Week 1

IGCSE Computer Science

Homework bundle for this week

本周作业合集

exercises.lol

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IGCSE Computer Science Name: ______ Score: ______

1. How many bits does one hexadecimal digit represent?
   - ☐ 4
   - ☐ 1
   - ☐ 8
   - ☐ 16
2. Add the binary numbers '0101' + '0011'. Give the 4-bit result.

   ____
3. How many different characters can 7-bit ASCII represent?

   ____
4. How many bytes are in 1 kibibyte (KiB)?

   ____________ bytes
5. Convert binary '10010110' to denary.

   ____
6. Overflow in an 8-bit register happens when:
   - ☐ the result is larger than 255 and needs a 9th bit
   - ☐ the numbers are negative
   - ☐ a bit is shifted right
   - ☐ the register is empty
7. Compared with ASCII, Unicode:
   - ☐ represents far more characters but uses more bits, so files are larger
   - ☐ uses fewer bits per character
   - ☐ can only store English
   - ☐ is the same size
8. An image is 100×100 pixels with a colour depth of 24 bits. What is its size in bits?

   ____________ bits
9. Convert denary 13 to binary (significant bits only).

   ____

10. A logical left shift by 1 multiplies an unsigned number by what?

____

IGCSE Computer Science

1. **4**

   One hex digit covers 16 values = a nibble = 4 bits.

2. **1000**

   5 + 3 = 8 = ‘1000‘.

3. **128**

   7 bits give 2^7 = 128 characters.

4. **1024 bytes**

   1 KiB = 1024 bytes (each storage unit steps up by 1024 = 2^10).

5. **150**

   128 + 16 + 4 + 2 = 150.

6. **the result is larger than 255 and needs a 9th bit**

   An 8-bit register holds 0–255; a bigger result needs a 9th bit that cannot fit, so it is lost.

7. **represents far more characters but uses more bits, so files are larger**

   Unicode covers many languages and emoji, needing more bits — so the same text is larger than in ASCII.

8. **240000 bits**

   width × height × colour depth = 100 × 100 × 24 = 240 000 bits.

9. **1101**

   13 = 8 + 4 + 1 → ‘1101‘.

10. **2**

    Each left-shift place multiplies by 2 (a right shift divides by 2).

IGCSE COMPUTER SCIENCE • EXERCISE SHEET

1.1 Number systems

Name: ____________ Class: ________ Date: __________ **Total: 34 marks**

KEY WORDS denary 十进制 • hexadecimal 十六进制 • binary addition 二进制加法 • overflow 溢出 • two's complement 补码

Objective

Build the skills to answer exam questions on **number systems 数制** — denary/binary/**hexadecimal 十六进制** conversion, **binary addition 二进制加法**, **overflow 溢出**, shifts, and **two's complement 补码**.

You must be able to:

- convert between denary, binary and hexadecimal
- add binary numbers and identify overflow
- carry out a logical shift; use two's complement for negatives

1 Worked examples

■ Conversions and two's complement

place value	128	64	32	16	8	4	2	1
bits	**1**	0	0	**1**	0	**1**	**1**	0

$150 = 128 + 16 + 4 + 2 \Rightarrow$ `10010110`

Place values 128…1; the 1s sit under the values that sum to the number

sign bit (negative)

place value	−128	64	32	16	8	4	2	1
bits	**1**	**1**	0	**1**	**1**	0	0	0

$-128 + 64 + 16 + 8 = -40$

Two's complement: the MSB is worth −128, so 11011000 = −40

Denary 100 → binary: $64 + 32 + 4 \rightarrow$ `01100100` → hex `64`.

■ The general methods, step by step

Denary to binary — divide by 2 and read the remainders bottom-to-top.

step	division	remainder
1	$150 \div 2 = 75$	0
2	$75 \div 2 = 37$	1
3	$37 \div 2 = 18$	1
4	$18 \div 2 = 9$	0
5	$9 \div 2 = 4$	1
6	$4 \div 2 = 2$	0
7	$2 \div 2 = 1$	0
8	$1 \div 2 = 0$	1

Reading bottom-to-top: `10010110`. Check with place values: $128 + 16 + 4 + 2 = 150$.

Binary to hexadecimal — split into nibbles of four bits from the right, then write each as one hex digit: `1100 1010` → `C A` → `CA`. Going back, expand each hex digit into four bits.

Binary addition. Add column by column from the right, carrying 1 when a column makes 2 (`1 + 1 = 10`). If a carry leaves the eighth column, the answer needs a ninth bit that the register cannot hold: that is **overflow** 溢出, and the stored answer is wrong.

Logical shift. A left shift of n places moves every bit n to the left, fills the right with zeros and multiplies the value by 2^n; a right shift divides by 2^n. Bits shifted out are lost, so a left shift can also lose the value.

Two's complement. Write the negative number by starting from the positive binary, inverting every bit, then adding 1. To read one, the leftmost bit is worth −128: `11011000` $= -128 + 64 + 16 + 8 = -40$.

