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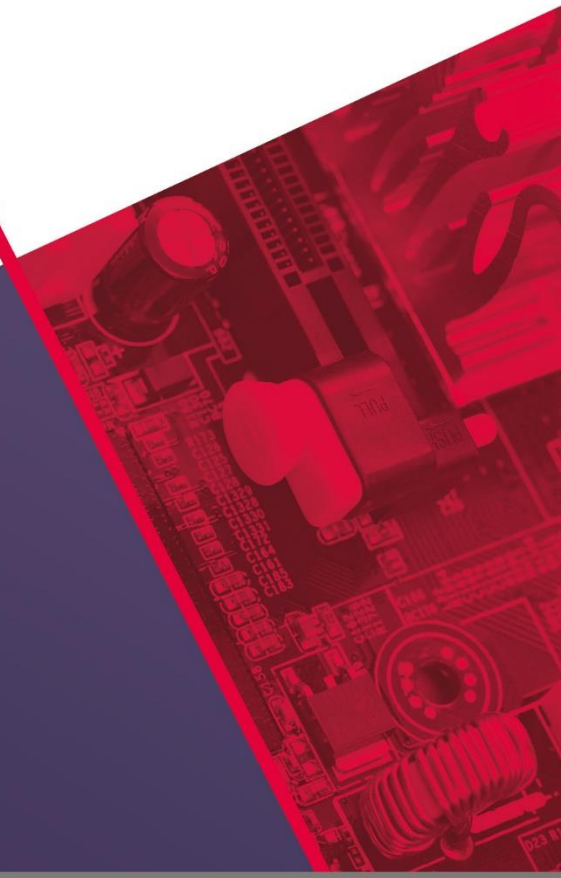
Hardware Essentials

MLHE172-01 V1.0



Hardware Essentials

MLHE172-01

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Version 1.0

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Introduction

The aim of this module is to provide you with knowledge of the different hardware and software components that make up a computer system, and the procedures that are followed to maintain and upgrade those components. You will gain an in-depth understanding of the functions and characteristics of the different computer components, including memory modules, processors, motherboards, power supplies, graphics display adapters, monitors, hard drives, CD-ROM and DVD drives, and peripherals such as printers, scanners, mouse devices and keyboards, as well as the cables and connectors that enable each component and peripheral to communicate with one another.

Common computer hardware problems and how to go about solving them will also be explained. This module will also cover the basics of networking, including the structure of networks, the various topologies and scopes, the Open Systems Interconnect (OSI) networking model, and the various network hardware components, connectors and cables that enable multiple networked computers to communicate with one another.

Assessment for pass

A pass is awarded for the unit on the achievement of all the pass assessment criteria.

Learning outcomes	Assessment criteria for pass To achieve each outcome a student must demonstrate the ability to:
LO1 Understand how the components of a computer system work	1.1 Describe the function of the motherboard 1.2 Identify the characteristics of processors and memory 1.3 Identify the characteristics of power, display and storage systems 1.4 Describe the function of peripherals
LO2 Understand the foundation of networks	2.1 Define networks 2.2 Identify the different types and topologies or networks 2.3 Explain the function of the OSI model 2.4 Describe the function of networking hardware
LO3 Be able to configure a computer system	3.1 Use hardware tools 3.2 Install and uninstall components 3.3 Set up the BIOS/CMOS program 3.4 Install an operating system
LO4 Be able to maintain a computer system	4.1 Install hardware drivers 4.2 Implement safety procedures when handling components 4.3 Troubleshoot computer-related problems 4.4 Perform maintenance checks

After completing this module, students will be able to:

- Describe and identify all internal components of a computer system; and disassemble and reassemble a computer system.
- Configure the BIOS/CMOS (basic input output system/complementary metal oxide semiconductor) setup.
- Install an operating system.
- Troubleshoot a system using system tools and diagnostic software.
- Perform common maintenance procedures to prolong the lifespan of a computer system.
- Install a Hypervisor and install a virtual machine.

Hands-on practical labs and exercises will test your ability to operate, maintain and upgrade a computer system and will help to develop computer-related problem-solving skills.

How to approach this module

This module is divided into **11** units. Each unit consists of:

- Theory
- Examples
- Exercises.

A theory examination and a practical examination will be written at the end of the module. Ensure that you know and understand the theory before continuing with an exercise or the examinations. Work through the examples in the reference book and complete all the exercises before attempting the examinations. Application questions will be asked in the exam – you must be able to apply your knowledge to practical situations.

You will **not** pass the examinations if you rush through the material without understanding what you have learned. The exams are designed to test theory, insight and practical skills. Theory exams will consist of true/false questions, multiple choice questions, multiple response questions and selection questions. The practical exam will present you with the opportunity to practise what you have learned on a computer.

It is very important to use all the study aids available to you. Some of the questions in the exams will test your general knowledge of advanced subjects that may not have been covered in the study guide, although the content in the study guide will be sufficient to ensure that you pass each unit.

The module is divided up as follows.

Table 1 – Module breakdown

Unit	Days	Notes
1	1	The backbone of the computer
2		The Central Processing Unit (CPU)
3		Memory
4		Power Supply Unit and Specialised Power Devices
5	1	Storage Devices
6		Display Systems
7		Other Peripherals
8		Networking Basics
9	1	Assembling a PC and installing Windows
10		Troubleshooting Common Devices
11		Virtualisation
	1	Theory examination
	1	Practical examination
Total	**5**	

NOTE	Examination questions are based on ALL the information provided in this study guide.

The structure of this study guide

All the units follow the same structure. You will be presented with the **outcomes for** each unit. These outcomes can be used as an indication of what is important and what you should focus on when going through the unit's material. **Notes** will follow this. Read these sections carefully.

You will be presented with **exercises** that will require you to apply your knowledge of the material. Ensure that you understand the exercises. Ask for help if you are unsure of what to do. **Revision questions** will give you an indication of what to expect in the exam, although you should not rely on these questions as your only reference. Some exam questions will undoubtedly be more difficult than the revision questions.

Icons used in this study guide

The beginning of a new unit. This icon represents the start of a new unit in the module.

Outcomes at the beginning of each section or unit. The outcomes outline what you are going to learn in each unit.

Testing the student's understanding. Answer all the questions to test your understanding of the content in the unit.

Labs/Work to be done on computer. Complete the exercises to gain practical experience.

Supplementary reading

This study guide covers the essentials of hardware and is by no means a complete guide to PC hardware. Please consult these references for more details on computer hardware, and maintaining and upgrading a PC.

References:

http://kb.iu.edu/data/aaml.html
http://www.computerhope.com/msdossys.htm
http://www.pchell.com/software/msdos-sys.shtml
http://technet.microsoft.com http://buildeasypc.com
CompTIA A+ Complete Study Guide (Sybex) A+ Essentials Support Skills Study Guide (GTS)
CTI A+ Study Guide

Unit 1 – The Backbone of the Computer

At the end of this unit, you will be able to:

- Describe motherboard components and functions.
- Distinguish between motherboard form factors.
- Understand internal and external bus controllers.

1.1 Introduction to hardware and software

A computer is made up of hardware, software and firmware:

Hardware Computer hardware refers to those components that you can touch and see. The components inside a computer and input and output devices are examples of hardware.

Software Computer software refers to programs that tell computer hardware what to do. Unlike hardware, software cannot be touched. There are two types of software:

- **System software** – Controls the start-up of your computer and then central controlling once it is running. An example of system software is an operating system.
- **Application software** – Programs used to control specific tasks such as editing a document. An example of application software is Microsoft Word.

Firmware Firmware is a software program that has been programmed into a hardware chip. The software's job is to control the hardware to which the chip is attached. An example of firmware is the Basic Input/Output System (BIOS).

1.2 Cases

In this module we will work on desktop computers. A desktop computer is designed to be used at a single location. The system case, which is also known as the chassis, is a metal or plastic box where internal components such as the motherboard are stored.

There are three types of cases:

- Desktop – Sits horizontally on a flat surface. It is wider than it is tall.

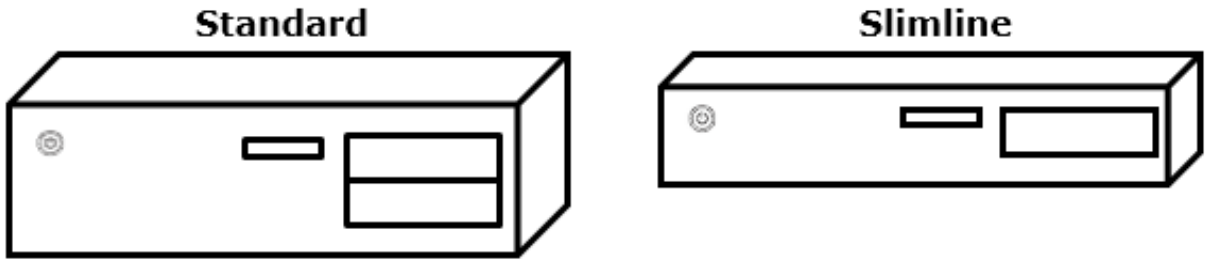


Figure 1 – Desktop cases

- Tower – Sits upright on a flat surface. It is taller than it is wide and comes in three sizes:
  - **Full-tower** – Has extra internal space for additional drives, expansion cards and backup power supplies. It is often used for servers.
  - **Midi-tower** – Used for high-end user computers and office computers. This case has space for extra devices and cards, but not as much space as the full-tower case.
  - **Mini-tower** – Has limited space for additional hardware. It is used for home and office computers.

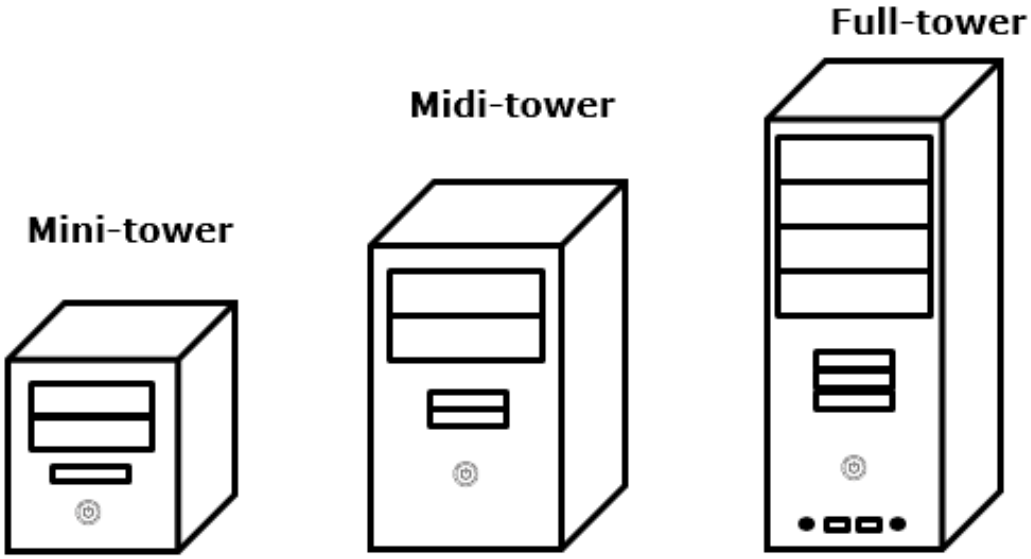


Figure 2 – Examples of towers

- Small form factor (SFF) – A super slimline case which can hold a limited number of components. It is typically used as a media centre entertainment system.

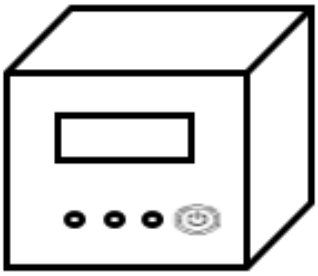


Figure 3 - Slimline

1.2.1 Parts of a tower

In this module, we will be working on a tower case. A case has a front, back and two side panels.

Looking at the front panel, you may find the following parts:

- Power switch – for turning the computer on and off
- Reset switch – for restarting the computer
- Light Emitting Diodes (LEDs) – show power status and drive activity
- Removable media drives – the doors for accessing removable media drives
- Input/Output (I/O) area – some computers have built-in I/O connections on the front of the case so that you can plug in a device that uses any of the available connections.

Looking at the back panel, you may find the following parts:

- Power Supply Unit (PSU) – this is almost always found at the top of the case, with its cooling fan, power plug and on/off switch. Note that some PSUs do not have a power on/off switch.
- Input/Output (I/O) area – has all of the on-board connections coming from the motherboard.
- Expansion area – has slots for expansion cards. Expansion cards are installed in slots on the motherboard and their connectors face outside the case.

Front	Back
	
a) Two removable media drive bays (5 inch) for Blu-ray and DVD discs. b) USB port for a media card reader. c) Media slot for a media card reader. d) Power on/off switch with LED. e) Media card reader slot. f) Hard drive activity LED. g) FireWire ports. h) USB ports. i) Headphone or speaker jack. j) Microphone jack.	a) PSU with its power plug. b) PSU fan. c) I/O on-board motherboard connection area. d) Expansion area with slots for expansion cards and blanking plates. A **blanking plate** or **slot cover** is a metal strip that covers empty expansion slots to help keep dirt and dust out of the case and to ensure proper air flow. Use them for unused slots. e) Two side panel screws. f) Certificate of Authenticity (CoA) label providing an identification number for the OS. g) Chassis fan/back vent. Fans help stop components from overheating.

1.3 Motherboards

The motherboard is the main circuit board that is found at the bottom of the personal computer (PC) which makes all other components work together to make the computer functional. It is the most important component because it connects all the other PC components together and allows them to communicate with one another. Also called the **main board** or **system board**, the motherboard is a **printed circuit board (PCB)** that holds the Central Processing Unit (CPU), chipset, memory and expansion slots in place. The motherboard contains the connectors for attaching additional circuit boards and also houses the CPU, Basic Input/Output System (BIOS), memory, mass storage interfaces, serial and parallel ports, expansion slots and all the controllers required for standard peripheral devices, such as the display screen, keyboard and disk drives. The motherboard chipset is soldered onto the motherboard and is made up of one or more integrated circuit chips, which perform peripheral and interface functions for the CPU. Every piece of hardware is directly or indirectly plugged into the motherboard. The motherboard has electric wires called **traces** that make up the **buses** of the system, and it distributes the power from the PSU to many components.

The motherboard has a great effect on the system speed and upgrade capabilities. Most PCs can be upgraded to a faster PC by replacing the CPU chip; it is also possible to add memory modules directly to the motherboard. To add additional core features, you may need to replace the motherboard entirely. Figure 4 illustrates the different motherboard components.

Some of the most popular motherboard/chipset manufacturers are ASUS, Abit, Gigabyte, MSI, Intel, SIS and VIA.

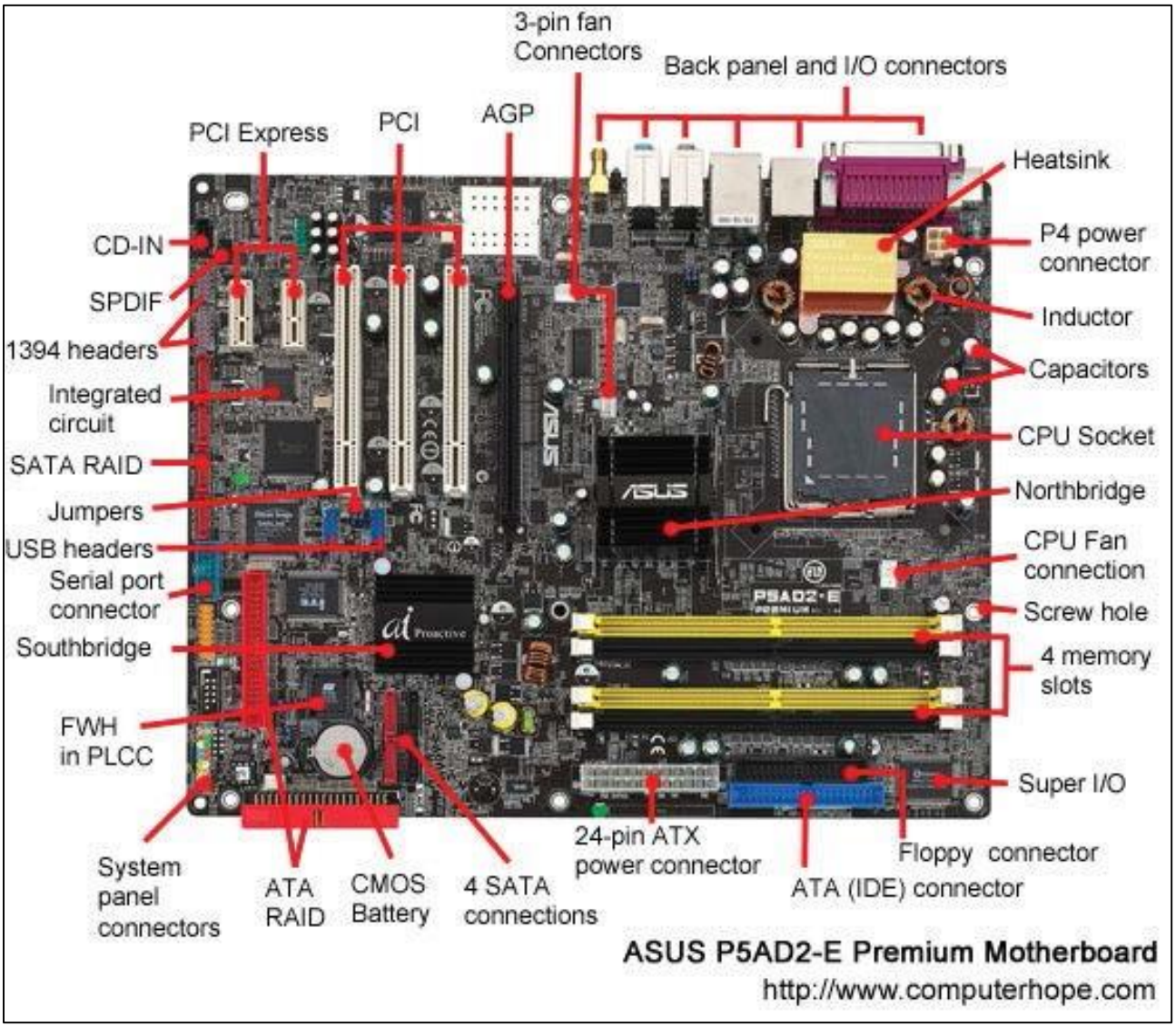


Figure 4 – Motherboard components

Sourced from: http://www.computerhope.com/jargon/m/mothboar.htm

1.4 Motherboard form factors

A motherboard's form factor describes its shape, physical layout, case type and power supply that can be used with it. Most motherboards are based on the ATX or mini-ATX design. Form factors enable motherboards to work with cases and PSUs. Motherboards must be installed in the appropriate case so that the ports and slot openings on the back panel fit correctly. Also, the PSU and motherboard need matching connectors. Different form factors define different connections.

There are many different motherboard manufacturers, resulting in many different form factors. Table 2 lists the most common form factors.

Table 2 – Form factors

Form factor	Size	Description
ATX, full size	30.5 cm x 24.4 cm Not all ATX boards are exactly the same size.	A commonly used motherboard which has many revisions. It supports up to seven expansion slots.
Micro-ATX (µATX)	24.4 cm x 24.4 cm Not all micro-ATX boards are exactly the same size.	It has up to four expansion slots and fits into a standard ATX case or the smaller micro-ATX case.
Mini-ITX	17 cm x 17 cm	A small form factor (SFF) board. A small amount of power is needed to support SFF boards. Lower power usage creates less heat. The lack of fan noise makes these boards ideal for media centre computers.
Nano-ITX	12 cm x 12 cm	These small boards are designed for smaller devices.
Pico-ITX	10 cm x 7.2 cm	These very small boards can be built into different types of mobile devices.

NOTE For more information on form factors, go to http://www.formfactors.org/default.asp

1.5 Typical motherboard components

PCs are composed of many internal components, which communicate with each other using a bus. A bus is physically implemented on the motherboard as tiny wires running between components. The bus carries data (data bus) and information about the location of data in memory (address bus). The bus also carries power to a component and the timing signals that are used to synchronise components.

1.5.1 Internal bus connectors

Computers support more than one expansion bus (refer to Table 2). Modern PCs use a multi-bus design for backwards compatibility and to support technology upgrades. The functionality of a PC can be extended with the use of an expansion/adapter/interface card (Figure 5). An adapter/expansion/interface card is a circuit board that fits into an expansion slot on the motherboard (Figure 6). It can have a variety of ports that allow you to connect different peripherals to your computer.

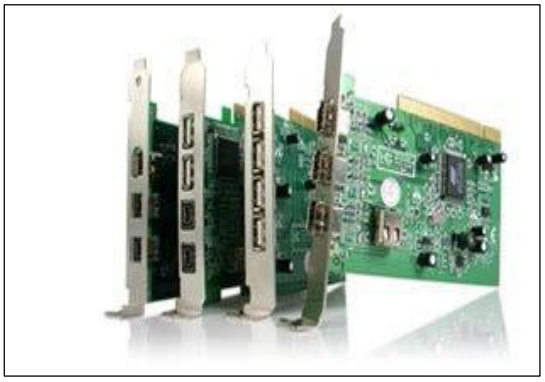


Figure 5 – Expansion cards

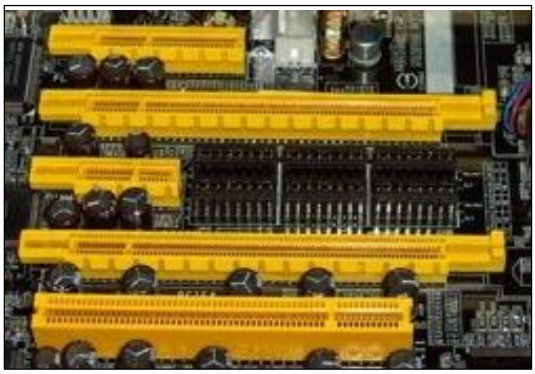


Figure 6 – Expansion slots

Table 3 – A summary of expansion slots and functions

Expansion slot	Description
PCI	• Peripheral Component Interconnect (PCI) • Supports Plug-and-Play • Supports 32-bit and 64-bit parallel transfers of data

AGP	• Accelerated Graphics Port (AGP)
	• Different standards:
	  ○ AGP 1x: 66MHz clock, 8 bytes/clock
	  ○ AGP 2x: 133MHz clock, 8 bytes/clock
	  ○ AGP 4x: 266MHz clock, 16 bytes/clock
	  ○ AGP 8x: 533MHz clock, 32 bytes/clock

PCIe	• Supported as the replacement for AGP • PCI Express (PCIe) is designed to rapidly increase the bandwidth (speed) for graphics cards. • PCI Express is 5x faster than 8x AGP. • PCIe is serial with point-to-point connections.
PCI-X	• An update of PCI; used mainly in server systems. • There are 32- and 64-bit versions with clock speeds of 66, 133, 266 and 533MHz.

1.5.2 External bus connectors

External bus connectors provide connections to various internal components. These bus connectors are also used to connect external peripherals, e.g. printers, mouse devices, etc. to the PC. These might also be an expansion card which is plugged into expansion slots. Figure 7 illustrates the different ports and connectors on a motherboard.

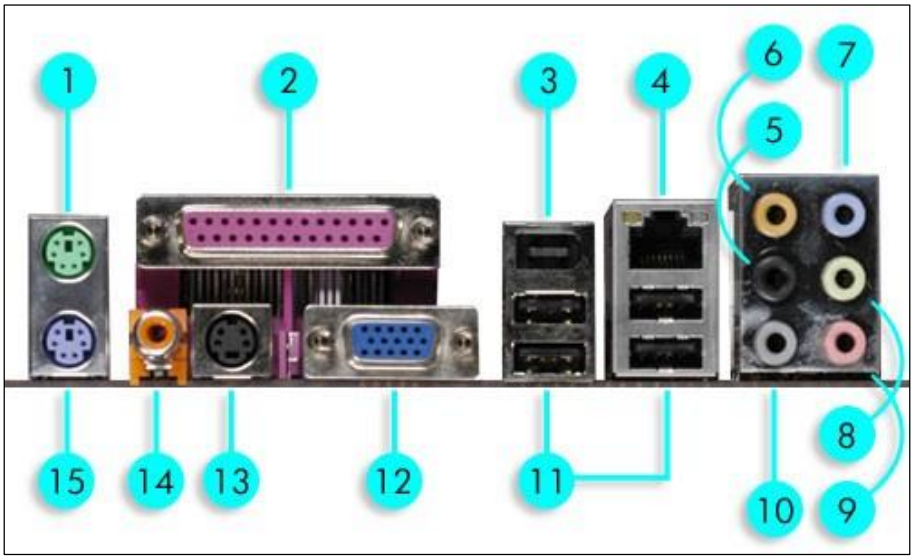


Figure 7 – Ports and connectors

Table 4 gives a description of the ports and connectors labelled 1-15 in Figure 7.

Table 4 – Computer ports and connectors

No.	Port	Description
1 and 15	PS/2 (green/purple)	• The PS/2 port is a 6-pin female port used to connect the mouse (green) and the keyboard (purple) to the PC. • Newer PCs have Universal Serial Bus (USB) connections for the mouse and keyboard.
2	Parallel Port	• This port is used to connect a printer, scanner or other device to a computer. • Modern printers have USB ports with a Type A and Type B connector. • The host (computer) port uses a 25-way female D connector (DB25F). • This port transmits data using an 8-bit parallel interface. Devices that use a parallel port transmit data over eight wires at the same time, with each wire carrying one bit of data. • The parallel cable has a 25-pin male D (DB25/Type A) connector at the PC end and a 36-pin Centronics (Type B) connector at the printer end. • Maximum cable length for a standard parallel cable is 5m.
3	IEEE 1394 Port	• The IEEE 1394 standard is a serial SCSI bus; it is referred to as Firewire. • IEEE 1394a transfers data at 400 Mbps. • IEEE 1394b (Firewire 800) supports transfer rates of up to 800 Mbps, with increased power from the bus to support larger devices.

		• A single Firewire port supports up to 63 devices. • Firewire provides support for hot swapping, which means a device can be inserted or removed while the PC is running, without requiring a restart. • Used for devices such as camcorders, satellite receivers and printers, and ideal for the transfer of real-time data such as video. • IEEE 1394a uses a 6-pin connector and IEEE 1394b uses a 9-pin connector.
4	RJ-45 (LAN)	• This port allows a connection to the Local Area Network (LAN) through a network device. • RJ-45 connectors are used with 4-pair, 8-wire unshielded twisted pair (UTP) cables. • UTP is the most common type of network data cable used today.
5	Rear Speaker Out (black)	• This port connects to the rear speakers on a 4-channel, 6-channel or 8-channel audio configuration.
6	Centre/Subwoofer Port (orange)	• This port connects the centre/subwoofer speakers.
7	Line In Port (light blue)	• This port connects a tape, CD, DVD player to other audio sources.
8	Line Out Port (lime)	• This port is suitable for connecting headphones or a speaker.
9	Microphone Port (pink)	• This port connects a microphone.
10	Side Speaker Out (grey)	• This port connects to the side speaker in an 8-channel audio configuration.

11	USB 2.0 Ports 1,2,3 and 4	• These 4-pin USB ports are available for connecting USB 2.0 devices.
		• Universal Serial Bus supports a wide range of peripherals, including mouse devices, keyboards, printers, scanners, digital cameras, cellular phones and external drives.
		• The USB has largely replaced parallel and serial ports as the standard method of connecting peripherals to a PC or laptop.
		• Supports hot-swappable devices (a device that can be inserted and removed without powering down the host PC).
		• Supports up to 127 daisy-chained (interconnection of computer devices in series one after another) devices.
		• Screened USB cables can be up to 5 m long.
		• Two connector types are defined by the USB spec:
		  ○ Type A – for connection to a host or hub port. A hub provides ports for multiple devices.
		  ○ Type B – for connection to a device.
		• USB 1.1 has transfer speeds of 12 Mbps for a screened cable.
		• USB 1.1 is also called the Full Speed USB.
		• USB 2.0 can handle transfer rates of up to 480 Mbps.
		• USB 2.0 is backwards compatible with USB 1.1, but USB 1.1 when plugged into a USB 2.0 port, will run at its lower speed (12 Mbps).

		• USB 2.0 is called the High-Speed USB. • USB 3.0 can handle transfer rates of up to 5 Gbps. • USB 3.0 is called the SuperSpeed USB.
12	Video Graphics Adapter Port	• This 15-pin port is for a VGA Monitor or other VGA compatible device.
13	S-Video	• This connector carries video signals. The video signal is split up into two channels providing a good quality image.
14	Coaxial S/PDIF Out Port	• This port connects an external audio output device via a coaxial S/PDIF cable.

1.6 Different types of computers

All computers come in different sizes, shapes, functions and motherboard form factors. Here is a list of different computer types and how they look internally and externally.

1.6.1 Desktop computers

A desktop computer is a computer that is intended to be used at a single location. A desktop is a tower with several peripheral devices connected to it.

Figure 8 – Desktop computer and motherboard

1.6.2 Laptops

A laptop is a portable computer that has similar functions to a desktop. It has an inbuilt keyboard, track pad and a LCD monitor.

Figure 9 – Laptop computer and motherboard

1.6.3 Servers

Servers are powerful computers that are designed to provide services to client machines in a computer network. These servers have programs that serve client requests and allocate resources like memory and software.

Figure 10 – Tower and rack server

1.6.4 PDAs

A Personal Digital Assistant (PDA) is a handheld computer that can be used as a digital organiser, audio player, web browser and much more.

Figure 11 – PDA computer and motherboard

1.6.5 Smartphones

A smartphone is a mobile phone that can perform more functions than a PDA. A smart phone lets you make telephone calls, send and receive emails, edit office documents, watch movies and more.

Figure 12 – Smartphone computer and motherboard

1.6.6 Wearable computers

Wearable computing devices are computers that can be worn on the body. Wearable computers can perform simple functions such as monitoring heart rate and more advanced functions similar to those of a smartphone.

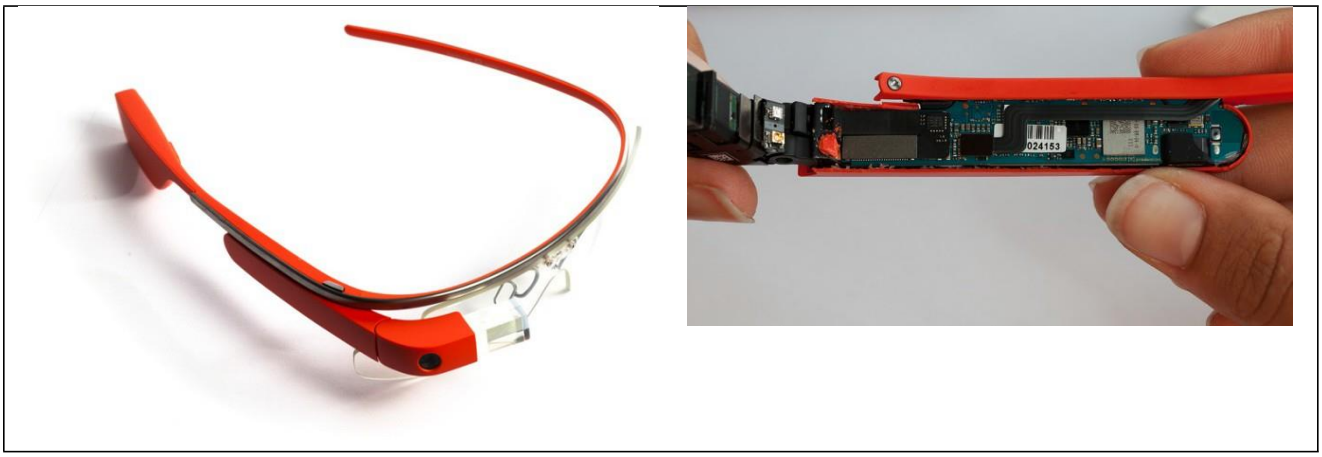


Figure 13 – Google glasses

1.6.7 Tablets

A tablet is larger than a smartphone or PDA. It has similar functions to those of a smartphone.

Figure 14 – Tablet computer and motherboard

NOTE	More information on computers may be found on the following website http://typesofcomputers.net/

1.7 Review questions

Answer the questions that follow to help you to reinforce what this unit has covered. If you are unsure of the answer to any question, then search for it in the text of this unit.

1. What component allows all devices to communicate with one another?

[1]

2. What is another name for a motherboard?

[1]

3. Name at least three of the most common motherboard manufacturers.

[3]

4. Name at least two characteristics that the motherboard form factor describes.

[2]

5. There are two types of software. Give a description of each type.

[4]

6. Complete the following table.

No.	Question	USB	Firewire
1	List three supported devices		
2	Transfer rates	USB 1.1_____ USB 2.0_____ USB 3.0_____	IEEE 1394a_____ IEEE 1394b_____
3	Supports up to_____devices		
4	USB type A connects to the ……		
5	USB type B connects to the ……		

[15]

7. Give a definition of a motherboard.

[2]

Total: 28 marks

NOTE	Complete this exercise on a piece of paper and submit it to your lecturer.

Unit 2 – The Central Processing Unit (CPU)

At the end of this unit, you will be able to:

- Understand processor functions.
- Define basic processor terminology.
- Identify processor packaging and processor types.

2.1 What is a CPU?

The Central Processing Unit, CPU, or processor is a programmable chip located on the motherboard which is responsible for executing program instruction code, performing mathematical and logical calculations, and controlling Input/Output (I/O) functions for the computer. The CPU is often referred to as the brain of the computer.

Figure 15 – A 4th Generation Intel Core i7 CPU

Sourced from: http://gizmodo.com/intel-haswell-review-can-a-laptop-cpu-keep-enthusiasts-511223469

The manufacturing process used to create transistors, and how tightly they and other electrical components can be packed on the chip, is shown in **n-microns** and **n-nanometre (ns)** measurements. One micron is a millionth of a metre and one nanometre is a billionth of a metre. The architecture and components included in a CPU (known as **microarchitecture**) are different from CPU to CPU.

2.2 Overview of processor types

Intel Corporation is the leading manufacturer of processors. Other manufacturers include AMD, Cyrix and IBM. Should you be interested in learning more about the processor types available, consult the relevant website. Two examples are www.intel.com and www.amd.com.

Mobile devices also use processors. Mobile devices and desktops have different needs, notably the need to use as little electricity as possible. The processors used for mobile devices are designed to extend the battery life and create less heat.

There are processors that are found in tablets. These are called ARM CPUs. ARM uses a reduced instruction set computer (RISC) chip architecture, and often runs faster and with less power than Intel and AMD-based CPUs. For more information on ARM CPUs, consult the following website http://www.arm.com/.

2.3 Functions of a processor

There are four main steps that all processors follow:

The first is to **fetch** instructions from the main computer's memory. Fetching instructions may also include reading data from an I/O module. This is then followed by the **decode** phase where instructions are decoded to decide what action will need to be taken. Once that has happened, the CPU will **execute** the desired operation. The final operation of the CPU is to **writeback** where the data of an executed task is analysed and results are written to the memory or I/O modules.

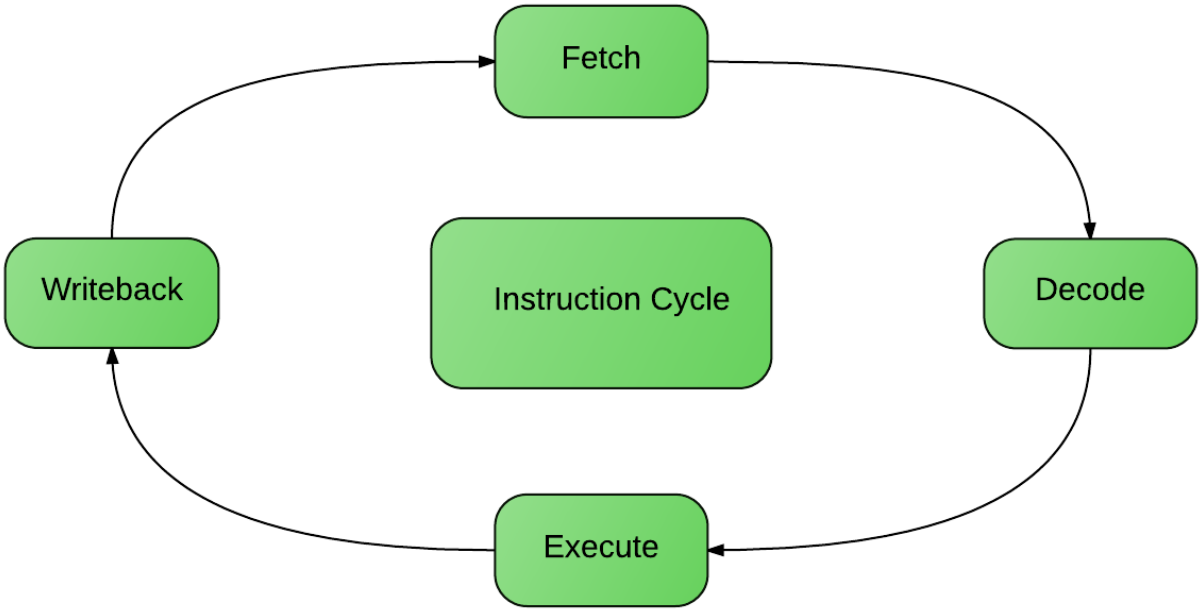


Figure 16 – Functions of a CPU

2.4 Processor terminology

2.4.1 System bus

Communication between the CPU and RAM (Random Access Memory) used to occur over what was known as the **front side bus (FSB)**, which ran between them. The original FSB architecture has been replaced by newer architectures, such as HyperTransport or Intel QuickPath Interconnect and Direct Media

Interface (DMI). The CPU still needs to communicate with the chipset and there are a few different ways that this is done, including:

- **Intel Direct Media Interface (DMI)** – can use multiple lanes, similar to PCIe.
- **Intel's QuickPath Interconnect (QPI)** – each core in a CPU has a separate two-way 20-lane QPI link to the chipset.
- **AMD HyperTransport** – used with the FSB to increase speed.

Many modern CPUs with integrated memory controllers have very fast point-to-point serial connections that run between multiple CPUs (cores), between integrated memory controllers and between CPUs (cores) and the chipset. Both QPI and HyperTransport have similarities but they are used differently. Both architectures allow much more data to be transferred in both directions at the same time (full-duplex), increasing bandwidth, and both use a double data rate (DDR) connection, meaning that data is sent on both the rising and falling edges of the clock signal.

The system bus is composed of two distinct parts: the data part and the address part.

2.4.1.1 Data bus

The data bus refers to the lines that carry the data being transferred. The width of the data bus refers to the number of bits that can be transmitted at one time. The wider the bus, the more information can be transmitted simultaneously.

2.4.1.2 Address bus

In order to access data stored on another component (such as system memory), the CPU sends out location information in the form of address lines. The address lines are routed to every other major component of the computer (RAM, ROM (Read Only Memory), expansion bus, etc.). When a CPU requests a particular address using the address bus, the data at that address is put on the data bus or copied from the data bus to that address.

2.4.2 Basic operation of the CPU

The CPU is designed to execute software (whether the software is an operating system or an application). When this software is executed, it is assembled into instructions by the CPU's instruction set and then loaded into memory. The CPU's control unit then fetches each instruction from memory in sequence and decodes each one. After being decoded, the control unit either executes the instruction itself or passes it to the Arithmetic Logic Unit (ALU) or Floating Pointing Unit (FPU) for execution. To assist the control unit/ALU/FPU, internal temporary storage areas known as CPU registers or General Purpose (GP) registers, hold instructions before and after processing.

2.4.3 Instruction set

In order to make the CPU perform tasks, it must be given instructions by a software program, as stated previously. The instructions that a CPU can process are referred to as its instruction set. CPUs can be classified as either CISC (Complex Instruction Set Computer) processors or RISC (Reduced Instruction Set Computer) processors. CISC processors are able to process complex instructions. These instructions usually need many cycles to execute. RISC processors are able to process simple, small sets of instructions in a minimum number of instruction cycles.

IBM-compatible CPUs use an instruction set called x86. The 32-bit version is called Intel Architecture-32. The 32-bit instruction set was updated with Single Instruction, Multiple Data (SIMD) instructions. This means that many applications make use of the same instructions but with different data. The instructions support the changed and increased demands of modern software such as 3D Graphics, Web browsing, speech recognition and mpeg video.

A 64-bit instruction set extends the original IA-32 architecture and doubles the number of GP and Streaming SIMD Extension (SSE) registers. Intel's version of this architecture is called EM64T; AMD's version is AMD64 or X86-64. Microsoft provides support for AMD x86-64 and Intel EM64T in different 64-bit Windows Operating System editions.

2.4.3.1 MMX

MMX is a Pentium microprocessor from Intel that introduced instruction set extensions to support SIMD, and is designed to run faster when playing multimedia applications. According to Intel, a PC with an MMX microprocessor runs a multimedia application up to 60% faster than one with a microprocessor having the same clock speed but without MMX. MMX is supported by Intel (Pentium MMX and later) and AMD (K6 and later) CPUs.

