BANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Computer Science and Engineering,
Term Final (Spring) Examination 2023: Jul-Sep 2023

Student Group: 36 < Earned Credit Hours ≤ 72

Subject: CSE 203, Data Structure and Algorithm I

Time: 3.00 hours **Full Marks: 180**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question-1** in **Section-A** and **Question-5** in **Section-B** are compulsory
c. Answer any other **TWO** questions out of **THREE** from each section.
d. Figures in the margin indicate full **marks**.
e. Assume reasonable data if necessary.
f. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-A

Question 1 **(Compulsory)**

It is the infamous last two weeks of the term at MIST! You have numerous tasks at your hand – submitting lab reports, preparing for final lab evaluations, CTs, project presentations and many more.

To keep track of all your tasks and to prioritize tasks so that you may do them efficiently, you thought you would design a to-do list app.

Of course, you would need some data structure to store the tasks. You decided to go with doubly linked list. Each node in your list would contain the following information –

- Task title (string)
- Due date (string)
- Priority (integer)
- Is completed (boolean)
- Necessary links to preceding and succeeding nodes.

Now, answer the following questions:

a. Write code snippet in C++ to insert a new item or node to the linked list. However, items should always be inserted in such a way that the to-do list is always sorted in descending order of priority. Note that, lower number means higher priority. **10**

b. Write necessary code snippets to delete an item from the to-do list. The item is deleted by it's title. Items may be deleted from the beginning, end or any other position of the linked list. **10**

c. You may also modify the priority of a task later. However, that would mean your linked list is not sorted anymore. **10**
Now, design an algorithm to re-sort the linked list. Use any algorithm that has complexity O(nlogn) while sorting an array. Determine the time complexity of that algorithm, considering linked list item access time. You may write only the pseudo code of your algorithm.

Question 2

a. Consider the scenario given in Question #1 again. You could have used an array of objects of class "to-do-list" for instance here as well. Explain when you should use arrays over linked list and vice versa, **10**

as example.

b. Compare between linear and binary search for an array of integers with appropriate diagrams **or** code snippets as example. Be sure to compare their computational complexity as well. **10**

c. Explain when we should use dynamic array lists over static array lists. Then, draw a flow chart that depicts the working procedure of a dynamic array list. **3+7**

Question 3

a. Consider the following two scenarios or use case: **10**

- "back" button is a web browser, where the last viewed page should be shown first.
- Service line inside a bank, where customer who arrived earlier should received service first.

Determine, between stack and queue, which data structure would be appropriate to use in the given scenarios.

Explain your choice by discussing the working principle of both data structures in brief.

b. Discuss how stack can be implemented using single linked list. Comment on if overflow and underflow conditions will be applicable here and if so how it may be solved. **10**

c. Explain the "crawl" problem in array implementation of queues. Then, propose a solution. **5+5**

Also, demonstrate with code snippet **or** diagrams how we may detect full or empty queues in an array implementation of circular queues.

Question 4

a. Define the height of a tree. Then, write appropriate pseudo code to find the height of a tree, "T". **5**

b. Find the post-order and inorder traversal of the Binary Search Tree (BST) in the following figure. **5**

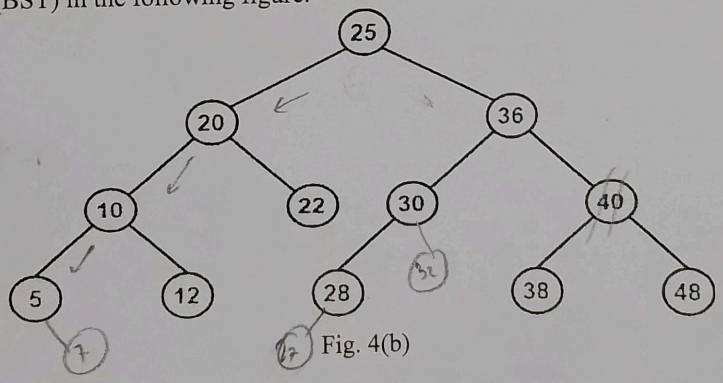


Fig. 4(b)

c. Determine how we may find the following for a BST: **10**

- Maximum element
- Minimum element
- Maximum path, as the path with the largest sum of elements while visiting from root to any leaf node.

