Past-paper walk-through

Number systems ▪ 1.1

eXercise

Questions in this set

- 0478/12 N25 Q1 ▪ 13 marks
- 0478/12 N25 Q2 ▪ 7 marks
- 0478/12 M25 Q1 ▪ 11 marks
- 0478/12 N24 Q3 ▪ 13 marks
- 0478/11 J24 Q2 ▪ 4 marks
- 0478/11 J24 Q3 ▪ 5 marks
- 0478/12 J24 Q3 ▪ 11 marks
- 0478/12 M24 Q8 ▪ 7 marks
- 0478/12 M24 Q1 ▪ 8 marks
- 0478/12 N23 Q2 ▪ 10 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 1

0478/12 N25 ▪ Q1 ▪ 13 marks

A toy store gives each of the toys it sells a unique code. The codes are 3-digit hexadecimal codes, for example A4B.

A computer is used to store a database of the codes. The computer has 12-bit registers.

(a) Give the largest hexadecimal number that can be stored in a 12-bit register. **[1]**

Question 1

0478/12 N25 ▪ Q1 ▪ 13 marks

A toy store gives each of the toys it sells a unique code. The codes are 3-digit hexadecimal codes, for example A4B.

A computer is used to store a database of the codes. The computer has 12-bit registers.

(b) Give the largest denary number that can be stored in a 12-bit register. **[1]**

Question 1

0478/12 N25 ▪ Q1 ▪ 13 marks

A toy store gives each of the toys it sells a unique code. The codes are 3-digit hexadecimal codes, for example A4B.

A computer is used to store a database of the codes. The computer has 12-bit registers.

(c) Two toys have the hexadecimal codes 429 and 1A3.

Convert the **two** hexadecimal codes to 12-bit binary numbers.

429 1A3 **[2]**

Question 1

0478/12 N25 ▪ Q1 ▪ 13 marks

A toy store gives each of the toys it sells a unique code. The codes are 3-digit hexadecimal codes, for example A4B.

A computer is used to store a database of the codes. The computer has 12-bit registers.

(d) Two binary numbers that are stored in the registers are 100010100001 and 011100001011.

Convert the **two** binary numbers to hexadecimal numbers.

100010100001 011100001011 **[2]**

Question 1

0478/12 N25 ▪ Q1 ▪ 13 marks

A toy store gives each of the toys it sells a unique code. The codes are 3-digit hexadecimal codes, for example A4B.

A computer is used to store a database of the codes. The computer has 12-bit registers.

(e)(i) Identify the name of the item of hardware. **[1]**

(e)(ii) Tick (✓) **one** box to show whether a barcode scanner is a type of input, output, process or storage device. **[1]**

A input

B output

C process

D storage

Question 1

(e)(iii) The barcode scanner contains a sensor.
Identify the type of sensor that the barcode scanner could contain. **[1]**
(e)(iv) A backup of the database is made at the end of each day using optical storage.
Describe how the database is written to the optical storage. **[4]**

Solution 1

(a)

Mark scheme

- FFF

Solution 1

(b)

Mark scheme

- 4095

Solution 1

(c) Worked steps

Hexadecimal and binary convert **one hex digit to four bits** — a nibble — because $16 = 2^4$. Take the digits one at a time and never go through denary.

- `429`: 4 → 0100, 2 → 0010, 9 → 1001, giving **0100 0010 1001**
- `1A3`: 1 → 0001, `A` → 1010, 3 → 0011, giving **0001 1010 0011**

Three digits give exactly **12 bits**, which is what the question asked for — so the leading zeros are part of the answer, not decoration. Writing 100 0010 1001 is a 11-bit number and loses the mark.

Solution 1

The four values worth having memorised are the nibble weights, **8 4 2 1**. Every hex digit is a subset of those: `A` is 10, so $8 + 2$, so 1010.

Mark scheme

- 0100 0010 1001
- 0001 1010 0011

Solution 1

(d) Worked steps

The reverse, and just as mechanical: group the bits in **fours from the right**, and convert each group.

- `1000 1010 0001` → `8, A, 1` → **`8A1`**
- `0111 0000 1011` → `7, 0, B` → **`70B`**

Twelve bits give exactly three groups, so nothing is left over. When a bit count is not a multiple of four, pad on the **left** with zeros — padding on the right multiplies the number by a power of two.