2.4.3.2 SSE

Many multimedia enhancements to the MMX instruction set were added to the processor. Streaming Single Instruction Multiple Data Extension (Streaming SIMD Extension) speeds up processing when working with the same data many times, because the same operations are applied on different datasets. SSE has 70 instructions.

2.4.3.3 SSE2 and SSE3

The Pentium 4 added 144 more instructions (SSE2) which were also incorporated by AMD in its 64-bit CPUs. However, AMD added eight more registers than Intel for use in 64-bit mode. Intel subsequently included the extra eight registers for its Intel 64 (EM64T) 64-bit processors. Coinciding with Intel's Prescott CPUs, 13 more instructions were added (SSE3) in 2004 for 32-bit Pentiums. SSE4 is a new set of SIMD instructions that is built upon the Intel 64 instruction set architecture. It adds around 50 new instructions and is designed to improve the performance of applications that are able to utilise SSE4, such as 3D games, video encoding, and image processing applications.

2.4.4 Multiprocessing

Multiprocessing is a method of computing in which different parts of a task are distributed between two or more similar physical CPUs, allowing the computer to complete operations more quickly and to handle larger, more complex procedures. Multiple processors greatly increase system performance, provided that the hardware and software support it. The motherboard must be capable of handling multiple processors and the processor must be compatible with a multiprocessing system. In addition, the operating system and application software must support multiprocessing.

2.4.5 Dual core

Dual core, Core Duo, Core 2 Duo. A dual core computer has two processors on the same chip. Each CPU has its own internal cache, but they share an external cache and the FSB. The processor is the workhorse of the computer, so this makes for a faster, more power-efficient computer, particularly when doing multiple tasks simultaneously.

2.4.6 Quad core

Quad core is a chip that has four independent cores which read and execute CPU instructions. Each core operates hand-in-hand with other circuits, such as cache, memory management and Input/Output ports.

Each individual core in a quad core processor can run multiple instructions at the same time, increasing overall speed for programs compatible with parallel processing. Most people tend to believe that quad core is twice as fast as the dual core, and four times faster than the single core, but that is not the case. Results vary depending on

the habits of the computer user, the nature of the programs being run and the compatibility of the processor with other hardware in the system as a whole.

2.4.7 Quad pumped

Computer pumping refers to how much data can be transferred per clock cycle. Computers these days are dual pumped or double pumped, which means every clock is capable of transmitting two bits of data, and quad pumped which means for every clock cycle four bits of data are sent.

Quad pumped may also be referred to as Quad Data Rate (QDR) and Quad Pumped Bus (QPB).

2.4.8 Intel Core

Intel Core is a brand name that Intel uses for various microprocessors. The current line-up of Core processors includes i3, i5 and i7. The number after the 'i' does not mean it has 3, 5 or 7 cores; it indicates their relative processing power.

The relative processing power of each core is signified by their Intel Processor Star Ratings, which are based on a collection of criteria such as the number of cores, clock speed (in GHz), size of cache, as well as some new Intel technologies like Hyper-Threading and Turbo Boost.

2.5 Packaging

This defines how the CPU looks and how it electronically connects to the motherboard. CPU packaging in the late 90s was based on a slot design in which the CPU came pre-installed on a Single Edged Contact (SEC) circuit board which was plugged into a slot on the motherboard.

Figure 17 – A fan with a CPU

2.5.1 Zero Insertion Force (ZIF)

In the past, you had to use force to plug a CPU into the socket to ensure that the CPU had a good, tight connection to the motherboard. A disadvantage with that method is that once a pin bends or breaks, the CPU will become unusable. The ZIF socket was then created with a locking lever to the side of the socket which, when lifted, brings the CPU slightly up out of the socket.

2.5.2 LGA, PGA and BGA

A **land grid array (LGA**) CPU package is manufactured by Intel. It has hundreds of contact pads or bumps at the bottom of the CPU that line up with socket pins. Some CPUs have pins; the sockets have holes into which the pins can be inserted. These are manufactured by AMD. The pins on the bottom of the AMD's **pin grid array (PGA)** CPUs line up with the holes in the sockets.

Mobile devices use a **ball grid array (BGA)**. The pins on the CPU are placed with balls of solder. The BGA, which typically has more pins than LGA and PGA, is first mounted and then heated to melt the solder.

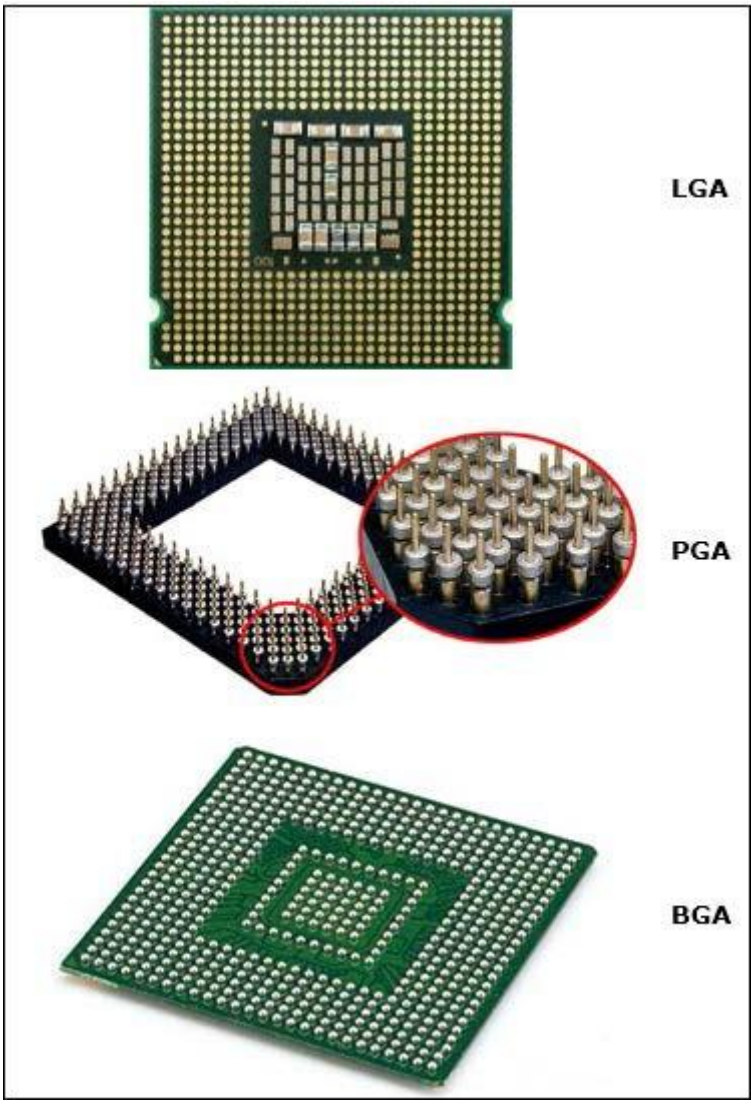


Figure 18 – CPU packaging

2.5.3 Common socket types

There are many different types of sockets used by the two major computer CPUs. Tables 5 and 6 list some modern Intel and AMD sockets. For Intel the socket type number shows the number of pins.

Table 5 – Common Intel sockets

Socket type	Number of pins	Information about socket
LGA 775	775	Also called Socket T. Replaced Socket 478.
LGA 1366	1366	Also called Socket B and designed to replace LGA 775 in some desktop computers.
LGA 2011	2011	Also called Socket R. It replaced LGA 1366 sockets in many desktop systems.
LGA 1156	1156	Also called Socket H or Socket H1.
LGA 1155	1155	Also called Socket H2 and replaced LGA 1156 in basic desktop systems.
LGA 1150	1150	Also called Socket H3, it succeeded Socket 1155.

Table 6 lists some modern AMD sockets.

Table 6 – Common AMD sockets

Socket type	Number of pins	Information about socket
Socket 940	940 (PGA)	The socket is square in shape and pins are arranged in a grid with the exception of four key pins used to align the processor and the corners.
Socket AM2	940 (PGA)	The socket is designed for desktop processors. It is incompatible with Socket 940.
Socket AM2+	940 (PGA)	Replaces AM2. CPUs that can fit in AM2 can also fit in AM2+.
Socket AM3	941 (PGA)	Replaces AM2+. Supports DDR3. CPUs designed for AM3 will also work in AM2+ sockets, but CPUs designed for AM2+ might not work in AM3 sockets.
Socket AM3+	942 (PGA)	Replaces AM3. CPUs that can fit in AM3 can also fit in AM3+.
Socket FM1	905 (PGA)	Used for accelerated processing units (APUs).
Socket F	1207 (LGA)	Used on servers and replaced by Socket C32 and Socket G34.

2.6 Processor performance issues

There are several factors/components that influence the performance of the CPU.

2.6.1 Math coprocessor

This component influences the speed at which the processor performs calculations, specifically calculations involving floating decimal point operations. Floating-point operations are used for calculating a large range of numbers quickly.

2.6.2 Clock speed

Clock speed is the speed at which the processor executes instructions. The clock speed is measured in megahertz (MHz – millions of cycles per second) or gigahertz (GHz) and as this value increases, the processing speed increases proportionally. The **system clock** provides the timing signal for the CPU and is used to synchronise the operation of all the components of the PC.

2.6.3 Cache memory

This is the storage area for frequently used data and instructions. A larger cache could result in performance normally associated with a faster CPU. Cache is a fast block of RAM that interacts between the CPU and the system RAM using a cache controller chip. It enhances performance by pre-loading instructions and data from RAM and passing it to the CPU on demand.

CPUs have internal cache RAM, supplemented by external Level 2 (L2) cache RAM. Most CPU designs incorporate L2 cache on the CPU. Some CPUs utilise Level 3 (L3) cache to enhance graphics performance although it is mostly used in server-level hardware.

2.6.4 The bus

The bus size influences the processor's ability to communicate with the rest of the system components. The larger the data bus of the CPU, the more data can be transmitted at one time. As the size of the address bus increases, the number of memory address locations that can be supported also increases.

2.6.5 Interrupt lines

These lines run from the expansion slot directly to the processor. Interrupt lines are used by devices when they need to get the attention of the CPU for processing time. The device sends an **interrupt request (IRQ)** to the processor. When a processor receives an IRQ, it suspends or interrupts its current activity to attend to the needs of the device that sent the IRQ. Two devices can share the same IRQ, provided that they are not used simultaneously. Table 7 lists the default IRQ assignments.

Early computer motherboards had a chip that provided eight IRQ lines numbered 0 to 7. Later, a second IRQ chip was added to provide channels 8 to 15. IRQ channel 2 is used to cascade the two IRQ chips together.

Table 7 – Default IRQ assignments

IRQ Line	Default Assignment
IRQ 0	System timer
IRQ 1	Keyboard
IRQ 2	Cascades to IRQ 9
IRQ 3	COM 2 and 4
IRQ 4	COM 1 and 3
IRQ 5	LPT2/Sound card
IRQ 6	Floppy controller
IRQ 7	LPT1 (Parallel Port)
IRQ 8	Real time clock (RTC)
IRQ 9	Cascades from IRQ 2
IRQ 10	Available
IRQ 11	Available
IRQ 12	PS/2 mouse port (available if not used)
IRQ 13	Math coprocessor
IRQ 14	Primary hard disk controller
IRQ 15	Secondary hard disk controller

2.6.6 DMA channels

Direct Memory Access (DMA) occurs when a device bypasses the CPU and writes information directly into memory. The CPU is then free to perform other tasks. Each bus has a different number of channels that can be used for DMA. In the event of two devices sharing a DMA channel, neither of them will function correctly. Table 8 lists the default DMA assignments.

Table 8 – Default DMA assignments

DMA Channel	Default Assignment
DMA 0	Available
DMA 1	Available
DMA 2	Floppy controller
DMA 3	Available
DMA 4	2nd DMA controller
DMA 5	Available
DMA 6	Available
DMA 7	Available

2.7 Exercise

- Do the following exercise with the assistance of your lecturer.
- Use one of the PCs in your Lab.

2.7.1 Complete the following table.

Processor type	
No of pins	
Processor speed	

2.7.2 List the IRQ Assignments from 1 – 15.

2.8 Review questions

Answer the questions that follow to help you to reinforce what this unit has covered. If you are unsure of the answer to any question, then search for it in the text of this unit.

1. What are the four major functions of the CPU? Give a short description of each.

   [8]

2. Clock speed is measured in _____ .

   [1]

3. Give the definition of the following processor components:

   Cache memory

   DMA

   Dual core

   Dual pumped

   [4]

4. List the IRQ and the default assignments from 1 – 15.

   [15]

5. When does a DMA occur?

   [2]

Total: 30 marks

NOTE	Complete this exercise on a piece of paper and submit it to your lecturer.

Unit 3 – Memory

At the end of this unit, you will be able to:

- Distinguish between RAM and ROM technologies.
- Understand the different memory types.
- Understand how memory is packaged.

3.1 Memory types

RAM (Random Access Memory) and ROM (Read Only Memory) are two basic types of chip-based storage in the PC. RAM and ROM are used to store data to which fast access is required.

3.2 RAM types

RAM is the workspace of the processor. The CPU uses this storage space to hold both program instructions and associated data.

RAM is most commonly used as the temporary working space of the CPU and other components of the PC, such as graphics cards. RAM is volatile, meaning the information it holds is dependent on a constant supply of power. All data stored on it will be lost if the computer is rebooted or turned off. RAM is packaged on a module, as shown in Figure 19.

Figure 19 – Laptop and PC RAM modules

3.2.1 Dynamic RAM (DRAM)

DRAM is called dynamic because it must be refreshed periodically or it will lose the data it stores. Refreshing DRAM consists of reading the contents from DRAM and immediately writing them back to DRAM. It stores the operating system, application programs and data while they are running. You are unlikely to encounter standard DRAM in newer PCs. DRAM is a memory chip that works like a spread sheet: it has numbered rows with cells. Each cell has a capacitor to store a charge to represent a 1 or no charge for a 0, and a transistor to read the charge state of the adjacent capacitor. The charge in the capacitor is constantly draining, which is why DRAM must be recharged or refreshed constantly. This refresh process occurs when the memory controller takes a tiny break and accesses all

the rows of data in the chip.

3.2.2 Static RAM (SRAM)

DRAM is often contrasted with SRAM (Static RAM). SRAM is able to store data as long as power is applied to it, without needing to be refreshed. SRAM is also four or five times faster than DRAM, but is also much more expensive. Both DRAM and SRAM lose their contents when the power to them is turned off. SRAM is used in small amounts in computers where very fast RAM is required, such as in the L2 cache of many CPUs.

Types of SRAM include:

- Asynchronous Static RAM
- Synchronous Burst Static RAM
- Pipeline Burst Static RAM.

3.2.3 Synchronous Dynamic RAM (SDRAM)

SDRAM is a variant of DRAM in which the memory speed is synchronised with the clock pulse from the CPU (the system clock). This synchronisation enables SDRAM to pipeline read and write requests. Pipelining enables the SDRAM to accept commands at the same time as it is processing other commands. There are variants of SDRAM**:**

- Single Data Rate SDRAM – SDR SDRAM
- Double Data Rate SDRAM – DDR SDRAM
- Double Data Rate 2 SDRAM – DDR2 SDRAM
- Double Data Rate 3 SDRAM – DDR3 SDRAM
- Double Data Rate 4 SDRAM – DDR4 SDRAM.

3.2.3.1 SDR SDRAM and DDR SDRAM

SDR SDRAM is the original SDRAM standard, which has since been replaced by DDR SDRAM. DDR SDRAM doubles the bandwidth of SDR DRAM (data is transferred twice in one cycle).

SDRAM DIMM modules are sold according to clock speed (MHz), bus speed (mega transfers per second) and transfer rate (megabytes per second).

NOTE	Refer to Tables 9 – 14, which contain the SDRAM standards for your interest only and do not form part of the examination objectives.

3.2.3.2 DDR2 SDRAM

DDR2 SDRAM, an abbreviation for double data rate two synchronous dynamic random access memory, is a type of SDRAM commonly used in personal computers and various digital electronics today. This offspring from SDRAM, a part of DRAM, is like an evolution from the DDR SDRAM; it can operate the external data bus twice as fast as its predecessor.

3.2.3.3 DDR3 SDRAM

Double Data Rate Three SDRAM (DDR3 SDRAM) is the third generation of DDR SDRAM.

DDR3 SDRAM improves on DDR2 SDRAM in several significant ways:

- Higher bandwidth owing to increased clock rate.
- Reduced power consumption owing to 90 mm fabrication technology.
- Pre-fetch buffer is doubled to 8 bits to further increase performance.
- The voltage of DDR3 SDRAM DIMMs is lowered from 1.8 V to 1.5 V. This reduces power consumption and heat generation, as well as enables more dense memory

configurations for higher capacities.

3.2.3.4 DDR4 SDRAM

DDR 4 is the newest iteration in DRAM, loaded with new features that improve speed, power, reliability and stacking capabilities for the enterprise, micro-server, ultrathin and tablet markets.

What are the new features of the DDR4?

- Up to 50% higher bandwidth than DDR3
- Up to 40% lower power consumption than DDR3
- Faster burst accesses
- Improved data signal integrity.

NOTE	Before fitting any new RAM module, check the correct speed at which the motherboard operates. SDRAM is designed to run at the speed of the front side bus.

3.2.4 Non-Volatile Random Access Memory (NVRAM)

NVRAM differs from DRAM and SRAM in that it retains the contents of its memory when the power is turned off. NVRAM is typically implemented using flash memory.

3.2.5 Rambus DRAM (RDRAM)

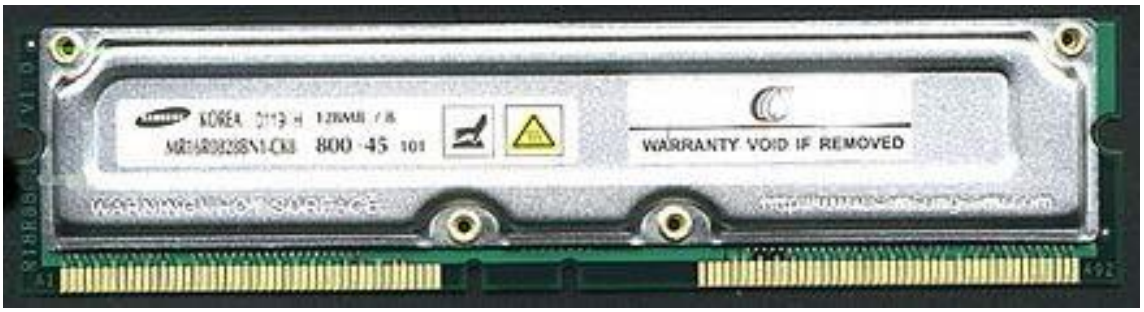


Figure 20 – RDRAM memory with integrated heat sink

RDRAM is a proprietary variant of DRAM, which was developed by Rambus, Inc. (Figure 20). RDRAM incorporates technical advantages such as:

- Packet-based command protocol
- Command pipelining
- Data pipelining
- Low voltage signaling
- Precise clocking.

Manufacturers that wish to utilise RDRAM technology must pay royalties to Rambus Inc.

3.2.6 Video RAM

Video RAM is specialised RAM, which is used on graphics cards. Video RAM is dual-ported, which means it can be accessed by two different devices simultaneously. This enables data to be read from video RAM (i.e. sent to the computer monitor) at the same time as data is written to video RAM.

3.3 Memory packaging

3.3.1 Dual Inline Memory Modules (DIMMs)

Dual Inline Memory Modules are used for most memory types, but DIMM modules are not interchangeable.

A given motherboard will only be able to fit SDRAM, RDRAM, DDR RAM, DDR2 RAM, DDR3 RAM or DDR4 RAM (not a mixture). In addition, there can be compatibility issues even if the memory is the correct type.

Compatibility with DIMMs is quite limited owing to the notch positions and the pin density, which are different:

- SDRAM – 168 pins and two notches
- DDR SDRAM – 184 pins and one notch
- DDR2 & DDR3 SDRAM – 240 pins (keyed differently)
- DDR4 – 284 pins.

3.3.2 Rambus Inline Memory Module (RIMMs)

Rambus Inline Memory Module is used for RDRAM memory. RDRAM has a 16-bit (single channel) and 32-bit (dual channel) bus width. RIMMS for 16-bit RDRAM have 184 pins and 232 pins for 32-bit RDRAM, but are otherwise similar to DIMM packaging and fit into a smaller connector.

3.4 Read Only Memory (ROM)

ROM is an integrated circuit memory chip that contains configuration data. ROM is typically used to store low-level hardware instructions such as the motherboard and graphics card BIOS. ROM is non-volatile and does not require a permanent power source to retain data.

ROM is commonly called firmware because its programming is fully embedded into the ROM chip. As such, ROM is hardware and software in one.

Data is fully incorporated in the ROM chip during manufacturing; data stored can only be erased or replaced if the chip is reprogrammed. This means permanent and secure data storage.

3.4.1 Erasable Programmable Read Only Memory (EPROM)

EPROM is a ROM-type chip that can hold data for 10-20 years. It can be programmed more than once. An EPROM programming is erased only through exposure to ultra violet light. The EPROM is configured or reconfigured using an EPROM programmer.

3.4.2 Electrically Erasable PROM (EEPROM)

Electrically Erasable PROM (EEPROM) has the added benefit of being able to be reprogrammed while it is still in the circuit board. Reprogramming is done by sending a special sequence of electrical signals to the chip. These signals erase all or part of the chip programming.

3.4.3 Firmware

We all use electronic devices, whether they are mobile phones, computers, routers, MP3 players, etc. These electronic devices include hardware, the physical electronic components, and software (programs that help these components to run effectively). Firmware is usually defined as a type of program that runs within an electronic device. Firmware is not categorised either as hardware or software, but as a mixture of both. Firmware is stored on ROM chips.

Each time your computer or electronic device boots up, firmware is b

ooted as well. Firmware can store its instructions permanently and does not require a power source. One of the most common types of firmware is the BIOS chip on your computer's motherboard. In the past, when new instructions were required for a BIOS chip, the entire motherboard usually needed replacing since the BIOS chip could not be rewritten. Now, firmware can easily be rewritten, enabling it to be upgraded with new features or to remove bugs and issues. Since firmware is found in practically all electronic devices, it has extended the life of these products, easily adding more functionality to them.

3.5 Additional information

The following tables will give you a glimpse of SDRAM standards. Consult the vendor website for a detailed and complete list.

Table 9 – DDR SDRAM standards

DDR SDRAM standard	Frequency (MHz)	Voltage
DDR	200	2.5/2.6
DDR2	533	1.8
DDR3	1066	1.5
DDR4	2133	1.05/1.2

NOTE Higher frequencies enable higher rates of data transfer. Lower voltages result in less heat radiation and longer battery life for portable computing devices. They also allow greater component density, which allows higher capacity in the same packaged size.

Table 10 – SDRAM DIMM module standards

DIMM module	Clock speed (MHz)	Bus speed	Transfer rate (MBps)
PC66	66	66	533
PC100	100	100	800
PC133	133	133	1066

Table 11 – DDR, DDR2 and DDR3 SDRAM standards

DIMM module	Chip type	Clock speed (MHz)	Data rate	Transfer rate (GBps)
PC-1600	DDR-200	100	200	1.6
PC2-3200	DDR2-400	200	400	3.2
PC2-4300	DDR2-533	266	533	4.3

Table 12 – DDR SDRAM standards – still being developed and improved

DDR SDRAM standard	Frequency (MHz)	Voltage
DDR	400-533	2.5
DDR2	667-800	1.8
DDR3	1066 to ...	1.5
DDR4	1067 – 1600	1.2

Table 13 – DDR2 SDRAM – normally packaged in DIMM modules

DIMM module	Chip type	Clock speed (MHz)	Data rate	Transfer rate (GBps)
PC2-3200	DDR2-400	200	400	3.2
PC2-4300	DDR2-533	266	533	4.3
PC2-5300	DDR2-667	333	667	5.2
PC2-6400	DDR2-800	400	800	6.4
PC2-8500	DDR2-1066	533	1066	8.5

Table 14 – DDR3 SDRAM modules

DIMM module	Chip type	Clock speed (MHz)	Data rate	Transfer rate (GBps)
PC3-8500	DDR3-1066	533	1066	8.5
PC3-10600	DDR3-1333	667	1334	10.66
PC3-12800	DDR3-1600	800	1600	12.8

3.6

3.7 Exercise

- Do the following exercise with the assistance of your lecturer.
- Use one of the PCs in your Lab.

[1]

Check:

3.6.1 Amount of memory you have on your PC_____.

3.6.2 Type of memory chips you are using_____.

[6]

3.7 Review questions

Answer the questions that follow to help you to reinforce what this unit has covered. If you are unsure of the answer to any question, then search for it in the text of this unit. [2]

1. Complete the following:

1.1 _____is a propriety variant of DRAM. [1]

1.2 _____uses flash memory and retains the contents of its memory when power is turned off. [1]

2. RAM is volatile.

   A. True
   B. False

3. Give definitions for the following terms:

   RAM
   ROM
   Firmware.

4. Explain briefly why the different DIMM modules are not compatible with each other.

Total: 11 marks

NOTE Complete this exercise on a piece of paper and submit it to your lecturer.

Unit 4 – Power Supply Unit and Specialised Power Devices

At the end of this unit, you will be able to:

- Understand the functions of a power supply.
- Know some of the most common power supply types.
- Know the power supply connectors.
- Troubleshoot power supplies and prevent problems associated with power supplies.
- Understand the uses of specialised power devices.

The Power Supply Unit (PSU) is the component that supplies power to a computer. Refer to Figure 21. It is designed to convert alternating current (AC) from the mains supply to usable low-voltage direct current (DC) for the internal components of the computer.

Power supplies are quoted as having a certain power output specified in Watts. A standard power supply typically delivers around 350 Watts, while a power supply for a gaming PC would be around 750 Watts or more.

The more components (hard drives, CD/DVD drives, graphics cards, ventilation fans, etc.) you have in your PC, the greater the power required from the power supply.

By using a PSU that delivers more power than is required, it will not run at full capacity, thereby prolonging its lifespan by reducing heat damage to the internal components of the PSU.

A power supply should always be replaced by an equivalent or superior power output (Wattage). A power supply is not user-serviceable; do not attempt to open a power supply without the proper knowledge and experience.

4.1 Types of power supplies

The type of power supply determines the compatibility with the motherboard type and the number of connectors it provides. Most power supplies are based on the ATX type. The common size is 150 mm wide x 86 mm high x 140 mm deep.

Below are power supply units that are commonly used:

- **Micro-ATX** – an SFF primarily used for micro-ATX cases. Micro-ATX is similar to ATX for compatibility, i.e. it uses the same standard ATX power connector and standard ATX I/O panel, and thus a micro-ATX motherboard will fit in a full-size ATX case. However, it typically has fewer power connectors than ATX PSUs.
- **TFX12V (Thin Form Factor with 12V connector)** – an SFF primarily used for micro-ATX systems.
- **SFX12V (Small Form Factor with 12V connector)** – an SFF primarily used for micro-ATX systems.

Figure 21 – Power supply

Sourced from: http://hardwaretexpert.wordpress.com/2010/11/18/computer-power-supply/

4.2 Power supply connectors

Table 15 contains a list of power supply connectors and their specifications.

Table 15 – Power supply connectors

Connector	Description
	4-pin Berg connector or mini-Molex This is used to connect the PSU to small form factor devices such as 3.5" floppy drives.
	4-pin Molex connector This is used to power various components, including hard drives and optical drives.
	20-pin Molex ATX power connector This is used to power the motherboard in ATX systems.
	4-pin Molex P4 12V power connector This is used specifically for Pentium 4 processor motherboards.
	6-pin AUX connector This provides 5V, and two connections of 3.3V.

	15-pin Serial ATA (SATA) power connector. A third voltage is supplied, 3.3 V, in addition to the traditional 5 V, and 12 V. There are two other less common SATA connectors: • A 6-pin SATA, also called slimline connector, supplies 5 V. • A 9-pin SATA, also called micro connector, supplies 3.3 and 5 V.
	Auxiliary 6-pin PCIe power connector used by high performance PCIe graphics cards that need additional voltage. PCI Express version 1 uses a 6-pin connector. PCI Express version 2 uses an 8-pin connector. A 6-pin with a separate 2-pin connector is available to provide compatibility for PCI Express version 1 and 2. PSUs designed for dual card systems will feature two PCIe connectors.

4.3 Troubleshooting power supplies

The most noticeable features of a power supply are the characteristic sound of a power supply and the whisper of its cooling fan.

If the voltages are too high, too low or missing, the system will not function effectively or at all. If the AC voltage fluctuates and causes the power supply to become overworked or overheated, the system is forced to reset or shut down.

Power supplies are mechanical/electrical devices with a limited lifespan. Eventually, every power supply fails. That is the destiny of all electrical devices. Their demise can be hastened by unprotected power surges or constant overloads from having to power too many hardware components.

4.3.1 Symptoms

A power supply is tasked with providing electricity to every component in a computer, so a faulty, underperforming unit will often cause a wide variety of symptoms, including, but not limited to:

- Failure to power up.
- General instability.
- Rebooting - randomly or when the computer is stressed.
- Hardware failure - owing to sudden power spikes/dips or long-term electric noise.
- Inability to boot up even though the motherboard light is on.
- At power on, there is no activity at all except for the fans and the disk starting to spin.
- Noisy fans can be caused by dust, lack of internal maintenance or a failing motor.

4.3.2 Solutions

- Power supply testers are available. These typically have a single socket for each common type of power supply connector, and use several light emitting diodes (LEDs) to indicate if the power supply is working.
- Dust may be removed by carefully blowing air through the supply with an air pump or gas duster (canned air).

- Troubleshooting power supply problems is limited to isolating the unit as the cause of your computer problems. Once you have determined the power supply is the culprit, there is little choice but to replace it. A power supply can be easily changed and is generally not expensive, so if one fails then a replacement is usually the most economical solution.
- Power supplies contain dangerous voltages and should only be opened by experienced and qualified engineers; there are no user serviceable parts inside.

NOTE	Always disconnect the PSU from the mains supply before removing the cover of the PC.

4.4 Specialised power devices

There are three main power devices that can prevent damage to a computer system. Refer to Figures 22–24:

- Line conditioners
- Uninterruptible power supplies
- Surge protector.

4.4.1 Line conditioners

This device provides flawless power by removing any stray noise and interference from the power line. Sources of interference could be electromagnetic interference (EMI) or radio frequency interference (RFI). It is ideally used when the PC power supply is too close to another power source, or if it is too close to a device that generates radio waves. A line conditioner will also protect against surges, sags (decrease in voltage) and lightning strikes. A power surge is an increase in voltage significantly above the designated level in the flow of electricity. When the increase lasts three nanoseconds (billionths of a second) or more, it is called a surge. When it only lasts for one or two nanoseconds, it is called a spike.

4.4.2 Uninterruptible Power Supplies (UPS)

Figure 22 – A small freestanding UPS

Sourced from:
http://apacelli.com/uninterruptible-power-supply-mge/mge-pulsar-m-2200-rt3u-hotswap/

A UPS is typically used to protect computers, telecommunication equipment and other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious business disruption or data loss. UPS units come in sizes ranging from units that will back up a single computer without a monitor (around 200 VA) to units that will power entire data centres or buildings (several megawatts).

This device is connected to the wall power outlet and regulates the power to the computer. The UPS ensures power supply is not interrupted in the event of a power failure. The computer is therefore connected to the wall power outlet via the UPS.

There are two types of UPS:

- Standby UPS
- Online UPS.

4.4.2.1 Standby UPS

A standby UPS, also referred to as an off-line UPS, uses a battery to supply power to the computer, but only when there is a drop in the voltage from the wall power outlet. When there is normal voltage flowing through the line, the computer draws power directly from the wall outlet. One drawback of this device is that it cannot always prevent sags from affecting the computer.

4.4.2.2 Online UPS

An online UPS provides power to the computer from its batteries at all times. Power from the wall outlet is used to charge these batteries. This device is very effective against spikes, sags and blackouts (a complete power outage).

4.4.3 Surge protector

A surge protector plugs multiple components into one power outlet. With all of the different components that make up a computer system, this is definitely a useful device.

The main job of a surge protector system is to protect electronic devices from surges and spikes. It is unusual for power from the wall outlet to be consistent. If the surge or spike is high enough, it can inflict serious damage on a PC. Even if increased voltage does not immediately damage your PC, it may put extra strain on its components, wearing them down over time.

Figure 23 – A surge protector power strip

Figure 24 – Surge suppressor

4.5 Review questions

Answer the questions that follow to help you to reinforce what this unit has covered. If you are unsure of the answer to any question, then search for it in the text of this unit.

1. What is the main function of a power supply?

[1]

2. Mention two internal computer components that could require additional power.

[2]

3. List the three available voltages used by a computer.

[3]

4. How many pins do the following connectors have?

4.1 ATX Power connector to the motherboard _____ [1]

4.2 SATA Power connector_____ [1]

5. Provide a solution to each of the following problems:

Problem	Solution
The computer is close to a source of radio waves that cause RFI.	
A server containing crucial information needs constant power supply to the PC.	

[2]

Total: 10 marks

NOTE	Complete this exercise on a piece of paper and submit it to your lecturer.

Unit 5 – Storage Devices

At the end of this unit, you will be able to:

- Identify the different storage devices.
- Understand the terms, concepts and function of storage devices.
- Describe the capabilities of PATA, SATA and SAS drives.
- Describe flash memory devices.
- Describe the capabilities of CD/DVD drives.

Storage devices typically use magnetic, solid state or optical technology to store data. The main storage device in a computer is one or more fixed hard drives. Other storage devices (such as CD or DVD drives, or tape drives) are used to transfer information to and from the computer. These are referred to as removable storage, as the disk media can be removed from the drive. Other forms of removable storage are flash memory devices used to store and transfer data between a device and a PC.

5.1 Hard drives

A hard disk drive (HDD) is also known as a hard disk, hard drive or physical disk. It stores the operating system, application files, user data and data shared over a network. The hard drive stores data until it is deleted, becomes corrupted or is destroyed. Internal hard drives are installed inside the computer tower with no outside access, while the external or removable hard drives sit outside and plug into the appropriate port.

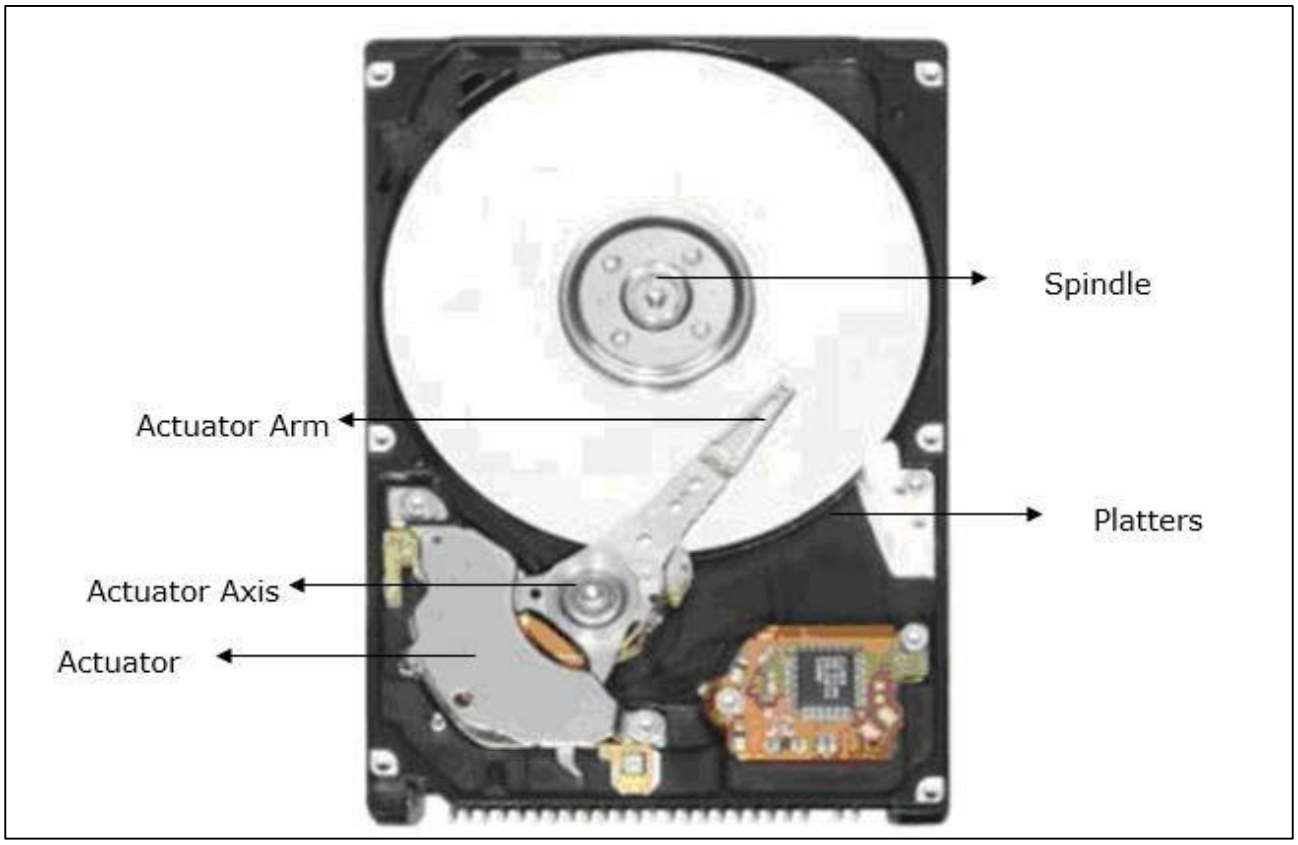


Figure 25 – The physical components of a hard drive

A hard drive has physical and logical components.

Physical components:

- **Platters** – A stack of magnetic coated glass or metal disks that are stacked on top of each other like a spindle, which spin together at high speeds. This is where the data is stored.
- **Read/write head** – Used to transfer data to and from a platter.
- **Actuator arm and axis** – The arm that is used to move the read/write heads over the surface of the platters.
- **Actuator** – The motor that moves the actuator arm.

Logical components:

- **Tracks** – These are the data storage rings where the hard drive is capable of containing information.
- **Sectors** – Tracks are divided into wedge shaped sections of the circular tracks. A sector is between 512 bytes and 4 KB in size and is the smallest unit of storage on a platter.
- **Clusters** – A cluster is a group of multiple sectors. This is where files are written to.
- **Cylinders** – One corresponding track on all surfaces of all platters is called a cylinder. For example, cylinder 0 is made of all track 0s on all platters inside the hard drive; cylinder 1 is made up of all track 1s on all platters, and so on.

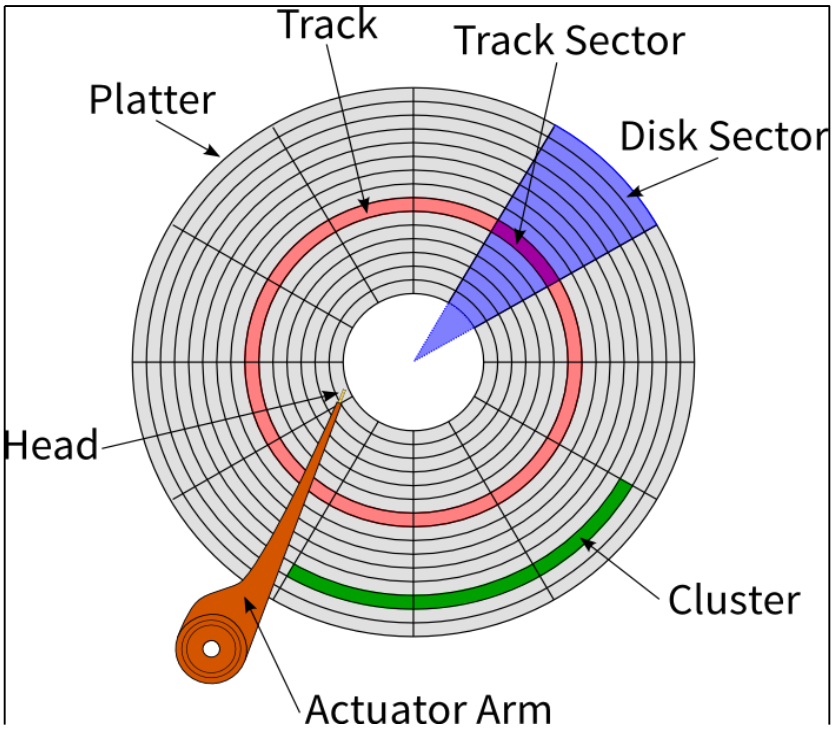


Figure 26 – An example of the logical components of a hard drive

Sourced from: http://lnx.cx/docs/vdg/output/Virtual-Disk-Operations.html

A new hard disk drive requires partitioning and formatting before it can be used.

5.1.1 Low-level formatting

Low-level formatting is done at the factory and is the process of writing index marks to the surface to enable the heads to locate tracks and sectors.

