SECTION 1 - Fundamental of hardware and software

1-1 Describe a general-purpose computer system

Four major functions of a computer systems

<table>
<thead>
<tr>
<th>Function</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>Accepts or takes in data</td>
</tr>
<tr>
<td>Processing</td>
<td>Manipulates data according to instructions</td>
</tr>
<tr>
<td>Output</td>
<td>Provides user with information</td>
</tr>
<tr>
<td>Storage</td>
<td>Stores data</td>
</tr>
</tbody>
</table>

Example: Buying items at a book store.

**Input** - The barcode reader scans the items to collect the name and price of the item.

**Processing** - The computer system adds up the prices of all the items bought.

**Output** - The Price of all the items are displayed to the user on the monitor along with the total price of all the item and after you have paid your sales receipt is also printed out.

**Storage** - The computer stores the transaction to be used again if needed.

1-2 Major hardware components of a computer system

The basic components of a computer system are **hardware** and **software**.

**Hardware** is the name given to the physical parts of a computer system.

**Software** is a set of instructions(program) that governs the operation of a computer system by telling the hardware how to work.

**HARDWARE**

There are five general categories of hardware:

1. **Central processing unit (CPU)** is the brain of a computer and is found inside of the system unit. The CPU has two main parts called Arithmetic and Logic Unit(\textbf{ALU}) and Control Unit(\textbf{CU}). The ALU performs the calculations and logic operations while the CU controls the flow and execution of data through the computer.
2. **Input devices** allow data and instructions to be entered into the computer system. A mouse, keyboard, scanner and webcam are all input devices.

3. **Output devices** get processed information out of a computer to be available to users. A printer, monitor(display screen) and speakers are all output devices.

4. **Main memory** also called RAM, primary storage or immediate access storage holds program and data currently being executed temporarily.

5. **Secondary storage** is permanent and stores data for future use. Hard disks, flash drives, CD-ROM and tape drives are secondary storage media.

Peripheral devices are pieces of hardware that can be added to a computer system. Input, output and storage devices may be peripheral devices such as the mouse, printer and an external hard disk drive.

### 1-3 Primary Storage Devices

**Primary storage** devices are used by the computer for its own use.

There are two types of primary storage devices: **Volatile storage** and **Non-volatile storage**.

Volatile storage devices loses all the data when the computer is turned off while non-volatile storage devices keeps the data even if the computer is turned off.

**Volatile storage devices**

- **Random Access Memory (RAM)** also called main memory, temporarily holds program and data that is currently being executed.

**Non-volatile storage devices**

- **Read-Only Memory (ROM)** is a permanent storage device that contains data that cannot be changed. Data in ROM is called firmware, which is a set of instructions that tells the computer what to do when it starts up. One of the set of instructions done by the ROM is called **Booting**, which is loading the operating system (Windows 7 or Linux) into main memory.

- **Programmable ROM (PROM)** is a type of ROM that can be programmed only once after it is manufactured. Once it is programmed it cannot be changed.

- **Erasable Programmable ROM (EPROM)** is a type or ROM that can be programmed just like PROM, but it can be erased then re-programmed more than once using an ultraviolet light.
Some computers can store small amount of data while others can store large amounts of data. But how do we measure data. If you have a glass of water and you want to measure how much is in it the unit of measurement you might use is *ounces*, but if you are measuring the amount of gas to put into your car you might change the unit from ounce and use *gallon instead*. The same with computers. The smallest unit of measurement in computers are *Bits* and the largest one we are going to use is *Terabyte*.

**Bits** (*Binary digits*) a computer stores data in bits. Bits are just a combination of 1s and 0s. For example, 10110011 are 8 bits of data. This means that a computer is a bi-stable device, which means it can be in 1 of 2 states; either a 0 or a 1.

**Byte** is a group of 8 bits or you can say 8 bits equals 1 Byte. 10010101 is a Byte. Every character you type on the keyboard(letter, number, symbol) uses up 1 Byte of storage. For example pressing letter A on the keyboard might be equal to 01000001 (1 byte).

**Word** is the largest amount of binary units that can be processed in one operation. Computers usually have a word size of 32 or 64 bits. **Word size** is the number of bits which can be transferred in a word.

Units of measurement from the smallest to largest are:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit</td>
<td>8 Bits</td>
</tr>
<tr>
<td>Byte</td>
<td>1024 Bytes</td>
</tr>
<tr>
<td>KB(KiloByte)</td>
<td>1024 KB</td>
</tr>
<tr>
<td>MB(MegaByte)</td>
<td>1024 MB</td>
</tr>
<tr>
<td>GB(GigaByte)</td>
<td>1024 GB</td>
</tr>
<tr>
<td>TB(TeraByte)</td>
<td></td>
</tr>
</tbody>
</table>

**Manipulating units of storage**

Let us try these examples first to help you understand conversions a bit more.

**Dollars to Cents**

- 1 dollar --> cents = 100 cents (working: 1x100=100) and
- 7 dollars --> cents = 700 cents (working: 7x100=700)

This tells us that if we are converting from a **bigger to a smaller** unit we have to **MULTIPLY**, because more of the smaller unit is needed to fill the space of the bigger unit.

