

23-22

Bangabandhu Sheikh Mujibur Rahman University, Kishoreganj
Department of Computer Science and Engineering
2nd Year 1st Semester B.Sc. (Engg.) Final Examination-2023
CSE 2101: Object Oriented Programming (3 Credits)

Time: 3 Hours

Full Marks: 70

INSTRUCTIONS

- a. Answer 05 out of 07 questions
- b. Figures in the margin indicate full marks

Question-1

- a. Why is the main method in Java declared as static? 02
- b. Write a Java code using switch case that implements the table below 04

Grade	School
1-5	Elementary School
6-8	Junior High
9-12	High School
>12	College

Given:

- grade is an integer initialized to a value greater than or equal to 1.
 - school is a string variable.
- c. What are the rules for defining the constructor? Describe constructor overloading with an example in Java. 05
 - d. Explain the working principle of JDK, JRE, and JVM. 03

Question-2

- a. Write a Java program to create a class called **Animal** with a method called `makeSound()`. Create a subclass called **Cat** that overrides the `makeSound()` method to bark. 05
- b. Write a Java program to create a class called **BankAccount** with private instance variables `accountNumber` and `balance`. Provide public getter and setter methods to access and modify these variables. 05
- c. Write down the differences between abstract class and interface. What will happen if we want to change the value of a field in the interface after initialization? 04

Question-3

- a. The abstract **Fruit** class has four subclasses named **Apple**, **Banana**, **Orange** and **Strawberry**. Write a Java program that demonstrates how to establish this class hierarchy. Declare one instance variable of type string that indicates the color of a fruit. Create and display instances of these objects. Override the `toString()` method of **Object** to return a string with the name of the fruit and its color. 06
- b. Write two interfaces. **Interface I1** contains a method called "methodA". **Interface I2** contains a method called "methodB". Now write a class "InterfaceTest" and implement both **Interface I1** and **Interface I2** in such a way that both methods "methodA" and "methodB" are implemented in the "InterfaceTest" class. 04
- c. In Java programming, "Multiple inheritance is not supported in classes but it's supported in interfaces". -Justify the statement. 04

Question-4

- a. State the differences between Default constructor, Parameterized constructor, and Copy constructor. 03
- b. Discuss the difference between method overloading and method overriding. Can we overload or override the main method in Java? 04

- c. Illustrate a scenario where compile-time polymorphism would be preferred over runtime polymorphism, and vice versa. Justify your choices. 03

- d. Consider the following code: 04

```
import java.util.HashMap;
class Test {
    public static void main(String[] args) {
        Circle c1= new Circle(10,20,5);
        Circle c2=new Circle(15,12,5);
        System.out.println(c1);
        System.out.println(c2);
        HashMap<Circle, String>m=new HashMap<>();
        m.put(c1,"I am Circle 1");
        System.out.println(m.get(c1));
        System.out.println(m.get(c2));
    }
}

class Point{
    private int x,y;
    Point(int x,int y){
        this.x=x;
        this.y=y;
    }
    public int getX(){
        return x;
    }
    public int getY(){
        return y;
    }
}

class Circle{
    private Point center;
    private int radius;
    Circle (int x, int y, int r){
        center=new Point(x,y);
        this.radius=r;
    }
    public String toString(){
        return "Circle: center (" +center.getX()+" "+center.getY()+" "+", radius: "+radius;
    }
}
```

Identify the output of the above code.

