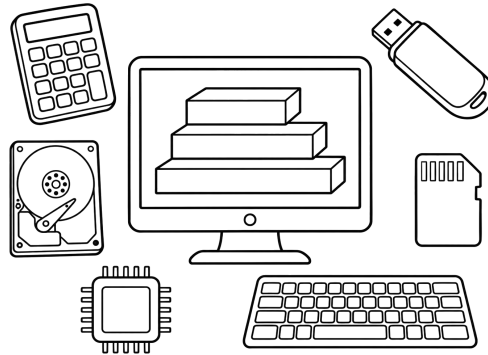


ICT

INFORMATION AND COMMUNICATION TECHNOLOGY

GRADE 10



UNIT 3

Data Representation Methods in the Computer System

Student Workbook



"The King of ICT"

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STUDENT DETAILS

Name:

School:

Institution:

Contact:

BEFORE WE START

What This Unit Is About

Read this page with your teacher

AT THE END OF THIS UNIT YOU WILL BE ABLE TO

- ☐ Explain how a computer represents data with only 0 and 1.
- ☐ Name the digits, the base and the weighting factors of four number systems.
- ☐ Find the MSD and LSD of a number, and the MSB and LSB of a binary number.
- ☐ Convert decimal numbers to binary, octal and hexadecimal numbers.
- ☐ Convert binary, octal and hexadecimal numbers to decimal and to each other.
- ☐ Compare storage units, and storage devices by capacity, speed and cost.
- ☐ Code numbers and text with BCD, ASCII and Unicode.

THREE RULES FOR THE COMPUTER ROOM

- **Always** ask your teacher before you open a program or plug in a pen drive.
- **Never** change the settings of a school computer or delete its files.
- **Never** eat or drink near the computer.

HOW TO USE THIS BOOK

First you **read** each chapter with your teacher. Then you **do** the practical tasks on a computer. Last you **write** the exercises.

Check every conversion the other way round.

YOU WILL USE

- A pencil and rough paper
- The **Calculator**
- **File Explorer**
- **Notepad** and **MS Word**

THE WORDS YOU WILL LEARN

Voltage level	Qubit	Number system	Base / Radix
Place value	Weighting factor	Bit	Octal
Hexadecimal	MSD / LSD	MSB / LSB	Remainder
Cluster	Nibble	Byte	Kilobyte
Gigabyte	Access speed	Cost per unit	BCD
ASCII	EBCDIC	Unicode	Pixel

"Only 0 and 1, yet they keep every song, photo and message. Learn their language!"

- THE KING OF ICT



CHAPTER 1

Number Systems in the Computer

? THE COMPUTER'S OWN LANGUAGE

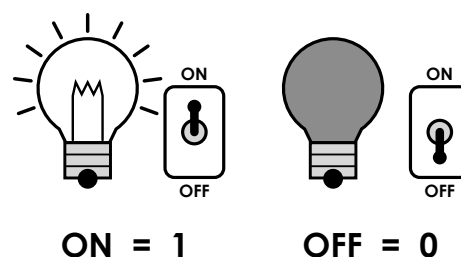
"The computer showed my name in English, so it understands English!" says Dilini. "No," says her brother. "Inside it there are only 0s and 1s."

He is right. Let us learn how the computer **represents data**, and the four **number systems** we use with computers.

3.1 Computer data representation

A computer cannot understand human language directly. It uses its own language with only two symbols: **0** and **1**.

Inside the computer, 0 and 1 are two different **voltage levels**, like a switch that is OFF or ON. Representing data with only 0 and 1 is called **binary representation**.



i NEW TECHNOLOGY: QUANTUM COMPUTING

Technology now also uses **multi-state representation**, with more than two states. This is called **quantum computing**. When one memory cell stores many values at the same time, the memory unit is called a **qubit** (quantum bit).

3.1.1 Number, base and place value

Each number system is made of a **number**, a **base** (radix) and **place values**.

NUMBER

A symbol which represents a unit or a quantity.

BASE / RADIX

The number of symbols used in a number system. It is written in decimal.

PLACE VALUE

The value given to a digit because of its position in a number.

Number system	Base	Digits (symbols) used - Table 3.1
Binary	2	0, 1
Octal	8	0, 1, 2, 3, 4, 5, 6, 7
Decimal	10	0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Hexadecimal	16	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F



3.2 The four number systems

We write the base as a small number at the right end: 1011_2 , 236_8 , $15E_{16}$. The base of a decimal number is often not written. Each position has a **weighting factor** (place value): a power of the base.

DECIMAL - BASE 10

Digits **0** to **9**. We calculate with them from childhood.

$$\begin{array}{cc} 10^1 & 10^0 \\ \boxed{2} & \boxed{5} \\ 10 & 1 \\ 25 = (2 \times 10^1) + (5 \times 10^0) = 20 + 5 \end{array}$$

BINARY - BASE 2

Digits **0** and **1**. One binary digit is a **bit**, the basic unit of the computer.

$$\begin{array}{cccccccc} 2^7 & 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 \\ \boxed{1} & \boxed{1} & \boxed{1} & \boxed{0} & \boxed{1} & \boxed{1} & \boxed{0} & \boxed{1} \\ 128 & 64 & 32 & 16 & 8 & 4 & 2 & 1 \\ \text{Weighting factors: } 2^0, 2^1, 2^2 \dots 2^7 \end{array}$$

