A website full of IGCSE, As/Alevel notes, guides and other resources. You're probably after some help in preparing for your IGCSE or A/As Level exams. Well, you've come to the right place! There is plenty to help you here: theory notes, guides, textbooks, revision videos and worksheets. Take a look around and good luck. Please do leave your comments, suggestions and requests for notes or handouts in Guestbook.
Input and Output Devices

The syllabus says that you should be able to:
identify the following input devices: keyboards, numeric keypads, pointing devices (including mouse, touch pad and tracker ball), remote controls, joysticks, touch screens, graphics tablet, magnetic stripe readers, chip readers, PIN pads, digital cameras, video cameras, webcams, scanners, microphones, sensors, MICR, OMR, OCR, barcode readers, light pens; identify suitable uses of the input devices stating the advantages and disadvantages of each; identify the following output devices: monitors (CRT, TFT), printers (laser, inkjet and dot matrix), plotters, speakers, control devices (motors, buzzers, lights, heaters); identify suitable uses of the output devices stating the advantages and disadvantages of each.

Notes covering this section:
- Input Devices - Keyboards
- Input Devices - Pointing Devices
- Input Devices - Audio / Visual
- Input Devices - Card Readers
- Input Devices - Reading Text / Codes
- Input Devices - Sensors
- Output Devices - Audio / Visual
- Output Devices - Printing / Plotting
- Output Devices - Control Actuators

Input - Keyboards

Alphanumeric Keyboard

A very common, general purpose, input device that allows text (abc...), numbers (123...) and symbols (%$@...) to be entered into a computer.

A keyboard is simply a set of buttons. Each button has a symbol assigned.
Numeric Keypad

A small keyboard that only has numbers. Used to enter numeric data into computers such as those in ATMs. Most computer keyboards have a numeric keypad on the right side, and most mobile phones (there are also computers) have a one for entering phone numbers, etc.

PIN Pad

This is a device with a numeric keypad used to enter a person’s Personal Identity Number (PIN) e.g. when paying with a credit card. PIN pads are also found on electronic door locks - you enter a PIN to unlock the door. These devices are used to move an on-screen pointer or cursor (usually an arrow). They are commonly used with graphical user interfaces (GUIs).

Mouse

A pointing device found on most PCs. Sensors on the bottom of the mouse detect when the mouse is moved. Data about this movement is sent to the computer. Often used to control the pointer in a GUI.

Touchpad / Track pad

A pointing device found on most laptops. Used instead of a mouse since it takes up less space. The user moves a finger across the touch pad and this movement data is sent to the computer. Usually used to control the pointer in a GUI.

Trackball / Tracker Ball
This pointing device is not moved about like a mouse; instead it has a large ball that the user spins. Data about which direction the ball is spun is passed to the computer. It can be used to control a GUI pointer. Tracker balls are often used by people with limited movement (disabled) or by the very young since they are easier to use than a mouse.

Touch Screen

A touch screen is an alternative to a separate pointing device. With a touch screen the user selects items on the screen by touching the surface. This makes touch screen systems very intuitive and simple to use.

Often used for information terminals in public places e.g. libraries or museums where mice or keyboards may be stolen or damaged. Because they are so intuitive to use, and now they are getting cheaper to manufacture, touch screens will probably become the most common hardware interface for our electronic gadgets.

Graphics Tablet

A pointing device often used by designers and artists to allow natural hand movements to be input to graphics applications. A stylus is held like a pen and moved over the surface of the tablet. Data about the stylus movements are sent to the computer. Since it is so like using a pen, it is very easy to create ‘hand-drawn’ sketches.

Joystick / Joy pad

Used mainly for playing games. The user moves the joystick left/right, forward/back and data about these movements are sent to the computer. Small joysticks can also be found on some mobile phones.

Light Pen

www.igcse.at.ua
The video data from a web cam is low quality compared to a full video camera. However it is good enough for web chats (e.g. using a messenger application such as MSN Messenger or Skype). Usually a web cam is clipped to the top of a monitor, but many laptops now have web cams built into the edge of the screen.

A light pen is a device used as a pointing device or to ‘write’ on the screen of a computer. Light pens are rarely used today since graphics tablets and high-quality touch screens provide similar functionality.

A device that ‘scans’ images, book pages, etc. Scanning is basically taking a close-up photograph (just very slowly and with great detail). The scanned image data is passed to the computer. The most common type of scanner is the flat-bed scanner which has a glass plate on which the item to be scanned is placed. The item is illuminated and an image of it is captured by a moving scan ‘head’. Scanned images can be further processed once inside the computer, e.g. OCR of printed text.

A device that captures digital photographs. Most digital cameras do not directly input data into a computer - they store photographs on memory cards. The photographs can later be transferred to a computer. A modern digital camera can capture 10 Megapixels or more per photograph - that's 10,000,000 colored dots (pixels) in every photo! A digital camera in fact contains a small computer that controls camera focus, stores images, etc. The camera's computer runs a very simple operating system (stored on ROM) and usually provides a menu-based GUI for the user.

A device that captures moving images, or video. Like a digital camera, most video cameras do not directly input data into a computer - the captured movies are stored on video-tape or memory cards and later transferred to a computer. However, there are some situations where video cameras do feed video data directly into a computer: television production and video-conferencing. In these situations the video data is required in real-time.

This is a very basic video camera used to feed live video into a computer. The video data from a web cam is low quality compared to a full video camera. However it is good enough for web chats (e.g. using a messenger application such as MSN Messenger or Skype). Usually a web cam is clipped to the top of a monitor, but many laptops now have web cams built into the edge of the screen.
All data could be input to a computer using a keyboard, but this would often be a slow process, and mistakes would be made. Sometimes speed and accuracy is required.

A card is inserted into the reader where metal contacts connect to the metal pads on the front face of the card. The reader can then access the memory chip and the data stored on it. Modern credit cards and ID cards don't use a magnetic strip. Instead they have a tiny 'chip' of computer memory embedded inside them. (These cards are often referred to as smart cards.) Data can be stored in this memory and read back using a 'chip' reader. A card is inserted into the reader where metal contacts connect to the metal pads on the front face of the card.

Many plastic cards, such as credit cards, have a strip of material that can be magnetized on the back. Data can be stored here in the form of magnetized dots. Usually the data stored on this strip in the same data shown on the front of the card (e.g. the credit card number, expiry date and customer name). The stripe allows this data to be input to a computer system faster and more accurately than by typing it in. A magnetic strip/stripe reader is used to read the data from the stripe. This is usually done by 'swiping' the card through a slot on the reader.

Many types of card use this system: id cards, phone cards, credit cards, door security cards, etc. All data could be input to a computer using a keyboard, but this would often be a slow process, and mistakes would be made. Sometimes speed and accuracy is required.

Analogue microphones to allow them to be used with chat and phone applications.

Satellite TV decoders use smart cards to store which channels a user has paid for. The data is encrypted so that it is not easy to alter (you can't add new channels without paying!) Many types of card use this system: id cards, phone cards, credit cards, door security cards, etc. All data could be input to a computer using a keyboard, but this would often be a slow process, and mistakes would be made. Sometimes speed and accuracy is required...

