose you are given a 4-bit binary ripple counter IC. The IC has following input and output pins: **(4+4+4=12)**

Input pins:	CLK: negative-edge triggered clock CLR: active low asynchronous reset V_{CC}: Power GND: Ground
Output pins:	$Q_{3...0}$: Flip flop outputs

If CLR is 0, then all flip flops inside the counter will be reset to the 0 state. Answer the following questions.

i. Show how you can construct a BCD counter (*that counts from 0000 to 1001*) using the given binary ripple counter IC and NAND gates.

ii. Assuming that the counter implemented inside the IC is a synchronous counter instead of a ripple counter (all inputs and outputs remain same), show you can convert it to a BCD counter.

iii. Using one or more units of the given counter IC, show how you can construct an 8-bit binary ripple counter.

(c) Design a three-bit register with three D flip-flops (*having both Q and Q' outputs*) and three 4-to-1 line multiplexers. There are two control inputs: *shift* and *load*. The register operates according to the following function table: **(12)**

shift	*load*	Register operation
0	0	No change
0	1	Shift right
1	0	Parallel load
1	1	1's complement of current output

Contd P/3

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(d) Why are ECL OR/NOR gates much faster than the other logic gates (e.g., DTL, TTL)? What are the drawbacks of ECL OR/NOR gates? **(6)**

4. (a) Draw the TTL NAND gate and briefly explain its operation. You don't need to calculate any current or voltage parameters. Just describe the state (cut-off/active/saturation/etc.) of transistors and the final output (low/high) for various input combinations. **(8)**

(b) What is active pull up in logic gates? What are the advantages of using the totem-pole output stage compared to a passive pull-up resistor in a TTL NAND gate? **(7)**

(c) Consider the DTL NAND gate shown in Fig. 4 with diode and transistor parameters as follows. For diodes, cut-in voltage V_γ = 0.6v and conduction voltage = 0.7v. For transistors, V_γ = 0.5v, $V_{BE(sat)}$ = 0.80v, $V_{CE(sat)}$ = 0.2v, and h_{FE} = 50. Assume reasonable values for any other unspecified parameter. **(4+6+5+5=20)**

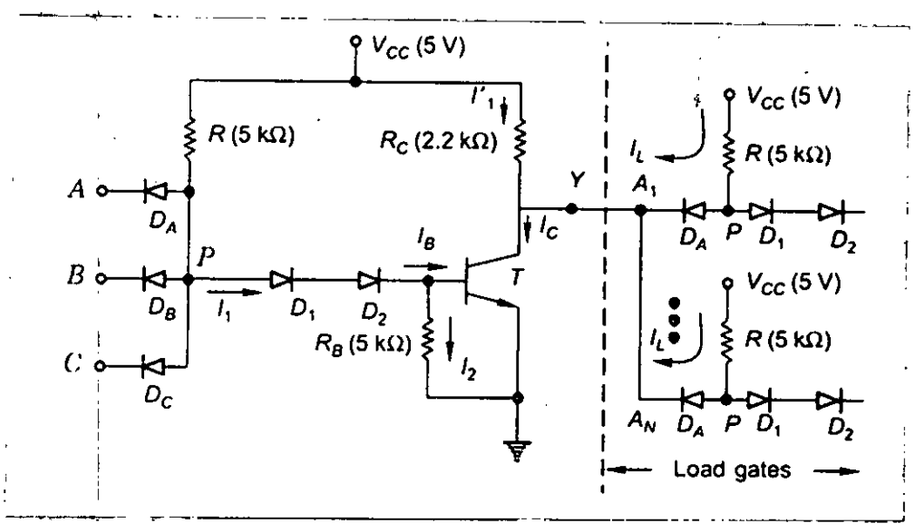

Fig. 4: DTL NAND gate

Answer the following questions.

i. Calculate I_B, I_C, V_P, V_γ when output is high.

ii. Calculate I_B, I_C, V_P, V_γ when output is low (assume no load is connected).

iii. Calculate fan-out of the gate.

iv. Calculate noise margins.

