Oxford Cambridge and RSA

Monday 12 June 2023 – Afternoon

A Level Computer Science

H446/01 Computer Systems

Time allowed: 2 hours 30 minutes

You can use:
- an HB pencil

Do not use:
- a calculator

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number						Candidate number				

First name(s) ____________________

Last name ____________________

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.

INFORMATION
- The total mark for this paper is **140**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **28** pages.

ADVICE
- Read each question carefully before you start your answer.

1 A small manufacturing business uses networked computers with closed source application software installed.

(a) A spreadsheet application package is used to calculate employee's wages.

(i) Give **one** benefit of using a spreadsheet application for this task compared to calculating wages manually.

Faster as you can just apply the same formula to multiple cells

.... [1]

(ii) Give **two** other types of application packages that the small business could use, giving an example of a task that the business could use each application for.

Application 1 word processor

Example of task 1 sending emails to staff

Application 2 presentation software

Example of task 2 to create presentations for clients and staff

[4]

(iii) Describe a drawback of using closed source software (rather than open source software) for the small business.

cost to purchase the software
- cannot modify since no source code as well as cannot fix bugs

.... [3]

(b) Each computer the business uses has a BIOS.

Tick (✓) **one** box in each row to identify whether each statement in the table is true or false.

Statement	True	False
BIOS stands for ~~Boot~~ Basic Input Output Standard		✓
The BIOS can be used to alter hardware settings, such as which storage device the computer boots from	✓	
BIOS settings are stored in ~~RAM~~ ROM		✓

[3]

The business uses virtual storage to hold regular backups of all of its data.

(c) Explain why virtual storage is well-suited for storing backups.

doesnt take up physical space, hence more local space,
can be accessed anywhere with an internet connection

[2]

(d) All computers owned by the business are connected together into a Local Area Network (LAN). Various network protocols are used in this network.

(i) Give **three** advantages to the business of connecting computers together in a LAN.

1 files stored centrally

2 backups / maintainance done locally

3 log on from any device in the lan

[3]

(ii) Explain what is meant by a network protocol.

A set of rules used to govern the transmission between devices

[2]

(iii) Give the names of **two** protocols that may be used in a LAN.

1 HTTP

2 HTTPS

[2]

(iv) Explain why protocol layering is used.

To provide indepencence of layer, so that layers can be modifed without affecting other layers. Easier to debug and find errors.

[3]

(e) One computer owned by the business monitors critical-safety features of manufacturing. All input data must be processed within a predictable timescale of a fraction of a second.

(i) State the type of operating system that should be used by this computer.

Real time

[1]

(ii) Give the name of **three** other types of operating system, and for each state its purpose.

Type 1 Embedded

Purpose 1 has a dedicated function

Type 2 Multi-tasking

Purpose 2 Run multiple programs at the same time

Type 3 Multi-user

Purpose 3 allows multiple users at the same time

[6]

When a device such as a keyboard or printer requires attention from the CPU, an interrupt is raised.

(f) Explain how an operating system deals with an interrupt.

Interrupt is checked for at start or end of each fetchexecute cycle.
If the interrupt is of a lower/equal priority to the current process then the current process continues
If the interrupt is raised contents of registers copied to stack
Flags are set to determine if interrupts are enabled / disabled
Program counter changed to point to Interrupt Service Routine (ISR) // ISR runs
After interrupt complete, previous register values restored back from stack
Flag is reset

[3]

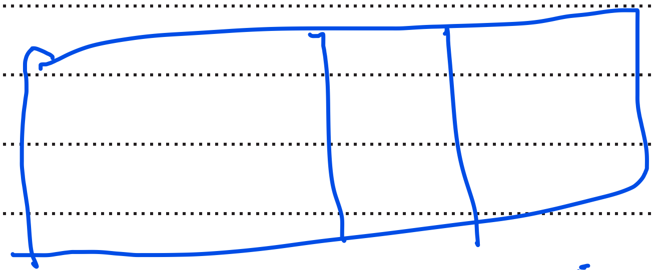
(g)* Memory management is a key function of an operating system. Explain how an operating system can manage the memory available to applications and why doing so is important.