OCTAL - BASE 8

Eight digits: **0** to **7**.

$$\begin{array}{ccc} 8^2 & 8^1 & 8^0 \\ \boxed{2} & \boxed{3} & \boxed{6} \\ 64 & 8 & 1 \\ 236_8 = (2 \times 8^2) + (3 \times 8^1) + (6 \times 8^0) \end{array}$$

HEXADECIMAL - BASE 16

Digits **0** to **9**, then **A** to **F** for 10 to 15.

$$\begin{array}{ccc} 16^2 & 16^1 & 16^0 \\ \boxed{1} & \boxed{5} & \boxed{E} \\ 256 & 16 & 1 \\ 15E_{16} = (1 \times 16^2) + (5 \times 16^1) + (14 \times 16^0) \end{array}$$

Weighting factors after the decimal point

$$\begin{array}{ccccccc} 10^2 & 10^1 & 10^0 & 10^{-1} & 10^{-2} \\ \boxed{3} & \boxed{0} & \boxed{2} & \boxed{7} & \boxed{5} \\ 100 & 10 & 1 & 0.1 & 0.01 \end{array}$$

$302.75 = 300 + 0 + 2 + 0.7 + 0.05$. After the decimal point the weighting factors are 10^{-1} , 10^{-2} ...

Decimal numbers and hexadecimal digits (Table 3.5)

Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

F, the largest hexadecimal digit, is **1111** in binary: four bits. So one hexadecimal digit can replace four bits, and hexadecimal is easier for humans to read than binary. It is used for computer **memory addresses**.

Colour codes use hexadecimal

Every colour on a computer is a mix of **red**, **green** and **blue** (RGB). Each value is from 0 to 255, so two hexadecimal digits can show it. Dark purple is R 135, G 31, B 120. In hexadecimal these are 87, 1F and 78, so its code is **#871F78**. A **#** or **&H** in front of a value shows that it is a hexadecimal number.

Colour	Hexadecimal value - Table 3.8	R	G	B
Dark purple	#871F78 or &H871F78	135	31	120



> DO IT - PRACTICAL 1 (TEXTBOOK ACTIVITY, PAGE 82)

Colour codes on the computer. **Ask your teacher first.**

1	Open the Calculator . Click the menu (three lines) and choose Programmer .
2	Click DEC and type 135 . Read the HEX line: 87 .
3	Do the same for 31 and 120 . Together they make the code #871F78 .
4	Find the hexadecimal values of the four colours in the table. Write each code.
5	In MS Word , click the arrow of Font Colour , then More Colours and Custom .
6	Type the R, G and B values of each colour and look at it. Some versions show the hex code too.

Colour	R	G	B	Hex value
Light pink	255	182	193	
Sky blue	50	153	204	
Green	0	255	0	
Yellow	255	238	0	

Programmer

135

HEX

87

DEC

135

OCT

207

BIN

1000 0111

DEC 135 = HEX 87

A Fill in the blanks

6 marks

Use the words in the box.

WORD BANK

voltage levels binary quantum qubit radix place value

- Inside the computer, 0 and 1 are two different
- Using only the symbols 0 and 1 is called representation.
- Using more than two states is called computing.
- A memory unit that holds many values at once is a
- The number of symbols in a number system is its base or
- The value of a digit because of its position is its

B Check the digits

6 marks

Can each number be right? Look at its digits and its base. Write YES or NO.

1

1201₂

2

386₈

3

9A₁₆

4

75₈

5

1G₁₆

6

101₂



C Complete the table

8 marks

Write the missing bases, digits and largest digits.

Number system	Base	Digits used	Largest digit
Binary		0, 1	
Octal	8		
Decimal		0, 1, 2 ... 9	
Hexadecimal			F

D Weighting factors

8 marks

Write the weighting factor (a power of the base) in the box above each digit.

1. 4065_{10}

4	0	6	5

2. 101101_2

1	0	1	1	0	1

3. 3075_8

3	0	7	5

4. $2AF_{16}$

2	A	F

E True or false

5 marks

Write T or F in the box.

- ☐ The base of any number system is written in decimal.
- ☐ The largest digit of the octal number system is 8.
- ☐ In hexadecimal, the digit C stands for 12.
- ☐ One hexadecimal digit can be written with 4 bits.
- ☐ In #871F78 the # shows that the code is a binary number.

F Answer these

4 marks

Write full sentences.

1. A number is written as 23_y . To which of the four number systems can it belong? Explain. (2 marks)

2. Why does the computer also use the hexadecimal number system? Give one use of it. (2 marks)



CHAPTER 2

Significant Digits and Decimal Conversions

? WHICH DIGIT MATTERS MOST?

"This phone costs Rs. 47 500. If the 4 becomes a 9, the price goes up by Rs. 50 000. If the last 0 becomes a 9, it goes up by only Rs. 9!" says Nimal.

The left digit has the **highest** weighting factor. We find such digits, and then convert decimal numbers into binary, octal and hexadecimal.

3.3 Most and least significant digits

The **most significant digit (MSD)** of a number has the highest weighting factor. The **least significant digit (LSD)** has the lowest. Read the number from left to right:

A WHOLE NUMBER

MSD: the first digit that is not 0.

LSD: the last digit, even if it is 0.

A NUMBER WITH A POINT

MSD: the first digit that is not 0.

LSD: the last digit that is not 0.

If the number is 0, the MSD and the LSD are both 0. The same rules work for binary, octal and hexadecimal numbers.

