EXAM PAPERS PRACTICE

5.2 Number bases

Name: _____

Class: _____

Date: _____

Time: **244 minutes**

Marks: **179 marks**

Comments:

Q1.

(a) Shade **one** lozenge to indicate which of the unsigned numbers listed in the table has the largest value.

Number base	Number	Largest value (shade one)
Binary	101101001	⬭
Hexadecimal	30A	⬭
Decimal	396	⬭

(1)

(b) This question uses a **normalised** floating point representation with a 7-bit mantissa and a 5-bit exponent, both stored using **two's complement**.

The following is a floating point representation of a number:

0 ●	1	0	1	1	0	0

Mantissa

1	1	1	0	1

Exponent

Calculate the decimal equivalent of the number. You **must** show your working.

_____

_____

_____

Answer _____

(2)

(Total 3 marks)

Q2.

Represent the **denary** number 123 in binary using 8 bits.

_____

_____

(Total 1 mark)

Q3.

How many different numbers can be represented using 8-bit binary?

_____

_____

(Total 1 marks)

Q4.

What is the **hexadecimal** equivalent of the **denary** number 123?

_____

_____

_____

_____

(Total 2 marks)

Q5.

Why are bit patterns often displayed using hexadecimal instead of binary?

_____

_____

(Total 1 mark)

Q6.

(a) What is the decimal equivalent of the hexadecimal number $D6_{16}$? Show your working.

_____

_____

_____

_____

(2)

(b) Represent the decimal value 9.375_{10} as an unsigned binary fixed point number, with 4 bits before and 4 bits after the binary point.

_____

_____

_____

_____

(2)

(c) Represent the decimal value -67_{10} as an **8-bit two's complement binary integer.**

_____

_____

_____

_____

(2)

(d) A computer represents numbers using 8-bit two's complement binary.

Using this representation perform the calculation:

01001000_2
01100011_2 +

_____

Answer:

_____

(1)

(e) What problem has resulted from performing the calculation using 8-bit two's complement binary?

_____

_____

(1)

(Total 8 marks)

Q7.

(a) What is the denary equivalent of the hexadecimal number A7?

You may use the space below for rough working. You may get some marks for your working, even if your answer is incorrect.

Answer _____

(2)

(b) Represent the denary value 7.625 as an **unsigned binary fixed point** number, with 4 bits before and 4 bits after the binary point.

Use the space below for rough working.

Answer _____

(2)

(c) Represent the denary value -18 as an **8-bit two's complement binary integer**.

Use the space below for rough working.

Answer _____

(2)

(d) What is the **largest positive denary value** that can be represented using **8-bit two's complement binary**?

Use the space below for rough working.

Answer _____

(1)

(e) Describe how **8-bit two's complement binary** can be used to subtract one number from another number. In your answer you must show how the calculation 23 – 48 would be completed using the method that you have described.

You may use the space below for rough working.

Answer _____

(4)

Figure 1 shows a state transition diagram for a finite state machine (FSM).

Table 1 shows the outputs produced by the finite state machine in **Figure 1** for some possible input strings. Some of the outputs are missing from the table below. Input strings are processed starting with the right-most bit.

Figure 1

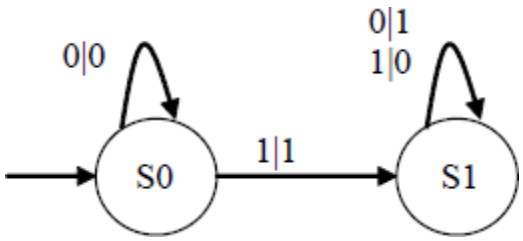


Table 1

Input string	Output string
00010011	11101101
00010010	**(a)**
00010100	11101100
00010101	**(b)**

(f) What output string should be in position **(a)** in the table?

_____

_____ **(1)**

(g) What output string should be in position **(b)** in the table?

_____

_____ **(1)**

(h) What is the purpose of the finite state machine shown in **Figure 1**?

_____

_____ **(1)**

(i) A finite state machine can be represented as a state transition diagram or as a state transition table. **Table 2** is an incomplete state transition table for **Figure 1**.

