



### **THE UNIVERSITY OF ZAMBIA**

School of Natural Sciences

Department of Computer Science

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## **CSC 2111 COMPUTER ARCHITECTURE**

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### **FINAL DEFERRED EXAMINATION**

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Date: 14<sup>th</sup> January, 2020

Time: 09:00 hrs – 11:00 hrs

Duration: 2 Hours

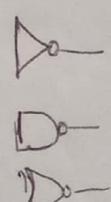
Venue: SPORTS HALL

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#### **INSTRUCTIONS**

1. This exam has THREE sections A and B.
2. Answer **ALL** the questions from **Section A**.
3. Answer **ANY TWO (2)** questions from **Section B**.
4. Clearly identify the problem being solved.

**SECTION A: ANSWER ALL QUESTIONS IN THIS SECTION [40 MARKS]**

1. Define the term *Instruction Set* and hence explain how it comes to be an aspect of computer architecture. [3 marks] ✓
2. Explain the features of the hierarchical nature of complex systems and state how these features are essential to both their design and their description? [5 marks]
3. A logic gate is an elementary building block of a digital circuit that implements a simple Boolean or logical function. Given two inputs, 0 and 0, show the circuit symbol and output for the following logical functions. (10 marks) ✓  
a. AND      b. OR      c. XOR      d. NAND      e. NOR
4. Mention the three (3) main events that can cause programme execution to come to a halt. [3 marks] ✓
5. Explain the differences among FIFO, LRU and LFU Replacement Algorithms. (3 marks) ✓
6. Describe four (4) behaviours of a bus as a shared transmission medium? (4marks) ✗
7. Explain four (4) features of the hierarchy of memory. (2 marks) ✓
8. Explain the difference between DRAM and SRAM in terms of the following characteristics: (10 marks) ✓
  - a. Technology
  - b. Speed
  - c. Size
  - d. Cost
  - e. Application

The handwritten diagram illustrates the hierarchy of memory. It consists of three stacked ovals. The top oval is labeled 'Cache' with a small 'C' to its left. The middle oval is labeled 'Main Memory' with a small 'M' to its left. The bottom oval is labeled 'Disk' with a small 'D' to its left. Lines connect the ovals from left to right, indicating the flow from Cache to Main Memory to Disk.

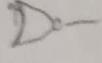
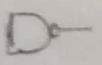
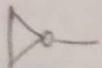
**SECTION b: ANSWER TWO (2) QUESTIONS IN THIS SECTION [60 MARKS]**

**QUESTION ONE**

- i. Illustrate the protocol stack for QPI and state the function of each layer. Be sure to state the data unit at each layer. [15 marks]
- ii. Provide a comprehensive discussion of the figure below. [15 marks]

**SECTION A: ANSWER ALL QUESTIONS IN THIS SECTION [40 MARKS]**

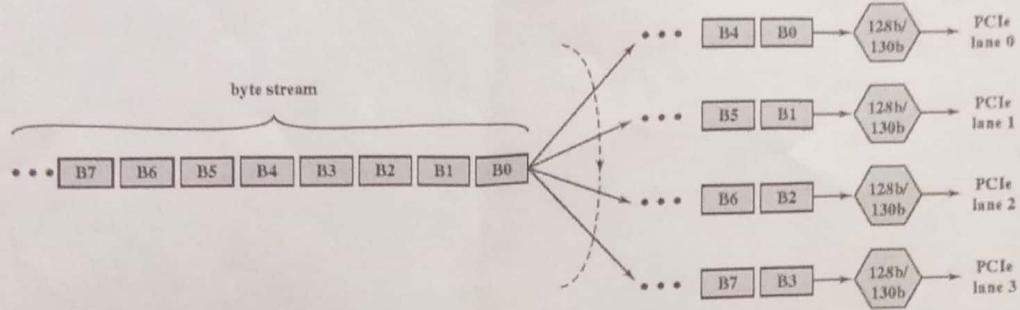
1. Define the term *Instruction Set* and hence explain how it comes to be an aspect of computer architecture. [3 marks]
2. Explain the features of the hierarchical nature of complex systems and state how these features are essential to both their design and their description? [5 marks]
3. A logic gate is an elementary building block of a digital circuit that implements a simple Boolean or logical function. Given two inputs, 0 and 0, show the circuit symbol and output for the following logical functions. (10 marks)
  - a. AND
  - b. OR
  - c. XOR
  - d. NAND
  - e. NOR
4. Mention the three (3) main events that can cause programme execution to come to a halt. [3 marks]
5. Explain the differences among FIFO, LRU and LFU Replacement Algorithms. (3 marks)
6. Describe four (4) behaviours of a bus as a shared transmission medium? (4marks) X
7. Explain four (4) features of the hierarchy of memory. (2 marks)
8. Explain the difference between DRAM and SRAM in terms of the following characteristics: (10 marks)
  - a. Technology
  - b. Speed
  - c. Size
  - d. Cost
  - e. Application



**SECTION b: ANSWER TWO (2) QUESTIONS IN THIS SECTION [60 MARKS]**

**QUESTION ONE**

- i. Illustrate the protocol stack for QPI and state the function of each layer. Be sure to state the data unit at each layer. [15 marks]
- ii. Provide a comprehensive discussion of the figure below. [15 marks]



## QUESTION TWO

Consider a machine with a main memory of 128 bytes and block size of 4 bytes. Data is addressed to the word and words are 2 bytes.

- What is the *number* and *range* of addressable locations in the main memory? **(2 marks)**
- What are the block numbers for addresses 16, 27, 43, and 54? **(8 marks)**
- Assuming that a 1-way set-associative mapped cache of 64 bytes is used with this machine,
  - How is the main memory address divided into tag, set, and word values? **(10 marks)**
  - What are the location details of the physical addresses 3, 15, 27, 7, 18 and 37 (in decimal) when they are stored in the cache? **(6 marks)**
  - Why is the tag value also stored in the cache? **(4 marks)**

## QUESTION THREE

Consider a single-platter disk with the following parameters:

$$\frac{7200}{1 \times 60} \rightarrow 120 \text{ ms}$$

- Rotation speed = 7200 rpm
- Number of tracks on one side of the platter = 27500
- Number of sectors per track = 350
- Seek time = 2 ms for every hundred tracks traversed.

Let the disk receive a request to access a random sector on a random track and assume the disk head starts at track 0.

- What is the average seek time? **(10 marks)**
- What is the average rotational latency? **(5 marks)**
- What is the transfer time for a sector? **(5 marks)**
- What is the total average time to satisfy a request? **(10 marks)**

*The End*



**THE UNIVERSITY OF ZAMBIA**

School of Natural Sciences

Department of Computer Science

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**CSC 2111  
COMPUTER ARCHITECTURE**

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**FINAL EXAMINATION**

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Date: 23<sup>rd</sup> December, 2020

Session: 09:00 – 12:00 HOURS

Duration: 2 Hours

Venue: NSLT

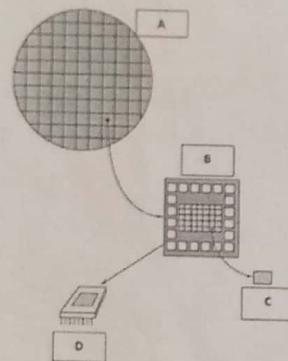
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**INSTRUCTIONS**

1. This exam has two sections A and B.
2. Answer **ALL** the questions from Section A.
3. Answer **ANY TWO (2)** questions from Section B.
4. Clearly NUMBER YOUR WORK.