Why hexadecimal is used: it is shorter than binary and easier for a person to read and copy without mistakes, and each hex digit maps to exactly four bits. It appears in MAC addresses, IP version 6 addresses, HTML colour codes, memory dumps and error codes.

2 Practice

2.1 Convert the denary number 45 to 8-bit binary. [2]

2.2 Convert the binary number `11001010` to hexadecimal. [2]

2.3 Convert the denary number 200 to 8-bit binary using the division method, showing your working. [3]

2.4 Convert the hexadecimal number `3F` to denary. [2]

2.5 Give two reasons why hexadecimal is used to represent binary numbers, and name two places where it is used. [4]

3 Exam-style questions

3.1 An 8-bit register can hold the denary values: [1]

- **A** 0 to 127
- **B** 0 to 255
- **C** 0 to 256
- **D** 1 to 255

3.2 Two 8-bit binary numbers are added: `01101100` + `00111010`.

(a) Work out the binary result. [2]

(b) Convert your answer to denary, and state whether overflow has occurred. [2]

3.3 A register holds `00110100`. Perform a logical left shift of 2 places and state the effect on the denary value. [2]

3.4 A microprocessor uses 8-bit registers.

(a) Convert the denary number 172 to 8-bit binary. [2]

(b) Convert your answer to (a) to hexadecimal. [2]

(c) The register holds `10110101`. This binary number is added to `01011100`. Complete the addition and give the 8-bit answer. [3]

(d) Explain whether overflow has occurred in part (c), and state what overflow means. [2]

(e) The register `00011010` has a logical left shift of 3 places applied. Give the result, and calculate the effect on the denary value. [3]

(f) The same register is used to hold two's complement numbers. Give the denary value of `11101100`. [2]

Solutions

2.1 $45 = 32 + 8 + 4 + 1 \rightarrow$ `00101101`.

2.2 `1100 1010` $\rightarrow$ `C` and `A` $\rightarrow$ `CA`.

2.3 $200 \div 2 = 100$ r0; $100 \div 2 = 50$ r0; $50 \div 2 = 25$ r0; $25 \div 2 = 12$ r1; $12 \div 2 = 6$ r0; $6 \div 2 = 3$ r0; $3 \div 2 = 1$ r1; $1 \div 2 = 0$ r1; reading bottom-to-top, `11001000`.

2.4 $3 \times 16 + 15 = 48 + 15 = 63$.

2.5 Any two reasons: it is shorter than binary, so it takes less space to write; it is easier for a person to read, copy and remember without mistakes; each hex digit is exactly four bits, so converting is quick. Any two uses: MAC addresses; IP version 6 addresses; HTML colour codes; memory dumps; error codes; assembly language and debugging.

3.1 **B**. An 8-bit register holds 0 to 255.

3.2 (a) `10100110`.
(b) $128 + 32 + 4 + 2 = 166$; no overflow (the result fits in 8 bits).

3.3 `11010000`; the value is multiplied by 4 (a left shift of $2 = \times 2^2$).

3.4 (a) $172 = 128 + 32 + 8 + 4$, so `10101100`.
(b) `1010 1100` $\rightarrow$ `A` and `C`, so `AC`.
(c) `10110101` + `01011100` = `00010001` with a carry out of the eighth column.
(d) Yes, overflow has occurred: the true answer needs nine bits, but the 8-bit register cannot store the ninth, so the stored answer is wrong.
(e) `11010000`; the denary value was 26 and becomes 208; a left shift of 3 places multiplies by $2^3 = 8$, and $26 \times 8 = 208$.
(f) $-128 + 64 + 32 + 8 + 4 = -20$.

1 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]

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

.... [1]

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

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

429 ....

1A3 ....
[2]

Working space

....

....

....

....

....

(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]

Working space

....

....

....

....

....

(e) The hexadecimal code for each toy is stored in a barcode that is displayed on each toy.

Each time a customer buys a toy, the barcode is scanned and the amount of stock stored in the database for that toy is reduced by 1.

An item of hardware is used in this system to receive the hexadecimal code from the barcode scanner and find it in the database. The item of hardware is built into a single chip.

(i) Identify the name of the item of hardware.

.... [1]

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

A input ☐

B output ☐

C process ☐

D storage ☐

[1]

(iii) The barcode scanner contains a sensor.

Identify the type of sensor that the barcode scanner could contain.

.... [1]

(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]

2 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.

```
  11110101
+ 00111001
```

[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.

Working space ....

....

....

....

....

Denary number ....

[3]

1 **(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
H	W	X	Y	Z	0	1
2	4	8	10	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]

(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.

```
  1 0 0 1 1 0 1 1
+ 0 0 0 1 0 0 1 1
```

[3]

(c) Binary addition can result in overflow.

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

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. ☐

[1]

3 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]

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

1 ....

....

2 ....

....

[2]

(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]

Working space

....

....

....

....