Write appropriate pseudo code for each case.

d. For the BST given in Figure 4(b), perform the following operations and redraw only the tree after each operation, no need for any explanation. **10**

- Insert 27
- Insert 32
- Delete 40
- Insert 7
- Delete 25

SECTION-B

Question 5 **(Compulsory)**

a. Explain how the BFS algorithm can find the shortest path in an unweighted graph. **08**

b. Imagine organizing a video game tournament with multiple players, and you want to keep track of each player's score in real time. However, you must also determine the highest scores within a given range of players. **08**
Select a suitable data structure to enable efficient range queries on the array of player scores. Analyze the reasons for selecting the data structure considering time and space complexity.

c. Develop a hash table data structure for a student registration system in a university. The system should efficiently store and retrieve student information using unique student IDs. The student information includes the fields: student id, and name. **14**
Implement the following functions:

- ***Hash_function (student_id):*** Create a hash function that takes a student ID as input and returns the hash value (index) for storing the student in the hash table.
- ***Add_student(Student):*** Implement a function to add new student to the hash table.
- ***Get_student(student_id):*** Implement a function to print the details of a student (if found).

Formulate the code for hash table implementation and demonstrate its usage by adding and retrieving few students.

Question 6

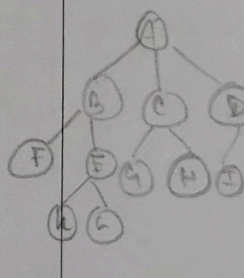
a. Define segment tree and its usage. **04**

b. Distinguish adjacency matrix and adjacency list representations regarding time and space complexity. **08**

.c. Show that KMP algorithm can avoid unnecessary character comparisons compared to the Naïve algorithm. **08**

d. Consider a social networking platform with a large user base. **10**

Graph
USER A: B, C, D
USER B: A, E, F
USER C: A, G, H
USER D: A, I, J
USER E: B, K, L
USER F: B
USER G: C
USER H: C
USER I: D
USER J: D
USER K: E
USER L: E



Simulate a BFS/DFS algorithm, on the given graph, starting from USER A and recommend three potential friends based on mutual friends. The most potential friend is the person with the most mutual friends with user A.

In this scenario, "mutual friends" refer to individuals who are friends with the specific user (starting point) and another user. For instance, if USER A and USER B are friends and USER C and A are friends, then USER B and C are mutual friends.

Question 7

a. Discuss the advantage and disadvantage of using hash tables. **04**

b. Imagine you have a network of interconnected friends on social media platform. You want to find out if there is a direct connection between you and your favorite celebrity, Shakib Al Hasan, provided that you have mutual friends. **08**

Formulate a code to determine if there is a connection between your profile and the profile of Shakib.

c. Explain the KMP algorithm to support multiple patterns matching in a given text. ***08***

d. Suppose you are analyzing a city's population growth over several years. Your job is to store the population data, and perform range queries to determine the average population growth rate over different time intervals. ***10***

Population Data	
Year	**Population**
2000	1000
2001	1200
2002	1350
2003	1500
2004	1800

Simulate range queries from 2000 and 2002 and from 2002 to 2004 to calculate the average population growth rate.

Question 8

a. Define skip list and its usage. **04**

b. Explain the process of collision-resolution in hash tables. **08**

c. "Every connected graph contains a spanning tree" Appraise the above given statement with suitable examples. **08**

d. Consider a scenario, where you analyze DNA sequences to identify similarities between different genomes. Your job is to search for specific DNA pattern within a set of DNA sequences. **10**

DNA Sequences:

- Sequence 1: ACGTACTGACGT
- Sequence 2: ACTGACGTCGTAC
- Sequence 3: ACGTAGTACTAC

Simulate the KMP algorithm to search for the DNA pattern "CGTAC" within the given sequences and determine the locations, where it matched.

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Subject: CSE 205, Object Oriented Programming Language

Time: 3.00 hours **Full Marks: 180**

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SECTION-A

Question 1 **(Compulsory)**

a. Describe the role of a destructor in dynamic memory de-allocation. Analyze the possible problems that may occur if the destructor is implemented incorrectly. **6**

b. To enable function overloading, it is necessary for the argument list of the functions to be different. Now, explain how function overloading can be achieved by varying the argument list, using suitable examples. **10**

c. You are tasked with implementing an airline ticketing system in C++. The system should allow passengers to book seats on a flight, view their booking details and manage seat availability. You need to complete the given code snippet (Code Snippet 1) to enable these functionalities. **14**

```
class Passenger{
    String name, seatNumber;
    public:
    //implement constructors, destructors, getter
and setter methods
    //add additional function as needed
};

class Flight{
    string flightNumber;
    int totalSeats, availableSeats;
    Passenger *passengerList;
    public:
    //implement constructors, destructors, getter
and setter methods
    void displayPassengerList(){}
   };

bool bookSeat(Passenger passenger, string
seatNumber){}

int main() {
    // Test the system functionalities
}
```

Code Snippet 1

Your job is to:

(i) Implement the functionalities in ***Flight*** class,

- The ***bookSeat*** function should assign a seat to a passenger and update the seat availability.
- The ***displayPassengerList*** function should display the list of passengers along with their seat numbers.

(ii) Test functionalities in the ***main*** function

- Create instances of flight and passenger classes
- Allow passengers to book seats, view the passenger list, etc.