Question-5

- a. Complete the following blank table with "Yes" or "No" to demonstrate what type of variables are visible from which classes. 05

	Private	Default	Protected	Public
Same Class				
Same Package Subclass				
Same Package Non-Subclass				
Different Package Subclass				
Different Package Non-Subclass				

- b. Consider the following instructions: 05

- Create a method named **readIntegersFromFile** that reads integers from a file and returns a list of integers. Use **throws** in the method signature to handle **IOException** and **NumberFormatException**.
- In the main method, use a **try-catch** block to call **readIntegersFromFile** and catch the exceptions thrown by it.
- Use another **try-catch** block inside the main method to divide 100 by each integer read from the file, catching **ArithmeticException** for any division by zero.
- Ensure that a **finally** block closes the file and prints a message indicating that the file operations are complete.

c. Consider the following java code:

04

```
public class TestExceptions {
    public static void main(String[] args) {
        String test = "yes";
        try {
            System.out.println("start try");
            doRisky(test);
            System.out.println("end try");
        } catch (ScaryException se) {
            System.out.println("scary exception");
        } finally {
            System.out.println("finally");
        }
        System.out.println("end of main");
    }
    static void doRisky(String test) throws ScaryException {
        System.out.println("start risky");
        if ("yes".equals(test)) {
            throw new ScaryException();
        }
        System.out.println("end risky");
    }
}
class ScaryException extends Exception {
}
```

- I. Identify the output of the above code.
- II. Identify the output of the code if the third line of the program were changed to `String test = "no";`

Question-6

- a. Define Coupling and Cohesion. Explain the following terms in the context of Object Oriented Design (OOD) principles with real life examples. 08
 - I. Single-responsibility Principle
 - II. Open-closed Principle and
 - III. Liskov Substitution Principle
- b. What is garbage collection in Java? Demonstrate how unreferenced objects are handled and discuss the `finalize()` and `gc()` methods in this context. 06

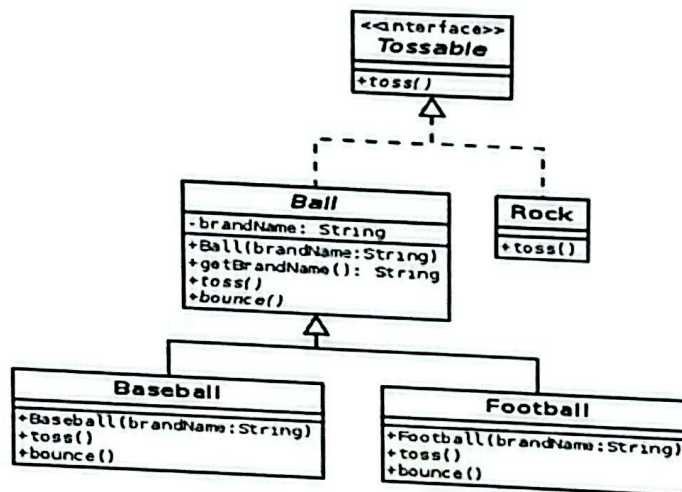
Question-7

- a. Write the Java codes for developing a payment processing system for an e-commerce platform. The platform supports multiple payment methods, such as Credit Card, PayPal, and Bank Transfer. Each payment method has its own unique way of processing a payment, but they all follow a general payment processing workflow. The requirements of the program are as follows: 06
 - Define a common interface named **Payment** for all payment methods. The interface should define the common functions **initiatePayment** and **processPayment**.
 - Create concrete classes for each payment method (CreditCard, PayPal, BankTransfer). Each payment class (CreditCard, PayPal, BankTransfer) should implement the **Payment** interface and provide its own implementation of the methods.
 - Implement a **PaymentProcessingSystem** class that should be able to accept any payment method that implements the **Payment** interface and process the payment.

b. Consider the following sets of class and interface declarations and draw the associated class diagrams: 04

- I. public interface Vinn { }
public abstract class Vout implements Vinn { }
- II. public abstract class Muffie implements Whuffie { }
public class Fluffie extends Muffie { }
public interface Whuffie { }
- III. public class Zoop { }
public class Boop extends Zoop { }
public class Goop extends Boop { }
- IV. public class Gamma extends Delta implements Epsilon { }
public interface Epsilon { }
public interface Beta { }
public class Alpha extends Gamma implements Beta { }
public class Delta { }

c. Develop a Java program to implement the following UML diagram. You do not need to fill in the method bodies for the toss or bounce methods. 04