**Cents to Dollars**

- 500 cents --> dollars = 5 dollars (working 500/100=5)

This tells us that if we are converting from a **smaller to a bigger** unit we have to **DIVIDE**.
Convert the following:

1. **3GB -> MB**
   
   **Solution:** **bigger to smaller** we multiply
   
   \[
   \begin{array}{c|c|c|c}
   GB & \rightarrow & MB \\
   3 & \times 1024 & = 3069 \\
   \end{array}
   \]
   
   **Answer** = 3096MB

2. **2GB -> KB** (NB: Going from **GB -> KB** we must pass through **MB**)
   
   **Solution:** **bigger to smaller** we multiply
   
   \[
   \begin{array}{c|c|c|c|c}
   GB & \rightarrow & MB & \rightarrow & KB \\
   2 & \times 1024 & x 1024 & = 2,097,152 \\
   \end{array}
   \]
   
   **Answer** = 2,097,152KB

3. **2KB -> bit** (NB: When converting to and from bits we use 8 AND NOT 1024)
   
   **Solution:** **bigger to smaller** we multiply
   
   \[
   \begin{array}{c|c|c|c}
   KB & \rightarrow & Byte & \rightarrow & bits \\
   2 & \times 1024 & x 8 & = 16,384 \\
   \end{array}
   \]
   
   **Answer** = 16,384bits

4. **40,960 bits -> KB** (NB: going from **bits -> KB** we must pass through **Bytes**)
   
   **Solution:** **smaller to bigger** we divide
   
   \[
   \begin{array}{c|c|c|c|c}
   bits & \rightarrow & Bytes & \rightarrow & KB \\
   40,960 & / 8 & / 1024 & = 5 \\
   \end{array}
   \]
   
   **Answer** = 5KB
Secondary storage devices and media

Storage device is the hardware that is used to store the data unto the storage medium or retrieve the data from the storage medium. For example, the CD-ROM (device) drive is used to read data from or store to the CD-ROM (media).

<table>
<thead>
<tr>
<th>Storage Media</th>
<th>Storage Device</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Floppy disk</td>
<td>Floppy drive</td>
<td>1.44MB</td>
</tr>
<tr>
<td>• Hard disk</td>
<td>Hard drive</td>
<td>GB - 4TB</td>
</tr>
<tr>
<td>• Magnetic tape cassette</td>
<td>Cassette player</td>
<td></td>
</tr>
<tr>
<td>Optical (uses laser)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• CD-ROM disk</td>
<td>CD-ROM drive</td>
<td>700MB</td>
</tr>
<tr>
<td>• DVD disk</td>
<td>DVD drive</td>
<td>4.7GB</td>
</tr>
<tr>
<td>Miniature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• USB flash drive</td>
<td>USB flash drive</td>
<td>MB - 32GB</td>
</tr>
<tr>
<td>• Flash memory card</td>
<td>Flash card reader</td>
<td>MB - 32GB</td>
</tr>
</tbody>
</table>

Terms associated with storage devices

Device Interfaces

A device interface determines how the storage device are physically connected to the computer.

- IDE, SCSI and SATA are interfaces found on a hard drive.
Read/write head, sectors, tracks and cylinders are all parts found within a hard drive.

- **Tracks** are concentric rings on the storage medium.
- A **sector** is a segment of a track on which data is stored.
- A **cluster** is a combination of sectors.
- A **cylinder** is a set of matched tracks on all platters.
- **Read/write head** is a mechanism that reads from or writes data to a disk storage medium.

**Magnetic tape** is a narrow plastic coated strip where data is recorded along the length of the tape. It is normally used for storing large amount of data at a relatively low cost.

Magnetic tape uses **Sequential access**, while flash drives, CD-ROMs and hard drives uses **Direct access**.

With **sequential access** you must go through the preceding data before getting to a specific data.

With **direct access**, the computer goes directly to a specific data on the storage medium.

**Access time** is the time taken to locate and retrieve data from storage.

A **buffer** is a temporary storage area for data that has to be transferred from one device to another. This is necessary because different parts of the computer operate at different speeds (e.g. printer and the CPU).
Input devices allow data and instructions to be entered into the computer system.

**Types and functions of Input devices**

- **Keyboard** is the most common device used to enter data into the computer. There are also special keyboards such as the Braille keyboard for the visually impaired.

- **A mouse** is also a common type of input device which is used to control the movement of the pointer on the screen. A mouse is a **pointing device**.

**Other pointing devices are:**

- **Joystick** - mainly used for playing games.
- **Trackball** is like an upside-down mouse. Instead of moving the whole mouse with your hand to control the pointer, the user rotates the ball with their fingers.
- **Touchpad/Trackpad** is found on notebook computers. It is a flat surface where the user glides their finger on to control the pointer on the screen.
- **Light-pen** is similar in shape to a pen but can detect light. It is used by touching the pen against the surface of the monitor screen and you can make a selection by clicking a button on the pen. Light-pens are useful with healthcare professionals who need to keep their hands free from contamination.

- **Touch screen/terminal** allows the user to press parts of the screen to activate different functions. Located at ATMs and supermarkets.

- **Voice response unit** uses a microphone to accept spoken words as data or instructions. The voice recognition software may require initial training by the user to recognize their voice pattern.

- **A graphic tablet** are used by artists, designers and architects to create accurate drawings. It works along with a stylus to draw on the graphic tablet which is transferred to the monitor screen.

- **A sound card** is normally an internal device found in the system unit which can be used to capture sounds from a microphone. It is also used to allow sounds to be outputted to speakers that are connected to it.

- **Webcam** is a video capturing device normally used in video chat and video conferencing.