Question 2

a. Evaluate the scenarios in which the compiler invokes a copy constructor automatically. Discuss the potential issues that may arise if a copy constructor is not implemented correctly. **6+4**

b. "In C++, the concept of friendship does not invoke inheritance, reciprocity or transitivity" **10**
Analyze the above statement with suitable examples.

c. Execution of the following code will lead to an error. Apply namespaces aliasing to ensure successful execution of the given code. **4**

```
namespace Outer{
    namespace Inner{
        int mul(int a, int b){
            return a*b;
        }
    }
}
int main() {
     int x = 4, y = 3;
     int pro = OI::mul(x,y);
     return 0;
}
```

d. Explain the output of the following code snippet. **6**

```
class MyClass{
    int *data;
    public:
    MyClass(int val){
        data = new int;
        *data = val;
    }
    int getValue() {
        return *data;
    }
    void setValue(){
        *data = val;
    }
};

int main(){
    MyClass Obj1(5);
    MyClass Obj2(Obj1);
    Obj1.setValue(20);
    cout<< Obj1.getValue();
    cout<<" "<<Obj2.getValue();
    return 0;
}
```

Question 3

a. Examine the concept of shallow copy and its implications when dealing with dynamically allocated resources. 6

b. Differentiate constructors and destructors. Discuss their similarities and differences in terms of purpose, usage and behavior. 6

c. Distinguish friend function with member functions. Discuss the scenarios in which friend functions are more appropriate than member functions. 2+8

d. Complete the code snippet given below. Create objects of ***Student*** and ***Instructor*** class. Set and print the CGPA of a student using functions from instructor class. 8

```
class student{
    private:
        float CGPA;
    public:
        int id;
        string name;
        //implement constructors and destructor
        void printInfo(){
            //print name and ID
        }
};
class Instructor{
    public:
    void setCGPA(Student *s, float cgpa){
        // set the cgpa of s
    }
    void printCGPA(Student st)
        //print the CGPA of student st
    }
};
```

Question 4

a. Discuss the potential conflicts that can arise when using multiple namespaces in the same score. Explain how namespaces aliases can be used to resolve naming conflicts 2+4

b. Explore the concept of ***const*** member functions and their significance in preventing modifications to object state. 6

c. Discuss how function overloading can be resolved at compile time based on function signature. 6

d. Define memory leak with suitable examples. Outline the scenarios that may cause this to happen. 6

e. Execution of the following code will lead to an error. Rewrite the code, by rectifying the error. 6

```
class Car{
    string model;
    int year;
public:
    Car(string model, int year){
    model = model;
    year = year;
}
int main(){
    Car car;
    return 0;
}
```

SECTION-B

Question 5 (Compulsory)

a.

```
1.    #include <iostream>
2.    using namespace std;
3.    class Complex {
4.        private:
5.            double real;
6.            double imaginary;
7.
8.        public:
9.            Complex(double real, double imaginary){
10.               this->real = real;
11.               this->imaginary = imaginary;
12.           }
13.   int main() {
14.     Complex c1(1, 2);
15.     Complex c2(3,4);
16.     int res;
17.
18.     Complex c3 = c1+c2;//c3 = (4,6) I.e, 1+3, 2+4
19.     res = C1(10) //returns (1+2)*10
20.     res = 10+C1;
21.     C2--;
22.     if(C1 == C2) {
23.         //check if real and img parts of c1 & c2 are
equal respectively
24.         cout<<"c1 and c2 are equal"<<endl;
25.     } else {
26.       cout<<"c1 and c2 are not equal"<<endl;
27.     }
28.
29. return 0;
30.}
```

Take a look at the code snippet given above.
Now, construct appropriate operator overloading functions in C++ so that the instructions given in lines 18-22 work as intended. The intended function of the operators are given as comments on the code.
For each operator, write the function as both member and non-member, if applicable. If it is not applicable, explain with proper reasoning. **20**

b. Explain Run Time Type introspection in OOP with appropriate code snippets. **5**

c. Differentiate between compile time and run time polymorphism with appropriate example of each **5**