5.1.2 Partitioning

Partitioning is the act of dividing the hard drive into sections called drives or volumes. You have to create at least one partition on the disk before performing a high-level format. This can be done through the Windows setup when building a new PC or through disk management when adding an extra hard disk.

Windows supports the following partitioning styles or schemes:

- **Master Boot Record (MBR)** – The MBR is the most common type of disk partitioning style used. MBR is the first sector of the hard drive that tells the computer how to load the OS and also how the hard drive is partitioned and how to load the OS.
- **GUID Partition Table (GPT)** – The **Global Unique Identifier (GUID) Partition Table** is a newer partitioning style that overcomes the limitations of MBR disks. GPT is recommended for disks that are larger than 2 TB.

5.1.3 High-level formatting

High-level formatting prepares a partition for use with an operating system by creating a file system on the partition.

5.1.4 File systems

Hard disk capacity gets bigger every year, and as they get larger using them in an efficient way becomes more difficult. The file system is the general name given to the logical structures and software routines used to control access to the storage on a hard disk system. Operating systems use different ways of organizing and controlling access to data on the hard disk, and this choice is dependent on the specific hardware being used. The same hard disk can be arranged in many different ways, and even multiple ways in different areas of the same disk.

5.1.4.1 FAT

File Allocation Table (FAT) is a file system supported by Windows and other operating systems, such as Linux, which makes it suitable for multi-boot systems and removable media that can be shared between operating systems.

There are two commonly used versions of FAT, namely FAT16 and FAT32:

- **FAT16** (just FAT) uses a 16-bit table to address clusters and supports a maximum partition size of 4 GB and file size of 2 GB.
- **FAT32** uses a 32-bit table to address clusters and supports a maximum of 32 GB in Windows and file size of 4 GB.

5.1.4.2 NTFS

New Technology File System (NTFS) is a secure 64-bit file system and is best for Windows systems. Microsoft recommends using NTFS for Windows operating systems, and the Windows 7 installation program only supports NTFS.

5.2 Solid state technology and hybrid drives

Solid state technology and hybrid devices use semiconductors, transistors and flash memory to create electrical components with no moving parts. Solid state technology is commonly used in desktop and laptop hard drives, memory cards, cameras, USB flash drives and other handheld devices.

Solid state drives (SSD) are storage devices that use non-volatile flash memory to keep their data when power is turned off. SSDs can be PATA, SATA, eSATA, SCSI, PCIe and USB for desktop computers. Some portable computers have mini-PCIe versions.

Hybrid hard drives (HDD) consist of a magnetic hard drive with flash memory to provide fast and reliable storage while using less power and creating less heat. Data that is used often can be temporarily stored or cached in flash memory so that the magnetic disks do not have to be read as often. This can extend the battery life of portable devices. Additionally, flash memory allows encryption and other security measures to be built into the drive.

5.3 Host bus adapter and drive standards

A **controller** is the drive's on-board circuitry that controls how the drive works and allows it to put data on the data bus. The data includes instructions for where to find and how to get to the data.

The **host bus adapter** or **host adapter** is the connection point between hard drives, optical drives, tape drives and the motherboard, allowing data to be moved to the CPU and RAM. Most motherboards have the host adapter built into their circuitry, which connects to headers where you plug in the drive's data cable.

A hard drive must have a set of rules to work properly. These rules make up a standard called an **interface** which oversees how the drive works with the system. Standards tell you the number of heads on the drive, to what commands the drive responds, the cables and connectors used with the drive, the number of drives supported and so on. There are two main bus standards for attaching drives to the computer:

- **Advanced Technology Attachment (ATA)** – Also known as integrated drive electronics (IDE). ATA is commonly used in home and office computers and network servers. There are two types of ATA – older PATA (Parallel ATA) and newer SATA (Serial ATA).
- **Small Computer System Interface (SCSI)** – Most commonly found in network servers.

5.3.1 PATA

Also referred to as **Integrated Drive Electronics (IDE)** or **Extended IDE (EIDE)**, PATA is an older IDE type that transfers data in parallel – that is, multiple bits are sent over multiple paths. With PATA, multiple drives can attach to the same bus and share that bus. PATA is used for internal drives such as hard, tape, zip and optical drives. Modern motherboards might have one PATA IDE header (although some have two or more).

The IDE headers are known as the **primary** or **primary IDE channel (IDE v 1)**, **secondary** or **secondary IDE channel (IDE 2)** and, if there is a third header, **tertiary IDE channel (IDE 3)**. Every PATA header (or channel) can have up to two drives (**0** and **1** or **master** and **slave**) connected. There are multiple PATA standards,

each supporting different MBps speeds.

The maximum cable length for both cables is 46 cm (18”). You will also find a 44-pin connector for attachment to smaller 2.5 inch drives.

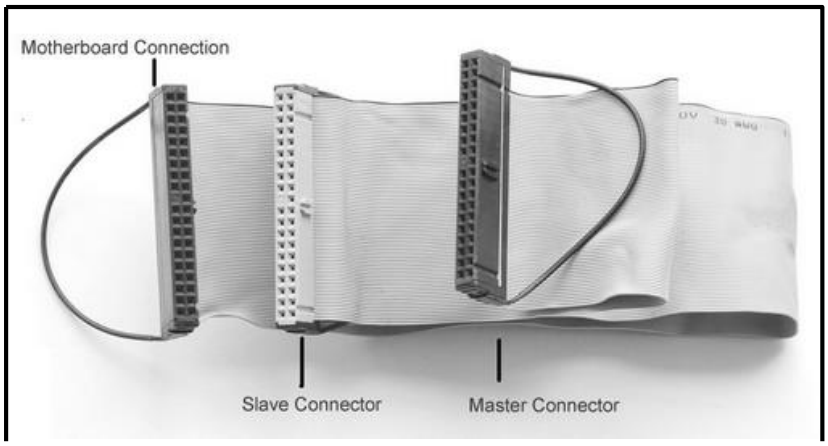


Figure 27 – An 80 wire PATA ribbon cable

Because a single ribbon cable can only connect to two drives and because each drive has its own controller, there is no ‘main’ controller that decides which drive is currently communicating with the motherboard.

Fortunately, IDE uses a **master** and **slave** configuration which allows the master controller on the one drive to tell the slave controller on the other drive when it can transfer data to and from the motherboard.

The master and slave setting can be configured by setting a jumper in between the power and data connectors on the drive itself. You use a jumper (a clip that covers and connects two pins on the back of the drive) to set the drive to master or slave.

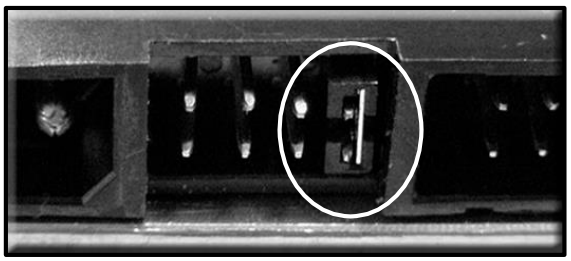


Figure 28 – A jumper on IDE drive

There is another type of IDE data cable called **cable-select** which has connectors that are colour coded to help you determine which device is master and which one is slave (rather than setting jumpers on the drive itself).

The following table explains three important jumper settings.

Table 16 – Drive jumper settings

Jumper setting	Direction
Master or **single drive**	The master drive is used to boot the computer. Use this setting if the drive is the only drive on the cable (single) or the drive is the master.
Drive is slave	This is the non-boot drive. Use this setting if the drive is an additional drive on the cable and the original drive on the same cable is set to master. To set a drive to slave, connect the jumper vertically to the correct pair of pins and connect the grey (middle) connector of the cable to the drive.
Cable select (CS)	Some drives have a cable-select configuration mode that automatically sets the drive as master or slave according to where you connect it to the IDE cable. This might be marked on the drive as CS. If you choose this configuration, you must use a cable-select cable.

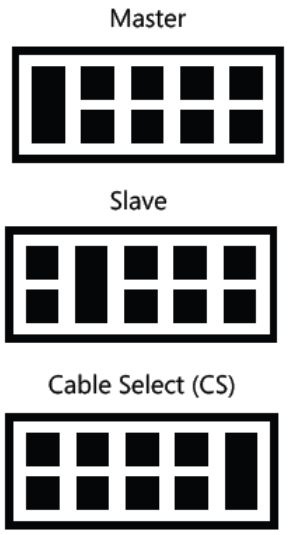


Figure 29 – Drive jumper example chart

Some other technologies that you need to understand in relation to PATA are:

- **Programmed input/output (PIO)** is a traditional I/O addressing scheme where the CPU communicates directly with the hard drive through the BIOS to send and receive data. There are different modes for PIO, each supporting different speeds.

- **Direct memory access (DMA)** transfer mode allows data to be transferred between the hard drive and RAM without going through the CPU using DMA commands. There are different modes for DMA with the latest mode called **UDMA (ultra DMA)**. With UDMA, the interface gains control of the PCI bus under the direction of the motherboard chipset, a process known as **bus mastering**. UDMA comes in different modes, which represent different transfer speeds, with the latest UDMA mode supporting 133 MBps speeds. Most often when installing the drive, the BIOS auto detects the drive and selects the fastest UDMA mode supported by the drive and BIOS.

- **Advanced technology attachment packet interface (ATAPI)** is an additional ATA specification which allows CD/DVD and tape drives to connect to an IDE channel by way of ATA controllers.

Logical block addressing (LBA) is an addressing scheme that tells the drive how to address a particular location on the disk surface. It is a particularly simple linear addressing scheme. Blocks are located by an integer index, with the first block being LBA 0, the second LBA 1 and so on. Driver software now handles drive addressing.

5.3.2 SATA

Serial Advanced Technology Attachment (SATA) has mostly replaced PATA and connects internal hard drives and optical drives to the motherboard. SATA is faster and has smaller data cables compared to PATA. SATA cables also support hot swapping, which allows drives to be added and removed while the computer is running.

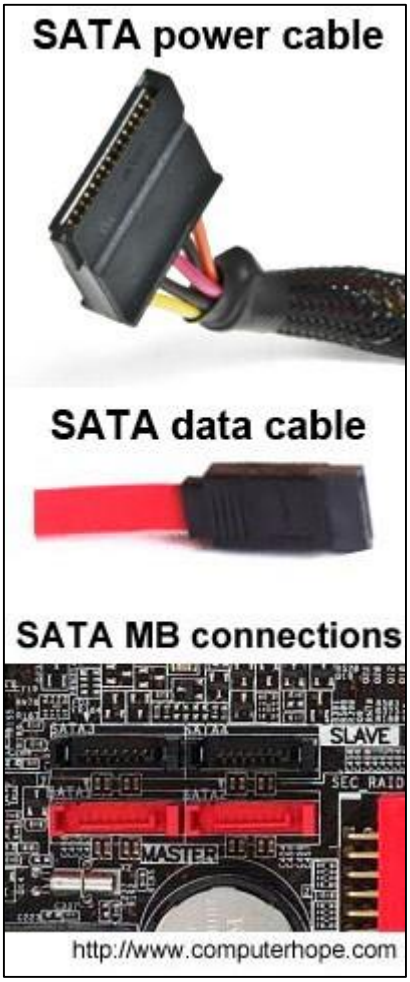


Figure 30 – SATA cable and connections

Sourced from: http://www.computerhope.com/jargon/s/sata.html

SATA drives have a point-to-point dedicated connection to the CPU; each drive has the entire connection bandwidth. SATA sends data in a serial format one bit at a time using only one wire. This allows it to use longer, thinner and more flexible cables that can be up to 1 m long. The cables have two 7-pin connectors.

SATA drives do not have a master/slave, cable select or termination jumpers or settings. Each drive connects to one motherboard port. There is no maximum number of drives. Motherboards come with multiple SATA ports where you can plug in the SATA drives. There are various SATA standards, with each one supporting a Gbps speed.

5.4 External hard drives

External hard drives may be used for backing up data, for adding extra storage space or for transferring data between devices. An external hard drive uses a USB, FireWire, eSATA or Ethernet network connection.

External SATA (eSATA) is an extension to the SATA bus at full speed to external drives. It uses connectors that are similar to the internal SATA but they are keyed differently. You can upgrade laptops to support eSATA devices by inserting an eSATA card. There are also USB-to-eSATA adapters.

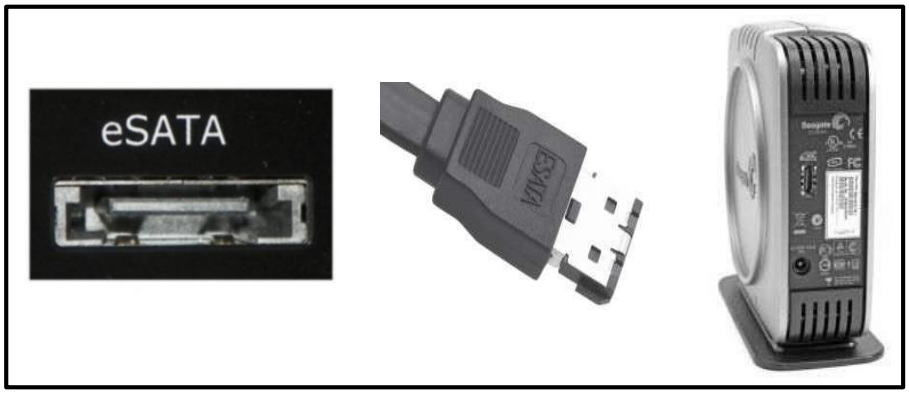


Figure 31 – eSATA port (left), connector (middle) and external hard drive (right)

5.5 Optical disc storage

An optical disc is the generic term for all different types of round, flat, thin, portable discs that are made of metal and plastic and have a protective coating. Optical discs are used to store, transfer and back up data, and distribute software. Optical discs include Compact Discs (CDs), Digital Video Discs or Digital Versatile Discs (DVDs) and Blu-ray Discs (BDs).

Figure 32 – Optical discs

5.5.1 Reading and writing to optical discs

An optical drive uses a laser beam to store data on the reflective metal surface of the optical disc. A high-powered laser beam writes data to the disc by burning or creating bumps called **pits** into the disc's metal surface, and a low-powered laser beam reads data by distinguishing between the pits and the flat areas of the metal surface (called **lands**) by the amount of light deflected when the laser beam hits the surface. The drive interprets the pit-to-land and land-to-pit changes to represent digital 1 and 0 bits. The bit pattern follows a continuous track which spirals from the inside of the disc outwards towards the edge of the disc.

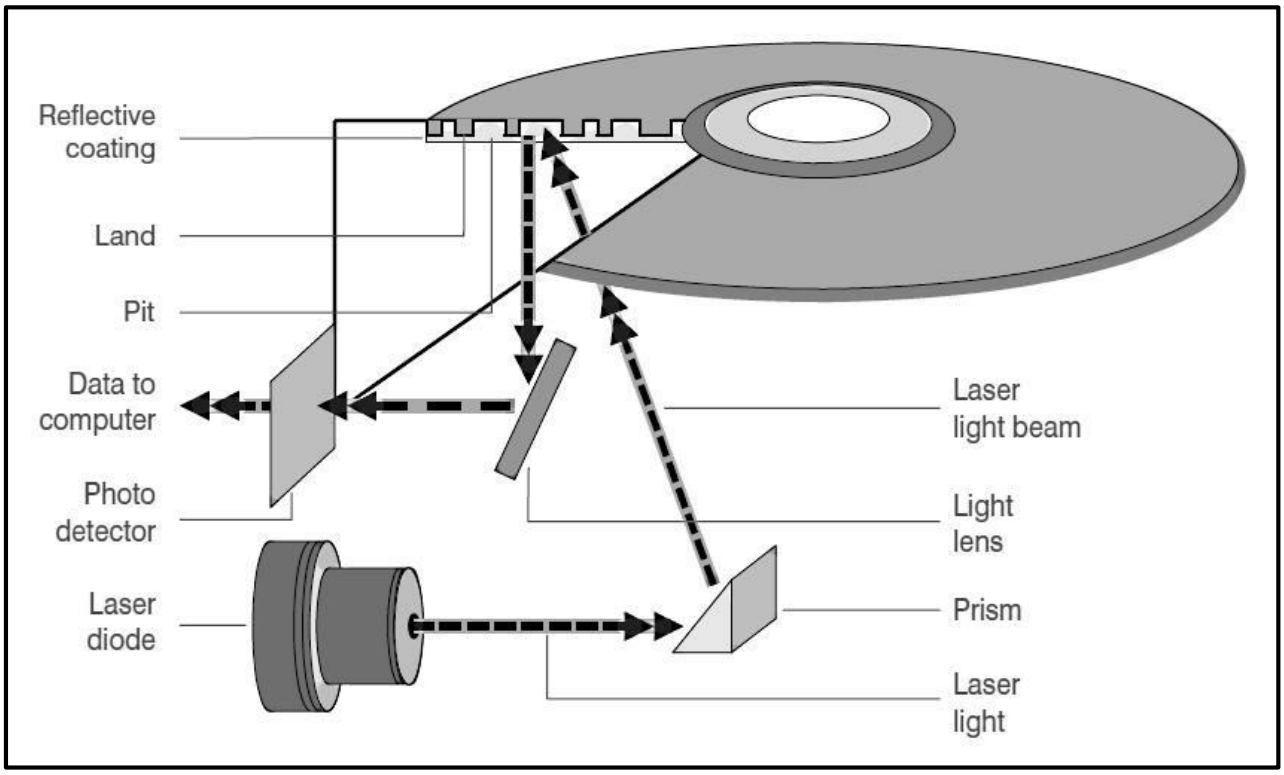


Figure 33 – Basic operation of an optical drive

5.5.2 Disc formats and standards

Below is a table that lists all optical disc terms that you will need to know.

Term	Definition
Burning	Also known as recording or writing. This is to write data to a disc.
Ripping	This is to copy data from a disc to the hard drive.
Session	A period of time in which something happens, where a file or files are added in the same operation.
Single-session	Writing data in one operation.
Multi-session	Writing data at a time without filling up the disc and then adding additional sessions later on until the disc is full.
Read only memory (ROM)	Data can only be read. You cannot change or delete data if the disc has data stored on it.
Recordable (R)	Also known as write once, which means data can only be written once and then the disc becomes read only.
Rewritable (RW)	Also known as re-recordable, this means data can be written, rewritten and erased multiple times.
Recordable Erasable (RE)	Blu-ray discs use RE to show that the disc is rewritable.
—R	The minus or dash is for single session media, which means you cannot add more data to the disc once burning has locked it, even if the disc has more space.
+R	The plus sign is for multiple sessions, which means you can add data to the disc in sessions.
Video	A format used to store digital video on DVD discs.

5.5.3 Optical disc capacity

5.5.3.1 CD
A CD can store data and video but has limited space. A CD-ROM can store 700 MB of data or 80 minutes of music.

5.5.3.2 DVD
DVDs can store data and videos.

- Single-sided, single layer DVD can store 4.7 GB
- Single-sided, dual-layer DVD can store 8.5 GB
- Double-sided, single-layer DVD can store 9.4 GB
- Double-sided, dual-layer DVD can store 17 GB
- DVD-video can store 17.1 GB
- DVD-audio can store 8.5 GB

5.5.3.3 BDs – Blu-ray Discs
BDs can store data and high definition (HD) videos.

- Mini-discs can store 7.8 GB per layer
- Double-sided, single-layer BD can store 25 GB
- Double-side, dual-layer BD can store 50 GB

5.5.4 Compatibility
CD drives can only read and write to CD formats. CD drives cannot read and write DVD and BD formats. Most DVD drives can read and write to CD and DVD formats but not BD formats. Depending on the drive features and model, BD drives can read, write and play CD and DVD formats using a compatible BD/DVD/CD optical head. To be certain as to which drive supports which formats, look in the drive's documentation or visit the manufacturer's website.

5.6 Flash memory

Flash memory is a non-volatile, solid state memory which stores data permanently or semi-permanently. Flash memory works by storing data in memory cells arranged in rows and columns. Each cell has a Field Effect Transistor (FET) which stays switched on or off when the power is turned off.

5.6.1 Flash drives
A flash drive can be used to carry data from one computer to another. Flash drives use a USB connector and support capacities ranging from hundreds of MB to 256 GB and go by the names including **flash drive**, **thumb drive**, **jump drive** and **key drive**.

Flash drives are made by multiple vendors. This means that they come in different sizes. Some have LED lights that show data reads and writes; some have write-protect switches to enable or disable writing of data in memory, and some have a cap that protects the connector from damage and dirt.

Figure 34 – Flash drives

To use a flash drive, you simply plug it into the USB port. The Operating System Plug-and-Play finds the drive and installs the driver. In most cases the **Autoplay** dialog box will be automatically displayed with various programs to open the files on the drive, or you can open **Windows Explorer** or **Computer** to get the drive.

If you unplug a flash drive from your computer while it is still transferring or saving data, you risk losing some valuable information or corrupting your data. Windows offers a tool designed to safely remove your device.

If you see the Safely Remove Hardware icon in the notification area, it means that your device is ready to be removed.

Figure 35 – Safely Remove Hardware icon

To safely remove a certain device, click the **Safely Remove Hardware** icon. In the list of devices, click on the device you want to remove. Windows will display a notification telling you it is now safe to remove your device.

Figure 36 – Notification message

Another method to remove your device is to click on the **Start** button. Click on **Computer**, right-click the device you want to remove and then click on **Eject**.

5.6.2 Memory cards

Memory card is a generic term for a number of small cards that store data. The cards appear as drives in Windows, but they usually do different jobs. They are a great way to store and transfer data. Memory card slots are often found on cameras, smartphones and music players. The cards come in different sizes and support hundreds of MB to multiple GB of storage.

Figure 37 – Different types of memory cards

5.7 Review questions

Answer the questions that follow to help you to reinforce what this unit has covered. If you are unsure of the answer to any question, then search for it in the text of this unit.

1. Match the description to the term:

a) The process of writing index marks to the surface to enable the heads to locate tracks and sectors.
b) The logical structure and software routines used to control access to storage on a hard disk.

1.1 File system _____ [1]
1.2 Low-level formatting_____ [1]

2. List the physical and logical components of a hard drive.

[16]

3. Complete the table:

No	Compare	PATA	SATA
1	Interface		
2	Drive connector		
3	Cable		
4	Power connector		

[8]

4. Give a short description of the technology used by SATA drives.

[2]

5. Complete the table:

CD/DVD format	Storage capacity
DVD-ROM	
CD-ROM	
Blu-ray	

[3]

Total: 31 marks

NOTE	Complete this exercise on a piece of paper and submit it to your lecturer.

Unit 6 – Display Systems

At the end of this unit, you will:

- Have a basic understanding of a graphics card and its major components.
- Understand the different display standards and how they affect the output of the monitor.

Figure 38 – Graphics card

6.1 Graphics card

The graphics card, or video adapter, controls the display on a monitor and creates the image on the screen. An example of a graphics card is shown in Figure 38. A graphics card converts the digital data signals of a computer into a format that can be displayed. A graphics display adapter is often an expansion card that can be plugged into an expansion slot on the motherboard. On some newer motherboards, the display adapter is incorporated as part of the motherboard chipset. When this is the case, it is called an on-board adapter. Display adapters like all adapters require special device drivers in order for the operating system to interact with them. Many graphics cards offer added functions such as video capture and TV output.

6.1.1 The major components

The graphics card is a printed circuit board with the following major components, namely the graphics processing unit, the video memory and the video BIOS.

The **Graphics Processing Unit (GPU**) is the graphics card's microprocessor. It carries out the instructions it receives from the operating system to render 2D and 3D images on-screen. It performs the function of generic graphics elements. The result of this processing is seen as output from the computer monitor.

The **video memory** is an integral component of graphics cards. Video memory temporarily stores the processed images, buffers, textures and other display attributes. Video memory usually provides faster access to data than normal RAM. Newer low-end graphics cards or on-board adapters use system memory (shared memory), while high-end dedicated cards may be manufactured with GDDR RAM, which is similar to DDR, DDR2, DDR3 and DDR4 RAM. Other cards may use a mixture of shared memory and dedicated memory.

A graphics card also has its own BIOS chip. This is the memory chip that stores the graphics card configuration data. The **video BIOS** or **firmware** is a basic program that provides instructions that allow the computer and software to interact with the card. Moreover, the video BIOS found on cards contains the instructions that control the video processing speed and the voltage passed through both the GPU and video memory.

6.1.2 The graphics card interface

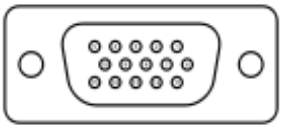
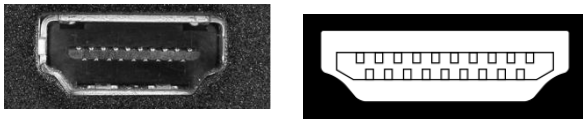
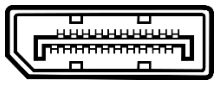
The graphics card fits into the slot that facilitates the connection between the card and the motherboard from which it draws power. The slot can be a PCI Express (PCIe) slot, PCI slot or an older AGP slot. Of the three, PCIe is preferred by gamers since it provides the fastest interface performance.

6.1.3 Graphics card connector types

The most common connectors that provide the connection between the card and the display unit are illustrated in Figure 39 and explained in Table 17.

Figure 39 – Display port, HDMI port and two DVI ports

Table 17 – Graphics card connector types

 HD-15F (VGA)	Analogue-based standard adopted in the late 1980s designed for CRT display units, also called a VGA (Video Graphics Array) connector. An analogue signal is a continuous variable signal which can be affected by electrical noise, image distortion, and sampling-error evaluating pixels.
 Digital Visual Interface (DVI)	Digital-based standard designed for display units such as flat panel displays (LCDs, plasma screens, wide high-definition television display units) and video projectors. It avoids image distortion and electrical noise by aligning each pixel from the computer to a display pixel, using its native resolution. Five different types of DVI interfaces exist, with each one supporting different speeds, features (analogue/digital), modes, and number and arrangement of pins.
 High Definition Multimedia Interface (HDMI)	A digital technology that supports both video and audio and allows the transmission of signals from a remote control unit to control multiple devices. HDMI is backwards compatible with DVI using a suitable HDMI-to-DVI adapter.
 Display Port	A digital display interface developed by Video Electronics Standards Association, which is used to connect a video source to a display device.

6.1.4 Important graphics card facts

Each motherboard supports only a limited range of graphics card formats, so always check your motherboard manufacturer before making a purchase. The motherboard, case and expansion cards are designed with compatibility in mind. Some graphics cards have only one port for connection to a standard monitor or projector, while more advanced cards may have ports for connections to multiple output sources, including additional monitors and televisions.

6.1.5 Graphics card maintenance

Very little maintenance is required for the adapter itself, but it is a good idea to visit the adapter manufacturer's web page periodically to download the latest drivers. Also, keep the expansion slots clean using the appropriate cleaning materials.

6.2 Display standards

Various computer display standards or display modes have been used in the history of the personal computer.

NOTE	Table 18 gives a summary list of the common video standards. For a complete detailed list, consult websites such as www.vesa.org. Video Electronics Standards Association (VESA) is a standards body for computer graphics which develops and publishes video standards.

Table 18 – A summary of the latest and most common video standards

Display mode name	Full name	Resolution
VGA	Video Graphics Array	640×480
SVGA	Super VGA	800×600
XGA	Extended VGA	1024×768
EVGA	Extended VGA	1024×768
SXGA	Super XGA	1280×1024
UXGA	Ultra XGA	1600×1200
WUXGA	Wide UXGA	1920×1200
WQXGA	Quad XGA	2560×1600
WQSXGA	Wide Quad Super XGA	3200×2048
WQUXGA	Wide Quad Ultra XGA	3840×2400
QSXGA	Quad Super Extended Graphics Array	2560×2048
HDMI 1080	High-Definition Multimedia Interface	1920×1080
HDMI 780	High-Definition Multimedia Interface	1280×720
HXGA	Hex Extended Graphics Array	4096 ×3072
WHXGA	Wide HXGA	5120×3200
HUXGA	Hex Ultra GA	6400×4800
WHUXGA	Wide HUXGA	7680×4800

6.3 Monitor

A monitor can use either Cathode Ray Tube (CRT) technology or Liquid Crystal Display (LCD) technology.

6.3.1 CRT monitors

The back of the screen in a colour CRT monitor is covered with different coloured chemical dots called phosphors (red, green and blue). Three electron guns located at the neck (or back) of the monitor shoot a beam of electrons towards the screen. When the beam of electrons strikes a phosphor dot, it glows. The beam of electrons scans across the screen from left to right and top to bottom in a pattern that paints the image we see on the screen.

Figure 40 – CRT monitor

6.3.2 LCD monitors

PCs are increasingly shipped with a flat-panel LCD. They have become much cheaper and of better quality in recent years. They take up less space and use less power as well.

With an LCD monitor, an electric current is passed through a semi-crystalline liquid (liquid crystals), causing the properties of the liquid crystals to change and align themselves with the current. An LCD pixel comprises cells (or sub-pixels) with filters that generate the red, green and blue colours, and transistors that vary the intensity of each sub-pixel, to create the range of colours that the display can generate. A fluorescent or light emitting diode (LED) backlight illuminates the LCD panel. There are two main types of LCD displays:

- **Active Matrix** (also called **Thin Film Transistor** [**TFT**]) – A TFT regulates the electrical charge that manipulates the crystal. The TFT uses a capacitor to provide the crystal with the appropriate current to remain in its existing state. Each individual pixel in a TFT display has its own transistor.

- **Passive Matrix** – This display type is used by some old, low quality screens. A passive matrix screen consists of two rows of transistors; one at the top and one at the side. When a particular pixel needs to be turned on, a signal is sent to its X and Y co-ordinate transistors, turning them on. This causes the voltage lines at those co-ordinates to intersect each other and energise the pixel.

Figure 41 – LCD monitor

6.3.3 LED LCD or OLED

Light Emitting Diode (LED) monitors and televisions (TVs) are LCDs with LED backlights. They either use RGB (red, green and blue) LED arrays behind the LCD panel, or use white edge LEDs around the inside frame and a light diffusion panel to spread the light evenly behind the LCD panel.

Using LEDs for backlighting reduces the thickness of the LCD panels and reduces the overall amount of electricity used. LEDs do not need AC power, so there is no inverter. Smaller devices such as laptops, tablets and display screens use LED backlights to save battery usage.

Some smaller devices such as smartphones and digital cameras, and bigger display screens such as monitors and TVs, use a related technology called **Organic Light Emitting Diode (OLED)** screens.

6.3.4 Plasma

A **plasma display** is another type of flat panel display. It can produce some bright colours but is more susceptible to screen burn-in. In addition, it draws more electricity than an LCD monitor. The plasma display tube includes millions of small cells filled with gas, and when voltage is applied to these cells, they can emit different coloured lights.

6.3.5 3D displays

Improvements in display technology and graphics processing have led to several 3D output devices, including 3D display screens, TVs, laptops, mobile devices and game consoles. The newest 3D displays use filters, prisms, lenses and other parts built into the screen to create the 3D effect and as a result, the user does not have to wear 3D glasses or other gear to experience the 3D effect.

Figure 42 – 3D monitor

Output displays are evaluated according to different characteristics. Table 19 lists these characteristics.

Table 19 – Display characteristics

Characteristic	Description
Pixel	Short for **picture element**, a small dot that can be turned on and off and joined with many other dots to create the image on screen. A pixel must be made up of at least one red, green and blue phosphor (triad) to create any colour. With more pixels, you can see more of the image and in more detail.
Resolution	The number of pixels used to create the image and addressed by software. Shown as the number of horizontal (across) pixels times the number of vertical (up and down) pixels. Values can range from hundreds to thousands of pixel counts for high-end displays. You can find out how many pixels are on the screen by multiplying the values together: 1024x768 = 786 432 pixels per screen. CRT monitors and graphics cards are designed to use several resolutions up to a maximum one. A higher number of pixels results in a higher resolution and an overall better image.
Native resolution	A single fixed resolution, such as 1680×1050, which enables LCD monitors to display the sharpest picture possible. Setting an LCD monitor to a different resolution other than the native one can severely degrade image quality, causing the image to appear fuzzy. See the monitor's documentation to find the native resolution.
Dot pitch	For CRTs, the distance between two adjacent phosphors of the same colour (e.g. red and red), measured in millimetres.
Screen size	The diagonal length of the screen surface, measured in inches. CRT monitors provide two numbers: the monitor size measures from two opposite diagonal corners of the plastic case (bezel), while the viewable image size (VIS) measures one edge of the actual screen to the opposite diagonal side of the screen. LCDs use the viewable image size. Common sizes are 15", 17", 19" and 21" with 30+" available.

Characteristic	Description
Aspect ratio	The screen's width divided by its height. The common resolutions, such as 1024×768, 1280×960, 1280×1024, and 1600×1200, match a 4:3 ratio. For example, for a display that supports 4:3 ratios, such as 1024×768, if you divide the first number by 4 and multiply the result by 3, it equals the second number. This means that for every 4 pixels running horizontally, there are 3 pixels running vertically. Depending on screen resolution, widescreens can have varying aspect ratios of 10:6, 16:9, 16:9.5 or 16:10.
Refresh rate	Refers to how quickly the monitor updates or redraws the screen, measured in Hertz (Hz) or times per second. Refresh rates for CRT monitors vary from 60 Hz or more, with 75 Hz or higher causing less flicker on screen and are ideal. There is no need to freshen up a dot on an LCD display because each one has its own transistor to light it up; it is either on or off. The refresh rate for an LCD monitor refers to how often a screen can update completely. Standard LCDs have a 60 Hz rate with models featuring 120 Hz and 240 Hz.
Response rate	The amount of time it takes for a pixel on an LCD monitor to change colour, to go from pure black to pure white and back again, measured in milliseconds (ms). The lower the response time the better, with better quality monitors having 8 ms times or less.
Brightness	Luminance is how bright the screen appears to your eyes, measured in nits or candelas per square metre (cd/m^2). Typical LCDs fall between 200 and 300 cd/m^2, with 500 cd/m^2 or better designed for gaming and home theatre systems.
Contrast ratio	The difference in the amount of light between the brightest (white) colour and the darkest (black) colour that the monitor can display. For example, a contrast ratio of 600:1 means that the white areas are 600 times the brightness of the black areas. The higher the ratio, the better.
Viewing angle	The number of degrees of angle at which you can see the screen from the sides and top and bottom, and can continue to see clearly defined images and accurate colours.
Colour depth	Also known as bit depth, it describes the number of bits that represent colour. Common colour depths include 4-bit (16 colours), 8-bit (256 colours), 16-bit (65,536 colours), 24-bit (16,777,216 colours), 32-bit (4,294,967,296 colours), 30-bit, 36-bit and 40-bit (billions of colours).

6.4 Monitor maintenance

Ensure that the monitor is always properly connected and that the cables are not in a walkway. Do not cover the ventilation holes on top of the monitor. Never attempt to open a monitor to service it. Use mild soap and water on a damp, clean, lint-free cloth to clean the monitor case. Use a monitor glass cleaner and/or monitor wipes to clean the screen.

6.5 Exercise

- Do the following exercise with the assistance of your lecturer.
- Use one of the PCs in your lab.

6.5.1 How do you change the resolution on your screen?

6.5.2 Change the resolution on your screen. Record what you are changing it to.

6.5.3 How does it affect the display?

6.5.4 Play around with the display settings and explore all the options, i.e. screensavers, background settings, refresh rate, etc.

6.6 Review questions

Answer the questions that follow to help you to reinforce what this unit has covered. If you are unsure of the answer to any question, then search for it in the text of this unit.

1. List three major components of the graphics card and give a short description of each.

[6]

2. Match the graphics card port/connector to the device it connects to:

2.1 Flat panel displays (LCD or plasma screens) _____

[1]

2.2 CRT displays _____.

[1]

3. Give one advantage of using the port in the answer to 2.1 over the port in your answer to 2.2.

[1]

4. _____is generally the video standard used for the native 17" and 19" LCD monitors at a resolution of_____.

[2]

5. Answer True or False.

The higher the screen resolution, the less information is displayed on the screen.

[1]

Total: 12 marks

NOTE	Complete this exercise on a piece of paper and submit it to your lecturer.

Unit 7 – Peripherals

At the end of this unit, you will be able to:

- Identify the various keyboards available.
- Identify the different mouse types.
- Identify different printers.
- Describe the function of a scanner.

In this unit, we will discuss some of the most common peripherals available. A peripheral device is a hardware device that allows a computer to perform additional functions, but is not something that the computer necessarily needs in order to work.

Peripheral devices are made up of three categories: input devices, output devices and input/output (I/O) devices.

7.1 Input devices

Input devices help us to interact with a computer. They provide us with a means of entering data for processing or manipulation.

7.1.1 Keyboard

This is the most common input device. A keyboard translates keystrokes into letters, characters or numbers. Keyboards come in many varieties and the following list covers some of the latest keyboards available.

7.1.1.1 Types of keyboards

Mechanical key-switch keyboards

A mechanical key-switch keyboard works by using an individual switch for each key. Under the key cap is a plunger. When you press a key, this plunger moves down and makes a connection between two signal lines coming from the keyboard controller in the keyboard.

These keyboards are simple to make, inexpensive and easy to service.

Capacitive keyboards

A capacitive keyboard has two sheets of semi-conductive material inside the keyboard. A thin sheet of Mylar separates these sheets. When a key is pressed, the plunger presses the two sheets of semi-conductive material together. This alters the total capacitance of the two sheets and the controller can tell, by the value returned, which key was pressed.

These keyboards are less complex, more durable and cheaper than mechanical key-switch keyboards, but cannot be repaired.

Wireless types

Wireless keyboards have become popular for their increased user freedom. However, a wireless keyboard needs batteries to work and may pose a security problem due to theft, since they can easily be picked up from the desk.

A wireless keyboard often includes a required combination of a transmitter and receiver unit which attaches to the computer's keyboard port. The wireless aspect is

achieved either by radio frequency (RF) or by infrared (IR) signals sent and received from both the keyboard and the unit attached to the computer. A wireless keyboard may use an industry standard called Bluetooth. Bluetooth is a short range radio technology. With Bluetooth, the transceiver may be built into the computer.

Alternatives to the 'regular' keyboard
There are many alternatives to the regular keyboard with special function keys for specialised uses. Some of these keyboards include gaming, multimedia (Figure 43), and virtual and touch screen keyboards.

Figure 43 – Multimedia keyboard

7.1.1.2 Keyboard connectors
Keyboards use a PS/2 connector or USB connectors.

7.1.1.3 Keyboard maintenance
The most important aspect of keyboard maintenance is keeping it clean. For this reason, it is important to keep all liquids and foods away from the keyboard.

If you do need to clean your keyboard, ensure that it is disconnected from the computer. Use a soft, damp cloth and a mild detergent to clean any dirt. Ensure that the keyboard is completely dry before using it again.

The keyboard can be submerged into a bucket of distilled, demineralised water if you happen to spill anything on the keyboard. Ensure that the keyboard is completely dry before using it again.

7.1.2 Mouse
The mouse converts movements on a horizontal surface (i.e. the movements of your hand on the desk) into movements of a pointer on the screen.

7.1.2.1 Types of mouse devices

Mechanical mouse
Inside the casing of the mouse is a round ball. The ball makes contact with two rollers. When the mouse is moved, the ball rolls and this causes the rollers to turn. These rollers are connected in turn to wheels that have small holes. Each wheel rotates between the arms of an optical sensor. As the wheel turns, the light flashes through the wheel and onto the optical sensor. As the speed and patterns of light pulse, the mouse sensors determine the speed and direction in which the mouse is moving. It then sends its interpretation to the computer and the mouse control software.

Optical mouse
The optical mouse has no ball. It uses an LED and contains a special purpose image-processing chip which allows the mouse to detect movement on a variety of surfaces.

Laser mouse
Infrared optical mouse devices use infrared sensors and laser mouse devices use infrared lasers to detect movement over a surface.

Figure 44 – The optical sensor from a Wireless IntelliMouse Explorer 3D mouse

A 3D mouse is a device that allows multifaceted navigation using ultrasound technology and offers at least three degrees of freedom. It allows a user to work with both hands simultaneously and is typically used in 3D applications, such as computer aided design and gaming consoles like the Nintendo Wii.

Gaming mouse
A gaming mouse is a device that is used by gamers. Gaming mouse devices typically have a wide array of controls and buttons and have a different design compared to a traditional mouse. Gaming mouse devices are held by gamers in three different styles of grip: palm grip, claw grip and fingertip grip.

7.1.2.2 Mouse connectivity

There are several available connectors for a mouse. The main two are:

- PS/2
- USB.

To transmit their input, typical cabled mouse devices use a thin electrical cord terminating in a standard connector, such as PS/2 or USB. Cordless mouse devices instead transmit data via infrared radiation (IrDA) or radio (such as Bluetooth).

7.1.2.3 Mouse maintenance

Older mechanical mouse devices experience problems because of accumulated dirt and dust in the mouse and require regular cleaning. Optical mouse devices require less maintenance.