Examples (Table 3.9)

Number	3290	425	1237.0	58.32	0.0975	0.4
MSD	3	4	1	5	9	4
LSD	0	5	7	2	5	4

3290

MSD

LSD

58.32

MSD

LSD

0.0975

MSD

LSD

Most and least significant bits (MSB and LSB)

Only binary numbers have a **most significant bit (MSB)** and a **least significant bit (LSB)**. We find them with the same rules. Write the weighting factor too:

Examples (Table 3.10)

Binary number	1001	011.101	1010	101.100
MSB	1 (2^3)	1 (2^1)	1 (2^3)	1 (2^2)
LSB	1 (2^0)	1 (2^{-3})	0 (2^0)	1 (2^{-1})

"Divide, write the remainder, repeat. Patience turns any number into binary."

- THE KING OF ICT



3.4 Converting decimal numbers to other bases

All the data we input is taken by the computer as binary digits. So we must know how to convert a base 10 number into another base.

Divide the number by the new base (2, 8 or 16) again and again, until the quotient is **0**. Write each **remainder** on the right. Then write the remainders from the **bottom to the top**.

To binary: divide by 2

$$\begin{array}{r} 2 \overline{) 46} \\ 2 \overline{) 23} \\ 2 \overline{) 11} \\ 2 \overline{) 5} \\ 2 \overline{) 2} \\ 2 \overline{) 1} \\ 0 \end{array} \quad \begin{array}{c} \boxed{0} \\ \boxed{1} \\ \boxed{1} \\ \boxed{1} \\ \boxed{1} \\ \boxed{0} \\ \boxed{1} \end{array} \uparrow$$

$$46_{10} = 101110_2$$

To octal: divide by 8

$$\begin{array}{r} 8 \overline{) 158} \\ 8 \overline{) 19} \\ 8 \overline{) 2} \\ 0 \end{array} \quad \begin{array}{c} \boxed{6} \\ \boxed{3} \\ \boxed{2} \end{array} \uparrow$$

$$158_{10} = 236_8$$

To hexadecimal: divide by 16

$$\begin{array}{r} 16 \overline{) 47} \\ 16 \overline{) 2} \\ 0 \end{array} \quad \begin{array}{c} 15 \rightarrow \boxed{F} \\ 2 \rightarrow \boxed{2} \end{array} \uparrow$$

$$47_{10} = 2F_{16}$$

In hexadecimal, a remainder from 10 to 15 is written as a letter: 10 = A, 11 = B ... 15 = F. So 47 has the remainders 15 and 2, and $47_{10} = 2F_{16}$.

> DO IT - PRACTICAL 2 (TEXTBOOK ACTIVITIES, PAGES 86 - 87)

Convert **37**, **85** and **125** on paper first. **Ask your teacher first.**

1	Open the Calculator . Click the menu (three lines) and choose Programmer .
2	Click DEC and type 37 . Read the BIN , OCT and HEX lines.
3	Tick your answers that are the same. Find the mistake in any wrong division.
4	Do the same for 85 and 125 . (BIN shows the bits in groups of four.)

Decimal	Binary	Octal	Hexadecimal	All right?
37				
85				
125				

A Find the MSD and LSD

8 marks

Write the most and the least significant digit of each number.

Number	MSD	LSD
56870 ₁₀		
154.01 ₁₀		
23.080 ₁₆		
AD239 ₁₆		

Number	MSD	LSD
0.00110 ₈		
720.05		
440		
120 ₈		



B Find the MSB and LSB

8 marks

Write each bit and its weighting factor, as in Table 3.10.

Binary number	MSB	LSB
1000 ₂		
011101 ₂		
0.11001 ₂		
1.0010 ₂		

Binary number	MSB	LSB
0.00110 ₂		
1011 ₂		
0.1 ₂		
0.10 ₂		

C Convert to binary

6 marks

Use a division ladder. Write the binary number on the line.

1 83₁₀

= ₂

2 257₁₀

= ₂

3 365₁₀

= ₂

D Convert to octal and hex

8 marks

Boxes 1 and 3: to octal (divide by 8). Boxes 2 and 4: to hexadecimal (divide by 16).

1 200₁₀

= ₈

2 200₁₀

= ₁₆

3 350₁₀

= ₈

4 350₁₀

= ₁₆

E Choose the correct answer

3 marks

Underline your answer.

- The LSB of 1010₂ is
 (a) 1 (b) 0 (c) 2 (d) 10
- 85₁₀ in octal is
 (a) 125₈ (b) 521₈ (c) 105₈ (d) 85₈
- In a division by 16, a remainder of 14 is written as
 (a) 14 (b) D (c) E (d) F



F Answer these

6 marks

Write full sentences.

1. Write the steps to convert a decimal number to an octal number. (2 marks)
2. Kasun converted 47_{10} to hexadecimal and wrote 215_{16} . What was his mistake? Write the correct answer. (2 marks)
3. Nimal says that the LSD of 3290 is 9, because a 0 is never significant. Is he correct? Explain. (2 marks)

CHAPTER 3

Converting Among Number Systems

? A SHORT CUT, PLEASE!