**SECTION A: ANSWER ALL QUESTIONS IN THIS SECTION [40 MARKS]**

1. Distinguish between the terms *computer architecture* and *computer organisation*. [2 marks]
2. Define the term *instruction set* and explain how it informs design choices in computer architecture. [4 marks]
3. Explain in what way the hierarchical nature of computer systems is essential to both their design and their description. [5 marks]
4. Draw the general flow diagram of an instruction cycle, labelling all parts. [4 marks]
5. Explain three (3) conditions under which programme execution may be halted. [3 marks]
6. Name and define the following acronyms: IR, MAR, I/O BR [3 marks]
7. Define the term *interrupt* and state the four (4) areas by which interrupts may be categorised. [5 marks]
8. The Figure below depicts the key concepts in an integrated circuit.
  - i. Name the parts labelled A, B, C and D. [4 marks]
  - ii. Explain the relationship among the parts. [4 marks]



9. Microelectronics revolutionised the computing industry.
  - i. What does the term discrete component mean in microelectronics? (1 mark)
  - ii. With the help of a diagram, explain the two (2) types of microelectronics that are required to perform all the functions of a computer. (5 marks)

**SECTION B: ANSWER TWO (2) QUESTIONS IN THIS SECTION [30 MARKS EACH]**

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**QUESTION ONE**

- i. Modern systems increasingly rely on point-to-point interconnection rather than shared buses.
  - a. Explain the three characteristics of point-to-point interconnection. **[6 marks]**
  - b. Consider two devices, A and B, communicating via QPI. Draw the layered protocol architecture used by the devices. **[4 marks]**
  - c. Distinguish between a Phit and a Flit. **[4 marks]**
  - d. Explain the credit scheme of QPI. **[6 marks]**
- ii. Assuming a CPU and memory share a 64-bit bus running at 200MHz. The memory needs 100ns to access a 128-bit value from one address.
  - a. How long does it take to read one address of memory? **[4 marks]**
  - b. How many random addresses can be read per second? **[4 marks]**
  - c. What is the bus throughput? **[2 marks]**

**QUESTION TWO**

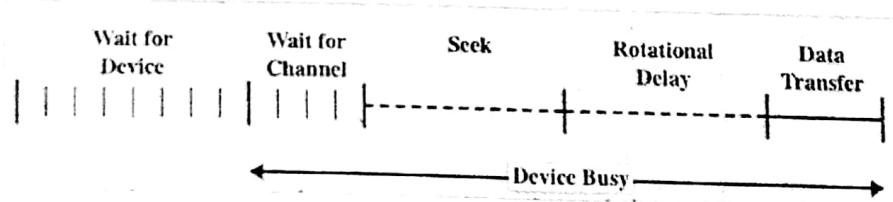
- i. The basic element of a semiconductor memory is the **memory cell**.
  - a. Outline the three properties shared by all semiconductor memory cells. **[3 marks]**
  - b. Two traditional forms of RAM used in computers are DRAM and SRAM.
    - i. Explain how DRAM works. **[3 marks]**
    - ii. Outline at least four (4) differences between the two types of RAM? **[4 marks]**
- ii. Explain four (4) features of the hierarchy of memory. **(4 marks)**
- iii. Explain the following methods of data access in memory systems: Sequential, random and associative. **[6 marks]**
- iv. Consider the need for a code that can detect and correct single-bit errors in 8-bit words.
  - a. Using a table, show how the data and check bits would be arranged. **[6 marks]**
  - b. Given that the 8-bit input word is **01010101**, with data bit D1 in the rightmost position, compute the check bits. **[4 marks]**

### QUESTION THREE

- i. Explain the differences among FIFO, LRU and LFU Replacement Algorithms. [3 marks]
- ii. Distinguish between Write Through and Write Back cache policies. [7 marks]
- iii. Consider a machine with a main memory of 256 bytes and block size of 8 bytes. Data is addressed to the word and words are 4 bytes.
  - a. What is the number and range of addressable locations in the main memory? [2 marks]
  - b. What are the block numbers for addresses 13, 27, 39, and 53? [2 marks]
- iv. Assuming that a 1-way set-associative mapped cache of 128 bytes is used with this machine,
  - a. How is the main memory address divided into tag, set, and word values? [6 marks]
  - b. What are the location details in terms of Tag, Set and Word of the physical addresses 2, 27, 45, 10, 50 and 57 (in decimal) when they are stored in the cache? [6 marks]
  - c. Explain why the tag value is also stored in the cache? [4 marks]

### QUESTION FOUR

- i. Magnetic disks are a type of external memory.
  - a. What is a Substrate in this context? [2 marks]
  - b. What material is the Substrate made out of? [1 mark]
  - c. Outline the benefits of using the material from (ii) above [5 marks]
  - d. What is the function of inter-track gaps? [2 marks]
- ii. A general timing diagram of disk I/O transfer is shown below.



- e) Explain what is meant by a Bus and Data Transfer [3 marks]  
f) Explain what is meant by a Cache [3 marks]

Ques 3. Explain what is meant by a Cache and how it is used to reduce memory access time [8 marks]

- a) Explain the working of Cache [6 marks]

- b) Explain the cache hierarchy [2 marks] [8 marks]

*The End*



# THE UNIVERSITY OF ZAMBIA

## School of Natural Science

Department of Computer Science

### **DEFERRED FINAL EXAMINATION**

**CSC 2101: INTRODUCTION TO COMPUTER SYSTEMS**

Date: Wednesday, 13<sup>th</sup> January 2021  
Time: 09:00hrs – 12:00hrs  
Duration: 3 Hours  
Venue: Sports Hall

#### **Instructions**

1. There are **Five (5) questions** and **two (2) sections** in this paper.
2. Each question carries **25 marks**,
3. *You are required to answer a total of Four (4) Questions*
  - a. *Answer all the questions in Section A*
  - b. *Choose one (1) question from Section B*

## **SECTION A**

**This Section has Three Questions. Answer all the questions**

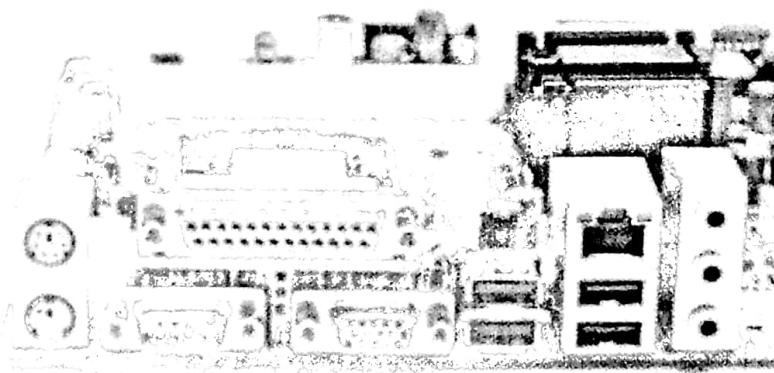
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### **Question I**

- a) Briefly describe each of the following [3 Marks]
  - i. Computer System
  - ii. Computer Architecture
  - iii. Computer Organisation
  
- b) Malicious software (malware) is any software designed to damage or to disrupt a system. Briefly describe each of the following Types of malware [4 Marks]
  - i. Spyware
  - ii. Viruses
  - iii. Worms
  - iv. Trojan Horses
  
- c) When the computer is booting, the basic input/output system (BIOS) will perform a POST to check on all of the internal components [8 Marks].
  - i. What do the following terms stand for
    1. BIOS
    2. POST
    3. CMOS
  - ii. Discuss how you can use the BIOS information to
    1. To learn about installed components
    2. Setup and configuration of functionality of the computer
  
