5. Data Types

The syllabus says that you should be able to:

a. identify different data types:
   - logical / Boolean
   - alphanumeric / text
   - numeric (real and integer)
   - date
b. select appropriate data types for a given set of data:
   logical/Boolean, alphanumeric/text, numeric and date;
c. describe what is meant by the terms
   - file
   - record
   - field
   - key field

Notes covering this section:
- Different Data Types
- Data Organisation
Different Data Types

Before we enter data into a computer system, we usually need to tell the computer what type of data it is. This is because the computer stores and processes different types of data in different ways...

Numeric Data

Numeric data simply means numbers. But, just to complicate things for you, numbers come in a variety of different types...

Integers

An integer is a whole number - it has no decimal or fractional parts. Integers can be either positive or negative.

Examples

<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
<td>45</td>
<td>1274</td>
<td>1000000</td>
<td>-3</td>
<td>-5735</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Real Numbers

Any number that you could place on a number line is a real number. Real numbers include whole numbers (integers) and numbers with decimal/fractional parts. Real numbers can be positive or negative.

Examples

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|
| 1  | 1.4534 | 946.5 | -0.0003 | 3.142 |

Some computer software used strange names for real data. You might see this data type referred to as 'single', 'double' or 'float'.

Currency

Currency refers to real numbers that are formatted in a specific way. Usually currency is shown with a currency symbol and (usually) two decimal places.

Examples

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>£12.45</td>
<td>-£0.01</td>
<td>€999.00</td>
<td>$5500</td>
</tr>
</tbody>
</table>

Percentage

Percentage refers to fractional real numbers that are formatted in a specific way - out of 100, with a percent symbol.

So, the real value 0.5 would be shown as 50%, the value 0.01 would be shown as 1% and the number 1.25 would be shown as 125%.

Examples

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>25%</td>
</tr>
<tr>
<td>1200%</td>
<td>-5%</td>
</tr>
</tbody>
</table>

Alphanumeric (Text) Data
Alphanumeric (often simply called 'text') data refers to data made up of letters (alphabet) and numbers (numeric). Usually symbols ($% ^+@, etc.) and spaces are also allowed.

**Examples**
- DOG
- "A little mouse"
- ABC123
- enquiries@bbc.co.uk

Computer software often needs to know that text data being input is actually text and not some kind of special command.

For this reason, text data is often input with *speech marks* (" . . ") around it:

"MONKEY"

(The speech marks also allow a single item of text data to have spaces inside)

"THIS IS ONE ITEM"

---

**Date and Time Data**

Date (and time) data is usually **formatted** in a specific way. The format depends upon the **setup** of the computer, the software in use and the user’s **preferences**.

**Date Examples**
- 25/10/2007
- 12 Mar 2008
- 10-06-08

**Time Examples**
- 11am
- 15:00
- 3:00pm
- 17:05:45

With inputting dates particular care has to be taken if the data contains American style dates and the computer is setup to expect international style dates (or vice-versa)...

The date 06/09/08 refers to 6th September 2008 in the international system, but would be 9th June 2008 in America!

Check your computer's settings.

---

**Boolean (Logical) Data**

Boolean data is sometimes called "logical" data (or in some software, 'yes/no' data). Boolean data can only have two values: **TRUE** or **FALSE**.

**Examples**
- TRUE
- FALSE
- YES
- NO
- ON
- OFF

Note that TRUE and FALSE can also be shown as YES / NO, ON / OFF, or even graphically as tick boxes (ticked / unticked).

---

**Selecting Data Types**

When we are presented with data to be input into a computer system, we must analyse it and select **appropriate data types** for each value...

E.g. For the following data, we might use the date types shown:

- Telephone number: Alphanumeric
- Name: Alphanumeric
- Date of Birth: Date

Note that the telephone number in the example to the left has a data type of **alphanumeric**.

You might think that it should be numeric, however phone numbers often have spaces, dashes, etc. which numeric data cannot have.
Data Organisation

An organised set of data is usually referred to as a database.

In a database data values that are related are grouped together to make a record, and all records contain similar items.

These ideas are best illustrated with a few diagrams. Let’s use the student data example from the previous section...

Records

The data shown is a group of related data items - all of the data refers to one student: Ben Smith.

A group of data like this is called a record.

File (Database)

A student database will of course have data relating to many students. Each student’s data is called a record, so the student database is made up of many records. (Note that sometimes a collection of records is simply called a file.)

Fields

If we examine a single record, we can see that it is made up of a number of different data items. The individual items are referred to as fields:

Field Names

Each field has a field name:

Key Field

In most databases, one of the fields is used to uniquely identify each record (the value of this field must be different for each record).

This special field is called the key field.

In our example database, the key field would be the student number, as every student will have a unique student number.

Database Viewed as a Table

It is quite common to view the data in a database as a table instead of one record at a time. A tabular view is compact and allows you to see a lot of records in one go.

Using the previous example records, the tabular view would be...

Next Up → 6. The Effects of Using ICT
6. The Effects of Using ICT

The syllabus says that you should be able to:

a. explain what is meant by software copyright;
b. describe what hacking is;
c. describe what a computer virus is;
d. explain the measures that must be taken in order to protect against hacking and viruses;
e. describe the effects of information and communication technology on patterns of employment, including areas of work where there is increased unemployment;
f. describe the effects of microprocessor-controlled devices in the home, including their effects on leisure time, social interaction and the need to leave the home;
g. discuss issues relating to information found on the Internet, including unreliability, undesirability and the security of data transfer;
h. describe the capabilities and limitations of IT;
i. describe the potential health problems related to the prolonged use of ICT equipment, for example repetitive strain injury (RSI), back problems, eye problems and some simple strategies for preventing these problems;
j. describe a range of safety issues related to using computers and measures for preventing accidents.

Notes covering this section:

- Social Effects
- Effects on Health
- Safety Issues
- Hacking
- Malware and Viruses
- Software Copyright
- Internet Use Risks
Social Effects

Effect of ICT on Patterns of Employment

The personal computer (PC) was developed in the early 1980s. Before this date, computers were huge, expensive machines that only a few, large businesses owned. Now PCs are found on almost every desk in every office, all over the world.

Because companies now have access to so much cheap, reliable computing power, they have changed the way they are organised and the way they operate. As a result, many people’s jobs have changed...

Areas of Increased Unemployment

Some jobs have been lost as a result of computers being used to do the same work that people used to do. Some examples of areas have suffered job losses:

Manufacturing

Many factories now have fully automated production lines. Instead of using people to build things, computer-controlled robots are used.

Robots can run day and night, never needing a break, and don’t need to be paid! (Although the robots cost a lot to purchase, in the long-term the factory saves money.)

Secretarial Work

Offices used to employee many secretaries to produce the documents required for the business to run.

Now people have personal computers, they tend to type and print their own documents.

Accounting Clerks

Companies once had large departments full of people whose job it was to do calculations (e.g. profit, loss, billing, etc.)

A personal computer running a spreadsheet can now do the same work.

Newspaper Printing

It used to take a team of highly skilled printers to typeset (layout) a newspaper page and to then print thousands of newspapers.

The same task can now be performed far more quickly using computers with DTP software and computer-controlled printing presses.

Areas of Increased Employment

Although many employment areas have suffered job losses, other areas have grown and jobs have been created.

Sometimes people who have lost their old job have been able to re-train and get a new job in one of these growth areas.
Some examples of areas where jobs have been created:

**IT Technicians**
All of the computers in a business need to be maintained: **hardware fixed, software installed**, etc.

**IT technicians** do this work.

**Computer Programmers**
All of the **software** that is now used by businesses has to be created by computer programmers.

Hundreds of thousands of people are now employed in the **software industry**.

**Web Designers**
Much of modern business is conducted **online**, and company **websites** are very important.

Company websites need to be **designed** and built which is the role of **web designers**.

**Help-Desk Staff**
People often need **help** using **computers**, and **software** applications.

Computer and software company have **help-desks** staffed by trained operators who can give **advice**.

**Computerising the Workplace - Good or Bad?**

As you have seen above, many jobs have changed over the past 30 years. But overall, is this a good thing, or a bad thing? It depends who you ask of course - If someone has lost their job because the work is now being done by a computer, that person will probably see it as a bad thing!

But, on the whole, the computerisation of **repetitive, menial** tasks (such as working on a factory production line, or calculating endless financial results) has freed people to do more **pleasant, less dangerous** jobs.