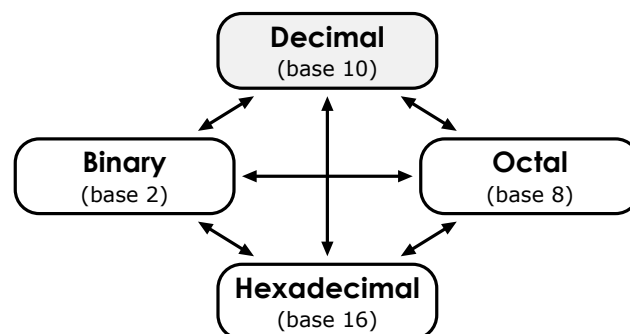
"To change 10111011100_2 into hexadecimal, I first changed it into decimal. It took me ten minutes!" says Sanduni.

There is a quicker way: an octal digit is **three bits** and a hexadecimal digit is **four bits**. Now we convert from any number system to any other.

3.5 Conversion among number systems

We can convert a number from any of the four number systems to any other (Figure 3.7). First we change binary, octal and hexadecimal numbers into **decimal**.

Multiply each digit by its weighting factor. Then **add** the answers.



"Check your answer the other way round. Good checkers become great thinkers."

- THE KING OF ICT



Three examples (textbook pages 88 - 90)

$$\begin{aligned}
 1101_2 &= (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0) \\
 &= (1 \times 8) + (1 \times 4) + (0 \times 2) + (1 \times 1) \\
 &= 8 + 4 + 0 + 1 \\
 &= \mathbf{13}_{10}
 \end{aligned}$$

$$\begin{aligned}
 1275_8 &= (1 \times 8^3) + (2 \times 8^2) + (7 \times 8^1) + (5 \times 8^0) \\
 &= 512 + 128 + 56 + 5 \\
 &= \mathbf{701}_{10}
 \end{aligned}$$

$$\begin{aligned}
 AB2_{16} &= (10 \times 16^2) + (11 \times 16^1) + (2 \times 16^0) \\
 &= 2560 + 176 + 2 \\
 &= \mathbf{2738}_{10}
 \end{aligned}$$

In hexadecimal, use the values of the letters: A = 10, B = 11 ... F = 15.

3.5.4 Clusters: binary to octal and hexadecimal

7, the largest octal digit, is 111 in binary, so every octal digit fits in **3 bits** ($8 = 2^3$). F, the largest hexadecimal digit, is 1111, so every hexadecimal digit fits in **4 bits** ($16 = 2^4$). (Tables 3.11 and 3.12)

Octal	3 bits
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

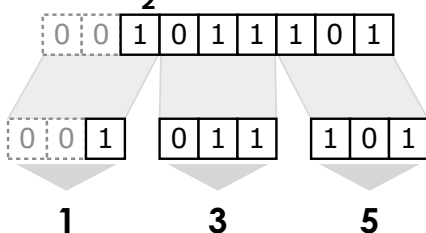
Hex	4 bits	Hex	4 bits
0	0000	8	1000
1	0001	9	1001
2	0010	A	1010
3	0011	B	1011
4	0100	C	1100
5	0101	D	1101
6	0110	E	1110
7	0111	F	1111

Binary to octal or hexadecimal

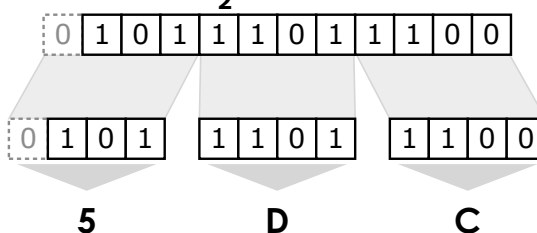
1. Make clusters of **3 bits** (octal) or **4 bits** (hexadecimal), starting from the **right**.
2. Add 0s on the left to complete the last cluster.
3. Write the digit of each cluster, from left to right.

Two examples (textbook pages 92 and 94)

1011101₂ to octal



10111011100₂ to hexadecimal



Binary number

Clusters of 4

Hexadecimal number

So $1011101_2 = 135_8$ and $10111011100_2 = 5DC_{16}$. The grey 0s were added to complete the clusters.



3.5.6 Octal and hexadecimal to binary

Do the opposite: write **each digit** in 3 bits (octal) or 4 bits (hexadecimal). Then join all the bits. 0s at the left end can be left out.

$$457_8 \quad \begin{array}{c|c|c} 4 & 5 & 7 \\ \hline 100 & 101 & 111 \end{array} = 100101111_2 \quad 2AE_{16} \quad \begin{array}{c|c|c} 2 & A & E \\ \hline 0010 & 1010 & 1110 \end{array} = 1010101110_2$$

3.5.8 Octal to hexadecimal, and back

Go **through binary**: write each digit in bits, then make **new clusters** from the right and write the new digits.

$$1057_8 \quad \begin{array}{c|c|c|c} 1 & 0 & 5 & 7 \\ \hline 001 & 000 & 101 & 111 \end{array}$$

↓ new clusters of 4

$$001000101111 = 22F_{16}$$

$$\begin{array}{c|c|c} 2 & 2 & F \end{array}$$

$$23A_{16} \quad \begin{array}{c|c|c} 2 & 3 & A \\ \hline 0010 & 0011 & 1010 \end{array}$$

↓ new clusters of 3

$$001000111010 = 1072_8$$

$$\begin{array}{c|c|c|c} 1 & 0 & 7 & 2 \end{array}$$

> DO IT - PRACTICAL 3 (TEXTBOOK ACTIVITIES, PAGES 89 - 96)

Check your conversions on a computer. **Ask your teacher first.**

1	Do each conversion in the table on paper first.
2	Open the Calculator in Programmer mode.
3	Click the base of the number: BIN , OCT or HEX . Then type the number.
4	Use the A to F keys for hexadecimal digits.
5	Read the answer on the line you need. Tick your answer if it is the same.