An input device that converts sound into a signal that can be fed into a computer. An Analogue is used for this (usually built into the computer's sound card) Many headphones now come with microphones to allow them to be used with chat and phone applications.
Magnetic Ink Character Recognition (MICR) is a technology that allows details from bank cheques to be read into a computer quickly and accurately. The cheque number and bank account number are printed at the bottom of each bank cheque in special magnetic ink using a special font. These numbers can be detected by an MICR reader.

Optical Character Recognition (OCR) is a software technology that can convert images of text into an actual text file that can then be edited, e.g. using word-processing software). The result is just as if the text had been typed in by hand. Advanced OCR software can recognize normal handwriting as well as printed text - this is usually called handwriting recognition.

Special OMR forms are used which have spaces that can be coloured in (usually using a pencil). These marks can then be detected by an OMR scanner. Common uses of OMR are multiple-choice exam answer sheets and lottery number forms. Optical Mark Recognition (OMR) is a technology that allows the data from a multiple-choice type form to be read quickly and accurately into a computer.

The scanned image of the page is then analyzed by the OCR software which looks for recognizable letter shapes and generates a matching text file.
Input - Sensors

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>

A barcode is simply a numeric code represented as a series of lines. These lines can be read by a barcode reader/scanner. The most common use of barcode readers is at Point-of-Sale (POS) in a shop. The code for each item to be purchased needs to be entered into the computer. Reading the barcode is far quicker and more accurate than typing in each code using a keypad. Barcode can be found on many other items that have numeric codes which have to be read quickly and accurately - for example ID cards.

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. An Analogue (ADC). Sensors are used extensively in monitoring / measuring / data logging systems, and also in computer control systems.
These devices are very common. They send data signals each time a button is pressed using infrared light or radio signals. The signals can control a computer (or a system that contains a small computer such as a DVD player) from some distance. Often used to control a presentation slideshow.

Output Devices

CRT Monitor

A monitor displays text and image data passed to it by the computer. A cathode-ray tube (CRT) monitor is the type that has been around for years and is large and boxy. CRT monitors are heavy and they take up a lot of desk space. They have largely been replaced by flat-screen monitors. However some are still used in the design industry since the colour accuracy and brightness of CRT monitors is excellent, and designers need to see true-to-life colours. Also, CRT monitors are generally cheaper than flat-screen monitors.

Flat-Screen Monitor (TFT or LCD)

Over the past few years, as they have come down in price, flat-screen displays have replaced CRT monitors. Flat-screen monitors are light in weight and they take up very little desk space. Modern flat-screen monitors have a picture quality that is as good as CRT monitors. TFT and LCD are two of the technologies used in flat-screen monitors: TFT is Thin-Film-Transistor, and LCD is Liquid-Crystal Display. Another technology that may replace these is OLED or Organic Light-Emitting Diodes.

Digital / Multimedia Projector

A projector connects to a computer, a DVD player or a satellite receiver just like a ordinary monitor.

The image is produced inside the device and then projected out through a large lens, using a powerful light source.
If you want to hear music or sounds from your computer, you will have to attach loudspeakers. They convert electrical signals into sound waves. Loudspeakers are essential for applications such as music editing, video conferencing, watching movies, etc.

Digital projectors are used in situations when a very large viewing area is required, for example during presentations, for advertising, or in your home for watching movies.

Output - Printing / Plotting

If you want a physical copy of some data on paper (a ‘hardcopy’) you will need a device that can make marks on paper - a printer or a plotter...

Dot Matrix Printer
A dot-matrix printer is named after the pattern (a grid or ‘matrix’) of dots used when creating the paper printout. These dots are formed by tiny pins in the printer’s print head that hit an inked ribbon against the paper leaving marks. As the print head moves along it leaves a pattern of dots behind it which can form letters, images, etc. Dot matrix printers often use continuous stationary: long, continuous strips of paper (rather than separate sheets of A4 like ink-jet and laser printers use). Dot-matrix print quality is poor, the printers are noisy, and there are much better printing systems available today. However, the dot-matrix printers are still used in certain situations:

- Since the pins actually hit the paper, several ‘carbon-copies’ can be printed in one go. An example of this is airline tickets which have several duplicate pages, all printed in one go
- The print mechanism is very cheap, and the inked ribbons last for a long time. So, where cheap, low-quality printouts are required, dot-matrix printers are used. An example is shop receipts.

Cheap, high-quality, full-colour printing became available during the 1980s due to the development of ink-jet printers. These printers have a similar print-head mechanism to a dot-matrix printer. The print-head passes left and right across the paper. However, instead of using pins to hit inky marks onto the paper, the ink-jet squirts tiny droplets of ink onto the surface of the paper. Several coloured inks can be used to produce full-colour printouts. The droplets of ink come from tiny holes (the jets) which are less than the width of a human hair in size. Each droplet creates a tiny dot on the paper. Since the dots are so small, the quality of the printout is excellent (1200 dots-per-inch are possible). This is perfect for photographs. Ink-jet printers are very quiet in use. Since they have so few moving parts they are also cheap to manufacture and thus cheap to purchase. However, the ink is very expensive to buy (this is how the printer companies make their profits!) so the printers are expensive to use.
Laser Printer

Laser printers are very complex devices, and thus expensive to buy. However they are very cheap to use. This is because they produce marks on paper using a fine dust called toner which is relatively cheap to buy. A single toner cartridge will often last for 5,000-10,000 pages of printing. The laser printer uses a complex system, involving a laser, to make the toner stick to the required parts of the paper. (This system is very different to a dot-matrix or ink-jet, and you don't need to know the details.)

Plotter

Plotters create hard-copy in a very different way to printers. Instead of building up text and images from tiny dots, plotters draw on the paper using a pen. The pens are held in an arm which can lift the pen up or down, and which can move across the paper. The arm and pen create a drawing just like a human could, but much more accurately and more quickly.

Different coloured pens can be used to produce coloured line drawings. Plotters are often used by designers and architects since they work with huge pieces of paper, far bigger than anything a normal printer could work with...
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…world. Examples

<table>
<thead>
<tr>
<th>What it Can Do</th>
<th>Actuator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creates light</td>
<td>Light bulb or LED</td>
</tr>
<tr>
<td>Increases temperature</td>
<td>Heater</td>
</tr>
<tr>
<td>Decreases temperature</td>
<td>Cooling Unit</td>
</tr>
<tr>
<td>Spins things around</td>
<td>Motor</td>
</tr>
<tr>
<td>Pushes water / air through pipes</td>
<td>Pump</td>
</tr>
<tr>
<td>Creates noise</td>
<td>Buzzer / Bell / Siren</td>
</tr>
</tbody>
</table>
Actuators are used extensively in computer control systems. Digital (DAC)

Motors can provide movement. For example, the motor in a washing machine can be controlled by a computer - it is switched on when the clothes are loaded for washing and switched off at the end of the wash. Computer-controlled motors are also found in microwave ovens (to turn the food around) and air-conditioning units (to drive the fan).

A pump is basically a motor attached to a device that can push water or air along pipes. When the motor is switched on, water or air flows along the pipes to places it is needed. Pumps are used in many places: as part of watering systems in greenhouses, in factories, etc.

Buzzers can provide noise. For example, the buzzer in a microwave oven can be switched on by the controlling computer when the food is cooked. Louder noises can be made using a siren or an electric bell, for example in a burglar alarm system.