Complete the **unshaded** cells in the table below.

Table 2

Input	Original state	Output	New state
0	**S0**	**0**	**S0**

1		**1**	**S1**
0	**S1**		**S1**

(3)
(Total 17 marks)

Q8.

(a) Represent the denary number 123 in binary using 8 bits.

Answer _____

(1)

(b) How many different denary numbers can be represented using 8-bit binary?

Answer _____

(1)

(c) What is the hexadecimal equivalent of the denary number 123?

Answer _____

(2)

(d) Why are bit patterns often displayed using hexadecimal instead of binary?

_____

_____

(1)

(Total 5 marks)

Q9.

The diagram below shows the contents of a memory location.

1	0	1	0	0	1	1	1

(a) What is the denary equivalent of the contents of this memory location if it represents an **unsigned binary integer**?

Use the space below for rough working.

Answer _____

(1)

(b) What is the denary equivalent of the contents of this memory location if it represents an **unsigned binary fixed point number**, with 4 bits before and 4 bits after the binary point?

Use the space below for rough working.

Answer _____

(2)

(c) What is the denary equivalent of the contents of this memory location if it represents a **two's complement binary integer**?

Use the space below for rough working.

Answer _____

(2)

(d) What is the **hexadecimal** equivalent of the binary pattern shown in diagram above?

Use the space below for rough working.

Answer _____

(1)

(Total 6 marks)

Q10.

A normalised floating point representation uses an 8-bit mantissa and a 4-bit exponent, both stored using **two's complement format.**

(a) In binary, write the largest positive number that can be represented using this normalised floating point system in the boxes below.

	•										

Mantissa Exponent

(1)

(b) This is a floating point representation of a number.

1	• 0	1	0	1	0	0	0	0	0	1	1

Mantissa Exponent

Calculate the denary equivalent of the number, showing how you have arrived at your answer.

Working: _____

_____

_____

Answer: _____

(2)

(c) Write the normalised floating point representation of the denary value 13.625 in the boxes below. Space has been provided for you to do rough work.

Rough Work: _____

_____

_____

Answer:

●											

Mantissa Exponent

(2)

(d) Write the normalised floating point representation of the denary value 0.34375 in the boxes below. Space has been provided for you to do rough work.

Rough Work: _____

_____

_____

Answer:

●											

Mantissa Exponent

(2)

(e) Explain what overflow is and give an example of a situation which might cause overflow to occur.

_____

_____

_____

_____

_____ **(3)**

(Total 10 marks)

Q11.

The binary pattern 1001 1000 0100 can be interpreted in a number of different ways.

(a) Convert the binary pattern to hexadecimal.

_____

(1)

(b) What is the decimal value if this binary pattern represents BCD?

_____

(1)

(c) The above binary pattern represents a normalised two's complement floating point number with an **eight** bit mantissa followed by a **four** bit exponent.

(i) State its value in **denary**.

_____

_____

_____

(3)

(ii) Give **one** reason for storing floating point numbers in normalised form.

_____

_____

(1)

(iii) How does the above binary pattern indicate that the floating point number is normalised?

_____

(1)

(iv) What is the largest positive denary number that can be stored using this representation?

_____

_____

(2)

(Total 9 marks)

Q12.

A programming language has two different data types for storing positive integers.

Data type `Integer1` uses a single byte to store data.

Data type `Integer2` uses two consecutive bytes to store data.

(a) The program statement below defines a variable `NoOfAccidents`.

```
Var NoOfAccidents : Integer1 ;
```

What is the largest value which can be assigned to `NoOfAccidents`?

_____

(1)

(b) Two more program statements are:

```
Var JourneyMileageA : Integer1 ;

Var JourneyMileageB : Integer1 ;
```

Interpreter software uses address 600 for storing a value for JourneyMileageA. See **Figure 1.**

Figure 1

Address	Contents
600	0101 0001
601	1010 1010
602	1111 1100
603	
604	
~	~
~	~
700	0000 0010
701	0000 1010
702	
703	

(i) State the **denary value** for the stored binary value.