- **Sensors** are used to capture data automatically and to pass the data to a computer where it is analyzed, stored and manipulated. There are different types of sensors. Some detect heat, light, movement, wind etc.

- **A remote control** uses infra-red light to operate another device such as, TVs, gates and toys.
✓ **Biometric systems** uses some part of a person’s body to uniquely identify them. Body parts commonly used are the fingerprints, face and iris.

✓ **Digital cameras** are used to take and store pictures digitally. These images can then be easily transferred to a computer using memory cards. Digital cameras can also be called an output device because the image can be also shown on the display screen directly from the camera.

✓ **Point of sale (POS) systems** are commonly used at shopping malls and supermarkets. It normally consists of a terminal at the checkout area, a barcode reader to scan the items, a receipt printer and a computer system that contains a database of all the items.

✓ **Barcode reader** - a barcode is a combination of thick and thin lines that provides data on an item. A barcode reader uses laser beams to scan the barcode found on items to obtain the name, manufacturer, price etc.

✓ **Optical mark reader/recognition (OMR)** identifies the absence or presence of dark marks on a form. It is normally used to mark multiple choice examinations.

✓ **Magnetic ink character reader (MiCR)** reads text printed with magnetic ink. It is used mainly for processing bank cheques.

✓ **Optical character recognition (OCR)** reads handwritten or printed characters and converts them into an electronic form which can then be edited. Some scanners come with an OCR software while others do not.
Output devices get processed information out of a computer to be available to users. The two main types of output are Soft copy and hard copy.

- **Soft copy** is temporary. It is output displayed in electronic form such as a monitor or sound output from speakers.
- **Hard copy** is permanent. It is output in printed form such as an examination paper that was printed from a printer.

**Types and functions of output devices**

- **Visual display unit (VDU)** is a device that displays output on a screen or monitor.
  - **Features of a computer screen**
    - **Size** - ranges from 9 to 50 inches.
    - **Resolution** - Pictures on a screen are made up of tiny dots called pixels. Resolution is the amount of pixels outputted on the screen (1440 x 768 pixels [horizontal x vertical]). The more the pixels the higher or more detailed the images will be.
    - **Type** - There are three main types:
      1. **Cathode ray tube (CRT)** - Used mainly in the past but are being replaced by LCD. Found mainly with old desktops.
      2. **Liquid crystal display (LCD)** - Takes up less space and consumes less energy than the CRT. Found mainly on laptops.
      3. **Light-emitting diode (LED)** - Found mainly on palmtop computers.

- **Printers** are output devices that produce hard copy output mainly on paper.

  Two categories of printers are impact and non-impact printers.

**Impact printers**

*Impact printers strike through a carbon or inked ribbon, like a type writer.*

- **dot-matrix printers** - Uses pins to print a pattern of dots on paper
- **line printers** - Prints an entire line at a time instead of printing each character individually.
**Non-impact printers**

Non-impact printer do not involve striking the paper.

- **Inkjet printer** - Operates by spraying small ink droplets unto the paper. The speed is measured by how many pages can be printed per minute.

- **Laser printers** - are high quality and high speed printers and are much faster than inkjet printers. A laser beam creates an image of the page on a drum, treated with a magnetically charged powder called toner. The paper is then pressed against the drum and fuses to the paper by using heat.

- **Thermal printers** - uses heat on chemically treated paper to form characters. A receipt printer found in stores is a thermal printer.

- **Plotters** - use coloured pens or toner to draw accurate and precise images on paper. Used by engineers to produce maps and large building plans.

- **Microfilm/microfiche output** - the output is printed on a roll of film (*microfilm*) or on a rectangular sheet of film (*microfiche*). The data printed is very small and needs to be magnified to be read using a *microfiche reader*.

- **Sound output** - A computer's *sound card* is used to send the sounds to *headphones* or *speakers* which enable the sounds to be heard.
NUMBER SYSTEMS (Bases)

The base is simply the number of digits that are available.

Four number systems used in computers are:

<table>
<thead>
<tr>
<th>Number System</th>
<th>Base</th>
<th>Range</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decimal (used in daily lives)</td>
<td>10</td>
<td>0-9 (0,1,2,3,4,5,6,7,8,9)</td>
<td>49₁₀, 83₁₀</td>
</tr>
<tr>
<td>Binary</td>
<td>2</td>
<td>0-1 (0,1)</td>
<td>01100101₂, 1001011₂</td>
</tr>
<tr>
<td>Octal</td>
<td>8</td>
<td>0-7 (0,1,2,3,4,5,6,7)</td>
<td>527₈, 615₈</td>
</tr>
<tr>
<td>Hexadecimal</td>
<td>16</td>
<td>0-9, A-F, where A=10 &amp; F=15</td>
<td>3E₁₆, 2CB₁₆</td>
</tr>
</tbody>
</table>

CONVERSIONS

Here are all the conversions that will be covered in this chapter.