Light bulbs and LEDs can be used to provide light, or to indicate something. For example, computer-controlled lights are used in traffic lights, at music concerts. Lights are used in car dashboards to show if any of the systems in the car have problems.
Heaters can provide heat, and coolers can cool things down.

A computer can switch a heater on or off when needed to keep a room or a greenhouse at the correct temperature during winter.

A computer can switch a cooling unit on or off to keep a room at the correct temperature during hot weather, or to keep food fresh.

3. Storage Devices and Media

The syllabus says that you should be able to:

describe common backing storage media and their associated devices: magnetic tapes, CDs (all types), DVDs (all types), DVD-RAM discs, HD DVD discs, Blue-Ray discs, hard discs, memory sticks, flash memory identify typical uses of the storage media, including types of access (e.g. serial/sequential, direct/random) and access speeds; describe the comparative advantages and disadvantages of using different backing storage media; define the term backup and describe the need for taking backups; describe the difference between main/internal memory and backing storage, stating the relative benefits of each in terms of speed and permanence.

What is Data Storage?

When we talk about ‘storing’ data, we mean putting the data in a known place. We can later come back to that place and get our data back again.

‘Writing’ data or ‘saving’ data are other ways of saying ‘storing’ data. ‘Reading’ data, ‘retrieving’ data or ‘opening’ a file are ways of saying that we are getting our data back from its storage location.

Main Memory

Main memory (sometimes known as internal memory or primary storage) is another name for RAM (and ROM). Main memory is usually used to store data temporarily. In the case of RAM, it is volatile (this means that when power is switched off all of the data in the memory disappears). Main memory is used to store data whilst it is being processed by the CPU. Data can be put into memory, and read back from it, very quickly. Memory is fast to access, but only holds data temporarily...

Backing Storage

www.igcse.at.ua
Backing storage (sometimes known as secondary storage) is the name for all other data storage devices in a computer: hard-drive, etc. Backing storage is usually non-volatile, so it is generally used to store data for a long time. Backing storage devices are slower to access, but can hold data permanently...

Storage Media & Devices

The device that actually holds the data is known as the storage medium (‘media’ is the plural).

The device that saves data onto the storage medium, or reads data from it, is known as the storage device. Sometimes the storage medium is a fixed (permanent) part of the storage device, e.g. the magnetic coated discs built into a hard drive. Sometimes the storage medium is removable from the device, e.g. a CD-ROM can be taken out of a CD drive.

Accessing Stored Data

We refer to a collection of data stored in a computer system as a ‘file’. Files are often organized into ‘folders’. Whenever you click ‘Save’ in an application, burn files to a CD-R, copy music onto your MP3 player, or drag and drop a file onto memory stick, you are using storage devices - devices that can store and retrieve data.

Serial / Sequential Access

A serial (or sequential) access storage device is one that stores files one-by-one in a sequence. A non-computer serial access device that will be familiar to you is a VHS videotape.

Because video is stored on a long piece of tape, when TV shows are recorded onto the tape, they go on one-by-one, in order...If you want to watch a show that you recorded earlier, you have to rewind / fast-forward through all other shows until you find it. Systems that store things on tape (video, music, computer data, etc.) are always serial access.

Direct / Random Access
A direct (or ‘random’) access storage device is one that stores files so that they can be instantly accessed - there is no need to search through other files to get to the one you want. An example of a direct access device would be a DVD movie. Unlike the VHS videotape movie, you can jump to any scene on a DVD. All parts of the DVD are directly accessible. This type of file storage is called direct access.

**Data Storage Capacity**

Some storage media can only store a very limited amount of data, whilst others can store vast amounts... Data storage capacity is measured in bytes (B). A thousand bytes is known as a kilobyte (kilo) $1,000B = 1kB$ A million bytes is known as megabyte (MB) $1,000,000B = 1MB$ A thousand million bytes is called a gigabyte (GB) $1,000,000,000B = 1GB$ A million bytes is called a terabyte (TB) $1,000,000,000,000B = 1TB$

Even very basic storage devices like a floppy disc can store over a megabyte of data - that's over 1 million letters or numbers! And modern hard drives can store a terabyte of data or more - that's more words than you could type even if you started now, and typed until your old age!

**Data Access Speeds**

Some storage devices can access data very quickly, whilst others are extremely slow... *Note: Modern back-up tapes have very fast access speeds, but only to save/read data sequentially (they are serial access devices).
Tapes are very slow if you want to read files out of order, since the tape has to be rewound and fast-forwarded. Access speeds are measured in bytes per second (Bps). Slow devices have speeds measured in thousands of Bps (kips). E.g. a floppy disc can save/read data at a speed of 60kBps. Fast devices have speeds measured in millions of Bps (Mips). E.g. a hard-drive can save/read data at a speed of 300MBps (5000 times quicker than the floppy!)

Magnetic Storage Devices / Media

Why Magnetic?

Magnetic storage media and devices store data in the form of tiny magnetized dots. These dots are created, read and erased using magnetic fields created by very tiny electromagnets. In the case of magnetic tape the dots are arranged along the length of an plastic strip which has been coated with a magnetisable layer (audio and video tapes use a similar technology). In the case of magnetic discs (e.g. floppy disc or hard-drive), the dots are arranged in circles on the surface of a plastic, metal or glass disc that has a magnetisable coating.

Hard Drives

Hard-drives have a very large storage capacity (up to 1TB). They can be used to store vast amounts of data. Hard-drives are random access devices and can be used to store all types of films, including huge files such as movies. Data access speeds are very fast. Data is stored inside a hard-drive on rotating metal or glass discs (called 'platters').

Fixed Hard Drive

A hard-drive built into the case of a computer is known as 'fixed'. Almost every computer has a fixed hard-drive. Fixed hard-drives act as the main backing storage device for almost all computers since they provide almost instant access to files (random access and high access speeds).

Portable Hard Drive

www.igcse.at.ua
Magnetic Tape

Magnetic tape is a large capacity, serial access medium. Because it is a serial access medium, accessing individual files on a tape is slow. Tapes are used where large amounts of data need to be stored, but where quick access to individual files is not required. A typical use is for data back-up (lots of data, but rarely only accessed in an emergency) Tapes are also used and in some batch-processing applications (e.g. to hold the list of data that will be processed).

Removable Media Magnetic Discs

Floppy Disc

A removable, portable, cheap, low-capacity (1.44MB) storage medium. Floppy discs are random access devices used for transfer small amounts of data between computers, or to back-up small files, etc. Access times are slow. Almost every PC used to have a floppy disc drive. These are obsolete now, having been replaced by higher capacity technology such as CD-ROMs, DVDs and USB memory sticks.

Zip Disc

A removable and portable storage medium, similar in appearance to a floppy disk, but with a much higher capacity (100MB, 250MB or 750MB). Zip discs are random access devices which were used for data back-up or moving large files between computers. Another obsolete storage device, zip discs were a popular replacement for floppy discs for a few years, but they never caught on fully before being superseded by cheaper media like CD-ROMs and CD-Rs.
Like the Zip disc, this system never really caught on and was superseded by far cheaper and more reliable and cheaper technology.