Bangabandhu Sheikh Mujibur Rahman University, Kishoreganj
Department of Computer Science and Engineering
2nd Year 1st Semester B.Sc. (Engg.) Final Examination-2023
CSE 2103: Data Structure and Algorithms-I (3 Credits)

Time: 3 Hours

Full Marks: 70

INSTRUCTIONS

- a Answer 05 out of 07 questions
- b Figures in the margin indicate full marks

Question-1

- a. Differentiate between linear and non-linear data structures, and describe the key factors used to evaluate the performance of an algorithm 04
- b. For each example below, there are two algorithms solving the same problem. Given the asymptotic runtimes for each, is one of the algorithms guaranteed to be faster? If so, which? And if neither is always faster, explain why. Assume the algorithms have very large input (i.e. N is very large). 06

- | | |
|--------------------------------|---------------------------------|
| I. Algorithm 1: $\Theta(N)$ | Algorithm 2: $\Theta(N^2)$ |
| II. Algorithm 1: $\Omega(N)$ | Algorithm 2: $\Omega(N^2)$ |
| III. Algorithm 1: $O(N)$ | Algorithm 2: $O(N^2)$ |
| IV. Algorithm 1: $\Theta(N^2)$ | Algorithm 2: $O(\log N)$ |
| V. Algorithm 1: $O(N \log N)$ | Algorithm 2: $\Omega(N \log N)$ |

- c. Define recursive function. Consider the following recursive function. 04

```
public void andslam(int N) {  
    if (N > 0) {  
        for (int i = 0; i < N; i += 1) {  
            for (int j = 1; j < 1024; j *= 2) {  
                System.out.println(i + j);  
            }  
        }  
        andslam(N / 2);  
    }  
}
```

For the given recursive functions, provide asymptotic bounds for the best case and worst case runtimes in $\Theta(\cdot)$ notation with proper explanations. Give the runtime in terms of N .

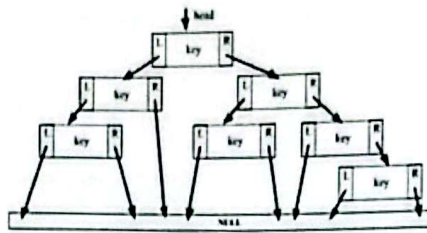
Question-2

- a. Describe the method for identifying the middle element of a singly linked list with an unknown number of elements in just one iteration through the entire list. Following that, discuss why a linked list is not an appropriate data structure for executing a Binary Search. 05

- b. A Node in a linked structure contains three elements: an integer *key* and two pointers, *L* and *R*, pointing to other Nodes. Given the figure showing the current state of the linked structure, write the *key* values of each Node after executing *func(head)*. The function *func* is defined as follows. 05

```
int func(Node *temp) {  
    if(temp == NULL) return 0;  
    int x = func(temp->L);  
    int y = func(temp->R);  
    temp->key = 1 + max(x, y); //max(x,y) returns the maximum value between x and y  
    return temp->key;  
}
```

You can assume that the *head* pointer has been declared globally.



- c. For the following recurrences, give an expression for the runtime $T(n)$ if the recurrence can be solved with the Master Theorem. Otherwise, indicate that the Master Theorem does not apply. 04
- $T(n) = 3T(n/2) + n$
 - $T(n) = 64T(n/8) - n^2 \log n$

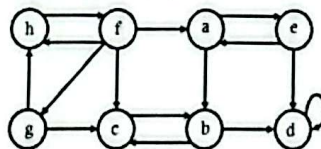
Question-3

- a. Compare the performance of using an adjacency list versus an adjacency matrix for implementing Breadth-First Search (BFS) on the following types of graphs: 03
- Complete Graph
 - Cycle Graph
- b. Consider the following table that outlines course prerequisites. A prerequisite must be completed before enrolling in a course. 05

Using Depth First Search (DFS), determine a valid sequence of courses to follow, ensuring that each course is taken only after all its prerequisites have been satisfied.