Number	Convert to	My answer	Calculator	Right?
101001_2	decimal			
374_8	decimal			
10101010110_2	octal			
$3DF_{16}$	binary			

A Complete the table

8 marks

Each row is one number. Write it in the empty boxes.

Decimal	Binary	Octal	Hexadecimal
29	11101		
		144	64
63			3F
	11111111	377	



B Convert to decimal

8 marks

Multiply each digit by its weighting factor. Then add.

1 111011_2

= ₁₀

2 221_8

= ₁₀

3 $12B_{16}$

= ₁₀

4 $A49_{16}$

= ₁₀

C Go through binary

8 marks

Change 1 and 2 to hexadecimal and 3 and 4 to octal. Show the bits.

1 76_8

= ₁₆

2 452_8

= ₁₆

3 96_{16}

= ₈

4 $15F_{16}$

= ₈

D Make the clusters

8 marks

Draw lines between the clusters. Then write the octal or hexadecimal number.

1

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

₂

= *octal* ₈

2

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

₂

= *octal* ₈

3

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

₂

= *hexadecimal* ₁₆

4

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

₂

= *hexadecimal* ₁₆

"Group the bits, and big numbers become small and friendly."

- THE KING OF ICT



E Write each digit in bits

8 marks

Octal: 3 bits for each digit. Hexadecimal: 4 bits for each digit.

Number	Each digit in bits	Binary number
245 ₈		
706 ₈		
B2C ₁₆		
78 ₁₆		

CHAPTER 4

Data Storage Capacity

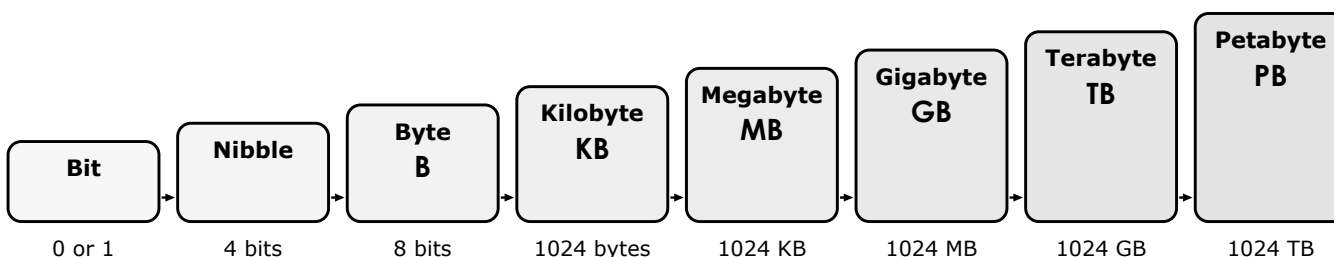
? IS MY PEN DRIVE BIG ENOUGH?

"My pen drive is 32 GB and my brother's hard disk is 1 TB. He says his disk holds as much as thirty-two of my pen drives. Is that true?" asks Hashini.

To answer, we need the units of **data storage capacity**, from bits to petabytes.

3.6.1 Units to measure data storage

A computer needs space to store data. We measure **data storage capacity** in units, from the smallest unit to the biggest:



i GOOD TO KNOW

- A **bit** (binary digit) is the smallest unit used to store data: 0 or 1.
- A **nibble** is half a byte. It is not used as much as bits and bytes.
- Kilobyte is written **KB** or kbyte. $1024 = 2^{10}$.
- Write gigabyte as **GB**. **Gb** means gigabit.
- Hard disk makers sometimes take 1024 as 1000.



How much text can they hold? (Table 3.13)

Name	Abbreviation	Approx. bytes	Exact bytes	Approx. text
Byte	B	One	1	One character
Kilobyte	KB (or K)	Thousand	1,024	Half a page
Megabyte	MB	One million	1,048,576	500 pages
Gigabyte	GB	One billion	1,073,741,824	500,000 pages
Terabyte	TB	One trillion	1,099,511,627,776	500,000,000 pages

3.6.2 Capacity, access speed and cost

Storage devices are different in their **capacity**, in their **access speed** (the time to read and write data) and in their **cost per unit** of storage (Figures 3.8, 3.9 and 3.10):

CAPACITY	ACCESS SPEED	COST PER UNIT
Small Register memory 1 KB Cache memory 3 - 32 MB CD 650 - 900 MB DVD 4.7 - 9 GB RAM 1 - 64 GB Flash memory 1 - 64 GB Hard disk 100 GB - 6 TB Magnetic tape 1 - 185 TB Large	Fast Register memory Cache memory RAM ROM Flash memory Hard disk DVD CD Magnetic tape Slow	High Register memory Cache memory RAM ROM Magnetic tape Flash memory Hard disk DVD Low

RAM: Random Access Memory · ROM: Read Only Memory
 CD: Compact Disc · DVD: Digital Versatile Disc

> DO IT - PRACTICAL 4 (TEXTBOOK OBSERVATION, PAGE 99)

Capacity of a disk and a pen drive. **Ask your teacher first.**

1	Open File Explorer . Right-click Local Disk (C:) and click Properties .
2	Write its Capacity (bytes and GB) and its Free space in the table.
3	Plug in the pen drive your teacher gives you, and do the same.
4	Divide the bytes by 1024 three times on the Calculator. Is it the GB value?
5	A pen drive shows a little less than its label: makers take 1000 for 1024.