7.1.2.4 Mouse buttons

A mouse has a number of buttons; there are mouse devices that have three or more buttons, such as the one shown in Figure 45. Depending on the user's preferences and software environment, the extra buttons may allow forward and backward Web navigation, scrolling through a browser's history, or other functions, including mouse-related functions such as quickly changing the mouse's resolution/sensitivity. Not all software supports these additional functions. The additional buttons become especially useful in computer games, where quick and easy access to a wide variety of functions can give a player an advantage. Because software can map mouse buttons to virtually any keystroke, function and application, extra buttons can make working with such a mouse easier and more efficient.

Figure 45 – Five button cordless mouse

7.1.3 Scanner

A charge-coupled device (CCD) allows light to be converted into electronic pulses. Scanners use CCDs and a light source to convert pictures into a stream of data.

There are two types of scanners:

- Flatbed scanners
- Handheld scanners.

7.1.3.1 Flatbed scanners

Flatbed scanners look very much like the top half of a photocopier. When a picture is scanned, it is placed face down on the glass. Software is then used to start the scan cycle. Flatbed scanners are usually USB or parallel devices.

7.1.3.2 Handheld scanners

Handheld scanners are handheld units, which contain a controller, a CCD and a light source in a small enclosure with wheels mounted on it. The carriage is placed in the user's hand. The scanner is placed on top of an item that is to be scanned, and the software starts the scanning process when it is pressed on the unit. The unit is moved over the item and scanning is stopped when the start button is released.

7.1.4 Webcam

A webcam is a digital camera that is connected to a computer. It allows anyone connected to the Internet to view either still pictures or videos of a user or other objects. Examples of applications that allow you to make such connections are Skype, Camfrog Video Chat and CyberLink YouCam.

Figure 46 – A webcam

7.2 Output devices

Output devices provide us with a means of viewing the information that we have entered into the PC.

Common output devices include:
- Graphics card and monitor (refer back to Unit 6)
- Printer
- Speaker
- Headset

NOTE	The list of output devices is quite extensive and only graphics cards, monitors and printers are covered in this module. Please consult vendors or the recommended references for more information.

7.2.1 Printers

There are many different printers available for normal and specialised printing requirements. Please consult the recommended websites for details of the different printers available. The main categories are: laser printers, inkjets, dot-matrix, multifunctional. Normally, home computer users will use inkjets, as they are relatively cheap but superior in quality to dot-matrix printers. Laser jets and other printers created by new technology are more expensive and more commonly found in office environments.

7.2.1.1 Impact (dot-matrix) printers

Dot-matrix printers use a set of closely spaced pins and an inked ribbon to print letters and characters on a page. These printers impact the page by firing the pins at an inked ribbon which leaves marks on the paper to print a character, similar to the operation of a typewriter. Dot-matrix printers vary in terms of speed and the number of pins they have. They can run at a speed of anywhere between 50 and 500 characters per second (cps). The number of pins varies between 9 and 24, and determines the quality of the print job. Dot-matrix printers are commonly used for printing purchase orders, shipping forms, labels, invoices and other multi-part forms.

7.2.1.2 Laser printers

Laser printers shine a laser beam to produce an image on a photosensitive drum. The drum is rolled and the electrically charged portions of the drum pick up toner (a black powdery substance). The toner on the drum is attracted and transferred to the page because the drum and the paper hold different electrical charges. Finally, using a combination of heat and pressure rollers, the toner is melted onto the surface of the page before exiting the printer. Laser printers print very fast, and the cartridges last for a long time. Colour laser printers use the same toner-based printing process as black and white (B/W) laser printers, except that they use separate colour toner cartridges. Depending on the type of printer, the printer might combine the four main colours and place them all on a single plate and print in a single pass; otherwise, it will print each of the four colours - cyan, magenta, yellow and black - in four passes respectively. Colour laser printers can also be used as a regular black and white laser printer.

7.2.1.3 Inkjets

Also known as bubble jet printers, inkjet printers spray ionised tiny drops of ink onto a page to create an image. This is achieved by using magnetised plates, which direct the ink's path onto the paper in the desired pattern. Almost all inkjets offer a colour option as standard, in varying degrees of resolution, and can also be used as a regular black and white printer. Inkjet printers are capable of producing high-quality print.

7.2.1.4 LED/LCD printers

These types of electro-photographic printers are identical to laser printers in most ways. Both LCD (liquid crystal display) and LED (light emitting diode) printers use a light source instead of a laser to create an image on a drum. These printers produce very high quality text and graphic printouts.

7.2.1.5 Plotters

Plotters are large-scale printers that are very accurate at reproducing line drawings. They are commonly used for technical drawings, such as engineering drawings or architectural blueprints.

7.2.1.6 Multifunction printers

Multifunction printers combine top-quality colour inkjet or laser printing with plain paper and faxing, colour copying and scanning, as well as telephoning, all in one convenient, space-saving machine. If you work from home, or have a small office, a multifunctional device may be ideal.

7.2.1.7 Dye sublimation printers

These professional devices are widely used in demanding graphic arts and photographic applications. These printers work by heating the ink so that it turns from a solid into a gas. The heating element can be set to different temperatures, thus controlling the amount of ink laid down in one spot. Dye sublimation printers require particularly expensive special paper, as the dyes are designed to diffuse into the paper surface, mixing to create precise colour shades.

7.2.2 Speakers

A speaker is a hardware device that is used to produce audio output that can be heard by the listener. Speakers are transducers that convert electromagnetic waves into sound waves.

Figure 47 – Computer speakers

7.3 Input/Output devices

An I/O device is a hardware device that has the ability to accept input and produce output.

7.3.1 Touch screen

A **touch screen** enables you to interact with it by touching areas of the screen, usually with your finger or with a stylus. A **stylus** (also called a **digital pen**, **electronic pen** or **tablet pen**) is a thin, plastic pressure-sensitive device that you can use to tap, write and draw on a touch screen. Some styluses are powered by the device with which it is used, while others have buttons or switches to perform actions such as erasing content or right-clicking and sending commands to the device using specific movements with the pen, known as *pen flicks*.

Figure 48 – Touch screen monitor

Touch screens are either a built-in screen such as in smartphones, or standalone screens like those used in many information or **point-of-sale systems (PoS)**.

Listed below are many types of touch screen technology:

- **Capacitive panel** is coated with material that stores small electrical charges. When your finger touches the screen, it conducts a small amount of electrical charge, reducing the charge on the screen's capacitive layer. Circuits measure the change in the charge and send this data to the touch screen controller on the device or software on the device for processing. Capacitive screens are high quality; they support multi-touch actions using multiple fingers and are generally not affected by items that do not conduct charges.

- **Resistive panel** has a glass panel coated with two main layers of electrically conductive and resistive material that face each other with a very small gap between them. When you touch the touch screen, the two layers are pressed together and the horizontal and vertical lines on the two layers register the exact location of your touch, allowing an electrical signal to be generated and sent to the device. Resistive screens are not as clear as capacitive screens.

- **Surface acoustic wave (SAW) panel** passes ultrasonic 'sound' waves over the touch screen panel. When the panel is touched, a part of the wave is absorbed, which allows the controller to calculate the position of the touch and determine what signal to send to the device. Because these waves pass over the screen, it is easy for outside objects to damage the device. SAW provides a clear image when compared to resistive and capacitive screens, and is suitable for banking and information kiosks.

- **Optical panel** uses cameras or sensors mounted on the screen to detect objects close to the screen's surface.

- **Infrared panel** uses LEDs that send out beams of light to form a grid over the surface of the screen and sensors that detect the light beams. When you break the beams of light travelling across the screen with your touch, the location of the break can be determined.

7.3.2 Communication devices

Communication I/O devices are those devices that are used to input data and give some sort of output. These devices include:

- Bluetooth adapters/dongles
- Modems.

7.3.3 Storage devices

Storage devices can be used to input data into the computer and have its output stored on the storage devices and used as input into a different computer. Storage devices are covered in Unit 5.

7.4 Review questions

Answer the questions that follow to help you to reinforce what this unit has covered. If you are unsure of the answer to any question, then search for it in the text of this unit.

1. List **two** common input devices.

[2]

2. List **two** common output devices.

[2]

3. List the **two** types of keyboards and their uses.

[4]

4. List two types of mouse connectors.

[2]

5. List two types of scanners.

[2]

6. Which type of printer will you use for the following?

6.1 printing photos:_____
6.2 printing technical drawings: _____

[2]

7. Select the correct answers. Circle all that apply.

A keyboard uses a:

a) PS/2
b) DIN-2 connector
c) USB connector
d) DB-25 connector

[2]

8. How do you clean a keyboard?

[1]

Total: 17 marks

NOTE	Complete this exercise on a piece of paper and submit it to your lecturer.

Unit 8 – Networking Basics

At the end of this unit, you will:

- Have a basic understanding of networks.
- Understand the difference between servers, hosts and workstations.
- Know the difference between the different types of networks and network topologies.
- Have a basic understanding of networking hardware.

A network is two or more computer systems linked together by some form of transmission medium that enables them to share information. The network technology is what connects the computers, but the purpose of a network is to provide services or resources to its users. These services may include access to shared files and folders, network printing and database applications.

Networks may be classified according to a wide variety of characteristics. This unit provides a general overview of some types and categories, and presents the basic components of a network.

8.1 Network scopes

The following terms broadly define the size and nature of a network.

8.1.1 Personal Area Network (PAN)

A PAN is a computer network used for communication among computer devices in close proximity to a person. Some examples of devices that are used in a PAN environment are printers, fax machines, telephones, PDAs or scanners. The reach of a PAN is typically within about a few metres.

Personal area networks may be wired with computer buses such as USB and FireWire. A wireless personal area network (WPAN) can also be created by using network technologies such as IrDA and Bluetooth.

8.1.2 Local Area Network (LAN)

A LAN is a network covering a small geographical area, like a home, office or building. For example, a library may have a wired or wireless LAN for users to interconnect local devices (e.g. printers and servers) and to connect to the Internet.

8.1.3 Campus Area Network (CAN)

A Campus Area Network is a computer network interconnecting a few local area networks (LANs) within a limited geographical area, such as in a university campus or corporate campus or a military base environment. Campus area networks may link a variety of campus buildings including departments, the university library and student halls of residence. A Campus Area Network is larger than a Local Area Network, but smaller than a Metropolitan Area Network (MAN) or Wide Area Network (WAN).

8.1.4 Metropolitan Area Network (MAN)

A Metropolitan Area Network is a network that connects two or more Local Area Networks or Campus Area Networks together, but does not extend beyond the boundaries of the immediate town/city.

8.1.5 Wide Area Network (WAN)
A WAN is a data communications network that covers a relatively broad geographical area (i.e. one city to another and one country to another country). Computers connected to a wide area network are often connected through public networks, such as the telephone system, or they can also be connected through leased lines or satellites. The largest WAN in existence is the Internet.

8.1.6 Global Area Network (GAN)
Global Area Network (GAN) specifications are in development by several groups, and there is no common definition. In general, however, a Global Area Network is a model for supporting mobile communications across an arbitrary number of wireless LANs, satellite coverage areas, etc.

8.1.7 Internetwork
An internetwork is two or more networks or network segments connected using a device such as a router. Any interconnection among or between public, private, commercial, industrial or governmental networks may also be defined as an internetwork.

In modern practice, the interconnected networks use the Internet Protocol (IP). There are at least three variants of internetworks, depending on who administers and who participates in them, namely:

- Intranet
- Extranet
- Internet

Intranets and extranets may or may not have connections to the Internet. If connected to the Internet, the intranet or extranet is normally protected from being accessed from the Internet without proper authorisation. The Internet is not considered part of the intranet or extranet, although it may serve as a portal for access to portions of an extranet.

8.1.7.1 Intranet
An intranet is a set of interconnected networks, using the Internet Protocol and IP-based tools such as Web browsers and File Transfer Protocol (FTP) tools that are under the control of a single administrative entity. That administrative entity closes the intranet to the rest of the world, and allows only specific users to access it. More commonly, an intranet is the internal network of a company or other enterprise. A large intranet will typically have its own Web server to provide users with Web-based information.

8.1.7.2 Extranet
An extranet is a network or internetwork that is limited in scope to a single organisation or entity, but which also has limited connections to the networks of one or more other trusted organisations or entities (e.g. a company's customers may be given access to some part of its intranet, creating an extranet, while at the same time the customers may not be considered 'trusted' from a security standpoint). Technically, an extranet may also be categorised as a CAN, MAN, WAN or other type of network, although, by definition, an extranet cannot consist of a single LAN; it must have at least one connection to an external network.

8.1.7.3 Internet
The Internet is a specific internetwork that consists of worldwide interconnections between governmental, academic, public and private networks. It is based upon the Advanced Research Projects Agency Network (ARPANET), which was developed by

DARPA by the U.S. Department of Defence – also home to the World Wide Web (WWW) and referred to as the 'Internet' with a capital I to distinguish it from other generic internetworks.

8.2 Peer-to-peer and server-based networking

8.2.1 Servers, workstations, clients and hosts defined

A **server** usually has larger hardware requirements and runs software that controls and maintains the network. A server 'serves' clients by providing resources to them over the network.

Any computer connected to a network is called a **workstation**.

A **client** is any network entity that can request resources from a server.

On a TCP/IP network, the term **host** refers to any network device that has an IP address. A host can be a server, workstation or any other network device, and typically offers resources to network clients.

8.2.2 Peer-to-peer networks

In peer-to-peer networks, each computer can act as both a client that requests resources and as a server that provides resources. There are no dedicated servers or a hierarchy among computers. In a peer-to-peer network, computers are located at the users' desk and the users act as their own administrator, planning their own security and local backups.

Peer-to-peer networks are appropriate when there are only a few users located in the same geographical location, security is not an issue, and the organisation (network) will have limited growth in the near future.

8.2.3 Server-based networks

As the number of users increases and the network starts expanding, a server-based network then becomes more practical than a peer-to-peer network.

A server-based network uses a network operating system designed to manage the entire network from a centralised point, which is installed on a server. Clients make requests to the server and the server responds with the requested information or access to the requested resource.

8.3 What is a topology?

Network topologies are illustrated in Figures 49, 50, 51 and 52. Computer networks may be classified according to the network topology upon which the network is based, such as bus, star, ring, mesh, star-bus or tree/hierarchical topology network, etc.

A topology is a map of the network. It signifies the way in which devices in the network see their logical relations to one another. The logical topology refers to the flow of data through the network. The logical topology is independent of the 'physical' layout of the network. The physical topology refers to the arrangement or physical layout of computers and cables, and the location of all network components.

Even if networked computers are physically placed in a linear arrangement, and if they are connected via a switch, the network has a star topology, rather than a bus topology. In this regard, the visual and operational characteristics of a network are distinct; the logical network topology is not necessarily the same as the physical topology.

8.3.1 Ring topology

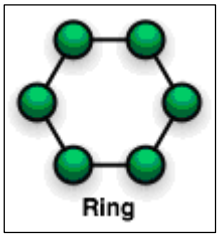


Figure 49 – Ring topology

The ring topology has computers connected in a circle. The computers are either directly or indirectly attached to the ring or indirectly via an intermediary device such as a Multi-Station Access Unit (MSAU). The ring topology is referred to as an active topology because each computer regenerates the signal. The ring topology makes it difficult to add new computers and the network will go down if an entity is removed from the ring.

8.3.2 Star topology

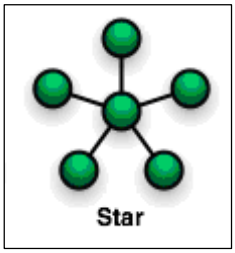


Figure 50 – Star topology

In the star topology, computers connect to a centralised component. The centralised component can be a component such as a hub, switch or a wireless access point (WAP). The star topology is easy to install and reconfigure.

8.3.3 Bus topology

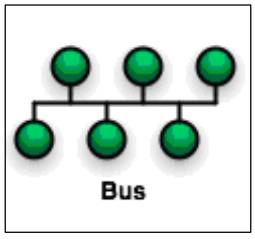


Figure 51 – Bus topology

The bus topology connects each computer to a single cable, often referred to as the backbone of the network. The bus topology is cheap to implement, uses the least amount of cabling, and is easy to install. However, it is difficult to reconfigure and a break in the cable disrupts the entire network.

8.3.4 Mesh topology

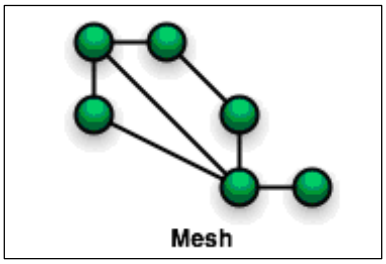


Figure 52 – Mesh topology

In a mesh topology, a path typically exists between each station and every other station in the network. This topology can be used in LANs but is more commonly used in Wide Area Networks (WANs). In a **full mesh topology**, every node is connected to every other node. In a **partial mesh topology**, some nodes are connected to more than one node, but not directly to every node.

8.3.5 Hybrid

Two different topologies are combined within the same network to benefit from the advantages of both topologies. This type of topology is very complex to set up.

8.4 The open systems interconnect (OSI) model

The **Open Systems Interconnect (OSI)** model is a theoretical architectural model designed to aid the understanding of the functionality of a network.

The OSI model consists of seven layers. The steps involved in transferring data from one computer to another computer in the same network are divided into tasks, each of which is executed at a specific OSI layer. The tasks for each specific layer are independent from the tasks in all the other layers. It is therefore possible to make changes to one layer without affecting the other layers (see Figure 53).

A **protocol** is a set of rules that define how devices communicate with each other. Devices need to agree on the format of the data to be able to communicate. A communication protocol provides this set of rules which define different tasks that must be performed in order to transfer data from one computer to another, i.e. how data is represented, error detection and correction, signalling and authentication.

The OSI model serves as a functional guideline for network communication and does not specify any standard. Many protocols, however, do comply with these guidelines. Each layer performs a different group of tasks required for network communication. This layered model describes what tasks must be performed by the protocol/service/layer to move data from the user interface (Layer 7) on the sending host down to its physical/network access (Layer 1), across the network, and then up each layer on the receiving host to its user interface (Application layer).

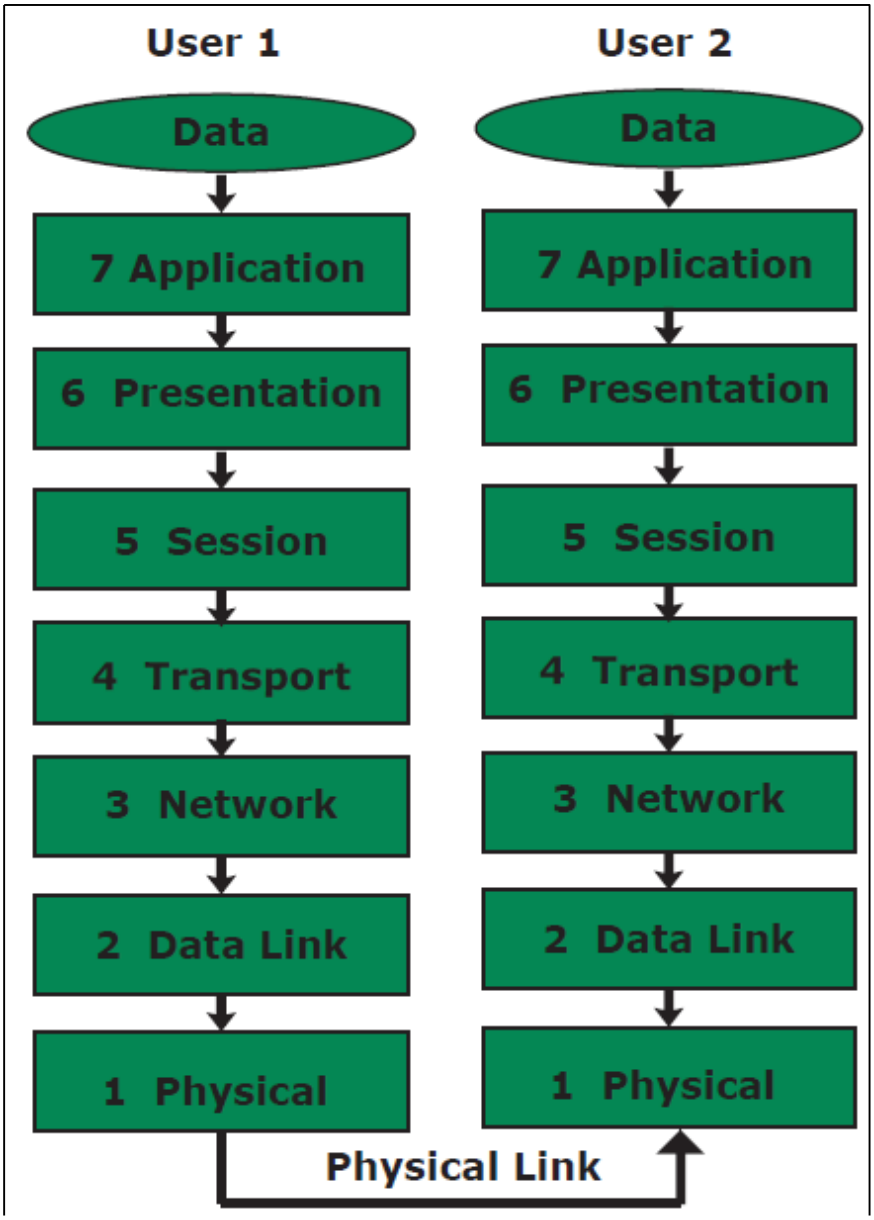


Figure 53 – The 7 layers of the OSI model

The application layer

The application layer is the OSI layer closest to the end user, which means that both the OSI application layer and the user interact directly with the software application. This layer interacts with software applications that implement a communicating component. Application layer functions typically include identifying communication partners, determining resource availability and synchronising communication. Some examples of application layer implementations include Telnet, File Transfer Protocol (FTP) and Simple Mail Transfer Protocol (SMTP).

The presentation layer

The presentation layer provides a variety of coding and conversion functions that are applied to application layer data. These functions ensure that information sent from the application layer of one system would be readable by the application layer of another system. Some examples of presentation layer coding and conversion schemes include common data representation formats, conversion of character representation formats, common data compression schemes and common data encryption schemes.

The session layer

The session layer establishes, manages and terminates communication sessions.

Communication sessions consist of service requests and service responses that occur between applications located in different network devices. These requests and responses are coordinated by protocols implemented at the session layer. Some protocols that function in this layer are NFS/RPC, ASP, SIP and RTP.

The transport layer

The transport layer accepts data from the session layer and segments the data for transport across the network. Generally, the transport layer is responsible for making sure that the data is delivered error-free and in the proper sequence. Flow control generally occurs at the transport layer. Flow control manages data transmission between devices so that the transmitting device does not send more data than the receiving device can process. Multiplexing enables data from several applications to be transmitted onto a single physical link. Virtual circuits are established, maintained and terminated by the transport layer. Error checking involves creating various mechanisms for detecting transmission errors, while error recovery involves acting, e.g. requesting that data be re-transmitted, to resolve any errors that occur. The transport protocols used on the Internet are TCP and UDP.

The network layer

The network layer defines the network address, which differs from the MAC address. Some network layer implementations, such as the Internet Protocol (IP), define network addresses in a way that route selection can be determined systematically by comparing the source network address with the destination network address and applying the subnet mask. Because this layer defines the logical network layout, routers can use this layer to determine how to forward packets. Because of this, much of the design and configuration work for Internetworks happens at Layer 3.

The data link layer

This provides a service to the network layer. It encapsulates the network layer information in a frame. The frame header contains information (for example, physical addresses) required to complete the data link functions.

The physical layer

The physical layer defines the electrical, mechanical, procedural and functional specifications for activating, maintaining and deactivating the physical link between communicating network systems. Physical layer specifications define characteristics such as voltage levels, timing of voltage changes, physical data rates, maximum transmission distances and physical connectors.

NOTE	Please consult one of the recommended books for a detailed explanation of the OSI model.

8.5 Basic network hardware components

All networks are made up of basic hardware building blocks to interconnect network devices, such as network interface cards (NICs), bridges, hubs, switches and routers. In addition, some method of connecting these building blocks is required, usually in the form of a cable (most commonly UTP Category 5e/6 or fibre optic cable) or wireless.

8.5.1 Twisted pair cable

Twisted pair cable uses one or more pairs of insulated strands of copper wire twisted around each other. There are different types of twisted pair cables, such as unshielded twisted pair (UTP) and shielded twisted pair (STP). Twisted pair uses electric voltages to transmit data (See Figure 54).

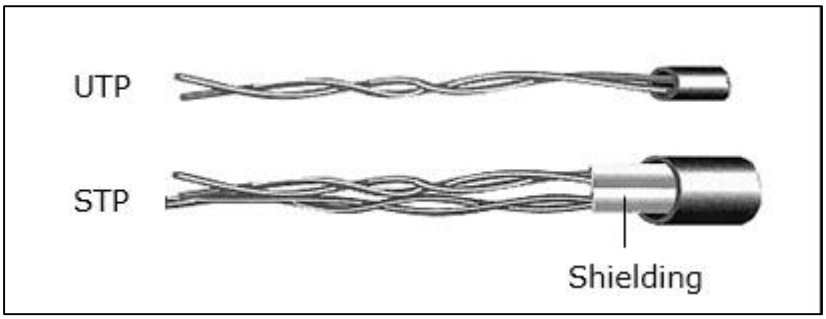


Figure 54 – Unshielded twisted pair and shielded twisted pair

Twisted pair uses RJ-45 connectors, which are similar to the RJ-11 telephone connectors, except RJ-45 houses eight cable connections (eight wires or four pairs), while RJ-11 houses only four connections (four wires or two pairs) (See Figure 55).

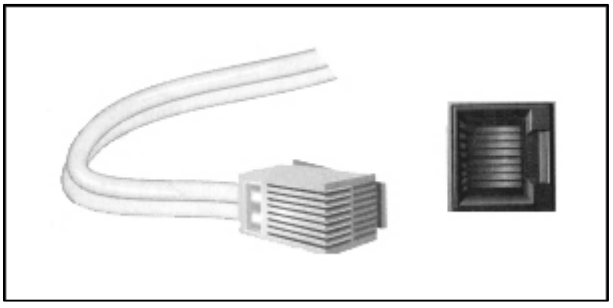


Figure 55 – RJ-45 connector and jack

8.5.2 Fibre optic cables

Fibre optic cables are widely used in fibre optic communication, which permits the transmission of light pulses over longer distances and at higher data rates than other forms of communication. Plastic or glass optical fibres are used instead of copper wires. Light signals that travel along fibre optic cables are not susceptible to electromagnetic interference and cannot be intercepted. Different types of fibre optic connectors are shown in Figures 56 and 57. ST, SC, FC, LC and MTRJ connector types are available.

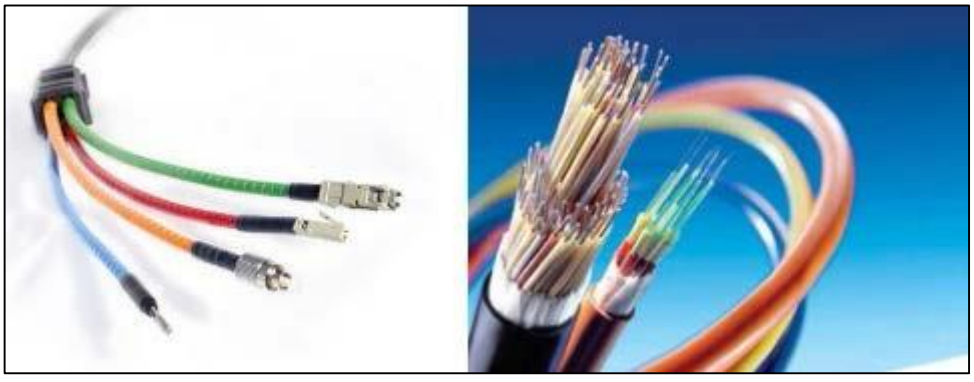


Figure 56 – Fibre optic cables

Figure 57 – ST fibre connector

8.5.3 Network interface cards

A network card, network adapter, NIC (network interface card) or Wireless NIC (WNIC) is a piece of computer hardware designed to allow computers to communicate over a network. An NIC provides physical access to a networking medium and often provides a low-level addressing system through the use of Media Access Control (MAC) addresses, which are unique to every card manufactured. A network card allows users to connect to each other and the network either through the use of a cable or wirelessly. Most motherboards nowadays come with an on-board network adapter; alternatively, one can be installed via a PCI or PCIe expansion slot.

Figure 58 – MBit/s WLAN PCI Card (802.11g)

8.5.4 Repeaters

A repeater is an electronic device that receives a signal on one port and retransmits that signal at a higher level or higher power to another port, so that the signal can cover longer distances without degradation.

8.5.5 Hubs

A hub is a connectivity device. A hub provides a common connection between computers in a star-configured network. A hub is often referred to as a multi-port repeater. Active hubs require electrical power and are able to regenerate and retransmit signals, as well as connect segments to ensure all hosts see all signals. Passive hubs simply connect the network segments together and provide no regeneration of the signal. Hybrid hubs are used to connect different cable types. Most hubs have been replaced by switches in modern networks.

8.5.6 Bridges

A bridge is used to separate one large network into two smaller segments. Bridges can be used to control and isolate the load of network traffic within a segment.

8.5.7 Switches

A switch is often referred to as an intelligent hub. It conserves bandwidth and improves performance. Switches are intelligent and route signals between ports. Instead of broadcasting a packet to all ports, as a hub does, the switch examines the data link header for the MAC address of the receiving station and forwards the packet directly to that port.

A **packet** is a unit of data that travels along the transmission medium from a source to a destination.

8.5.8 Wireless Access Points (WAP)

A WAP is a device that has a transmitter and a receiver (called a transceiver) and centrally connects wireless clients to each other using radio waves on specific frequencies and to the cable Ethernet network. Wireless clients such as laptops and smartphones must use the same frequency to connect to the WAP.

The AP will have one or more antennae and an RJ-45 Ethernet port. You plug the AP into a network cable and then plug the other end of the cable into a switch, and your WLAN should be able to connect to your cabled network. Most APs draw their power from a wall outlet. More advanced APs use PoE. Using PoE, you only need to plug one Ethernet cable into the AP to provide both power and a network connection.

8.5.9 Routers

A **router** connects networks together to create an internetwork. As a Layer 3 device, the router works by understanding packets and protocols to find out what network packets are coming from and what network they must go to. You can have multiple routers on a network and all of them will monitor the network and choose the best path to forward packets to their destination. If part of the network is very busy, a router can automatically forward packets along a less busy path.

A router can connect networks that use the same and different networking technologies, such as in LANs, WANs and on the Internet. You can join your Ethernet LAN to the Internet to give Internet access to LAN users using a router, and you can use it to break up a large Ethernet LAN into smaller sections called **subnets** (which are identified by a unique network address). Departments and groups that share computers and servers are good candidates for dividing a large network into smaller subnets. Once divided, computers and servers for each department can be placed into their own subnet to communicate with each other.

8.6 Review questions

Answer the questions that follow to help you to reinforce what this unit has covered. If you are unsure of the answer to any question, then search for it in the text of this unit.

1. List three variants of internetworks. [3]

2. Differentiate between a server, host and a workstation. [3]

3. Give definitions for the following:

   Ring topology
   Bus topology
   LAN
   GAN
   Router.

   [5]

4. Name the seven layers of the OSI model.

   7. _____

   6. _____

   5. _____

   4. _____

   3. _____

   2. _____

   1. _____

   [7]

Total: 18 marks

NOTE	Complete this exercise on a piece of paper and submit it to your lecturer.

Unit 9 – Assembling a PC and Installing an Operating System

At the end of this unit, you will be able to:

- Apply the basic handling guidelines.
- Understand ESD and its implications on the PC.
- Know the basic PC tools.
- Assemble a PC.
- Have a basic understanding of the BIOS.
- Install an operating system.
- Install drivers.

This unit takes you through the process of assembling a PC, installing an operating system, installing drivers for your hardware components and basic troubleshooting. It also gives you a brief overview of the BIOS.

9.1 Safety first

As a technician, you will be dealing with hands-on service, repair, maintenance and upgrading of computers and other equipment; therefore, you need to be aware of some general safety tips.

When dealing with health and safety, two terms are often used: compliance and regulation.

- Compliance means to obey a rule or law.
- Regulation is a rule designed to control the behaviour of people to whom it applies.

While thinking about safety, you must obey the regulations of the local government authorities, which might mean wearing protective gear or taking extra safety steps when working in the workplace.

Compliance often relates to what software the computer technician can or cannot install on the customer's or user's computer. Check with management or the local government's website for more information.

Regulations that typically affect computer maintenance include:

- **Health and safety laws** – designed to keep the workplace safe from danger (hazards).
- **Building codes** – designed to ensure the health, safety and protection of people when it comes to how the building is built, and who makes use of and works in it. Building code rules ensure that fire prevention and electrical systems are not damaged and are safe to use.
- **Environmental regulations** – rules on how to correctly dispose of old or unused equipment, because haphazard disposal of obsolete or unwanted equipment can negatively affect the environment.

Although the rules about workplace safety are determined by local government authorities in different areas and may vary widely from country to country, keeping the workplace environment safe is generally the responsibility of employers and employees who need to work together to keep it safe.

- Employers are responsible for providing a safe and healthy working environment for the persons (employees) who work for them.
- Employees are responsible for obeying company rules concerning workplace equipment, installing devices/software, wearing protective gear, not interfering with safety equipment, and reporting any dangers and accidents.

The company's health and safety procedures should be set out in a handbook that is given to all staff. These procedures should:

- Explain what to do when there is a fire or other emergency.
- Identify the people who are responsible for health and safety, such as first aiders and fire marshals.
- Identify dangerous areas and safety steps to take when entering those areas.
- Describe best practices for using and taking care of the workspace and equipment.
- Create incident reporting steps for identifying and removing hazards and

guarding against accidents. In an emergency situation, you should:

1) Keep calm and not act irrationally.
2) Raise the alarm and contact emergency services, giving them details about the emergency and your location.
3) Make the scene safe, e.g. when faced with a fire, make sure you have an escape route, or if risking an electrical shock, disconnect the power (if possible).
4) Only if you have training and it is safe to do so, do what you can to neutralise the emergency, e.g. give first aid or use fire-fighting equipment to extinguish the fire.

9.2 Safety guidelines

Guidelines help to ensure that proper procedures are followed and precautions are taken. Below are some important guidelines that you should follow when working in a computer environment.

- The first thing to know about electricity is that your body conducts electricity, which means that electricity will pass through your body. This can give you an electric shock, which can cause several symptoms from muscle spasms to severe burns, to a heart attack and even death. There is a danger that broken, faulty or incorrectly installed electrical equipment may give you an electric shock, so one should always keep this in mind every time you work on any type of electrical equipment!

- The second thing to know is that computer equipment uses electricity. Always turn off the power by shutting down the computer properly first. Switch off the power at the wall outlet, unplug the computer from the wall outlet, and hold down the power button for a few seconds to drain power from certain components. In addition, before you open the chassis of a laptop, remove its power adapter and battery.

- Do not open and work inside computer power supply units, monitors and laser printers unless you have been trained to do so. These components store power for periods of time after being switched off and unplugged. You should follow all warning signs printed on these systems.

- Faulty electrical equipment and failure to respect electricity can lead to a fire risk. Every computer workbench needs a fire extinguisher, but make sure that you use the correct one to tackle the type of fire. For electrical and computer fires, the best type of fire extinguisher to use is a **carbon dioxide (CO_2)** gas fire extinguisher. However, you must be careful when using it in confined spaces as the CO_2 and the smoke from the fire will quickly replace the available oxygen in the room, making it difficult for you to breathe. Although dry powder extinguishers can also be used for electrical/computer fires, you must be careful because they can damage the electronic equipment. Although there are many other types of extinguishers, such as water and foam, these should not be used for electrical/computer fires.

Be sure to read the instructions on the fire extinguisher before you use it. Although theory is great, there is no substitute for hands-on safety training, which might be available in your company. Here is a basic run-down on how to use a fire extinguisher.

You can use the memory aid 'P-A-S-S' to help you remember the following:

P: Pull the safety pin from the fire extinguisher's top handle.
A: Aim the hose at the bottom of the fire, not at the flames.
S: Squeeze the top handle to release the substance from the extinguisher.
S: Sweep the hose from side to side at the base of the fire until the fire is completely extinguished.

- It is important for electrical equipment to be tested regularly by a qualified electrician to ensure that the equipment is safe to use.

- Electrical equipment must be fitted with a fuse of the correct rating according to the instructions on the equipment. A fuse is a safety component that stops too much electricity from damaging electrical wiring and equipment. When too much electricity flows through the fuse or more than it can handle (its *rating*), it blows and cuts off the electricity supply. Once the fuse is blown, it must be replaced with a new one. Most computer equipment is rated at 3A or 5A (amps). A fuse that is rated too low will blow too easily and one that is rated too high may not blow when it should.

- Electrical equipment, including computer and equipment racks, must be grounded. **Grounding** is a safety measure that protects people from electric shock, safeguards against fire and protects equipment from damage. By its nature, electricity always seeks the path of least resistance to the ground. Computer equipment is connected to the building ground by way of a ground plug.

- Ensure that there are enough power outlets available. Do not overload power outlets, as this could be a potential fire hazard. You can use an appropriate power strip (an extension lead with multiple sockets) when you need to plug multiple devices into one power outlet.

- Electricity can pass through metal and most liquids, so keep these items away from electrical equipment.

- Take note of the following when using tools and cables:
  - Always use properly insulated tools and cables
  - Never hold tools by their metal parts
  - Touch only insulated handles of tools and cables
  - Only use tools for their intended purpose (See Figure 59a).

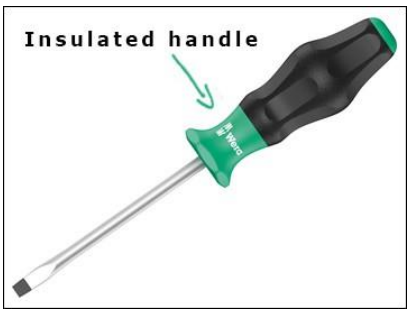


Figure 59a

- Always test live parts with a multimeter. A multimeter is useful for measuring various electrical properties (Figure 59b).

Figure 59b – A multimeter

- Avoid touching visible electrical contacts with any part of your skin.
- Do not work with electricity in wet surroundings, especially on wet floors.
- Keep your hands and the surrounding area clean and dry.
- Remove your watch and other jewellery, and secure loose clothing before handling equipment.
- Immediately replace or isolate damaged equipment or cables that could be dangerous.
- Cables can be a trip hazard. Use proper cable management products, such as cable ties, to tie up multiple cables on the floor and inside the computer box, and do not run cables across walkways.
- Do not leave any equipment in walkways or at the edge of a desk.
- When lifting and moving objects:
  - Never pick up heavy objects with your back. Rather bend your knees and then lift with your legs to avoid injuring your back. Reverse this process when putting the object down.
  - Make sure that you have a tight grip on the object before picking it up.
  - Keep your back straight when carrying the object.
  - Make sure that the path you take to carry the object is clear.
  - Be careful when handling large, awkward or hot objects or objects with sharp or rough edges. If necessary, wear protective gear, such as gloves, for these

objects.
    - For objects that are too heavy or awkward to carry, ask another person for help or use a trolley to move the object.

9.3 Electrostatic discharge (ESD)

Electrostatic discharge (ESD) occurs when two objects with a dissimilar static charge come into contact with one another. The shock that you feel at the tip of your finger when touching a door handle, for example, is the discharge of electrons between you and the door handle.

ESD can damage the components of a computer. The damage might not be apparent immediately, but it can become apparent over time. It is strongly recommended that you use the following ESD prevention equipment when repairing a computer.

9.3.1 Anti-static wrist straps

Also known as ESD straps. One end is wrapped around the technician's wrist, while the other end is attached to a computer case. This ensures that the strap is grounded. Alternatively, the other end could be attached to the ground pin of the AC outlet.

9.3.2 ESD mats

It is good practice to place all components on one of these mats and to stand on the ESD mat while working with computer hardware. These mats drain all excess charges, eliminating the danger of ESD.

9.3.3 Anti-static bags

These bags are ideal for packaging and discarding electronic components such as memory chips, expansion cards and motherboards. They are designed to collect static charges on the outside, thereby shielding the components on the inside.

9.3.4 Anti-static carpets

These carpets do not build up static electricity. Most IT companies use anti-static carpets.

9.3.5 Modifying relative humidity

ESD problems are common when the air is dry. Maintaining the relative humidity at approximately 50% will greatly reduce ESD.

9.4 Tools required

- Screwdriver – A Phillips -head (cross-point) screwdriver is what is used for most PCs. However, there is a variety of screwdrivers that accommodate different-sized screws. Make sure the head of the screwdriver matches the size of the screw.
- Screw extractor – A screw extractor is used to get loose screws out of the motherboard, especially screws that are difficult to reach. Beware, loose screws on the motherboard could cause a short circuit.
- Flashlight – A flashlight can be useful while working on the PC in a badly lit area.
- Tweezers – Helpful for switching jumpers.

There are a variety of other useful tools, including pliers to grip things, wire cutters to cut cables, strippers or crimpers to strip and crimp cables, and multimeters to test different power properties such as current and voltages.