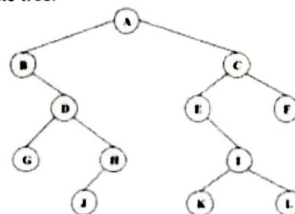
Course	Prerequisite
CSE 2203	CSE 1105
CSE 2220	CSE 2205, CSE 2203
CSE 2205	CSE 1105
CSE 2215	CSE 2203
CSE 2279	CSE 1169

- c. Identify the strongly connected components within the given graph. Utilize an appropriate algorithm to develop your solution, providing a step-by-step simulation of the process. Finally, illustrate the resulting component graph. 06



Question-4

- a. A graph with n vertices and $n-1$ edges is a tree. Express your opinion on this statement, and provide necessary examples to support your answer. 02
- b. Discuss how a Binary Search Tree can be used for sorting a sequence of integers. 02
- c. A finite tree T has at least one vertex v of degree 4, and at least one vertex w of degree 3. Prove that T has at least 5 leaves. 04
- d. Given the following binary tree, write the pre-order, in-order, and post-order traversals of its vertices and then discuss how to check if a given binary tree is BST or not. Consider the node A as the root of the tree. 06



Question-5

- a. Describe the operations of a Disjoint Set, and then propose a technique to improve the running time of the following function *findset* for finding the representative of an element within the disjoint set. You may assume that the elements of the disjoint set are integers, represented as the index of the *parent* array. The function is written in C language. 04
- ```

int findset(int x){
 if(x == parent[x]) return x;
 return findset(parent[x]);
}

```
- b. Consider the following matrix *G* that represents an undirected weighted graph. In the matrix,  $G[u][v] = w$  represents that there is an edge between *u* and *v* and the weight of the edge is *w* where *w* is a positive integer.  $G[u][v] = 0$  indicates that there is no edge between *u* and *v*. 10

| G | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| A | 0 | 8 | 1 | 3 | 0 | 0 |
| B | 8 | 0 | 0 | 3 | 0 | 0 |
| C | 1 | 0 | 0 | 4 | 3 | 1 |
| D | 3 | 3 | 4 | 0 | 2 | 2 |
| E | 0 | 0 | 3 | 2 | 0 | 1 |
| F | 0 | 0 | 1 | 2 | 1 | 0 |

Demonstrate all the necessary steps to calculate the minimum spanning tree of the given graph *G* using Kruskal's algorithm. At each step of the algorithm, illustrate the relevant operations of the disjoint set, utilizing the union by size heuristic.

### Question-6

- a. Explain how using a Heap improves the performance of Prim's algorithm compared to using an array to manage the sequence of vertices with the lowest key. 04
- b. When a sequence consists of *n* values that are all equal and need to be inserted into a heap, demonstrate that the overall time complexity for inserting these values is  $O(n)$  rather than  $O(n \log_2 n)$ . Provide an example to illustrate your explanation. 04
- c. Consider a two dimensional coordinate system where  $i^{th}$  point is represented as  $P_i(x_i, y_i)$ . Distance between 2 points  $P_i$  and  $P_j$  is measured as  $|x_i - x_j| + |y_i - y_j|$ . 06

Now a list of 4 points are given in Table-1.

| i | Point | $x_i$ | $y_i$ |
|---|-------|-------|-------|
| 1 | $P_1$ | 2     | -10   |
| 2 | $P_2$ | 4     | 0     |
| 3 | $P_3$ | 2     | 6     |
| 4 | $P_4$ | 0     | 0     |

Illustrate a weighted graph from the scenario described above where points are labeled as vertices and weight of an edge is calculated by the distance of two of its end vertices. Construct a minimum spanning tree of the graph using Prim's algorithm showing all the necessary steps and mention the cost of the tree as well.

