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SUBJECT:	<b>Computing</b>
PAPER NUMBER:	I
DATE:	29 <sup>th</sup> August 2022
TIME:	9:00 a.m. to 12:05 p.m.

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**Directions to Candidates**

- Answer **ALL** questions.
  - Good English and orderly presentation are important.
  - All answers are to be written on the booklet provided.
  - The use of flowchart templates is permitted but calculators may **not** be used.
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1. Berta has developed the following Java code snippet to fill in all the elements in an array.

```

1  Scanner sc = Scanner(System.in);
2  int num[] = new int num[100];
3
4  for (int i = 0; i <= 100; i++){
5      num[i] = sc.nextInt();
6  }
```

- a. Despite the program compiling successfully, Berta's program stops running suddenly during execution. Briefly describe the reason for this. (2)
- b. Rewrite the snippet of code above using a `do-while` loop. (3)

**(Total: 5 marks)**

2. Consider the following snippet of Java code:

```

1  public abstract class Song{
2      double duration;
3      String songName;
4      String genre;
5      Song(){ }
6      public abstract boolean playSong ();
```

- a. Suggest **TWO** ways with which the class can be modified to conform better to the concept of encapsulation. (2)
- b. Overload the constructor such that the data to be saved in the properties are specified (and passed along as arguments) when an object of the `Song` class is created. (2)
- c. State why any class inheriting the `Song` class must also implement a method called `playSong()`. (1)

**(Total: 5 marks)**

***Please turn the page.***

3. a. Produce the truth table for the following logic expression:

$$Y = (A+B) \oplus (C.D)$$

(3)

b. Draw the logic circuit for the expression in part (a).

(2)

**(Total: 5 marks)**

4. a. What is the range of an 8-bit register using two's complement? (2)

b. Show how the calculation 45-24 would be worked out using 8-bit two's complement registers. Show all your working in binary. (2)

c. Name **ONE** reason why a sign and magnitude system cannot be used in applications which require mathematical accuracy. (1)

**(Total: 5 marks)**

5. Name the addressing mode of the operand in boldface in each of the following assembly instructions:

a. SHL **BX**, 2; (1)

b. MOV [**54E1H**], AX; (1)

c. AND DX, [**BX**]; (1)

d. MOV DX, [**BX+DI**]; (1)

e. MOV AX, **#08H**. (1)

**(Total: 5 marks)**

6. a. Calculate the number of instructions executed in the assembly program below, showing your working via a trace table:

```

MOV DX, 020H      ; set DX to the value 20 hex
MOV AX, 002H      ; set AX to the value 2 hex
LOOP: SHR DX, 1    ; right-shift DX by one
CMP AX, DX        ; compare AX to DX
JG LOOP           ; if DX > AX, jump to LOOP
END               ; end of program
    
```

(4)

b. From the program in part (a) give an example of a pseudo-directive. (1)

**(Total: 5 marks)**

7. Charlie needs to create a Java program which temporarily stores incoming tasks in a data structure. He is unsure whether to use arrays or ArrayLists, and then again whether to use a queue or a stack.
- Compare and contrast in **TWO** ways, arrays and ArrayLists. (2)
  - Outline the main difference between a queue and a stack. (2)
  - Define pointers. (1)

**(Total: 5 marks)**

8. a. Use the set of numbers {56, 33, 1, 32, 28}, to show step-by-step how an insertion sort algorithm would sort them in ascending order. (4)
- b. Name any **ONE** other sorting algorithm apart from insertion sort. (1)

**(Total: 5 marks)**

9. Alan is developing a Bed & Breakfast booking system. A customer can book online by providing the dates to be booked. The system returns the rooms available for those dates and then the customer can select the desired room and provide personal details. Then, the manager Alan receives the booking order from the system who then approves or rejects the booking. If approved, the system then saves the booking in a bookings file.