`JourneyMileageA =`_____

(1)

(ii) The program statement:

```
JourneyMileageB := 138 ;
```

stores the data value for `JourneyMileageB` at address 603.

What **binary value** will be stored at location 603?

_____

(1)

(c) Another program statement is:

```
Var TotalMileage : Integer2 ;
```

The interpreter software uses locations 700 and 701 to store a value for `TotalMileage` with the most significant byte stored at location 700. See **Figure 1.**

What is the **denary value** assigned to `TotalMileage`?

_____

(1)

(d) Programs also work with character data.

ASCII Code Table

Character	Decimal	Character	Decimal	Character	Decimal
<space>	32	I	73	R	82
A	65	J	74	S	83
B	66	K	75	T	84
C	67	L	76	U	85
D	68	M	77	V	86
E	69	N	78	W	87
F	70	O	79	X	88
G	71	P	80	Y	89
H	72	Q	81	Z	90

(i) Using the ASCII code table shown above, what is the **7-bit binary ASCII** code for character 'B'?

_____

(1)

(ii) When a parity bit is included, character codes are stored as 8-bit binary numbers where the most significant bit is a parity bit. This system will use **even parity.**

Describe how the parity bit is used during data transmission of a single character.

_____

_____

_____

(2)

(Total 7 marks)

Q13.

The table below shows the contents of three memory locations.

Address	Memory contents
56	0011 0111
57	1000 1001
58	1100 0000

If the binary codes each represent a pure binary integer, what are the denary numbers

stored at locations 56 and 57?

Address	Memory contents	Denary
56	0011 0111	
57	1000 1001	

(Total 2 marks)

Q14.

Figure 1 below shows an area of main memory storing a text file which is about to be sent to a printer.

Address	Contents
0	
1	
...	
...	
150	0100 0101
151	0101 1000
152	0100 0001
153	0100 1101

Table 1

ASCII Code Table

Character	Decimal	Character	Decimal	Character	Decimal
<Space>	32	I	73	R	82
A	65	J	74	S	83
B	66	K	75	T	84
C	67	L	76	U	85
D	68	M	77	V	86
E	69	N	78	W	87
F	70	O	79	X	88
G	71	P	80	Y	89

H	72	Q	81	Z	90

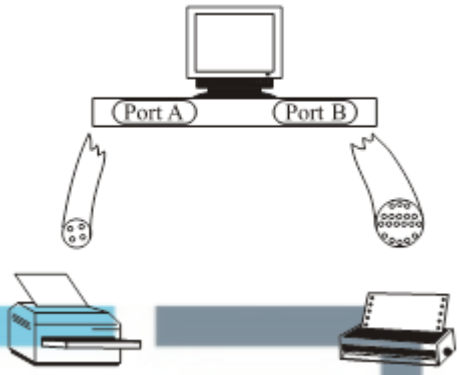
(a) Assuming the first character to be printed is held at address 150, show the **first four** characters to be printed on the page. Use **Table 1.**

_____

(3)

(b) **Figure 2** shows there are two printers available on the PC and they are connected to the computer. One is connected to port A, the other to port B.

Figure 2



The cable which connects to port A has 4 wires and connects to a USB printer.

The cable which connects to port B has 25 wires of which eight are used for sending data bits.

(i) What does USB stand for?

_____

(1)

(ii) What type of data transmission occurs using Port B?

_____

(1)

(iii) The computer communicates with the printer connected to port B using a **handshaking protocol.** Explain this term.

_____

_____

_____

_____

(2)

(iv) The port B cable uses 8 wires for data bits. Using a handshaking protocol, the other wires are used to send various signals. Name **one** signal.

_____

(1)

(v) **Figure 1** shows the first four bytes of the text file to be printed. Name **two** necessary items of software resident in main memory at the time the printout is produced.

1. _____

2. _____

(2)

(Total 10 marks)

Q15.

(a) Convert the denary values 27 and –19 into 8-bit binary integers using two's complement format.

27									
–19									

(3)

(b) Add together your **two** 8-bit binary values.

27									
–19									
Result									

(2)

(c) The result has an additional bit.