- d) System utility software is a set of tools that helps configure, analyse and optimize computer resources to help users perform multiple tasks efficiently. It is software designed to help to analyse, configure, optimize or maintain a computer. Utility software is used to support the computer infrastructure in contrast to application software, which is aimed at directly performing tasks that benefit ordinary users. Briefly discuss each of the following Windows Operating system utility software tools below [10 Marks]
  - i. Disk Management Utility
  - ii. Control Panel Utilities
  - iii. Action Centre
  - iv. Device Manager
  - v. Event Viewer

## **Question II**

- a) The UNZA, Department of Computer Science has attached you to National Airports Cooperation upon completion of your second-year undergraduate on internship programme. Your Job description will largely be a computer system engineer. The tasks include working at the help desk, repair and troubleshooting of the computers, printers, copiers, switches and routers. In this type of work, injury prevention is everyone's responsibility and part of the company work policy. You will therefore need to stay alert to situations that could result in an injury. Based on what you learnt in the computer systems course, **developing and using safe work practices** is by far the best method for preventing injuries in the workplace. [11 Marks]
- i. Explain the purpose of safe working conditions and procedures
  - ii. Identify safety procedures to protect equipment from damage and data from loss
  - iii. Identify safety procedures to protect the environment from contamination
- b) Monitors and Projectors are the major display technologies used in computer systems. Briefly discuss each of the following technologies [4 Marks]
- i. Cathode-ray tube (CRT)
  - ii. Liquid crystal display (LCD)
  - iii. A light-emitting diode (LED)
  - iv. Plasma
- c) The University of Zambia with more than 2000 employees has given you a Job as an intern. You have been attached to the support centre department. Your role will be upgrading old desktop computers, servers and Laptop computers for the university workers. Using your knowledge in the computer systems course, you know that it is important to work in a logical, methodical manner when working with computer components. Using the diagram of the motherboard shown below [10 Marks]
- i. Name and List the major hardware components that make up a desktop computer.
  - ii. Explain how you would go about to assemble the components list in (i) above in a logical, methodical manner to come up with a working computer using the motherboard below



## Question III

- a) The use of communication skills to determine customer problem is an important aspect for a customer care service provider. You have been given the customer care job at MTN Zambia, and one of the first tasks for you as a technician is to determine the type of computer problem or phone problem that the customers are experiencing. Describe the key steps needed as a technician to determine the customer problem [4 Marks]
- b) Mobile devices organize icons and widgets on multiple screens for easy access. Android Operating System uses the system bar, displayed on the bottom of the screen, to navigate apps and screens. Describe each of the following features with respect to IOS and Android mobile operating systems [3 Marks].
- i. Widgets
  - ii. Screen Orientation
  - iii. Screen Calibration
- c) The diagram below shows a spreadsheet with results for 4 students. The continuous Assessment (CA) has a total of 40% and the final Examination is 60%. For the Continuous Assessment 10% is for the Labs, 10% assignments and 20% Tests [18 Marks].

N12	A	B	C	D	E	F	G	H	I	J
1	#	Name	Student ID	Labs (10%)	Assignments (10%)	Tests (20%)	Average Continuous Assessment (40%)	Final Examination (60%)	Course Grade (100%)	
2	1	Martin	1111	71	83	77		83		
3	2	Ruth	2222	75	81	91		85		
4	3	Isaac	3333	79	89	87		80		
5	4	Sarah	4444	68	74	83		91		
6	5	Jacob	5555	81	78	88		73		
7		Lowest Score								
8		Highest Score								
9		Average Score								
10										
11										
12										
13										
14										

Copy and Complete the Table by writing the formulae to compute the following

- i. Give the formula that can be used to compute the following
  - (1) The Lowest score for the **Labs, Assignments and Tests**
  - (2) The Highest score for the **Labs, Assignments and Tests**
  - (3) The Average score for the **Labs, Assignments and Tests**
- ii. The formula used to compute the **Average Continuous Assessment** for each student
- iii. The formula used to compute the **Course Grade** for each student
- iv. Which student had the highest exam score and which student had the lowest exam score?

## **SECTION B**

**This Section has TWO Questions. Choose one question**

### **Question I**

- a) Data cables transmit data between the motherboard and storage devices, such as hard drives. Describe each of the following data cables by giving the major characteristics [6 Marks]
  - i. PATA cable
  - ii. SATA cable
  - iii. Floppy drive data cable
- b) A physical topology defines the way in which computers, printers, and other devices are connected to a network. Draw a well labelled diagram and discuss each of the following physical topologies [8 Marks]
  - i. Bus
  - ii. Ring
  - iii. Star
  - iv. Hierarchical or Extended Star Topology
- c) The OSI model and the TCP/IP model are both reference models used to describe the data communication process. The TCP/IP model is used specifically for the TCP/IP suite of protocols and the OSI model is used for development of standard communication for equipment and applications from different vendors [11 Marks].
  - i. Draw the well labelled diagrams showing the **7 layers of the OSI Model** and **4 layers of TCP/IP Models**
  - ii. Give the function of each layer of the OSI Model

## **Question II**

- a) Memory modules are memory chips that have been soldered on to a special circuit board for easy installation and removal. Give a brief description for each of the following [5 Marks]
- DIP
  - SIMM
  - DIMM
  - RIMM
  - SODIMM
- b) The diagram below shows the computer components hardware. Hardware is the physical equipment such as the case, storage drives, keyboards, monitors, cables, speakers, and printers. Briefly discuss each of the following computer component by giving its function (purposes) and major characteristics [10 Marks]
- Motherboard
  - Power Supply
  - CPUs
  - Internal Bus System
  - ROM and RAM



- c) The troubleshooting process is a guideline to help solve computer problems in a logical and efficient manner. Usually these are grouped into six (6) major steps. Step 1 and Step 2 have been given below. List and describe the last four steps [10 Marks]
- *Step 1: Identify the problem*
  - *Step 2: Establish a theory of probable cause*
  - *Step 3: .....*
  - *Step 4: .....*
  - *Step 5: .....*
  - *Step 6: .....*

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**End of the Examination**



# THE UNIVERSITY OF ZAMBIA

## School of Natural Science

Department of Computer Science

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# FINAL EXAMINATION

**CSC 2101: INTRODUCTION TO COMPUTER SYSTEMS**

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Date: Wednesday, 30<sup>th</sup> December 2020  
Time: 09:00hrs – 12:00hrs  
Duration: 3 Hours  
Venue: NSLT

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### **Instructions**

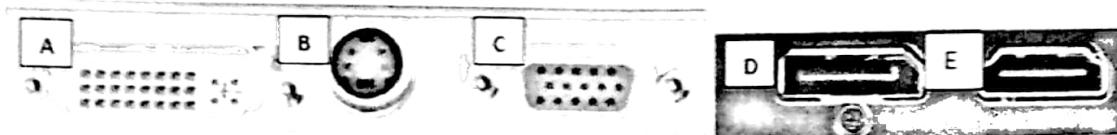
1. There are **Five (5) questions** and **two (2) sections** in this paper.
2. Each question carries **25 marks**,
3. You are required to answer a total of **Four (4) Questions**
  - a. *Answer all the questions in Section A*
  - b. *Choose one (1) question from Section B*

# **SECTION A**

**This Section has Three Questions. Answer all the questions**

## **Question 1**

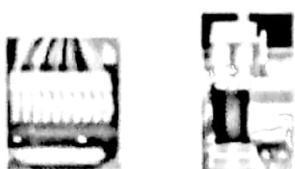
- /a) Briefly describe each of the following [3 Marks]
- Computer System
  - Computer Architecture
  - Computer Organisation
- /b) A video port connects a monitor cable to a computer. Display cables on the other hand transfer video signals from the computer to display devices. Name the five major video ports and connector types shown in the diagram below (A, B, C, D, E) [5 Marks]