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

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

14 ....

100 ....

250 ....
[3]

Working space

....

....

....

....

....

....

(d) A binary integer that is stored in a register in the computer has a logical left shift performed on it.

(i) Describe the process of the logical left shift that is performed on the binary integer.

....

....

....

.... [2]

(ii) State what effect this will have on the binary integer.

....

.... [1]

(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]

2 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.

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. ☐

[1]

(b) Denary numbers can be converted to hexadecimal.

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

20 ....

32 ....

165 ....
[3]

Working space

....

....

....

....

3 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]

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

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.	☐

[1]

(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]

(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]

3 Binary is a base 2 number system.

(a) Give the name of the number system that is base 16.

.... [1]

(b) **Three** denary numbers are entered into a computer. The computer converts the numbers and stores them as binary.

(i) Give the binary number that would be stored for each of the denary numbers.

10 ....

50 ....

201 ....
[3]

Working space

....

....

....

....

....

(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]

1 Computers represent different types of data in binary.

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

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. ☐

[1]

(b) One form of data is characters.

The American standard code for information interchange (ASCII) denary number for the character 'N' is 78.

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

A 81 ☐

B 80 ☐

C 79 ☐

D 77 ☐

[1]

(ii) Give the binary number for the ASCII denary number for 'N'.

.... [1]

Working space

....

....

....

(iii) Explain how the word 'RED' is represented using a character set.

....

....

....

[2]

(c) Sound can be represented as binary.

(i) Explain why recording sound with a higher sampling resolution creates a more accurate recording.

....

....

....

.... [2]

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

....

.... [1]

8 **(a)** Hexadecimal can be used to represent binary numbers.

(i) Convert the denary number 236 into hexadecimal.

....

.... [1]

Working space

....

....

....

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

....

.... [1]

(b) Two's complement can be used to represent positive and negative binary integers.

(i) Convert the two's complement integer 10110111 into denary.

Show all your working.

....

....

....

....

.... [2]

(ii) Convert the denary number 45 into an 8-bit two's complement integer.

....

.... [1]

Working space

....

....

....

(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]

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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.

.... [1]

Working space

....

....

....

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

.... [2]

Working space

....

....

....

(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.

Working space ....

....

....

....

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.

....

....

....

....

....

.... [4]

1.2 Text, sound and images

Name: ____________ Class: ________ Date: __________ **Total: 30 marks**

KEY WORDS resolution 分辨率 • colour depth 颜色深度 • unicode 统一码 • sample resolution 采样分辨率 • sample rate 采样率

Objective

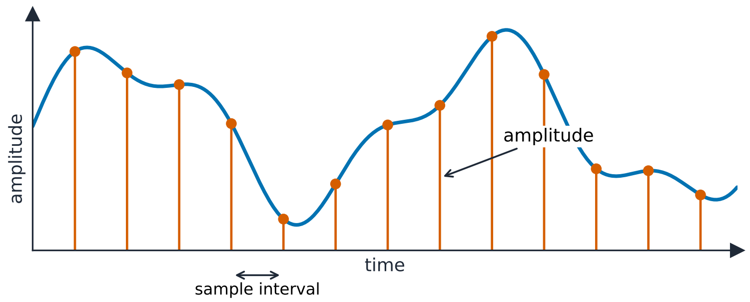
Build the skills to answer exam questions on **text, sound and images** 文本、声音与图像 — character sets, **sampling** 采样, pixels, and file-size calculations.

You must be able to:

- compare ASCII and Unicode
- define sample rate, sample resolution, resolution and colour depth
- calculate image and sound file sizes

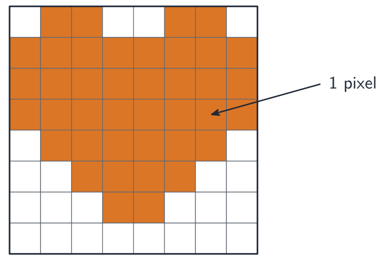
1 Worked examples

■ Sampling and pixels



sample rate = samples/s · Nyquist ≥ $2f_{max}$

Sampling records the wave's height (amplitude) at regular moments



resolution = 8 × 8 pixels

An image is a grid of pixels; resolution = number of pixels, colour depth = bits per pixel

- **image bits** = width × height × colour depth. **sound bits** = sample rate × resolution × seconds.

■ Text, sound and images: the same three questions

For every kind of data the exam asks the same things: how is it represented, what makes the file bigger, and what is the trade-off?

Text. Each character has a code. **ASCII** uses 7 bits, giving 128 characters, which is enough for English but not for other alphabets. **Unicode** 统一码 uses more bits per character (16 or more), so it covers every writing system, emoji included, but the same text takes more storage.

Sound. The wave is **sampled**: its amplitude is measured at regular intervals.