There are downsides though. Many people can now access their office network from home via The Internet. This means they can **work from home** (remote working) which sounds pretty nice. However it often results in people working **longer hours** and missing out on home life.

**Microprocessor-Controlled Devices in the Home**

**What is a Microprocessor?**

A microprocessor is a small CPU built into a single ‘chip’ (see right).

Very powerful microprocessors can be found in PCs (the Core 2 Quad processor made by Intel is one example) but smaller, less powerful microprocessors can be found in many **everyday devices** in our homes.

Typically, a special type of microprocessor, called a **microcontroller**, is used in everyday devices.

In a single ‘chip’, a microcontroller contains:

- **A CPU**
- **Some RAM**

When people talk about computer ‘chips’ they are referring to the little, black, square devices that you can see stuck to computer circuit.
Some ROM (Used for storing the devices software)

Often microcontrollers also contain ADCs and DACs to allow easy connection to devices such as sensors and actuators.

(For more information about computer control systems, sensors and actuators, here).

Examples of Microprocessor-Controlled Devices

Many of the electronic devices that we use contain a microprocessor...

Some devices are used for entertainment:
- Games consoles
- DVD players
- MP3 players

Some devices help to make our lives easier (labour-saving devices):
- Programmable microwave ovens
- Programmable washing machines
- Home security systems
- Mobile telephones

The Effect of These Devices on Our Lives

Look at the list of devices above. Now try to imagine living without them - washing your clothes by hand! Life would be a lot tougher.

Microprocessor-controlled devices mean that we have more leisure time to relax and enjoy ourselves instead of doing household chores.

We are able to communicate with people very easily using computers, mobile phones, etc. We can become part of online social networks, making friends with people from all over the world.

Computers and Internet connections mean that many of the tasks that involved us leaving the house, for example, shopping for music, clothes or food, can now be done on-line.

Online shopping gives us more choice of products and saves us time. It is also great from those who are unable to get out of the house easily, such as the elderly, or the disabled.

Next Up → Effects on Health
Effects on Health

If we use a computer for many hours (as people often do at work), there are some health issues that might affect us...

Eye-Strain

One health issue that can occur after using computers for a long time is eye-strain (tiredness of the eyes).

This is caused by looking at a monitor which is a constant distance away. The muscles that focus your eyes do not move, and so get tired and painful. Eye-strain can also cause headaches.

This problem can be solved:

- Look away from the monitor at regular intervals – re-focus on distant or close objects to exercise the muscles in the eye.
- Take regular breaks.
- Use an anti-glare filter in front of the monitor to cut down on screen reflections that can also tire the eyes.

Back and Neck Ache

Many people suffer from back and neck pain after working at a computer for a long time. This is usually due to them having a bad sitting posture.

This problem can be solved:

- Use an adjustable, ergonomic chair, and take the time to set it up properly.
- The computer keyboard and monitor should be at the correct height for the seated person (keyboard lower than the elbow, top of monitor at eye level).
- Take regular breaks: get up, walk around, stretch your muscles.

Repetitive Strain Injury (RSI) in Wrists and Hands

Any repetitive movement (same movement over and over again) can result in a health problem called repetitive strain injury (RSI).

In particular, typing and using a mouse for long periods are common causes of RSI in the wrist (it is often called carpal-tunnel syndrome).

This problem can be solved:

The science of how we interact with the objects around us is called ergonomics.

An ergonomic chair is one that fits the body well, giving support to areas such as the lower back (lumbar region)
• Use a **wrist-rest** to support the wrists while typing and when using the mouse.
• **Take regular breaks** from typing or using the mouse.
Safety Issues

You wouldn't imagine that using computers could be dangerous, but there are a few situations that can result in accidents...

Trailing Cables

Computer equipment is often connected to lots of **cables**: power, network, etc.

If these cables are laying on the floor, they can cause people to **trip** over them

**Solution:** Place cables inside **cable ducts**, or **under the carpet** / flooring

Spilt Drinks or Food

If any **liquids** are **spilt** on electrical equipment, such as a computer, it can result in **damage** to the equipment, or an **electric shock** to the user.

**Solution:** Keep drinks and food away from computers

Overloaded Power Sockets

Plugging too many **power cables** into a socket can result in the socket being **overloaded**, overheating, and a **fire** starting.

**Solution:** Never plug too many cables into a socket. Always make sure there are fire **extinguishers** nearby

Heavy Objects Falling

Many items of computer equipment are very **heavy**: CRT monitors, laser printers, etc. Heavy items can cause serious injury if they fall on people.

**Solution:** Make sure equipment is placed on **strong tables** / shelves

Next Up → Hacking
Hacking

What is Hacking?

The word 'hacking' has several meanings, but in the context of ICT, it is normally taken to mean breaking in to a computer system.

Why Do Hackers Hack?

A hacker may break into a system just out of curiosity or for the challenge - can they get through the system’s defences? But, it is more likely that they are breaking in to access data, usually because the data has value.

For example, if a hacker enters your computer and steals financial information such as your credit card number, or the password to your bank account, they could use that information to make purchases.

If a lot of information about you is stolen, a hacker could use this to impersonate you on-line.

They might apply for new credit cards, take out bank loans, buy cars, etc. all in your name.

This is known as identity theft.

Can a Computer be Protected from Hacking?

Just as in the real world, there is no guaranteed way to stop someone breaking into a building (you can make it very difficult, but every security system has its weaknesses), there is also no guaranteed way to stop someone breaking into a computer system.

However, you can make it difficult enough so that a hacker moves on and looks for an easier target.

You should:

- Use strong passwords to protect your user login account
- Never reveal your login password to anyone else
- Place a firewall between your computer and any network
- Disconnect from networks when you are not using them
- Encrypt any sensitive information (just in case they get in)

Next Up → Malware and Viruses
Malware and Viruses

What is Malware?

Malware is short for malicious software.

Malware is the name given to any software that could harm a computer system, interfere with a user’s data, or make the computer perform actions without the owner’s knowledge or permission.

Basically malware is software that you really don’t want to have on your computer!

People can end up with malware installed on their computer system in a variety of ways:

- Installing software that seems ok, but has malware hidden inside (know as a 'Trojan Horse').
- Having their computer hacked, and the software installed by the hacker.
- Visiting dodgy websites and clicking on infected links
- The computer being infected by a computer virus

Some examples of malware:

- Spyware (spys on you)
- Adware (pops up adverts all the time)
- Root kits (allows a hacker full access to your computer)

Ironically, one of the most infamous bits of spyware around is called Antivirus XP 2008/9.

This software is advertised as a genuine anti-virus product (for free too!), but if you install it, you’ve actually installed some malware. (Read more here)

The software will ‘scan’ your computer, then tell you that your computer is infected. You’ll then be bullied with endless pop-ups into paying a fee to have your computer ‘disinfected’.

In fact the only infection you really have is the fake anti-virus!

It is estimated that the creators of this malware have made millions of dollars from innocent, gullible computer users.

It’s best to assume that if software is given away for free, there is probably something dodgy about it - Use Google to check any software out before downloading and installing

So, What is a Computer Virus?

A computer virus is a piece of software that can ‘infect’ a computer (install itself) and copy itself to other computers, without the users knowledge or permission.

Most computer viruses come with some kind of ‘payload’ - the malware that does something to your computer.

For example, the virus might install some spyware (software that watches what you do with your computer), it might search your computer for credit card information, or it might install software that gives someone remote control of your computer (turning it into a ‘zombie”).

How Can a Computer Be Protected from Viruses?

There are some simple things you can do to help prevent a virus infecting your computer:

- Install anti-virus software and keep it up-to-date (this is the most important thing you can do!)
• Install anti-malware software (stops software installing without your knowledge)
• Never download and install software from the Internet unless you are certain it is from a source you can trust
• Don’t open e-mail attachments unless you have scanned them (even a file that seems to be a picture can contain a virus)
• Don’t click links in websites that seem suspicious (if a site is offering prizes / free stuff / etc. be suspicious!)
• If someone gives you a memory stick or CD-ROM, run a virus scan on it before opening any files.
• Don’t trust cracked versions of software from file-sharing sites (often these have viruses and other malware added to them - a Trojan horse)

Next Up → Software Copyright

igcseict.info © 2009 Steve Copley
Software Copyright

What is Software Copyright?

When someone creates an original piece of software, that person then holds something called the copyright for that software. (This is also true when people create books, films and songs.)