Create a Level 0 (Context diagram) DFD for this scenario. (5)

**(Total: 5 marks)**

10. a. Jake is a politician who has been promising a tunnel traffic management system for ages. Outline **THREE** stages that Jake's project should be subjected to, before commissioning the design of the tunnel traffic management system. (3)
- b. Briefly describe **TWO** reasons why it is important to use prototyping once the system design stage of Jake's project is reached. (2)

**(Total: 5 marks)**

11. Evelyn is building her own processor. Her processor will have several 16-bit registers to store data and instructions being exchanged directly to and from RAM.

a. Within this context outline the importance of creating a Program Counter and a Current Instruction Register. (2)

b. Briefly describe to Evelyn the importance of including some form of cache memory. Moreover, compare the relative data access speeds of processor registers, RAM and cache. (3)

**(Total: 5 marks)**

12. A memory component has a 16-bit address bus.

a. If the memory component is byte-addressable, what is its capacity in kilobytes?  
**Note:** you can provide your answer in index form. (2)

b. If the memory component is word-addressable, with each word being 2 bytes long, what is its capacity in bytes? (1)

c. Outline the function of the memory address map. (2)

**(Total: 5 marks)**

**Please turn the page.**

13. Judith is studying how process scheduling and management works such that she can start working on creating scheduling algorithms of her own.
- Outline the **THREE** states which a process can be set to. (3)
  - Briefly describe what is process deadlock and how it can occur. (2)

**(Total: 5 marks)**

14. a. In relation to Operating Systems (OS), briefly describe the concept of device handshaking. (2)
- b. Briefly contrast the use of software polling against the use of vectored interrupts when an OS services interrupt requests. (3)

**(Total: 5 marks)**

15. Herb is setting up a web server to start offering web hosting and email services.
- Briefly describe any **TWO** e-mail protocols which Herb might need to set up services for. (4)
  - Why is it important for the server to have an I.P. address? (1)

**(Total: 5 marks)**

16. a. Contrast serial data communication with parallel data communication. (2)
- b. Name and briefly describe any **TWO** network topologies. (3)

**(Total: 5 marks)**

17. The following are BNF definitions for syntax rules which could be implemented in a programming language.

`<assign> ::= <var> = <exp>`

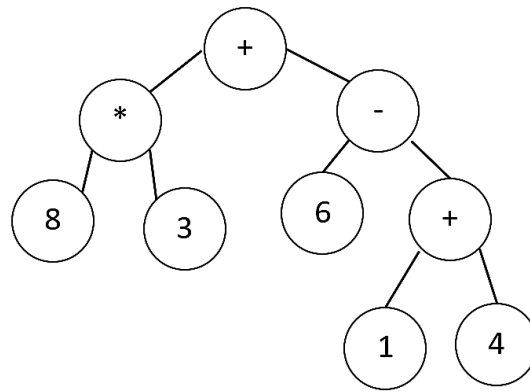
`<var> ::= A | B | C | D`

`<exp> ::= <var> | <var> + <exp>`

- Name **ONE** terminal and **ONE** non-terminal symbol from the syntax rules above. (1)
- Use syntax diagrams to represent the three syntax rules above. (4)

**(Total: 5 marks)**

18. John is designing a compiler for simple mathematical expressions.
- Outline a data structure which could be used in the compilation process to check that a statement is syntactically correct. (1)



b. Use the tree structure above to write down the equivalent infix and postfix expressions. (4)

**(Total: 5 marks)**

19. Jane has been tasked with designing a data warehouse for a search engine company.
- Outline **TWO** advantages of relational databases over flat file databases. (2)
  - Compare and contrast, in at least **THREE** ways, the hierarchical database model with the network database model. (3)

**(Total: 5 marks)**

20. Chelsea is designing a database for a youth hostel. This database will be accessible online via a booking website.
- Outline **TWO** ways with which data can be secured against unauthorised access in a database. (2)
  - Chelsea came up with a data model containing the following two entities.

**GUEST**(guestID, name, mobile, nationality)

**RESERVATION**(dateofarrival, numberofdays, resvID)

- Briefly describe how you would relate the two entities together. (1)
- Suggest with reason the cardinality of the relationship between the two entities. (2)

**(Total: 5 marks)**




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### Directions to Candidates

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- 

1. Bid4Me is a software development company that is being asked (in May) to develop a software system for a silent auction at a New Year's charity event. This means that people at a gala dinner will install an app on their smartphones and make monetary offers for an object being sold e.g. an antique vase. Bid4Me's work involves mostly the development of similar systems to the one being proposed.