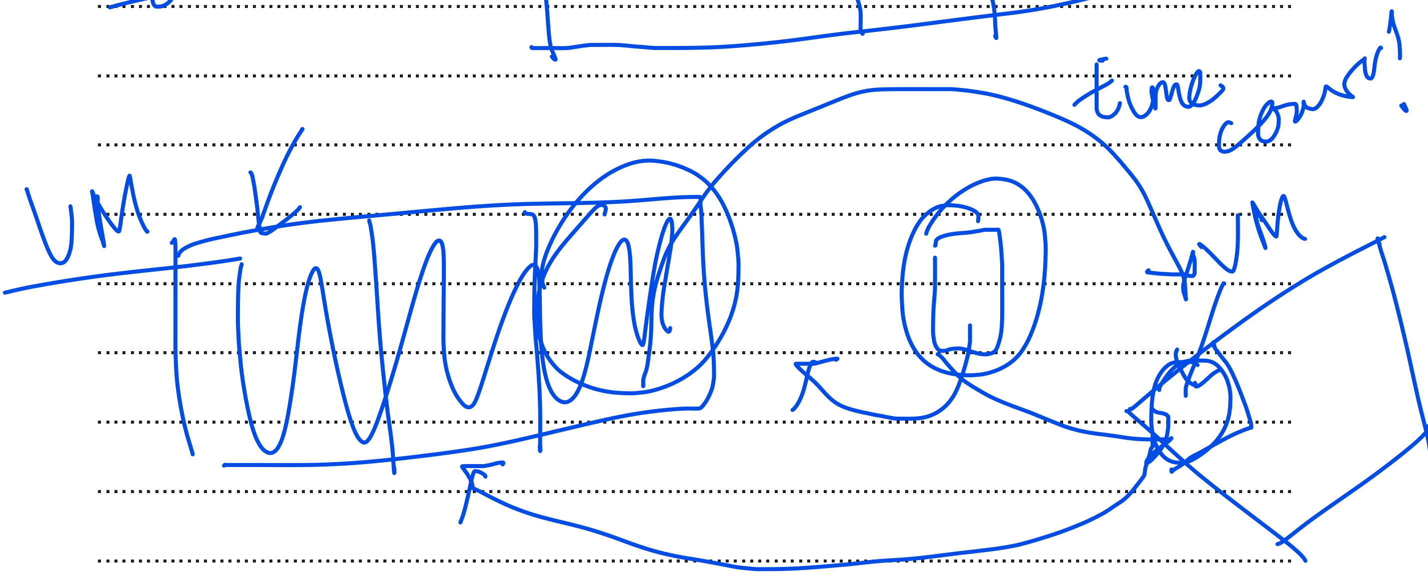
You should include the following in your answer:

- the different actions carried out by an operating system to manage memory
- how memory that is being managed can be split up
- why memory management is important. **[9]**

Paging

Segmentation





A01

Memory management means to ensure that RAM is used efficiently and not wasted

Removes data not needed anymore (garbage collection), frees up space and allocates memory to applications

Paging or segmentation may be used to split up memory

Paging uses fixed size divisions whereas segmentation uses varying size divisions

Paging is where memory is divided physically

Segmentation is where memory is divided logically

Virtual memory may be used when RAM is (almost) full to enable applications to continue to run

A02

If RAM is unavailable or full, applications cannot be loaded

Data transferred out of RAM into virtual memory to free up space and then transferred back again when needed

Also includes security so that data stored in memory is not vulnerable

Memory management is important for a well-running machine. If not, RAM would rapidly run out and fill up with unneeded data/instructions and so no new applications could run

Paging causes internal fragmentation whereas segmentation causes external fragmentation

A page table is used to map page location which is

A03

RAM is much more expensive than secondary storage (per unit/GB) so virtual memory is useful rather than having to buy more RAM

Over use of virtual memory causes slow down and even disk thrashing if pages have to be swapped back and forth too often

Paging can be more effective because any free memory space can be used to swap data in and out whereas with segments, lots of space will sit unused until a segment the right size is available

Segmentation errors can cause memory leakage which would cause the system to crash

2 Sundip writes an algorithm to carry out addition and subtraction. The algorithm will use an initially empty stack with the identifier `numbers` and will take input from the user.

The action the algorithm takes depends on the value input by the user. These actions are listed in **Fig. 2**.