Holding the copyright for software means that you have the protection of the law if anyone tries to steal your software.

Under copyright law, people must not:

- Copy the software for other people
- Lend the software to other people
- Rent the software to other people
- Install the software on a network when other users can access it (unless it is a special 'network' version)

If someone breaks the copyright, they can be punished by fines or even by imprisonment.

The reason for this is that creating software can involve the work of many people and may take thousands of hours. It is only fair that all of this effort is protected

Illegally copying software is often referred to as software piracy.

If you make a copy of a game for a friend, get the latest version of Windows from a dodgy shop, or 'borrow' some software from work, you are probably breaking the law.

For example, a team of 120 people put in over 1 million person-hours of work to create the game Halo 3. The development of the game took over three years.

That's a huge amount of time and effort, and the company that created the game ought to be paid for their work. Paying a few dollars for a game that took so much effort to create actually seems like pretty good value!

Next Up → Internet Use Risks
Internet Use Risks

The Internet and World Wide Web are a fantastic resource for finding and sharing information. The Web contains literally billions of web pages containing information about every topic imaginable.

However we need to take care when using the Internet to look for information, or to send information...

Reliability of Information

The Internet and Web are not regulated - there is no organisation that controls who can create web pages or what those pages can contain. Anyone can create web pages and say anything they want to.

In many ways this is a good thing. It means that corrupt organisations or governments, who have always been able to hide details of their activities, are no longer able to do so. When bad things happen, people write about it on the Web and the world gets to know, and hopefully do something about it.

But it’s also a bad thing. It means that people or organisations can easily spread lies and hatred. There are thousands of websites containing bigoted viewpoints, and thousands more that are full of information that is biased, inaccurate, or just plain wrong.

So... how do you which web pages to believe, which information to trust?

- Check several sources of information (go to lots of different websites). If they all say them same thing, it is likely to be true
- Stick to websites that belong to trusted organisations. If the website address ends in .gov.uk (the UK government site) it is more likely to be reliable than one like www.tomiscool.net
- Look at the spelling and grammar used. Reliable websites are usually checked for errors. Too many spelling errors mean it’s probably not to be trusted.

Undesirable Information

In addition to the Web being full of websites with inaccurate information, there are also a huge number of websites that contain highly offensive, or illegal material.

Avoiding this type of material can be tricky. Many organisations such as schools, some governments (e.g. for religious reasons), and also many parents, make use of web page filtering software. This software attempts to prevent offensive and illegal material being accessed.

Even if filtering software is not installed on a computer, you can still take steps to help you avoid these types of sites:

- Use the ‘safe search’ feature on search engines such as Google.
- Don’t click the links that are shown in junk email (spam)
- Think carefully about the keywords that you use to search with.

Security of Data Transferred Using the Internet

As has been discussed already, you should always consider encrypting any sensitive or personal data that is sent or accessed...
over a public network such as The Internet.

Many websites, especially online shopping or online banking sites, require you to enter personal information, such as credit card numbers, social security IDs, etc. To make sure your data is safe, these websites use encryption - they are called secure websites.

You should always make sure that a website is secure before giving personal information...

- The website URL (address) should begin with http://... (normal, unsecure sites have addresses that start with http://...)
- Your web browser should show a closed padlock icon

Below are screenshots of two different web browsers, both showing a secure site. You can see the https://... URL and also the padlock icon:

URLs have several parts, e.g.

http://www.bbc.co.uk/schools

- The first part is the protocol (language) to be used. In this case it is HTTP (HyperText Transmission Protocol). A secure website would use HTTPS (S = Secure)
- The next part is the name of the web server (the computer that gives out the web pages). In this case it is www.bbc.co.uk
- The final parts are the location and name of the web page on the web server. In this case it is schools

Next Up → 7.1 ICT Use in Everyday Life
7.1 ICT Use in Everyday Life

The syllabus says that you should be able to:

have an understanding of a range of IT applications in their everyday life and be aware of the impact of IT in terms of:

a. communicating applications
   - newsletters
   - websites
   - multimedia presentations
   - music scores
   - cartoons
   - flyers / posters
b. data handling applications
   - surveys
   - address lists
   - tuck shop records
   - clubs and society records
   - school reports
   - school libraries
c. measurement applications
   - scientific experiments
   - electronic timing
   - environmental monitoring
d. control applications
   - turtle graphics
   - control of lights, buzzers and motors
   - automatic washing machines
   - automatic cookers
   - central heating controllers
   - burglar alarms
   - video recorders / players
   - microwave ovens
   - computer controlled greenhouse
e. modelling applications
   - 3D modelling
   - simulation (e.g. flight or driving)
   - spreadsheets for personal finance
   - spreadsheets for tuck shop finances

Notes covering this section:

- Communicating Ideas
- Handling Data
- Measuring Things
- Controlling Things on the Screen
- Controlling Real-World Things
- Modelling Things
Communicating Ideas

Why Use IT to Help Communicate Information?

Desktop Publishing

Website Design

Multimedia Design

Creating Music

Producing and Editing Pictures

Next Up → Handling Data
Handling Data

Why Use Databases?

Where Are Databases Used?

Next Up → Measuring Things
Measuring Things

How Can Computers Measure Things?

A sensor, such as a temperature sensor, can be connected to a computer. The computer can then monitor the signal from the sensor, reacting to changes, or it can record the data from the sensor at predefined time intervals.

Note: If the sensor is an analogue one then an analogue-to-digital converter (ADC) will be required.

Where is Computer Measurement Used?

Anywhere that data needs to be gathered regularly, a computerised data-logging system can be used. Some examples are shown below...

Scientific experiments

Many experiments can be set up and left to run with a data-logging system measuring things like the temperature of a liquid, etc.

Weather stations

Often these are placed in very remote areas to collect data about rainfall, temperature, wind-speed, wind-direction, etc. Data needs to be gathered all day, every day. This data can then be used by weather forecasters to help predict the weather over the coming days.

Environmental monitoring

Scientists are very concerned about the effect that humans are having on the environment. Computer-based data-logging is often used to help gather evidence of these effects: the level of water in a dam, the speed of water flowing down a river, the amount of pollution in the air, etc.

Why Use Computers to Measure Things?

The main reasons that you would want to use a computer-based data-logging system, instead of a person taking measurements are...

• Computers do not need to take breaks - they can log data all day, every day, without stopping
• Computers take much more accurate readings than humans can
• Computers can take data readings more frequently (1000s of times a second if necessary)
• Since the logged data is already in a computer, the data can be analysed more quickly and easily (graphs drawn instantly, etc.)
• Data logging systems can operate in difficult environments (e.g. in the Arctic, or on top of a mountain)
• People are free to do other more useful tasks (rather than watching a thermometer)

Next Up → Controlling Things On the Screen
Turtle Graphics

One system designed to teach students the basics of computer programming and control, is called ‘Turtle’ Graphics.

A ‘turtle’ is an on-screen object that follows command given to it by the user. As the turtle moves around the screen it drags a ‘pen’ that leaves a trail behind it.

The command language is called ‘LOGO’. LOGO has many commands, but the ones most commonly used are:

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORWARD n</td>
<td>Move forwards n steps</td>
</tr>
<tr>
<td>BACKWARD n</td>
<td>Move backwards n steps</td>
</tr>
<tr>
<td>LEFT n</td>
<td>Turn left n degrees</td>
</tr>
<tr>
<td>RIGHT n</td>
<td>Turn right n degrees</td>
</tr>
<tr>
<td>PENUP</td>
<td>Lift the ‘pen’ up from the ‘paper’</td>
</tr>
<tr>
<td>PENDOWN</td>
<td>Drop the ‘pen’ down onto the ‘paper’</td>
</tr>
<tr>
<td>REPEAT n</td>
<td>Repeat the commands between these two commands n times</td>
</tr>
<tr>
<td>END REPEAT</td>
<td></td>
</tr>
</tbody>
</table>

Using these commands, any number of shapes and patterns can be drawn. Here are some simple examples...

```
FORWARD 20  FORWARD 20
RIGHT 90   RIGHT 90
FORWARD 10 FORWARD 10
RIGHT 90   RIGHT 90
FORWARD 10 FORWARD 5
LEFT 90    PENUP
FORWARD 10 FORWARD 10 LEFT 90
RIGHT 90   PENDOWN REPEAT 6
FORWARD 10 FORWARD 5 FORWARD 10
RIGHT 90   RIGHT 90
FORWARD 20 FORWARD 10 END REPEAT
```

This is the story about how the on-screen cursor came to be called a ‘turtle’...