- ✓c) Malicious software (malware) is any software designed to damage or to disrupt a system. Briefly describe each of the following types of malware [5 Marks]
- Adware
  - Spyware
  - Viruses
  - Worms
  - Trojan Horses
- d) Upon completion of your second-year courses in Computer Science degree programme at the University of Zambia, you have been awarded the 2 months internship job at our power utility company called ZESCO. Your Job description will largely be a computer system engineer. The tasks include working at the help desk, repair and troubleshooting of the computers, printers, copiers, switches and routers. In this type of work, injury prevention is everyone's responsibility and part of the company work policy. You will therefore need to stay alert to situations that could result in an injury. Based on what you learnt in the computer systems course, **developing and using safe work practices** is by far the best method for preventing injuries in the workplace. [12 Marks]
- Explain the purpose of safe working conditions and procedures
  - Identify safety procedures to protect equipment from damage and data from loss
  - Identify safety procedures to protect the environment from contamination

## Question II

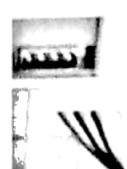
- a) Upon graduation in computer science at the University of Zambia, you have been employed to work at the call center at the telecommunication company. The use of communication skills to determine customer problem is an important aspect for you as an expert. One of the first tasks for you as a technician is to determine the type of computer problem or phone problem that the customer is experiencing. Describe the key steps needed as a technician to determine the customer problem [4 Marks]
- b) Power cables are used to distribute electricity from the power supply to the motherboard and other components. Give the function of each of the following power cables below and the components to which they supply power [5 Marks]



AUX



SATA

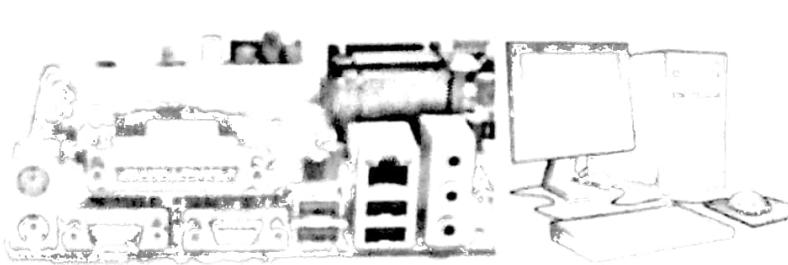
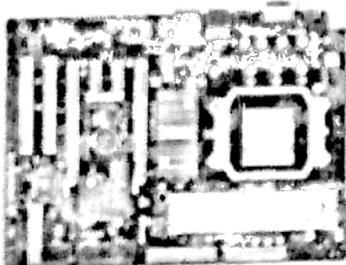


Molex



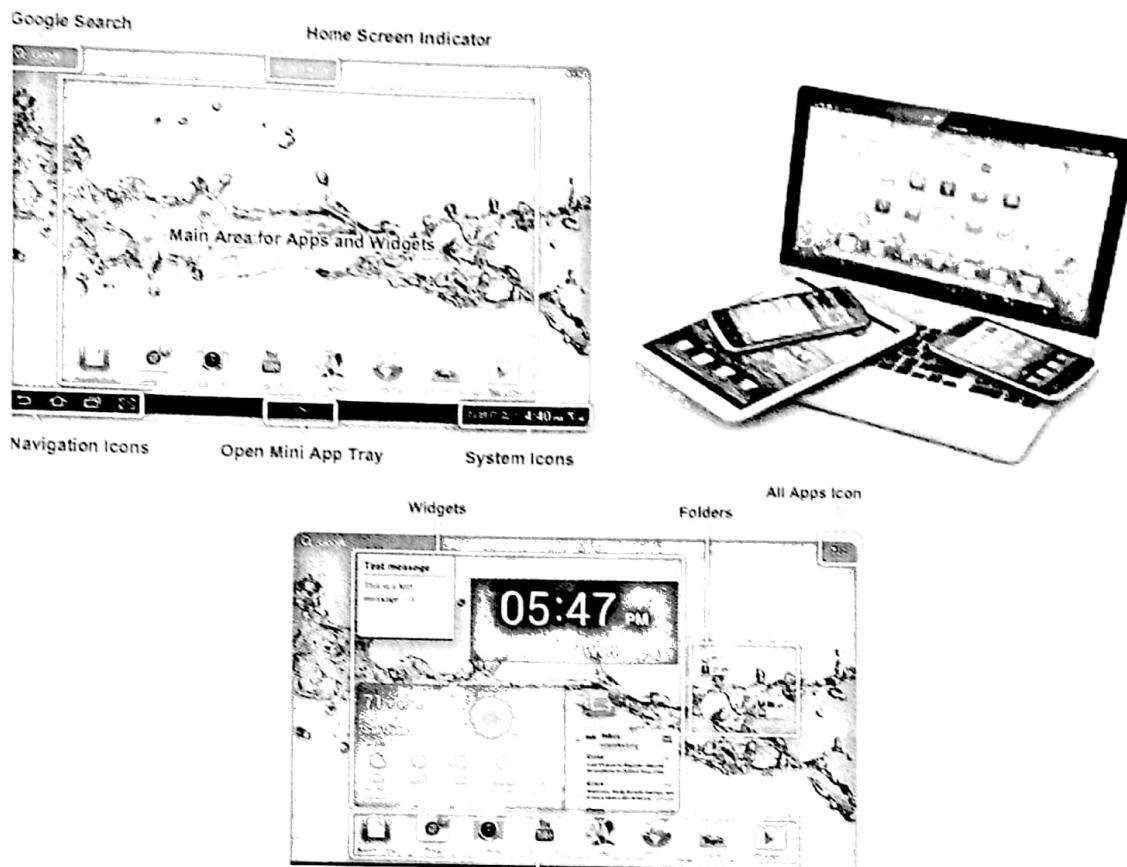
Berg

- c) Monitors and Projectors are the major display technologies used in computer systems. Briefly discuss each of the following technologies [5 Marks]
- i. Cathode-ray tube (CRT)
  - ii. Liquid crystal display (LCD)
  - iii. A light-emitting diode (LED)
  - iv. Plasma
  - v. Digital Light Processing
- d) The University of Zambia with more than 2000 employees has given you a Job as an intern. You have been attached to the support centre department. Your role will be upgrading old desktop computers, servers and laptop computers for the university workers. Using your knowledge in the computer systems course, you know that it is important to work in a logical, methodical manner when working with computer components. Using the diagram of the motherboard shown below [11 Marks]
- i. Name and List the major hardware components that make up a desktop computer.
  - ii. Explain how you would go about to assemble the components list in (i) above in a logical, methodical manner to come up with a working computer using the motherboard below

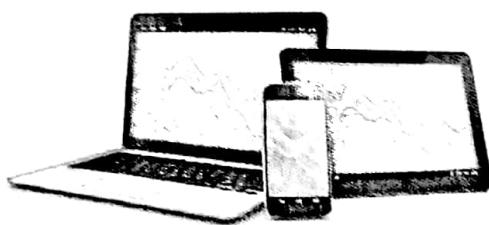


## **Question III**

- a) Mobile devices organize icons and widgets on multiple screens for easy access. Android Operating System uses the system bar, displayed on the bottom of the screen, to navigate apps and screens. Describe each of the following features with respect to IOS and Android mobile operating systems [ 4 Marks].
- Widgets
  - Notification Centre
  - Screen Orientation
  - Screen Calibration



- b) A mobile device is any device that is hand-held, light, and typically uses a touchscreen for input. Most mobile devices use touchscreens to allow users to physically interact with the screen and type on a virtual keyboard. Briefly discuss each of the following types of touch screens below [4 Marks];
- Capacitive
  - Resistive



- c) On 31 December 2019, the World Health Organization was informed of a cluster of cases of pneumonia of unknown cause detected in China. A novel coronavirus SARS coronavirus-2 was subsequently identified from patient samples. The outbreak of respiratory disease has now been detected in more than 70 locations internationally, including Zambia. The virus has been named "SARS-CoV-2" and the disease it causes has been named "Coronavirus Disease 2019" (abbreviated "COVID-19"). The University of Zambia has been requested by the government to help test the level of infection in four districts in Lusaka Province as shown in the spreadsheet below. Four Schools and four districts are participating on the project [17 Marks].