Drive	Capacity (bytes)	Capacity (GB)	Free space (GB)
Local Disk (C:)			
Pen drive			



A Fill in the blanks

8 marks

Use the words in the box.

WORD BANK

bit nibble eight kilobyte gigabit access Register tape

1. The smallest unit used to store data in the computer is the
2. Half of a byte, or 4 bits, is called a
3. One byte is made of bits.
4. 1024 bytes make one
5. We write gigabyte as GB. 'Gb' means
6. The time a device takes to read and write data is its speed.
7. memory has the smallest capacity and the fastest access speed.
8. Magnetic has the largest capacity but the slowest access speed.

B Match them

6 marks

Match each device with its capacity (Figure 3.8).

A - The device		B - Its capacity
1. Register memory		A. 4.7 - 9 GB
2. Cache memory		B. 1 KB
3. Compact Disc (CD)		C. 1 TB - 185 TB
4. DVD		D. 650 - 900 MB
5. Hard disk		E. 100 GB - 6 TB
6. Magnetic tape		F. 3 MB - 32 MB

C Answer these

4 marks

Show your working.

1. Write these from the fastest to the slowest: hard disk, register memory, CD, RAM. (2 marks)
2. Hashini's pen drive is 32 GB and her brother's hard disk is 1 TB. How many such pen drives can the hard disk hold? Show your working. (2 marks)



D Calculate

10 marks

Use 1 byte = 8 bits, 1 nibble = 4 bits, 1 KB = 1024 bytes and so on.

1. 3 bytes = ... bits
2. 6 nibbles = ... bytes
3. 2 KB = ... bytes
4. 5 MB = ... KB
5. 4096 MB = ... GB
6. 1 TB = ... MB
7. 512 MB = ... GB
8. 2 GB = ... KB
9. 16 bits = ... bytes
10. 3 PB = ... TB

CHAPTER 5

Coding Systems

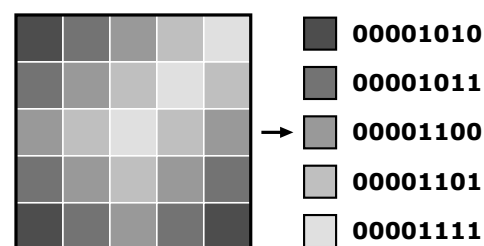
? WHAT DOES THE COMPUTER KEEP FOR 'A'?

"When I press A on the keyboard, the screen shows A. But what is kept inside the computer?" asks Ravindu.

It keeps the bit pattern **1000001**. Every number, letter, picture and sound gets a code of 0s and 1s. The rules for these codes are **coding systems**.

3.7 Coding systems

When we enter data, the computer changes it into patterns of 0 and 1. Binary codes are used to store numbers, letters, special characters, images and sounds. A **picture** is a grid of **pixels** (dots) and each colour has its own binary code. A **sound** wave is changed into digital data. The letter A uses 7 bits: 1000001. In this unit we learn the coding systems **BCD**, **ASCII** and **Unicode**.



3.7.1 BCD - Binary Coded Decimal

BCD represents **decimal numbers**. Each decimal digit is changed **separately** into **4 bits**. So the digits are easy to read and display, and there are no rounding errors. BCD is used in **digital clocks**, **calculators** and **money** calculation systems.

Decimal digits and BCD codes (Table 3.14)

Decimal	0	1	2	3	4	5	6	7	8	9
BCD	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001

37₁₀ 3 7
 0011 0111 = 0011 0111

Example: 37 in BCD. Each digit gets its own 4 bits. (In binary, 37 is 100101 - BCD is different!)



3.7.2 ASCII

ASCII (American Standard Code for Information Interchange) first used a **7-bit** code, so it can represent **128** characters ($2^7 = 128$). It is used to represent **text**. ASCII was designed and approved by **ANSI** (American National Standards Institute).

Example: the word School (textbook page 105)

Character	S	c	h	o	o	l
Decimal	83	99	104	111	111	108
ASCII code	1010011	1100011	1101000	1101111	1101111	1101100

ASCII codes of the capital letters (from the appendix table)

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

EBCDIC (textbook appendix) is another code: A is 65 in ASCII but 193 ($C1_{16}$) in EBCDIC.

3.7.3 Unicode

BCD can show 10 characters and ASCII 128, but Sinhala, Tamil, Japanese and Chinese have more. So **Unicode** was designed: **16 bits** for **65 536** symbols ($2^{16} = 65\,536$). Version 17.0.0 added 4 803 characters, so it can now represent **159 801** characters.

Unicode gives a **unique number** to every number, letter and symbol in any program or operating system. Made by the Unicode Consortium, it is used for websites and newspapers (Figure 3.12).

Sinhala letters	Tamil letters	Special symbols	Picture symbols
අ ආ ඉ ක ම ය	அ ஆ இ க ம ய	Σ Ω π Á Ñ ß	☺ ☀ ☂ ☎ ✈ ❤
one unique code each	one unique code each	one unique code each	one unique code each

> DO IT - PRACTICAL 5 (TEXTBOOK ACTIVITY, PAGE 105)

Type letters with their codes. **Ask your teacher first.**

1	In Notepad , hold Alt , type 73 on the number pad and let go. I appears!
2	Do the same with 67 and 84 . Then type POT with codes from the ASCII table.
3	On the Calculator (Programmer, DEC) type 73 and read BIN . Fill in the table.
4	In MS Word type 0D85 and press Alt + X : a Sinhala letter. 0B85 gives Tamil.

