1(a) A digital coffee making machine has a CPU that uses the Little Man Computer Instruction Set.

Little Man Computer operates on a computer system based on the Von Neumann Architecture.

i. State **two** features of the Von Neumann architecture.

1 ---

---

2 ---

---

[2]

ii. Describe **one** feature, **not** part of the standard Von Neumann Architecture, which contemporary CPUs may have in order to improve performance.

---

[2]

(b) Part of the coffee making machine's code asks the user to press a button to select strength. The code outputs 1 which will switch on a green light to indicate a valid selection or outputs 0 to indicate an invalid selection.

The code is shown below:

```
                INP
                STA    entry
                LDA    max
                SUB    entry
                 BRP    accept
                LDA    redLight
                BRA    printAndEnd
accept          LDA    greenLight
printAndEnd     OUT
                HLT
greenLight      DAT    1
redLight        DAT    0
max             DAT    5
entry           DAT
```

Fig. 1

i. Tick the appropriate boxes below to indicate which inputs will result in a green light (i.e. code outputs 1) and which with a red light.

Input	Green Light	Red Light
1		
2		
3		
4		
5		
6		
7		
8		
9		

[2]

ii. Explain which registers and buses are used, and the values they store/carry, when the line `LDA redLight` is executed (after it has been fetched and decoded). You should assume the address `redLight` refers to memory location 11.

---

[6]

iii. Write code in a high-level language or pseudocode that has the same functionality as the code in Fig. 1.

[3]

iv. * Discuss the differences between assembly code and high-level languages. You should refer to:

- the advantages and disadvantages of writing programs in assembly code rather than a high-level language
- when each approach might be used
- why the coffee machine was programmed in assembly code.

[9]

2(a) A software company decides to build an operating system for OCR smart watches.

Memory management is one of the functions of an operating system.

i. List **three** functions, other than memory management, of an operating system.

1

2

3

[3]

ii. Part of a computer's memory is represented below (Fig. 2). The operating system divides the memory into equally sized chunks.

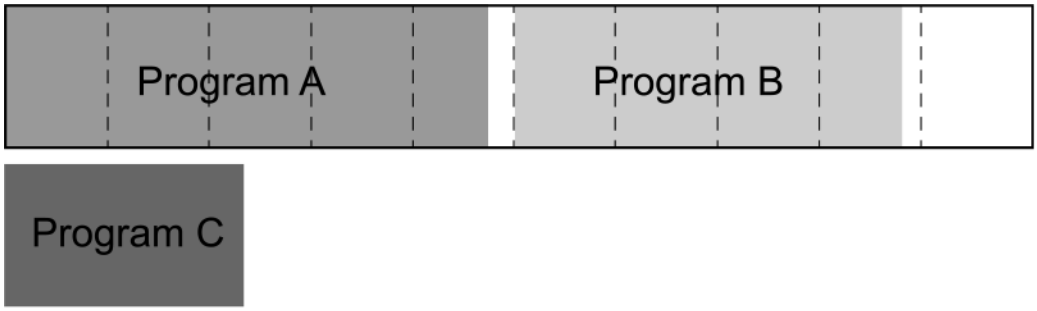

Fig. 2

iii. State the name of the type of memory management used in Fig. 2.

[1]

iv. The operating system needs to load program C into memory but there is not enough space. Describe how

the operating system would use virtual memory to load program C.

[3]

(b) The company sets up a website to promote the watch. Part of the website is shown below. The sentence 'Download The Factsheet' is a hyperlink to the file factsheet.pdf which is stored in the same folder as the HTML file for the webpage.

Features

The new OCR Smart Watch:

1. Uses the CB2 RISC processor for long battery life
2. Stores up to 20hrs of music
3. Tracks fitness

Download The Factsheet

i. Write the HTML to produce the extract from the webpage above. You can assume it will be placed within the `<body>` tags of a pre-existing page. You do not need to specify the font.

---

[5]

ii. Explain what happens when a search engine indexes the page. You do not need to discuss ranking.

---

[3]

iii. Explain why using a RISC processor rather than a CISC processor is likely to result in increased battery life.

[3]

3(a) An airport holds details of flights in a database using the table `Flight`. An extract of the table is shown below.

FlightID	FlightNumber	DestinationCode	DestinationName	DepartureDate	DepartureTime
1355	OC0089	JFK	John F. Kennedy	03/07/18	09:50
1453	CS1573	LHR	Heathrow	03/07/18	10.30
1921	OC7750	JFK	John F. Kennedy	04/07/18	8.30
1331	AM0045	YHZ	Halifax	04/07/18	14.25
1592	HB0326	RTM	Rotterdam	04/07/18	19.10
1659	CS0123	LHR	Heathrow	04/07/18	07.20

Describe what the SQL statement below does.

```
SELECT FlightNumber FROM Flight WHERE DestinationCode='JFK'
```

---

[2]

(b) The airport cancels all its flights to Heathrow on 4th July 2018.