<table>
<thead>
<tr>
<th>Section</th>
<th>Conversion</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DEC → BIN</td>
<td>Use 3 column (Remainder) table</td>
</tr>
<tr>
<td></td>
<td>DEC → OCT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DEC → HEX</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>BIN → DEC</td>
<td>Use expansion table</td>
</tr>
<tr>
<td></td>
<td>OCT → DEC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HEX → DEC</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>BIN → OCT</td>
<td>Group the BITS</td>
</tr>
<tr>
<td></td>
<td>BIN → HEX</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>OCT → BIN</td>
<td>Separate each digit</td>
</tr>
<tr>
<td></td>
<td>HEX → BIN</td>
<td>Groups of 4</td>
</tr>
<tr>
<td>5</td>
<td>BCD → DEC</td>
<td>Separate each digit</td>
</tr>
<tr>
<td>6</td>
<td>DEC → BCD</td>
<td></td>
</tr>
</tbody>
</table>
SECTION 1 CONVERSIONS

Rules for converting from a **Decimal** $\rightarrow$ (**BIN**, **OCT**, **HEX**):

1. Use the **3 column(remainder) table**.
2. In the 1st column place the **Base number** you are converting to. *(divisor)*
3. In the 2nd column place the **Decimal** value. *(dividend)*
4. In the 3rd column place the **Remainder**.
5. **Divide** the DEC by the Base until it gets to 0.
6. The **answer** is the remainder written from the **bottom** to the **top**.

**Examples**

1. Convert the following from **DEC** $\rightarrow$ **BIN**: *(write your answer using 8 bits)*
   
   a) $25_{10} \rightarrow \text{BIN}_2$
   
<table>
<thead>
<tr>
<th>Base</th>
<th>Dec</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

   Bottom to top gives **11001**
   contains 5 bits so add 3 0's at the beginning
   Answer is **00011001**$_2$ (using 8 bits)

   b) $48_{10} \rightarrow \text{BIN}_2$
   
<table>
<thead>
<tr>
<th>Base</th>
<th>Dec</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

   Bottom to top gives **110000**
   contains 6 bits so add 2 0's at the beginning
   Answer is **00110000**$_2$ (using 8 bits)

2. Convert the following from **DEC** $\rightarrow$ **OCT**:
   
   a) $38_{10} \rightarrow \text{OCT}_8$
   
<table>
<thead>
<tr>
<th>Base</th>
<th>Dec</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>38</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

   Answer is **46**$_8$

   b) $69_{10} \rightarrow \text{OCT}_8$
   
<table>
<thead>
<tr>
<th>Base</th>
<th>Dec</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>69</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

   Answer is **105**$_8$

3. Convert the following from **DEC** $\rightarrow$ **HEX**:
   
   a) $155_{10} \rightarrow \text{HEX}_{16}$
   
<table>
<thead>
<tr>
<th>Base</th>
<th>Dec</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>155</td>
<td>11</td>
</tr>
<tr>
<td>16</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>16</td>
<td>0</td>
<td>9</td>
</tr>
</tbody>
</table>

   Answer is **9B**$_{16}$

   b) $30_{10} \rightarrow \text{HEX}_{16}$
   
<table>
<thead>
<tr>
<th>Base</th>
<th>Dec</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>30</td>
<td>14</td>
</tr>
<tr>
<td>16</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>16</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

   Answer is **1E**$_{16}$
SECTION 2 CONVERSIONS

Rules for converting from (BIN, OCT, HEX) \(\rightarrow\) Decimal:

1. Place each digit in a column of the table created.
2. The 2nd row from right to left always begins with 1, then multiplied by the base of the number above.
3. Multiply the 1st row by the 2nd, then add them together to get your answer in Decimal.

Examples

1. Convert the following from BIN \(\rightarrow\) DEC:
   a) \(11001_2 \rightarrow \text{DEC}_{10}\)
      
      \[
      \begin{array}{cccccc}
      \text{Column} & 1 & 1 & 0 & 0 & 1 \\
      \text{Value} & 2^4=16 & 2^3=8 & 2^2=4 & 2^1=2 & 2^0=1 \\
      \end{array}
      \]
      \(\leftarrow\) Multiply by base(2) from right to left
      Answer = \(25_{10}\)

   b) \(110000_2 \rightarrow \text{DEC}_{10}\)
      
      \[
      \begin{array}{cccccc}
      \text{Column} & 1 & 1 & 0 & 0 & 0 \\
      \text{Value} & 32 & 16 & 8 & 4 & 2 \\
      \end{array}
      \]
      \(\leftarrow\) Multiply by base(2) from right to left
      Answer = \(48_{10}\)

2. Convert the following from OCT \(\rightarrow\) DEC:
   a) \(105_8 \rightarrow \text{DEC}_{10}\)
      
      \[
      \begin{array}{cccc}
      \text{Column} & 1 & 0 & 5 \\
      \text{Value} & 8^2=64 & 8^1=8 & 8^0=1 \\
      \end{array}
      \]
      \(\leftarrow\) Multiply by base(8)
      Answer = \(69_{10}\)

   b) \(46_8 \rightarrow \text{DEC}_{10}\)
      
      \[
      \begin{array}{rr}
      & 4 & 6 \\
      \end{array}
      \]
      \(\leftarrow\) Multiply by base(8)
      Answer = \(38_{10}\)

3. Convert the following from HEX \(\rightarrow\) DEC:
   a) \(9B_{16} \rightarrow \text{DEC}_{10}\)
      
      \[
      \begin{array}{rr}
      & 9 & B \\
      \end{array}
      \]
      \(\leftarrow\) Multiply by base(16)
      Answer = \(155_{10}\)

   b) \(1E_{16} \rightarrow \text{DEC}_{10}\)
      
      \[
      \begin{array}{rr}
      & 1 & E \\
      \end{array}
      \]
      \(\leftarrow\) Multiply by base(16)
      Answer = \(30_{10}\)
SECTION 3 CONVERSIONS