Solution 1

Use uppercase letters, and remember $\texttt{A} = 10$ through $\texttt{F} = 15$. The group $\texttt{1011}$ is $8 + 2 + 1 = 11 = \texttt{B}$, and the middle group of all zeros is still a digit: dropping it turns $\texttt{70B}$ into $\texttt{7B}$.

Mark scheme

- 8A1
- 70B

Solution 1

(e)(i)

Mark scheme

- Microprocessor

(e)(ii)

Mark scheme

- A

(e)(iii)

Mark scheme

- Light

Solution 1

(e)(iv)

Mark scheme

- Any four from:
- - The disk is spun
- - A laser is shone onto the disk
- - Pits are burnt into the disk
- - Pits are in a (spiral) track
- - Pits and lands represent binary values

Question 2

0478/12 N25 ▪ Q2 ▪ 7 marks

Two binary numbers are stored in a computer.

(a) Add the **two** binary numbers using binary addition.
Give your answer in binary. Show all of your working.

$$\begin{array}{rr} & 11110101 \\ + & 00111001 \end{array}$$

Question 2

[4]

(b) A logic right shift of **three** places is performed on the binary number 11110101. Give the denary number for the binary number that would be stored after the logical shift of **three** places has occurred. Show all of your working. **[3]**

Solution 2

(a) Worked steps

Add column by column from the right, carrying into the next column — the same procedure as denary, except that the carry happens at 2.

- $0 + 0 = 0$
- $0 + 1 = 1$
- $1 + 1 = 0$, **carry 1**
- $1 + 1 + 1 = 1$, **carry 1**

Four marks, and they are for four different things: **one mark per correct nibble** (so two), **one for the working** — four or five carries written in — and **one for showing the overflow**.

Two of those four are lost by candidates who get the arithmetic right:

Solution 2

- **Write the carries down.** They are a mark of their own, and an answer with no working cannot be given partial credit if one column slips.
- **Say "overflow".** Two 8-bit numbers can sum to nine bits, and the ninth has nowhere to go in an 8-bit register. Label it as an overflow rather than silently dropping it or writing a nine-bit answer — the register holds the low eight bits, and the flag is what records that the result is wrong.

Mark scheme

- One mark for each correct nibble 2
- One mark for a correct method of working for example 4 or 5 correct carries
- One mark for showing an overflow error

Solution 2

- (1) 111 1
- 11110101
- $+$
- 00111001
- 1
- 0010 1110

Solution 2

(b) Worked steps

A **logical** shift fills the vacated bits with **zeros**, whatever the sign bit is — that is the difference from an arithmetic shift.
Shifting 1111 0101 right three places:

- one place: 0111 1010
- two places: 0011 1101
- three places: 0001 1110

Then convert to denary using the place values 128 64 32 16 8 4 2 1:

Solution 2

- $0001\ 1110 = 16 + 8 + 4 + 2 = \mathbf{30}$

Three marks: showing the **binary after the shift**, a **valid method** for converting it, and the **correct denary number**. So write down all three stages — the shifted binary, the sum of place values, and the total.

Solution 2

Each right shift **halves** the value, discarding any remainder. 1111 0101 is 245, and $245 \div 8 = 30.6$, which truncates to 30 — a quick check on the answer.

Mark scheme

- One mark for showing the binary number after the shift
- One mark for valid method of working to convert to denary
- One mark for correct denary number
- - 00011110
- - 16 + 8 + 4 + 2
- - 30

Question 1

0478/12 M25 ▪ Q1 ▪ 11 marks

(a) Complete the sentences about number systems.
Use the items from the list.
Some of the items in the list will **not** be used. You should only use an item once.

- A
- B
- C
- D
- E
- F
- G

Question 1

- H
- W
- X
- Y
- Z
- 0
- 1
- 2
- 4
- 8
- 10

Question 1

- 16
- 127
- 128
- 255
- 256

The binary number system is base ___. The smallest denary number that can be represented as an 8-bit binary number is ___. The largest denary number that can be represented as an 8-bit binary number is ___.