The SQL statement below shows all the data for flights going to Halifax. Rewrite it so it instead removes all flights to Heathrow on 4th July 2018.

```
SELECT * FROM Flight WHERE DestinationName='Halifax'
```

[3]

(c) Tables often have primary and secondary keys.

i. State why `DestinationCode` would not be a suitable primary key for the `Flight` table.

[1]

ii. State why `DestinationCode` would be a suitable secondary key for the `Flight` table.

[1]

(d) The airline wishes to ensure the database is normalised.

i. Describe why the database can be considered to be in First Normal Form.

[2]

ii. Describe why the database can be considered to be in Second Normal Form.

[2]

iii. Describe why the database can **not** be considered to be in Third Normal form.

[2]

(e) The airport wishes to allow airlines to be able to access the data it has on flights via the internet.

Describe **one** format or method the airport could use to provide the data to the airlines so they can use it in their own applications.

---

[2]

4(a) The internet can be considered an example of a WAN.

Describe what is meant by the term 'WAN'.

---

[2]

(b) The internet uses a set of protocols referred to as the TCP/IP stack. The TCP/IP stack consists of four different layers, each with its own set of protocols.

i. Explain why protocols are important on a network.

---

[2]

ii. State the name of the **four** layers of the TCP/IP stack.

1 ---

2 ---

3 ---

4 ---

[4]

5(a) A software company is producing software that allows users with severe mobility issues to input data into a computer.

The software flashes up letters on the screen one at a time. The user sends a signal to the computer when the letter they want appears on the screen.

State the name of an input device and describe how it could be used by a user with very limited mobility in their hands and arms to send a signal to the computer.

Device name: ----------

How it would be used: ----------

---

[2]

(b) Rather than displaying the whole alphabet, once the first letter has been entered, the program only shows letters that could be possible according to words in its dictionary. All possible words are stored in a tree data structure.

The program is tested on a sample dictionary of four words, represented as a tree in Fig. 3:

```
BARON
BATHS
BELOW
BELTS
```

i. Annotate Fig. 3 to show how the word BELTS would be removed from the tree.

[2]

ii. Annotate Fig. 3 to show how the words BEACH and BONE would be added to the tree.

[2]

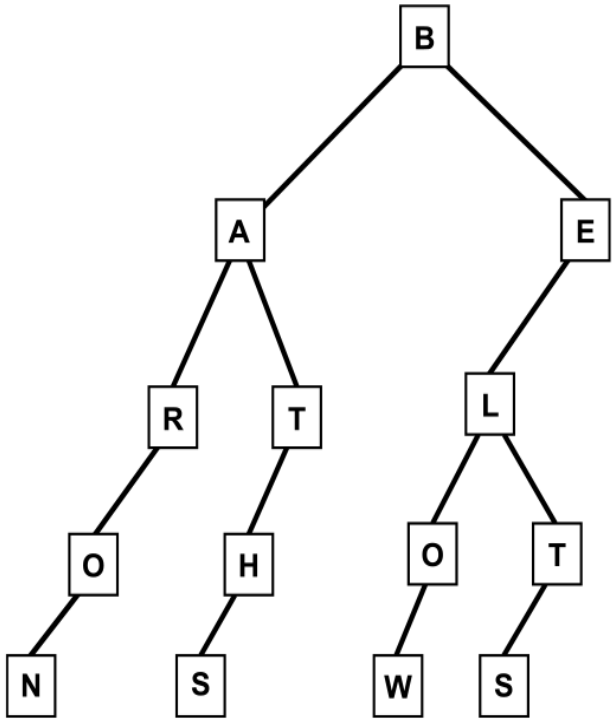

Fig. 3

(c) The developer decides she wants to make the software program open source.

Explain the benefits to the users of the software being open source.

[2]

6 * *'Technology is changing too quickly for the law to keep up.'*

Discuss to what extent you agree with the statement above. In your discussion you should explain which laws regulate the use of technology and how advancements in technology have made the laws difficult to enforce/implement.

[12]

7(a) A taxi firm is investigating replacing its drivers with self-driving cars.

Explain why the self-driving system will use a real-time operating system.

[3]

(b) The code for the self-driving system has been written using an object-oriented programming language.

It recognises obstacles in the road and then classifies them.

The class for `Obstacle` is shown below.

```
public class Obstacle
     private moving //Boolean value
     private distance //Real num ber given in metres
     private direction //Integer given as between 1 and 360 degrees

     public procedure new(givenMoving, givenDistance, givenDirection)
        moving=givenMoving
        distance=givenDistance
        direction=givenDirection
     endprocedure

     public procedure updateDist ance(givenDistance)
             distance=givenDistance
     endprocedure

endclass
```

i. Write a line of code to create an object called `bollard` of type `Obstacle` which is not moving and is 7.8 metres away in a direction of 8 degrees.