**Optical Storage Devices / Media**

**Why 'Optical'?**

Optical storage devices save data as patterns of dots that can be read using light. A laser beam is the usual light source. The data on the storage medium is read by bouncing the laser beam off the surface of the medium. If the beam hits a dot it is reflected back differently to how it would be if there was no dot. This difference can be detected, so the data can be read. Dots can be created using the laser beam (for media that is writable such as CD-Rs). The beam is used in a high-power mode to actually mark the surface of the medium, making a dot. This process is known as ‘burning’ data onto a disc. This is a magnified view of the dots on the surface of a CD. The different patterns of dots correspond to the data stored on the disc.

**Read-Only Optical Discs**

Read-only optical discs have data written onto them when they are manufactured. This data cannot be changed.

**CD-ROM**

Compact Disc - Read-Only Memory (CD-ROM) discs can hold around 800MB of data. The data cannot be altered (non-volatile), so cannot be accidently deleted. CD-ROMs are random-access devices. CD-ROMs are used to distribute all sorts of data: software (e.g. office applications or games), music, electronic books (e.g. an encyclopedia with sound and video.)

**DVD-ROM**
Digital Versatile Disc - Read-Only Memory (DVD-ROM) discs can hold around 4.7GB of data (a dual-layer DVD can hold twice that). DVD-ROMs are random-access devices. DVD-ROMs are used in the same way as CD-ROMs (see above) but, since they can hold more data, they are also used to store high-quality video.

High Capacity Optical Discs

Blue-Ray

Blue-Ray disks are a recent replacement for DVDs. A Blue-Ray disc can hold 25 - 50GB of data (a dual-layer Blue-Ray disc can hold twice that). Blue-Ray disks are random-access devices. Blue-Ray disks are used in the same way as DVD-ROMs (see above) but, since they can hold more data, they are also used to store very high-quality, high-definition (HD) video.

The 'Blue' part of Blue-Ray refers to the fact that the laser used to read the disc uses blue light instead of red light. Blue light has a shorter wave-length than red light (used with CDs and DVDs). Using a blue laser allows more data to be placed closer together on a Blue-Ray disc, than on a DVD or CD, so Blue-Ray has a much higher storage capacity than these older discs.

HD DVD

High-density DVD (HD-DVD) discs can hold around 15GB of data (a dual-layer HD-DVD can hold twice that). HD-DVDs are random-access devices. HD-DVD discs are used in the same way as DVD-ROMs (see above) but, since they can hold more data, they are also used to store very high-quality, high-definition (HD) video.

The HD-DVD format was launched at the same time as Blue-Ray. For about a year they competed to be the 'next DVD'. For various reasons, Blue-Ray won the fight, and the HD-DVD format has been abandoned.

Recordable Optical Discs

Recordable optical discs can have data written onto them ('burnt') by a computer user using a special disc drive (a disc 'burner').
CD-R and DVD-R

CD-Recordable (CD-R) and DVD-recordable (DVD-R) discs can have data burnt onto them, but not erased. You can keep adding data until the disc is full, but you cannot remove any data or re-use a full disc.

CD-RW and DVD-RW

CD-Rewritable (CD-RW) and DVD-Rewritable (DVD-RW) discs, unlike CD-Rs and DVD-Rs, can have data burnt onto them and also erased so that the discs can be re-used. When CD-Rs and DVD-Rs are burnt, the laser makes permanent marks on the silver-coloured metal layer. This is why these discs cannot be erased. When CD-RWs and DVD-RWs are burnt the laser makes marks on the metal layer, but in a way that can be undone. So these discs can be erased.

DVD-RAM

DVD-Random Access Memory (DVD-RAM) discs are a type of re-writable DVD. They often come in a floppy-disc style case (to protect the disc). DVD-RAM discs have a similar capacity to a normal DVD, holding 4.7GB of data. DVD-RAM discs are random-access devices. DVD-RAM discs are used in many camcorders (video recording cameras).

The discs are much higher quality than normal DVD-RWs and can reliably store data for up to 30 years. This means that they are often used for video and data back-up and archiving.

Solid-State Storage Devices

'Solid-State'?

The term ‘solid-state’ essentially means ‘no moving parts’. Solid-state storage devices are based on electronic circuits with no moving parts (no reels of tape, any spinning discs, any laser beams, etc.) Solid-state storage devices store data using a special type of memory called flash memory...

Flash Memory

Flash memory is a type of Electronically-Erasable Programmable Read-Only Memory (EEPROM). Flash memory is non-volatile (like ROM) but the data stored in it can also be erased or changed (like RAM) to store data for up to 30 years.
RAM. Flash memory can be found in many data storage devices... You might wonder why, since flash memory is non-volatile, normal computers don't use it instead of RAM. If they did we would have computers that you could turn off, turn back on again and no data would be lost – it would be great! The reason is speed – saving data to flash memory is very slow compared to saving it to RAM. If a computer were to use flash memory as a replacement for RAM it would run very slowly. However some portable computers are starting to use flash memory (in the form of solid-state 'discs' as a replacement for hard-drives. No moving parts mean less to go wrong and longer battery life.

USB Memory Sticks

Memory sticks (or 'thumb-drives') have made many other forms of portable storage almost obsolete (why burn a CD or DVD when you can more easily copy your files onto a memory stick?). Memory sticks are non-volatile, random-access storage devices. Each of these small devices has some flash memory connected to a USB interface. Plug it into your computer and it appears as a drive. You can then add files, erase files, etc.

You can use it to move any type of file between computers. Flash memory used to be very expensive, but in recent years it has become much cheaper and you can now buy a 16GB memory stick for just a few dollars.

Memory Cards

Many of our digital devices (cameras, mobile phones, MP3 players, etc.) require compact, non-volatile data storage. Flash memory cards provide this and come in a variety of shapes and sizes. One of the most common formats used by digital cameras is the SD Card.

The cards store the digital images taken by the camera. Mobile phones contain a Subscriber Identity Module (SIM) card that contains the phone's number, the phonebook numbers, text messages, etc. Many phones also have extra memory cards to store music, video, photos, etc. (e.g. Tiny Micro-SD cards).

Smart Cards

Many credit cards (e.g. 'chip-and-pin' cards), door entry cards, satellite TV cards, etc. have replaced the very limited storage of the magnetic strip (the dark strip on the back of older cards) with flash memory. This is more reliable and has a much larger storage capacity. Cards with flash memory are called smart cards.
Backing Up Data

What is a Backup?
A backup simply means making one or more copies of your data. For example, if you have a folder of photos stored on the hard-drive of your laptop, you might back them up by copying them to a CD-R.

Note: If you move the photos from the hard-drive to a CD-R, you do not have a back-up - you still only have one copy of the photos, but now they are on a CD instead of the hard-drive. You only have a backup if you have a second copy of your data.

Why Backup Your Data?
If you delete a file by accident, your computer breaks, your laptop is stolen, or your business burns to the ground, having a backup copy means that you have not lost your precious data. You can recover your lost files and continue working.

Most businesses use computers to store very important data (customer records, financial information, designs for products, etc.) If this data is lost, the business could possibly have to close. Backing-up business data is essential.