- **Sampling rate** 采样率 is the number of samples each second (in Hz or kHz). A higher rate follows the wave more closely, giving better quality and a larger file.
- **Sample resolution** 采样分辨率 (bit depth) is the number of bits used per sample. More bits record the amplitude more accurately, again improving quality and increasing the file size.

$$\text{file size (bits)} = \text{sampling rate} \times \text{sample resolution} \times \text{seconds} \times \text{channels}$$

Worked example. A 30-second mono recording is sampled at 44 100 Hz with a resolution of 16 bits. Size = 44 100 × 16 × 30 = 21 168 000 bits = 2 646 000 bytes ≈ 2.6 MB. (Divide bits by 8 for bytes, then by 1024 for kibibytes, then by 1024 again for mebibytes.)

Images. A bitmap is a grid of **pixels** 像素.

- **Resolution** is the number of pixels, for example 1920 × 1080.
- **Colour depth** 颜色深度 is the number of bits per pixel; n bits give 2^n colours, so 8 bits give 256 colours and 24 bits give over 16 million.

$$\text{file size (bits)} = \text{width} \times \text{height} \times \text{colour depth}$$

Worked example. An image of 800×600 pixels with a colour depth of 24 bits: $800 \times 600 \times 24 = 11\,520\,000$ bits $= 1\,440\,000$ bytes ≈ 1.4 MB. Doubling the colour depth doubles the file size; doubling both width and height multiplies it by four.

2 Practice

2.1 State the difference between ASCII and Unicode. [2]

2.2 Define sample rate. [1]

2.3 Give one advantage and one disadvantage of Unicode compared with ASCII. [2]

2.4 Calculate the file size, in bytes, of a 10-second mono sound recording sampled at 8000 Hz with a resolution of 8 bits. [3]

2.5 State what happens to the file size of an image if its colour depth is increased from 8 bits to 16 bits. [1]

3 Exam-style questions

3.1 Increasing the colour depth of an image will: [1]

- **A** reduce the file size
- **B** increase the file size and quality
- **C** have no effect
- **D** reduce the resolution

3.2 An image is 200×100 pixels with a colour depth of 8 bits.

(a) Calculate the file size in bits. [2]

(b) Convert your answer to bytes. [1]

3.3 A sound is recorded for 20 seconds at a sample rate of 10 000 Hz with a sample resolution of 8 bits. Calculate the file size in bits. [2]

3.4 A student records a podcast and takes a photograph for its cover.

(a) Explain what is meant by sampling rate and by sample resolution. [2]

(b) The recording lasts 60 seconds, is mono, is sampled at 22 050 Hz and uses a resolution of 16 bits. Calculate the file size in mebibytes. [4]

(c) The student halves the sampling rate. State the effect on the file size and on the sound quality. [2]

(d) The cover photograph is 1200×900 pixels with a colour depth of 24 bits. Calculate its file size in mebibytes. [3]

(e) Explain why a colour depth of 24 bits allows over 16 million different colours. [2]

(f) The student's text file of show notes contains Chinese characters. Explain why it must use Unicode rather than ASCII. [2]

Solutions

2.1 ASCII uses fewer bits (7) and fewer characters; Unicode uses more bits and can represent many more characters/languages.

2.2 the number of samples taken each second.

2.3 Advantage: Unicode represents the characters of every writing system, not just English. Disadvantage: it uses more bits per character, so the same text takes more storage.

2.4 $8000 \times 8 \times 10 = 640\,000$ bits; $640\,000 \div 8 = 80\,000$ bytes.

2.5 It doubles.

3.1 B. A greater colour depth increases the file size (and quality).

3.2 (a) $200 \times 100 \times 8 = 160\,000$ bits.
(b) $160\,000 \div 8 = 20\,000$ bytes.

3.3 $10\,000 \times 8 \times 20 = 1\,600\,000$ bits.

3.4 (a) The sampling rate is the number of samples taken each second; the sample resolution is the number of bits used to store each sample.
(b) $22\,050 \times 16 \times 60 = 21\,168\,000$ bits; $\div 8 = 2\,646\,000$ bytes; $\div 1024 \div 1024 = 2.52$ MiB.
(c) The file size halves; the quality falls, because the samples follow the shape of the original wave less closely.
(d) $1200 \times 900 \times 24 = 25\,920\,000$ bits; $\div 8 = 3\,240\,000$ bytes; $\div 1024 \div 1024 = 3.09$ MiB.
(e) Each pixel has 24 bits, and each bit has two possible values; the number of combinations is $2^{24} = 16\,777\,216$.
(f) ASCII has only 128 codes, which cover the English alphabet, digits and punctuation but no Chinese characters; Unicode uses more bits per character, so it has enough codes for every writing system, including Chinese.

3 A student has a portable device. He uses an on-screen keyboard to write messages to his friend.

(a) Explain how the text the student writes is converted to binary to be processed.

....

....

....

....

....

.... [3]

(b) The device has 4 gibibytes (GiB) of random access memory (RAM).

(i) State the amount of RAM the device has in mebibytes (MiB).