Rules for converting from BIN → (OCT, HEX):

1. Group the BITS
   - For OCT split the bits in groups of 3 starting from the right
   - For HEX split the bits in groups of 4 starting from the right
2. For each group, convert to DEC
3. Join the numbers together

1. Convert the following from BIN → OCT:
   a) 10110100₂ → OCT₈

   Groups of 3, then convert each group to DEC
   
   \[
   \begin{array}{c|c|c|c}
   1 & 0 & 0 \\
   \hline
   2^2 = 4 & 2^1 = 2 & 2^0 = 1 \\
   \hline
   \end{array}
   \]
   
   \[
   \begin{array}{c|c|c|c}
   1 & 1 & 0 \\
   \hline
   2^2 = 4 & 2^1 = 2 & 2^0 = 1 \\
   \hline
   \end{array}
   \]
   
   \[
   \begin{array}{c|c|c|c}
   1 & 0 & 0 \\
   \hline
   2^2 = 4 & 2^1 = 2 & 2^0 = 1 \\
   \hline
   \end{array}
   \]

   \[
   \begin{array}{c|c|c|c}
   2 + 0 = 2 \\
   \hline
   4 + 2 + 0 = 6 \\
   \hline
   4 + 0 + 0 = 4
   \end{array}
   \]

   Answer is 264₈

2. Convert the following from BIN → HEX:
   a) 10011110₂ → HEX₁₆

   Groups of 4, then convert each group to DEC
   
   \[
   \begin{array}{c|c|c|c|c}
   1 & 0 & 0 & 1 \\
   \hline
   2^3 = 8 & 2^2 = 4 & 2^1 = 2 & 2^0 = 1 \\
   \hline
   \end{array}
   \]
   
   \[
   \begin{array}{c|c|c|c}
   1 & 1 & 1 & 0 \\
   \hline
   2^3 = 8 & 2^2 = 4 & 2^1 = 2 & 2^0 = 1 \\
   \hline
   \end{array}
   \]
   
   \[
   \begin{array}{c|c|c|c|c}
   1 & 0 & 0 & 1 \\
   \hline
   2^3 = 8 & 2^2 = 4 & 2^1 = 2 & 2^0 = 1 \\
   \hline
   \end{array}
   \]

   \[
   \begin{array}{c|c|c|c|c}
   8 + 0 + 0 + 1 = 9 \\
   \hline
   8 + 0 + 0 + 0 = 14 \text{ (E)}
   \end{array}
   \]

   Answer is 9E₁₆
SECTION 4 CONVERSIONS

Rules for converting from (OCT, HEX) → BIN:

1. **Separate** each digit.
2. Convert each individual digit to binary using 3 BITS (OCT) or 4 BITS (HEX).
3. **Join** all the bits together.

1. Convert the following from OCT → BIN.

   a) $603_8 \rightarrow \text{BIN}_2$

   6 | 0 | 3  **separate each digit, then convert to BIN using 3 BITS each.**

   \[
   \begin{array}{c|c|c}
   2 & 6 & R \\
   \hline
   2 & 3 & 0 \\
   2 & 1 & 1 \\
   0 & 1 & \\
   \end{array}
   \]

   $6 = 110$

   Answer is $11000011_2$

2. Convert the following from HEX → BIN.

   a) $2B7_{16} \rightarrow \text{BIN}_2$

   2 | B | 7  **separate each digit, then convert to BIN using 4 BITS each.**

   \[
   \begin{array}{c|c|c}
   2 & 2 & R \\
   \hline
   2 & 1 & 0 \\
   0 & 1 & \\
   \end{array}
   \]

   $2 = 10$, using 4 BITS

   $2 = 0010$

   \[
   \begin{array}{c|c|c}
   2 & B(11) & R \\
   \hline
   2 & 5 & 1 \\
   2 & 2 & 1 \\
   2 & 1 & 0 \\
   \end{array}
   \]

   B = 1011

   Answer is $001010110111_2$
SECTION 5 CONVERSIONS

NB - Binary Coded Decimals (BCD) are always done in groups of 4.

Very similar to HEX but with BCD each group only range from 0 - 9.

Rules for converting from a BCD → DEC:

1. **Split** the bits in groups of 4
2. For each group, convert to DEC
3. **Join** the numbers together

1. Convert the following from BCD → DEC:
   a) 1001 0000 0110 → DEC

   \[
   \begin{array}{cccc}
   1 & 0 & 0 & 1 \\
   0 & 0 & 0 & 0 \\
   0 & 1 & 1 & 0 \\
   \end{array}
   \]

   \[
   \begin{array}{cccc}
   8 & 4 & 2 & 1 \\
   0 & 0 & 0 & 0 \\
   0 & 4 & 2 & 1 \\
   \end{array}
   \]

   \[
   \begin{array}{cccc}
   8 + 0 + 0 + 1 \\
   0 + 0 + 0 + 0 \\
   0 + 4 + 2 + 0 \\
   \end{array}
   \]

   \[
   \begin{array}{cccc}
   = 9 \\
   = 0 \\
   = 6 \\
   \end{array}
   \]

Answer in DEC is \(906_{10}\)

SECTION 6 CONVERSIONS

Rules for converting from a DEC → BCD:

1. **Separate** each digit
2. Convert each Decimal digit to BIN, using 4 BITS
3. **Join** the bits together