When the LOGO language was first developed, home computers did not have graphical displays – all they could show on the screen was text.

So, instead of an on-screen cursor that moved, the computer was connected to a small buggy which had motors and a pen inside. The computer could turn the motors on or off and so make the buggy move.

The buggy had a plastic dome on top that made it look a bit like a tortoise (or, as Americans would call it, a ‘turtle’)

Next Up → Controlling Real-World Things
Controlling Real-World Things

How Can Computers Control Things?

A computer control system, like any system, is made up of three parts...

1. **Input** devices called **sensors** feed data into the computer.
2. The computer then **processes** the input data (by following a set of instructions).
3. As a result of the processing, the computer can **turn on or off** output devices called **actuators**.

1. **Input** devices called **sensors** feed data into the computer.
2. The computer then **processes** the input data (by following a set of instructions).
3. As a result of the processing, the computer can **turn on or off** output devices called **actuators**.

The best way to understand how a computer can control things is to think about how a person controls something...

For example, how does a human control a car when he/she is driving?

The person looks ahead at the road to see what is approaching, thinks about what he/she has seen, then acts upon it (turns the steering wheel and/or presses the pedals).

In other words the person reacts to what is happening in the world around them.

Computer-controlled systems work in a similar way – the system detects what is happening in the world around it, processes this information, and then acts upon what it has detected.

Sensors

A normal PC has no way of knowing what is happening in the real world around it. It doesn’t know if it is light or dark, hot or cold, quiet or noisy. How do we know what is happening around us? We use our eyes, our ears, our mouth, our nose and our skin - our senses.

A normal PC has no senses, but we can give it some: We can connect sensors to it...

A sensor is a device that converts a real-world property (e.g. temperature) into data that a computer can process.

Examples of sensors and the properties they detect are...

<table>
<thead>
<tr>
<th>Sensor</th>
<th>What it Detects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Temperature</td>
</tr>
<tr>
<td>Light</td>
<td>Light / dark</td>
</tr>
<tr>
<td>Pressure</td>
<td>Pressure (e.g. someone standing on it)</td>
</tr>
<tr>
<td>Moisture</td>
<td>Dampness / dryness</td>
</tr>
<tr>
<td>Water-level</td>
<td>How full / empty a container is</td>
</tr>
<tr>
<td>Movement</td>
<td>Movement nearby</td>
</tr>
<tr>
<td>Proximity</td>
<td>How close / far something is</td>
</tr>
<tr>
<td>Switch or button</td>
<td>If something is touching / pressing it</td>
</tr>
</tbody>
</table>

Note: many sensors are analogue devices and so need to be connected to the computer using an analogue-to-digital convertor.

Actuators
A normal PC has no way of affecting what is happening around it. It can’t turn on the lights, or make the room hotter. How do we change what is happening around us? We use our muscles to move things, press things, lift things, etc. (and we can also make sound using our voice).

A normal PC has no muscles, but we can give it some. In fact we can give it the ability to do lots of things by connecting a range of actuators to it...

An actuator is a device, controlled by a computer, that can affect the real-world.

Examples of actuators, and what they can do are...

<table>
<thead>
<tr>
<th>Actuator</th>
<th>What it Can Do</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light bulb or LED</td>
<td>Creates light</td>
</tr>
<tr>
<td>Heater</td>
<td>Increases temperature</td>
</tr>
<tr>
<td>Cooling Unit</td>
<td>Decreases temperature</td>
</tr>
<tr>
<td>Motor</td>
<td>Spins things around</td>
</tr>
<tr>
<td>Pump</td>
<td>Pushes water / air through pipes</td>
</tr>
<tr>
<td>Buzzer / Bell / Siren</td>
<td>Creates noise</td>
</tr>
</tbody>
</table>

Note: some of these devices require an analogue signal to operate them. This means that they need to be connected to the computer using a digital-to-analogue converter.

Making Decisions (The Process)

The steps followed by the computer in a control system are just about the same for all systems...

1. Check the data from the sensors
2. If necessary, turn on/off one or more of the actuators
3. Go back to step 1

That’s it! Of course the details vary, but that is basically how things work.

Where is Computer Control Used?

Many of the devices that we use in our everyday lives are controlled by small computers...

- Washing machines
- Air-conditioning systems
- Programmable microwave ovens

If we look beyond our homes, we come across even more systems that operate automatically under the control of a computer...

- Modern cars have engines, brakes, etc. that are managed and controlled by a computer
- Most factory production lines are computer-controlled, manufacturing products with little or no human input
- Traffic lights are switched on and off according to programs running on computers which manage traffic flow through cities

Of course, car engines, factories and traffic lights were not always computer-controlled. Before microprocessors even existed, car engines ran, factories produced goods and traffic lights changed.

However using computers to manage these systems has brought many benefits...
Why Use Computers to Control Thing?

It is often far better to have a system that is managed and controlled by a computer rather a human because...

- Computers never need breaks - they can control a system without stopping, all day, every day
- Computers don't need to be paid. To buy and install a computerised control system can be very expensive, but, in the long-term, money is saved by not having to employee staff to do the work
- Computers can operate in conditions that would be very hazardous to human health, e.g. nuclear power stations, chemical factories, paint-spraying areas
- Computers can control systems far more accurately, and respond to changes far more quickly than a human could

An Example Control System - An Automated Greenhouse

A computer-controlled greenhouse might have a number of sensors and actuators:

- A light sensor to detect how much light the plants are getting
- A temperature sensor to see how cold/hot the greenhouse is
- A moisture sensor to see how wet/dry the soil is
- Lights to illuminate the plants if it gets too dark
- A heater to warm up the greenhouse if it gets too cold
- A water pump for the watering system
- A motor to open the window if it gets too warm inside

The process for this system would be...

1. Check light sensor
   - If it is dark, turn on the lights
   - If it is not dark, turn off the lights
2. Check temperature sensor
   - If it is too cold, turn on heater and use motor to close window
   - If it is too warm, turn off heater and use motor to open window
3. Check the moisture sensor
   - If soil is too dry, turn on the water pump
   - If soil is too wet, turn off the water pump
4. Go back to step 1 and repeat

Note that if you have to describe a control process, never say that anything like:

"the temperature sensor switches on the heater"

This is totally wrong!

Sensors cannot control anything - all they can do is pass data to the computer.

The computer takes the actions and turns on/off the actuators.

Next Up → Modelling Things

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Modelling Things

What is a Computer Model?

A computer model is a computer program that attempts to simulate a real-life system. In other words, it is a virtual version of something in the real-world.

The computer model is designed to behave just like the real-life system. The more accurate the model, the closer it matches real-life.

Why Are Computer Models Used?

There are several reasons that computer models are used...

- To test a system without having to create the system for real (Building real-life systems can be expensive, and take a long time)
- To predict what might happen to a system in the future (An accurate model allows us to go forward in virtual time to see what the system will be doing in the future)
- To train people to use a system without putting them at risk (Learning to fly an airplane is very difficult and mistakes will be made. In a real plane mistakes could be fatal!)
- To investigate a system in great detail (A model of a system can be zoomed in/out or rotated. Time can be stopped, rewound, etc.)

Examples of Computer Modelling

Designing Safer Cars

A computer model of a car can be used to test how safe the design of the car is in a crash.

The virtual car can be crashed over and over again, the effects investigated and the design easily changed until it is as safe as possible.

This is much quicker and cheaper than building and crashing real cars!

Weather Forecasting

A computer model of a weather system can be used to predict storms.
The wind patterns, temperatures, etc. for the whole planet are simulated using very powerful computers. If the computer model is accurate (it is very difficult to make an accurate model since our planet is rather big) then weather forecasters can use it to fast-forward into the future to see a prediction of what the weather will be tomorrow, next week, next month.

(Since weather is so complex, and the models are not (yet) accurate enough, often the weather forecast is wrong!)

Building Better Bridges

A computer model of a bridge can be used to test the design.

Bridges have to be able to survive extreme weather conditions. It is obvious not practical to build a real bridge and then wait to see if it falls down in a storm. Instead, a computer model of the bridge is created and tested in virtual storms.

If the model breaks, it can be quickly and cheaply re-designed and re-tested. If it doesn’t break, the real bridge can be built, confident that it will survive real storms.