---

[2]

ii. Describe an example of encapsulation in the class definition code above.

---

[2]

iii. Describe the advantages of using encapsulation.

[2]

(c) The self-driving program recognises people as a special type of obstacle and the class `Person` should inherit the methods and attributes of `Obstacle`. People are treated like other obstacles except:

- when the `updateDistance` method is called, if the person is more than 2 metres away but is 5 metres (or less) away, the method `Controls.beepHorn()` is called.
- when the person is 2 metres away (or closer), the method `Controls.applyBrakes()` is called as well as `Controls.beepHorn()`.

Complete the class `Person`.

```
class Person
              ------------------------
     public procedure updateDistance(givenDistance)

          ------------------------------------------------------------

          ------------------------------------------------------------

          ------------------------------------------------------------

          ------------------------------------------------------------

          ------------------------------------------------------------

          ------------------------------------------------------------

          ------------------------------------------------------------

          ------------------------------------------------------------

          ------------------------------------------------------------

          ------------------------------------------------------------

          ------------------------------------------------------------

          distance=givenDistance
     endprocedure
endclass
```

[5]

(d) Give **one** advantage and one disadvantage to the customers of the taxi using self-driving cars rather than drivers.

Advantage

Disadvantage

---

[2]

8(a) A student writes a program to apply a symmetric encryption algorithm to work on messages of up to 25 ASCII characters.

Describe what is meant by the term 'ASCII'.

---

[2]

The encryption algorithm works in the following way.

A message of up to 25 characters (spaces and punctuation are not included) is placed in a 5×5 array. Any leftover spaces are filled with random letters. The message I LOVE COMPUTER SCIENCE becomes:

I	L	O	V	E
C	O	M	P	U
T	E	R	S	U
I	E	N	C	E
T	O	W	R	M

The key is a sequence of ten numbers.

In this example we will use `1 2 3 4 5 1 2 3 4 5.` The first 5 numbers state how many spaces the rows 0 to 4 must be rotated right.

A key with the first 5 digits `1 2 3 4 5` would result in

E	I	L	O	V
P	U	C	O	M
R	S	C	T	E
E	N	C	E	I
T	O	W	R	M

The next 5 digits state how many spaces down the columns 0 to 4 should be rotated.

Applying the last 5 digits `1 2 3 4 5` to the grid above would give

T	N	C	O	V
E	O	C	T	M
P	I	W	E	E
R	U	L	R	I
E	S	C	O	M

Part of the pseudocode for the algorithm is written below.

```
global array grid[5,5]
addMessage()
// letters and random letters have been entered
// into the 2D array, grid

for i = 0 to 4
      x = getNextDigitInKey()
      shiftRow(i,x)
next i

for i = 0 to 4
      x = getNextDigitInKey()
      shiftColumn(i,x)
next i

//Now reassemble array back into string.
```

(b) Show the result of running the algorithm on the grid and key below. **[2]**

KEY: 3 3 3 3 3 1 1 1 1 1

T	O	P	S	E
C	R	E	T	M
E	S	S	A	G
E	Y	R	P	L
U	O	G	G	Q

Grid after only the rows are shifted:

Grid after columns have also been shifted:

(c) Write the procedure `shiftRow`.

[4]

(d) * Modern encryption is much stronger than the method described in the first part of this question.
Discuss the impact of modern encryption on society. You should refer to:

- The importance of asymmetric encryption and how it differs from symmetric encryption.
- Different circumstances in which symmetric and asymmetric encryption may be used.

---

[9]

9(a) Demonstrate how the bytes below are added together. Show your working.

01101010
00111111+

[2]

(b) Demonstrate how the bottom byte below is subtracted from the top byte. Show your working.

11001111
00111001 -

[2]

(c) Convert the binary number shown below to hexadecimal.

00110111100001111

[2]

(d) The number below is represented in floating point format with a 5-bit mantissa in two's complement followed by a 3-bit exponent in two's complement. Calculate the denary value of the number, showing your working.

01001 010

[3]

(e) The numbers below are represented in floating point format with a 5-bit mantissa in two's complement followed by a 4-bit exponent in two's complement. Normalise the numbers shown below, showing your working.

00011 0010

[2]

11100 0110

[2]

(f) Show the byte below after having an AND applied with the masking byte.

Byte	1	0	1	1	1	0	0	1
AND	1	1	1	1	1	1	1	1
Result								

[1]

(g) Show the byte below after having an OR applied with the masking byte.

Byte	1	0	1	1	1	0	0	1
OR	1	1	1	1	1	1	1	1
Result								

[1]

10(a)

Draw a logic gate diagram to represent the Boolean expression

$Q \equiv \neg A \vee B$

[2]

(b) Find the Boolean expression represented in the Karnaugh Map below. Show your working.

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

[5]

END OF QUESTION PAPER