1. Convert the following from DEC → BCD:
   a) 906\(_{10}\) → BCD

   \[
   \begin{array}{ccc}
   2 & 9 & R \\
   2 & 4 & 1 \\
   2 & 2 & 0 \\
   2 & 1 & 0 \\
   \end{array}
   \]

   \[
   \begin{array}{ccc}
   2 & 0 & R \\
   0 & 0 & 0 \\
   \end{array}
   \]

   \[
   \begin{array}{ccc}
   2 & 6 & R \\
   2 & 3 & 0 \\
   2 & 1 & 1 \\
   \end{array}
   \]

   \[
   \begin{array}{ccc}
   6 = 110, \text{ using 4 BITS} \\
   0 = 0000 \\
   \end{array}
   \]

Answer in BCD is \(1001\ 0000\ 0110\)
UNSIGNED BCD vs SIGNED BCD

In an unsigned BCD representation, the sign (+ or -) is ignored. In a signed BCD representation, the 1st four bits are used to determine if the number is positive or negative.

- 1000 is positive (+)
- 1001 is negative (-)

Positive BCD examples:
- 1000 1001 0010 0001 = +921
- 1000 0110 0101 = +265

Negative BCD examples are:
- 1001 1001 0010 0001 = -921
- 1001 1011 0110 0101 = -365

ADDING BINARY DIGITS

There are 5 basic rules to follow when adding Binary:
1. 0 + 0 = 0
2. 0 + 1 = 1
3. 1 + 0 = 1
4. 1 + 1 = 10 in DEC, 1 + 1 = 2 but we know binary only consists of 0s and 1s. If we convert DEC(2) → BIN the result is 10₂
5. 1 + 1 + 1 = 11 in DEC, 1 + 1 + 1 = 3 but we know binary only consists of 0s and 1s. If we convert DEC(3) → BIN the result is 11₂

1. Add the following Binary Digits

a) 1001 and 0101

```
  1
1001
+ 0101
____0 10
```

b) 10111 and 110

```
  11
10111
+ 0110
____101 10
```

1001 + 0101 = 1110₂

10111 + 110 = 11101₂
REPRESENTING POSITIVE AND NEGATIVE INTEGERS

There are two main methods for representing Positive and Negative integers:

- Sign & Magnitude
- Two's Complement

SIGN & MAGNITUDE

7 BITS are used to determine the value of the integer (Magnitude)

1 BIT is reserved to determine the sign (Sign Bit)

- If the sign bit is 0, it is positive
- If the sign bit is 1, it is negative

Example: Using sign & magnitude, determine if the following bits are positive or negative.

<table>
<thead>
<tr>
<th>Sign bit</th>
<th>Magnitude</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0110101</td>
<td>Negative</td>
</tr>
<tr>
<td>1</td>
<td>1110110</td>
<td>Negative</td>
</tr>
<tr>
<td>0</td>
<td>1100001</td>
<td>Positive</td>
</tr>
<tr>
<td>0</td>
<td>0100101</td>
<td>Positive</td>
</tr>
<tr>
<td>1</td>
<td>0001101</td>
<td>Negative</td>
</tr>
</tbody>
</table>

1. Represent +30 and -30 in sign and magnitude

Convert DEC → BIN

<table>
<thead>
<tr>
<th>2</th>
<th>30</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

30 = 11110, contains 5 bits, so add 2 0s at the beginning

30 = 0011110  (magnitude)

For +30, the sign bit will be 0   +30 = 00011110
For -30, the sign bit will be 1   -30 = 10011110
TWO’S COMPLEMENT  (Represented in standard 8 BITS)

If the number is negative
Rules are:
1. Convert the DEC $\rightarrow$ BIN, using 8 Bits
2. Change zeros to ones and ones to zeros (One's complement)
3. Add 1 to the result above (Two's complement)

If the number is positive, only do step 1 above.

1. Represent the following using Two's complement:
   a) +47 and -47

Step 1: Convert 47 $\rightarrow$ BIN.

<table>
<thead>
<tr>
<th>2</th>
<th>47</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

47 = 101111, contains 6 bits, so add 2 0s

+47 00101111

Step 2: 11010000 (1’s complement)

Step 3: +1

-47 11010001 (2’s complement)

Therefore
+47 = 00101111
-47 = 11010001
The Two's complement comes in very handy when attempting to subtract numbers.

Computers normally cannot directly subtract numbers.

For example:

It cannot do 15-10
What a computers does instead is to add a negative number: 15 +(-10)
15-10 and 15+(-10) actually means the same thing.

This means you have to use 2's complement to represent the negative number.

1. Calculate the following using 2's complement:
   a) 12 - 5, rewritten as: 12 +(-5)

   Convert 12 \rightarrow\text{BIN}
   
   12 \rightarrow\text{BIN} is 00001100

   Convert -5 \rightarrow\text{BIN}
   
   5 \rightarrow\text{BIN} is 00000101
   5 must be changed to -5 , using 2's complement
   
   11111010 (1's complement)
   + 1
   \text{-5} 11111011 (2's complement)

   Then add the numbers: 12 + (-5)
   
   1111
   0001100 (12)
   + 11111011 (-5)
   \text{\texttt{10000111}} (7) NB: if there is an extra Bit, get rid of it

   b) Subtract 101 from 11011, Rewritten as 11011 + (-101)

   Convert 11011 \rightarrow\text{BIN}
   
   11011 = 00011011

   Convert -101 \rightarrow\text{BIN}
   
   101 is negative, so change the bits then add 1.
   