The hexadecimal number system is base ___. Each hexadecimal digit is equivalent to ___ bits. The numbers 1 to 9 are used and the number 10 is represented by ___. The hexadecimal number system continues up to the number 15, which is represented by ___. **[7]**

Question 1

0478/12 M25 ▪ Q1 ▪ 11 marks

(b) Two 8-bit binary numbers are given.
Add the two 8-bit binary numbers using binary addition.
Give your answer in binary. Show all your working.

$$\begin{array}{r} 1\ 0\ 0\ 1\ 1\ 0\ 1\ 1 \\ +\ 0\ 0\ 0\ 1\ 0\ 0\ 1\ 1 \\ \hline \end{array}$$

[3]

Question 1

0478/12 M25 ▪ Q1 ▪ 11 marks

(c) Binary addition can result in overflow.

Tick (✓) **one** box to show the correct definition of overflow in binary addition. **[1]**

A The answer has created a negative number that cannot be represented in binary addition.

B The answer is the result of a logical shift that cannot be performed in binary addition.

C The answer is too large to represent in the number of bits available.

D The answer is too small to represent in the number of bits available.

Solution 1

(a)

Mark scheme

- 1 mark for each correct item (in bold)
- The binary number system is base 2. The smallest denary number that can be represented an 8-bit binary number is 0. The largest denary number that can be represented an 8-bit binary number is 255.
- The hexadecimal number system is base 16. Each hexadecimal digit is equivalent to 4 bits. The numbers 1 to 9 are used and the number 10 is represented by A. The hexadecimal number system continues up to the number 15, which is represented by F.

Solution 1

(b) Worked steps

Add column by column from the right, carrying at 2 rather than at 10:

- $0+0=0$, $0+1=1$, $1+1=0$ **carry 1**, $1+1+1=1$ **carry 1**.

Three marks: **one for the working** and **one for each correct nibble**.
The working mark is the one to secure first, because it does not depend on getting the sum right. Write the carries in their own row above the columns — a row of small 1s over the columns they carry into — and keep the digits in straight vertical columns.

Two checks worth making before you leave it:

Solution 1

- **Convert both numbers to denary and add them there.** If the two totals disagree, one column has slipped, and you will know which by comparing nibbles.
- **Watch for a ninth bit.** Two 8-bit numbers can sum to nine, and if one appears it is an **overflow** — say so rather than writing a nine-bit answer.

Solution 1

Mark scheme

- 1 mark for correct working, 1 mark for each correct nibble
- For example:
- 1 0 0 1 1 0 1 1
- $+$ 0 0 0 1 0 0 1 1
- 1 0 1 0 1 1 1 0
- 1 1 1

Solution 1

(c)

Mark scheme

- C

Question 3

0478/12 N24 ▪ Q3 ▪ 13 marks

A user enters data that is hexadecimal into a computer system. The data is converted to binary to be processed by the computer.

(a)(i) Give **one** similarity between hexadecimal and binary. **[1]**

(a)(ii) Give **two** differences between hexadecimal and binary.

1. 2. **[2]**

Question 3

0478/12 N24 ▪ Q3 ▪ 13 marks

A user enters data that is hexadecimal into a computer system. The data is converted to binary to be processed by the computer.

(b) Data that is denary can also be converted to binary.

Give the binary number for each of the **three** denary numbers.

15 180 235 **[3]**

Question 3

0478/12 N24 ▪ Q3 ▪ 13 marks

A user enters data that is hexadecimal into a computer system. The data is converted to binary to be processed by the computer.

(c) Denary numbers can also be converted to hexadecimal.

Give the hexadecimal number for each of the **three** denary numbers.

14 100 250 **[3]**

Question 3

0478/12 N24 ▪ Q3 ▪ 13 marks

A user enters data that is hexadecimal into a computer system. The data is converted to binary to be processed by the computer.

(d)(i) Describe the process of the logical left shift that is performed on the binary integer. **[2]**

(d)(ii) State what effect this will have on the binary integer. **[1]**

Question 3

0478/12 N24 ▪ Q3 ▪ 13 marks

A user enters data that is hexadecimal into a computer system. The data is converted to binary to be processed by the computer.