How Are Backups Created?
Personal backups of the data on your hard-drive can be made by...
Burning files to a CD-R, Copying files to an external hard-drive, Copying the files to another computer on a network.
4. Computer Networks

The syllabus says that you should be able to:

1. describe a router and its purpose;
2. describe the use of WIFI and Bluetooth in networks;
3. describe how to set up a small network involving access to the Internet, understanding the need to set up the use of a browser, email and an ISP;
4. identify the advantages and disadvantages of using common network environments such as the Internet;
5. describe what is meant by the terms user id and password, stating their purpose and use;
6. identify a variety of methods of communication such as:
   - fax,
   - e-mail,
   - bulletin boards,
   - tele/video conferencing;
7. define the terms:
   - Local Area Network (LAN)
   - Wireless Local Area Network (WLAN)
   - Wide Area Network (WAN)
8. describe the difference between LANs and WANs, identifying their main characteristics;
9. describe the characteristics and purpose of common network environments, such as intranets and the Internet;
10. describe other common network devices (including hubs, bridges, switches and proxy servers);
11. discuss the problems of confidentiality and security of data, including problems surrounding common network environments;
12. identify the need for encryption, authentication techniques, including the use of user identification and passwords, when using common network environments such as the Internet.
What is a Network?

A network is two or more computers, or other electronic devices, connected together so that they can exchange data. For example, a network allows computers to share files, users to message each other, a whole room of computers to share a single printer, etc. Network connections between computers are typically created using cables (wires). However, connections can be created using radio signals (wireless / Wi-Fi), telephone lines (and modems) or even, for very long distances, via satellite links. A computer that is not connected to a network is known as a standalone computer.

Why Use Networks?

Using a computer connected to a network allows us to...

- Easily share files and data
- Share resources such as printers and Internet connections
- Communicate with other network users (e-mail, instant messaging, video-conferencing, etc.)
Store data centrally (using a file server) for ease of access and back-up
Keep all of our settings centrally so we can use any workstation

In particular, if we use a computer connected to The Internet, we can...

Make use of on-line services such as shopping (e-commerce) or banking
Get access to a huge range of information for research
Access different forms of entertainment (games, video, etc.)
Join on-line communities (e.g. MySpace, Facebook, etc.)

Why Not Use Networks?

Using a computer connected to a network means that...

The computer is vulnerable to hackers
If the network breaks, many tasks become very difficult
Your computer can more easily be attacked by a virus

In particular, if we use a computer connected to The Internet we have to be careful about revealing personal information, We have to be careful to avoid suspect websites that might contain malware, We have to be aware that information found on The Internet is not always accurate or reliable,

Computers in a Network

Computers connected together to create a network fall into two categories: servers and clients (workstations).
Clients

Client computers, or workstations, are the normal computers that people sit at to get their work done. When you use your Web browser, you are in fact using a Web client. When you type in the URL of a web page, you are actually providing the address of a Web server. e.g. www.bbc.co.uk is the address of the BBC’s web server. Your Web browser/client asks this server for the web page you want, and the server ‘serves’ the page back to the browser/client for you to see.

Servers

Servers are special, powerful computers that provide ‘services’ to the client computers on the network. These services might include:

- Providing a central, common file storage area
- Sharing hardware such as printers
- Controlling who can or can’t have access the network
- Sharing Internet connections

Servers are built to be very reliable. This means that they are much more expensive than normal computers. In a small network one server might provide all of these services. In a larger network there might be many servers sharing the work.

Types of Network

Local Area Network (LAN)
Wireless Local Area Network (WLAN)

However, WLANs are more difficult to make secure since other people can also try to connect to the wireless network. So, it is very important to have a good, hard-to-guess password for the WLAN connections. Typically, the range of a wireless connection is about 50m, but it depends how many walls, etc. are in the way.

Wide Area Network (WAN)

A Wide Area Network is a network that extends over a large area. A WAN is often created by joining several LANs together, such as when a business that has offices in different countries links the office LANs together. Because WANs are often geographically spread over large areas and links between computers are over long distances, they often use quite exotic connections technologies: optical fiber (glass) cables, satellite radio
Bluetooth (Personal Area Network)

Bluetooth is a wireless networking technology designed for very short-range connections (typically just a few meters). The idea of Bluetooth is to get rid of the need for all of those cables (e.g. USB cables) that connect our computer to peripheral devices such as printers, mice, keyboards, etc. Bluetooth devices contain small, low-power radio transmitters and receivers. When devices are in range of other Bluetooth devices, they detect each other and can be 'paired' (connected).

Typical uses of Bluetooth:
- Connecting a wireless keyboard to a computer
- Connecting a wireless mouse to a computer
- Using a wireless headset with a mobile phone
- Printing wirelessly from a computer or PDA
- Transferring data / music from a computer to an MP3 player
- Transferring photos from a phone / camera to another device
- Synchronizing calendars on a PDA and a computer
- Because Bluetooth networking only works over very short distances, and with devices belonging to one user, this type of network is sometimes called a 'Personal Area Network'.

LAN Topologies

The word topology means ‘arrangement’, so when we talk about the topology of a network, we mean how the different parts are arranged and connected together. There are three common network topologies...

The Internet is an example of global WAN. In fact it is the world's largest WAN.

Computers on the International Space Station are linked to the Internet, so the you could say the Internet is now the first off-planet WAN!
Bus Network

In this type of network, a long, central cable, the ‘bus’ is used to connect all of the computers together. Each computer has a short cable linking it to the ‘buses’. A bus network...

- Is cheap to install (just one long cable)
- Can be quite slow since all computers share the same cable when communicating
- Will stop working if there is a break in the central bus cable.

Ring Network

In this type of network each computer is connected to a loop of cable, the ‘ring’. (If you took a bus network and connected the ends of the bus cable together, you would have a ring network.) A ring network...

- Can cope with a break in the ring cable since all computers are still joined together (it is now a bus network)

Star Network

In this type of network every computer is connected to a central device. The device passes messages between computers. At the centre of a star network you might use a hub (cheap, but slower) or a switch (more expensive, but faster). A star network...
Hybrid Network

- Is quite expensive to install (you have to buy lots of cable and the central device)
- Is very fast since each computer has its own cable which it doesn’t need to share
- Can cope with a broken cable (only one computer will be affected)
- Will stop working if the central device breaks
- Is the most common network topology

A hybrid network is simply one that combines two or more of the above basic topologies. E.g. A network that has several star networks linked together is a hybrid network.
Any computer that is to be connected to a network needs to have a network interface card (NIC). Most modern computers have these devices built into the motherboard, but in some computers you have to add an extra expansion card (small circuit board). Some computers, such as laptops, have two NICs: one for wired connections, and one for wireless connections (which uses radio signals instead of wires). In a laptop, the wireless radio antenna is usually built in to the side of the screen, so you don't need to have a long bit of plastic sticking out the side of your computer!

Cables are still used in most networks, rather than using only wireless, because they can carry much more data per second, and are more secure (less open to hacking).

A hub is a device that connects a number of computers together to make a LAN. The typical use of a hub is at the centre of a star network (or as part of a hybrid network) - the hub has cables plugged into it from each computer. A hub is a 'dumb' device: if it receives a message, it sends it to every computer on the network. This means that hub-based networks are not very secure - everyone can listen in to communications.