Bridges can also be tested to see if they can cope with heavy traffic. The virtual bridge can be loaded with a traffic jam of virtual trucks to check that it won’t collapse.

A similar system is used by building designers, especially for very large or tall buildings, such as skyscrapers.

Running a Business

A computer model of a business can be used to help predict future profits.

If the workings of a business can be modelled accurately, in particular the financial systems, then these models can be used to make predictions. The models are used to help answer 'what if ...?' type questions, e.g. "What if we decrease the workforce by 15%? Will our profits increase or decrease?"

Based on the answers that the model gives, the managers of the business can make decisions.

Training Pilots to Fly an Airplane

Trainee pilots have many hours of lessons in flight simulators before being allowed to fly a real airplane.

Flight simulators behave almost exactly like real airplanes since they are controlled by a computer with a very accurate and realistic model of the airplane. The main difference is that the simulator can’t actually crash!

Pilots can make mistakes without putting anyone’s life at risk.
Flight simulators can provide a pilot with any number of highly realistic flying situations: storms, engine failures, low cloud hiding the runway, etc.

The experience that pilots gain whilst using the simulator means that when they eventually start flying real airplanes, they already have many of the required skills.

There are also car simulators that are used to help train learner drivers, and also ship simulators to help ship captains learn how to navigate and manoeuvre large ships such as oil tankers.

Next Up → ICT Use in the Workplace
7.2 ICT Use in the Workplace

The syllabus says that you should be able to:

understand the differences between batch processing, on-line processing and real-time processing.

You should have an understanding of a wider range of work-related IT applications and their effects, including:

a. communication applications
   - the Internet
   - electronic mail
   - fax
   - electronic conferencing
   - mobile telephones

b. publicity and corporate image publications
   - business cards
   - letterheads
   - flyers
   - brochures

c. applications in manufacturing industries
   - robotics in manufacture
   - production line control

d. applications for finance departments
   - billing systems
   - stock control
   - payroll

e. school management systems
   - registration
   - records
   - reports

f. booking systems
   - travel industry
   - theatre
   - cinemas

g. applications in banking
   - Electronic Funds Transfer (EFT)
   - ATMs for cash withdrawals and bill paying
   - credit/debit cards
   - cheque clearing
   - phone banking
   - Internet banking

h. applications in medicine
   - doctors' information systems
   - hospital and pharmacy records
   - patient monitoring
   - expert systems for diagnosis

i. applications in libraries
   - records of books and borrowers
   - issue of books

j. the use of expert systems
   - mineral prospecting
   - car engine fault diagnosis
   - medical diagnosis
   - chess games

k. applications in the retail industry
   - stock control
   - POS
   - EFTPOS
   - internet shopping
   - automatic re-ordering

Notes covering this section:

- Modes of Computer Use
- Expert Systems
- Communication in Business
- Publicity & Corporate Image
- Manufacturing Products
- Business Finance
- Booking Systems
- Banking & Payment Systems
- Retail (Selling) Systems
- Medical & Hospital Systems
- School Management Systems
- Library Systems
Modes of Computer Use

You are used to using a personal computer by sitting down in front of it, and interacting with it directly (opening files, running applications, etc.)

However not every computer is a personal computer. Some computers are huge and are shared by many users. Some computers are embedded in systems that control things such as factories, or aircraft. And businesses often use computers in totally different ways to you...

Batch Processing

Sometimes we have a lot of data to process and it is all of a similar form (e.g. we might have to calculate the pay for 10,000 employees - the calculations we have to do for each employee are very similar)

In cases like this, we can prepare the data into a set or 'batch' and hand it over to the computer to be processed in one go. Once we have prepared the batch of data, no user input is required - the computer works its way through the data automatically.

This type of data processing is known as batch processing.

An advantage of this type of system is that the processing can occur when the computer is not being used for anything else (e.g. at night). The job is setup, people go home, and when they return the next morning the work has been done.

Typical application where batch-processing can be used:

- Payroll processing
- Processing bank cheques
- Printing of bank statements
- Updating of a stock database

Real-Time Processing

Sometime we need to process data immediately - we cannot wait and process it later (e.g. using batch processing)

For example, if we want to book a seat on a flight, the booking must be processed immediately. We can’t put it in a pile and do it later, because other people might be trying to book the same seat!

If an item of input data must be processed immediately, and the result is ready before the next input data is accepted, this is known as a real-time system.

Typical application where real-time processing must be used:

- Any type of monitoring system (e.g. hospital patient monitoring)
- Any type of computer control system (e.g an automatic production line, an aircraft auto-pilot, the system controlling a nuclear power station, etc.)
- Payment systems (e.g. EFPOS and ATM cash withdrawal)
- All booking systems (e.g. flight booking, cinema seat booking, etc.)
- Computer games (e.g. FPS, driving games, etc.)
On-Line Processing

An on-line system is one where the user is directly interacting with the computer - the user is 'on-line' with the computer.

So, any system where the user is entering data directly into the computer must be an on-line system. If data is being entered and then processed, it's an on-line processing system.

Examples of on-line processing systems:

- All booking systems (e.g. flight booking, cinema seat booking, etc.)
- Computer games (e.g. FPS, driving games, etc.)

Nowadays we tend to use the term 'on-line' to mean connected to the Internet.

However, historically, the term means that the user is connected to the computer. When a person wanted to use one of the old multi-user, mainframe computers, they would have to connect their terminal - taking it 'on-line'

Next Up → Expert Systems
Expert Systems

What is an Expert System?

An expert system is computer software that attempts to act like a human expert on a particular subject area.

Expert systems are often used to advise non-experts in situations where a human expert is unavailable (for example it may be too expensive to employ a human expert, or it might be a difficult to reach location).

How Do Expert Systems Work?

An expert system is made up of three parts:

- A user interface - This is the system that allows a non-expert user to query (question) the expert system, and to receive advice. The user-interface is designed to be simple to use as possible.
- A knowledge base - This is a collection of facts and rules. The knowledge base is created from information provided by human experts
- An inference engine - This acts rather like a search engine, examining the knowledge base for information that matches the user's query

The non-expert user queries the expert system. This is done by asking a question, or by answering questions asked by the expert system.

The inference engine uses the query to search the knowledge base and then provides an answer or some advice to the user.

Where Are Expert Systems Used?

Medical diagnosis (the knowledge base would contain medical information, the symptoms of the patient would be used as the query, and the advice would be a diagnose of the patient’s illness)

Playing strategy games like chess against a computer (the knowledge base would contain strategies and moves, the player’s moves would be used as the query, and the output would be the computer’s ‘expert’ moves)

Providing financial advice - whether to invest in a business, etc. (the knowledge base would contain data about the performance of financial markets and businesses in the past)

Helping to identify items such as plants / animals / rocks / etc. (the knowledge base would contain characteristics of every item, the details of an unknown item would be used as the query, and the

The Scottish health service has a self-diagnosis expert system you can try on-line here.
advice would be a likely identification)

Helping to **discover locations to drill for water / oil** (the knowledge base would contain characteristics of likely rock formations where oil / water could be found, the details of a particular location would be used as the query, and the advice would be the likelihood of finding oil / water there)

Helping to **diagnose car engine problems** (like medical diagnosis, but for cars!)

Next Up → Business Communication
Banking & Payment Systems

Electronic Fund Transfer (ETF)

ETF is a system that allows money transfer instructions to be sent directly to a bank's computer system. Upon receiving one of these instructions, the computer system automatically transfers the specified amount from one account to another.

Transfer instructions can come from other banks or from businesses.

A very common use of EFT is when a large business pays its employees' salaries. On pay day, the businesses tells the bank to move money from the business account to the employees' bank accounts...

![Diagram of Business Account, EFT Instruction, and Bank Computer System]

Other examples of where EFT is used are discussed in some of the following sections...

If money is transferred from one bank account to another, nothing is physically moved - no piles of cash are picked up and moved from one place to another.

The amount of money in a bank account is simply a number in the bank's computer system.

When money is transferred between accounts, all that happens is one number in the system gets bigger and another gets smaller.

Obviously the EFT system has to be very secure - the bank can't allow just anyone to send transfer instructions (otherwise we would all be sending messages to bank computers to move money into our accounts!)

The EFT system uses very strong encryption for all messages and the encryption keys are only given to trusted partners (other banks and big businesses).

Using Cash Machines (ATMs)

ATMs can be used to for a range of banking services...