   00001011
   11111010 (1's complement)
   + 1
   \text{\texttt{11111011}} (2's complement)

   Then add the numbers: 12 + (-5)
   
   111111
   00011011
   + 11111011
   \text{\texttt{100010110}} NB: if there is an extra Bit, get rid of it.
The main things to consider when choosing a computer are:

1. **CPU (Type and speed)** – The processor performs almost all of the computation and controls the functioning of the other devices. The most common brands are Intel and AMD. The processor power is measured by its clock speed in megahertz (MHz) or gigahertz (GHz), where 1 GHz = 1000 MHz. Faster clock speed will produce faster computer processing power, and will be more expensive.

   *Examples of processor specifications are:*
   - 1.0 GHz AMD Athlon 4
   - Intel Pentium 4 processor @ 2.8 GHz
   - Intel Core Duo @ 2.0GHz

2. **Memory** – A typical RAM specification has the following format:

   4 GB DDR2 SDRAM at 1333MHz (2 DIMMs)

   1. Size: Common RAM sizes are 512 MB, 1 GB, 2 GB and 4 GB. The bigger the better.
   2. Type: The three main types of memory are DDR, DDR2 (The most common) and DDR3.
   3. Speed: Some specifications may include the RAM speed. Common speeds are 667, 800, 1066 and 1333 MHz.
   4. Number of RAM modules: The specification may tell you how many DIMMS (RAM modules) there are. In the example above the 4 GB are split into two memory modules.
3. **Hard Drive** – The three factors you most consider when purchasing a hard drive are:

- The size (measured in gigabytes or terabytes); typical sizes are 500GB, 750GB, and 1.5TB
- Speed (measured in revolutions per minute); typical speeds are 5400rpm and 7200rpm
- The interface type (IDE, SATA or SCSI)

4. **Expansion Slots**

   Motherboards have slots where you can plug in expansion cards such as video cards or sound cards. These are called expansion slots. There are three main types that you may encounter: PCI, AGP and PCI Express.

5. **Ports**

   At the back of your computer and sometimes at the front you’ll find several ports where you can plug in external peripheral devices. Each type of port has a specific shape so that you can’t plug in a device in the wrong place. Some ports include: PS/2, USB, VGA and FireWire (the fastest).
There are two main categories of software

- Application software
- System software

1. Application software

**Application software** are programs that enable the user to carry out a specific task. It is installed according to the requirements of the user. It is not needed for the computer to function.

**Examples of application software**

- Microsoft Office
- Windows media player
- Sims 2
- Peachtree accounting
There are three (3) main types of application software:

A. **General Purpose Software**

*General purpose* software is software that can be used for a common variety of tasks. This means that the software is not specialized to do a specific task.

**Examples of General Purpose**
- Word processors (Microsoft Word)
- Spreadsheets (Microsoft Excel)
- Databases (Microsoft Access)

**Two(2) types of General purpose software are:**
*Software Suite* is a combination of application programs sold as a package that can run as separate applications. For example, *Microsoft Office* and *Open Office*.

*Integrated Software* is also a combination of application programs, but it can only run as a single program. The user can easily switch from one type of application to the next without exiting the program. For example, *Microsoft Works* and *Apple Works*.

**Advantages of Integrated Software**
- Low cost
- Sharing information between applications will be hassle-free
- Very similar screen displays are used which makes learning easier

**Disadvantages of Integrated Software**
- Each application is limited to basic functions
- You may only want to use one of the app. programs, but you still have to install the entire package.

B. **Special Purpose Software**

*Special purpose* software is designed to perform a specific or special task. For example, you can have:

**For example, you can have:**
- a program just for *accounting* such as Peachtree accounting
- a program just for *engineering design* such as Solid Works or
- *Nero*, which is a program mainly for copying or writing to CDs or DVDs.

C. **Custom-written Software**

Both *general purpose* and *special purpose* application software can be purchased through software retailers (stores), but sometimes a company might need a special software built just for them.

*Custom-written Software* is software written by a developer or programmer to meet the specific needs of a company.
### 2. System Software

System software are programs that enable the computer system to run properly and efficiently. System software must be installed before application software can run.

There are three types of System software:

- ✔ Operating Systems
- ✔ Utilities
- ✔ Translators

#### A. Operating systems

An **Operating System (OS)** is a collection of software that manages computer hardware resources and provides services for application software programs.

OS are the most important programs and must be present in all computer systems.

Examples of Operating systems

- ✔ Windows XP, Windows 7
- ✔ MAC OS X
- ✔ Linux
- ✔ UNIX

#### B. Utilities

**Utilities** are system programs that can be added to the main Operating System to increase the efficiency of the computer system.

Examples of utilities

- ✔ Anti-virus software
- ✔ Back-up software
- ✔ Disk defragmenters

#### C. Translators

Computers only understand **binary language** *(machine language)*

**Translators** are software that converts other programming language instructions to machine language.
Functions of an Operating System

When a computer system is switched on the OS is loaded into main memory in order for the computer to start up. This process is called booting.

The OS performs the following main functions

Process management

Process management allocates time for processes to use the CPU, keeps a check on other processes that are waiting to use the CPU, or signals when the CPU is available.

File management

The OS is responsible for creating, deleting, renaming of files and folders and also for making back-up copies of files.