Hubs are pretty much obsolete now (you can't buy them any more), having been superseded by cheap switches.
A switch, like a hub, is a device that connects a number of computers together to make a LAN. The typical use of a switch is at the centre of a star network (or as part of a hybrid network) - the switch has cables plugged into it from each computer. A switch is a more ‘intelligent’ device than a hub: if it receives a message, it checks who it is addressed to, and only sends it to that specific computer. Because of this, networks that use switches are more secure than those that use hubs, but also a little more expensive.

### Router

A router is a network device that connects together two or more networks. A common use of a router is to join a home or business network (LAN) to the Internet (WAN). The router will typically have the Internet cable plugged into it, as well as a cable, or cables to computers on the LAN.

Alternatively, the LAN connection might be wireless (Wi-Fi), making the device a wireless router. (A wireless router is actually a router and wireless switch combined) Routers are the devices that join together the various different networks that together make up the Internet.

These routers are much more complex than the one you might have in your home.

### Proxy Server

A proxy server is a computer setup to share a resource, usually an Internet connection. Other computers can request a web page via the proxy server. The proxy server will then get the page using its Internet connection, and pass it back to the computer who asked for it. Proxy servers are often used instead of router since additional software can be easily installed on the computer such as anti-virus, web filtering etc.
A bridge is a network device that typically links together two different parts of a LAN. Whereas a router is usually used to link a LAN to a WAN (such as the Internet), a bridge links independent parts of a LAN so that they act as a single LAN.

A firewall is a device, or a piece of software that is placed between your computer and the rest of the network (where the hackers are!) If you wish to protect your whole LAN from hackers out on the Internet, you would place a firewall between the LAN and the Internet connection. A firewall blocks unauthorized connections being made to your computer or LAN. Normal data is allowed through the firewall (e.g. e-mails or web pages) but all other data is blocked. In addition to physical devices, firewalls can also be software. In fact most computer operating systems have a software firewall built in (e.g. Windows, Linux and Mac OS).
Modem

Before the days of broadband Internet connections, most computers connected to the Internet via telephone lines (dial-up connections). The problem with using telephone lines is that they are designed to carry voices, which are analogue signals. They are not designed for digital data. The solution was to use a special device to join the digital computer to the analogue telephone line. This device is known as a modem. A modem contains a DAC and an ADC. The DAC in the modem is required so that the digital computer can send data down the analogue telephone line (it converts digital data into noises which is exactly what the telephone line is designed to carry.)

The reason telephone lines were used is that almost every building in the world is already joined to every other via the telephone system? Using the telephone system for connecting computers meant that people didn’t have to install new wires to their houses and offices just for computer use. In the last few years however, this is exactly what people have done. Special cables have been installed just for Internet access. These special cables are designed to carry digital data, so no modem is required. The word modem is an abbreviation of Modulator Demodulator. A modulator acts as a DAC, and a demodulator acts as an ADC.

The Internet

So, simply put, a modem is required because computers are digital devices and the telephone system is analogue. The modem converts from digital to analogue and from analogue to digital. If you have ever used a dial-up connection, you have probably heard the noises sent by the modem down the telephone line. They sound like a horrible screeching beeping sound.
The Internet is a world-wide network that has grown and evolved from an experimental network (Arpanet) created by the US military back in the 1960s. Over the years, as more and more computers and networks have connected to this network, it has grown into the Internet that we know today. The Internet connects millions of people, and thousands of businesses, governments, schools, universities and other organizations.

What Can We Use the Internet For?

The Internet provides the network connections that link computers together. There are many ways that we can use these connections:

- View web pages on the WWW (World-Wide Web)
- Sending and receiving e-mail messages
- Sharing files
- Communicating using voice (VOIP) and video (video-conferencing)
- Playing multi-player games
- Listening to streamed music or watching streamed video

The small, hand-drawn map above shows the plan for the first connections between four computers on the Arpanet. It was drawn by one of the engineers who created the network back in 1969. From these tiny beginnings, the Internet has grown to a size that would be hard to believe forty years ago. Statistics published at the start of 2008 show that 1.3 billion people now have access to the Internet (20% of world population).

Intranets

An intranet is the name given to a private network that provides similar services to The Internet: e-mail, messaging, web pages, etc. However, these services are only for the users of the intranet - they are private, not public (unlike Internet services which are generally public).
Businesses and other organizations often have intranets for use by their employees. Typical uses of an intranet would be:

- Viewing internal web pages (e.g. company calendars, etc.)
- Internal e-mail and instant-messaging between workers
- Sharing of internal documents

Setting Up a Small Network

If you were asked to build a small, Internet-connected network from scratch, what would you need to do? You would need to buy some hardware:

- One or more switches / hubs - to link devices together
- Network cables to connect devices to the switch, etc.
- A separate wireless access point (or this could be part of the switch) - to allow wireless devices (e.g. laptops or smart-phones) to join the network
- A router to connect your LAN to the Internet (WAN)
- A firewall to protect your network from hackers
- Possibly a bridge if you already have a section of network and you want your new network to connect to it
- Server(s) to manage network functions such as network security, network file storage, shared resources (such as printers)

You would need to organize some other things:

- Set up an account with an Internet Service Provider (ISP)
- Get an Internet connection installed from the ISP to your location
- Configure various bits of hardware and software so that everything worked with the network

For any network that is more complex than a small home network, there is allotting to do.

It's not just a case of buying the parts and connecting them together... Networks are pretty complex thing to set-up. The people who do this are called Network Engineers. It's a very interesting technical job, if you like that sort of thing!
Network & Data Security

As soon as your computer is connected to a network, you have to start thinking about security — security of your files, information, etc. A network allows a person who does to have physical access to your computer (they are not sitting in front of it) to gain access all the same. If your computer is connected to a network, other people can connect to your computer. A person who gains unauthorized access to a computer system is often called a hacker.

Preventing Unauthorized Access

There are a number of security measures that you can take to prevent hackers accessing your computer and all of the data stored on it:

Physical Security

The first thing to make sure of is that no unauthorized people can physically access (sit down in front of) any of the computers on your network. For example, by keeping office doors locked.

Use a Username and Have a Good Password

The most common way to protect your computer’s data is to setup user accounts with usernames and passwords. Anyone not having a username, or not knowing the correct password will be denied access. For this to be effective passwords must be chosen that are not easy to guess. Passwords should

- Routers and switches have to be configured (settings changed)
- Network devices need to be given network addresses
- Software needs to be configured to use the network
- Etc...
be a random combination of lowercase letters, uppercase letters and numbers (and symbols if this is allowed):

- ‘Weak’ passwords: password, 123456, David, 27dec1992
- ‘Strong’ passwords: s63gRdd1, G66ew$dQ, gdr298783X

Some computer systems replace the typing of usernames and passwords with other forms of user identification such as ID cards, fingerprint readers, voice-print recognition, etc. Strong passwords are often hard to remember. Here is a good method for creating a password that is very strong, but also easy to remember:

Think of a phrase that you will never forget...

“My favorite food is chocolate ice cream”

Take the first letter of each word...

mfficic

Change some letters to similar numbers: I to 1, o to 0, s to 5, etc. and make some letters (e.g. the first and last) uppercase...