Value input	Action to take
A	• Pop two values from the `numbers` stack • Add the two values • Push the result back onto the `numbers` stack
S	• Pop two values from the `numbers` stack • Subtract the first popped value from the second • Push the result back onto the `numbers` stack
E	• Pop one value from the `numbers` stack • Output this value • End program
Any other value	• Push the input value to the `numbers` stack

Fig. 2

(a) Complete the pseudocode here to implement Sundip's algorithm.

```
do
    value = input("Enter a value")
    if ....value == "E".... then
        num = numbers.pop()
        print(num)
    elseif value == "A" or ....value == "S".... then
        numone = numbers.pop()
        numtwo = numbers.pop()
        if value == "A" then
            numbers.push....(numone + numtwo)....
        elseif value == "S" then
            numbers.push(numtwo - numone)
        endif
    else
        numbers.push(....value....)
    endif
until value == ...."E"....
```

[5]

(b) (i) Complete the diagram to show the state of the stack after each value is entered into the algorithm. The letters will complete an action stated in **Fig. 2**.

The state of the stack after the first value, 8, has been completed for you.

Input 8	7	A	6
	7		6
8	8	15	15

[3]

(ii) Complete the following table to give the output from this algorithm when the following set of inputs are entered by the user. The letters will complete an action stated in **Fig. 2**.

Input data (from left to right)	Output
9 3 A E	12
10 5 A 8 S E	7
25 5 S 2 3 A S E	15

8
15
5 3 2
20

[3]

2

If the user enters **4 2 S A E** , the algorithm will not work correctly.

(iii) Explain what problem this input data will cause and why the problem occurs.

4 and 2 are popped and 2 is pushed A causes an attempt to pop two values but only one present Causing a stack underflow

[3]

(c) A stack is one data structure that is available for Sundip to use. She could also use a queue, list, linked list, array or tuple.

(i) Describe **one** difference between a stack and a queue.

Stack is FILO Queue is FIFO

[2]

(ii) Describe **one** difference between an array and a list.

Arrays are static , list is a dynamic data structure

[2]

(iii) State **how a** tuple is different to a list.

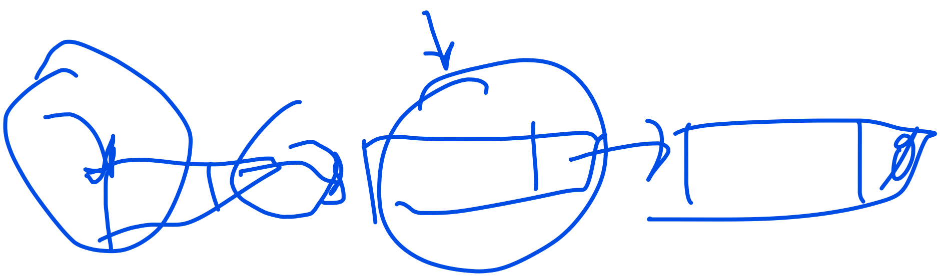
A tuple canot be changed

[1]

(iv) Describe how the **second** item in a linked list would be accessed using pointer values.

Go to the first position indicated by the start pointer. From the first position, read the next pointer value amd follow this pointer value and access the data item

[3]



3 (a) (i) Convert the denary number **189** to hexadecimal.

10→A

189 → 1011 1101

11 13

15 F

B D

BD

.... [1]

(ii) Convert the unsigned binary number **1010101111** to hexadecimal.

0010 1010 1111

2 10 15

A F

2AF

.... [1]

(b) Negative binary values can be represented using either sign and magnitude or two's complement.

(i) Convert the denary number **-107** to an 8-bit binary number using sign and magnitude.

± 64 32 16 8 4 2 1

1 1 1 0 1 0 1 1

.... [1]

(ii) Convert the denary number **-107** to an 8-bit binary number using two's complement.

107 → 01101011

10010100 (1's)

1

10010101 → -128 64 32 ... 1 0 0 1 0 1 0 1

.... [1]

(iii) Give **one** advantage of storing values using two's complement instead of sign and magnitude.

twos complement allows for larger range.

.... [1]

(c) Show how the denary value **-15.75** can be represented as a normalised floating point binary number using 8 bits for the mantissa and 4 bits for the exponent.

01 +
10 -

You must show your working.

-16 8 4 2 1 . 1/2 1/4 1/8 ← fixed point
1 0 0 0 0 . 0 1 0 two-complement

1 0 0 0 0 0 1 0 0 1 0 0

[4]

(d) The normalised floating point binary number 0100 1110 is stored using 4 bits for the mantissa and 4 bits for the exponent, both in two's complement.

Convert this number to denary.

You must show your working.

-8 4 2 1

0 . 1 0 1 0 0 1 1 1 0 → -2

1 1/2 1/4 1/8

0.00100

1/8 = $\boxed{0.125}$

[3]

(e) Complete each of the following sentences relating to the storage of floating point binary numbers with an appropriate word.