Question 6

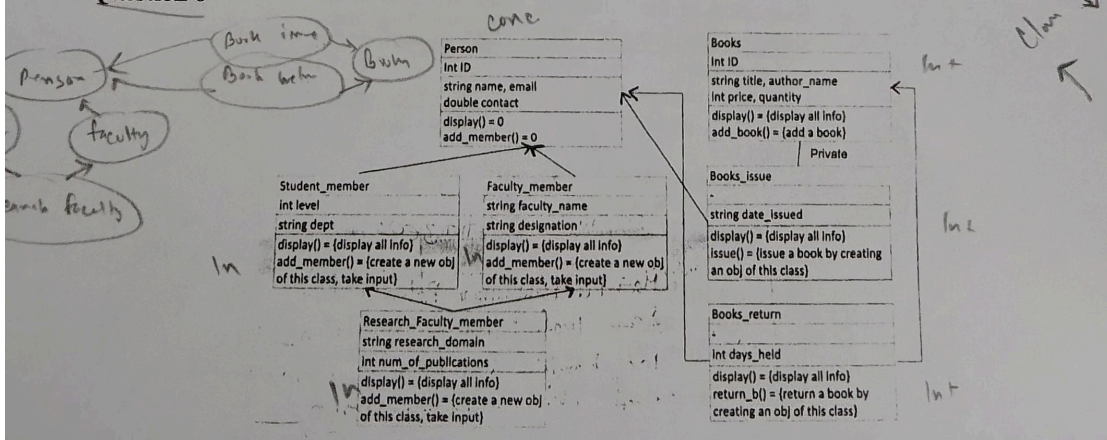

Fig. 1: Inheritance scenario for Q6 and Q7

Take a look at the inheritance scenario of a sample library management system given in figure 1.

Note that all inheritances are public, unless stated otherwise in the figure. The second, third and fourth rows of each table denote the private, protected, and public members/methods of a class. The first row denotes the class name.
Now, answer questions 6(a) – 6 (d)

a. Identify interface, abstract and concrete classes. Define pure virtual function and explain why it is used in inheritance scenarios, such as this one. **6**

b. Identify all the multilevel and multiple inheritances in this scenario. Either draw them individually or denote them in one figure. **6**

c. "Books-issue" privately inherits the "Books" class. **8**
If *BI1* is an object of "Books_issue", would we face any errors if we write the following instruction in main()?

```
BI1.add_book();
```

If so, how may we overcome it? Explain with necessary code snippets.

d. Take a look at the following code snippet, written inside main(): **10**

```
Student_member *S1;
Research_Faculty_member R1;
S1 = &R1;
S1-> display();
```

Determine if the right display function will be called. Utify your answer with proper reasoning.
If the wrong function is called, how may it be solved? Give code snippets as example and explain.

Question 7

a. Take a look at the inheritance scenario given in Figure 1 again. **15**
Identify the diamond problem(s) present in the scenario.
Then, demonstrate how it can be solved with appropriate code snippets.

b. Suppose, "ID" present in the class may now either be integer or string. **10**
Determine which technique in C++ we may use to accommodate this change. Explain the concept.
Demonstrate with code snippets as well.

c. Explain the need for virtual destructors with an appropriate code snippet, or example **5**

Question 8

a. Differentiate between "eerr" and "clog" streams in C++. **5**
Comment on when we would prefer which one with example scenarios.

b. Demonstrate how objects can be stored and retrieved from files with example code snippets. **10**

c. Define "manipulators" in C++. Demonstrate their usage with at least two code snippets. **5**

d. Explain the concept of exception handling in C++ with example code snippets. **10**

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Subject: CSE 217. Theory of Computations

Time: 3.00 hours **Full Marks: 180**

INSTRUCTIONS:

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SECTION-A

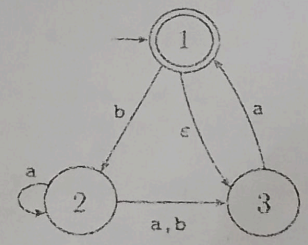
Question 1 (Compulsory)

a. Design a deterministic finite automata (DFA) that has an alphabet $\Sigma = \{0, 1, 2, \langle Reset \rangle\}$. We treat <Reset> as a single symbol. This automator keeps a running sum of the numerical input symbols it reads. Every time it receives the <Reset> symbol, it resets the sum to 0. It accepts if the sum is 1 modulo 3, showing only the state diagram should suffice. **10**

b. Explain determinism and non-determinism. **4**

c. Discuss the importance of studying automata in Computer Science. Briefly explain the role of a state in a finite automator. **6**

d. Convert the non-deterministic finite automator (NFA) shown below to an equivalent deterministic finite automator (DFA). You need to show the detailed steps. **10**



Question 2

a. Consider the NFAs, $N_1 = (Q_1, \Sigma, \delta_1, q_1, F_1)$ and $N_2 = (Q_1, \Sigma, \delta_2, q_2, F_2)$ that recognize the languages L_1 and L_2 respectively. You want to construct NFA $N = (Q, \Sigma, \delta, q_0, F)$ to recognize $L_1 \cup L_2$. Write down the expressions for δ and explain in detail each part of the expressions in plain English (stressing on the purpose). **16**

b. Differentiate between the NFA and DFA **4**

c. Design an NFA for the language, $L = \{a^n b^n | w \text{ has an equal number of a's and b's, } n \leq 3, \text{ with an alphabet, } \Sigma = \{a,b\}\}$
Showing only the state diagram will suffice. You may be penalized for using more states than the required minimum. **10**