.... [1]

(ii) State the amount of RAM the device has in tebibytes (TiB). Your answer can be given rounded to 3 decimal places.

.... [1]

Working space

....

....

....

....

....

(c) Explain why the portable device needs RAM.

....

....

....

....

....

.... [3]

(d) The device has a fingerprint scanner to allow the student to unlock the portable device.

Circle only **three** terms that can be used to describe the fingerprint scanner.

authentication	biometric	malware	parity check
firewall	input device	output device	storage device

[3]

5 Text, images and sound are represented as binary to be processed by a computer.

(a) Complete the table by writing the missing terms and descriptions about representing text, images and sound as binary.

Term	Description
character set	....
....	This is the number of samples taken each second when recording sound.
pixel	....
resolution	....
....	This is the number of bits used to represent a colour in an image.

[5]

(b) The size of an image file is 1000 bytes.

Give the size of the image file in bits.

.... [1]

(c) The size of a sound file is 4096 mebibytes (MiB).

Give the size of the file in gibibytes (GiB).

.... [1]

Working space

....

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IGCSE Computer Science: **s25 11**

3 An image is converted to binary to be represented by a computer.

Complete the table with the missing terms and definition about representing an image.

Term	Definition
....	This is the smallest component of an image.
resolution	....
....	This is the number of bits used to create each colour in an image.
....	This is additional data that is stored with an image that can provide information such as the time and date the image was taken.

[4]

2 A student has an image file stored on their computer.

(a) The image file was taken by a digital camera.

Tick (✓) **one** box to show whether a digital camera is an example of an input, output, process or storage device.

A input ☐

B output ☐

C process ☐

D storage ☐

[1]

(b) The size of the image file is 3072 bytes.

(i) Give the size of the image file in kibibytes (KiB).

.... [1]

(ii) State the number of nibbles in 1 byte.

.... [1]

Working space

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(c) The image file has a colour depth of 32 bits.

(i) State what is meant by a colour depth of 32 bits.

....

.... [1]

(ii) The colour depth of the image file is changed to 64 bits.

Explain what effect this change has on the image file.

....

....

....

[2]

(d) The student uses lossless compression to compress the image file.

Explain how the image file is compressed using lossless compression.

....

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.... [3]

1 A student records himself singing a song for his music project. The recorded sound is converted to binary to be processed by a computer.

(a) Give **one** input device the student can use to record the song.

.... [1]

(b) The student uses sound editing software to edit the recorded sound.

Tick (✓) **one** box to show whether sound editing software is an example of application, security, system or utility software.

A application software ☐

B security software ☐

C system software ☐

D utility software ☐

[1]

(c) Two binary numbers stored from the recording are 00011001 and 10110100.

(i) Convert the **two** binary numbers to denary numbers.

00011001 ....

10110100 ....

[2]

Working space

....

....

....

....

(ii) Convert the **two** binary numbers to hexadecimal numbers.

00011001 ....

10110100 ....

[2]

Working space

....

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....

(iii) A logical right shift of two places is performed on the binary number 10100100.

Give the binary number that would be stored after the logical shift has taken place.

.... [1]

Working space

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(d) The two's complement 8-bit binary integer 11001001 is also stored.

Convert the two's complement 8-bit binary integer to denary. Show all of your working.

Working space ....

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Denary value ....

[2]

(e) The table contains terms and descriptions about the process of converting analogue sound to binary.

Complete the table with the missing term and descriptions.

Term	Description
....	This is the measurement of the height (amplitude) of a sound wave taken at regular time intervals.
sample rate	....
sample resolution	....

[3]

2 An artist creates an image on a computer.

(a) State what is meant by the colour depth of an image.

....

.... [1]

(b) Describe the relationship between the resolution of the image and the file size of the image.

....

....

....

.... [2]

(c) The artist compresses the image file before uploading it to their website. Users can download the image file from the website to print as a poster.

The image file is compressed using lossless compression.

(i) Explain the reasons why the artist chose lossless compression instead of lossy compression to compress this image file.

....

....

....

....

....

.... [3]

(ii) Identify **one** lossless method of compressing an image.

Describe your chosen method.

Method ....

Description ....

....

....

....

....

[3]

(d) The artist emails the image file to their friends.

(i) Explain how a file is broken down into packets and transmitted over a network.

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....

.... [5]

(ii) The packets can use many different methods of data transmission to travel.

Complete and annotate the diagram to show the difference between serial full-duplex transmission between two computers and parallel simplex transmission between two computers.

Serial full-duplex transmission:

Computer 1		Computer 2

Parallel simplex transmission:

Computer 1		Computer 2

[3]

3 A user enters text into a computer system, using a keyboard.

An American standard code for information interchange (ASCII) character set is used to convert the text to binary.

(a) Identify **one** other character set that could be used to convert the text to binary.

.... [1]

(b) The character ‘A’ is represented by the denary ASCII number 65.

The character ‘m’ is represented by the denary ASCII number 109.

(i) Convert the **two** denary ASCII numbers to binary.