(e) A negative binary integer needs to be stored in a register in the computer.
Give the name of the number system that can be used to represent negative binary integers. **[1]**

Solution 3

(a)(i)

Mark scheme

- They are both number systems

(a)(ii)

Mark scheme

- - Binary is base-2 whereas hexadecimal is base-16
- - Binary only uses numbers whereas hexadecimal also uses letters // Binary only uses 0 and 1 whereas hexadecimal uses 0 to 9/A to F

Solution 3

(b)

Mark scheme

- - (0000)1111
- - 10110100
- - 11101011

Solution 3

(c)

Mark scheme

- E
- 64
- FA

Solution 3

(d)(i)

Mark scheme

- Any two from:
- ▪ Each/All/Every value/digit/bit in the binary number is shifted/moved to the left
- ▪ The left most/most significant bit is lost
- ▪ A 0 is added as the right most/least significant bit

Solution 3

(d)(ii)

Mark scheme

- The binary integer is multiplied by 2

Solution 3

(e)

Mark scheme

- Two's complement

Question 2

0478/11 J24 ▪ Q2 ▪ 4 marks

Hypertext markup language (HTML) colour codes can be represented as hexadecimal.

(a) Tick (✓) **one** box to show which statement about the hexadecimal number system is incorrect. **[1]**

A	It uses the values 0 to 9 and A to F.
B	It can be used as a shorter representation of binary.
C	It is a base 10 system.
D	It can be used to represent error codes.

Question 2

0478/11 J24 ▪ Q2 ▪ 4 marks

Hypertext markup language (HTML) colour codes can be represented as hexadecimal.

(b) Denary numbers can be converted to hexadecimal.

Convert the **three** denary numbers to hexadecimal.

20 32 165 **[3]**

Solution 2

A It uses the values 0 to 9 and A to F.

B It can be used as a shorter representation of binary.

C It is a base 10 system. ✓

D It can be used to represent error codes.

Answer: **C**

Question 3

0478/11 J24 ▪ Q3 ▪ 5 marks

The binary number 10100011 is stored in random access memory (RAM).

A logical left shift of **three** places is performed on the binary number.

(a) Give the 8-bit binary number that will be stored after the shift has taken place. **[1]**

Question 3

0478/11 J24 ▪ Q3 ▪ 5 marks

The binary number 10100011 is stored in random access memory (RAM).

A logical left shift of **three** places is performed on the binary number.

(b) Tick (✓) **one** box to show which statement about a logical left shift of **two** places is correct. **[1]**

A It would divide the binary number by 2.

B It would multiply the binary number by 2.

C It would divide the binary number by 4.

D It would multiply the binary number by 4.

Question 3

0478/11 J24 ▪ Q3 ▪ 5 marks

The binary number 10100011 is stored in random access memory (RAM).

A logical left shift of **three** places is performed on the binary number.

(c) 10100011 can be stored as a two's complement integer.

Convert the two's complement integer 10100011 to denary. Show all your working. **[2]**

Question 3

0478/11 J24 ▪ Q3 ▪ 5 marks

The binary number 10100011 is stored in random access memory (RAM).

A logical left shift of **three** places is performed on the binary number.

(d) The binary number is measured as a byte because it has 8 bits.

State how many bytes there are in a kibibyte (KiB). **[1]**

Solution 3

(a)

Mark scheme

- 00011000

Solution 3

(b)

Mark scheme

- D

Solution 3

(c) Worked steps

The leading bit is **1**, so the number is negative and the place values cannot simply be added up. Use **flip and add one**:

1. **Invert every bit** of 1010 0011 $\rightarrow$ 0101 1100.
2. **Add one** $\rightarrow$ 0101 1101.
3. Read that as an ordinary binary number: $64 + 16 + 8 + 4 + 1 =$ **93**.
4. Put the sign back: the answer is **−93**.

Two marks: one for the **working** and one for the **answer**, so the flip and the add-one both have to appear on the page.

Solution 3

The alternative route, which is quicker once trusted, is to treat the **top bit as −128**:

- $-128 + 32 + 2 + 1 = -93$

Both are accepted, and doing one as a check on the other costs a single line.

Solution 3

The mistake to avoid is reading 1010 0011 as 163 and then writing a minus sign in front of it. The sign bit is not a separate flag — it carries a place value of its own, which is exactly what "two's complement" means.