9.5 Requirements

Hardware required
- PC case
- Hard drive
- CD-ROM/DVD-ROM drive
- Processor
- Processor cooling fan
- Motherboard
- Memory modules
- Power supply
- Graphics card
- Keyboard and mouse
- Monitor
- Drive cables
- Screws
- Power cords (for both the PC and the monitor)

Software required
- Device drivers (these usually come with the hardware above).
- Operating systems (for the purpose of this module, we will install Windows 7 and Windows 8 as the operating system. Experiment with alternative operating systems such as Linux.)
- Oracle VM Virtual Box

When following the steps in the following sections, please keep in mind that there are many different ways to set up and configure a PC and different hardware specifications exist. For this reason, regard the sections below as a basic guideline for assembling and disassembling the most common components of a PC. The lecturer will assist you with this exercise.

9.6 Disassembling the PC

Computer cases come in different shapes and sizes, but the most common ones are the desktop model and the tower model.

The method for opening the case may vary slightly because of the differences in shape and size. If at any time you are unsure of the procedure to follow, please ask your lecturer for guidance.

- Following the handling guidelines discussed earlier, disconnect all cables leading into the computer. Ground yourself.
- Remove the case screws with a star-shaped screwdriver. A desktop case usually has four or five screws on the back panel to hold the cover in place.
- Gently slide the cover out. This movement will depend on the design of the case.
- Place the cover in a safe place and turn the computer for easy access to the internal components.

NOTE	To avoid any damage, ask your lecturer to demonstrate how you would disassemble the various parts found inside your computer.

9.7 Assembling the PC

NOTE	The motherboard and power supply unit are already installed.

9.7.1 Installing the processor and CPU fan

1. Locate the processor socket on your motherboard. The installation will be slightly different depending on the type of processor the motherboard supports.
2. Raise the lever or lid on the socket and slowly insert the processor in the socket. Make sure pin 1 of the CPU matches pin 1 on the socket; otherwise, the CPU could be damaged. It will go in gently if it is correctly aligned. Do NOT force the CPU into the socket.
3. Close the lever or lid, which will hold the CPU securely in place.
4. Use fresh thermal compound and place the CPU fan and heat sink assembly on top of the CPU and push down the metal clips of the fan and heat sink assembly so that it clips onto the motherboard.
5. The CPU fan has a power connector, which needs to be connected to a CPU fan power socket on your motherboard.

NOTE	To avoid any damage, ask your lecturer to demonstrate how you would install a processor and CPU fan. Ask your lecturer where and how to use the thermal compound.

9.7.2 Installing memory

1. Find the RAM slots (banks) on the motherboard.
2. Notice the memory banks have tabs (usually white) on each side. Release the tabs so that they bend to each side (or face outwards).
3. Hold each corner of the RAM, placing it on top of bank 1. Notice that the RAM has a notch on the connector to prevent the memory from being inserted the wrong way around.
4. Gently push the module down into the slot, and the tabs will click and latch onto the side of the memory module and lock it into place. If there is more than one module, perform the same steps as above but place the RAM in memory bank 2, and so on.

9.7.3 Installing the graphics card

1. Insert the graphics card carefully into an open AGP/PCIe/PCI slot.
2. Some graphics cards require more power; an extra power connector is needed to power it. Be careful not to touch the pins.
3. Screw the backing plate of the card down onto the case.

9.7.4 Installing the hard drive/CD/DVD drive

How to configure these drives depends on how many drives need to be installed and on the type of drive being installed.

9.7.4.1 Drive installation

1. Determine which drive bay will hold the hard drive. In most cases, the hard drive goes into a 3.5-inch slot towards the front of the case, near the bottom.
2. Slide the hard drive into the bay, and line up the screw holes on the drive with the drive rack. Be sure the drive connectors face the back of the case or motherboard.
3. Fasten the hard drive into place using the appropriate screws.
4. Should you need to install a second hard drive, repeat the previous three steps.
5. Attach the ribbon cable to the correct socket on the motherboard and attach the other end of the cable to the PATA hard drive. Refer back to Unit 5 for master/slave settings and cable orientation. With SATA, the cable goes to a SATA controller on the motherboard and the opposite end of the cable plugs into the drive. In the case

of multiple drives, start with SATA_1 and move on. There are no jumper settings to consider for SATA drives.
6. Attach the power cable to the drive. Choose a power lead from the power supply and plug it into the power connector on the hard drive. The connector for SATA will be keyed so that it will only fit in the correct way.

9.7.4.2 CD/DVD drive

1. Slide the CD/DVD drive into an empty compartment or bay - usually the top most compartment or bay.
2. Connect the CD/DVD drive to the data cable.
3. Hook the DVD to the power connector.
4. Attach the ribbon cable to the correct socket on the motherboard and attach the other end of the cable to the PATA hard drive. Refer back to Unit 5 for master/slave settings and cable orientation. With SATA, the cable goes to a SATA controller on the motherboard and the opposite end of the cable plugs into the drive. In the case of multiple drives, start with SATA_1 and move on. There are no jumper settings to consider for SATA drives.
5. Attach the power cable to the drive. Choose a power lead from the power supply and plug it into the power connector on the hard drive. The connector for SATA will be keyed so that it will only fit in the correct way.

9.7.5 Installing the sound card

1. Most modern sound cards are designed to connect to the PCI or PCIe slot of the motherboard.
2. Align the sound card with the slot. Gently push down the card so that the connector pins are completely embedded in the slot. Once the card is seated correctly into position, screw the backing plate of the card down onto the case.

9.7.6 Connecting the LED switches

Now that all the necessary basic hardware components have been installed, there are still a few more things to do before switching on the PC for the first time. The ATX case has a power switch, which turns the PC on, a reset switch for resetting the system, a power LED that comes on when the PC is switched on, and a hard drive LED, which flashes when data is being written to or read from the hard drive. There is also an internal speaker.

Figure 60 – Power and reset switch

The switches and LEDs need to be connected to their corresponding connectors on the motherboard. Different motherboards place the connectors in different locations. Please refer to the motherboard manual to locate where the connectors are. The connectors for the switches and LEDs are normally grouped together. They should look similar to the connectors shown in the image below.

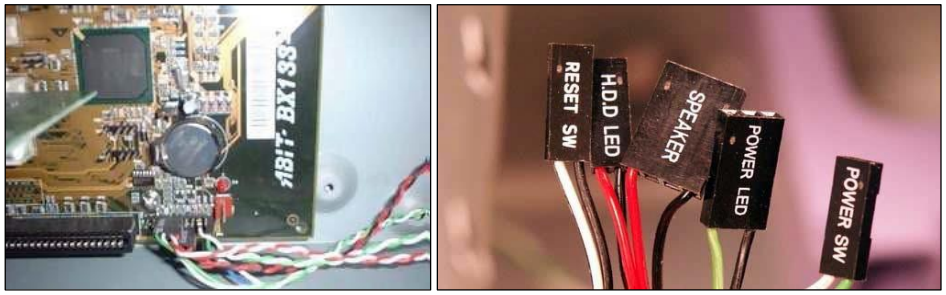


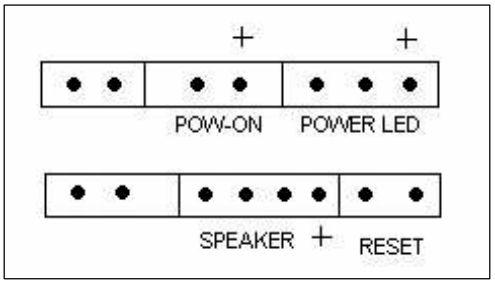
Figure 61 - Switch and LED connectors

Every cable is normally labelled; they are usually named as follows but could be slightly different according to the type of motherboard and power supply.

Power switch	Power/PWR-SW
Reset switch	Reset
Power LED	Power LED/PWR-LED
Hard drive LED	HDD-LED/IDE LED
Speaker	SPK/Speaker

The connectors on the motherboard are also labelled but may be too small to see. Instead, refer to the motherboard manual, which will provide details for this.

The image below shows how the pins may be organised on your motherboard. The + sign indicates the cable orientation. Each connector is marked with a raised triangle, which indicates pin 1 and should be aligned to the + sign.



Once all the cables are connected to the correct pins on the motherboard, the PC can be switched on.

At this point, close the cover of the ATX case but do not screw it on just yet, as you might have possible problems that need rectifying.

1. Connect all the cables to the back of the ATX case. These could include:
   - The main power cable that connects to the power supply.
   - The mouse and keyboard that connect to the USB/PS/2 ports.
   - Monitor cable that connects to the graphics card port, etc.
   - The speakers.
2. Switch on the power at AC wall outlet.
3. Switch the monitor on first.

4. The power supply might have a main power switch at the back so make sure that it is switched on.
5. Now switch the PC on by pressing its power switch.

If all the tasks have been performed without any mistakes and provided that none of the main components are faulty, the PC should boot up. You should hear a single beep from the motherboard speaker to indicate that the power on self-test (POST) has been performed and all the components that were checked are in good working order. When the PC boots up, the name of the BIOS manufacturer will be shown on the screen. The CPU type, speed and the amount of memory should also be displayed.

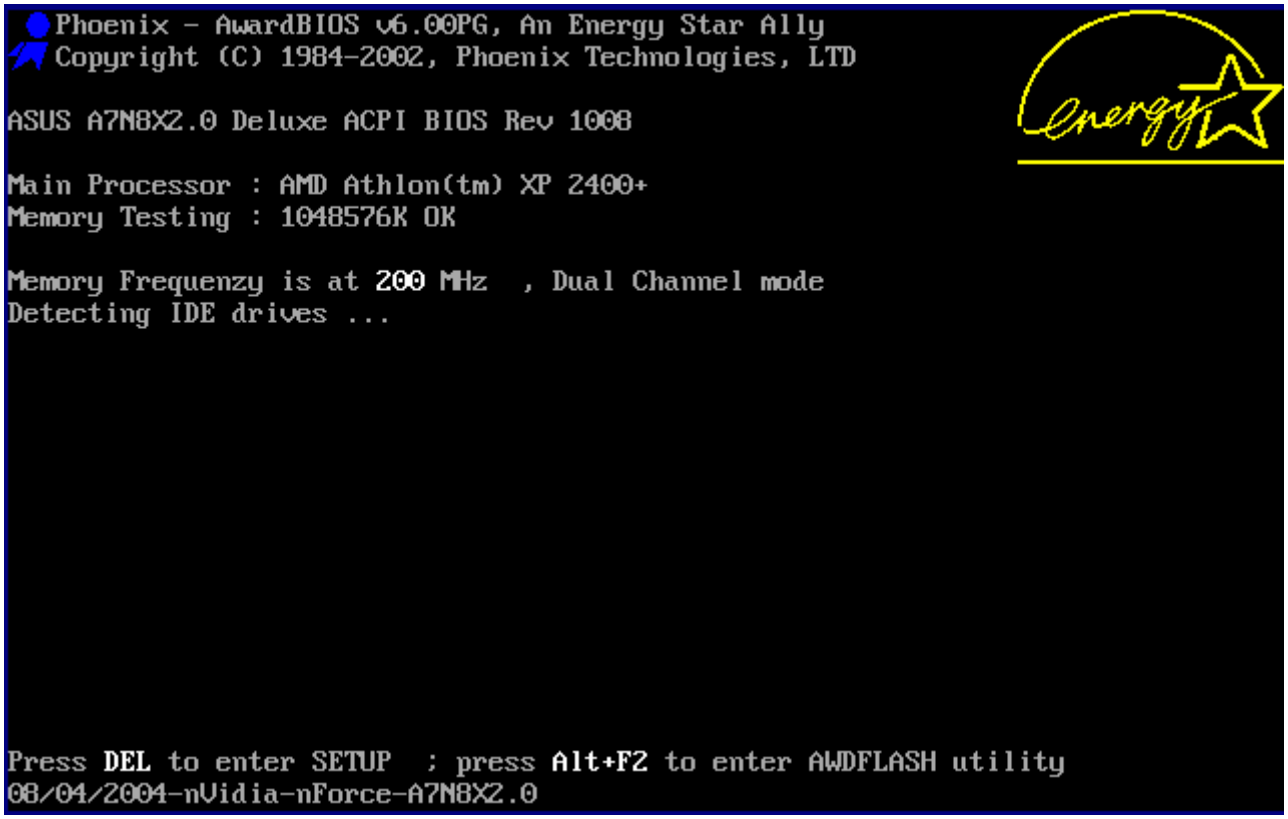


Figure 62 – POST screen

If the motherboard has a plug-and-play BIOS and is set to automatic device detection by default, then the IDE devices should be automatically detected. If the motherboard does not detect the hardware, proceed to the BIOS/CMOS setup screen by pressing DEL or F1 or F2 on your keyboard. You might need to press another key to access the BIOS/CMOS setup, depending on the motherboard.

Proceed to section 9.8, which explains how to configure the BIOS/CMOS and hard disks, and install an operating system. If the PC does not switch on, go to the troubleshooting section in this study guide for possible solutions.

9.8 Overview of the BIOS/CMOS settings

There are different versions of BIOS (basic input/output system), but most BIOS versions have similar settings/features. This setup guide gives you an idea of how to configure various BIOS settings. Please note that configuring the BIOS incorrectly could cause the system to malfunction. Therefore, it is recommended that you follow the BIOS guidelines provided with the motherboard manual.

9.8.1 A typical BIOS/CMOS setup and all the options

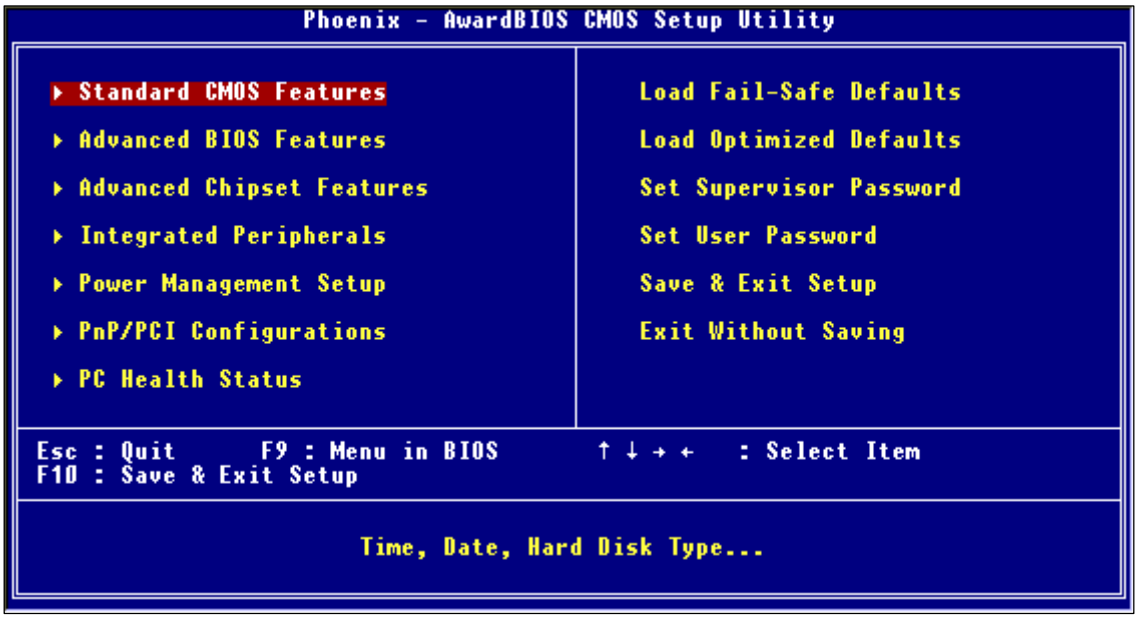


Figure 63 – BIOS/CMOS setup

9.8.1.1 Standard CMOS (complementary metal oxide semiconductor) features

The basic BIOS features such as date, time, etc. can be set up here. Use the arrow keys to move around and press Enter to select the required option. Specify what IDE/SATA devices there are, such as hard drive, CD-ROM, ZIP drive, etc. The easiest way to set up these devices is by leaving it set to auto. This allows the BIOS to detect the devices automatically, making it unnecessary to set it up manually. At the bottom, it also displays the total memory installed in your system.

9.8.1.2 Advanced BIOS features

There are numerous advanced settings, which can be selected if required. For most cases, leaving the default setting should be adequate. In many CMOS setup programs, the boot sequence is set here.

9.8.1.3 Advanced chipset features

Here the contents of the chipset buffers can be set up. The contents are closely related to the hardware and it is therefore recommended that the default settings be left as is until more experience is acquired. Having an incorrect setting configured here can make the system unstable.

9.8.1.4 Integrated peripherals

This menu allows you to change the various I/O devices, such as IDE controllers, serial ports, parallel ports, keyboards, etc. Changes can be made when necessary. Most integrated sound, modem and network components can be enabled or disabled here.

9.8.1.5 Power management setup

The power management setup screen allows you to set up various power saving features when the PC is in standby or suspend mode.

9.8.1.6 PnP/PCI configurations

This menu allows configuration of PCI slots. Assign IRQs for various PCI slots here. It is recommended that the default settings are kept because configuring IRQs manually can become complicated. All current PCs use PnP BIOS, PnP OSs and PnP adapter cards so there is no reason to set IRQs manually.

9.8.1.7 PC health status

This menu displays the current CPU temperature, the fan speeds, voltages, etc. You can set the warning temperature here, which will trigger an alarm if the CPU exceeds the specified temperature.

9.8.1.8 Load Fail-Safe defaults

If changes are made to the BIOS and the system becomes unstable as a result of the change, revert to the default setting. However, if many changes are made and you do not know which one is causing the problem, choose the option Load Fail-Safe Mode Defaults from the BIOS menu. This uses a minimal performance setting, but the system will run in a stable way. From the dialog box, choose Y, followed by <ENTER>to load Fail-Safe Defaults.

Figure 64 – Load Fail-Safe Defaults option

9.8.1.9 Load Optimized Defaults

Like the Fail-Safe mode described above, this option loads the BIOS default settings but runs the system at optimal performance. From the dialog box, choose Y, followed by <ENTER> to load Optimized Defaults.

Figure 65 – Load Optimized Defaults option

9.8.1.10 Set password

To password protect the BIOS, specify a password here. This will prevent unauthorised users from accessing and changing your BIOS settings.

Figure 66 – Enter Password option

9.8.1.11 Save and exit setup

Select this option to save any changes you make to the BIOS. From the dialog box, choose Y.

Figure 67 – Save to CMOS and Exit option

9.8.1.12 Exit without saving

Choosing N from the dialog box means no changes will be saved.

Figure 68 – Quit without saving option

9.9 UEFI

Unified Extensible Firmware Interface (UEFI) is a standard firmware interface that is meant to replace the BIOS. It is designed to improve software interoperability and address limitations of the BIOS.

Figure 69 – An example of a UEFI screen

UEFI has already replaced BIOS on many systems. It acts as super-BIOS, doing the same job as BIOS but in a 32- or 64-bit environment, and offers additional features such as browsing the Web and launching games without booting the OS, as well as opening the CMOS Setup program. You can think of UEFI as a mini-OS that runs on top of the computer's firmware, enabling you to do many tasks at boot time by using your mouse. It works as a non-hardware-specific, non-OS-specific, 32- or 64-bit boot loader. This does not make POST or system setup go away. They still exist, but UEFI runs instead of BIOS.**]**

Figure 70 – An example of a UEFI screen

NOTE	For more information on UEFI, access the UEFI forum at www.uefi.org.

9.10 Installing Windows 7

9.10.1 Ensure that the system meets the following requirements.

Hardware requirements	Minimum	Recommended
Minimum disk space	40 GB	80 GB
Minimum RAM	1 GB	4 GB+
Minimum processor speed	1 GHz	4 GHz or faster
Display	DirectX9	DirectX9 or later

If there are no Windows 7 drivers for all the hardware components, download all the drivers from the hardware manufacturer website and save all the necessary drivers on a CD-R before starting the installation.

In order to boot from the Windows 7 CD/DVD, set the boot sequence in the BIOS under the BIOS setup option and make sure that the first boot device is set to CD- ROM/DVD-ROM.

9.10.2 The Windows 7 installation process is demonstrated in steps 1 to 14.

Step 1
Place Windows 7 DVD in your DVD-ROM drive and start the PC. Windows 7 will start to boot up and display the following progress bar.

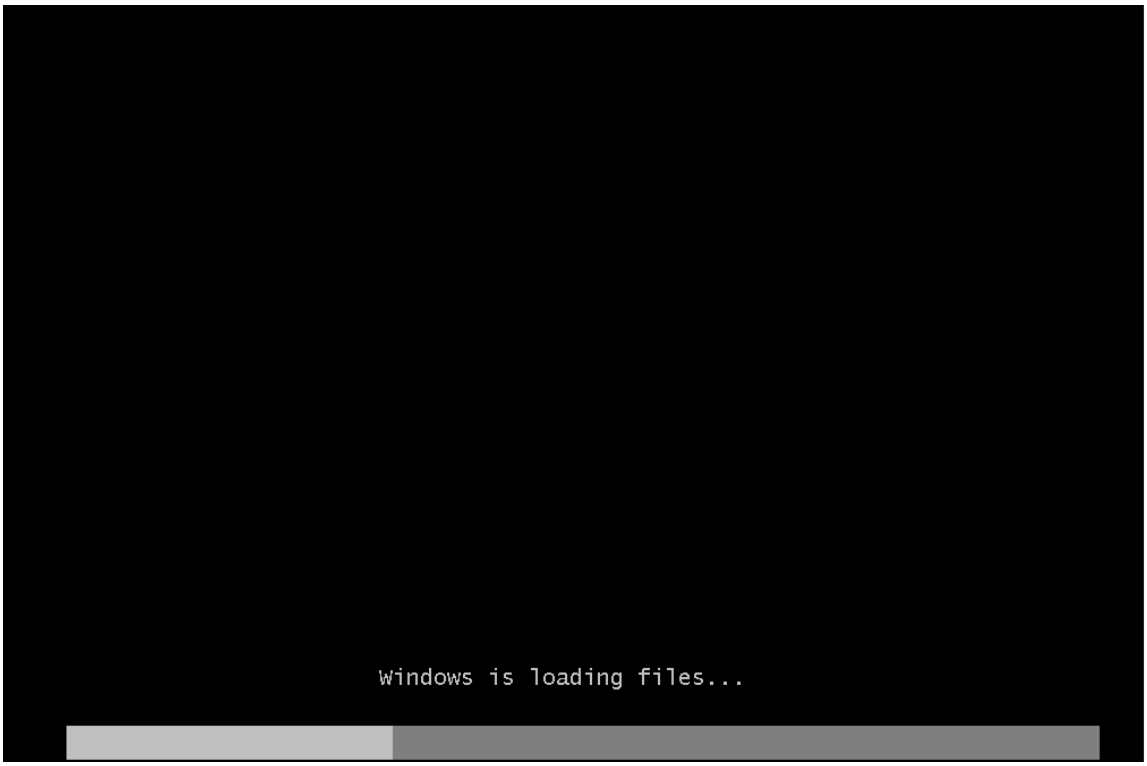


Figure 71 – Windows is loading files

Step 2
The next screen allows you set up the language, time and currency format, keyboard or input method. Choose the required settings and click Next to continue.

Figure 72 – Install Windows

Step 3
The next screen allows for installation or repair of Windows 7. Click on 'Install now' to perform a fresh install.

Figure 73 – Install now

Windows setup will start.

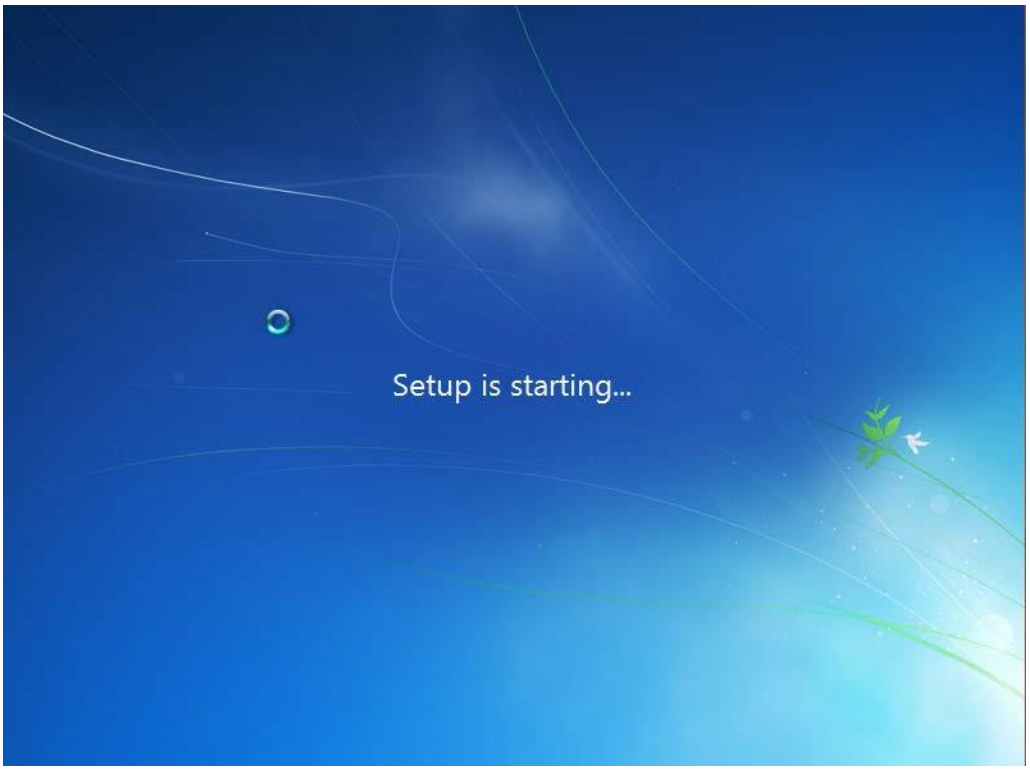


Figure 74 – Setup is starting

Step 4
The End-User License agreement page will come up. Click 'I accept the license terms' and click Next.

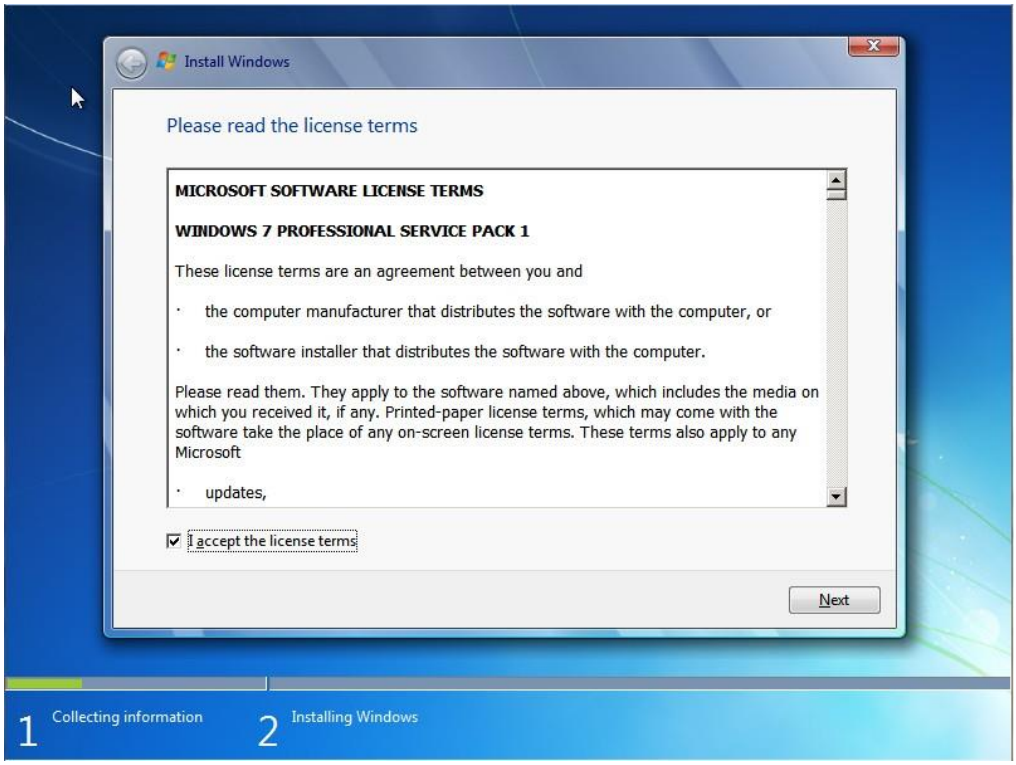


Figure 75 – License terms

Step 5
Click the 'Custom (advanced)' option.

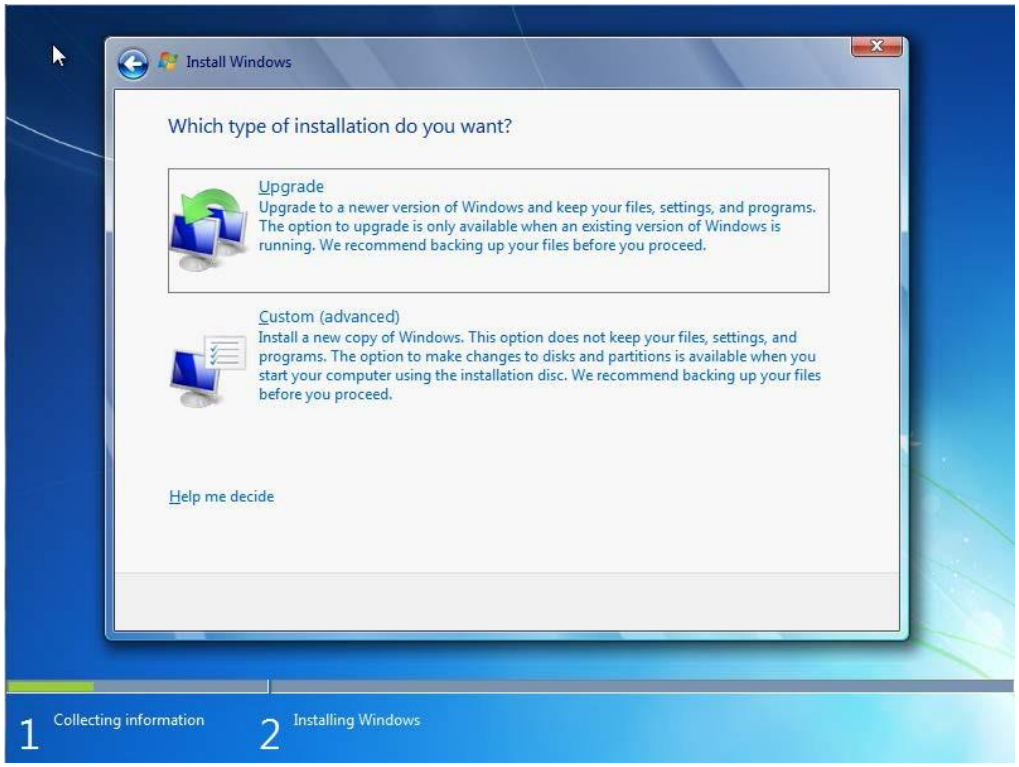


Figure 76 – Which type of installation do you want?

Step 6
Select where you want to install Windows 7 operating system. Depending on how your computer has been set up, ask your lecturer for confirmation on where to install your Windows. Click Next.

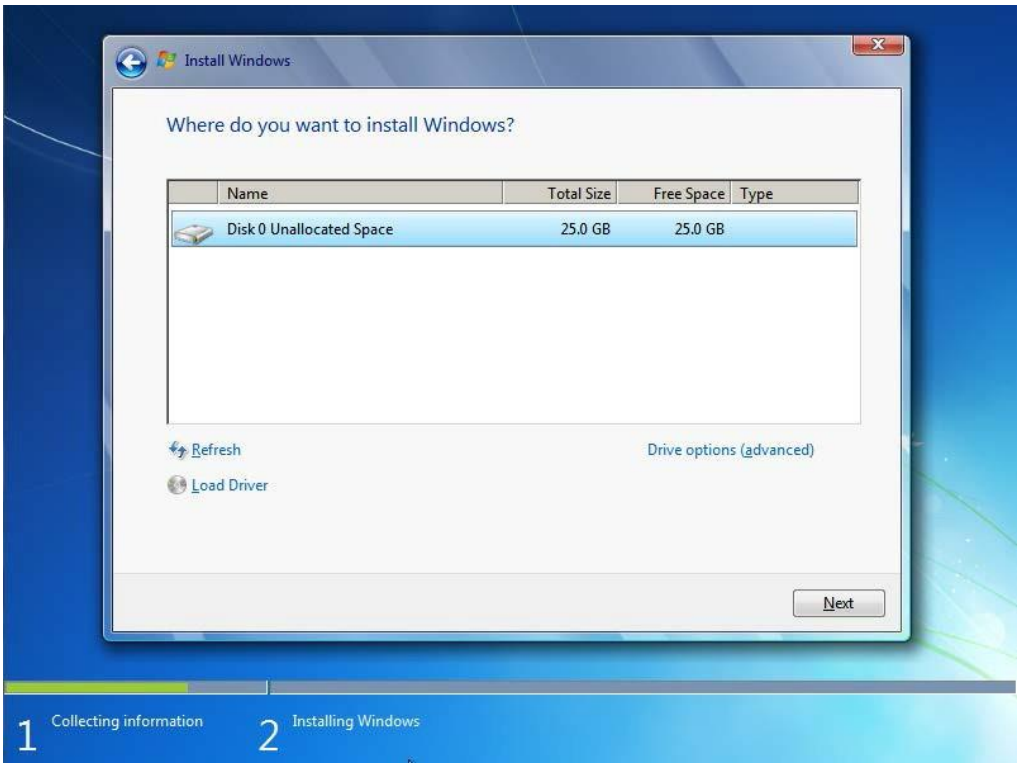


Figure 77 – Where do you want to install Windows?

Step 7
Windows will start installing. Do not switch off your computer or restart it. During the installation process, Windows may restart several times. Do not press any power switch until Windows prompts you to do so.

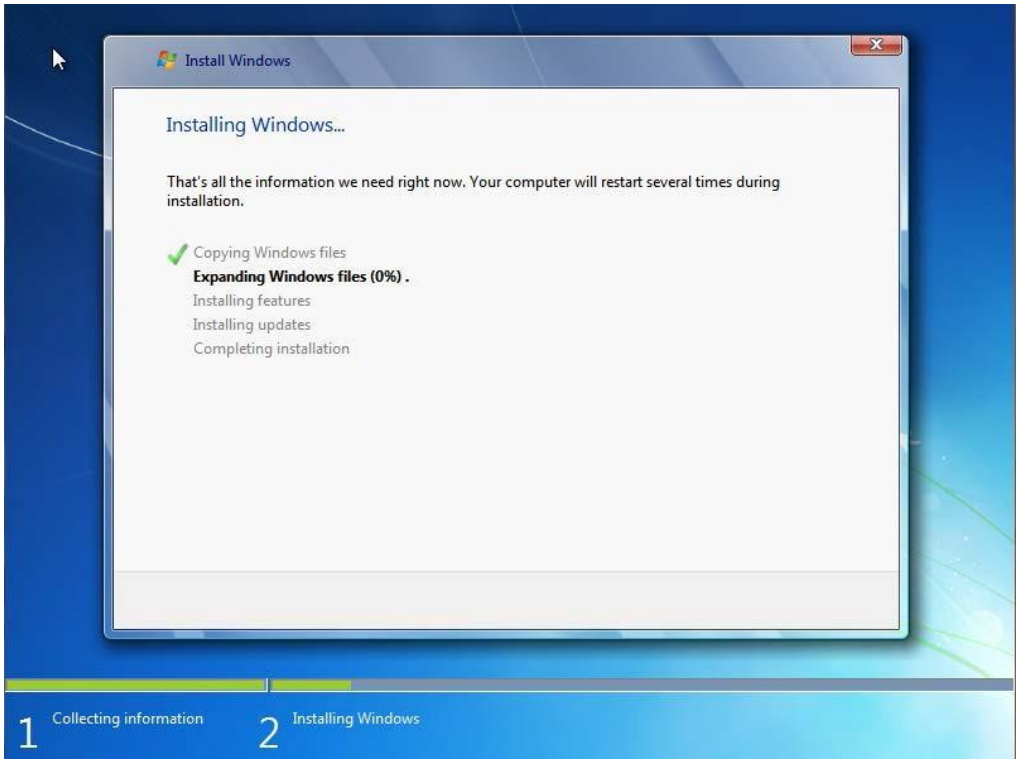


Figure 78 – Windows is installing

Step 8
The Installing Windows will change to a screen informing you that Setup is preparing your computer for first use.

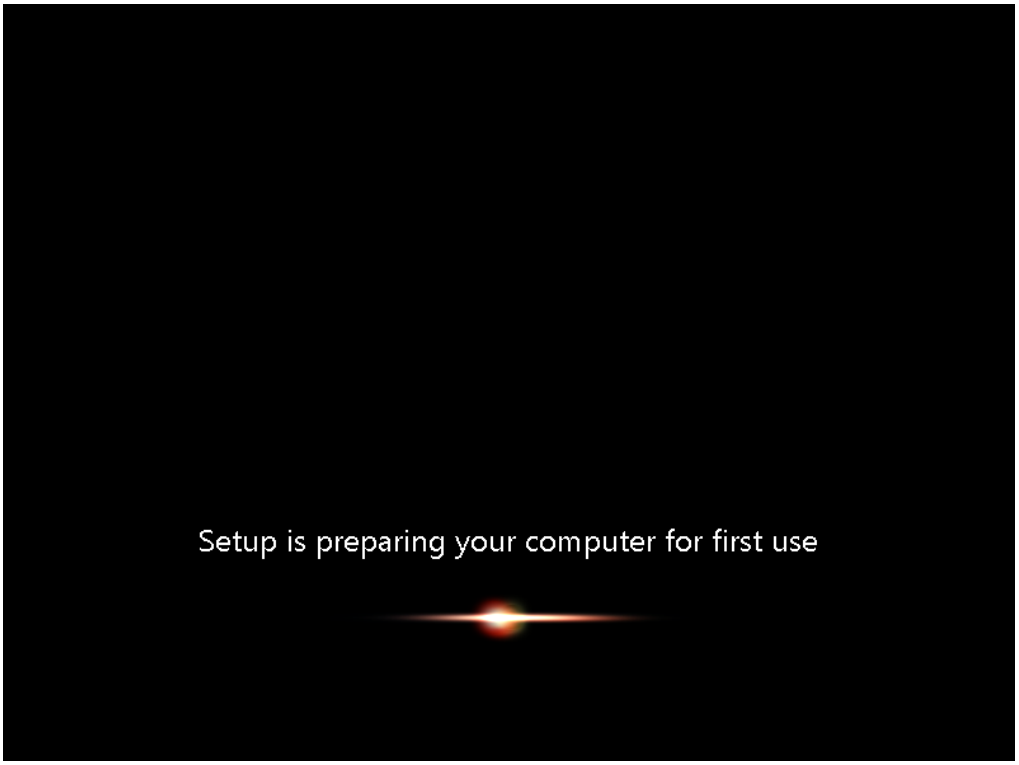


Figure 79 – Windows will set up your computer for first use

Step 9
On the next page, provide a user name and PC name. When typing in your username, your computer name will change to the same name. You may still change your computer name to have a different name from the user name.

Figure 80 – Choose a user name for your account

Step 10
Provide Windows with a password. Retype the password for confirmation.

Set a password tip, just in case you forget the password that you have chosen.

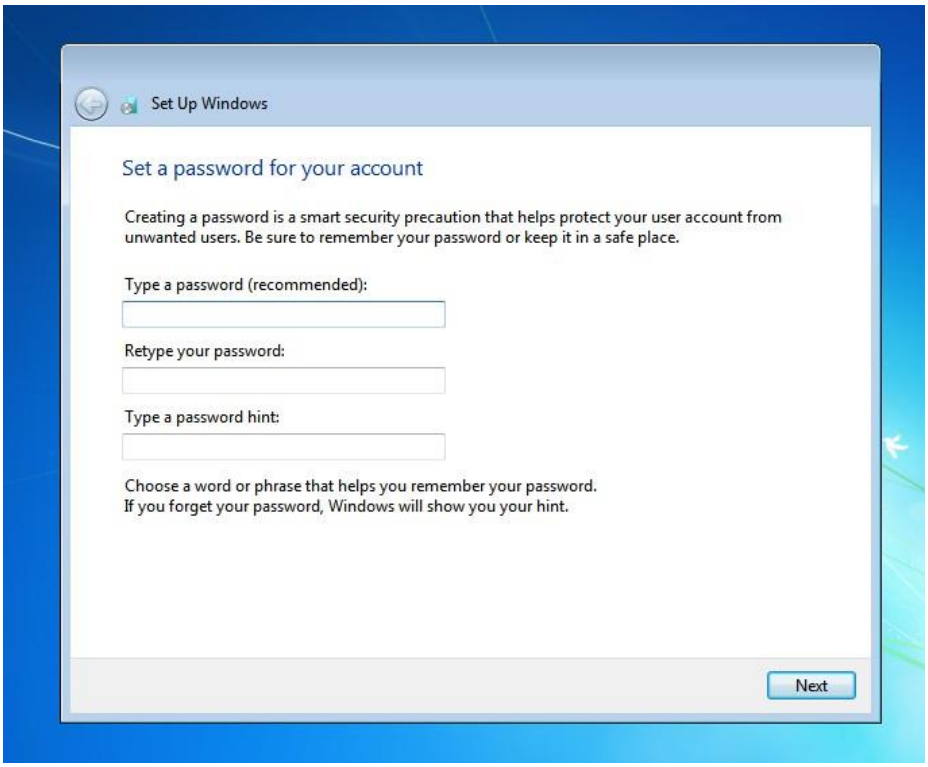


Figure 81 – Set a password for your account

Step 11
Click on the Use recommended settings option.