- Withdrawing cash
- Depositing money
- Checking the balance of accounts
- Transferring money between accounts
- Paying bills

A customer identifies him/herself and their bank account by using a bank card. The card is inserted into the ATM where it is read by a magnetic strip reader or a smart card reader. The customer also types a secret PIN into the ATM's numeric keypad to confirm that they are the real owner of the card.

ATMs can be used by customers of other banks as the ATM can use EFT...

If a customer of Bank A uses her debit card to withdraw cash from an ATM belonging to Bank B:

1. Bank B gives her the cash
2. Bank B now is owed money by Bank A
3. Bank B sends an EFT instruction to Bank A asking for money to be transferred from the customer's account to Bank B.
4. Bank B has now been paid back

Electronic Payments for Goods (ETFPOS)

Banks allow goods to be paid for electronically, using a system called Electronic Fund Transfer at Point-of-Sale (ETFPOS).

A full description of ETFPOS can be found here.
It is now very common for bank customers to access their bank account from home using online banking services.

Customers use a computer and connect to the bank’s secure (encrypted) website where they login (usually with a username and a password).

Customers can use the online banking system to:

- Check the balance of bank accounts
- Pay bills
- Transfer money between accounts (using EFT)
- Apply for loans, or other services

Processing Cheques (Cheque 'Clearing')

Banks have to deal with thousands of handwritten, paper cheques every day.

When a cheque arrives at a bank, the information on the cheque has to be entered into the bank’s computer system so that the correct funds can be transferred between the correct accounts. Entering this data quickly and accurately is a time-consuming and difficult task.

To help speed things up, a special system of printing is used on cheques that can be read by a reader connected to the computer system. At the bottom of every cheque, printed in a special font using magnetic ink, is the bank account number and cheque number:

![MICR Example]

Each cheque is passed through an MICR reader that can read these special numbers. (A small reader is shown here, but in large banks the MICR readers are much bigger and can hundreds of cheques.

The handwritten part of the cheque (the payee and the value of payment) can be entered into the computer system by either using a human to read the writing and typing the data in, or by using OCR.

Next Up → Retail (Selling) Systems
Retail (Selling) Systems

What is a Point-of-Sale?

The **Point-of-Sale** (POS) in a store is the place that you pay for your purchases. It is usually where the till (cash register) is located.

A typical POS will have...

- A method of **inputting** the codes of goods purchased - usually a **bar-code scanner**. The codes are then used to find more information about the goods, such as price, from a database
- A system to accept **electronic payments** - EFTPOS (see below)
- A system to **update the stock-level** of goods whenever they are sold, and possibly to automatically re-order goods that have low stock-levels (see below)
- A method of producing a **receipt** for purchases - usually a small dot-matrix printer

Handling Electronic Payments (EFTPOS)

When you use a **bank card** to pay for a purchase in a store, the payment is made using a system called **Electronic Fund Transfer at Point-of-Sale** (EFTPOS).

This is how it works...

1. Customer gives the bank card to the cashier

2. The cashier runs the card through a **card reader** (the customer may have to enter a **PIN**). The cashier enters the **value** of the purchase

3. The store’s system then **connects** to the bank computer and sends a **message**

4. The bank computer uses the **account number** to access the **customer’s record** and checks the **balance**

5. The bank computer sends back a confirmation or rejection **message** to the store’s system
The cashier now confirms the purchase and an EFT message is sent to the bank.

The bank computer subtracts $100 from the customer’s account and adds $100 to the store’s account.

The cashier gives the card back to the customer along with a receipt.

‘Chip & PIN’ Payment System

Most bankcards no longer rely on a magnetic strip to store customer account details. Instead the cards are smart cards. The cards contain a small amount of computer memory with the account information stored inside.

Smart cards are more secure (since the data is encrypted) and more reliable than magnetic strip cards.

When a customer wishes to pay for goods in a store, the customer inserts the bankcard into a smart card reader, and then types in a PIN to confirm that they are the true owner of the card. Once the PIN is verified, the customer can remove the card.

One of the reasons this system has proven popular is the extra level of security it provides for users: At no time does the bankcard need to be handled by anyone other than the card owner, so with this system there is less chance of the card being stolen or copied.

The nickname for the tiny memory device inside the bankcard is a ‘chip’, and the system uses a PIN as identity proof, so the system is nicknamed ‘Chip and PIN’ in the UK.

Automatic Re-Ordering of Stock

In many stores, the POS system is linked to the stock control system.

Pin stands for Personal Identification Number.

PIN stands for Personal Identification Number.

A PIN is usually a four digit secret code used to confirm a person’s identity (e.g. when withdrawing cash from an ATM).

Note: You should not say ‘PIN number’ since that would mean ‘Personal ID Number number’!

Stock means the things that you have in your store / warehouse.

‘Stock Control’ is the system that keeps track of what you have in stock.
The stock-control system updates the stock-levels in the stock database for the purchased goods.

If the stock-level falls below a pre-set value, the stock-control system sends an order to the suppliers.

The suppliers send a delivery to the store.

The stock-control system updates the stock-levels in the stock database for the delivered goods.

Internet Shopping (e-Commerce)

In the last few years, Internet shopping has become very popular. Stores like Amazon and the iTunes Store are some of the largest retail businesses in the world. Online you can buy anything from air flights to fresh eggs.

Customers like Internet shopping because...

- The convenience of being able to browse goods from your home
- Stores are open 24 hours a day, every day of the year
- The wider range of choice - can access stores all over the world
- Easy if you have limited mobility (due to a disability, or old age)
- Goods are often cheaper than in stores
- Payment is simple using credit cards or services such as PayPal

Businesses like Internet shopping because...

- Lower costs since no expensive retail stores and less staff
- Lower costs = lower selling prices = higher sales = bigger profits
- Many more potential customers

However there are some problems too...

- You cannot try items before purchasing (e.g. clothes)
- You may have to wait several days before receiving your goods
- Returning goods or getting help can be difficult
- There is a security risk using credit cards online. The card details may be stolen and used to commit fraud.

Next Up → Medical & Hospital Systems
8 Systems Analysis & Design

The syllabus says that you should be able to:

8.1 Analysis
a. describe different methods of researching a situation (such as observation, interviews, questionnaires and examination of existing documentation);
b. state the need for establishing the inputs, outputs and processing in both the existing system and the proposed system;
c. state the need for recording information about the current system;
d. state the need for identifying problems with the current system;
e. state the need for identifying suitable hardware and software for developing a new system;
f. state the need for identifying the user and information requirements necessary to resolve the identified problems;
g. state the need for specifying the required hardware and software.

8.2 Design
a. state the need for producing designs for documents, files, forms/inputs, reports/outputs and validation;
b. design data capture forms and screen layouts to solve a given problem;
c. design reports layouts and screen displays to solve a given problem;
d. design validation routines to solve a given problem;
e. design the required data/file structures to solve a given problem.

8.3 Implementation
a. identify the different methods of system implementation (such as parallel running, phased implementation, direct changeover);
b. identify suitable situations for the use of the methods in a), giving advantages and disadvantages of each;
c. describe testing strategies that would be employed in implementing the new system (such as the use of normal, abnormal and extreme data as well as the use of test data and real/live data);
d. identify improvements that could be needed as a result of testing.

8.4 Verification
a. identify the need for, and the different methods of, verification when entering data.

8.5 Documentation
a. identify the components of technical documentation for an information system (such as program coding, program flowcharts, system flowcharts, hardware and software requirements, file structures, list of variables, validation routines);
b. identify the components of user documentation for an information system (such as purpose and limitations, hardware and software requirements, how to use the system, input and output formats, sample runs, error messages, trouble-shooting guide).

8.6 Evaluation
a. explain the need for evaluating a new system in terms of the efficiency, ease of use, and appropriateness of the solution;
b. state the need for comparing the solution with the original task requirements;
c. state the need for identifying any limitations and necessary improvements to the system;
d. state the need for evaluating the users' responses to the results of testing the system.
What is Systems Analysis?

Systems Analysis is, as the name states, the analysis of systems!

The systems that we are talking about are the systems within organisations and businesses - systems of communication, financial systems, manufacturing systems, etc. - basically the systems that make the organisation or business work.

A person who analyses systems is known as a Systems Analyst.

Often systems analysts are employed by organisations of businesses to help them improve their systems and so become more efficient, and for businesses, more profitable.