### Question-7

- a. Determine the maximum number of nodes in a binary tree of height *k*. 02
- b. Explain when a doubly linked list is more efficient than a singly linked list. 02
- c. Describe how a complete binary tree can be represented using both an array and a linked data structure. 03
- d. Determine the longest common subsequence between the two strings provided below. 07
- ABCBDAB
  - BDCABA
- Present the relevant matrix and detail all necessary steps to support your solution.

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**2<sup>nd</sup> Year 1<sup>st</sup> Semester B.Sc. (Engg.) Final Examination-2023**  
**CSE 2105: Computer Architecture (3 Credits)**

**Time: 3 Hours**

**Full Marks: 70**

**INSTRUCTIONS**

- a. Answer 05 out of 07 questions
- b. Figures in the margin indicate full marks

**Question-1**

- a. Demonstrate the manufacturing process of Integrated Circuit (IC) chips in detail. Assume a 20 cm diameter wafer has a cost of 15, contains 100 dies, and has 0.031 defects/cm<sup>2</sup>. 4
  - (I) Find the yield for the wafer.
  - (II) Find the cost per die for the wafer.
  - (III) If the number of dies per wafer is increased by 10% and the defects per area unit increases by 15%, find the die area and yield.
- b. Explain the need for using SPEC CPU Benchmark. The results of the SPEC CPU2006 bzip2 benchmark running on an AMD Barcelona has an instruction count of  $2.389 \times 10^{12}$ , an execution time of 750 s, and a reference time of 9650 s. 4
  - (I) Find the CPI if the clock cycle time is 0.333 ns.
  - (II) Find the SPECratio.
  - (III) Find the increase in the Execution time if the number of instructions of the benchmark is increased by 10% without affecting the CPI.
- c. Define Response Time and Throughput. Analyze whether the following changes to a computer system increase throughput, decrease response time, or improve both. 3
  - (I) Replacing the processor in a computer with a faster version.
  - (II) Adding additional processors to a system that uses multiple processors for separate tasks—for example, searching the web.
- d. A compiler designer is trying to decide between two code sequences for a particular machine. Based on the hardware implementation, there are three different classes of instructions: Class A, Class B, and Class C, and they require 2, 1, and 4 CPIs, respectively. The first code sequence has 2 instructions of Class A, 1 instruction of Class B, and 3 instructions of Class C. On the other hand, the second code sequence has 3 instructions of Class A, 2 instructions of Class B, and 2 instructions of Class C. Identify the code sequence that executes the most instructions, also identify the sequence that will be executed faster. Find out the CPI for each sequence. 3

**Question-2**

Consider the following MIPS assembly code:

```
LD R1, 45(R2)
ADD R7, R1, R5
SUB R8, R1, R6
OR R9, R5, R1
BNEZ R7, target
ADD R10, R8, R5
XOR R2, R3, R4
```

- a. Identify each type of data dependency; list the two instructions involved; identify which instruction is dependent; and, if there is one, name the storage location involved. 5
- b. Use MIPS five-stage pipeline (fetch, decode, register, execute, write-back) and assume a register file that writes in the first half of the clock cycle and reads in the second half cycle. Which of the dependencies that you found in part (a) become hazards and which do not? Why? 5
- c. Describe the concept of exceptions and interrupts. How are they handled by the processor? 4

- d. Describe Direct Memory Access (DMA) and then explain how it improves system performance. Moreover, briefly explain how the interconnection network topology affects the performance of a multiprocessor system. 5

**Question-6**

- a. Explain the working procedure of noninverting and inverting buffers. Construct a logic diagram for an 8x3 memory unit. The memory should have 8 words, each containing 3 bits. 4
- b. Illustrate how a pulse generator operates. Explain the two ways to organize a 4-Mbit memory chip. Compare the row/column organization and the interleaved organization. Include diagrams to illustrate the different organizational structures. 4
- c. Draw the schematic diagram of a single transistor DRAM cell containing a capacitor. Why does DRAM (Dynamic Random-Access Memory) need to be refreshed every few milliseconds? Discuss the implications of this refresh requirement on the performance of DRAM. 3
- d. Construct a 16-bit register from single bit flip-flops. Discuss the rationale behind inverting the clock signal at the input during the construction of this register. 3