65 ....

109 ....

[2]

Working space

....

....

....

....

(ii) Convert the **two** denary ASCII numbers to hexadecimal.

65 ....

109 ....

[2]

Working space

....

....

....

....

(c) The character 'y' is represented by the binary ASCII number 01111001.

(i) Convert the binary ASCII number to denary.

.... [1]

Working space

....

....

....

....

(ii) Convert the binary ASCII number to hexadecimal.

.... [1]

Working space

....

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....

(iii) A logical right shift of two places is performed on the binary ASCII number 01111001.

Give the binary number after the logical right shift of **two** places is performed.

.... [1]

Working space

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....

(d) The character 'T' is represented by the binary ASCII number 01010100.

The character 't' is represented by the binary ASCII number 01110100.

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

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.... [3]

5 A musician is recording herself playing the music for a song on the piano.

(a) Explain how the analogue sound is recorded and converted to digital.

....

....

....

....

....

....

....

....

....

.... [5]

(b) State **two** ways that the accuracy of the recording could be increased.

1 ....

2 ....
[2]

(c) The musician compresses the sound file using lossless compression instead of lossy compression.

Explain why the musician would choose to use lossless compression instead of lossy compression.

....

....

....

....

....

.... [3]

(d) The musician types the words for the song into a document.

Two character sets that can be used when converting text to digital are the American standard code for information interchange (ASCII) and Unicode.

Explain the differences between the ASCII character set and the Unicode character set.

....

....

....

....

....

....

....

.... [4]

5 A band is recording their new song. They need to consider the sample rate and sample resolution of their recording.

(a) Give **one** benefit of using a higher sample rate to record the song.

....

.... [1]

(b) Give **one** drawback of using a higher sample rate to record the song.

....

.... [1]

(c) Describe what is meant by sample resolution.

....

....

....

.... [2]

(d) The band wants to compress the sound file, but they do **not** want any data to be permanently removed.

Identify the compression method that should be used.

.... [1]

3 When keys are pressed on a keyboard, the text is converted to binary to be processed by the computer.

(a) Describe how the text is converted to binary to be processed by the computer.

....

....

....

....

....

.... [3]

(b) Text that is input into a computer can be stored in a text file.

A text file can be compressed using lossless compression.

(i) State what effect this has on the file size.

....

.... [1]

(ii) Describe how lossless compression compresses the text file.

....

....

....

....

....

....

....

.... [4]

(iii) Give **two** reasons why the text file may have been compressed.

1 ....

....

2 ....

....

[2]

IGCSE COMPUTER SCIENCE • EXERCISE SHEET

1.3 Data storage and compression

Name: ____________ Class: ________ Date: __________ **Total: 29 marks**

KEY WORDS compression 压缩 • lossless 无损 • lossless compression 无损压缩 • lossy 有损 • lossy compression 有损压缩

Objective

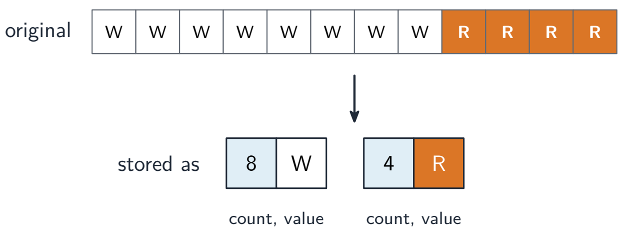
Build the skills to answer exam questions on **data storage and compression** 数据存储与压缩 — storage units, **lossless** 无损 and **lossy** 有损 compression, and **run-length encoding** 行程编码.

You must be able to:

- use the storage units (each ×1024)
- compare lossless and lossy compression
- apply run-length encoding (RLE)

1 Worked examples

■ Compression



RLE stores each run once as a count and a value (lossless)

- **lossless:** no data lost, original rebuilt exactly (text, programs); e.g. RLE.
- **lossy:** permanently removes data → much smaller (photos, music, video).
- units: byte → KiB → MiB → GiB, each ×1024.

■ Compression: what is thrown away, and what is not

Lossless compression 无损压缩 keeps every bit of the original: the file is rebuilt exactly. **Lossy compression** 有损压缩 permanently removes data the user is unlikely to notice, so the file cannot be rebuilt exactly but is much smaller.

Run-length encoding (RLE) is lossless. It replaces a run of identical values with a pair: how many, then which value. The pixel row `w w w w b b w w` becomes `4 w 2 b 2 w`. It works well on an image with large areas of one colour and badly on a photograph, where neighbouring pixels differ, and it can even make such a file larger.

Worked example. Compress `0 0 0 0 0 1 1 0 0 0` with RLE, then say how many bits are saved if each value and each count needs 4 bits.

1. The runs are five 0s, two 1s, three 0s.
2. The encoding is `5 0 2 1 3 0`: six values instead of ten.
3. Original: $10 \times 4 = 40$ bits. Compressed: $6 \times 4 = 24$ bits. Saved: 16 bits.