Mff1c1C

A random-looking mixture of letters and numbers. As long as you like chocolate ice cream you will never forget your password!

Always Install and Use a Firewall

A firewall is a device, or a piece of software that is placed between your computer / LAN and the rest of the network / WAN (where the hackers are!) You can read about firewalls in the Networking Hardware section.

Securing Your Data
Often we have data that is private or confidential. This data needs to be protected from being viewed by unauthorized people. This is especially true if the data is to be sent via a public network such as The Internet. The best way to protect data is to encrypt it...

**Data Encryption**

Encryption is the process of converting information into a form that is meaningless to anyone except holders of a ‘key’. For example, if Alice wants to send important, personal messages to Bob, she must go through the following steps... Encryption has been used for centuries to protect secrets. Military leaders as far back as roman times have used encryption to protect important messages sent to their armies, messages that must be kept secret from the enemy. If the messenger was caught by the enemy, the message, being encrypted, remained secret because they didn’t know the code to decrypt it. First Alice needs to generate a secret ‘key’. The key is usually a very long, random number.

The encryption scheme shown here is called Symmetric Key, or Single Key encryption. There are many better schemes, such as Public Key Encryption, but the one shown here is the easiest to understand! Alice must then give a copy of this key to Bob.

Now that Bob has a copy of the key, each time Alice needs to send him a message she starts by encrypting it using special encryption software and the secret key.

She must make sure that nobody else can get to the key (So maybe Alice will visit Bob and give him a copy of the key on a memory stick or floppy disc). The encrypted message now looks like a jumble of random letters and numbers. Alice then sends the encrypted message to Bob. She can use a public network like the Internet, since, even if it gets stolen, the encrypted message cannot be read or understood without the key. When Bob receives the message, he uses special decryption software and his copy of the secret key to decrypt the message. Bob can now read the original message from Alice.
5. Data Type and Organization

The syllabus says that you should be able to:

1. identify different data types:
   - logical / Boolean
   - alphanumeric / text
   - numeric (real and integer)
   - date

2. select appropriate data types for a given set of data: logical/Boolean, alphanumeric/text, numeric and date;

3. describe what is meant by the terms
   - file
   - record
   - field
   - key field

4. describe different database structures such as
   - flat files
   - relational tables
   - relationships
   - primary keys
   - foreign keys;

5. state the difference between analogue data and digital data;

6. explain the need for conversion between analogue and digital data.

Notes covering this section:

- Different Data Types
- Data Organization
- Types of Database
- Analogue and Digital Data

Help with this section: Ask questions and get help on this section of the syllabus in the help forum.

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

- 12
- 45
- 1274
- 1000000
- -3
- -5735

**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

- £12.45
- £0.01
- €999.00
- $5500

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

- 100%
- 25%
- 1200%
- -5%

Inside the computer the 50% is stored as a real number: 0.5, but when it is displayed it is shown formatted as a percentage.

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
Text data is often input to a computer with speech marks ("...") around it:

"MONKEY"

These tell the computer that this is text data and not some special command.

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

## Selecting Data Types

When we are presented with data to be input into a computer system, we must analyze it and select appropriate data types for each value...e.g. For the following data, we might use the date types shown:

<table>
<thead>
<tr>
<th>Data Name</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Text</td>
</tr>
<tr>
<td>Height</td>
<td>Real</td>
</tr>
<tr>
<td>Date of Birth</td>
<td>Date</td>
</tr>
<tr>
<td>Phone No.</td>
<td>Alphanumeric</td>
</tr>
<tr>
<td>Pay Rate</td>
<td>Currency</td>
</tr>
<tr>
<td>Tax Rate</td>
<td>Percentage</td>
</tr>
</tbody>
</table>

### Example Data

- "Bob Gripper"
- 1.85
- 19 May 1980
- 012 44565
- £35.75
- 15%

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 Organization
An organized set of data is usually referred to as a database. Databases can be a little difficult to understand, so I'll try to illustrate the concept with a few diagrams. We will use some student data as an example. Here are our students...Databases can be found at the heart of almost every computer system:

- Databases of users
- Databases of files
- Databases of WebPages
- Databases of blog entries
- Databases of photos
- Databases of products

Databases are everywhere!

<table>
<thead>
<tr>
<th>ID No.</th>
<th>Name</th>
<th>Dobb.</th>
<th>Phone</th>
<th>Class</th>
<th>Tutor</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>356</td>
<td>Jess Dobb.</td>
<td>3 Mar 1995</td>
<td>7564356</td>
<td>5B</td>
<td>Mr. Noggin</td>
<td>56</td>
</tr>
<tr>
<td>459</td>
<td>Site Dobb.</td>
<td>9 Jan 1994</td>
<td>8565634</td>
<td>6Y</td>
<td>Mr. Noggin</td>
<td>56</td>
</tr>
<tr>
<td>412</td>
<td>Hamada Dobb.</td>
<td>12 Nov 1994</td>
<td>7465846</td>
<td>5B</td>
<td>Mr. Noggin</td>
<td>56</td>
</tr>
<tr>
<td>502</td>
<td>Hamada Dobb.</td>
<td>3 Mar 1995</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

You'll see that each student has some data associated with them (name, dob. etc.) We want to store this data in an organized way so that we can easily access it in the future. We want to create a student database. So, how should we organize this data?
What is a Record?

The set of data associated with a single object or person is known as a record. In the example of our students, the data associated with each student is a record. Here is Jess's record... Each student has their own record just like Jess's but with different data.

The data in each record is different, but each record has the same structure. (Each one has a name, dob. phone, etc.) We say that each record contains the same fields. A database is a collection of records. You can imagine a single record being a card with one the details of one person/object written on it. A database would be a boxful of these record cards... This is exactly how a lot of old, manual databases used to look. If you went to a public library 30 years ago, and you wanted to find a specific book, you would have to look through boxes of index cards until you found the details of your book.

What is a Field, and What is a Field Name?

You'll see that each of our student's records contain the same items. These items are known as fields. Each field has a field name (e.g. 'Date of Birth'). Each field will contain different data in each of the records (e.g. in Jess's record, the Phone field contains 7564356, but in Seta's record the Phone field contains 8565634 - same field, different data values). It can be a bit confusing - what's the difference between the field, the field name, and the data in the field?!

Imagine that you were manually filling in a record card for Jess. The card would have various labels and boxes to write in...

- The field is the box that you would write in
- The field name is the label next to the box
- The data is what you would write in the box

Each of our student records contains seven fields:
What are a Key Field / Primary Key?

- Name? No - we have two Hamada
- Date of Birth? No - Jess and Hamada share the same birthday
- Phone? No - two or more students may live at the same address
- Class / Tutor / Room? No - each class has many students

It is very important that every record in a database can be individually identified. We need to be sure that when we access a record, we are accessing the correct one. Take a look at our students - what item of data identifies them from all of the other students? Because all of these fields might contain the same data for more than one record, we can't use them to identify each record. So... we have given each student an ID number. We can guarantee that this number will be unique for every student. The ID number is the ideal field to use to uniquely identify each individual record. We call this field the Key Field, or Primary Key.

Database Viewed as a Table

It is quite common to view the contents of 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. Our student database would look like this... The tabular view of a database is exactly the view that you see when working with your database software (e.g. Microsoft Access).