A systems analyst would generally perform the following steps in the order shown...

1. **Research**
   - Collecting information about the present system works

2. **Analysis**
   - Examining out how the present system works and identifying problems with it

3. **Design**
   - Coming up with a new system that will fix the present systems problems

4. **Production**
   - Creating the new system from the design. (Note: details of this stage are not required for iGCSE)

5. **Testing**
   - Checking if the newly created system works as expected

6. **Documentation**
   - Creating documents that describe how to use the new systems, and how it works

7. **Implementation**
   - Replacing the present system with the new system

8. **Evaluation**
   - Checking that the new system meets all expectations

It's very important you understand that just about everyone has a slightly different way of describing the stages of Systems Analysis.

Some textbooks you might read will include more steps, others will have less. Some use different names for the stages.

Don't worry about this! They are describing the same overall process.

What is important is that you understand how the process works, and that you can describe some of the key activities that are required along the way.

It's very important you understand that just about everyone has a slightly different way of describing the stages of Systems Analysis.

Some textbooks you might read will include more steps, others will have less. Some use different names for the stages.

Don't worry about this! They are describing the same overall process.

What is important is that you understand how the process works, and that you can describe some of the key activities that are required along the way.

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**Note...**

The CIE syllabus lists topics for System Analysis in an order that does not always flow logically from topic to the next.

To make Systems Analysis as easy to understand as possible I have chosen to split the topic up into the slightly different stages shown here and described on subsequent pages.

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**Next Up → Researching the Present System**
Researching the Present System

Before the systems analyst can make any recommendations about a new system, they first have to understand how the present system works.

Gathering / Collecting Information

As much information about the present system needs to be gathered as possible. The system analyst can use a number of techniques...

Observation

This involves the systems analyst walking around the organisation or business, watching how things work with his/her own eyes.

Observation allows the systems analyst to gather first-hand, unbiased information.

The downside to observation is that often people won’t work the way they normally do if they know they are being watched.

Interviews

The systems analyst can interview key people within the system to find out how it works.

Interviews allow lots of very detailed information to be gathered, but they take a long time to do, so are not possible if large groups of people are involved.

Questionnaires

With large groups of people, a questionnaire is a quick and simple way to gather information.

However the information gathered is limited by the questions set by the systems analyst (people could have a lot of useful information in their heads, but if the questionnaire doesn’t ask the right questions, they will not be able to pass it on)

Also many people do not take the time to fill in questionnaires seriously.

Collecting Documents

Most businesses and organisations use documents to record information, or to communicate information (forms get filled in and passed to other offices, etc.)

The systems analyst needs to collect examples of the documents used to get an understanding of the type and quantity of data that flows through the business or organisation.

Next Up → Analysing the Present System
Analysing the Present System

Having collected as much information about the present system as possible, the systems analyst now looks though it all to understand how the system works, and to try and identify problems that need to be fixed...

Identifying the Inputs, Outputs and Processes

Every system has inputs and outputs and the systems analyst needs to identify the data input to the present system, and the data output.

This is because any new system that is designed will have to deal with similar inputs and outputs as the present system.

For example, the payroll system in a business might have the following inputs and outputs...

Any new system that is created will need to take in the same input data (the number of hours worked by employees), and will have to produce the same three outputs.

For similar reasons, the systems analyst also has to understand how the present system works (the processes — who does what and when)...

This is important because some parts of the present system may work very well, and it would be a waste of time and effort to replace them.

Identifying Problems

No system is perfect and it is the job of the systems analyst to try and identify where the problems in a system are.

If these problems can be fixed, the system will work more smoothly, be more efficient and, in the case of a business, be more profitable.

In the above payroll example, the following problems might be identified...

- The payroll often takes over three days to process, resulting in many employees being paid late
- Timesheets sometimes get lost before being processed. This means that sometimes pay has to be estimated
- The reports sent to management do not show enough information.

New System Requirements Specification

Now the problems with present system are understood, the system analyst can begin to plan how the new system will fix those problems.

The systems analyst specifies a list of requirements for the new system (‘requirements’ simply means targets or aims).

This list is usually called the Requirements Specification.

For the payroll example the requirements might be...

1. Payroll processing should be completed within 24 hours
2. The recording of hours worked should use a system that means the data cannot be lost
3. Management reports should contain detailed information about pay for each department, overtime payments and average hours worked by each employee
4. Management reports should be electronic so that managers can analyse the data more easily
Any new system that is designed must meet these requirements.

**What Hardware and Software Will Be Required?**

The systems analysts will now need to decide what hardware and software will be required for the new system...

### Hardware

- How many computers?
- What type of network?
- How many servers?
- Any special input devices? (e.g. barcode readers)
- Any special output devices?

### Software

- Is ready-made, off-the-shelf software available?
- Is custom-written software required?

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**Off-the-shelf software** is software that is created for use by a large range of customers - it tends to be quite general-purpose.

**Custom-written software** is designed and written specifically for one customer.

**Off-the-shelf software:**

- **Cheaper**
- More reliable (because most problems will have been found by one of the many users)
- Has lots of support and help available (because lots of other people are using it)

**Custom-written software:**

- **Very expensive**
- Provides exactly what the customer needs (a ‘perfect fit’)
- Only has one user, so little help is available

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Next Up → Designing a New System
Designing a New System

Using the list of requirements, the systems analyst now has to design the new system.

In most cases the new system will be computer-based. The ease with which computers can communicate and process data means that are usually the best tool for the job.

Designing the System Inputs

To get data into a system is a two-part process:

1. Data must first be ‘captured’ (collected in a way that then makes it easy to input)
2. Data must be input into the computer

The systems analyst will select a data capture method and data input method that best suit the requirements of the new system.

Choosing the Best Data Capture and Data Input Methods for the System

Collecting data into a form that is ready for input to a computer system can be done in many ways...

**Paper Forms**

Form can be a simple ones with **spaces for numbers and text** to be written in. The data form this form would then be **typed** into the computer.

Forms can also be **machine-readable**, such as **OMR forms**

**Barcode Reader**

Barcode readers capture the **numeric code** that the barcode represents.

Typically used with **POS systems** and also **stock-control systems**

**Card Reader**

Many cards contain data stored on a **magnetic strip** or in a small bit of **memory** (smart cards) which can be captured with a **card reader**

Used in systems such as **EFTPOS**

**Camera**

Capture **still or moving images** which can then be input to a computer for processing

In the payroll example, the hours worked by the employees could be captured using...

- A paper form (a timesheet) - simple and cheap, but the needs to be manually input (slow) and the form can be lost
- Barcode reader - employees could have ID cards and swipe them at the start and end of work (can cheat easily)
- Fingerprint reader - employees could put a finger on the reader at the start and end of work (hard to cheat)

Designing On-Screen Forms for Data Input

Much of the data that enters computer systems needs to **typed in**. A **well-designed on-screen form** can make this task **easier** and quicker.

On-screen forms should...

- Have all of the necessary **fields**
• Have obvious places for user input (boxes, use of colour, etc.)
• Use appropriate controls (see right) for each field
• Have text box controls that are the right size for the data
• Have easy-to-understand instructions (if needed)
• Make good use of the screen area available

This is an example of a well-designed on-screen form used to enter details of an employee...

As data is entered into the form, it needs to be checked for accuracy. Two techniques help us do this: validation and verification...

Data Validation Techniques

When data is input to a computer, it is a good idea for the computer to check that the data is sensible (no dates of birth in the future, etc.)

Checks like this are called validation checks (is the data valid?)

Different validation checks can be used on different fields, depending on the type of data being entered...

Presence Check Is data actually present in a field, or has it been missed out?

Range Check Is the data value within a set range? (E.g. an exam mark should be between 0% and 100%, a month should be between 1 and 12)

Length Check Is an item of text too short or too long?

Type Check Is the data the correct type? (E.g. the letter 'A' should not be allowed in a numeric field)

Format Check Is the data in the correct format? (E.g. a date of birth should be entered as dd/mm/yyyy)

Data Verification Techniques

Data validation only checks whether the data entered is sensible - it does not mean that the data is the right data.

For example, if you are entering a date of birth and you mistype it...

• Correct date of birth: 12/11/1982
• Date of birth entered: 12/11/1928

... you would not see an error, since 12/11/1928 is a valid date of birth.

To check that data is the correct value, we use a system called data verification.

There are two methods of data verification...