Where each is used. Lossless: text and program files, where a single wrong character matters, and image formats such as PNG. Lossy: MP3 audio (frequencies outside the range people hear well are removed, and quieter sounds masked by louder ones are dropped) and JPEG images (fine colour detail the eye is poor at seeing is discarded).

Why compress at all: the file takes less storage space, transmits in less time and uses less bandwidth, and a streamed file buffers less.

2 Practice

2.1 State one benefit of compressing a file. [1]

2.2 State how many bytes are in 1 KiB. [1]

2.3 Name the type of compression used for a text file, and give a reason. [2]

2.4 Identify two reasons for compressing a file before sending it over the internet. [2]

2.5 Give the run-length encoding of `b b b w w b b b b`. [2]

3 Exam-style questions

3.1 Which compression type permanently removes data? [1]

- **A** lossless
- **B** lossy
- **C** run-length encoding
- **D** both are reversible

3.2 A file must be compressed.

(a) State whether a text file should use lossless or lossy compression, and why. [2]

(b) Apply run-length encoding to the run `AAAAABBB`. [2]

3.3 Explain why RLE works well for an image with large areas of one colour. [2]

3.4 A photographer stores images and sound recordings.

(a) Explain the difference between lossy and lossless compression. [2]

(b) A black-and-white image row is `w w w w w b b b w w`. Give the run-length encoding of this row. [2]

(c) Each colour and each run length is stored in 4 bits. Calculate the number of bits saved by the encoding in part (b). [3]

(d) Explain why run-length encoding would be a poor choice for a detailed photograph. [2]

(e) The photographer compresses a sound recording with a lossy method. Describe two things the compression removes, and identify one situation in which she must not use lossy compression. [3]

(f) Give two benefits of compressing the files before uploading them to a website. [2]

Solutions

2.1 any of: uses less storage; needs less bandwidth; shorter transmission time.

2.2 1024 bytes.

2.3 Lossless; every character must be reconstructed exactly, because losing even one would change the meaning of the text.

2.4 Any two of: the file transmits faster; it uses less bandwidth; it takes less storage space at the other end; a streamed file buffers less.

2.5 `3 b 2 w 4 b`.

3.1 **B**. Lossy compression permanently removes data.

3.2 (a) lossless; because every character must be kept exactly (a text file cannot lose data).
(b) `5A 3B` (5 A's then 3 B's).

3.3 large areas of one colour are long runs of the same value; RLE stores each run as a single count + value, saving a lot of space.

3.4 (a) Lossy compression permanently removes data the user is unlikely to notice, so the original cannot be restored exactly; lossless compression keeps all the original data, so the file can be rebuilt exactly.
(b) `5 w 3 b 2 w`.
(c) Original: $10 \times 4 = 40$ bits; compressed: $6 \times 4 = 24$ bits; saved: $40 - 24 = 16$ bits.
(d) In a photograph, neighbouring pixels are rarely identical, so the runs are very short; each run still needs a count and a value, so the encoded file may be no smaller, or even larger.
(e) Any two of: frequencies outside the range people hear well are removed; quieter sounds masked by louder ones are dropped; the sampling rate or resolution is reduced. She must not use lossy compression when the original quality must be preserved, for example a master recording that will be edited further.
(f) Any two of: the pages load faster for visitors; less storage is used on the server; less bandwidth is used, so costs are lower.

2 An employee of a company sells houses. He sends images of the houses to his company.

(a) The employee compresses the image files using lossy compression before sending them. Lossy compression reduces the size of the image files.

Give **two** other reductions that lossy compression makes to the images.

1 ....

2 ....
[2]

(b) The image data is broken down into packets to be sent across a network to the company.

The destination internet protocol (IP) address is read by a device in the network. The device uses the IP address to forward the packet towards its correct destination.

(i) State the name of the device that reads the destination IP address.

.... [1]

(ii) Identify the part of the packet where the destination IP address is found.

.... [1]

(c) The IP address has an IPv6 format.

Give **three** characteristics of the IPv6 format.

1 ....

....

2 ....

....

3 ....

....
[3]

(d) An echo check is used to check for errors after the image has been transmitted.

Draw and annotate a diagram to show how the echo check would detect any errors.

[3]

(e) The image data is encrypted using symmetric encryption.

(i) Tick (✓) **one** box to show the correct statement about symmetric encryption.

A Encrypted text is known as plain text. ☐

B The most secure form of encryption. ☐

C The encryption key is shared with any device receiving the encrypted data. ☐

D Two different keys are used. ☐

[1]

(ii) Give **one** other type of encryption that could be used.

.... [1]

1 The size of a file can be measured using different data storage units.

(a) Tick (✓) **one** box to show the smallest data storage unit.

A byte ☐

B gibibyte (GiB) ☐

C kibibyte (KiB) ☐

D nibble ☐

[1]

(b) State how many tebibytes (TiB) are equal to 2 pebibytes (PiB).