<table>
<thead>
<tr>
<th>ID No.</th>
<th>Name</th>
<th>D.o.B.</th>
<th>Phone</th>
<th>Class</th>
<th>Tutor</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>356</td>
<td>Jess</td>
<td>3 Mar 1995</td>
<td>7564356</td>
<td>5B</td>
<td>Mr Noggin</td>
<td>56</td>
</tr>
<tr>
<td>412</td>
<td>Hamad</td>
<td>12 Nov 1994</td>
<td>7465846</td>
<td>5B</td>
<td>Mr Noggin</td>
<td>58</td>
</tr>
<tr>
<td>459</td>
<td>Sita</td>
<td>9 Jan 1994</td>
<td>8585834</td>
<td>6Y</td>
<td>Ms Take</td>
<td>18</td>
</tr>
<tr>
<td>602</td>
<td>Hamad</td>
<td>3 Mar 1995</td>
<td>8654846</td>
<td>6B</td>
<td>Mr Noggin</td>
<td>56</td>
</tr>
</tbody>
</table>

Each row of the table corresponds to a database record...

A 'flat-file' database is one that only contains a single table of data. All of the data in the database is stored in this one place. The student database example that we looked at in the previous section was a flat-file database... The database work that you have to do for the practical exam always uses flat-file databases.
The column headings correspond to the database field names...

Each cell of the table corresponds to a field, and contains an item of data...

Types of Database

Flat-File Databases

A 'relational' database is one that contains two or more tables of data, connected by links called relationships. Why would you want to have more than one database table? Take a look at the student database example....
Notice that the table contains several items of data that are repeated over and over again:

- **Class (5B)**
- **Tutor (Mr. Noggin)**
- **Room (56)**

In fact, every student in class 5B will have these items of data.

Repeated data in a database is generally considered a bad thing:

- It wastes space in the database
- It takes time to input, typing the same data over and over (and mistakes may be made)
- It is a pain to update (if class 5B gets a new tutor, we have to find every 'Mr. Noggin' and change it to the new name)

So how do we avoid repeated data? You have to understand the concept of relational databases, but you will not be required to use/create them in the practical exam!

### Multiple Tables

**Student Table**

<table>
<thead>
<tr>
<th>ID No.</th>
<th>Name</th>
<th>D.o.B.</th>
<th>Phone</th>
<th>Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>356</td>
<td>Jess</td>
<td>3 Mar 1995</td>
<td>7564356</td>
<td>5B</td>
</tr>
<tr>
<td>412</td>
<td>Hamad</td>
<td>12 Nov 1994</td>
<td>7465848</td>
<td>5B</td>
</tr>
<tr>
<td>459</td>
<td>Sita</td>
<td>9 Jan 1994</td>
<td>8665834</td>
<td>6Y</td>
</tr>
<tr>
<td>502</td>
<td>Hamad</td>
<td>3 Mar 1995</td>
<td>6554546</td>
<td>5B</td>
</tr>
</tbody>
</table>

**Class Table**

<table>
<thead>
<tr>
<th>Class</th>
<th>Tutor</th>
<th>Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>5B</td>
<td>Mr. Noggin</td>
<td>56</td>
</tr>
<tr>
<td>6Y</td>
<td>Ms Take</td>
<td>18</td>
</tr>
</tbody>
</table>

The solution is to split the data: The repeating data is removed from the main table, and placed in a table of its own...

Note: we need to leave the Class field in the main table as we still need to know which class each student belongs to, but the data relating to each class (Tutor, Room) can be removed. So, now the main Student table just contains data directly related to students, whilst the new Class table contains data directly related to classes. Note that both tables are independent, and each one has its own key field /primary key:

- **Student table key field is student ID number**
- **Class table key field is class code**

Ok... so we've solved the repeating-data problem, but we seem to have created a new problem: how do we know the name of each student's tutor - it's no longer in the Student table? Now imagine that class 5B has a new tutor... How much data would you need to update? That's correct: only one
Remember that, with a flat-file, we had to find every student in class 5B and update the tutor field.

### Linking Tables - Relationships

We need to link the table together so that we can connect a student to a specific tutor and room. The common field in both tables is the Class field. We use this field to create a relationship (link) between the two tables. Now imagine that class 5B has a new tutor... How much data would you need to update? That's correct: only one item! Remember that, with a flat-file, we had to find every student in class 5B and update the tutor field.

<table>
<thead>
<tr>
<th>Student Table</th>
<th>Class Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID No.</td>
<td>Name</td>
</tr>
<tr>
<td>356</td>
<td>Jess</td>
</tr>
<tr>
<td>412</td>
<td>Hamad</td>
</tr>
<tr>
<td>459</td>
<td>Sita</td>
</tr>
<tr>
<td>502</td>
<td>Hamad</td>
</tr>
</tbody>
</table>

Note that to create the relationship; we are using the key field (primary key) from one table to link it to another.

### Analogue and Digital Data

An analogue signal is one which has a value that varies smoothly. It is easiest to understand this by looking at an example:

An analogue signal is one which has a value that varies smoothly. It is easiest to understand this by looking at an example:

Analogical pressure waves through air

Analogical electrical signal along wire

The sound waves that your mouth produces when you speak are analogue - the waves vary in a smooth way. These waves can be converted into an electrical signal by a microphone. This electrical signal is also analogue:

www.igcse.at.ua
Computers (and most other modern electronic devices such as cameras, mobile phones, etc.) are ‘digital’ devices because they process data in the form of numbers (digits).

- Computer software is a collection of numeric codes which tell the computer what to do
- Text that you type into a computer is stored as numeric codes
- Images inside a computer are stored as numeric values (different values for different coloured pixels)

Everything stored and processed inside a computer is a number (digital). Computers are unable to process analogues signals because they are digital devices. For digital devices such as computers, to work with analogue devices, conversion is required...All numbers stored inside a computer are stored using a system called binary. Binary only uses 0s and 1s for all numbers. You don’t need to understand this rather strange counting system for iGCSE, but it is at the heart of all digital devices. When text is stored in a computer, each letter is actually stored as a number (because that is all computers can store). The numeric codes used for letters are defined by a system called the American Standard Code for Information Interchange (ASCII). For example, the letter ‘A’ has the ASCII code 65.

**Analogue to Digital Convertor (ADC)**

A good example of a computer peripheral that requires an ADC is a microphone. When you plug a microphone into a computer, you are actually plugging it into an ADC which converts the analogue signals from the microphone into digital data that the computer can then process. If you want to attach an analogue input device to a digital device such as a computer, you will need an analogue to digital convertor (ADC).

**Digital to Analogue Convertor (DAC)**

If you want to attach an analogue output device to a digital device such as a computer, you will need a digital to analogue convertor (DAC). A good example of a computer peripheral that requires a DAC is a loudspeaker or headphones. When you plug a loudspeaker into a computer, you are actually plugging it into a DAC, which takes digital data from the computer and converts it into analogue signals which the loudspeaker then converts into sound.

Another device that contains a DAC is an MP3 player. The music data stored in the player is all digital, but the player produces analogue signals which the headphones convert into sound. The ADC and DAC in a computer that are used for connecting microphones and loudspeakers are part of the computer’s sound card.

www.igcse.at.ua