Figure 82 – Help protect your computer and improve Windows automatically

Step 12
Change the time and date, and click Next.

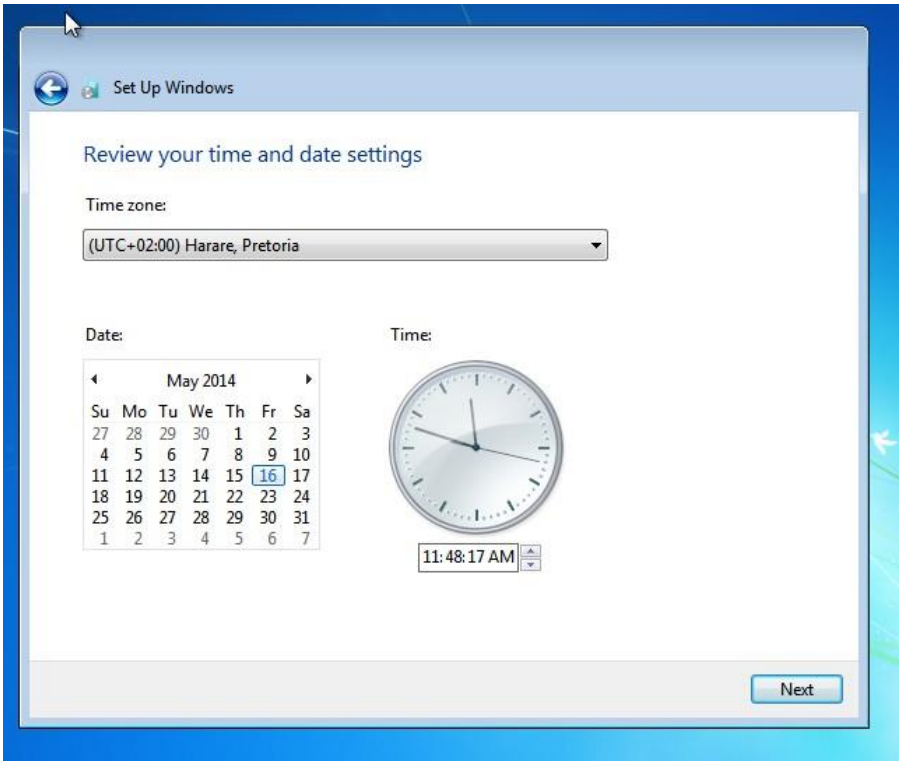


Figure 83 – Add in the time and date Step 13

Click Public network. This is if you are not on a network. Confirm with your lecturer if you are on a network or not.

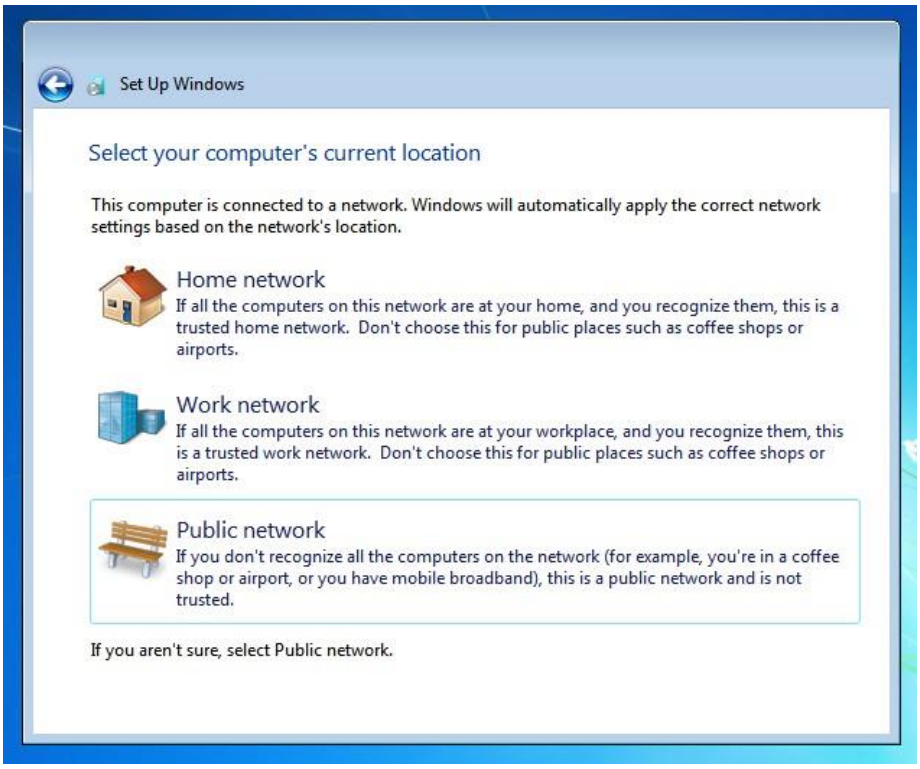


Figure 84 – Select your computer's current location

Step 14
Once Windows is done installing, you will be directed to the desktop. Once the desktop is displayed, you may remove the DVD from the DVD drive.

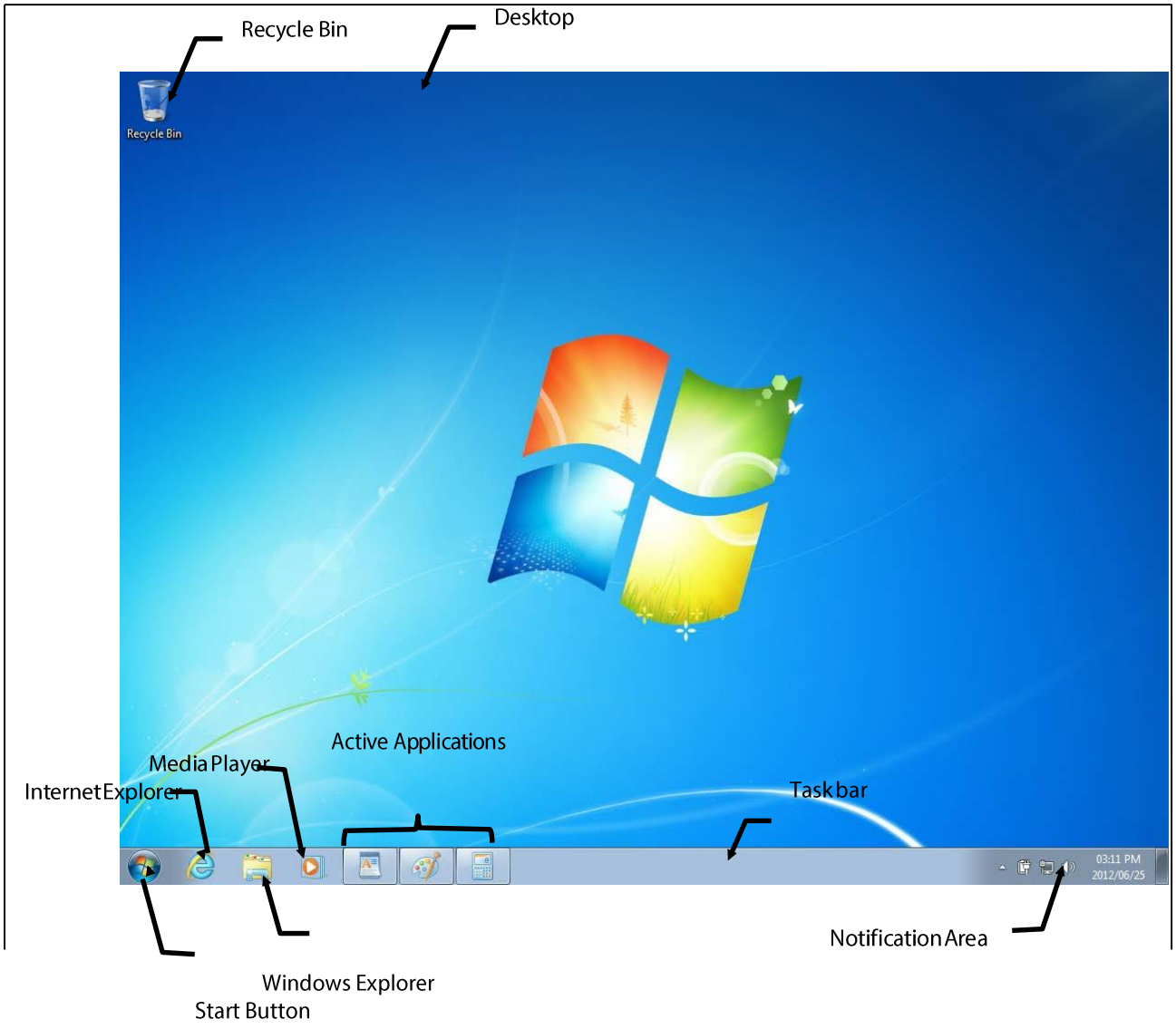


Figure 85 – Windows 7 desktop

9.11 Review questions

Answer the questions that follow to help you to reinforce what this unit has covered. If you are unsure of the answer to any question, then search for it in the text of this unit.

1. List **six** handling rules a technician should remember when repairing a computer.

[6]

2. Circle the correct answer.

   ESD is an acronym for:

   a) Electric System Degradation
   b) Electrostatic Discharge
   c) Electro Silicon Discharge
   d) None of these.

[1]

3. Is the following statement True or False?

   Electrostatic discharge occurs when two objects of a similar charge come into contact with one another.

4. Circle the correct answer. [1]

   Relative humidity should be maintained at:

   a) 50%
   b) 90%
   c) 70%
   d) 40%

[1]

5. List the **two** types of cases discussed in this unit.

[2]

6. When repairing a computer, what is the name of the most commonly used screwdriver?

[1]

7. What is the danger of leaving a loose screw in the computer?

[1]

Total: 13 marks

NOTE	Complete this exercise on a piece of paper and submit it to your lecturer.

Unit 10 – Troubleshooting Common Devices

At the end of this unit, you will be able to:

- Perform preventative maintenance on your PC.
- Identify common PC errors and apply suggested solutions.
- Upgrade your PC.

10.1 Troubleshooting

As you work progressively more with PCs, you will learn more about what can happen in terms of hardware failure and the causes of such mishaps. Listed below are a few such possibilities and the most likely causes.

10.1.1 Motherboard

Problem
The power is on but the system is dead.

Possible causes
- ESD, electric spike or overheating damage.
- Bent or damaged connector pins.
- Dirt inside the plugs or connectors, and on the board.
- Chip creep refers to the gradual loosening of an integrated circuit in its socket primarily as a result of thermal cycling (expansion and contraction during the normal heating and cooling cycles of an electronic system) and aided by vibration (e.g. due to cooling fans). The chip can loosen to the point that poor electrical contact between the chip and socket reduces the signal quality, causing failure.
- A manufacturing fault on the motherboard, in which case you can send it back to the manufacturer for replacement.

Upgrading
If the motherboard is to be upgraded, the following will most likely have to be upgraded: the CPU, RAM and, if the old board used AGP, the graphics card. This is because parts are upgraded at a rapid rate, and older motherboards typically do not support the newer parts such as CPUs, RAM and new slots such as PCI Express. The reason the graphics card must be replaced (unless you receive on-board graphics with the new motherboard) is that most of the new boards only use PCI Express video slots.

10.1.2 Monitor

Problem
The power light does not illuminate when the monitor is switched on.

Solution
Ensure that the main power cable is plugged into the power supply. Ensure that the power cable is a known good cable. A faulty monitor could also be the cause of this.

Problem
The power light is illuminated, but nothing is displayed on screen.

Solution
Adjust the brightness and contrast settings of the monitor.

Problem
The image quality is poor.

Solution
Acquire a better quality graphics card.

10.1.3 Memory

Problem
The computer does not boot.
The memory test fails and the system halts.

Solution
Ensure that the motherboard supports the speed and type of RAM used.
Find and replace the faulty memory modules.
Ensure that the memory modules are inserted correctly.

Upgrading
Installing more RAM can have a significant impact on performance.
High performance memory offers additional stability and reliability, and is recommended for use with more intensive applications.

10.1.4 CPU

Problem
CPU problems usually include locking up or unprompted reboots.

Solution
Check for CPU damage caused by overheating or incorrect insertion of the processor into the socket.

Check the temperature of the processor in the BIOS under power and voltage settings if the computer is able to switch on. If it is overheating, check that the case has proper airflow, that the heat sink is properly fitted, and that the conductive thermal paste used is of an adequate quality and quantity. Also, check that the fan is not excessively dirty or possibly not working at its correct speed.

Bad performance can be caused by an incorrect clock speed setting set in the BIOS or an incorrectly assigned voltage. If the processor is overclocked, it is going to use a higher voltage and work harder than it should. Both of these factors lead to overheating.

Upgrading
If overheating is a concern, one can buy an improved heat sink or fan, or even get a liquid cooling system, which will effectively cool down the PC and can eliminate fan noise.

If having multiple system-intensive programs open at one time, one can buy either a dual-core processor to replace the current one (if the motherboard supports it) or an additional processor for a dual processor motherboard.

10.1.5 Hard drives

Problem
The HDD is not being detected by the BIOS.

Solution
Check that the data cables between the motherboard and drive are fitted correctly and there is power going to the hard drive (check power cable).

In the case of IDE hard drives, check if the hard drive jumper is set to master and any other device sharing the same cable is set to slave.

Check if the motherboard ports are enabled in the BIOS.

Upgrade
The hard disk is generally not upgraded often and should not need to be done too regularly. Be sure to consider drives with caching, as they experience large increases in performance over non-cached drives. Also, if the motherboard supports it, acquire a SATA drive instead of normal IDE, as SATA experiences large performance gains over the older IDE interface.

10.1.6 Printer

Problem
Most printers have a self-test mode that can assist in the troubleshooting process. The most common problems that occur are relatively easy to troubleshoot. Common problems include:

- The printer is not plugged in and switched on.
- The printer is not online.
- The printer is out of paper.
- There is a paper jam.
- There is no toner or ink in the printer.
- The paper quality is not suitable for the specific printer.

10.1.7 Power supply
A common problem experienced with power supplies is erratic rebooting or freezing. The supply could either be faulty or forced to supply power to more devices than it can cater for.

10.1.8 Display devices
Assigning additional memory to an on-board display adapter from the BIOS can be done to improve performance slightly. Otherwise, acquire a new model of graphics card to experience a drastic performance increase.

New monitors give better image quality and improved refresh rates, which can be better for your eyesight.

10.1.9 Peripherals and input devices
Make sure that the latest drivers and OS updates are installed, and that the devices are clean and undamaged.

Purchasing better peripheral products can make a large difference to the computer and can increase the PC’s capability.

10.2 Preventive maintenance

Preventive maintenance measures are vital to prolong the lifespan of a PC. It is important to actively maintain the hardware to prevent the premature failure of the equipment.

Table 20 presents a basic guideline of a maintenance schedule that could be followed.

Table 20 – Preventive maintenance checks

Frequency	Check
Daily	Make sure that the system is correctly aired, and that the ventilation slots are not obstructed in any way.
Weekly	Clean the exterior case of the computer and monitor. Clean the peripherals. Install any necessary driver or OS updates. Install any additional updates, such as antivirus or antispyware.
Monthly	Check that the fans are working. Run hard disk checks. Check that the cabling is correctly connected.

10.3 Power on Self-Test (POST)

The POST is performed every time the computer is booted. It tests system components and it initiates the system devices. Should POST detect any faulty devices during the test, it will indicate that there is a faulty component by means of an error code. These codes are either a series of beeps that can be heard or it can be a text message that is displayed on screen. You should consult the technical documentation of your motherboard or BIOS for a specific explanation of the code. Table 21 lists common beep codes.

Please refer to your motherboard manual to confirm what the beeps represent. Different motherboards provide different beep codes.

Table 21 – Common POST beep codes

Beep Code	Problem	Possible Solutions
One short beep	No RAM installed or detected	Install RAM. Ensure that the RAM installed is compatible.
No beep, system dead	Power supply	Check that the power has been turned on. Check that the power cord is plugged into the system/main power supply correctly. Replace the power supply unit.
Continuous beeps	Power supply or keyboard	Check that the power cord is plugged into the system correctly. Check that the power cord is plugged into the main power supply correctly. Check if a key on the keyboard is stuck. Check if something is resting on the keyboard.

No beep, DOS prompt	May be a defective speaker	Check system speaker.
One short beep, nothing on the screen	Display subsystem (graphics card/monitor)	Check monitor power. Check the video cable. Check that the graphics card is seated correctly.
One long beep, one short beep	System board	Check that all cards, memory and chips are seated firmly. Check for proper power connections to the system board. Use diagnostic software and hardware to troubleshoot the system board further.
One long beep, two short beeps	Display subsystem (graphics card/monitor)	Check the monitor power. Check the video cable. Check that the graphics card is seated correctly.
One long beep, three short beeps	Display subsystem (graphics card/monitor)	Check the monitor power. Check the video cable. Check that the graphics card is seated correctly.
Two short beeps	Configuration error	Check the error code number.

10.4 Review questions

Answer the questions that follow to help you to reinforce what this unit has covered. If you are unsure of the answer to any question, then search for it in the text of this unit.

1. When you turn your computer on, nothing happens. The monitor does not come on and the power supply fan is not running. You switch the computer off and on again and still nothing happens. What is the most likely cause?

   [2]

2. Your computer is experiencing random problems. These problems disappear as soon as you reboot the computer. What should you do to prevent this from happening?

   [2]

3. You have just installed a new sound card in your computer. When you boot the computer, the card is not recognised. In addition, your modem which has always worked has stopped working. What is the most likely cause of this?

   [2]

4. You have just installed an additional hard drive, but the hard drive is not detected when you switch the PC on. What is the most likely cause (2 marks)? What is a solution to this problem (2 marks)?

   [4]

Total: 10 marks

NOTE	Complete this exercise on a piece of paper and submit it to your lecturer.

Unit 11 – Virtualisation

At the end of this unit, you will be able to:

- Define virtualisation.
- Define a hypervisor and a virtual machine.
- Install a hypervisor.
- Create a new virtual machine and install an operating system on the virtual machine.

Virtualisation is the simulation of software and/or hardware that provides you with the ability to run multiple operating systems on a single physical computer at the same time. The idea behind virtualisation is to run special software called a **Hypervisor** or **Virtual Machine Manager** on a physical computer known as the **host,** to create more software-based computers called **virtual machines (VM)**.

11.1 Hypervisor

The **hypervisor** or **virtual machine manager (VMM)** is an extra layer of software, installed either on top of the host OS or directly on the physical hardware, which provides a platform to create and run one or more VMs on the host computer and manages the flow of input and output calls made between each guest and the physical hardware (CPU, memory, storage) in a fair and timely manner.

There are two types of hypervisors:

- **Bare-metal or native** – This is where the hypervisor runs directly on the physical hardware without an operating system beneath it. Then multiple guest operating systems can run as VMs on top of the hypervisor.

  Bare-metal and native virtualisation are primarily used for server virtualisation to run virtual servers and by web-hosting companies and by companies that offer cloud-computing solutions.

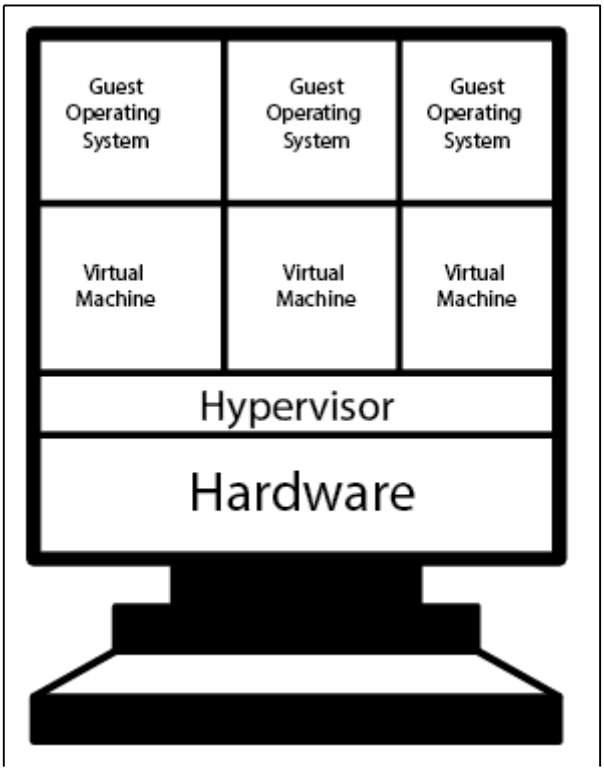


Figure 86 – Bare-metal or native virtualisation architecture

- **Hosted** – This is where the hypervisor runs as a program within the host's operating system, which in turn runs on the physical hardware. The host operating system can be any operating system, such as Windows, Linux or MAC OSX.

  Hosted hypervisor enables desktop users to run an instance of one or more other operating systems without the complications of dual booting.

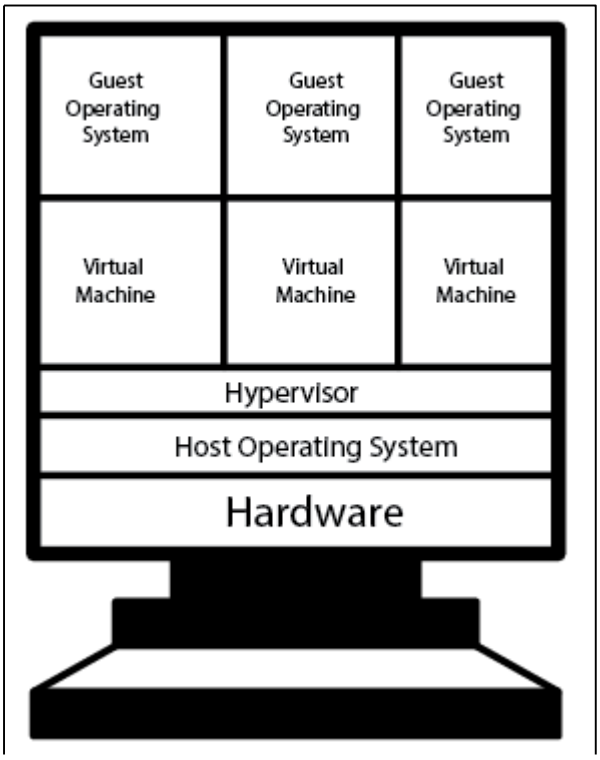


Figure 87 – Hosted virtualisation architecture

11.2 Reasons for virtualisation

Most companies are moving towards virtualisation. Here is a list of benefits of virtualisation.

- Minimises hardware costs
- Provides disaster recovery
- Consolidates idle workloads
- Balances loads
- Tests software
- Centralised server management
- Conserves power
- Deploys server's faster
- Legacy applications
- Security

11.3 Installing VirtualBox

For the purpose of this module, we will install Oracle VirtualBox. VirtualBox at the time of writing is in version 4.3.10. Updates are regularly released and are freely accessible from https://www.virtualbox.org/.

In this exercise, you will learn how to install VirtualBox. Ask your lecturer to place the VirtualBox exe. on your desktop.

Step 1
Double-click on the VirtualBox icon found on your desktop.

Figure 88 – VirtualBox icon Step 2

If a security warning dialog box pops up, click on Run to start the VirtualBox wizard.

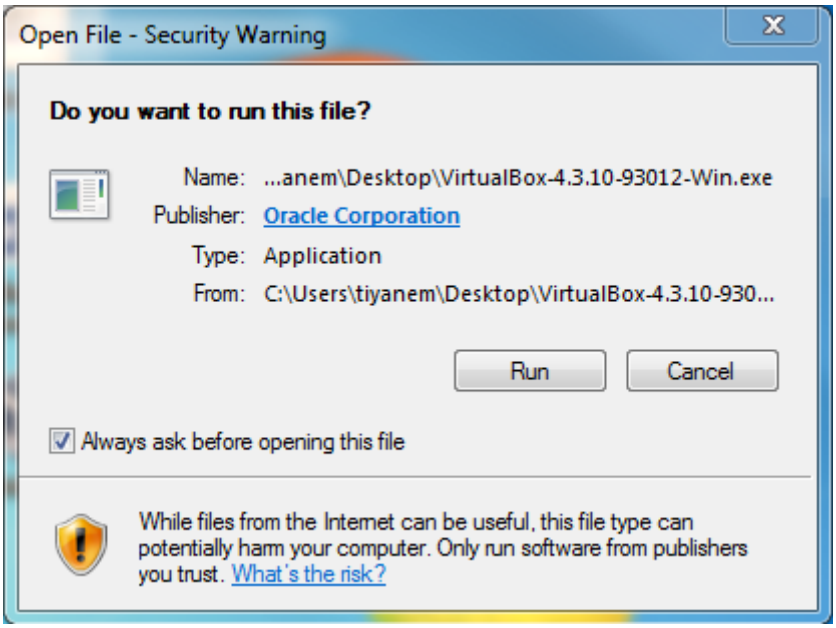


Figure 89 – Security Warning

Step 3
The VirtualBox Setup Wizard page will appear. Click Next.

Figure 90 – VirtualBox Wizard

Step 4

In the Custom Setup page, you can select the way you want features to be installed. Leave the default setup and click Next.

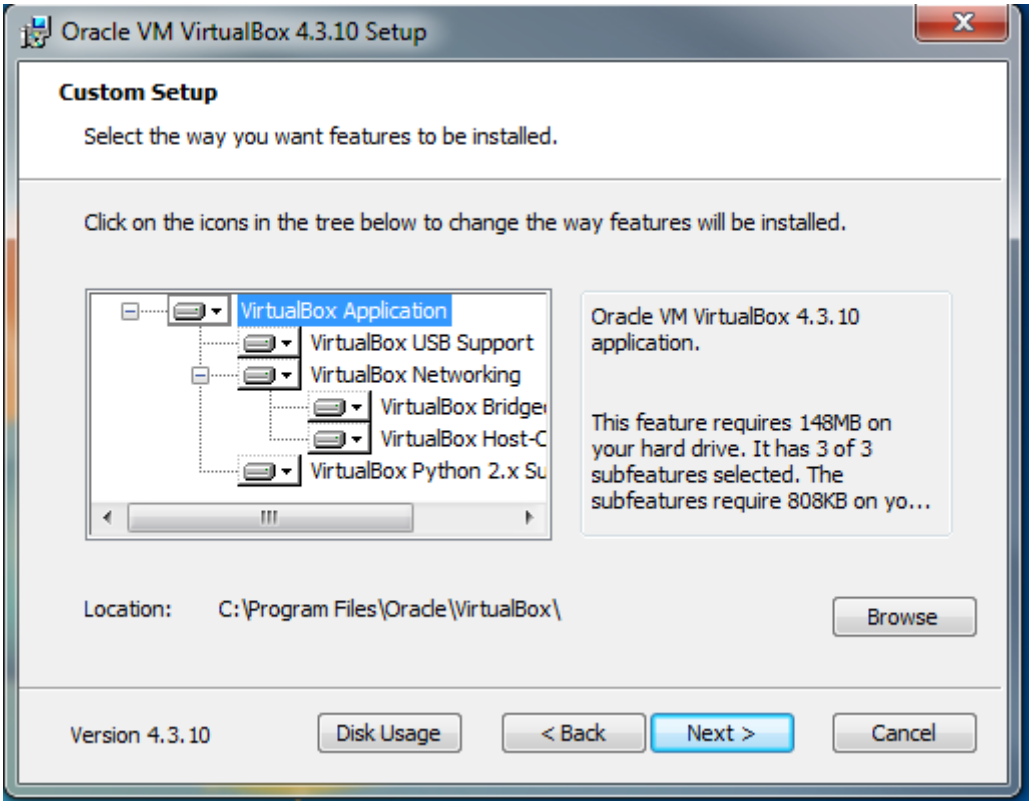


Figure 91 – Custom Setup Step 5

The next page will also be the Custom Setup page. Click Next to accept the default setup.

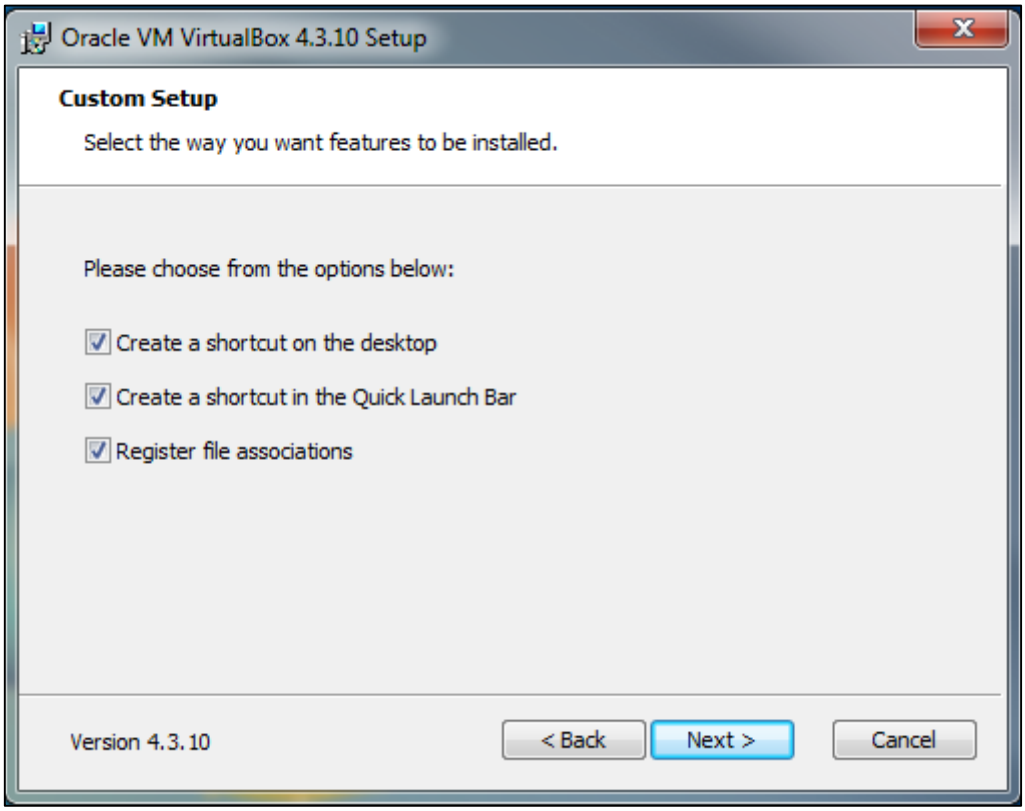


Figure 92 – Custom Setup

Step 6
The next page is a Network Interfaces warning page. If you are on a network, you will temporarily be disconnected from your network. Click Yes to continue with your installation.

Figure 93 – Network Interfaces warning Step 7
The next page is the Install page. Click on Install to start installing VirtualBox.

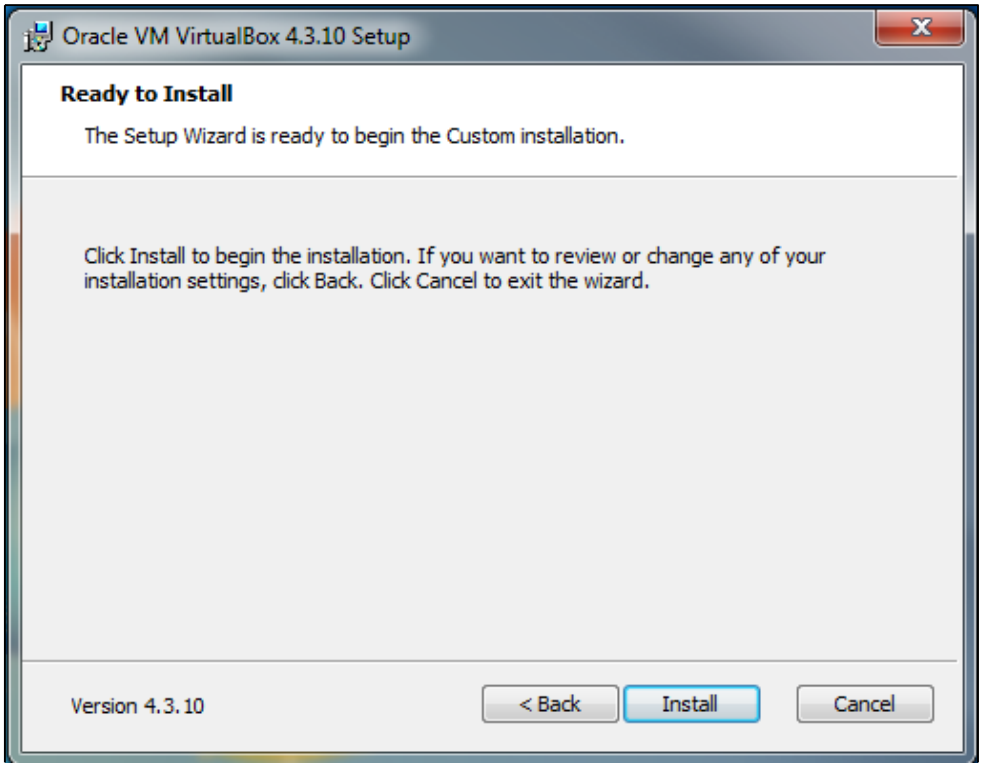


Figure 94 – Ready to Install

Step 8
While VirtualBox is installing, there will be several Windows Security dialog boxes that will pop up. Click on Install to accept the device settings installation.

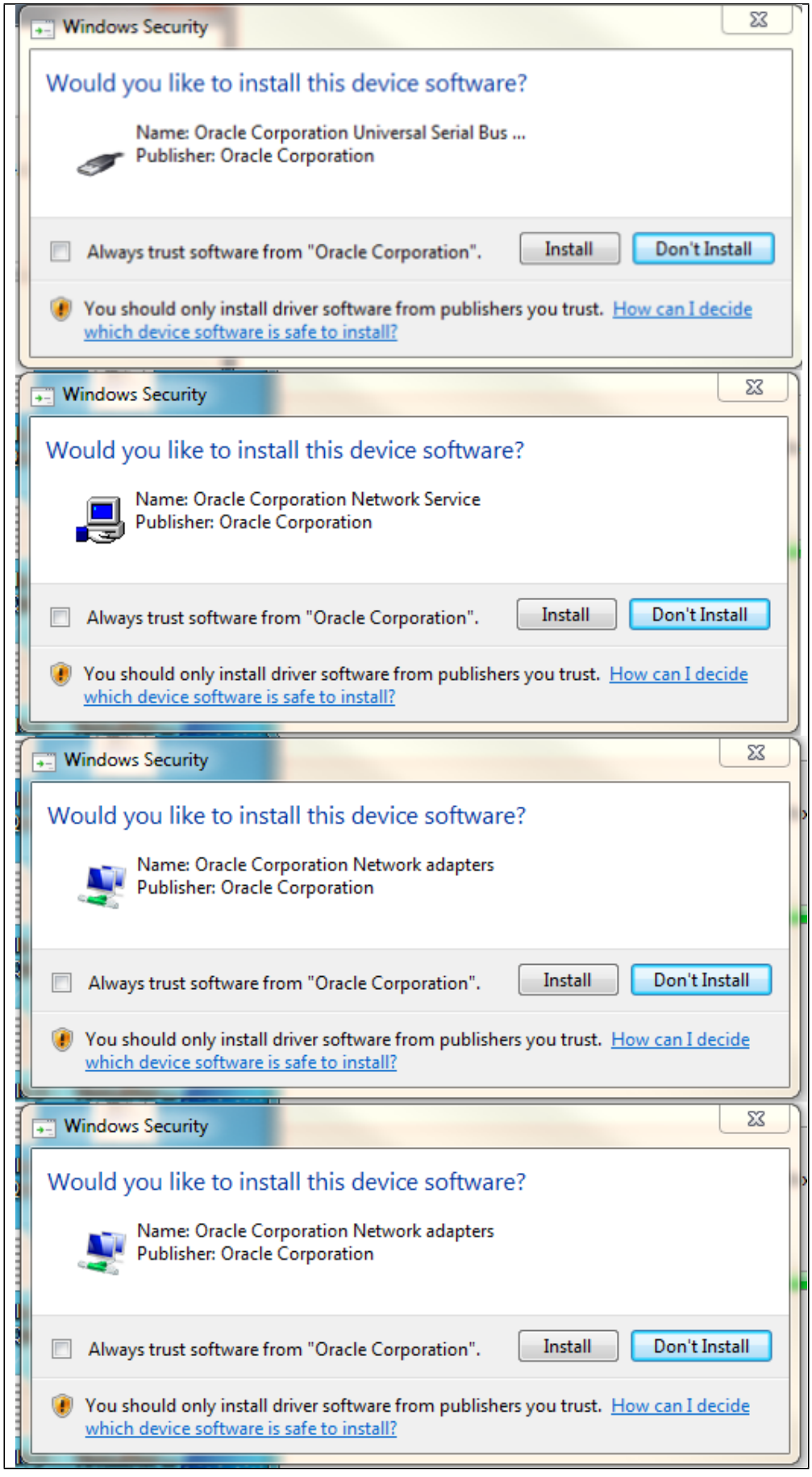


Figure 95 – Windows Security

Step 9
The final step is to click Finish.

Figure 96 – Installation is complete

Figure 97 shows the VirtualBox interface.

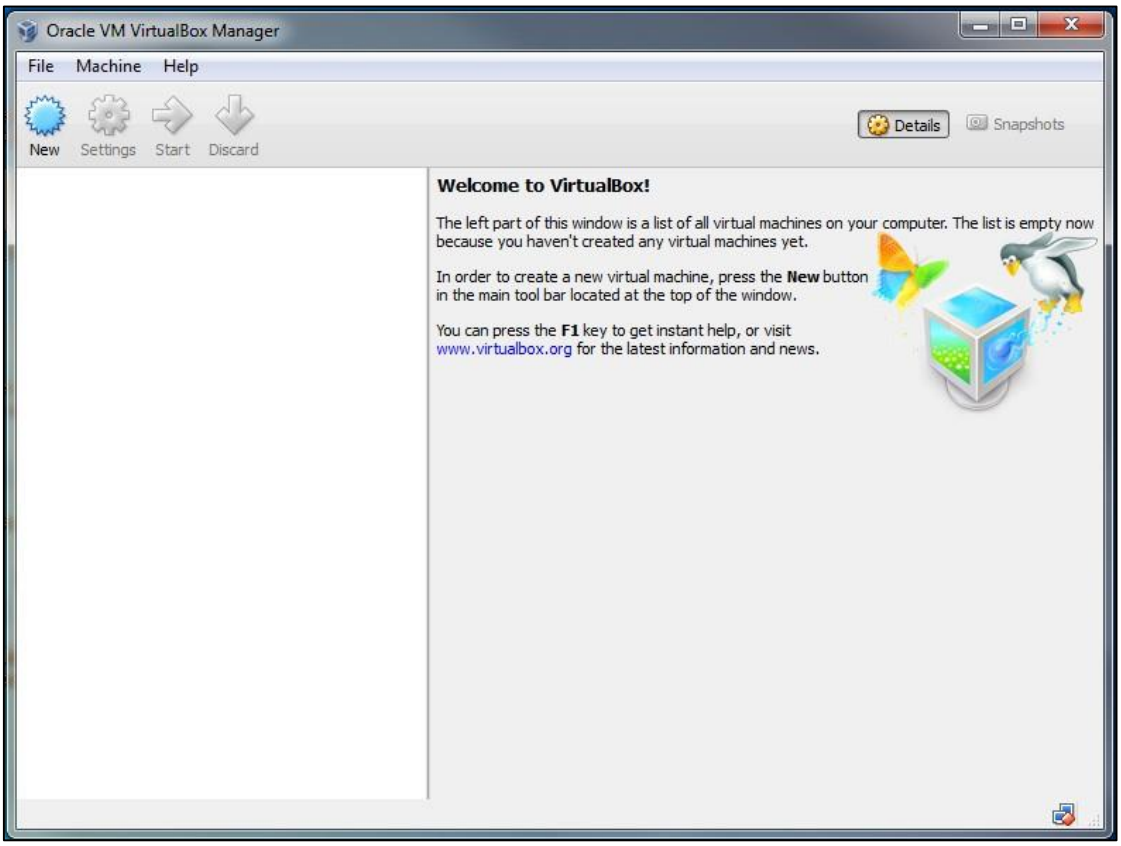


Figure 97 – VirtualBox interface

11.4 Virtual Machine

A **VM** contains its own software representation of the host's physical hardware, called **virtual hardware**. Virtual hardware includes the CPU, hard disk and network interface cards. The virtual hardware allows the VM to run a standard operating system called the guest OS.