**Question-7**

- a. Describe how the superscalar architecture improves the performance of a processor. Additionally, define the concept of cache hits and cache misses. 4
- b. Contrast between a multiprocessor system and a multi-computer system. In a shared memory system, explain two schemes to maintain cache-coherence. 4
- c. To compete with the newly invented printing press, a medieval monastery decided to mass-produce handwritten paperback books by assembling a vast number of scribes in a huge hall. The head monk would then call out the first word of the book to be produced and all the scribes would copy it down. Then the head monk would call out the second word and all the scribes would copy it down. This process was repeated until the entire book had been read aloud and copied. Which of the parallel processor systems does this system resemble most closely? Justify your statement. 3
- d. Explain the roles of Coprocessor and Network Processor in computer architecture. Discuss the architecture of a typical Network Processor board and chip with a detailed diagram. 3

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2<sup>nd</sup> Year 1<sup>st</sup> Semester B.Sc. (Engg.) Final Examination-2023

**STA 2107: Probability and Statistics (3 Credits)**

Time: 3 Hours

Full Marks: 70

**INSTRUCTIONS**

- a. Answer 05 out of 07 questions
- b. Figures in the margin indicate full marks

**Question-1**

- a. A sample consists of following data which specifies the life of 25 laptop batteries of a particular brand recorded to the nearest tenth of a year. 4  
4.2, 4.7, 3.1, 3.3, 3.8, 3.9, 2.6, 3.4, 3.1, 3.5, 3.1, 2.6, 4.1, 3.2, 3.9, 3.5, 3.0, 1.9, 4.4, 3.3, 3.7, 2.5, 3.7, 1.6, 3.6  
Construct a relative frequency distribution.
- b. Draw a histogram to represent the frequency distribution in part (a) and comment on the shape of the distribution. 4
- c. Draw an ogive for the life of laptop batteries and hence find 6  
(i) the proportion of batteries with life less than 3 years  
(ii) the proportion of batteries with life greater than 4 years, and  
(iii) the proportion of batteries with life between 3.25 and 3.75 years.

**Question-2**

- a. Describe a situation in which it is more appropriate to use each of the following as a measure of central tendency: i. median ii. Mode iii. Mean. Starting the conditions involved, write down the empirical relationships between mean, median and the mode. 4
- b. For a set of non-zero positive values  $x_1, x_2, \dots, x_n$ , prove that  $A \geq G \geq H$ . Where A, G and H are the arithmetic mean, geometric mean and harmonic mean, respectively. 4
- c. What is coefficient of variation? What are its advantages over the other measures of dispersion? If the average score of male students is 3.0 and the standard deviation of their scores is 0.25, and if the corresponding figures for female students are 2.9 and 0.25, do the scores of male students are in greater variability? Why? 6

**Question-3**

- a. Define skewness and kurtosis. How do you measure skewness and kurtosis using moments? 4
- b. What is the moment of a distribution? Establish the general relationship between raw moments and central moments and hence express the first four central moments in terms of raw moments. 4
- c. The first four moments of a distribution about the value 5 of the variable are 2, 20, 40, and 250. Calculate the mean, variance,  $\beta_1$  and  $\beta_2$ . Comment on the nature of the distribution. 6

**Question-4**

- a. Define the following terms with example: 4  
Random experiment, Sample space, Event, Mutually exclusive events.
- b. Explain conditional probability. Show that for two events A and B-  $P(A/B)=P(A)$  if the events A and B are independent. 4
- c. A survey was conducted among students of Dhaka University (DU), Rajshahi University (RU), and Chittagong University (CU) to know their opinion regarding 4-year honors course. The percentages of favoring 4-year honors course were 21% if students were from DU; 45% if students were from RU; and 75% if students were from CU. If selection of students from a university was equally likely, what is probability that the selected student will be in favor of 4-year honors course? Given 6

that the student is in favor of a 4-year course, what is the probability that he/she comes from DU? From CU? From RU?