	A	B	C	D	E	F	G	H	I
1	No.	UNZA - SCHOOL		Districts				Average	
2	1	UNZA Vet Medicine	Kafue	Chongwe	Lusaka	Chilanga			
3	2	UNZA Public Healthy	71.0	77.0	83.0	74.0			
4	3	UNZA School of Medicine	75.0	72.0	81.0	69.0			
5	4	UNZA N/S (CS & Biology Dept.)	73.0	78.0	80.0	75.0			
6		Lowest COVID-19 Infection							
7		Highest COVID-19 Infection							
8		Average COVID-19 Infection							
9									
10									
11									
12									
13									

Copy and Complete the Table by writing the formulae to compute the following

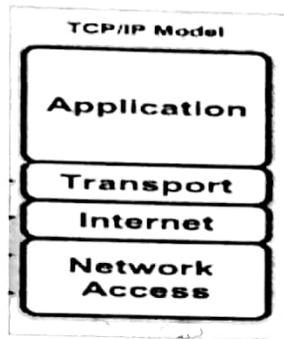
- Give the formula that can be used to compute the following
  - The Lowest infection level in each District
  - The Highest infection level in each District
  - The Average infection level in each District
- The formula used to compute the average level of infection from all the samples collected by each School
- Which District has the highest COVID-19 Infection?
- Which District has the least COVID-19 Infection?

## **SECTION B**

**This Section has TWO Questions. Choose one question**

### **Question I**

- a) Latency is the amount of time it takes data to travel from source to destination. Data is transmitted in one of three modes. Discuss each of the following transmission modes [3 Marks]
  - i. Simplex
  - ii. Half-duplex
  - iii. Full-duplex
- b) Briefly describe each of the following types of Computer Networks [4 Marks]
  - i. Local Area Network (LAN)
  - ii. Metropolitan Area Network (MAN)
  - iii. Wireless Local Area Network (WLAN)
  - iv. Wide Area Network (WAN)
- c) The OSI model and the TCP/IP model are both reference models used to describe the data communication process. The TCP/IP model *as shown in the diagram below* is used specifically for the TCP/IP suite of protocols and the OSI model is used for development of standard communication for equipment and applications from different vendors [10 Marks].
  - i. Draw a well labelled similar diagram showing the **7 layers of the OSI Model**
  - ii. Give the function of each layer of the OSI Model



- d) An Operating System (OS) is an interface between a computer user and computer hardware. It is a software which performs all the basic tasks like file management, memory management, process management, handling input and output, and controlling peripheral devices such as disk drives and printers [8 Marks]
  - i. Give two examples of open-source operating systems and two examples of non-open-source operating systems
  - ii. Describe each of the following categories of the operating systems by giving the major characteristics and at least one example in each case
    1. Desktop Operating System
    2. Network Operating System

## Question II

1) Explain what is the logic behind using a self-starting motor to start the engine of a car? What are the major parts used in the self-starting motor?

Ans:

Self-starting

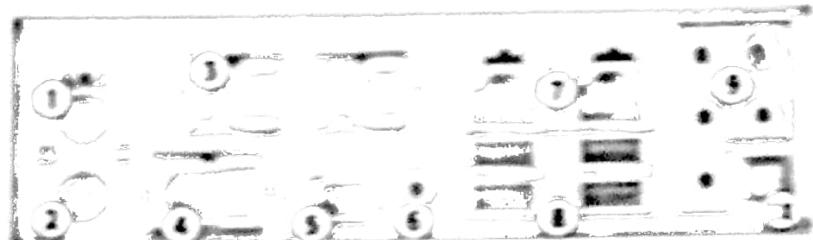
Motor

Ans:

The self-starting motor is a device which automatically starts the engine of a vehicle. It consists of a motor which is connected to the battery and has a switch which is controlled by the driver.

- Step 1: Identify the problem
- Step 2: Formulate a theory & problem cause
- Step 3: Test the Theory & Determine cause
- Step 4: Formulate a Plan of Action & Rectify the Problem and Implement the solution
- Step 5:
- Step 6:

2) Explain how the following components are used in the self-starting motor of a car.



3) Explain the working principle of the self-starting motor. How does it work? What are the major parts used in the self-starting motor? What are the advantages and disadvantages of using a self-starting motor in a car? Explain the working principle of the self-starting motor.

- Working principle
- Major parts
- Advantages
- Disadvantages

End of the Examination



# **THE UNIVERSITY OF ZAMBIA**

## **School of Natural Sciences**

Department of Computer Science

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### **END OF YEAR EXAMINATION**

### **CSC 2901 DISCRETE STRUCTURES**

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Date: Friday 18<sup>th</sup> December, 2020

Time: 09:00hrs – 11:00hrs

Duration: 2 Hours

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#### **Instructions**

1. There are **two (2) sections** in this paper.
2. *Answer all the questions in Section I and choose **any two (2) questions** from Section II*

**SECTION A: ANSWER ALL QUESTIONS.**

**[40 Marks]**

1. Let  $A$  and  $B$  be sets. Define the following [2 Marks]
  - a.  $A \subseteq B$  [2 Marks]
  - b.  $A - B$ , the difference set [2 Marks]
  - c.  $A \oplus B$ , the symmetric difference set [2 Marks]
  - d.  $A'$  [2 Marks]
  - e.  $|A|$ , the cardinality of  $A$  [2 Marks]
2. Define the following [4 Marks]
  - a. What is an algorithm? [4 Marks]
  - b. Mention four of the characteristics of algorithms. [2 Marks]
  - c. Discuss the two ways in which an algorithm can be expressed [2 Marks]
3. Let  $A$  and  $B$  be sets, define the following [2 Marks]
  - a. The Cartesian product of  $A$  and  $B$  [2 Marks]
  - b. The relation  $R$  of from  $A$  and  $B$  [4 Marks]
  - c. Equivalence relation [2 Marks]
4. State the division algorithm [2 Marks]
5. Let  $a, b$  be integers and  $n$  be a positive integer. Explain what does  $a$  is congruent to  $b$  modulo  $n$  i.e.  $a \equiv b \pmod{n}$  mean? [4 Marks]
6.
  - a. Let  $A$  be a set of 0s and 1s and  $(A, +, \cdot, 0, 1)$  be a Boolean algebra. Suppose  $x, y$  and  $z$  be in  $A$ . State the following laws of a Boolean algebra.
    - i. Commutative law [2 Marks]
    - ii. Distributive law [2 Marks]
    - iii. DeMorgan's law [2 Marks]

**SECTION B: ANSWER ONLY TWO OF THE FOUR QUESTIONS. EACH QUESTION HAS 30 MARKS.**

1. Consider the algorithm in the pseudocode below

```
algorithm mystery(m, n)
    input m and n, positive integers
    output ???
    q = 0
    r = m
    while m > n do
        m = m - n
        q = q + 1
    end while
    print q
    print m
end
```

- a. Draw the flowchart for the code above. [10 Marks]
- b. Simulate the execution of
  - i.  $mystery(8, 3)$  [6 Marks]
  - ii.  $mystery(3, 8)$  [4 Marks]

\*\*\*\*\*END OF EXAMINATON\*\*\*\*\*

## CSC2901 – DISCRETE STRUCTURES

### TEST 2

ANSWER ALL QUESTIONS

1.