Character	I	C	T
Decimal code	73		
ASCII (7 bits)			



A Write in BCD

7 marks

Change a binary, octal or hexadecimal number to decimal first.

Number	Decimal value	BCD code
302	302	
2136	2136	
7295	7295	
4506	4506	
11101 ₂		
2B ₁₆		
43 ₈		

B ASCII codes

6 marks

Write the word POT in ASCII. Use the table on the ASCII page.

Character	Decimal code	ASCII code (7 bits)
P		
O		
T		

C Decode the message

5 marks

A friend sent you the name of a city in ASCII. Which city is it?

ASCII code	1001011	1000001	1001110	1000100	1011001
Letter					

D Which coding system?

6 marks

Tick the correct column.

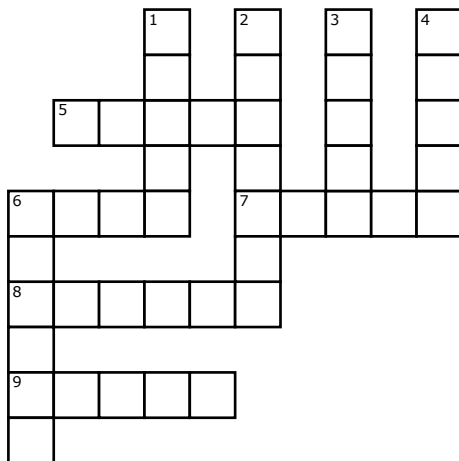
The use	BCD	ASCII	Unicode
Shows the digits on a digital clock	☐	☐	☐
A Sinhala newspaper website	☐	☐	☐
Uses 7 bits for 128 characters	☐	☐	☐
Writes each decimal digit with 4 bits	☐	☐	☐
Uses 16 bits for 65 536 symbols	☐	☐	☐
Designed and approved by ANSI	☐	☐	☐



E Crossword

10 marks

All the words are in this unit. Write one letter in each square.



ACROSS

5. A 7-bit code for 128 characters (5)
6. Eight bits (4)
7. Number system with base 8 (5)
8. Half of a byte (6)
9. Another word for the base (5)

DOWN

1. Fast memory between register and RAM (5)
2. A code for the letters of all languages (7)
3. A quantum bit (5)
4. One dot of a picture (5)
6. Number system with base 2 (6)

F Answer these

6 marks

Show your working.

1. What is the largest digit that one BCD code can show? Write its code. (2 marks)

2. In ASCII, the letter A is 1000001. What is the ASCII code of F? Show how you found it. (2 marks)

3. Convert 45_8 to a BCD number. Show your working. (2 marks)

G True or false

7 marks

Write T or F in the box.

1. ☐ BCD writes each decimal digit with 4 bits.
2. ☐ In BCD, the number 37 is written as 100101.
3. ☐ ASCII first used 7 bits, so it can show 128 characters.
4. ☐ ASCII can show all the Sinhala and Tamil letters.
5. ☐ Unicode uses 16 bits to represent 65 536 different symbols.
6. ☐ In the textbook appendix, A has the same code in ASCII and in EBCDIC.
7. ☐ A picture is stored as pixels, and each colour has a binary code.



REVISION

Unit 3 in One Page

Read this the night before the test

Topic	The key facts
Binary representation	Only 0 and 1 (two voltage levels). Quantum computing uses more states (qubits).
Number system	Numbers, a base (radix) and place values. The base is the number of symbols.
Four systems	Binary base 2 (0, 1) · Octal base 8 (0 - 7) · Decimal base 10 (0 - 9) · Hexadecimal base 16 (0 - 9, A - F).
Weighting factors	Powers of the base: $2^0, 2^1, 2^2 \dots 16^0, 16^1 \dots$ After a point: $10^{-1}, 10^{-2} \dots$
MSD / LSD	MSD: the first digit on the left that is not 0. LSD: the last digit on the right (after a point: the last that is not 0). MSB / LSB: the same for bits.
Decimal to other bases	Divide by 2, 8 or 16 until the quotient is 0. Read the remainders from the bottom to the top (15 = F).
To decimal	Multiply each digit by its weighting factor and add: $1101_2 = 8 + 4 + 0 + 1 = 13_{10}$.
Clusters	Binary to octal: clusters of 3 bits. Binary to hexadecimal: clusters of 4 bits, from the right. Octal and hexadecimal: go through binary.
Storage units	8 bits = 1 byte · 4 bits = 1 nibble · 1024 B = 1 KB · 1024 KB = 1 MB · 1024 MB = 1 GB · 1024 GB = 1 TB · 1024 TB = 1 PB.
Devices	Register and cache memory: fastest, smallest, highest cost per unit. Magnetic tape: largest and slowest.
Coding systems	BCD: 4 bits for each decimal digit. ASCII: 7 bits, 128 characters (ANSI). Unicode: 16 bits, 65 536 symbols of all languages.
Pictures and sound	Each pixel colour has a binary code. Sound waves are changed into 0s and 1s.