.... [1]

Working space

....

....

....

(c) The size of a file needs to be reduced.

(i) Give the name of the process that is used to reduce the size of a file.

.... [1]

(ii) One reason the size of a file may need reducing is so that it has a shorter transmission time.

Give **one** other reason why the size of a file may need reducing.

....

.... [1]

1 Data can be measured using different units of storage.

(a) Tick (✓) **one** box to show which of the following is the largest unit of data storage.

A tebibyte (TiB) ☐

B pebibyte (PiB) ☐

C mebibyte (MiB) ☐

D gibibyte (GiB) ☐

[1]

(b) A computer has primary storage.

Give **one** example of primary storage.

Explain the purpose of your chosen example.

Example ....

Explanation ....

....

....

.... [3]

(c) All data is converted to binary to be processed by a computer.

(i) Calculate the binary number for the denary number 175. Show all your working.

....

....

....

....

.... [2]

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(ii) Give the binary number for the given hexadecimal numbers.

15 ....

2D ....

091 ....

[3]

Working space

....

....

....

....

(d) Binary integers can be added together.

Add the **two** binary integers using binary addition. Show all your working. Give your answer in binary.

```
  1 1 1 0 0 0 1 1
+ 1 1 0 0 1 1 0 0
  ---------------
```

[4]

(e) Calculate the denary number for the two's complement binary integer 10001110. Show all your working.

....

....

....

.... [2]

2 An employee has a report that they need to email to their employer.

The employee compresses the report file before emailing it.

(a) State the effect the compression has on the report file.

[1]

(b) Give **two** benefits of compressing the report file before emailing it.

1

2

[2]

(c) The employee decides to use lossless compression to compress the file.

Explain why lossy compression is **not** suitable.

[3]

(d) When the employee enters the email address, the computer uses Unicode to convert the email address to binary.

(i) State what Unicode is an example of.

[1]

(ii) Give **two** advantages of the computer using Unicode instead of American standard code for information interchange (ASCII).

1

2

[2]

(iii) Give **one** disadvantage of the computer using Unicode instead of ASCII.

[1]

(e) The report is broken down into packets to be emailed.

(i) Circle **three** items of data that can be found in the packet header.

trailer	originator's address	payload
interrupt	input	operating system
destination address	antivirus	packet number

[3]

(ii) Each packet is sent along a different path from the employee's device to the employer's device.

Tick (✓) **one** box to show the name of this method of sending packets.

A packet networking ☐

B packet circuiting ☐

C packet switching ☐

D packet transferring ☐

[1]

(iii) A hardware device is used to control the path that each packet takes.

Give the name of this hardware device.

[1]

(f) The email data is checked for errors after it has been transmitted, using an echo check and a checksum.

(i) Explain how the echo check is used to check for errors in the email data.

[3]

(ii) In the checksum error detection method, two values are compared after transmission. If the values do **not** match, an error is detected.

Explain why the values **not** matching would show an error has occurred.

....

....

....

.... [2]

(g) The email data is encrypted using asymmetric encryption before it is sent.

(i) Give **one** reason why the email data is encrypted.

....

.... [1]

(ii) Give **one** similarity between symmetric encryption and asymmetric encryption.

....

.... [1]

(iii) Give **two** differences between symmetric encryption and asymmetric encryption.

1 ....

....

2 ....

....

[2]

IGCSE Computer Science: **s24 13**

1 The size of a file can be measured in different units.

(a) State how many bits there are in a byte.

.... [1]

(b) State how many kibibytes (KiB) there are in 2 mebibytes (MiB).

.... [1]

(c) Identify the unit of data that is equal to 4 bits.

.... [1]

2 A student has a sound file that is too large to be stored on their external secondary storage device. The student compresses the sound file to make the file size smaller.

The compression method used reduces the sample rate and the sample resolution of the sound file.

(a) State what is meant by the sample rate and sample resolution.

Sample rate ....

....

Sample resolution ....

....

[2]

(b) Identify which type of compression has been used to compress the sound file.

....

.... [1]

(c) The student sends the sound file to a friend. The file is transmitted across a network that uses packet switching.

(i) Identify **two** pieces of data that would be included in the header of each packet.

1 ....

2 ....

[2]

(ii) Explain how the file is transmitted using packet switching.

....

....

....

....

....

....

....

....

....

.... [5]

3 A new computer comes with primary and secondary storage.

(a) Data storage is measured using binary denominations.

Complete each conversion.

8 bytes = ... nibbles

512 kibibytes (KiB) = ... mebibytes (MiB)

4 gibibytes (GiB) = ... mebibytes (MiB)

1 exbibyte (EiB) = ... pebibytes (PiB)

[4]

Working space

....

....

....

....

(b) Random access memory (RAM) is an example of primary storage.

Give **three** examples of data that is commonly stored in RAM.

1 ....

2 ....

3 ....

[3]

(c) Describe the purpose of secondary storage.

....

....

....

.... [2]

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