(i) Give the name of this bit _____

(1)

(ii) How can it be used? _____

_____

(1)

(d) State your binary values for 27 and –19 in Hexadecimal.

27_____

–19_____

(2)

(Total 9 marks)

Q16.

The figure below shows the main memory and processor of a computer system. Data moves between these **two** components along the data bus which uses parallel data

transmission.

(a) (i) Show the binary representation for the denary value 59.

_____

(1)

(ii) Add to the diagram in the figure an 8-bit data bus connecting the components showing the value 59 in its binary form being transferred from the main memory to the processor.

(2)

(b) Give **three** possible interpretations of the byte being read in part (a) (ii).

1. _____

2. _____

3. _____

(3)

(Total 6 marks)

Q17.

The binary pattern 1001 0111 0100 can represent different numbers.

(a) State its hexadecimal representation.

_____

(1)

(b) State its value in denary if it represents an unsigned fixed point number with four bits after the binary point.

_____

(2)

(c) State its value in denary if it represents a two's complement fixed point number with four bits after the binary point.

_____

_____

(2)

(d) (i) State its value in denary if it represents a normalised two's complement floating point number with an eight bit mantissa followed by a four bit

exponent.

_____

_____

_____

(3)

(ii) Give a reason for storing floating point numbers in normalised form.

_____

_____

(1)

(Total 9 marks)

Q18.

The binary pattern 1000 1100 0100 can be interpreted in a number of different ways.

(a) State its value in **denary** if it represents an unsigned fixed point number with four bits after the binary point.

_____

(2)

(b) (i) State its value in **denary** if it represents a two's complement floating point number with an eight bit mantissa followed by a four bit exponent.

_____

(3)

(ii) The floating point number 1000 1100 0100 is said to be normalised.

How does the bit pattern indicate that this number is normalised?

_____

_____

(1)

(iii) Why should floating point numbers be stored in normalised form?

_____

_____

(1)

(Total 7 marks)

Q19.

The contents of a computer word is shown in a debugger as &D15A, where the symbol '&' denotes a hexadecimal number.

(a) What binary pattern does this represent?

_____

(2)

(b) If this represents a memory address, how many address lines will the system bus require if it is to convey the binary equivalent of &D15A?

_____

(1)

(Total 3 marks)

Q20.

The binary pattern 1011 1110 0100 could be interpreted in a number of different ways.

(a) State its hexadecimal representation.

_____

(1)

(b) State its value in denary if it represents an unsigned fixed point number with four bits after the binary point. Use the space below to show your working.

_____

(3)

(c) State its value in denary if it represents a two's complement integer.

_____

(2)

(d) The system stores floating point numbers in *normalised form* using 2's complement, with an 8-bit mantissa and a 4-bit exponent as follows.

(i) State the value of 1011 1110 0100 in denary if it represents a two's complement floating point number. Use the space below to show your working.

_____

(3)

(ii) This floating point number is said to be normalised.

How does the bit pattern indicate that this number is normalised?

_____

_____

(1)

(Total 10 marks)

Q21.

(a) A system stores integers in **16 bits**. Using binary representation, show the steps of subtracting 6 from 18, using two's complement.

_____

_____

_____

_____

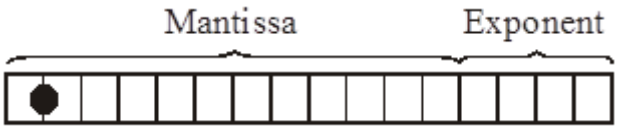
_____

_____

_____

(4)

(b) The system stores floating point numbers in *normalised form* using 2's complement with a 12-bit mantissa and a 4-bit exponent as follows.



(i) A floating point number is stored in main memory at symbolic address Num1. Complete the table below, showing the contents of the memory location using binary notation and the value in decimal.

Symbolic Address	Hexadecimal Representation	Binary Representation	Decimal Value
Num1	A802		

(4)

(ii) Why should floating point numbers be stored in normalised form?