★ TICK WHEN YOU CAN DO IT

- ☐ I can name the digits, base and weighting factors of four number systems.
- ☐ I can find the MSD and LSD of a number, and the MSB and LSB of a binary number.
- ☐ I can convert decimal numbers to binary, octal and hexadecimal.
- ☐ I can convert binary, octal and hexadecimal numbers to decimal.
- ☐ I can convert between binary, octal and hexadecimal with clusters.
- ☐ I can compare storage units and devices by capacity, speed and cost.
- ☐ I can write numbers in BCD and letters in ASCII.

"Read every question twice. Then answer like a king."

- THE KING OF ICT



WORD POWER

Unit 3 Word List

Thirty words you must know

Word	What it means
Binary representation	Representing data with only two symbols, 0 and 1.
Voltage level	One of the two electrical levels that show 0 and 1 inside the computer.
Multi-state	Using more than two states for data, as in quantum computing.
Qubit	A quantum bit: a memory unit that holds many values at the same time.
Number system	A method to represent numbers with a fixed set of symbols.
Base / Radix	The number of symbols used in a number system.
Place value	The value of a digit because of its position in a number.
Weighting factor	A power of the base for each position, like 2^3 or 16^1 .
Bit	A binary digit, 0 or 1. The smallest unit of data.
Octal	The number system with base 8 (digits 0 to 7).
Hexadecimal	The number system with base 16 (0 to 9 and A to F).
MSD / LSD	The most / least significant digit of a number.
MSB / LSB	The most / least significant bit of a binary number.
Quotient / Remainder	The answer of a division / what is left over.
Cluster	A group of 3 bits (octal) or 4 bits (hexadecimal).
Nibble / Byte	4 bits / 8 bits.
Kilobyte (KB)	1024 bytes.
Megabyte (MB)	1024 KB, or 1 048 576 bytes.
Gigabyte (GB)	1024 MB. Gb (with a small b) means gigabit.
Terabyte / Petabyte	1 TB = 1024 GB. 1 PB = 1024 TB.
Register memory	The fastest storage, with the smallest capacity (about 1 KB).
Access speed	How fast a device can read and write data.
Cost per unit storage	The cost of storing one unit of data on a device.
BCD	Binary Coded Decimal: each decimal digit in 4 bits.
ASCII	American Standard Code for Information Interchange: 7 bits, 128 characters.
ANSI	American National Standards Institute. It designed and approved ASCII.
EBCDIC	Another character code in the textbook appendix (A = 193).
Unicode	A 16-bit code for 65 536 symbols of all languages.
Colour code	A colour written in hexadecimal: #871F78 is R 135, G 31, B 120.
Pixel	One dot of a picture. Each colour has a binary code.

"Learn the words first. Then the ideas will follow you everywhere."

- THE KING OF ICT



END OF UNIT

Unit 3 Test

Time: 45 minutes

Total: 40 marks

Name _____

Class _____

Marks

1 Choose the correct answer

8 marks

Underline your answer.

1. The base of the hexadecimal number system is
 (a) 2 (b) 8 (c) 10 (d) 16
2. Which one is NOT a correct octal number?
 (a) 765_8 (b) 108_8 (c) 17_8 (d) 400_8
3. The MSD and the LSD of 58.32 are
 (a) 5 and 3 (b) 8 and 2 (c) 5 and 2 (d) 8 and 3
4. 1101_2 in decimal is
 (a) 11 (b) 12 (c) 13 (d) 14
5. 47_{10} in hexadecimal is
 (a) $2F_{16}$ (b) $2E_{16}$ (c) 57_{16} (d) 215_{16}
6. To convert a binary number to octal, we make clusters of
 (a) 2 bits (b) 3 bits (c) 4 bits (d) 8 bits
7. One nibble is equal to
 (a) 2 bits (b) 4 bits (c) 8 bits (d) 1024 bits
8. Which coding system can represent Sinhala and Tamil letters?
 (a) BCD (b) ASCII (c) Unicode (d) binary

2 Fill in the blanks

8 marks

One word or number in each blank.

1. The number of symbols in a number system is its base or
2. Place values like 2^0 , 2^1 , 2^2 are called factors.
3. The bit at the right end of the number 1010_2 is its
4. To convert a decimal number to octal, we keep dividing it by
5. One hexadecimal digit can be written with bits.
6. 1024 kilobytes make one
7. memory is the fastest storage in the computer.
8. The ASCII coding system was designed and approved by



3 Complete the conversions

8 marks

Do the working on rough paper. Write only the answer.

	Number	To	Answer
1	29₁₀	base 2	
2	100₁₀	base 8	
3	250₁₀	base 16	
4	101101₂	base 10	

	Number	To	Answer
5	157₈	base 10	
6	2C₁₆	base 10	
7	110101110₂	base 8	
8	10111101₂	base 16	

4 Answer these

16 marks

Write in the space given.

1. Convert 75₁₀ to a binary number. Show your working. (3 marks)

2. Convert 3B6₁₆ to an octal number through binary. Show your working. (3 marks)

3. (a) How many bytes are in 2 KB? (b) Write from the fastest to the slowest: hard disk, cache memory, magnetic tape, RAM. (3 marks)

4. (a) Write 2026 in BCD. (b) In ASCII, G is 71 and O is 79. Write GO in 7-bit ASCII. (4 marks)

5. Why was the Unicode system designed? Write one place where it is used. (3 marks)