Proof Reading After the data has been entered a person compares the original data with the data in the computer (either on the screen or using a print-out).

If mistakes are spotted they can be corrected by the person.

Proof-reading is quick and simple, but doesn’t catch every mistake.

Double-Entry The data is entered into the computer twice (preferably by two different people).

The computer compares the two sets of
data to see if they match. If not it generates an error and a person will need to correct the mistake.

Double-entry takes more time and effort, but it catches almost every mistake.

Designing the System Processes

Any system has to process the data it is given. The system designer has a number of things to consider...

Designing Data and File Structures

A data structure is an organised collection of data. Most commonly, this will be some sort of database in which data will be stored as it is being processed.

When designing a database, the system designer needs to consider:

- The type of data being stored (numbers, text, dates, etc.)
- The size of the data (how long is a typical name, etc.)
- The field names to use
- How many records will need to be stored

(see the Data Types section for more details about these)

The designer also need to consider which backing storage device and media will be suitable to store the data:

- How often will the data need to be accessed
- How quickly the data needs to be accessed
- How large will the data files be

So, for example, if there is a large amount of data that needs to be accessed quickly, and regularly, then a hard drive would be the best storage device to use.

Designing the How the Data Will be Processed

Of course, the system designer also needs to design the actual steps to be followed to processing the data (the algorithm).

(This part of the design is outside of the scope of the IGCSE syllabus, but I've mentioned it for completeness)

You don't need to know how to write algorithms for IGCSE!

Designing the System Outputs

There are usually two types of output from a system that need to be designed:

- On-screen reports (information displayed on the monitor)
- Printed reports (hard-copy to be mailed, filed, etc.)

Designing On-Screen Reports

Designing an on-screen report is similar to designing an on-screen form (see above). There are a number of things that the designer should consider.

On-screen reports should...

- Show all of the necessary fields
- Have fields that are the right size for the data
- Have easy-to-understand instructions (if needed)
- Make good use of the screen area available
- Make good use of colours and fonts to make the data clear

On-screen reports can include more than just text...

Reports can include:

- Text
- Images
- Bar charts
- Pie charts
- Animations
- Video
This is an example of a well-designed on-screen report used to show details of an employee...

**Designing Printed Reports**

Designing a printed report is just like designing an on-screen report (see above), except that the report needs to fit a piece of printer paper, rather than the screen. The report might also include page numbers, a header / footer, etc.

This is an example of a well-designed printed report used to show details of an employee...

**Next Up → Testing the New System**

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Testing the New System

Once the system has been created, it needs to be thoroughly tested.

A test plan is usually written whilst the system is being developed. The test plan will contain details of every single thing that needs to be tested.

For example:

- Does the system open and close properly?
- Can data be entered?
- Can data be saved?
- Can reports be printed?
- When you do something wrong, does an error message appear?
- Is invalid data rejected? E.g. if you are not allowed to enter an amount above £1,000 on the system then a value of 1,001 should not be accepted (i.e. does the validation work?)

Test plans are very detailed, and contain many tests. Each test is specified very precisely.

A typical test would contain:

- Details of what is being tested
- The test data to use
- What is expected to happen when the test is performed

Selecting Test Data

When choosing what data to use to test a system, you need to think about why we are testing the system: to see if it works, and to check it doesn’t break.

To do this, we use three types of test data...

**Normal Data Values** This is data that would normally be entered into the system.

The system should accept it, process it, and we can then check the results that are output to make sure they are correct.

E.g. In a system that was designed to accept and process test marks (percentages), then normal test values would include:

- 10
- 25
- 63
- 89

**Extreme Data Values** Extreme value are still normal data. However, the values are chosen to be at the absolute limits of the normal range.

Extreme values are used in testing to make sure that all normal values will be accepted and processed correctly.

E.g. In a system that was designed to accept and process test marks (percentages), then extreme test values would be:

- 0 (lowest possible value)
- 100 (highest possible value)

In systems that deal with text, the extreme values are defined by how long the text can be. The limits would be:

- "" (nothing entered)
- "ABCDEF..." (max. length)

**Abnormal Data Values** This is data that should not normally be accepted by the system - the values are invalid.

The system should reject any abnormal values.

Abnormal values are used in testing to make

E.g. In a system that was designed to accept and process test marks (percentages), then abnormal test values would include:

- -1
- 101
- 200
- -55
sure that invalid data does not break the system.

When is the System Tested?

Testing is normally done in two stages...

The first phase of testing is done by the designers and engineers who created the system, usually before the system is delivered to the customer.

The test data that is used in this first phase is similar to data that would be used by the actual customer.

The second phase of testing is done after the system has been delivered and installed with the customer.

The data used in the second phase is usually 'live' data - data that is actually part of the customer's business/organisation.

What Happens if the System Fails Some Tests?

The whole point of testing is to try and find areas that don't work as they should, or areas that can be improved.

If any failures are found, the systems analyst goes back and does some further research, analysis and design to fix these areas.

Next Up → Documenting the New System
Implementing the New System

The implementation of the new system occurs when the old system is replaced by the new one.

There are a few ways of implementing a new system...

**Direct Changeover**

The old system is stopped completely, and the new system is started. All of the data that used to be input into the old system, now goes into the new one.

This is its advantages...

- Takes the minimal time and effort
- The new system is up and running immediately

But there are also disadvantages...

- If the new system fails, there is no back-up system, so data can be lost

**Parallel Running**

The new system is started, but the old system is kept running in parallel (side-by-side) for a while. All of the data that is input into the old system, is also input into the new one.

Eventually, the old system will be stopped, but only when the new system has been proven to work.

This is its advantages...

- If anything goes wrong with the new system, the old system will act as a back-up.
- The outputs from the old and new systems can be compared to check that the new system is running correctly

But there are also disadvantages...

- Entering data into two systems, and running two systems together, takes a lot of extra time and effort

**Phased Implementation**

The new system is introduced in phases, gradually replacing parts of the old system until eventually, the new system has taken over.

This is its advantages...

- Allows users to gradually get used to the new system
- Staff training can be done in stages

But there are also disadvantages...

- If a part of the new system fails, there is no back-up system, so data can be lost

Next Up → Testing the New System
Evaluating the New System

Once the new system has been implemented and is in full use, the system should be evaluated (this means that we take a long, critical look at it).

The purpose of an evaluation is to assess the system to see if it does what it was supposed to do, that it is working well, and that everyone is happy with it.

What Does an Evaluation Look For?

When the systems analyst evaluates the new system, the following questions will be asked:

<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>...efficient?</strong></td>
<td>Does it operate quickly, smoothly and with minimal waste?</td>
</tr>
<tr>
<td></td>
<td>Is the system saving time, and resources?</td>
</tr>
<tr>
<td><strong>...easy to use?</strong></td>
<td>Are all of the system's users able to use the system easily and effectively?</td>
</tr>
<tr>
<td></td>
<td>Can new staff understand and use the system with minimal training?</td>
</tr>
<tr>
<td><strong>...appropriate?</strong></td>
<td>Is the system suitable for the particular business / organisation?</td>
</tr>
<tr>
<td></td>
<td>Does the system actually meet the needs of the business / organisation?</td>
</tr>
</tbody>
</table>

But how can we find the answers to these questions?

How is a System Evaluated?

The systems analyst will use a number of techniques to evaluate the system...

**Check against the Requirements Specification**

If you remember, earlier on in the Systems Analysis, the old system was analysed, and a checklist of targets was drawn up for the new system.

This list was called the Requirements Specification.

The systems analyst will use this document to check the new system. Going through the requirements one-by-one the analyst will check if they have been met.

**Check the Users' Responses**

It is essential to get feedback from the users of the system...

- Do they like it?
- Does it make their work easier?
- What, if anything, could be improved?

The systems analyst can get this feedback in the same way they collected information about the original system...

- Questionnaires
- Interviews
- Observations
What Happens Next?

The outcome of the evaluation will be to identify any limitations or problems with the new system.

The system analyst will then need to begin the task of system analysis from the beginning, but this time analysing the new system, and then designing, testing and implementing improvements.

Thus the whole process repeats...

The fact that the process of Systems Analysis is often repeats over and over (constantly building upon and improving systems) means that it is often referred to a a cyclic (repeating) process.

The stages of Systems analysis are often shown in a circle

Next Up → Nothing! That's the end of the theory notes

So what now...?
Take a break, have a stretch, get a snack.
Then... go back to the beginning and read them all again!