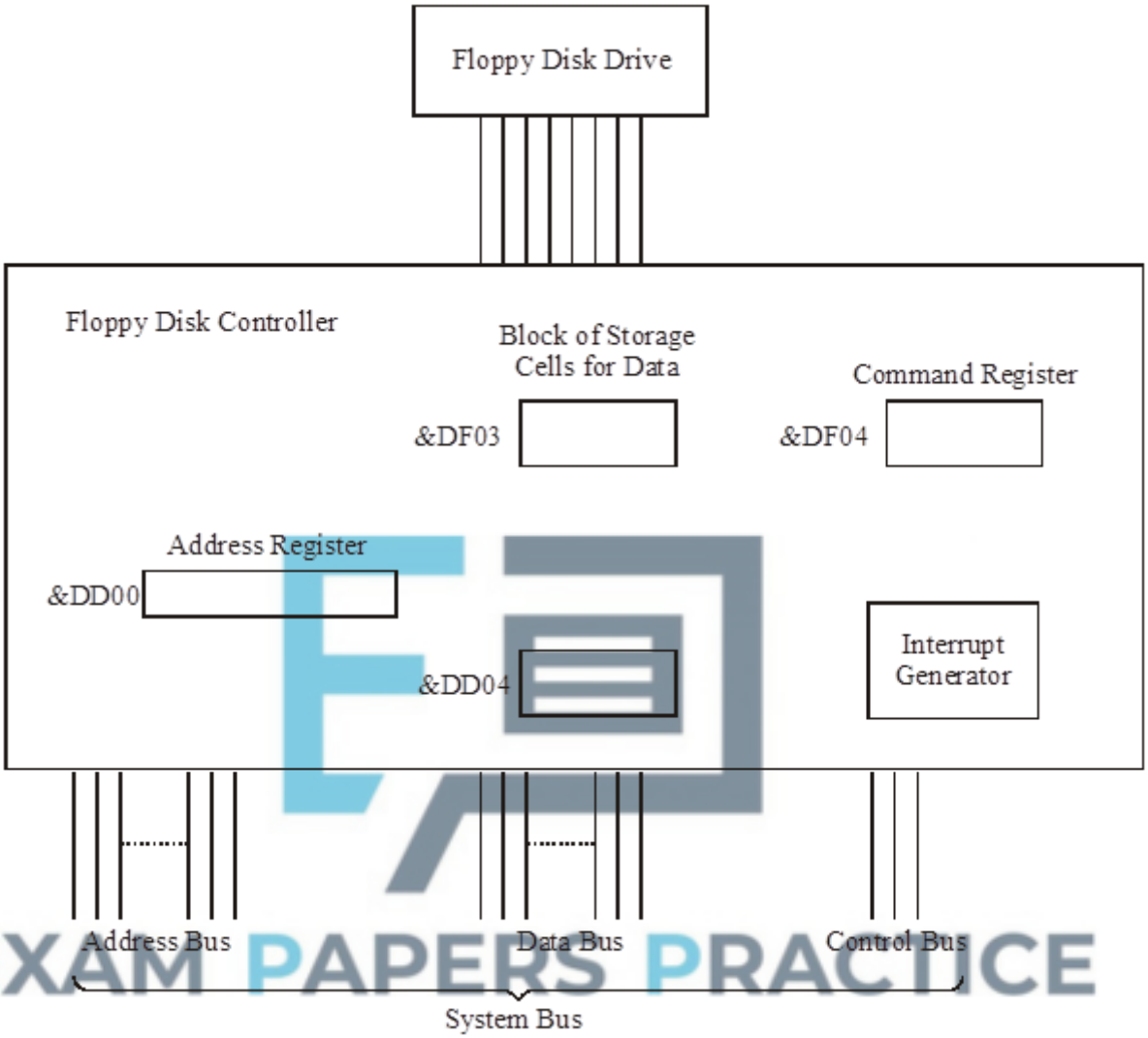
_____

_____

(1)

(Total 9 marks)

Q22.



The above diagram shows a simplified view of a floppy disc controller. A processor connected to the system bus uses this bus to move and control movement of binary words to and from the set of registers and storage cells (buffer) in the floppy disk controller.

Each register and each storage cell in the floppy disk controller has a unique machine address. For example, the command register has the machine address &DF04. The symbol '&' denotes a hexadecimal number.