Increasing the number of bits used for the mantissa increases the accuracy of the number that can be stored.

Increasing the number of bits used for the exponent increases the size of the number that can be stored.

[2]

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4 A team of programmers create a robot that will be used in a factory. The robot will be able to do the work of multiple humans.

The programmers discuss whether to write the instructions for the robot in assembly language or a high-level language.

(a) Describe **two** differences between assembly language and high-level languages.

Difference 1 ......Assembly language uses mnemonics HLL uses English-like words

Difference 2 ...Assembly language uses an assembler to convert to machine code
HLL uses a translator (compiler/interpreter) to convert to machine code

[4]

(b) The robot uses a multi-core processor. The programmers assume that this means that the robot will execute programs more quickly than using a single core processor.

(i) Give **one** reason why this assumption can sometimes be true.

Can exectute muliple instructions

[1]

(ii) Explain why this assumption is not always true.

Program may not be written to specifically use multiple cores
there are other factors that influence processing speed

[2]

(c)* The robot stores data internally and also communicates with other robots and users via a wireless network which is password protected. All data for these tasks is secured using either encryption or hashing.

Compare the robot's use of encryption and hashing for storing and communicating data.

You should include the following in your answer:

- the different types of encryption that could be used and how this would secure data
- how hashing could be used to secure data and which data would be suitable
- why encryption and hashing are used by the robot for stored data and communications.

[9]

Encryption converts data into data that cannot be understood using a key.

Symmetric encryption uses the same key for both encryption and decryption

Asymmetric encryption uses two keys, one for encryption, one for decryption

Encryption is two-way, so data can be restored to original form, but key is required.

Hashing is a one-way (non-reversible) mathematical process that produces a value from the input value

For robot's data storage, symmetric encryption is useful as no keys to share/transmit.
For robot-robot/user communication, asymmetric encryption / public key encryption means that only the public key needs to be shared. Data can be encrypted/decrypted with this while the private key is kept secure.
Also possible to verify identity of sender / origin of data using asymmetric encryption.
Hashing is useful for information (e.g. password) that needs to be verified but does not need to be known at any point; once hashed, it is impossible to return to it

Encryption useful for most data storage as anyone hacking into the robot will not be able to read/understand the data
Hashing is useful for data storage of password / other items that need to be verified, hash of input compared against hash stored to confirm correctness.
Hashing is not useful for data that needs to be returned to the user as impossible to return to.
Encryption useful for data transmission as data intercepted cannot be decrypted without the key

(d) The robot provides a web-based interface for users. The home screen webpage for this interface is shown in **Fig. 4**.

Fig. 4

(i) Complete this HTML code that will display the webpage shown in **Fig. 4**.

```
<html>
    <head>
        <title>Robot User Interface</title>
    </head>
    <body>
        <h1>Robot prime directives</h1>
        <ul>
            <li>Serve the company trust</li>
            <li>Protect data</li>
            <li>Uphold standards</li>
        </ul>
    <a href = "updates.html">Updates</a>
    <p>login</p>
    <form action="dologin.php">
        Password
        <input type = "password" name="pw">
        <input type = "submit">
    </form>
    </body>
</html>
```

[5]

(ii) Write CSS code that could be used in an external stylesheet to format all text using the <h1> tag as white with a red background.

h1 {
color : white ;
background - color : red ;
}

[3]

The robot's web interface uses images that show the robot in action. These photographs have been taken using a digital camera.

(e) The programmers do not want other people to download and use these images.

(i) State the name of **one** relevant piece of legislation and describe how this would protect these images.

Legislation Copyright Designs and Patents Act

Description Gives the author ownership of the photograph

Permission can be bought

[3]

For other areas of the web interface, the programmers need to use images that they have not created themselves.

(ii) Give **two** ways that they could make sure these images are used legally.

1 Purchase the images

2 Ask permisission of the author/ photgrapher

[2]

(f) Details of all users that have accessed the robot are stored in a database table called `TblAccessLog`. This table stores the username and user type of each user. When a user accesses the robot, the current date is added to the `DateAccessed` field for that user.

A selection of the data from this table is shown here. Username is the key field.

Username	UserType	DateAccessed
Mrphy003	User	08/05/21, 07/06/21, 08/06/21
Lwis076	Admin	17/04/21, 19/07/21
Bbby412	NotNeeded	01/06/21, 02/07/21, 14/07/21

`TblAccessLog`

(i) Write an SQL statement to delete all records from the table `TblAccessLog` for users who have a UserType of `"NotNeeded"`.