- a. Let  $R = \{(a,a), (c,c), (a,b), (b,a), (a,c)\}$  be a relation on a set  $A = \{a,b,c\}$ . Explain if  $R$  is
  - i. Reflexive
  - ii. Symmetric
  - iii. Antisymmetric
  - iv. Transitive
  
- b. Let  $R = \{(1,2), (2,3), (2,4)\}$ 
  - i. Show that  $R$  is not transitive.
  - ii. Find the transitive closure of  $R$ .

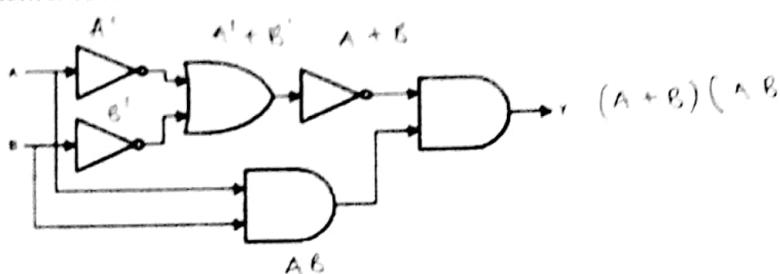
2.

- a. Suppose  $A$  and  $B$  are sets, use Venn diagrams to illustrate the following sets
  - i.  $A - B$
  - ii.  $A - (A - B)$
  
- b. Using analytical means, show that  $A - (A - B) = A \cap B$  [Hint:  $A - B = A \cap B^c$ ]

(3.)

- a. Derive the formula for finding the sum of the first  $n$  odd numbers. [Note: the  $n$ th odd number is expressed as  $2n - 1$ ]
  
- b. Use the principle of Mathematical induction to prove that your formula is correct.

4. Consider the logic network below



- a. Write the Boolean expression for this logic network.
- b. Simplify the expression in i) above.
- c. Show that for elements  $x$  and  $y$  in a Boolean algebra
  - i.  $xy + x'y = y$



# **THE UNIVERSITY OF ZAMBIA**

## **School of Natural Sciences**

### **Department of Computer Science**

#### **FINAL EXAMINATION**

#### **CSC 2000**

#### **Computer Programming**

Date: 21<sup>st</sup> December 2020  
Time: 14:00hrs – 17:00hrs  
Duration: 3 Hours  
Venue: NSLT

#### **Instructions**

1. There are **two (2) sections** in this exam paper.
2. Only the java programming language should be used in this exam
3. *Answer all the questions in Section A and choose any three (3) questions from Section B*

## **SECTION A. Short answers (40 marks)**

You are required to answer all questions in this section.

1. What is polymorphism and how is it related to dynamic binding and method matching? [6 marks]
2. What is method overloading and overriding? [4 marks]
3. The Java programming language is said to be both an interpreted and compiled language. Briefly discuss the pros and cons of this approach as compared to interpreted only and compiled only languages. [6 marks]
- ✓ 4. Briefly discuss any four key characteristics of Java. [4 marks]
- ✓ 5. Is there a difference in performance of Java programs that implicit and explicit importing? [2 marks]
- ✓ 6. Java purists often emphasize the importance of following naming conventions when coming up with identifier names. Why is it important to follow naming conventions? [4 marks]
- ✓ 7. List relational operators that are implemented in the Java programming language and the corresponding mathematical operators. [3 marks]
- ✓ 8. What are selections and why are they important in programming? [4 marks]
- ✓ 9. Why are sentinels important when implementing loops in Java? [2 marks]
- ✓ 10. Write short code showing the implementation of an enhanced for loop and how it can be used to traverse an array. [5 marks]

Dynamic binding is the binding of a method call to the method by its runtime  
Polymorphism is the ability to make more than one form. It is a property that allows  
subclasses to share the same functionality of the superclass but have  
unique interpretation.

Polymorphism can be achieved by  
Method Overloading, Method Overriding  
and Multiple Inheritance

## **SECTION B (60 marks)**

Answer any three (3) of the five (5) questions. Each question carries **20 marks**

**1.** Inheritance is fundamental concept in Object Oriented Programming

- a. What is inheritance and why is it important to understand this concept? **[4 marks]**
- b. A programmer has written code below. But, it is showing a compile time error. Can you identify what mistake he has made? How can it be corrected? **[4 marks]**

```
class X
{
    //Class X Members
}

class Y
{
    //Class Y Members
}

class Z extends X, Y
{
    //Class Z Members
}
```

- c. Briefly discuss the output of running the following code. **[4 marks]**

```
class A
{
    int i = 10;
}
class B extends A
{
    int i = 20;
}
public class MainClass
{
    public static void main(String[] args)
    {
        A a = new B();
        System.out.println(a.i);
    }
}
```

- d. What is constructor chaining? **[4 marks]**

- e. Briefly discuss the output of the following code. **[4 marks]**

```

class A
{
    public A()
    {
        System.out.println("Class A Constructor");
    }
}
class B extends A
{
    public B()
    {
        System.out.println("Class B Constructor");
    }
}
class C extends B
{
    public C()
    {
        System.out.println("Class C Constructor");
    }
}
public class MainClass
{
    public static void main(String[] args)
    {
        C c = new C();
    }
}

```

2. Objects are a very important concept in Object Oriented Programming. For this reason, a good programmer needs to understand classes and objects.
- a) What are objects and how are they related to classes? **[3 marks]**
- b) What are numeric wrapper classes and why are they important in the world of Java programming? **[3 marks]**
- c) What are the four types of relationships that can exist between two classes? **[4 marks]**
- d) Given the following code

```

public class Student{
    private int computerNumber;
    private String name;
}

```

1. The first step is to identify the type of soil you have. This can be done by performing a simple soil test or by consulting with a local agricultural extension office.
2. Once you know the type of soil you have, you can begin to plan your garden layout. Consider factors such as sunlight exposure, water availability, and soil drainage when determining where to plant each crop.
3. It's important to choose crops that are well-suited to your specific growing conditions. For example, if you have heavy clay soil, you may want to avoid crops like tomatoes, which require well-drained soil.
4. When selecting seeds, look for varieties that are specifically bred for your climate and soil type. This will increase your chances of success and help ensure that your plants reach their full potential.
5. Proper soil preparation is key to a successful garden. This includes tilling the soil to break up clumps, adding organic matter like compost or manure, and ensuring the soil has the right pH level.
6. Watering is another critical factor in gardening. Make sure to water your plants consistently, especially during dry spells. Be sure to water at the base of the plant rather than from above, as this can lead to fungal diseases.
7. Fertilizing is also important, but it's important to use the right type and amount of fertilizer. Over-fertilizing can actually harm your plants, so it's best to follow the instructions on the package.
8. Finally, don't forget about pests and diseases. Keep an eye out for any signs of trouble, and take action as soon as you notice them. This might involve picking off affected leaves or stems, or applying a natural pesticide.