#### Question-5

- Define expected value of a random variable. How do you find the expected value of a function of a random variable? 4
- Every day, the number of network blackouts,  $X$  has a distribution (probability mass function). Find  $E(X)$ ,  $Var(X)$ . 4
- The installation time, in hours, for a certain software module has a probability density function  $f(x) = \frac{4}{3}(1 - x^3)$  for  $0 < x < 1$ . 6
  - Find the mean and the standard deviation of installation time.
  - If installation cost is computed as  $25X+50$ , find mean and standard deviation of installation cost.

#### Question-6

- The probability that a certain type of IC chip will fail after installation is 0.06. A memory board for a computer contains twelve such chips. The operation will be satisfactory if ten or more of the chips on the board do not fail.
  - What is the probability that a memory board operates satisfactorily?
  - Find the mean number of IC chip in a memory board that will not fail after installation and its standard deviation.
  - If there are five such memory boards in a given computer, what is the probability that at least four of them operate satisfactorily?
  - Find the mean number of satisfactory memory board in a computer and its standard deviation.
- Define Poisson distribution. When do you use Poisson approximation to a Binomial distribution? Automobile battery of a particular brand malfunctions with probability 0.001. Use two different distributions to calculate the probability that at least one out of 1000 batteries will malfunction.
- Jobs are sent to a printer at an average rate of 4 jobs per hour.
  - What is the expected time between jobs?
  - What is the probability that a job will take 10 to 15 minutes to complete?
  - What is the probability that the next job is sent within 5 minutes?

#### Question-7

- Installation of some software package requires downloading 82 files. Installation time follows normal distribution with mean 20.5 minutes and with a standard deviation of 3.2 minutes. What is the probability that the software is installed in less than 15 minutes? 4
- The strength of steel wire made by an existing process is normally distributed with a mean of 1250 and a standard deviation of 150. A batch of wire is made by a new process, and a random sample consisting of 25 measurements gives an average strength of 1312. Assume that the standard deviation does not change. Is there evidence at the 5% level of significance that the new process gives a larger mean strength than the old? To address the problem, you need to do the following: 4
  - Identify the hypotheses, the test statistic and the decision rule.
  - Compute the observed value of your test statistic, and
  - Make decision regarding the null hypothesis and comment on your findings.
- A computer manager needs to know how efficiency of her new computer program depends on the size of incoming data. Efficiency will be measured by the number of processed requests per hour. Applying the program to data sets of different sizes, she gets the following results 6

|                            |      |      |      |      |      |      |      |      |
|----------------------------|------|------|------|------|------|------|------|------|
| Data size (gigabytes), $x$ | 8    | 5    | 12   | 12   | 10   | 8    | 15   | 10   |
| Processed requests, $y$    | 33.2 | 32.7 | 29.2 | 26.3 | 29.4 | 34.8 | 23.6 | 27.5 |

Estimate the regression line of  $Y$  on  $X$  and interpret the slope parameter.

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**EEE 2109: Electronics (3 Credits)**

Full Marks: 70

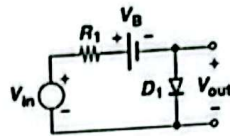
Time: 3 Hours

**INSTRUCTIONS**

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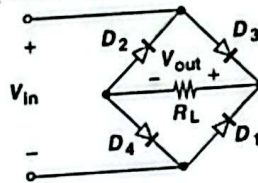
**Question-1**

- a. Explain the behavior of a p-n junction diode under reverse and forward bias conditions. 8
- b. Plot the input/output characteristics of the circuit shown in Fig. below using an ideal model for the diodes. 6