DELETE FROM TblAccessLog
WHERE UserType = "NotNeeded"

[2]

(ii) State **two** requirements for a database to be in First Normal Form (1NF).

1 Primary key must be there

2 All data in attributes must be atomic (cannot be further split up)

[2]

(iii) Explain why the structure of `TblAccessLog` means that this database is **not** in First Normal Form (1NF).

DateAccessed has non-atomic data

[2]

5 A `doCheck()` function takes an integer value as a parameter, carries out a series of calculations and returns an integer value.

The function is shown here.

```
function doCheck(number)
      temp = str(number)
      max = temp.length - 1
      total = 0
      for x = 0 to max
            total = total + int(temp.subString(x,1))
      next x
      return total MOD 10
endfunction
```

3

0

19 % 10

3 + 1 + 7 + 8

= 19

(a) State the value returned from the function when `doCheck(3178)` is called.

9

[1]

(b) Write an algorithm that will:

- allow the user to enter an integer value
- pass the value entered into the `doCheck()` function as a parameter
- store both the value input and the value returned from the function in a text file with name "storedvalues.txt"

You should write your algorithm using either pseudocode or program code.

```
num = input("enter a number")
value=doCheck(num)
txtfile = openWrite("storedvalues.txt")
txtfile.writeLine(num)
txtfile.writeLine(value)
txtfile.close()
```

[5]

Turn over

6 **(a)** A computer scientist has created the following logic circuit shown in **Fig. 6**.

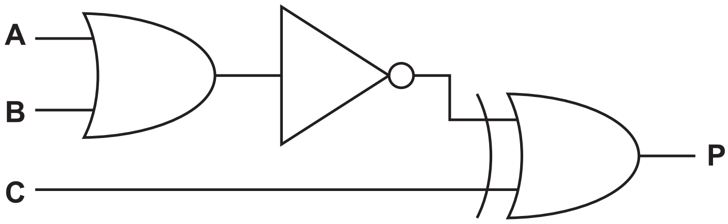

Fig. 6

(i) Give the Boolean expression that represents the logic circuit shown in **Fig. 6**. Do not attempt to simplify the expression.

NOT(A OR B) XOR C

.... **[2]**

(ii) Complete the truth table for the logic circuit shown in **Fig. 6**.

A	B	C	P
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

[3]

The following Karnaugh map represents another logic circuit.

CD \ AB	00	01	11	10
00	1	1	1	1
01	1	1	0	0
11	0	0	0	0
10	0	0	1	1

(b) Use this Karnaugh map to find the simplified expression for this circuit.

You should highlight the map as appropriate and write the expression here.

$\bar{A}\bar{C} + A\bar{D}$

[4]

0 1 dont write that ~~0~~
1 0 letter

0
0 → letter negated $\bar{A}$

1
1 → letter A

7* The Regulation of Investigatory Powers Act (2000) has been described as both a vital legal tool to ensure the public's safety and an attack on an individual's freedoms.

Evaluate the purpose and use of the Act.

You should include:

- the additional powers given under the Act
- to whom these powers are given
- the perceived benefits and/or drawbacks of the Act.

[12]

Implements additional rights regarding surveillance / monitoring of individuals and acquisition of communications data
Provides the right for many organisations (including the Police and security services) to do this.
Purpose is to detect crime and defend national security (e.g. terrorism, public disorder)
Gives access to individuals' private communications, such as emails, text messages, phone calls, Internet history.
Some people feel this is an invasion of their privacy

Monitoring can be carried out by far more organisations than just the Police and Security services – for example, local councils, the pension regulator and the Environment Agency are all able to use surveillance or request data about individuals.
If files are encrypted, the Act gives powers to force the handover of keys (from individuals or organisations) with a 2 year prison sentence possible on refusal.
Wide ranging powers have allowed Police and Security services to intercept criminals' communications and stop / disrupt crime

(e.g. terrorism) can be detected and stopped before they occur, making the public safer.
However, some say that it is now a "snooper's charter", with more organisations using their powers for minor offences such as detecting those lying about their address to get children into a better school or fly-tipping.
Many communication tools (e.g. WhatsApp) now include end-to-end encryption by default so that messages cannot be divulged by the organisation because they do not have access to it. Other encryption tools include plausible deniabilit

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).