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Source: [Gardening Know How](https://www.gardeningknowhow.com)

**THE UNIVERSITY OF ZAMBIA**  
**School of Natural Sciences**  
Department of Computer Science  
**CSC 2000 Test 2**

Date : 14<sup>th</sup> December 2020

Duration : 60 minutes

1. Write Java code that implements the following UML. [50 marks]

Course	
-courseName: String	The name of the course
-students: String[]	An array to store the students for the course
-numberOfStudents: int	The number of students (default: 0)
+Course(courseName: String)	Creates a course with the specified name
+getCourseName(): String	Returns the course name.
+addStudent(student: String): void	Adds a new student to the course
+dropStudent(student: String): void	Drops a student from the course.
+getStudents(): String[]	Returns the students in the course
+getNumberOfStudents(): int	Returns the number of students in the course

2. A parallel array is a structure that contains multiple arrays. Parallel arrays use two or more arrays to represent a collection of data where each corresponding array index is a matching field for a given record. For example, if there are two arrays, one for names and one for ages, the array elements at names [2] and ages [2] would describe the name and age of the third person

Name	Computer#	CHE 1000	PHY 1010	MAT 1100	BIO 1412
John Sibeso	201923211	45	54	45	54
Jack Phiri	201923212	56	65	78	89
Jane Banda	201923213	98	67	43	45
Kalumbi Bwalya	201923214	76	33	58	82

You have been tasked to write a program in Java which does the following

- Stores the results in the table above using a parallel array [20 marks]
- Print a performance report for a student given the student's computer#. The report should indicate the overall position in class for the given student. Overall position is calculated by adding the scores for all the subjects and ranking the students based on the sum. The report should also indicate whether the student's score is above average for each subject. [30 marks]



**THE UNIVERSITY OF ZAMBIA**  
**School of Natural Sciences**  
Department of Computer Science

**END OF YEAR EXAMINATION**

**CSC 2912  
NUMERICAL ANALYSIS**

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Date: Monday 28<sup>th</sup> December, 2020  
Time: 14:00hrs – 16:00hrs  
Duration: 2 Hours

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**Instructions**

1. There are **two (2) sections** in this paper.
2. *Answer all the questions in Section A and choose any two (2) questions from Section B*

**SECTION A: ANSWER ALL QUESTIONS****[40 MARKS]**

1. Let  $f: X \rightarrow Y$  be a function and  $x_0$  be a point in  $X$ . Define the following.
  - a.  $f$  is continuous at  $x_0$  [4 Marks]
  - b.  $f$  is differentiable at  $x_0$  [4 Marks]
2. Let  $p^*$  be the approximation of a value  $p$ . Define the following
  - a. Absolute error of approximating  $p$  by  $p^*$  [4 Marks]
  - b. Relative error of approximating  $p$  by  $p^*$  [4 Marks]
3. State the following
  - a. Rolle's theorem [4 Marks]
  - b. Intermediate value theorem [4 Marks]
  - c. Fixed-point theorem [4 Marks]
4. Suppose  $(x_0, y_0), (x_1, y_1)$ , and  $(x_2, y_2)$ , are points for a function  $f$ . Outline the appropriate approximations of the
  - a. three-point formulas for  $f'(x_0), f'(x_1)$ , and  $f'(x_2)$ , [6 Marks]
  - b.  $\int_{x_1}^{x_2} f(x) dx$  Using the
    - i. Trapezoidal rule [3 Marks]
    - ii. Simpson's [3 Marks]

**SECTION B: ANSWER TWO OF THE FOUR QUESTIONS. EACH QUESTION CARRIES 30 MARKS**

1. a. Let  $f: X \rightarrow Y$  be a function and  $x_0$  be a point in  $X$ .
  - i. Show that if  $f$  is differentiable on  $x_0$ , then it is also continuous at  $x_0$  [8 Marks]
  - ii. Suppose  $f$  is continuous in  $[a, b] \subseteq X$ , and  $f'(x) \neq 0$  for all  $x$  in  $[a, b]$ , show that  $f$  has at most one root in  $[a, b]$ . [Hint: assume  $f$  has two roots in  $[a, b]$  and show this lead to a contradiction using the Rolle's theorem] [6 Marks]
- b. Let  $f: R \rightarrow R$  be a function defined as  $f(x) = e^{x/2}$ .
  - i. Derive  $P_4$ , the 4<sup>th</sup> Taylor polynomial about  $x_0 = 0$ . [8 Marks]
  - ii. Use  $P_4$  to approximate  $\sqrt{e}$  [4 Marks]
  - iii. What is the error bound for this approximation [4 Marks]

2.

- a. Show that  $f(x) = x^2 - 2$  has a root in  $[1, 2]$  [6 Marks]
- b. How many iterations are required to approximate  $\sqrt{2}$  in  $[1, 2]$ , to  $10^{-3}$  accuracy using the Bisection method. [6 Marks]
- c. Show that the fixed point of  $g(x) = 1 + 1/(x + 1)$ , is the root of  $f(x) = x^2 - 2$ . [8 Marks]
- d. Hence use the fixed-point iteration to approximate  $\sqrt{2}$  [10 Marks]

The following values are to be used in questions 3 and 4 below.

x	0.2	0.4	0.6	0.8	1.0
f(x)	0.31	0.65	0.94	1.32	1.46

3. Approximate  $f(0.5)$  using

- a. Neville's iterated method ✓ [15 Marks]
- b. Newton's divided differences ✓ [15 Marks]

4.

- a. Use the correct three-point formula to find  $f'(0.6)$  [8 Marks]
- b. Approximate

$$\int_{0.2}^{1.0} f(x) dx$$

Using the composite

- i. Trapezoidal rule [10 Marks]
- ii. Simpson's rule. [12 Marks]

[Ensure you use all the points in both cases]

\*\*\*\*\* END OF EXAMINATION \*\*\*\*\*



# **THE UNIVERSITY OF ZAMBIA**

## **School of Natural Sciences**

**Department of Computer Science**

### **DEFERRED EXAMINATION**

#### **CSC 2912**

#### **NUMERICAL ANALYSIS**

Date              Thursday 12<sup>th</sup> January 2012  
Time              14:00hrs - 16:00hrs  
Duration        2 Hours

#### **Instructions**

- 1) Answer **any two (2) sections** in the paper.
- 2) Answer **any two (2) questions** in Section A and **any two (2)** questions in Section B.

**SECTION A: ANSWER ALL QUESTIONS****[40 MARKS]**

1. Let  $f: X \rightarrow Y$  be a function and  $x_0$  be a point in  $X$ . Define the following:  
a.  $f$  is continuous at  $x_0$ . [4 Marks]  
b.  $f$  is differentiable at  $x_0$ . [4 Marks]
2. Let  $p^*$  be the approximation of a value  $p$ . Define the following:  
a. Absolute error of approximating  $p$  by  $p^*$  [4 Marks]  
b. Relative error of approximating  $p$  by  $p^*$  [4 Marks]
3. State the following  
a. Rolle's theorem [4 Marks]  
b. Mean-value theorem [4 Marks]  
c. Taylor's theorem [4 Marks]
4. Suppose  $(x_0, y_0), (x_1, y_1)$ , and  $(x_2, y_2)$ , are points for a function  $f$ . Outline the appropriate approximations of the  
a. three-point formulas for  $f'(x_0)$ ,  $f'(x_1)$ , and  $f'(x_2)$ . [6 Marks]  
b.  $\int_{x_1}^{x_2} f(x) dx$  Using the  
i. Trapezoidal rule [3 Marks]  
ii. Simpson's [3 Marks]