Question 3

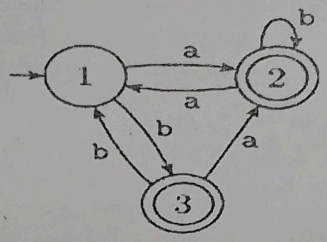
a. Formulate the regular expression for the following languages over the alphabet {a,b}

(i) $L1 = \{w|w$ has at least one a$\}$
(ii) $L2 = \{w|w$ contains the string aab as a substring$\}$
(iii) $L3 = \{w|w$ has a length of 3 and its multiple$\}$
(iv) $L4 = \{w|w$ is a string of even length$\}$
(v) $L5 = \{w|w$ is a string of odd length$\}$

b. Convert the following regular expressions to equivalent NFAs: 8

(i) $a(abb)^* \cup b$
(ii) $a^+ \cup (ab)+$
(iii) $(a \cup b^+)a^+b^+$

c. Convert the following DFA to its equivalent regular expression by using the concept of generalized non-deterministic finite automator (GNFA). You need to deduce the regular expression in detailed steps. 8



d. If $\sum = \{0,1\}$, then determine the following powers of sigma for: 4

(i) $\sum^0$
(ii) $\sum^2$
(iii) $\sum^*$
(iv) $\sum^+$

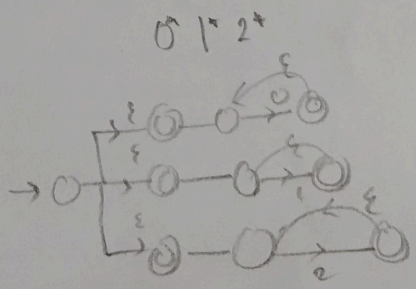
Question 4

a. Define non-regular language. Write down the formal definition of pumping lemma. 8

b. Prove that the language $L = \{0^n1^n2^n|n\geq 0\}$ over the alphabet $\sum = \{0,1,2\}$ is not regular by using pumping lemma. 8

c. Define generalized non-deterministic finite automata (GNFA). Write down the conditions of GNFA. 8

d. What are the regular operations? Define each of the regular operations. 6



SECTION-B

Question 5 (Compulsory)

a. Formulate context free grammars that generate the following languages:

(i) The set of all strings of balanced parentheses over the alphabet $\Sigma = \{(,)\}$ For example, (()), (()()), ε are in the language whereas ((()), ()),)(are not in the language.

(ii) $L = \{0^n1^n | n \geq 0\} \cup \{1^n0^n\} n \geq 0\}$

(iii) $L = \{w | w \in \{a,b\}^*, n_a(w) = n_b(w)\}$

(iv) $L = \{0^n1^m |\ m, n \geq 0;\ 2n \leq m \leq 3n\}$

b. Define ambiguous grammar. Show that the following grammar is ambiguous. 8

- S -> AB|C
- A->aAb|ab
- B-> cB|c
- C->aCc|aDc
- D->bD|b

c. Define the followings with an example: 4

(i) Leftmost Derivation

(ii) Rightmost Derivation

d. Construct parse tree using the following context free grammar for the string 'aabaa' for each of the derivations. 6

G = {S -> aAS|aSS|e, A->SbA|ba}

(i) Left Derivation Tree

(ii) Right Derivation Tree

Question 6

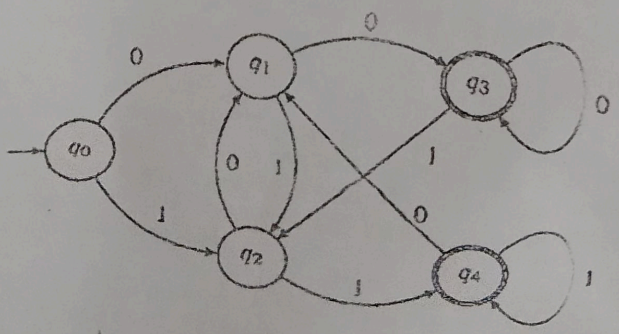
a. Write down the formal definition of Chomsky Normal Form (CNF). Mention the main steps of conversion to Chomsky Normal Form from Context Free Grammar. 8

b. Consider the following Context Free Grammar (CFG) and convert it into an equivalent Chomsky Normal Form (CNF). 12

- S->aXbX
- X->aY|bY|ε
- Y->X|C

You need to show the steps.

c. Design a Context Free Grammar from the following Deterministic Finite Automata. 10



Question 7

a. Design a pushdown automata (PDS) that recognizes the language $L = \{WW^R | W \varepsilon \{0,1\}^*\}$
Draw its transition diagram. Note that PDAs are non-deterministic.

b. Write down the formal definition of pumping lemma for Context free languages. 8

c. Prove that the language $L = \{0^i1^j2^i3^j \mid i \geq 1 \text{ and } j \geq 1\}$ is not context free by using pumping lemma. 10

Question 8

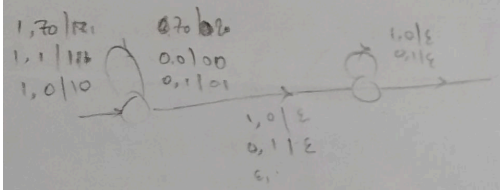
a. Construct a PDA P from the following CFG G. 6
- S -> aTb|b
- T-> Ta|ε

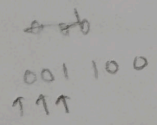
Showing only the state diagram should suffice.