**Question-2**

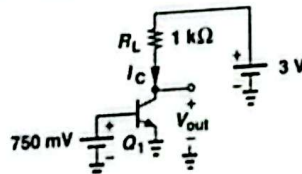
- a. Assuming a constant-voltage model for the diodes, plot the input/output characteristic of a full-wave rectifier circuit depicted in Fig. below. 4



- b. Draw the circuit diagram of a full-wave rectifier circuit and describe its operation. 6
- c. Given the scenario of a cell phone receiving a signal from a base station, where the signal strength increases as the user approaches the base station, there is a risk that the signal level may become large enough to saturate the circuits within the receiver chain. To prevent saturation and ensure proper functioning, it is crucial to limit the signal amplitude. Design a circuit to limit the signal amplitude to  $\pm 100$  mV as the user comes closer to the base station, with the diode turn-on voltage,  $V_{D,on}$ , set at 800 mV. 4

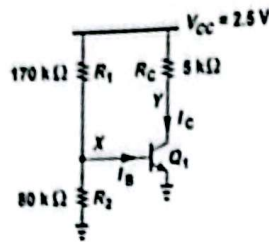
**Question-3**

- a. Describe the operation of a BJT in the active mode. Include the conditions required for the base-emitter and base-collector junctions. 7
- b. Determine the output voltage in Fig. below if  $I_S = 5 \times 10^{-16}$  A. 7

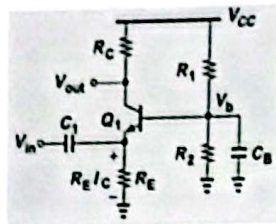


#### Question-4

- a. Calculate the collector current of  $Q_1$  in the following Figure. Assume  $\beta = 100$  and  $I_S = 10^{-17}$  A.

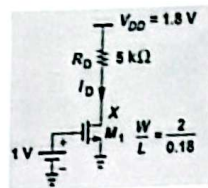


- b. Design a CB stage in the following Figure for a voltage gain of 10 and an input impedance of  $50 \Omega$ . Assume  $I_S = 5 \times 10^{-18}$  A,  $V_A = \infty$ ,  $\beta = 100$ , and  $V_{CC} = 2.5$  V.



#### Question-5

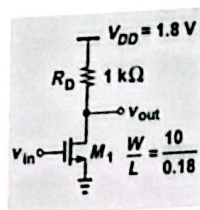
- a. Explain the channel pinch-off in MOSFET.
- b. Calculate the bias current of  $M_1$  in the following Figure. Assume  $\mu_n C_{ox} = 100 \mu A/V^2$  and  $V_{TH} = 0.4$  V. If the gate voltage increases by 10 mV, what is the change in the drain voltage?



- c. Plot the  $I_D$ - $V_{DS}$  characteristics for different values of  $V_{GS}$  for a MOSFET and briefly explain its salient features.

#### Question-6

- a. Explain the small signal model for the Common Source MOSFET.
- b. A MOSFET is biased at a drain current of 0.5 mA. If  $\mu_n C_{ox} = 100 \mu A/V^2$ ,  $W/L = 10$ , and  $\lambda = 0.1 V^{-1}$ , calculate its small-signal parameters.
- c. Calculate the small-signal voltage gain of the CS stage shown in the following Fig. below if  $I_D = 1$  mA,  $\mu_n C_{ox} = 100 \mu A/V^2$ ,  $V_{TH} = 0.5$  V, and  $\lambda = 0$ . Verify that  $M_1$  operates in saturation.



**Question-7**

- a. Explain the gain, input resistance, and output resistance of both inverting and non-inverting operational amplifier (op-amp) configurations. 8
- b. The circuit shown in Fig. below is called a "unity-gain" buffer. Note that the output is tied to the inverting input. Determine the output voltage if  $V_{in} = +1\text{ V}$  and  $A_o = 1000$ . 6