Mark scheme

- One mark for correct working
- Example: Flip and add
- One mark for correct answer: -93

Solution 3

(d)

Mark scheme

- 1024

Question 3

0478/12 J24 ▪ Q3 ▪ 11 marks

Binary is a base 2 number system.

(a) Give the name of the number system that is base 16. **[1]**

(b)(i) Give the binary number that would be stored for each of the denary numbers.
10 50 201 **[3]**

(b)(ii) Explain why the data is converted to binary by the computer. **[2]**

(c) The two binary integers 00110000 and 01100110 are added together.
Add the binary integers using binary addition and show your answer in binary. Show all your working. **[3]**

(d) The denary integer -32 is stored as a two's complement integer.
Calculate the two's complement integer that would be stored.
Show all your working. **[2]**

Solution 3

(a)

Mark scheme

- Hexadecimal

Solution 3

(b)(i)

Mark scheme

- 1010
- 110010
- 11001001

Solution 3

(b)(ii)

Mark scheme

- Two from:
- ▪
- Computers use logic gates/switches ...
- ▪
- ... that only process the values 1 and 0 // that only have two states

Solution 3

(c) Worked steps

Add column by column from the right, carrying at 2.
Three marks: **one for evidence of working** — for example two carries written in — and **one for each correct nibble**.
The working mark is independent of the answer, so write the carries down first, in their own row above the columns. Keeping the digits in straight vertical columns is what prevents the single most common error, which is adding two bits that are not actually in the same place.

Solution 3

Check by converting both numbers to denary, adding there, and converting the total back. Any disagreement points straight at the column where the carry went astray.

Mark scheme

- One mark for evidence of working, for example 2 carries
- One mark for each correct nibble (Max 2)
- 1 1
- 0 0 1 1 0 0 0 0
- 0 1 1 0 0 1 1 0
- 1 0 0 1 0 1 1 0

Solution 3

(d) Worked steps

Negative numbers are stored in **two's complement**, and the procedure is always the same three steps:

1. Write the **magnitude** in 8 bits: $32 = \texttt{0010 0000}$.
2. **Invert every bit**: `1101 1111`.
3. **Add one**: `1110 0000`.

So -32 is **`1110 0000`**.

Two marks: one for the **working** and one for the **binary answer**, so all three steps belong on the page.

Solution 3

Two checks. The result must start with **1**, because it is negative. And adding it to the positive form should give eight zeros with the carry falling off the end: $0010\ 0000 + 1110\ 0000 = (1)\ 0000\ 0000$. ✓

Mark scheme

- One marking for evidence of working
- For example, flip and add
- One mark for correct binary
- 11100000

Question 8

0478/12 M24 ▪ Q8 ▪ 7 marks

(a)(i) Convert the denary number 236 into hexadecimal. **[1]**

(a)(ii) Give **one** benefit of using hexadecimal instead of binary to represent data. **[1]**

(b)(i) Convert the two's complement integer 10110111 into denary.
Show all your working. **[2]**

(b)(ii) Convert the denary number 45 into an 8-bit two's complement integer. **[1]**

(c) Logical shifts are performed on binary integers.
State the mathematical effect of a right shift of **four** places on a positive binary integer. **[2]**

Solution 8

(a)(i) Worked steps

Go **through binary** rather than dividing by 16.

- $236 = 128 + 64 + 32 + 8 + 4 = 1110\ \ 1100$
- Split into nibbles: $1110 = 14 = \mathbf{E}$, $1100 = 12 = \mathbf{C}$
- So 236 is `EC`

Solution 8

Check by expanding in base 16: $14 \times 16 + 12 = 224 + 12 = 236.$ ✓

Mark scheme

- EC

Solution 8

(a)(ii)

Mark scheme

- Any one from:
- ▪ Easier for humans to read/remember
- ▪ Shorter for humans to enter
- ▪ Less likely for humans to make mistakes
- ▪ Easier for humans to spot errors/debug
- ▪ Takes up less space onscreen

Solution 8

(b)(i) Worked steps

The leading bit is 1, so `1011 0111` is negative. **Flip and add one**:

1. Invert: `0100 1000`
2. Add one: `0100 1001`
3. Read it: $64 + 8 + 1 = \mathbf{73}$
4. Restore the sign: $\mathbf{-73}$

Two marks — one for the working, one for the answer — and the question says *show all your working*, so the inverted value and the add-one both have to appear.