Memory management

Main memory or RAM stores programs and data that are presently being used by the CPU. The OS allocates areas of memory to different programs so that each program can run effectively.

Input/Output management

There are many input or output devices that can be plugged up to the computer. The OS makes the communication possible between the input and output devices and the computer.

Provide security

By using passwords or backing up files

Provides a friendly user interface

A user interface is the method by which the user interacts with the computer system. The OS provides the user with a friendly interface that will help the user to interact with the computer system.
Distinguishing between:

**Multiprogramming, Multitasking, Multiprocessing.**

**A. Multiprogramming**

**Multiprogramming** is the ability of a computer to open **2 or more programs** at the same time. More than one program lies in main memory (RAM)

- **Example of multiprogramming**
  
  Having Microsoft word, Paint and the calculator opened at once.

**B. Multitasking**

**Multitasking** is the ability to execute **2 or more tasks** at the same time. Each task is given a slice of the CPU's time and they take turns until they are done. A turn is so short that the CPU can switch between tasks many times a second that it looks like the CPU is executing multiple tasks at a time.

- **Example of multitasking**
  
  Listening to music on the computer while browsing the internet at the same time.

**C. Multiprocessing**

**Multiprocessing** is the ability of a computer to execute a **program on two or more processors** simultaneously (at the same time).

- If one processor (CPU) can only do one task at a time, why not get two or more processors in the same computer system? If your computer has 2 processors, it can then run two tasks at the same time. This means a single program can use both processors at the same time so it can run faster.
Types of processing modes

4 types of processing are:

A. **Batch processing** (also known as offline processing)

**Batch processing** is when the data collected is grouped together and processed at a later point of time such as weekly or monthly.

*Examples of batch processing*

- Electricity and telephone bills are usually collected then calculated on a monthly basis
- Salaries are calculated and paid to employees at the end of the week or month.

B. **Online processing**

**Online processing** is when data collected is processed right away and is updated immediately.

It allows a user to interact with the computer expecting an immediate response or process.

*Examples of online processing*

- An ATM machine
- Booking a flight online
- Ordering books on the internet

C. **Real-time processing**

**Real-time processing** is a method for inputting, processing and outputting data continuously, and is used to control activities as they happen.

*Examples of real-time processing*

- Aircraft control
- Controlling robots
- Traffic lights

D. **Time sharing**

**Time sharing** is a method of processing that allows many users to use a computer simultaneously.
Types of User Interfaces

A user interface is the way in which a user interacts with a computer system.

It can be **Software interface**, such as
- Command-driven, menu-driven and graphical user interface

Or **Hardware interface**, such as
- Touch screens, Special keyboards, sensors and non-visual interfaces

1. **Software interfaces**

Software interface is the way in which you can interact with programs on the computer system.

Three common software interfaces are:
- Command-driven
- Menu-driven
- Graphical user interface

A. **Command-driven user interface**

Command-driven user interface is one where the user has to key in commands (instructions) using a special command language.

- The main interface device for the command-driven interface is the **keyboard**.

  **Advantage**
  
  Many tasks can be done with a single command.

  **Disadvantage**
  
  It requires you to remember the commands and their correct syntax.

B. **Menu-driven user interface**

Menu-driven user interface is one where the user can select commands from one or more menus.
- In a non-graphical environment, menus will be chosen using the arrow keys on the keyboard.
- In a graphical environment, menus can be chosen using a mouse pointer.

- A menu can be a **drop-down** or a **pop-up menu**.

  **Advantage**
  
  The user does not have to remember the commands and their correct syntax.

  **Disadvantage**
  
  Sometimes the user cannot see all the options that are available in the menu right away.
C. Graphical user interface (GUI)

GUI is one that uses images to represent the choices that the user can make. Also known as WIMP interface, because this interface provides the user with Windows, Icons, Menus and Pointers.

- The main interfacing device for the GUI is the mouse.

**Advantage**
GUI can be very helpful for a novice user as they do not have to remember the commands and is provided with icons to choose from.

**Disadvantage**
It is slower than command-driven interface because you may have to click many icons to complete a task.

2. Hardware Interfaces

Hardware interfaces are special devices with additional features that will make the interaction much easier. Keyboards, mice, screens and speakers are part of the standard user interface, but additional hardware devices can be used as part of the user interface to match the needs of a particular user.

Examples of hardware interfaces:

A. Special Keyboards
- Ergonomic keyboard is shaped so that it is more comfortable to use.
- Overlay keyboard replaces the keys with a flat touch sensitive panel. This is normally found at fast food restaurants (KFC) to avoid dust and grease from entering the keyboard.
- Braille keyboards are available for blind people.

B. Touch screen
- Touch screens are special devices that make it easier to input data using a stylus of fingers.

C. Sensors
- Sensors capture data automatically and passes it to a computer. Sensors are useful in providing interfaces for people who cannot use standard devices such as keyboards. People with disabilities can use head movements to communicate with a computer.

D. Non-visual Interfaces

The computer can use sounds to alert a user that a virus is detected.

More complex sounds can also be used to support users:
- Speech synthesis is the production of human speech with the help of special software. The computer will be able to dictate typed or scanned documents especially for users with visual impairment.
- Voice recognition is the ability of a computer to listen to a users voice and convert it to text. The computer may also be able to listen to your voice and obey you commands. For example you can tell the computer to "Open Microsoft Office Word".