**SECTION B: ANSWER TWO OF THE FOUR QUESTIONS. EACH QUESTION CARRIES 30 MARKS**

- 1.
- a. Let  $f: X \rightarrow Y$  be a function and  $x_0$  be a point in  $X$ .
- i. Show that if  $f$  is differentiable on  $x_0$ , then it is also continuous at  $x_0$  [8 Marks]
- ii. Suppose  $f$  is continuous in  $[a, b] \subseteq X$ , and  $f'(x) \neq 0$  for all  $x$  in  $[a, b]$ , show that  $f$  has at most one root in  $[a, b]$  using the Mean-value theorem [6 Marks]
- b. Let  $f: R \rightarrow R$  be a function defined as  $f(x) = e^{x^2}$ .
- i. Derive  $P_4$ , the 4<sup>th</sup> Maclaurin polynomial. [8 Marks]
- ii. Use  $P_4$  to approximate  $e$  [4 Marks]
- iii. What is the relative error of this approximation? [4 Marks]



# **THE UNIVERSITY OF ZAMBIA**

## **School of Natural Sciences**

Department of Computer Science

### **Deferred FINAL EXAMINATION**

**DATABASES AND INFORMATIONS  
MANAGEMENT SYSTEMS  
CSC 2702**

Date            18<sup>th</sup> January, 2021  
Time          14:00hrs - 17:00hrs  
Duration      3 Hours  
Venue         SPORTS HALL

#### **Instructions**

1. Answer **all** the questions in **Section A**
2. Choose **any THREE (3)** questions in **Section B**

SECTION A

Answer ALL Questions in this section. Both questions carry an equal weight of **20 Marks**.

**Question 1 [20 Marks]**

- i. Define the following terms briefly in not more than 3 lines: [ **5 Marks** ]
  - a. *Database*
  - b. *Database program*
  - c. *Database System*
  - d. *Record*
  - e. *Attribute*
- ii. What is a DBMS, and what are its functions? (list at least 3 functions) [ **5 Marks** ]
- iii. Describe the main components you are likely to find in a DBMS environment? [ **5 Marks** ]
- iv. Give at least 5 reasons why the file based system approach is desirable over the database approach. [ **5 Marks** ]

**Question 2 [20 Marks]**

- i. Explain what it means to say a database displays both *entity integrity* and *referential integrity*? [ **4 Marks** ]
- ii. Define the following terms in relation to the database: [ **4 Marks** ]
  - a. Intentions
  - b. Extension
- iii. Draw a well labelled diagram of the ANSI-SPARC DBMS architecture and describe the different aspect of it. [ **6 Marks** ]
- iv. What are the three components that describe a data model? [ **3 Marks** ]
- v. State three categories in which you can classify data models? [ **3 Marks** ]

**SECTION B**

There are FOUR questions in this section. All questions carry an equal weight of **20 Marks**.

Choose only **three (3)** question!

#### Question 1 ✓

- i In relation to Relational Database Model, list at least five (5) attributes that differentiate relations from tables. **[5 Marks]**
- ii Suppose you wanted to apply for a Job in a database computing environment, what are the five (5) different roles you may likely find? **[5 Marks]**
- iii What do you mean when you say "cardinality of the relation" and "degree of the relation" when you are talking about relational databases? **[4 Marks]**
- iv What two conditions must be met before an entity can be classified as a weak entity? Give an example of a weak **[2 Marks]**
- v Discuss the difference between a composite key and a composite attribute. How would each be indicated in an Entity Relationship Diagram? **[4 Marks]**

#### Question 2 ✓

- i Define the following terms **[5 Marks]**
  - a Composite key
  - b Super key
  - c Candidate key
  - d Foreign key
  - e Primary key
- ii Briefly describe the four (4) integrity constraints that are associated with relational database model? **[4 Marks]**
- iii What is the difference between a "view" and "base relation"? **[2 Marks]**
- iv Give at least 3 reasons why the file based system approach is undesirable over manual filing system? **[3 Marks]**
- v What three data anomalies are likely to be the result of data redundancy? **[6 Marks]**

#### Question 3

- i What is a partial dependency? With what normal form is it associated? **[4 Marks]**

- ii. Explain the difference between "Functional Dependency" and "Transitive Dependency". **[4 Marks]**
- iii. What two conditions must be met before an entity can be classified as a weak entity? Give an example of a weak **[4 Marks]**
- iv. Discuss the difference between a composite key and a composite attribute. How would each be indicated in an Entity Relationship Diagram? **[4 Marks]**
- v. Briefly, but precisely, explain the difference between single-valued attributes and simple attributes. Give an example of each. **[4 Marks]**

#### Question 4

- i. State and define at least three (3) examples of integrity constraints associated with relational database models. **[6 Marks]**
- ii. Define the following terms in relation to the database. **[8 Marks]**
  - a. Schema
  - b. View
  - c. Data independence
  - d. Data model
- iii. What are the three components that describe a data model? **[3 Marks]**
- iv. What are three examples of record based data models? **[3 Marks]**

## SECTION A [40 marks]

### ANSWER ALL QUESTIONS IN THIS SECTION

#### Question 1 [20 marks]

a) A parent may terminate the execution of one of its children for a variety of reasons.

Explain the reasons. **[4 marks]**

b) Some CPUs provide for more than two modes of operation. What are two possible uses of these multiple modes? **[4 marks]**

✓ c) What are the four main purposes of an operating system? **[4 mark]**

✓ d) Distinguish between the client-server and peer-to-peer models of distributed systems. **[4 marks]**

✓ e) How could a system be designed to allow a choice of operating systems from which to boot? What would the bootstrap program need to do? **[4 marks]**

#### Question 2 [20 marks]

a) What are two differences between user-level threads and kernel-level threads? Under what circumstances is one type better than the other? **[4 marks]**

✓ b) The memory layout of a process is typically divided into multiple sections. List the sections. **[4 mark]**

✓ c) List the process states. **[4 marks]**

✓ d) What resources are used when a thread is created? How do they differ from those used when a process is created? **[4 marks]**

✓ e) What is the main difficulty that a programmer must overcome in writing an operating system for a real-time environment? **[4 marks]**

Main advantage of layered approach  
System design approach is a type of layered system design & it is easier to make changes if required because changes only affect one layer.

The information is kept in a single structure hence bugs or errors are less.

## **SECTION B [60 marks]**

**ANSWER ANY THREE (3) QUESTIONS IN THIS SECTION**

### **Question 3 [20 marks]**

- a) Discuss multithreading models. **[7.5 marks]**
- b) There are several reasons for providing an environment that allows process cooperation. Explain the reasons. **[5 marks]**
- c) Some early computers protected the operating system by placing it in a memory partition that could not be modified by either the user job or the operating system itself. Describe two difficulties that you think could arise with such a scheme. **[7.5 marks]**

### **Question 4 [20 marks]**

- a) What is the main advantage of the layered approach to system design? What are the disadvantages of the layered approach? **[7.5 marks]** ✕
- b) Discuss the operating-system structure. **[5 marks]**
- c) Give two reasons why caches are useful. What problems do they solve? What problems do they cause? If a cache can be made as large as the device for which it is caching (for instance, a cache as **[7.5 marks]** *large as a disk*) why not make it large and eliminate the device.

### **Question 5 [20 marks]**

- a) What resources are used when a thread is created? How do they differ from those used when a process is created? **[7.5 marks]**
- b) Discuss the operating-system design and implementation. **[5 marks]**
- c) Describe the actions taken by a kernel to context-switch between kernel-level threads. **[7.5 marks]** ✕

### **Question 6 [20 marks]**

- a) Briefly explain any three scheduling algorithms. **[7.5 marks]**
- b) Discuss the computing environments. **[5 marks]**
- c) List five services provided by an operating system, and explain how each creates convenience for users. In which cases would it be impossible for user-level programs to provide these services? Explain your answer. **[7.5 marks]**

**THE END**