(i) Translate &DD00 into denary.

_____

_____

(1)

(ii) How many bits are required to represent &DD00 in binary?

_____

(1)

(iii) How many address lines will the system bus require if it is to convey the binary equivalent of &DD00?

_____

(1)

(iv) Calculate the number of data cells from addresses &DD04 to &DF03, inclusive, in the floppy disk controller.

_____

_____

(1)

(Total 4 marks)

Q23.

A *recursively-defined* procedure B, which takes an integer as its single parameter, is defined below. The operators DIV and MOD perform integer arithmetic.
x DIV y calculates how many times y divides exactly into x. For example 7 DIV 3 = 2
x MOD y calculates the remainder that results. For example 7 MOD 3 = 1.

```
Procedure B (Number)
  If (Number = 0) OR (Number = 1)
    Then Print (Number)
    Else
     B (Number DIV 2)
     Print (Number MOD 2)
  EndIf
EndProcedure
```

(a) What is meant by recursively-defined?

_____

_____

(1)

(b) Why is a stack necessary to execute procedure B recursively?

_____

_____

(1)

(c) Dry run the procedure call *B(53)* showing clearly the values of the parameter and the printed output for the six calls of *B*.

Call Number	Parameter
1	53
2	26
3	13

4	
5	
6	

Printed Output: _____

(6)

(d) What process does procedure B describe? _____

(1)

(Total 9 marks)

Q24.

(a) (i) Convert the hexadecimal number BD93 to binary.

_____

(1)

(ii) The contents of register A is 1011 1010 0000 0011.
These bits are a representation of a number in twos complement, with the leftmost 10 bits as the mantissa and the rightmost 6 bits as the exponent.

Convert this number into decimal. Show your working.

_____

(3)

(b) Give **two** reasons why floating point numbers are normalised.

1. _____

_____

2. _____

_____

(2)

(Total 6 marks)

Q25.

Bit patterns can be interpreted in a number of different ways. A computer word contains the bit pattern 0011 0110.

(a) What is its decimal value if it represents a pure binary integer

_____

(1)

(b) (i) The ASCII value for the character '2' is 50. What is the character stored in the computer word 0011 0100?

_____

(2)

(ii) Name **one** other standard coding system for coding information expressed in character or text-based form.

_____

(1)

(c) One method of storing graphics in a computer system is as vector graphics.

(i) Name **one** other method.

_____

(1)

(ii) Describe how a black-and-white image would be stored using your method.

_____

_____

_____

_____

(2)
(Total 7 marks)

Q26.

The operators DIV and MOD perform integer arithmetic.
x DIV y calculates how many times y divides into x, for example 7 DIV 3 = 2.
x MOD y calculates the remainder that results after the division, for example 7 MOD 3 = 1.

(a) The following algorithm uses an array Result. Dry run this algorithm by completing the trace table below.


```
x ← 5
Index ← 0
REPEAT
    y ← x MOD 2
    x ← x DIV 2
    Index ← Index + 1
    Result[Index] ← y
UNTIL x = 0
```

y	x	Index	Result		
			[3]	[2]	[1]
–	5	0	–	–	–
1	2	1	–	–	1

(6)

(b) What is the purpose of this algorithm?

_____

(1)

(Total 7 marks)

Q27.

(a) A binary pattern might represent a decimal *integer* or a decimal *real number.* In a computing context, give an example of

(i) a decimal integer _____

(ii) a decimal real number _____

(iii) The binary data 00110111 represents an unsigned real number in fixed point form, with the binary point between bits 1 and 2, e.g. 1101.11. Convert this number into decimal, showing all your working.

(4)

(b) Convert the binary data 10110111 00111110 into hexadecimal.

(1)

(c) Give **one** example of where hexadecimal numbers are used, and explain why they are used here rather than binary numbers.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q28.

Convert the binary number 01001110 into

(a) hexadecimal,

_____

(1)

(b) denary.

_____

(1)

(Total 2 marks)

Q29.

Convert the denary value 61 into

(a) binary,

_____

(1)

(b) hexadecimal.

_____

(1)

(Total 2 marks)