Contd P/4

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SECTION – B

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

5. (a) Design a logic circuit which will take two 2 bit numbers X_1X_0 and Y_1Y_0 and finds the sum. You have to use 3-8 line decoder that has I_0, I_1, I_2 as input lines, O_7, ... O_0 output lines. The decoder is enabled by active low enables EN_1' and EN_2' (Use the minimum number of extra logic gates.) **(15)**

(b) Rima gave subject choices from eight subjects which were indexed from *A* to *H*. She followed the priority order *D, A, B, E, F, H, C, G* (*D* has the highest priority and G has the lowest priority). Find the Boolean function of her choices and show the steps of the designing the function. **(15)**

(c) How can decoder work as a demultiplexer? **(5)**

6. (a) Using K-Map minimize $f(w, x, y, z) = \Sigma(2, 7, 8, 12, 15) + d(6, 9, 13)$. Find the *Prime Implicants and Essential Prime Implicants, and the Minimal Sums.* Write down the responsible *minterm for each Essential Prime Implicant.* **(15)**

(b) Design a logic circuit for a 2 bit odd parity generator. **(10)**

(c) Express the following function F as a sum of minterms and as product of maxterms.

F(*w, x, y, z*) = x'y + yz + w'z **(10)**

7. (a) There is a multiplexer that has a two selection bits C_1C_0. If $C_1C_0 = 11$, Q_0 is selected; if $C_1C_0 = 10$, Q_1 is selected; $C_1C_0 = 01$, Q_2 is selected; $C_1C_0 = 00$, Q_3 is selected. The circuit is activated by active low EN_1' and active high EN_2. Design a 16 to 1 multiplexer using the above mentioned multiplexer. (Design of the circuit will have the mentioned symbols). **(15)**

(b) You have a multiplexer that has eight input lines I_0, I_1, $I2$,... I_7. These lines can be selected by $S_2S_1S_0$. The switch is activated by two active low enables EN_1' and EN_2'. (The selection policy of the switch is as follows. If $S_2S_1S_0 = 000$, I_0 is selected; if $S_2S_1S_0 = 001$, I_1 is selected; $S_2S_1S_0 = 010$, I_2 is selected; ... so on). Design the SOP function f = SOP (0, 2, 4, 5, 7, 9, 12, 14) using the above mentioned multiplexer. **(15)**

(c) Design a logic circuit for $f(A, B, C) = II$ (0, 2, 3, 5, 7) with NAND gates only. **(5)**

8. (a) Design a 3 bit magnitude comparator logic circuit. **(13)**

(b) Design adder-subtractor which takes two 4 bit numbers *A* and *B*. Addition and subtraction are selected by a selector bit S, if S is given 0 the circuit produces *A* + *B*, if S is given 1, the circuit produces *A*-*B*. **(12)**

(c) Find the carry generation and carry propagation equations for a 3 bit Carry Look Ahead (CLA) adder. **(10)**

L-2/T-2/BME **Date: 16/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-2/T-2 B. Sc. Engineering Examinations 2020-2021

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

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** questions.

1. (a) Elaborate the structure and processing steps of collagen to make it a biomaterial candidate. Explain the sensitivity of SME and PE to thermomechanical treatment. **(12+13=25)**

   (b) Molecular structure of polymer affects its formability and degree of crystallinity- justify the statement. **(10)**

2. (a) Choose a suitable polymer for an artificial heart implant. Give reasons behind your choice. Illustrate the synthesis method of that biomaterial. **(19)**

   (b) What are the impacts of addition of Ni, Cr, Mo and W on the performance of Co - based alloy? **(16)**

3. (a) For fiber-reinforced composites, length of the fiber is an important factor for determining the composite properties. Explain the validity of the statement. **(13)**

   (b) To identify the oxidative states of the impurity elements in a synthesized bio-ceramic, which characterization technique would you prefer among AES, SEM, XPS? Justify your choice. Compare AES with XRF based on their accuracy and working principle. **(12+10=22)**

4. (a) Illustrate the structure of biological teeth and then compare its property with the biomaterial commonly used as dental implant. **(20)**

   (b) You need to compare relative cytotoxicity of three shapes of a Ti alloy with varying density. Two of the samples have rough and irregular surfaces. Which method of toxicity test would you choose? Justify your choice. If you have time restriction, would your choice change? **(15)**

Contd P/2

SECTION – B

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

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

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

(c) Analyse the effect of cross-linking and branching on properties of polymeric materials. **(15)**

6. (a) 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)**

(b) Distinguish between the characteristics of ductile and brittle failure of materials. **(10)**

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

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

(c) 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)**

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)**