11.5 Installing a VM

In this exercise you will learn how to install a VM.

Ask your lecturer for a Windows 8.1 installation disc to be able to complete this exercise.

Step 1
Open the VirtualBox hypervisor.

Step 2
Click on the New icon found in the top left hand corner of the Window.

Figure 98 – New icon Step 3

You will have to give your VM a name and select the operating system that you will be installing. Type in Windows 8 in the Name field; VirtualBox will automatically change the type and version for you. Click Next.

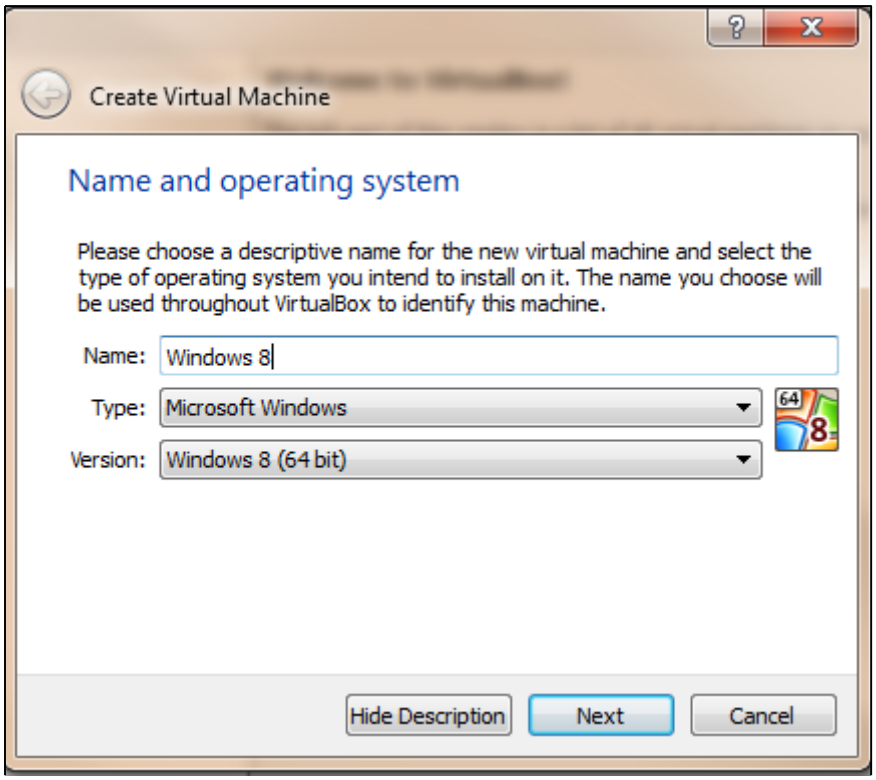


Figure 99 – Name and operating system

Step 4
VirtualBox will automatically select the amount of RAM that will be allocated to your VM. Accept the default size by clicking Next.

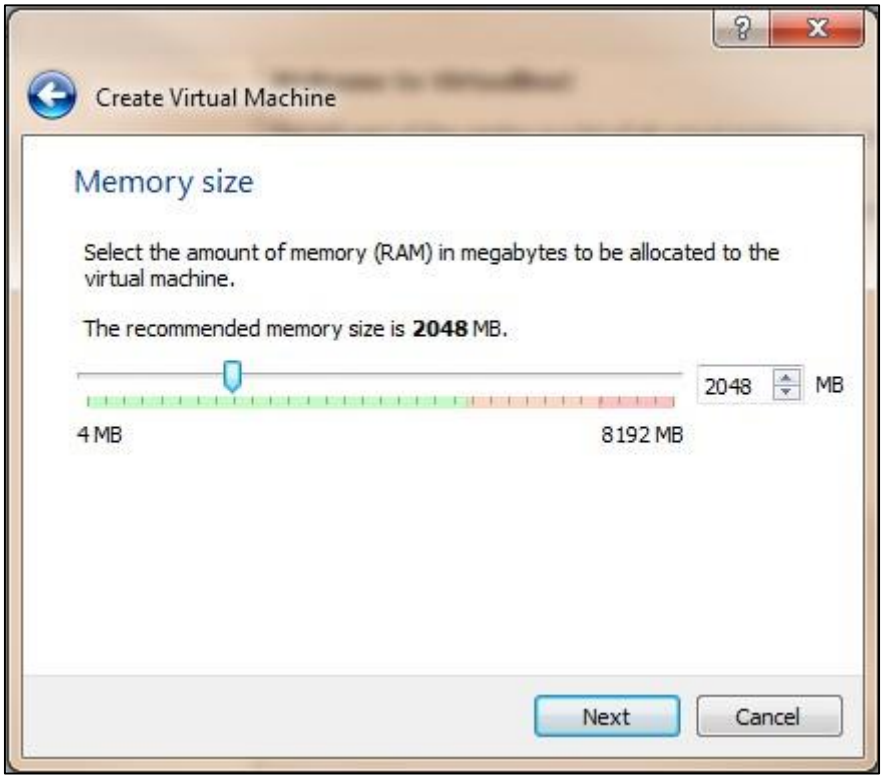


Figure 100 – Memory size Step 5

VirtualBox will display a recommended size for your VM's hard drive. Make sure the 'Create a virtual hard drive now' radio button is selected, and click Create.

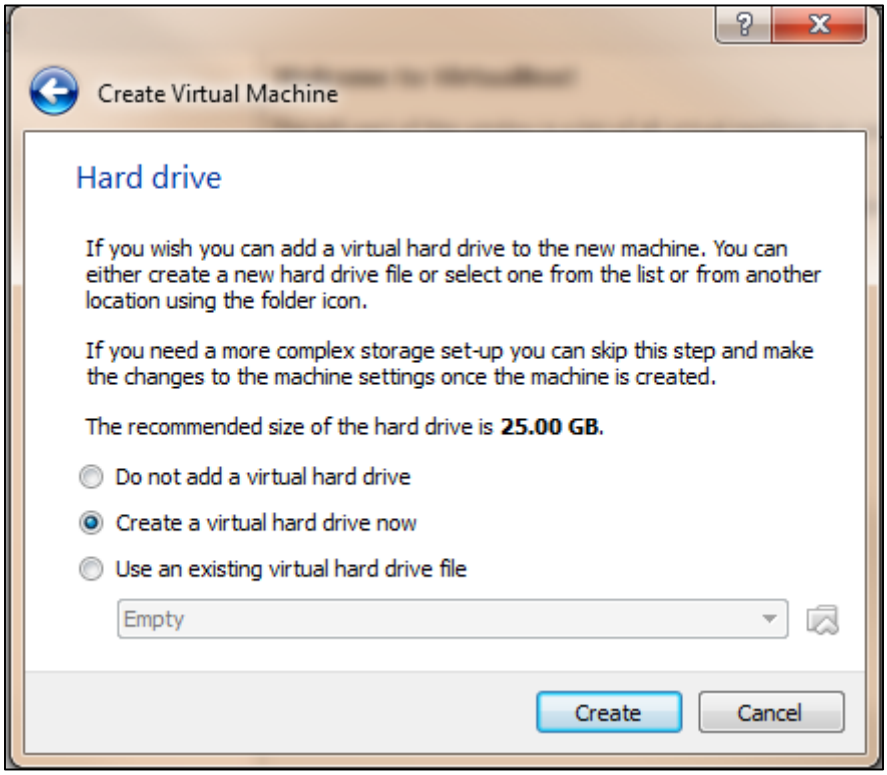


Figure 101 – Hard drive

Step 6
On the Hard drive file type, you will select the file type that your VM will be using. Click Next to accept the default file type.

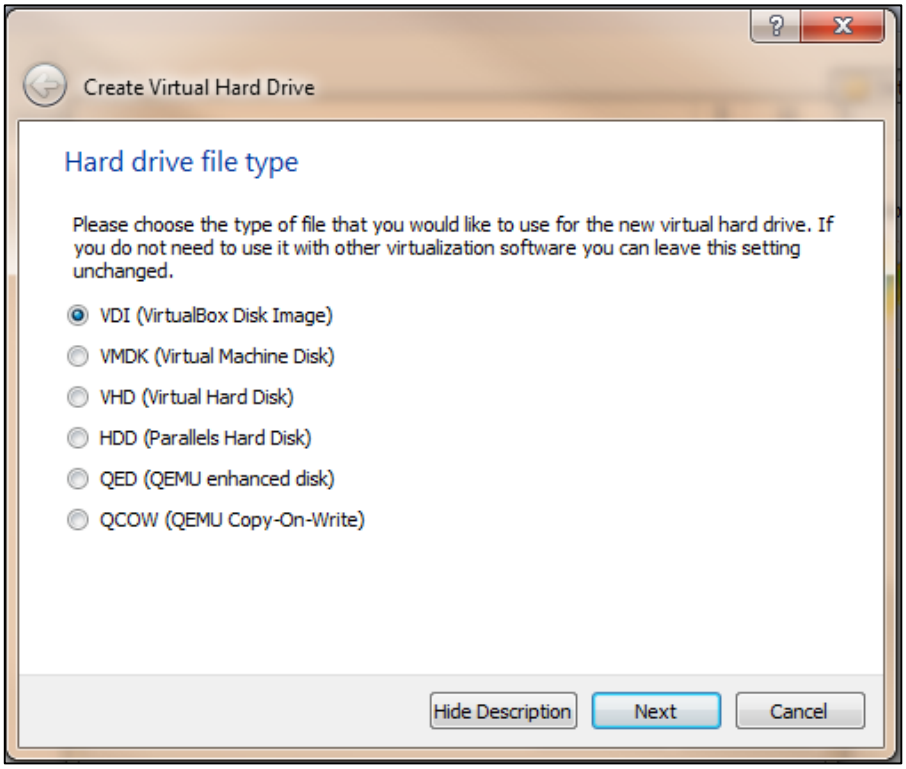


Figure 102 – Hard drive file type Step 7

The Storage on the physical hard drive page will allow you to select whether the VM hard drive file should grow as it is being used or if it will be a fixed size. Select the Dynamically allocated option, and click Next.

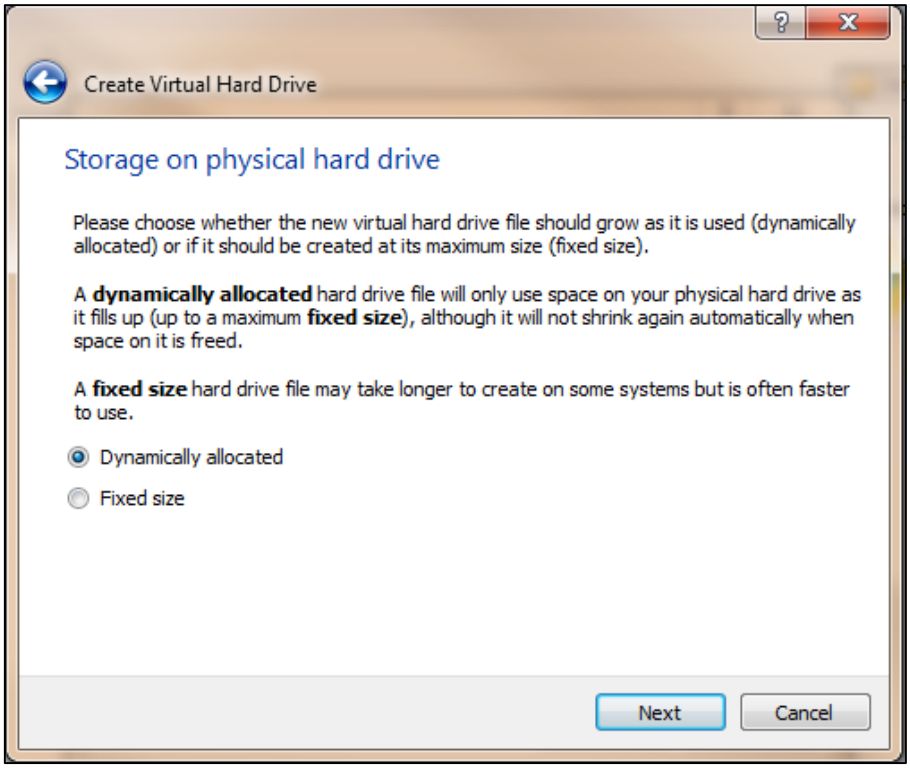


Figure 103 – Storage on physical hard drive

Step 8

On the File location and size page, you can select where the VM file will be saved and also change the size of the virtual hard drive. To accept the default, click Create.

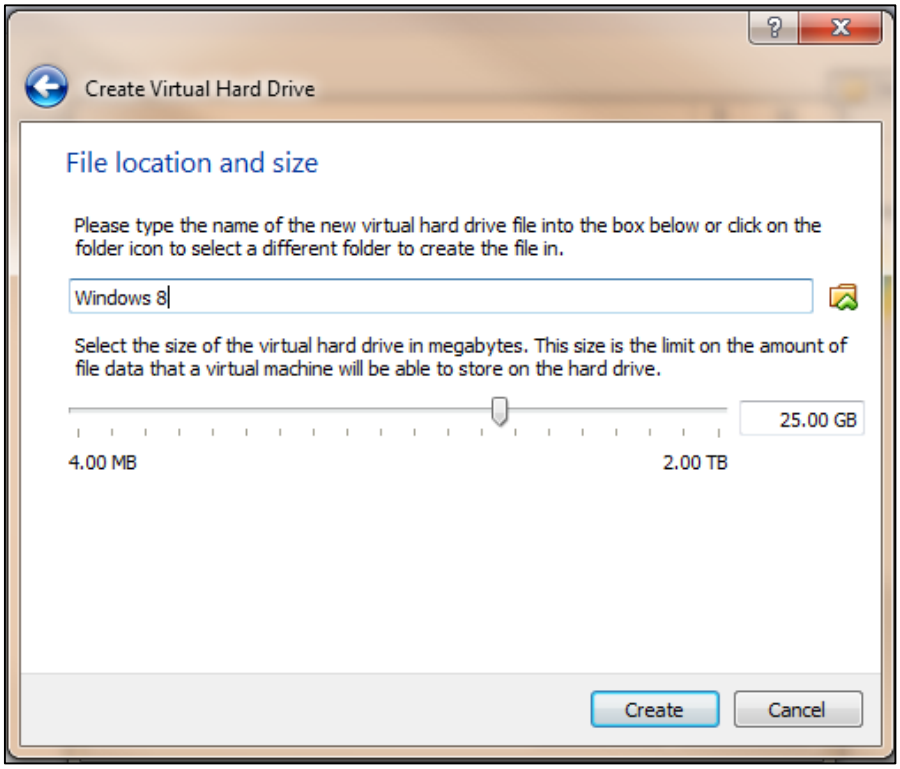


Figure 104 – File location and size

Step 9

Once you have created your VM, the VirtualBox Manager will be displayed, showing the newly created VM.

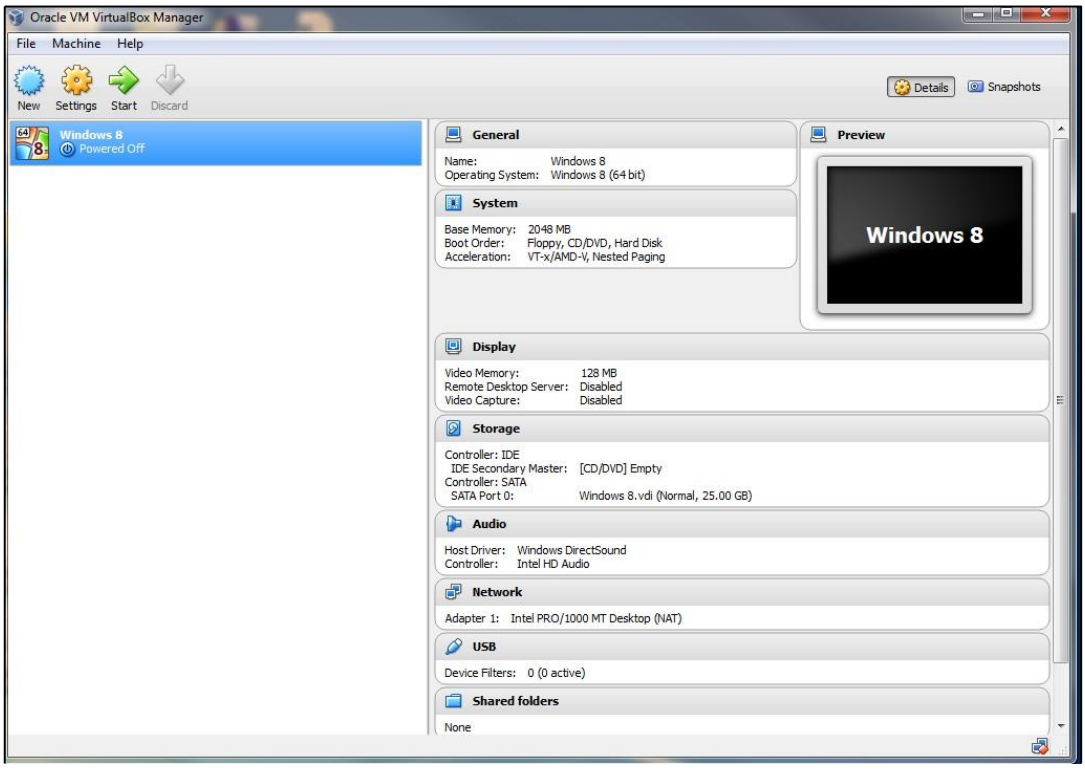


Figure 105 – VirtualBox Manager showing the newly created VM

Step 10
Before installing an OS on a VM, insert your installation disc in the CD/DVD drive. Click the Start button to begin to start your VM.

Step 11
A dialog box appears prompting you to select a virtual optical disk file or a physical optical drive. If you have multiple CD/DVD drives, you will have to select the one you will be using to install Windows. If you have one CD/DVD drive, VirtualBox will automatically select the drive for you. Click Start.

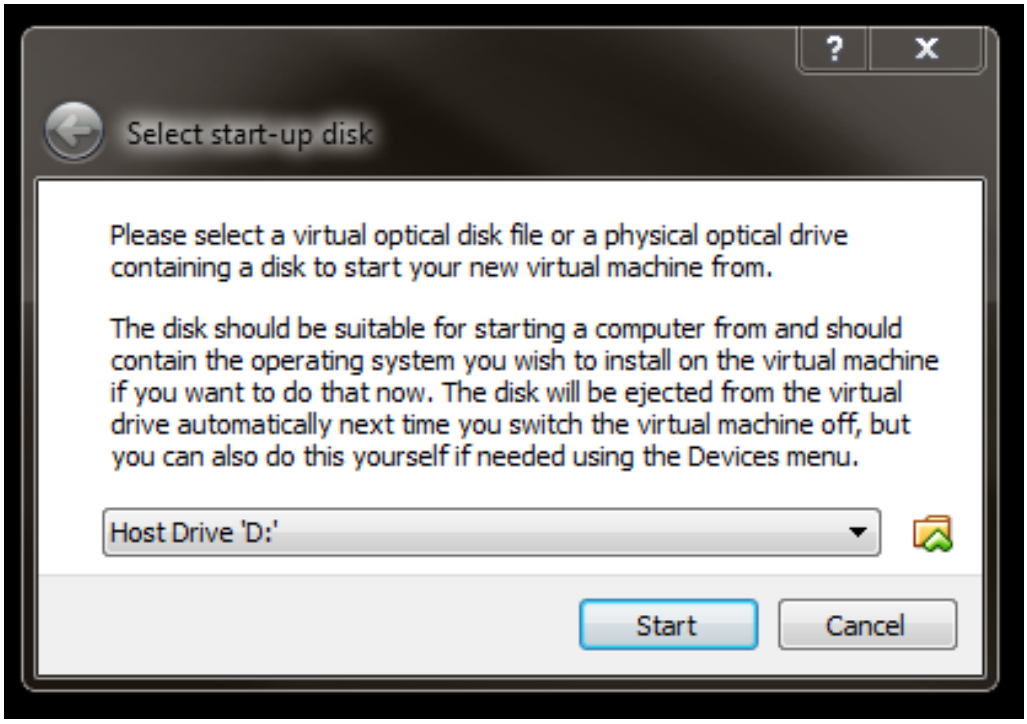


Figure 106 – Select start-up drive

Step 12

When the Windows Setup window appears, select the correct time and currency format, and click Next.

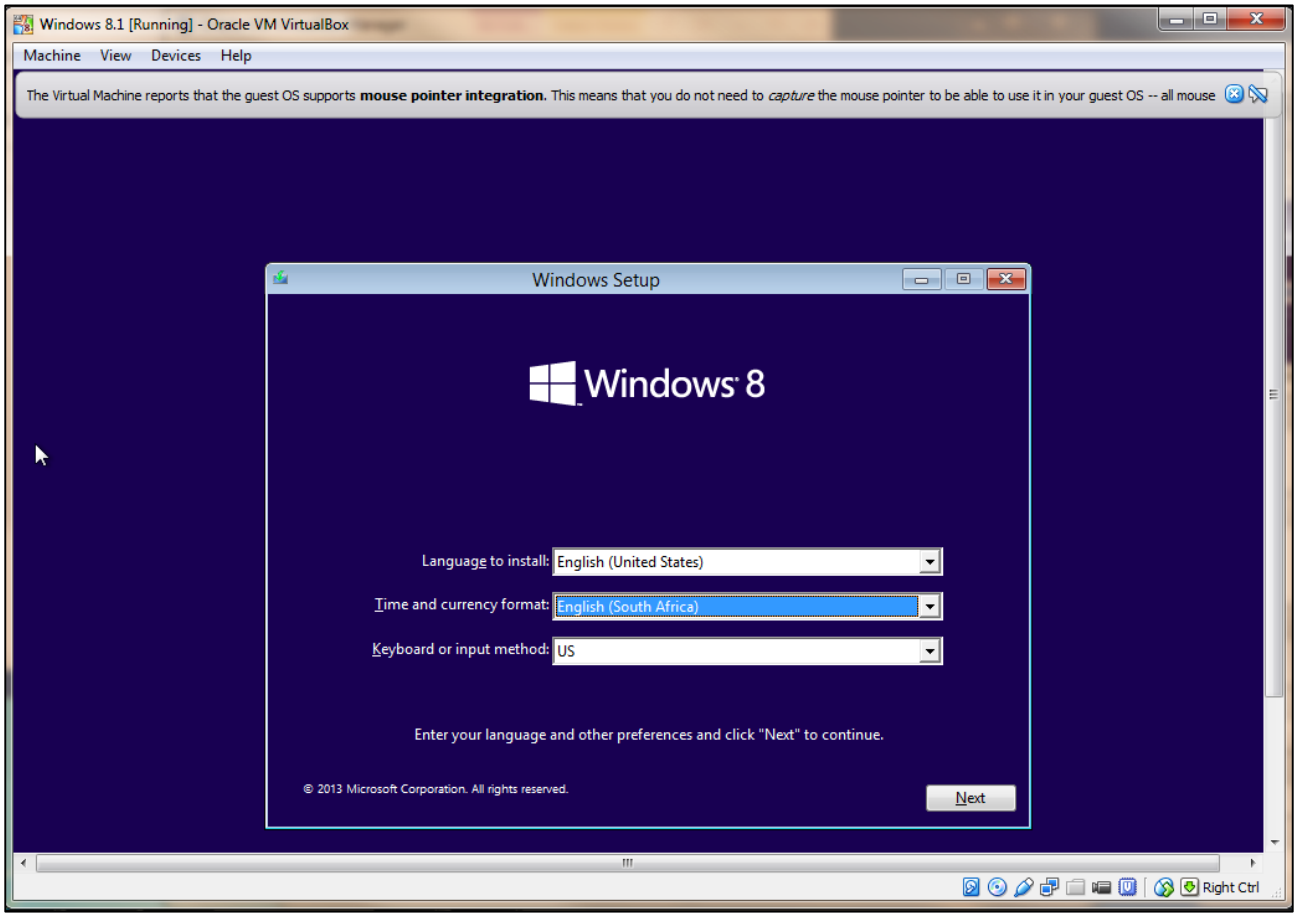


Figure 107 – Windows Setup

Step 13
Click Install now.

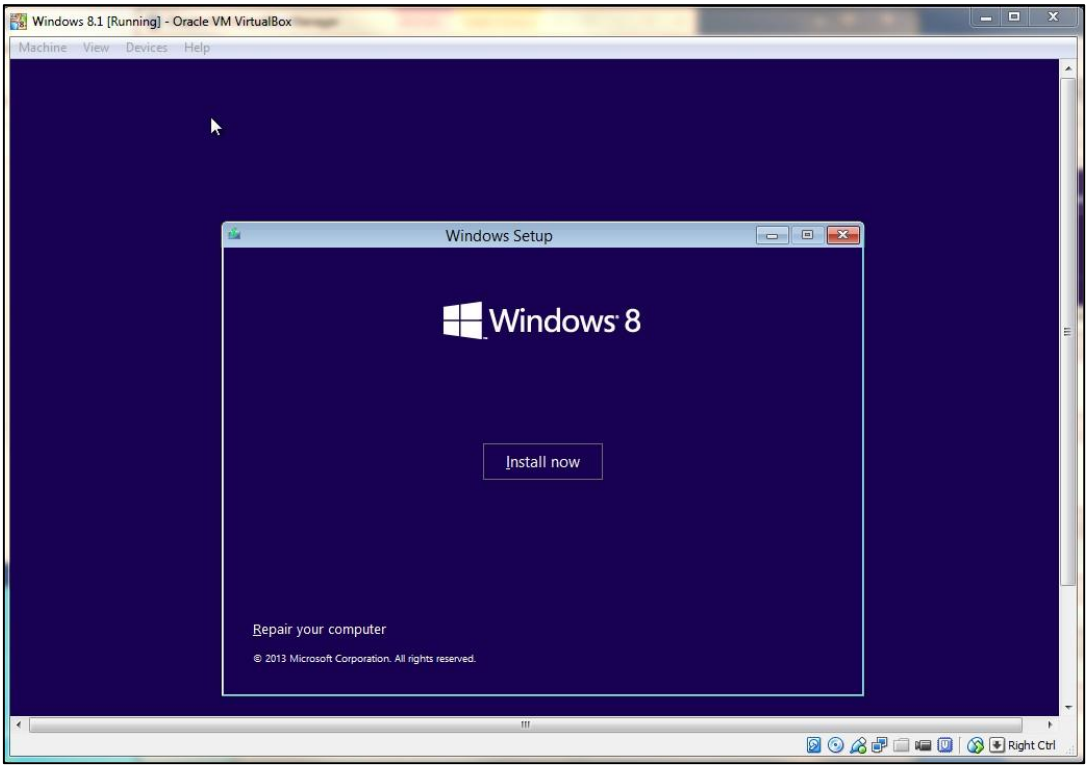


Figure 108 – Install now option

Step 14
To accept the License terms, check the check box at the bottom of the License terms window, and click Next.

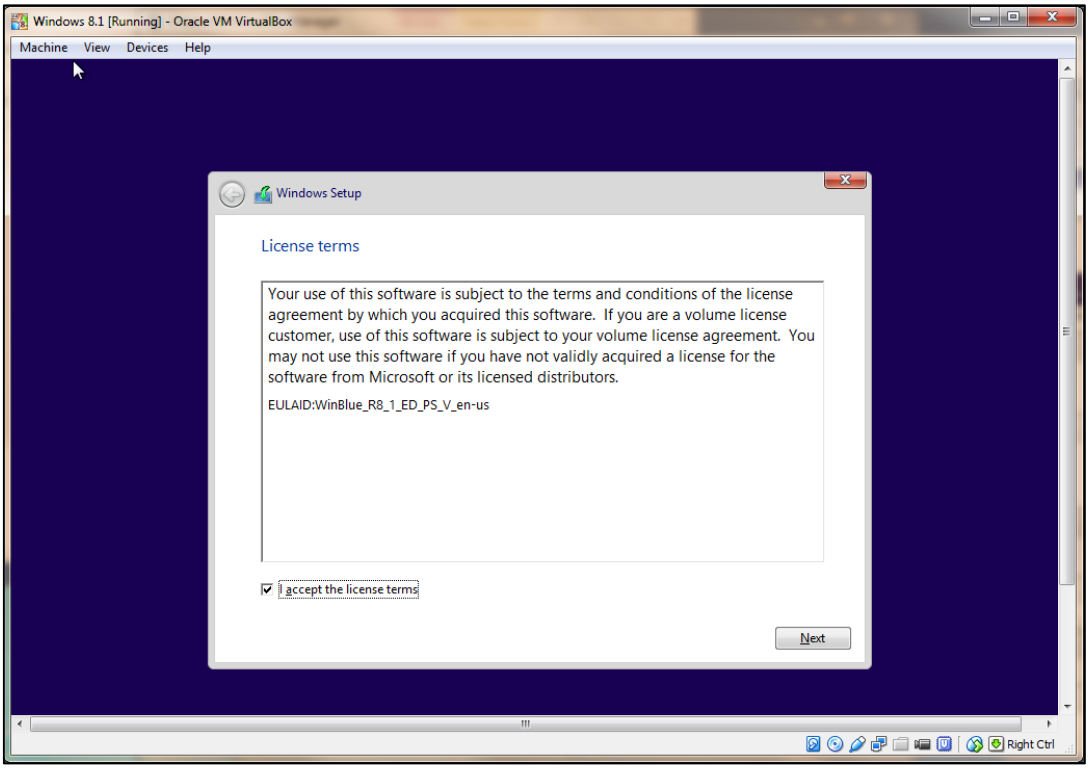


Figure 109 – License terms Step 15

When you see the question 'Which type of installation do you want?', click on Custom: Install Windows only (advanced).

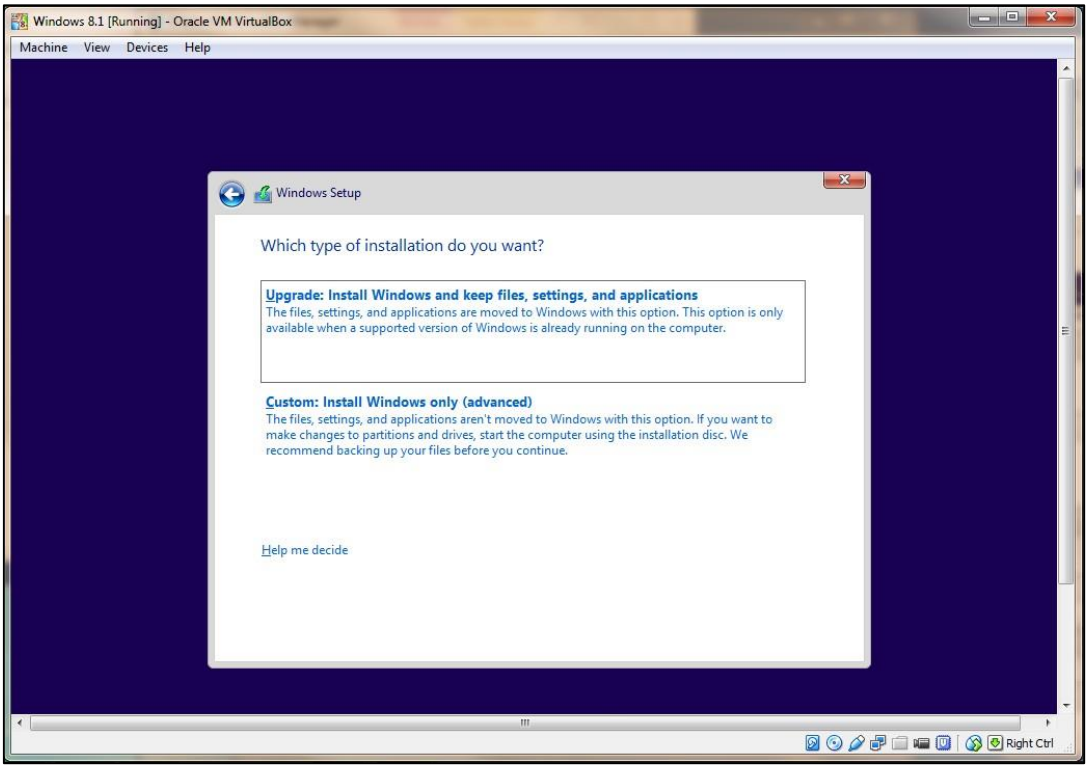


Figure 110 – Which type of installation do you want?

Step 16
Select 'Where do you want to install Windows?' Since this is a VM, you have already located where you want your Windows to be installed. Click Next.

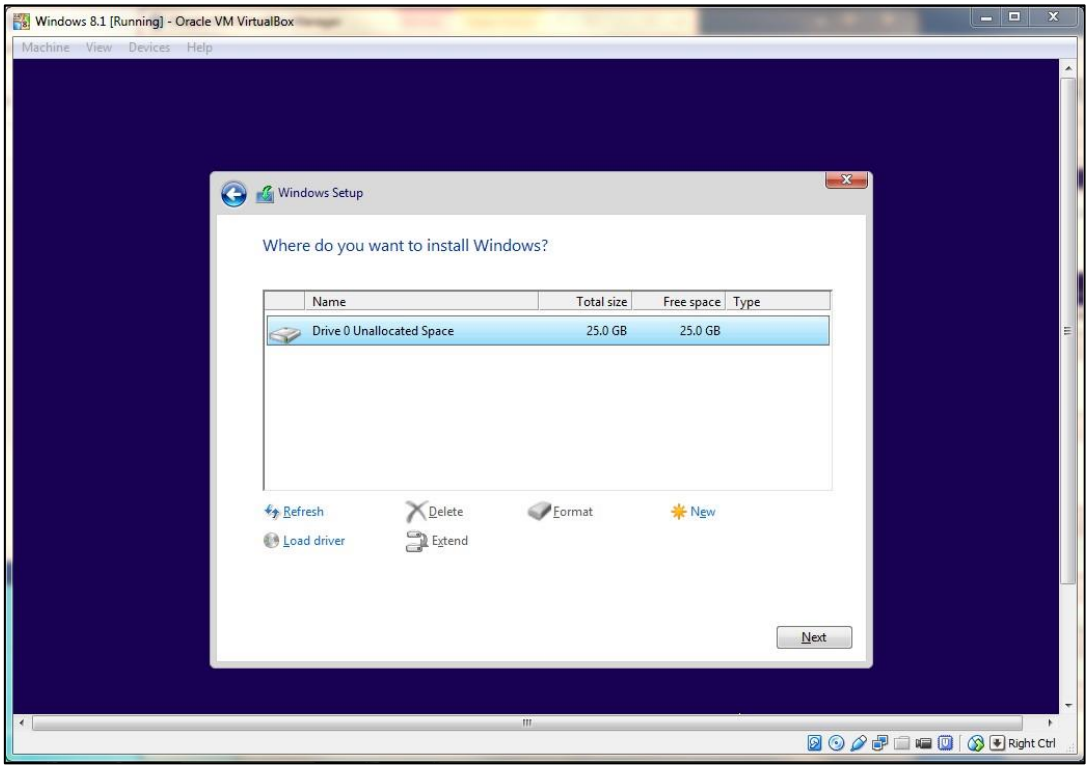


Figure 111 – Where do you want to install Windows? Step 17

Windows will start installing. Your VM may reboot several times; do not close your VM or stop your VM. This will halt the installation process.

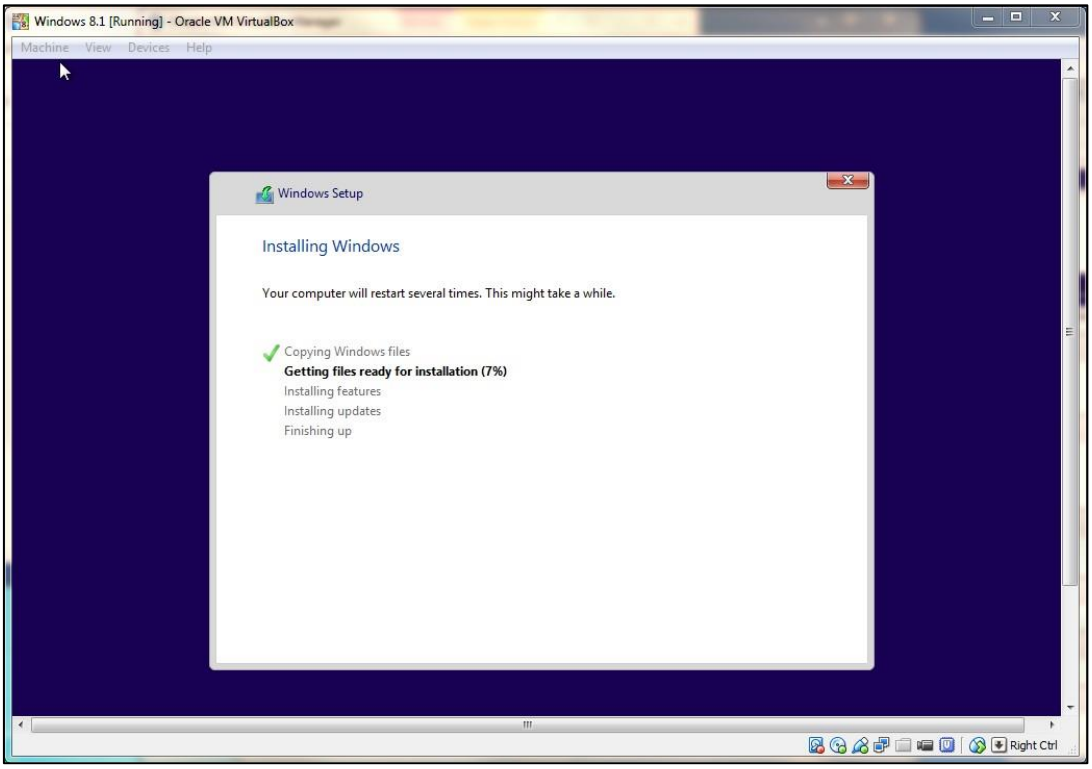


Figure 112 – Installing Windows

Step 17
The Personalize screen will appear. Here you may choose a PC name and pick a colour you would like for your PC. If you cannot see the entire Personalize screen, use the scroll bars on the right. Scroll down, and click the Next button.

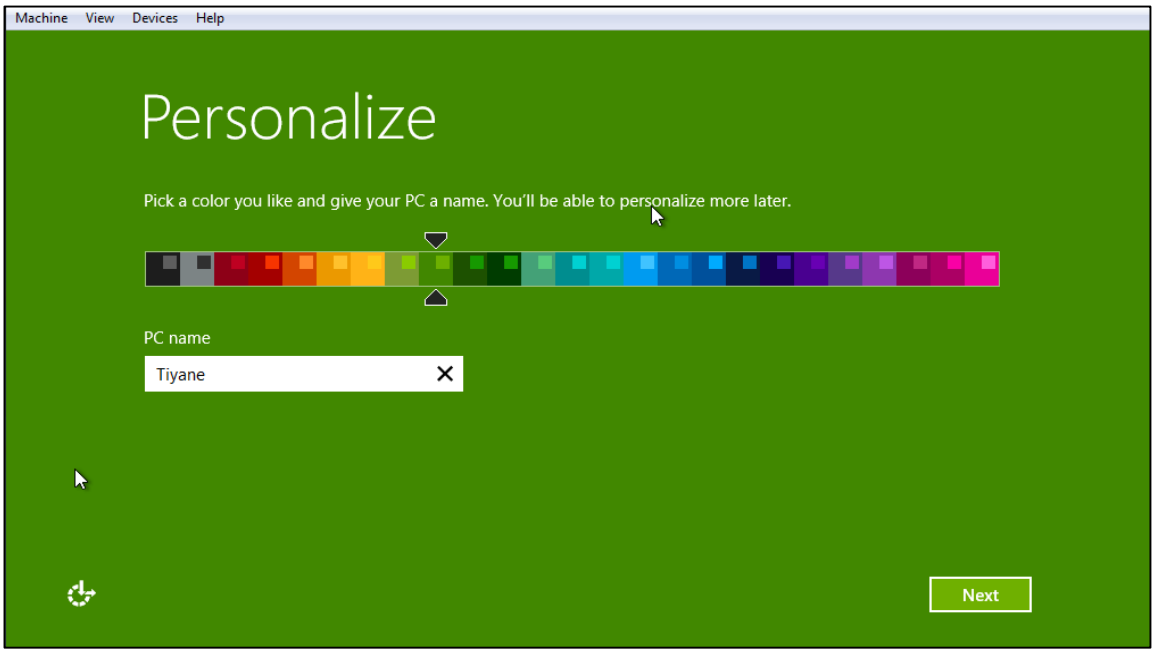


Figure 113 - Personalize

Step 18
On the Settings screen, click Customize.