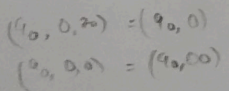
b. Write briefly about Turing thesis and few arguments for accepting the thesis. 4

c. Design a Turing Machine (TM) for accepting the language $L = \{0^{2^n} | n \geq 0\}$, the language consisting of all strings of 0s, whose length is a power of 2. Show the state diagram of the TM along with brief description of the algorithm. 12

d. Define decidability and decidable language. Prove that for a DFA, the language A_{DFA} is decidable language. 8







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Subject: EECE 269, Electrical Drives and Instrumentation

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SECTION-A

Question 1 (Compulsory)

a. "A DC motor and a DC generator can be made with the same machine" analyze the statement with related working principle. **10**

b. Explain the commutation principle and identify the issues if commutator malfunctions in a DC generator. **10**

c. A short shunt compound generator delivers a load current of 40 A at 220 V and has armature, series-field and shunt-field resistances of 0.05 Ω, 0.50 Ω and 200 Ω, respectively. Calculate the induced e.m.f and armature current. Consider 2.0 V per brush for contact drop. **10**

Question 2

a. Prove that, armature torque in a DC motor is directly proportional to the product of flux per pole and armature current. **10**

b. Illustrate the characteristics curves of series and shunt motor. Also list the types of braking in a DC motor with their principles and potential applications. **10**

c. A 4 pole 240 V, lap connected shunt motor gives 1200 kW when running at 1200 rpm and drawing armature and field currents of 50 A and 1.0 A, respectively. It has 520 conductors. Its resistance is 0.1 Ω. Assuming 2 V per brush, **10**
find : a) Total torque b) Useful torque c) Useful flux/pole d)Rotational losses e) Efficiency

Question 3

a. Mr. Jake is working with a practical transformer while his friend Ms. Amy is working with a fictional ideal transformer. Justify the reason why Ms. Amy identifies non idealities on Jake's transformer illustrating its vector diagram considering all types of losses and leakage for different loads. **10**

b. Deduce the emf equation of a single phase transformer and find the voltage transformation ratio (K). Also identify the reason of using laminated core in a transformer. **10**

c. A 50 kVA, 4400/220 V transformer has $R_1 = 3.45\ \Omega$, $R_2 = 0.009\ \Omega$. The values of reactances are $X_1 = 5.2\ \Omega$ and $X_2 = 0.15\ \Omega$, respectively. Calculate for the transformer : **10**

(i) Equivalent resistance and reactance referred to primary.
(ii) Equivalent reactance and resistance referred to secondary.
(iii) Total Cu loss using equivalent resistances referred to each side at rated current condition.

Question 4

a. Mr. Tanjiro works at Payra Power Plant. Due to coal shortage, he cannot run the alternator at previous speed. Analyze how he can still produce constant 50 Hz frequency in lower speed deriving expressions for the alternators electrical properties required for the compensation. **10**

b. Explain why induced emf in an alternator varies according to the type of load connected to the terminal with necessary illustration. **10**

c. A 3 phase, star connected alternator supplies a load of 10 MW at p.f 0.85 lagging and at 11 kV (terminal voltage). Its resistance is 0.1 Ω per phase and synchronous reactance 0.66 Ω per phase. Calculate the value of emf generated. **10**

SECTION-B

Question 5 *(Compulsory)*

a. Specify the properties that define a transducer to be "Active" and "Passive". Also show that the gauge factor of a strain gauge is characterised by, **10**

$$G_f = 1 + 2\upsilon$$

b. From the Fig. 5(b), the thermistor 'R' shows the following relationship with temperature, T: **12**

$$R(T) = R_o \exp\left[\beta \left(\frac{1}{T} - \frac{1}{T_o}\right)\right]$$

where, $R_o = 3.2\ k\Omega$, $\beta = 4250$ K and $T_o = 298$ K.
When the relay is energized it turns 'OFF' a room heater; otherwise, it keeps the room heater 'ON'.

Find the threshold temperature at which the room heater will be turned "OFF". Also, find the state of the heater when the temperature is

(i) 35°C
(ii) 12°C.