Solution 8

The alternative is to give the top bit a place value of **−128**: $-128+32+16+4+2+1=-73$. Either method scores; using one to check the other is free.

Mark scheme

- One mark for working, one mark for answer
- - e.g. showing flip and add 1
- $10110111 = 01001001$
- - −73

Solution 8

(b)(ii) Worked steps

Positive numbers need no complementing at all — an 8-bit two's complement integer that is positive is just the ordinary binary, with a **0** in the top bit.

- $45 = 32 + 8 + 4 + 1 = \texttt{0010 1101}$

Solution 8

Check the range before writing anything down: 8-bit two's complement holds -128 to $+127$, so 45 fits comfortably. And check the leading bit is 0 — a positive number whose top bit is 1 would be a different, negative value.

Mark scheme

- 00101101

Solution 8

(c)

Mark scheme

- One mark each
- ▪ Divide
- ▪ ...by 16 / 24

Question 1

0478/12 M24 ▪ Q1 ▪ 8 marks

Computers represent different types of data in binary.

(a) Tick (✓) **one** box to show the reason why computers use binary to represent data. **[1]**

- **A** Computers only allow 1s and 0s to be entered.
- **B** Computers are made of switches and gates that can only be on or off.
- **C** Binary does not need to be converted into other forms of data to be displayed.
- **D** Both computers and humans can quickly process binary data.

Question 1

0478/12 M24 ▪ Q1 ▪ 8 marks

Computers represent different types of data in binary.

(b)(i) Tick (✓) **one** box to identify the ASCII denary number for the character 'Q'. **[1]**

A	81
B	80
C	79
D	77

(b)(ii) Give the binary number for the ASCII denary number for 'N'. **[1]**

(b)(iii) Explain how the word 'RED' is represented using a character set. **[2]**

Question 1

0478/12 M24 ▪ Q1 ▪ 8 marks

Computers represent different types of data in binary.

(c)(i) Explain why recording sound with a higher sampling resolution creates a more accurate recording. **[2]**

(c)(ii) Give **one** other way that the accuracy of a sound recording can be improved. **[1]**

Solution 1

- **A** Computers only allow 1s and 0s to be entered.
- **B** Computers are made of switches and gates that can only be on or off. ✓
- **C** Binary does not need to be converted into other forms of data to be displayed.
- **D** Both computers and humans can quickly process binary data.

Answer: **B**

Question 2

0478/12 N23 ▪ Q2 ▪ 10 marks

2 A register stores the binary number:

1	1	1	0	0	0	1	1

(a) Give the denary number for the binary number stored in the register.

Question 2

Working space

Question 2

(b) Give the hexadecimal number for the binary number stored in the register.

Question 2

Working space

Question 2

(c) A logical left shift of **two** places is performed on the binary number stored in the register.

Complete the binary register to show its contents after this logical left shift.

[1]

(d) The negative denary number −99 needs to be stored in the register.

Complete the register to show the binary number that would be stored, using two's complement. Show all your working.

Question 2

Register:								

[2]

(e) The number 01001100 is added to 11100011

Add the two 8-bit binary numbers, using binary addition.

Give your answer in binary. Show all your working.

Solution 2

(a)

Mark scheme

- —
- 227
- 1

Solution 2

(b)

Mark scheme

- One mark for each correct character in the correct order:
- –
- E3
- 2

Solution 2

(c) Mark scheme

- 1
- 0
- 0
- 0
- 1
- 1
- 0
- 0

Solution 2

- 1

Solution 2

(d)

Mark scheme

- One mark for suitable working method e.g. flip and add 1
- One mark for correct answer
- —
- 10011101
- 2

Solution 2

(e) Mark scheme

- One mark for each correct nibble (max 2)
- One mark for correct working e.g. correct carry
- One mark for showing overflow bit
- 1
- 1 1 1 0 0 0 1 1
- + 0 1 0 0 1 1 0 0
- 1 0 0 1 0 1 1 1 1
- 4