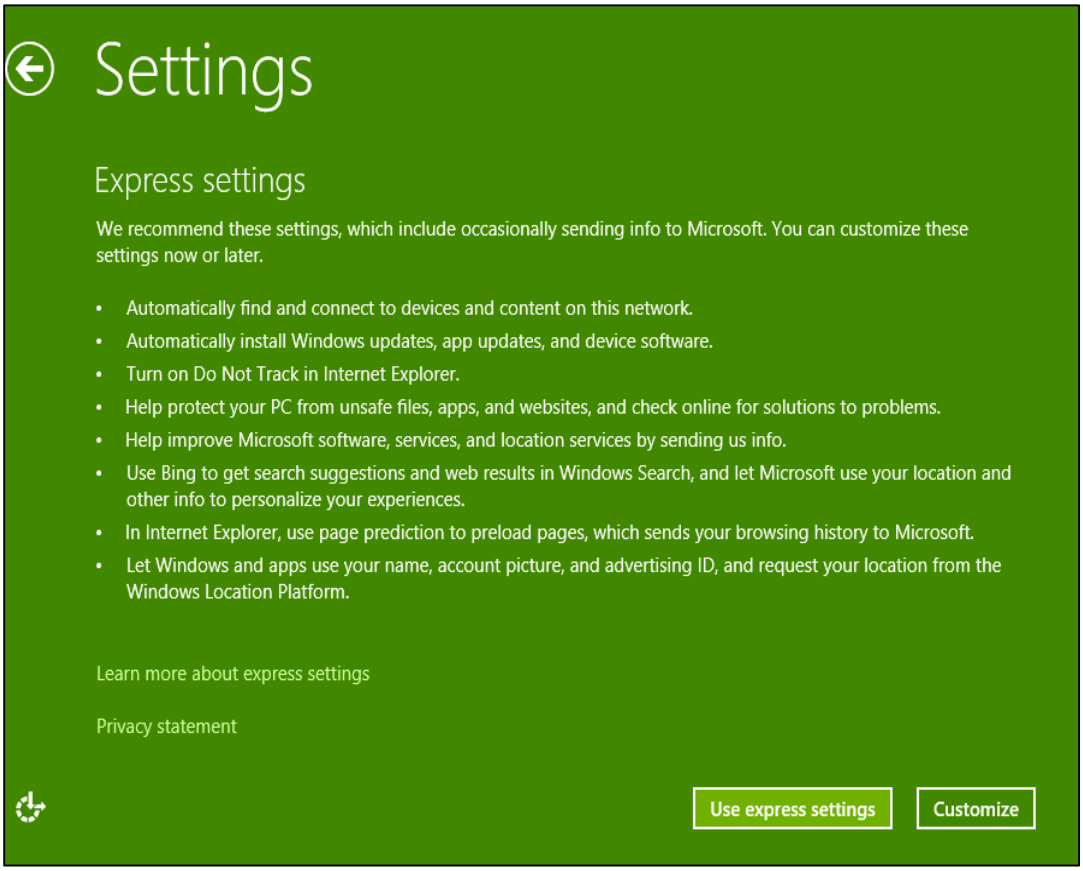


Figure 114 - Settings

Step 19
In the network section of the settings, click 'No' For networks in public places.

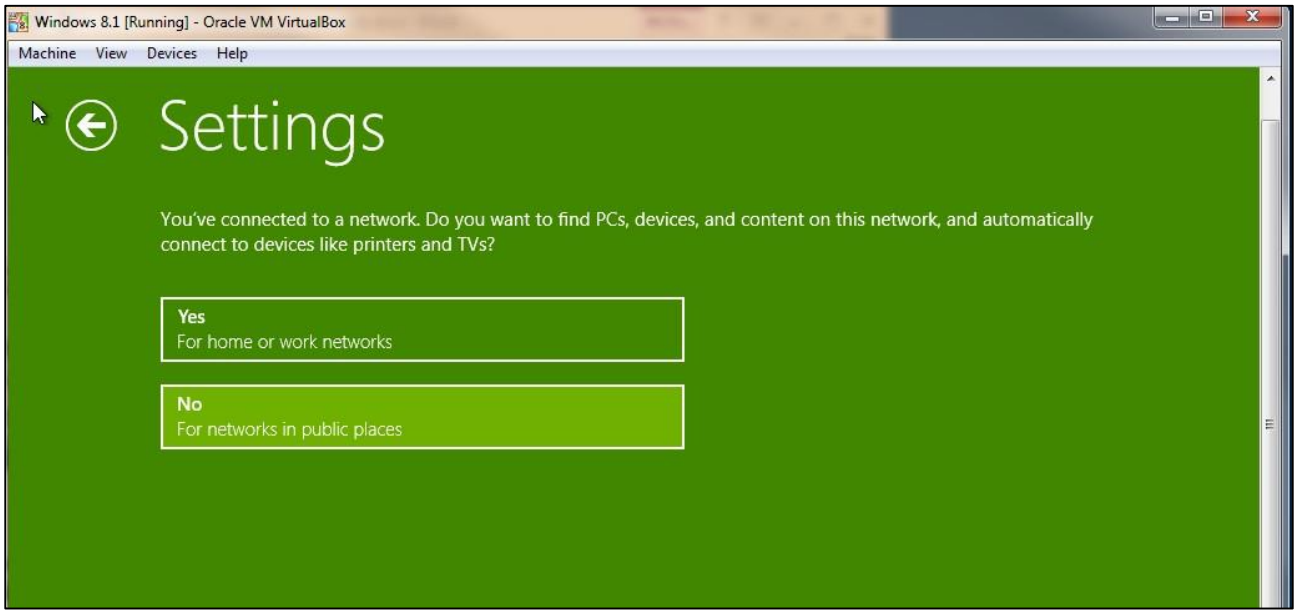


Figure 115 – Connect your PC to a network Step 20

Click Next to accept the defaults of how your PC should run updates.

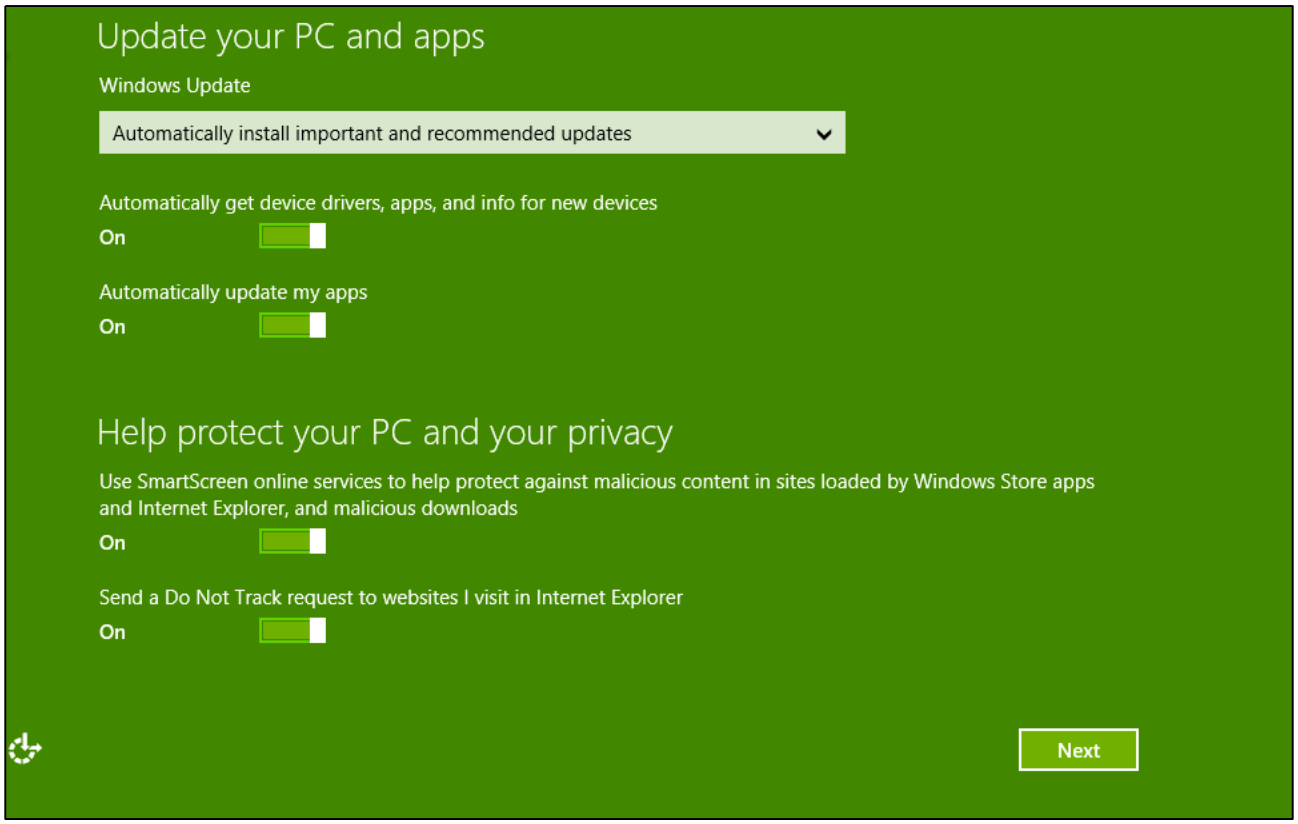


Figure 116 – Update your PC and apps

Step 21

Click Next to accept the defaults of how Windows checks for online solutions and how Windows will help improve Microsoft products and services.

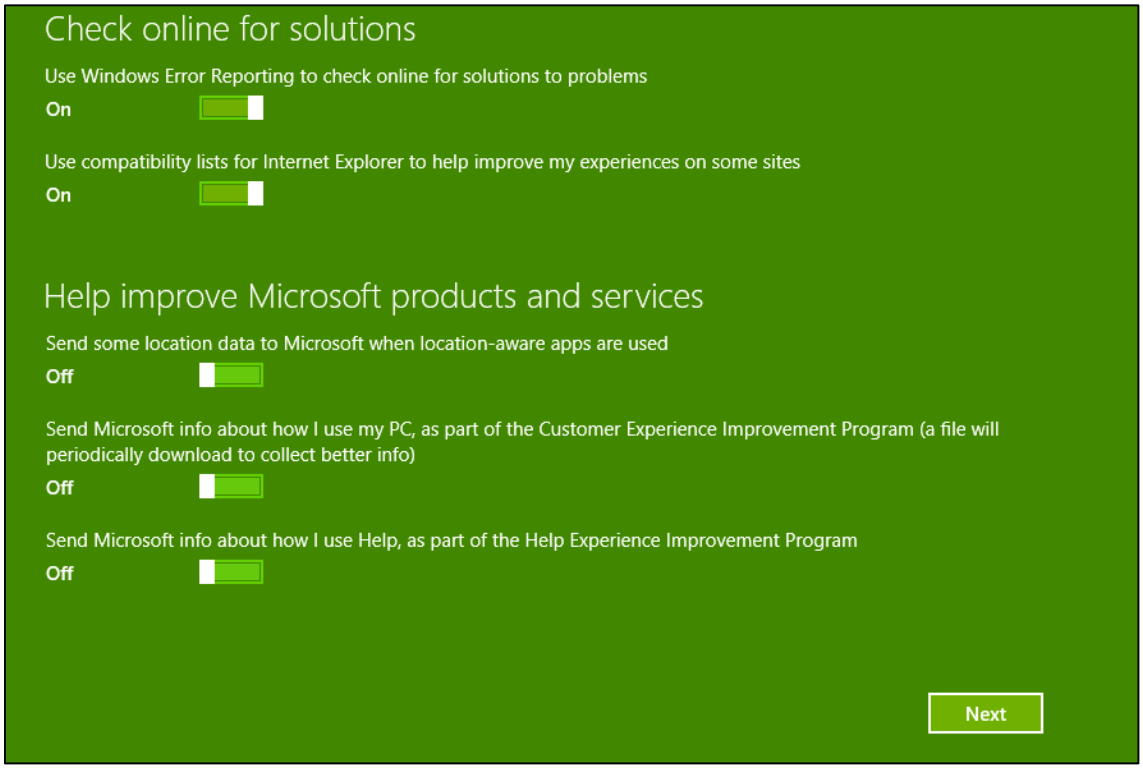


Figure 117 – Check online for solutions and help improve Microsoft products and services

Step 22

Click Next to accept default of how you share information with Microsoft and other services.

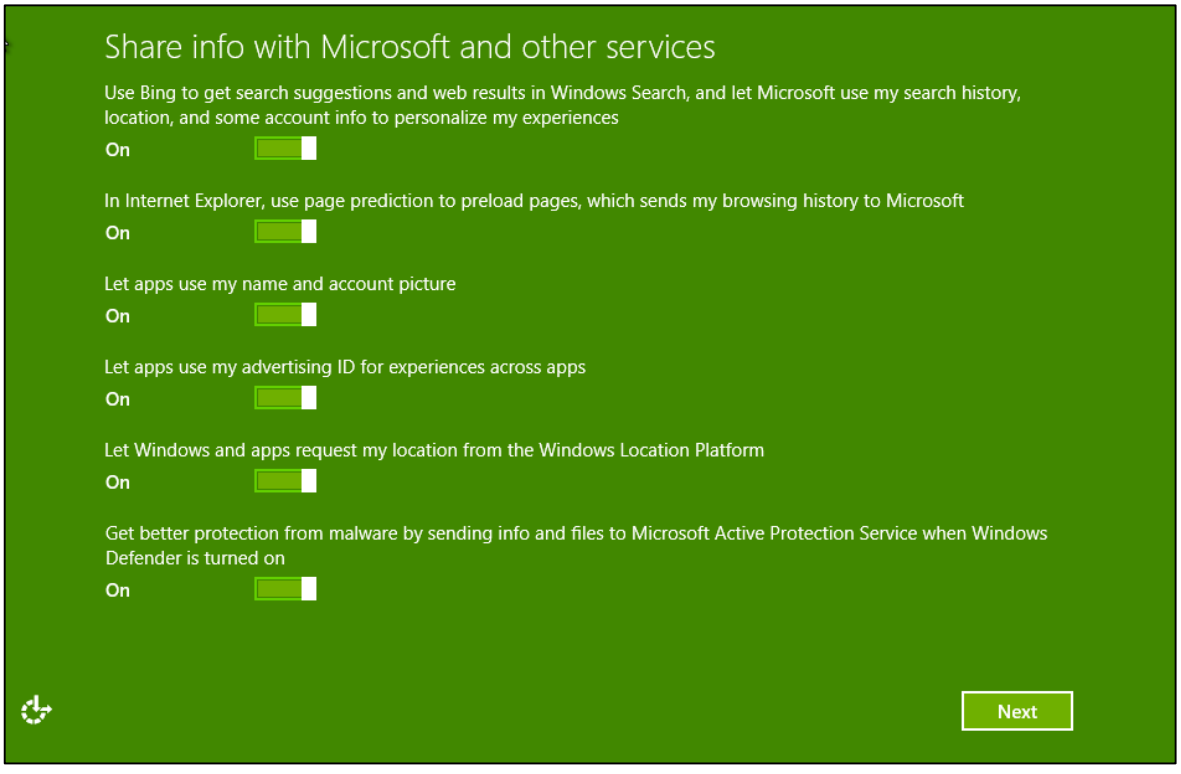


Figure 118 – Share information with Microsoft and other services

Step 23
Enter your Microsoft account. If you do not have an Internet connection, the connection will fail.

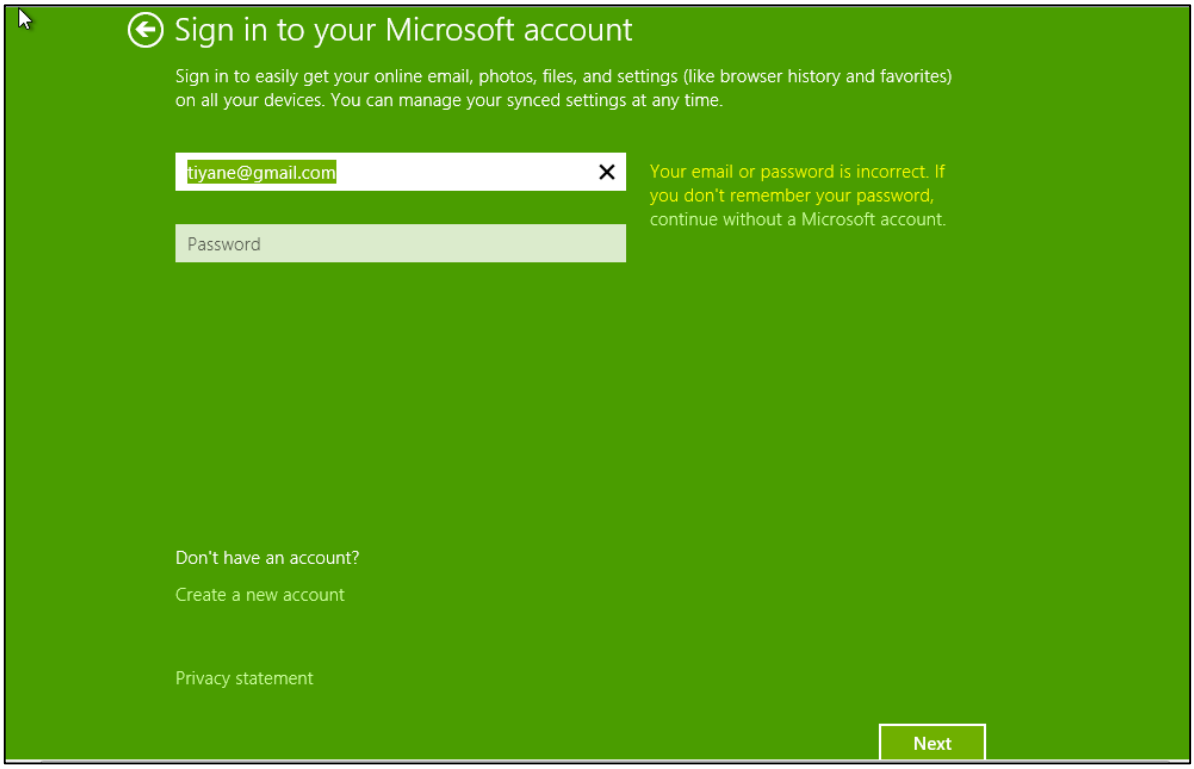


Figure 119 – Your email or password is incorrect

Step 24

Click Continue without a Microsoft account. On the next screen, click Create a local account.

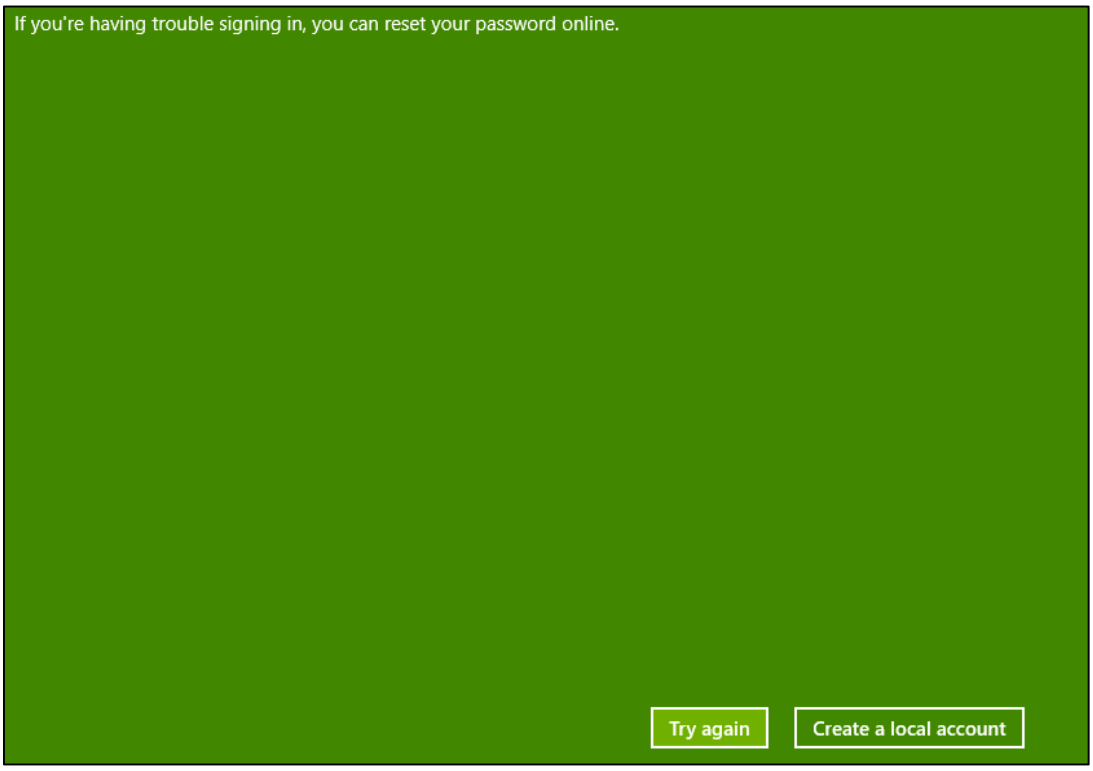


Figure 120 – Create a local account

Step 25
Add a username and password. Then click Finish.

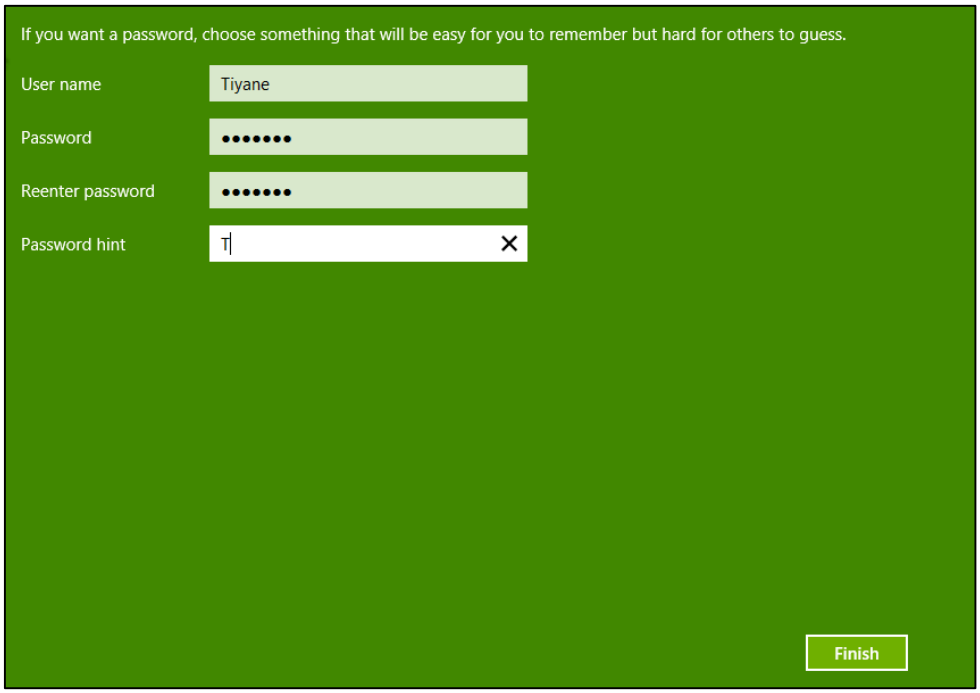


Figure 121 – Create a user name and password Step 26

Windows will be done installing when the Windows 8 desktop appears. You may now remove the installation disc.

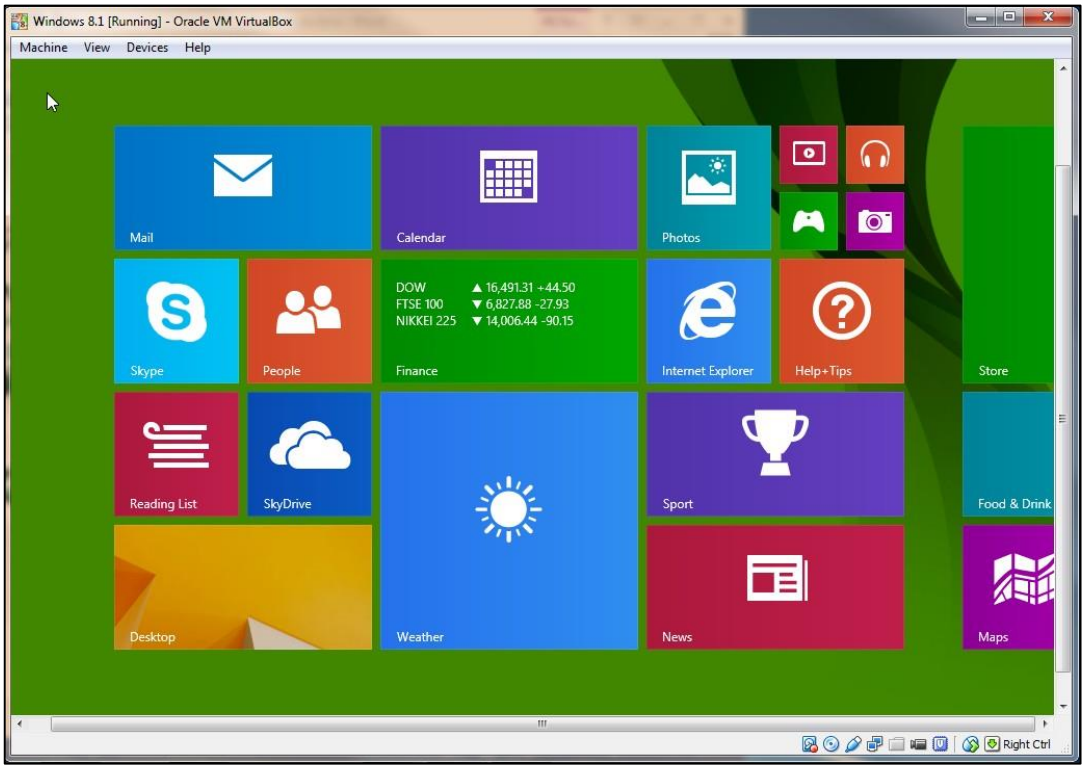


Figure 122 – Windows 8 desktop

NOTE	This module only covers how to install Windows 8. You may continue exploring the interface and the different features offered in Windows 8.

11.6 Capturing and releasing keyboard and mouse

If a click mouse warning message appears at the top of the VM after you have clicked inside the VM window, click the close button.

Figure 123 – Mouse pointer integration warning message

To activate the VM, all you need to do is click inside the VM window or on the title bar. The VM will then own the mouse and/or keyboard so that you can use them. To return ownership to the host, simply click outside the VM window.

11.6.1 Typing special characters

Some key combinations are reserved for host operating systems only. For example, you will not be able to enter **<Ctrl> + <Alt> + <Delete>** to reboot the guest OS, because this key combination is usually hardwired into the host OS and will therefore reboot the host, not the guest. If instead you want to send these key combinations to the guest OS, you can:

- Use the item in the **Machine** menu of the running VM. For example, there you will find **Insert Ctrl+Alt+Delete**. See Figure 124.

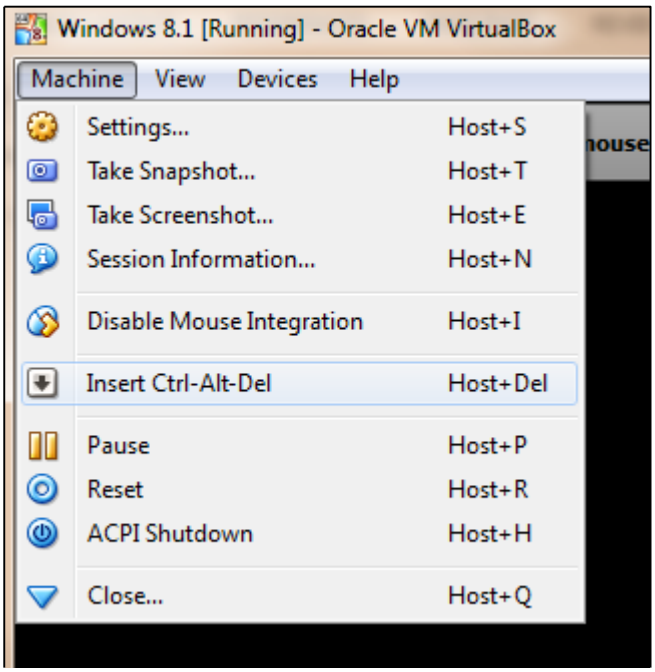


Figure 124 - VM Machine menu

- Press special key combinations with the Host key, which VirtualBox will translate for the VM. For example, **<Host > + <Del>** will send **<Ctrl>+<Alt>+<Del>** to the guest (to reboot it).

For **<Alt> + <Tab>** (to switch between open windows) and some other keyboard combinations, you can configure whether the host or guest will be affected by these combinations by configuring the settings in **File > Preferences > Input > Auto-capture keyboard**.

Answers to Review Questions

Unit 1

1. What component allows all devices to communicate with one another?

   The motherboard.

   [1]

2. What is another name for a motherboard?

   Circuit board (1). It could also be called a system board or main board. [1]

3. Name at least three of the most common motherboard manufacturers.

   VIA, SIS, Asus, Abit, Gigabyte, MSI, Intel. [3]

4. Name at least two characteristics that the motherboard form factor describes.

   - **Physical layout.**
   - **Shape, type of case, power supply.**

   [2]

5. There are two types of software. Give a description of each type.

   - **System – Controls the start-up of your computer and the central controlling thereafter.**
   - **Application – Programs used to control specific tasks such as editing a document.**

   [4]

6. Complete the following table.

No.	Question	USB	Firewire
1	List three supported devices	**Mouse, keyboard, cell phones, external drives**	**Camcorders, satellite receivers, video cameras**
2	Transfer rates	USB 1.1: **12 Mbps** USB 2.0: **480 Mbps** USB 3.0: **5 Gbps**	IEEE 1394a: **400 MHz** IEEE 1394b: **800 MHz**
3	Supports up to _____ devices.	**127**	**63**
4	USB type A connects to the …… USB type B connects to the ……	**Host/hub ports** **Device**	

[15]

7. Give a definition of a motherboard.

   A motherboard is the main circuit board. It connects all of the other computer components together and allows them to communicate with one another.

   [2]

Total: 28 marks

Unit 2

1. What are the four major functions of the CPU?

The first is to fetch instructions from the main computer's memory. Fetching instructions may also include reading data from an I/O module. This is then followed by the decode phase where instructions are decoded to decide what action will need to be taken. Once that has happened, the CPU will execute the desired operation. The final operation of the CPU is to writeback where the data of an executed task is analysed and results are written to the memory or I/O modules.

[8]

2. Clock speed is measured in **MHz** or **GHz**.

[1]

3. Give the definition of the following processor components:

3.1 Cache memory

Storage area for frequently used data and instructions.

3.2 DMA

Devices bypass the CPU to access memory directly.

3.3 Dual core

Two processors on the same chip.

3.4 Dual pumped

Refers to how much data is capable of being transferred per clock cycle.

[4]

4. List the IRQ and the default assignments from 1-15.

Consult Table 7 for the answers.

[15]

5. When does a DMA occur?

Direct Memory Access (DMA) occurs when a device bypasses the CPU and writes information directly into memory.

[2]

Total: 30 marks

Unit 3

1. Complete the following:

1.1 **RDRAM** is a proprietary variant of DRAM. [1]

1.2 **NVRAM** uses flash memory and retains the contents of its memory when power is turned off. [1]

2. Answer True or False:
RAM is volatile.

True

[1]

3. Complete the table with definitions for the given terms.

Term	Definition
RAM	**Random Access Memory, Working Space, Temporary Memory/Volatile lost when power is switched off.**
ROM	**Read Only Memory, Permanent Memory used to store information on how a device should operate/BIOS.**
FIRMWARE	**Device containing both hardware and software. Program that runs within an electronic device.**

[6]

4. Explain briefly why the different DIMM modules are not compatible with each other.

DIMMs are not compatible due to **pin density** and **notch positions**. [2]

Total: 11 marks

Unit 4

1. What is the main function of a power supply?

To convert AC voltages to DC voltages for the motherboard components. [1]

2. Mention two internal computer components that could require additional power.

Tape drives
Ventilation fans
Certain graphics cards [2]

3. List the three available voltages used by a computer.

3.3, 5 and **12** [3]

4. How many pins do the following connectors have?

4.1 ATX Power connector to the motherboard

20 pins [1]

4.2 SATA Power connector

15 pins [1]

5. Provide a solution to each of the following problems.

Problem	Solution
The computer is close to a source of radio waves that cause RFI.	**Line Conditioner**
A server containing crucial information needs constant power supply to the PC.	**Uninterruptible Power Supply (UPS)**

[2]

Total: 10 marks

Unit 5

1. Match the description to the term:

a) The process of writing index marks to the surface of the disk to enable the heads to locate tracks and sectors.
b) The logical structure and software routines used to control access to storage on a hard disk.

1.1	File system	**b**	[1]
1.2	Low-level formatting	**a**	[1]

2. List the physical and logical components of a hard drive.

- **Platters – Magnetic coated glass or metal disks that are stacked on top of each other like a spindle, which then spin together at high speeds. This is where the data is stored.**
- **Read/write head – Used to transfer data to and from a platter.**
- **Actuator arm and axis – The arm that is used to move the read/write heads over the surface of the platters.**
- **Actuator – The motor that moves the actuator arm.**
- **Tracks – The data storage ring where the hard drive is capable of containing information.**
- **Sectors – Tracks are divided into a wedge shaped section of one of the circular tracks. A sector holds bet**ween 512 bytes and 4 KB of data **and is the smallest unit of storage on a platter.**
- **Clusters – A cluster is a group of multiple sectors. This is where files are written to.**
- **Cylinders – One corresponding track on all surfaces of all platters is called a cylinder. For example, cylinder 0 is made up of all track 0s on all platters inside the hard drive; cylinder 1 is made up of all track 1s on all platters, and so on.**

[16]

3. Complete the table.

No	Compare	PATA	SATA
1	Interface	**Parallel**	**Serial**
2	Drive connector	**40 pin**	**7 pin**
3	Cable	**45 cm**	**1m**
4	Power connector	**4 pin Molex**	**15 pin**

[8]

4. Give a short description of the technology used by the SATA drives.

Serial Advanced Technology Attachment uses serial data transmissions to transfer data between a computer and a mass storage device, such as a hard disk drive or optical drive.

[2]

5. Complete the table.

CD/DVD format	Storage capacity
DVD-ROM	**4.7–17 GB**
CD-ROM	**700 MB or 185 MB**
Blu-ray	**25 GB per layer**

[3]

Total: 31 marks

Unit 6

1. List three major components of the graphics card and give a short description of each.

   CPU – graphics card microprocessor carries out instructions for the OS.
   Video Memory – temporary store for processed images, buffers, textures, display images.
   Video BIOS – memory chip that stores the graphics card configuration data. The video BIOS or firmware is a basic program that provides instructions that allow the computer and software to interact with the card.

   [6]

2. Match the graphics card port/connector to the device it connects to.

2.1 Flat panel displays (LCD or plasma screens)

   DVI (HDMI is also popular) [1]

2.2 CRT displays

   HD-15F

   [1]

3. Give one advantage of using the port given in the answer to 2.1 over the port given in the answer to 2.2.

   No image distortion.
   No electrical noise. [1]

4. **SXGA** is generally the video standard used for the native 17" and 19" LCD monitors at a resolution of **1280x1024**.

   [2]

5. Answer True or False:

   The higher the screen resolution, the less information is displayed on the screen.

   False [1]

Total: 12 marks

Unit 7

1. List **two** common input devices.

   Mouse, keyboard, scanner

   [2]

2. List **two** common output devices.

   Monitor, speaker, headset

   [2]

3. List the **two** types of keyboards and their uses.

   Wireless – used for transportability.
   Multimedia kb – special keys for accessing music, Web or other programs.
   Gaming kb – allows keystroke combinations to be assigned to one keystroke. [4]

4. List two types of mouse connectors.

   USB & PS/2 [2]

5. List two types of scanners.

   Flatbed and handheld [2]

6. Name the type of printers used for:

   6.1 printing photos – **dye sublimation**

   6.2 printing technical drawings – **plotters** [2]

7. Select the correct answers. Circle all that apply.

   A keyboard uses a:

   a) PS/2
   b) DIN-2 connector
   c) USB connector
   d) DB-25 connector. [2]

8. How do you clean a keyboard?

   Use a soft, damp cloth and a mild detergent to clean any dirt. Ensure that the keyboard is completely dry before using it again.

   The keyboard can be submerged in a bucket of distilled, demineralised water if you happen to spill anything on the keyboard. Ensure that the keyboard is completely dry before using it again.

   [1]

Total: 17 marks

Unit 8

1. List three variants of internetworks.

   Internet
   Extranet
   Intranet [3]

2. Differentiate between a server, host and a workstation.

   Server – Larger hardware requirements, provides resources to network clients.
   Workstation – User's computer connected to the network.
   Host – Any network device with an IP address. [3]

3. Give definitions for the following:

   Ring topology
   Computers are either directly attached in a ring or communicate via a multi-station access unit. Each computer regenerates the signal.

   Bus topology
   Each computer is connected to a single cable.

   LAN
   Local area network – A network in a small area like a home, office or building.

   GAN
   Global area network – Model for supporting mobile communications across a number of wireless LANs.

   Routers
   Determine the best route to forward data packets across a network and connect networks together. [5]

4. Name the seven layers of the OSI model.

   7. **Application**
   6. **Presentation**
   5. **Session**
   4. **Transport**
   3. **Network**
   2. **Data**
   1. **Physical** [7]

Total: 18 marks

Unit 9

1. List **six** handling rules a technician should remember when repairing a computer.

   - **Most electrically sensitive hardware components come in an anti-static bag, which is designed to protect the electronics from stray static charges. Leave components in these bags until they are ready to be installed.**
   - **Turn off the computer and unplug the power supply before you remove the computer case. Although there is hardly any shock hazard when the computer is turned on, you might accidentally touch a component with a screwdriver. This could short-circuit that component.**
   - **If possible, ground yourself before you touch the inside of a computer. This will discharge any build-up of static electricity that could cause damage to components. The easiest way to ground yourself is to touch the metal casing of the computer.**
   - **Place the computer on a solid, well-lit surface.**
   - **It is always good practice to keep a small, compartmentalised container to store screws and other small parts.**
   - **Never use excessive force. In most cases, a gentle nudge or pull will loosen the component. If a component does not fit, it is most likely in the wrong slot or it is the wrong way around.**
   - **Keep a mental picture/draw a diagram of where cables are attached.**

   [6]

2. Circle the correct answer.

   ESD is an acronym for:

   a) Electric System Degradation
   b) Electrostatic Discharge
   c) Electro Silicon Discharge
   d) None of these. [1]

3. Is the following statement True or False?

   Electrostatic discharge occurs when two objects of a similar charge come into contact with each another.

   False [1]

4. Circle the correct answer.

   Relative humidity should be maintained at:

   a) 50%
   b) 90%
   c) 70%
   d) 40% [1]

5. List the **two** types of cases discussed in this unit.

   Tower
   Desktop [2]

6. When repairing a computer, what is the name of the most commonly used screwdriver?

   Phillips Screwdriver is the most common. However, there are various other screwdrivers that can be used.

   [1]

7. What is the danger of leaving a loose screw in the computer?

   It could cause a short circuit. [1]

Total: 13 marks

Unit 10

1. When you turn your computer on, nothing happens. The monitor does not come on and the power supply fan is not running. You switch the computer off and on again and still nothing happens. What is the most likely cause?

   No power is supplied to the PC. Could be from the main power supply or a faulty power supply. [2]

2. Your computer is experiencing random problems. These problems disappear as soon as you reboot the computer. What should you do to prevent this from happening?

   This is normally associated with RAM problems such as chip creep. Regularly check that RAM modules are properly inserted or replace RAM if necessary. [2]

3. You have just installed a new sound card in your computer. When you boot the computer, the card is not recognised. In addition, your modem that has always worked has stopped working. What is the most likely cause?

   There is an IRQ conflict. [2]

4. You have just installed an additional hard drive but the hard drive is not detected when you switch the PC on. What is the most likely cause? What is a solution to this problem?

   It could be an incorrect jumper setting. Check and change the setting if necessary. [2]

   Alternatively, the hard drive is not automatically detected. Put it on auto detect in the BIOS. Also check the cable and connectors as well as power to the device. It could also be a faulty hard drive.

   [2]

Total: 10 marks

Examination Requirements

Examination

The examination will be made up of a theory and a practical examination. The theory examination counts 70% and the practical examination counts 30% of your total mark.

The **theory** examination will be made up of:

- One word questions
- Multiple choice questions
- Written (medium and long) questions.

The **practica**l examination will be based on:

- Building a computer
- Installing two operating systems, Windows 7 and Windows 8
- Troubleshooting.

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Hardware Essentials – Evaluation Form

MLHE172-01 V1.0

How would you evaluate the following criteria for the *Hardware Essentials* module? Place a ✓ or ✗ in one of the five squares that **best** indicates your choice. Your response will help us to improve the quality of the study guide and module, and will be much appreciated.

	Very poor	Poor	Fair	Good	Excellent
The text and explanations in the study guide were clear					
There were enough examples in the text					
There were enough exercises for you to do					
Your lecturer was able to help you					
How would you rate this module?					

What did you enjoy?

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Campus: _____ Lecturer: _____ Date: _____

Kindly remove this evaluation form and return it to your lecturer or senior lecturer so that it can be forwarded to the Division for Courseware Development. Thank you.