- a. Argue in terms of technical feasibility and timeliness feasibility whether or not Bid4Me should accept to develop the proposed system. (3)
- b. Explain **TWO** methods which could be used by Bid4Me to ensure that all client requirements are elicited before systems analysis. (3)  
Moreover, list **ONE** advantage and **ONE** disadvantage for both methods mentioned. (3)

From requirements elicitation it was discovered that the system should allow an auctioneer to create a list of items with opening prices before the auction. Then the auctioneer will activate/open the bid for items one at a time. For each item, bidders will be allowed to bid as many times as they like until the auctioneer closes the bid. Finally, each participating bidder can view a list of items won so far.

- c. Draw a Use-Case Diagram for the proposed bidding system representing the requirements described above. (9)
- d. Suggest with reason which system design approach Bid4Me is more likely to adopt (in terms of top-down or bottom up). (2)

**(Total: 20 marks)**

**Please turn the page.**

2. Dora has collected data about her friends such that she can keep track of the scores in a curling tournament. She has created a table called "tournament" and the fields Player and Team have been chosen as the primary key.

<u>Player</u>	Contact details	<u>Team</u>	Team colour	Team sponsor	Points scored for team
Ross Geller	79001100 mysandwich@g.com	Dinoz	Yellow	Museum of Dinos	Dinoz - 34
Monica Geller	79171227 seven@g.com	TeamMonica	Purple	Central Perk	TeamMonica - 43
Joey Tribbiani	99448321 nosharing@j.com	Dinoss	Yellow	Museum of Dinos	Dinoz - 23
Rachel Green	94302813 notabreak@m.com	TeamMonica	Purple	Central Perk	TeamMonica - 1 Dinoz - 3
Chandler Bing	77384731 jokes@c.net	Dinoz	Yellow	Museum of Dinos	Dinoz - 10 TeamMonica - 12
Janice Hosenstein	99112233 omg@j.com	TeamMoca	Purple	CP	TeamMonica - 2
Phoebe Buffay	99448321 lobster@g.com	TeamMonica	Purple	Central Perk	TeamMonica - 15

- a. Write down the output of the following SQL query when it is executed on the "tournament" table.

```
SELECT COUNT(player), team FROM tournament GROUP BY team; (2)
```

- b. State **TWO** issues with how the data is stored in the above table. (2)
- c. Transform the table above to **3<sup>rd</sup>** Normal Form showing all steps involved using standard notation with explanations. (10)
- d. Draw an E-R diagram, using Crow's foot notation, representing the normalised database developed in part (c). (6)

**(Total: 20 marks)**

3. Consider the following Java code:

```
public class User {
    protected String userName;
    protected int experiencePoints;

    User (String userName) {
        this.experiencePoints = 0;
        this.userName = userName;
    }
    public String getUserName() {
        return this.userName;
    }
}

public class Guest extends User {
    private boolean hasCookies;

    Guest (String userName, boolean hasCookies) {
        super(userName);
        this.hasCookies = hasCookies;
    }

    Guest (String userName){
        super(userName);
    }
}

public class Member extends User{
    private String password;

    Member (String userName, String password) {
        super(userName);
        this.password = password;
    }
}
```

a. What is the output if the following code is executed?

```
User[] usr = new User[4];
usr[0] = new Guest("g1", true);
usr[1] = new Guest("g2", false);
usr[2] = new Member("m1", "abc");
usr[3] = new Member("m2", "def");
for(User u: usr) System.out.println(u.getUserName());
```

(2)

b. What is the size of the `usr` array? (1)

c. Name and explain the difference between a `List` and an `ArrayList`. (2)

d. Outline **ONE** reason why it is possible for the `usr` array to save objects of both `Member` and `Guest` types? (1)