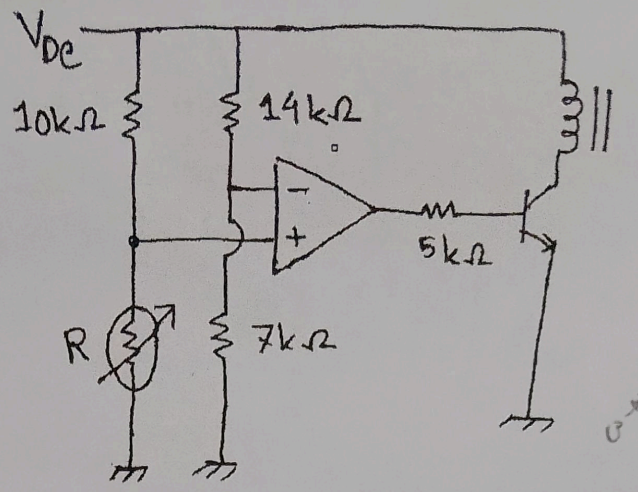

Fig. 5(b)

c. Explain interference of inductive coupling with neat diagram and discuss how the problem can be solved at higher frequencies. **08**

Question 6

a. Design a resettable RC ramp generator circuit that has a slope of 3 Volts/ms. Also derive the expression of its output. **10**

b. Professor 'Z' had to repair a faulty temperature measurement system. While checking, she found that the measurement system employed a 3 bit analog signal having range of -4 to 3 Volts. She updated the system to have lesser quantization error to get a digital output. Determine- **10**

(i) Number of quantization level.
(ii) Step size.
(iii) Digital output when analog voltage is 2 Volt.
(iv) Quantization error.

c. Explain the techniques and their requirements for the high current protection and high voltage protection of measurement devices. **10**

Question 7

a. An instrumentation amplifier has two points of 10 mV and 5 mV. **12**

(i) Design a circuit which will provide an output of 500 mV. Calculate the amplifier gain.
(ii) If now input voltage is changed to 155 mV and 153 mV respectively, determine the output voltage.

b. Define piezoelectric crystal with some examples. Show that, accumulated voltage across a rectangular piezoelectric slab is proportional to the strain. **0**

c. The thermocouple shown in Fig. 7(c) produces a voltage difference of 500 μV for a 10°C temperature difference. Design the circuit for an output voltage of 5 mV.

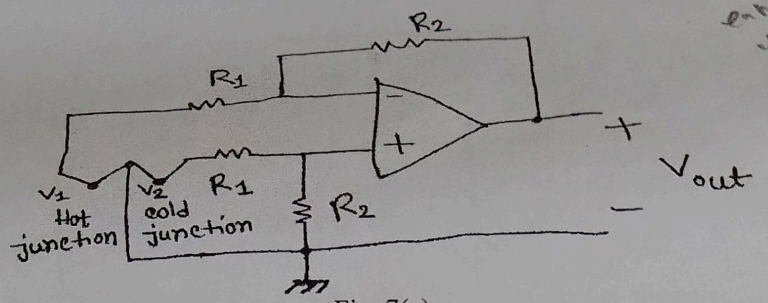

Fig. 7(c)

d. Define different types of ground in electrical circuit. Why they should be isolated from each other? **05**

Question 8

a. With an appropriate diagram, explain the working principle of an X-Y recorder. **08**

b. The message signal shown in the Fig. 8(b) is sampled at 500 samples/sec. Sketch the approximated pulse-modulated signal if the modulation scheme is : **10**

(i) PAM (Pulse Amplitude Modulation), and
(ii) PDM (Pulse Duration Modulation).

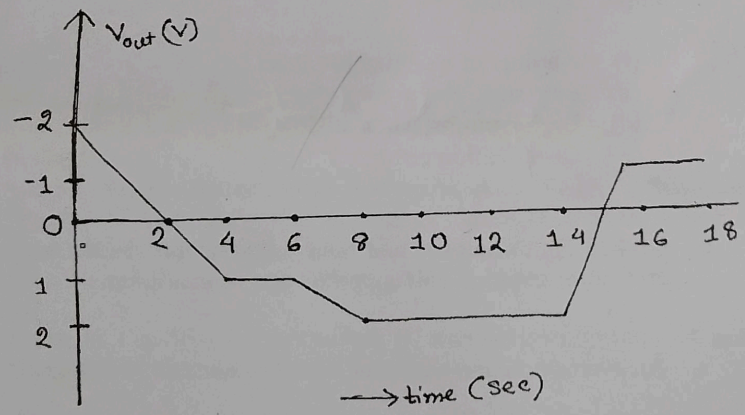

Fig. 8(b)

c. The maximum charging current of the input opamp in a sample & hold circuit is 150 mA and the droop current is 100 pA. Determine the expected droop rate if the acquisition time for a 4 V step is 8μs. **06**

d. Illustrate the block diagram of the functional elements of an instrumentation system. **06**