**Question continues on next page.**



- e. Outline **ONE** reason why it is possible to have two constructors in the same class. (1)
- f. Can the `userName` attribute in the `User` class be accessed directly by the methods in the `Member` and `Guest` subclasses? Explain? (2)
- g. Write the code for a method in the `User` class which allows a caller class to obtain the `XP` for a particular object. (3)
- h. Add a method to the `Member` class called `changePassword()`. This method should receive the old text password and the new text password. Then if the old password matches the one stored in the object's attribute, the new password should replace the old password. A confirmation is returned to the caller method via a boolean variable (that is, true if changed and false if unchanged). (8)

**(Total: 20 marks)**

4. This question is about formal language translation.

- a. Define the following using the BNF notation:
  - i. an integer; (2)
  - ii. a vowel (from the English language); (2)
  - iii. a hexadecimal number with four digits followed by the letter H. (2)
- b. Explain the difference between a lexeme and a token. (2)
- c. One of the tasks performed during lexical analysis is the removal of redundant text. Give **TWO** examples of source code that would be considered as redundant text at this stage. (2)
- d. Describe **TWO** functions of the symbol table during compilation. (2)
- e. Distinguish between syntax analysis and semantic analysis and also provide an example of an error each type of analysis would detect. (4)
- f. Describe the process of 'just-in-time compilation'. (2)
- g. Describe the role of the 'virtual machine' in Java. (2)

**(Total: 20 marks)**

- 5. a. Represent the number  $232_{10}$  in binary. (2)
- b. Perform **TWO** right shifts **on the previous answer** and show the decimal representation for **each** step. (4)
- c. Deduce the mathematical operation being performed on the number with every right shift. (2)

d. Consider the following assembly language program:

```

MOV AX, 5    ; Move 5 into AX
MOV BX, 0    ; Move 0 into BX
MOV CX, 0    ; Move 0 into CX
LOOP: CALL SUB ; Call Subroutine
ADD BX, CX   ; BX = BX + CX
DEC AX      ; Decrement AX
CMP AX, 0    ; Compare AX with 0
JNE LOOP    ; If not equal to 0, jump to LOOP
SUB:  MOV CX, AX ; MOV AX into CX
      SHL CX, 1  ; Left Shift CX by 1
      RET       ; Return

```

- i. Identify and give examples of a conditional jump instruction, a label, a mnemonic and an arithmetic operation. (4)
- ii. By showing your working, show the number of iterations that the program takes to execute. (6)
- iii. What are the contents of BX and CX after execution? (2)

**(Total: 20 marks)**

6. a. Using appropriate technique/s, derive the equivalent expression of an AND gate, by using only NOR gates, and draw the equivalent circuit of an AND gate. (5)

b. Using truth tables only, show that:

- i.  $A \text{ XOR } B = (A + B) \cdot \overline{(A \cdot B)}$  (3)
- ii.  $A \cdot (B + C) = A \cdot B + A \cdot C$  (6)
- iii.  $A + B \cdot C = (A + B) \cdot (A + C)$  (6)

**(Total: 20 marks)**

7. a. Your employer wants you to design a computer system based on the von Neumann model. Draw a diagram of such a machine, highlighting the connections between the different components together with the directions of such connections. (10)

b. A processor can perform data transfer using two techniques; either synchronous, or asynchronous.

- i. Distinguish between synchronous and asynchronous data transfer, mentioning in particular the difference between both transfer methods and their implementation complexity. (4)
- ii. Describe how a processor can write the byte  $0A_{16}$  to memory address 106, both synchronously and asynchronously, to memory. Mention the buses used for data transfer. (6)

**(Total: 20 marks)**

**Question continues on next page.**

8. a. Noel wants to write a program in assembly which references another part of memory. He is unsure of whether he's going to use physical addresses or logical addresses. What is the difference between the two types of addresses? (2)
- b. While running, a program may be allocated any free partition in memory and can be moved in memory during execution. Name and describe the **TWO** ways that relocation of addresses is performed. (6)
- c. Caroline's hobby is programming a simple operating system at home. The main problem she is facing is how to effectively allocate space on the hard disk so that files are stored and can be accessed quickly. The three techniques she is considering are contiguous, linked, and indexed block allocation. By listing the advantages and disadvantages of **each**, identify the most effective block allocation technique that Caroline can use and why. (12)

**(Total: 20 marks)**