PBANGLADESH UNIVERSITY OF PROFESSIONALS
Military Institute of Science and Technology
B.Sc. in Computer Science and Engineering,
Term Final (Spring) Examination 2023: Jul-Sep 2023

Student Group: 36<Earned Credit Hours ≤ 72

Subject: Math 205, Differential Equation, Laplace Transform and Fourier Analysis

Time: 3.00 hours **Full Marks: 180**

INSTRUCTIONS:

a. Use **SEPARATE** answer scripts for each section.
b. **Question-1** in **Section-A** and **Question-5** in **Section-B** are compulsory
c. Answer any other **TWO** questions out of **THREE** from each section.
d. Figures in the margin indicate full **marks**.
e. Assume reasonable data if necessary.
f. **Symbols** and **abbreviations** used have their usual meanings.

SECTION-A

Question 1 (Compulsory)

a. Define order and degree of a differential equation. Obtain the differential equation of the circles tangent to the x-axis and sketch several representative members of the family. **15**

b. Define homogeneous function. Solve the following D.E. **15**

$$y^3dx - (x^3 - xy^2)dy = 0$$

Question 2

a. Define exact differential equation and integrating factor. Find for which value of $N(x,y)$ the following differential equation is exact **18**

$$(x^3 + xy^2)dx + N(x,y)dy = 0$$

Also solve the obtained exact D.E.

b. A thermometer is removed from a room where the temperature is 70°F and is taken outside, where the air temperature is 10°F. After one-half minute the thermometer reads 50°F. What is the reading of the thermometer at $t = 1\,min$? How long will it take for the thermometer to reach 15°F? **12**

Question 3

a. For the following D.E. set up the correct linear combination of y_p **15**

$$\frac{d^2y}{dx^2} - 3\frac{dy}{dx} + 2y = 2x^2 + e^x + 2xe^x + 4e^{3x}$$

b. Write down the standard form of Cauchy-Euler equation. Solve the following D.E. **15**

$$x^2\frac{d^2y}{dx^2} + 4x\frac{dy}{dx} + 2y = 4\ln x$$

Question 4

a. Define partial differential equation. Find a partial differential equation by eliminating a & b from $z = axe^y + \frac{1}{2}a^2e^{2y} + b$ **10**

b. Using Charpit's method, solve and find a complete integral of **10**

$$z = px + qy + p^2 + q^2$$

c. A circuit is in series has a constant electromotive force of $100V$, a resistor of 10Ω and a capacitor of 2×10^{-4}Farads. The switch is closed at time $t = 0$, and the charge on the capacitor at this instant is 0. Find the charge & current at time $t > 0$. **10**

SECTION-B

Question 5 (Compulsory)

a. Use the method of Fourier transform to determine the temperature at any point x at an instant of time t in a solid bounded by the planes $x = 0$ *and* $x = 2$. At the boundary ends, the temperature of solid is zero while the initial temperature is $2x$. 15

b. Define Fourier series. Expand in Fourier series of the function $f(x) = x \sin x$ in $(-\pi, \pi)$. Hence deduce that 15

$$\frac{\pi}{4} = \frac{1}{2} + \frac{1}{1.3} - \frac{1}{3.5} + \frac{1}{5.7} \cdots$$

Question 6

a. Evaluate the Fourier integral of the function $f(x)$, where 15

$$f(x) = \begin{cases} 0, & when\ x < 0 \\ \frac{1}{2}, & when\ x = 0 \\ e^{-x}, & when\ x > 0 \end{cases}$$

b Find the Fourier transform of $f(x) = \begin{cases} 1, & when\ |x| < a \\ 0, & when\ |x| > a \end{cases}$ and hence prove that $\int_0^\infty \frac{\sin \alpha}{\alpha} d\alpha = \frac{\pi}{2}$. 15

Question 7

a. Define Laplace transform. Find the Laplace transform of t^n. 10

b. Use $L\{f'(t)\} = sF(s) - f(0)$, find $L\{\frac{\cos\sqrt{t}}{\sqrt{t}}\}$. 10

c. Find the Laplace transform of the half wave rectified sinusoidal 10

$$f(t) = \begin{cases} sint; & for\ 2n\pi < t < (2n+1)\pi \\ 0; & for\ (2n+1)\pi < t < (2n+2)\pi \end{cases}$$

Question 8

a. Apply convolution theorem to evaluate $L^{-1}\{\frac{1}{(s+1)(s^2+1)}\}$. 08

b. Use the method of Laplace transform to solve 16

$$(D^2 + 3D + 2)y = \exp(-t)$$

where $y(0) = 4,\ y'(0) = 1$

c. Solve the following differential equation by using Laplace transform 12

$$y'' - ty' - 2y = 4, y(0) = -1, y'(0) = 0$$