Booklet 1

This covers the following topics found in section 1 of the computer studies syllabus:

This booklet contains a number of examples of computer applications and ties in with section 1 of the computer studies syllabus.

1.1   Computer-Aided Design (CAD)

CAD is used in the design and development of new products in a variety of applications both at home and on a commercial/industrial basis. Examples of typical CAD applications include:

- aerospace
- architecture
- car/vehicle design
- construction (e.g. roads, services, surveying, tunnels, bridges, etc.)
- consumer goods (e.g kettles, toasters, etc.)
- digital circuits
- factory layouts (e.g. ergonomics)
- fashion design
- garden/landscape gardening
- heating systems
- interior designs (houses, offices, etc.)
- lighting systems (e.g. to get lighting effects at a concert)
- machinery design
- plant design (chemical, nuclear, etc.)
- ship building

CAD systems usually require considerable processor power and a number of input and output devices; for example:

- large screens
- light pens
- devices such as trackerballs, mouse and graphics tablets
- plotters to draw scale and full size drawings
- high specification graphics cards
- spacemouse/spaceball
- some systems support stereoscopic drawings where 3D spectacles can be worn and the user sees a 3D image

The features usually found in a CAD package include:

- wire frame
- 2D and 3D modelling
- library of parts which can be used in new drawings
- validation and verification of designs against original specification
- ability to link with computer-aided manufacture (CAM)
- facility to calculate the mass of the actual object once built
- facility to calculate the cost of producing the article
- features such as rotation, colour, zoom, etc.
- simulation of designs without the need to build a prototype
- create engineering drawings from solid models
- import and export to allow the exchange of data with other software packages
- kinematics (i.e. check moving parts in assemblies don't interfere with each other)
- routing of cables and hoses

There are many advantages and disadvantages of using CAD rather than manual producing drawings using pen and paper:

advantages of CAD	disadvantages of CAD
- it is easier to modify drawings	- risk of deskilling
- a library of parts can be kept	- high training costs to use packages
- ability to do automatic costings	- can move work overseas
- ability to model the design	- one CAD operator can do work of 5
- can do ergonomic study	manual draftsmen

Developments

CAD packages can now be linked to 3D ink jet printers which produce an actual prototype model by building up slices/layers in fine powder (e.g. resin) which are bonded by an adhesive from the print head. The models produced actually work.

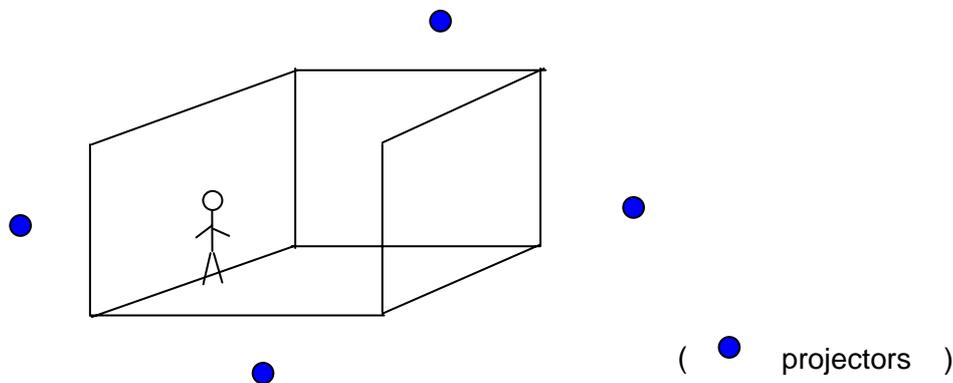This saves time and money since an actual prototype doesn't need to be made.

1.2 Virtual Reality (VR)

This is an artificial 3D environment created by a computer system. Very often the user wears data goggles, data helmet or data gloves to give a feeling of "being there". Apart from feeding sensory input to the user, these devices also monitor user actions e.g. data goggles track eye movement and respond by sending new video input.

As indicated above, a number of devices are used to interface with virtual reality systems. These can be summarised below:

Data goggles/helmets – these use display screens and optical systems that send 3D images to the eyes. Motion sensors measure the position and orientation of the head; this information is sent back to a computer which enables it to adjust the image being sent to the user. Data gloves, suits containing sensors and joysticks are all used to interface with a virtual reality system depending on the application.

The CAVE is a VR system which provides the illusion of 3D by projecting images on the walls and floor of a room. Participants wearing data goggles can enter the room and freely walk about. Sensors in the goggles and in the room continually track the participants' position and adjust the images based on this information.

(● projectors)

Areas of use

Entertainment   Used in films/television as special effects (e.g. the "holodeck" in *Star Trek: The Next Generation* and the Brazilian tv show *Conquista da Titã* where the studio audience wear VR helmets in a space simulation). Virtual reality is also used in many computer arcade games.

Marketing   Used in virtual tours around houses and hotels, kitchen designs, ergonomics, etc.

Training   Areas of use include: military training, medical/dental training, teaching personnel how to use equipment and in general areas where training is dangerous and/or expensive e.g. flight simulators, car driving simulators, operating devices under water or in outer space, etc.

Design   Design of chemical and nuclear plants, ergonomic studies (e.g. factory layouts), helping to develop devices for handicapped people, etc.

How we create virtual reality images for use on a computer system

When a virtual tour of, for example, a house is shown on a website the images need to be first created and then manipulated. The following summarises how this can be done (a similar method/technique could be used for various applications):

- take photos with, for example, a digital camera
- the photos are taken from a single point (reference point)
- the camera is rotated around the room as a number of photos are taken
- the images are "stitched" together using special imaging software
- photo images are re-sized and re-configured for Internet use
- use *hotspots* on the web page to allow a user to move around the house (e.g. from room to room). Integrate plans and maps into the image to allow user to navigate the house.
- developments such as *broadband*, large computer memories and compression software have allowed virtual tours to be offered on the Internet and/or CD/DVD files.

Advantages of using virtual reality

- it is safer (since techniques can be tried out in advance without the dangers of the real operation e.g. maintaining a nuclear plant where it is possible to try a task on a computer first to learn how to do it; if mistakes are made the results would be harmless; e.g. doing a medical task on a "virtual" patient is much safer in case of mistakes, etc.)
- cost savings (no need to build the real thing which could save large sums of money e.g. testing out a real moon buggy or building a part of a chemical plant would be very expensive).
- it is possible to do tasks which would normally be impossible (e.g. walking inside a nuclear reactor, doing a task in outer space, etc.)
- there is a feeling of "being there" which makes the training more realistic and can allow a number of very realistic scenarios to be tested out e.g. how to deal with an emergency on a chemical plant which could be made to be really realistic!!

1.3   Monitoring and control

Examples of use

Monitoring   hospitals (monitoring patient's vital signs), chemical and nuclear plants (monitoring key parameters), burglar alarms (monitoring for intruders), etc.

Control   traffic lights (controlling the sequence of lights to maintain optimum traffic flow), chemical and nuclear plants (opening and closing valves, safety systems, etc.), etc.

How it is done

- sensors gather information from the application being monitored or controlled
- the data being gathered is often analogue in nature and therefore requires translating into digital using an analogue to digital converter (ADC) to enable the computer or microprocessor to "understand" and process the data from the sensors
- the computer or microprocessor will compare the incoming data with the data values stored in memory
- if **monitoring,** the computer/microprocessor system will warn the user in the form of a sound (e.g. a siren if a burglar alarm, a loud beeping sound if monitoring patients in a hospital) and/or read outs (e.g. heart rate trace in hospital monitoring system, temperature reading on a chemical plant).
- if a **control** system, the computer will send a signal to a device which will be converted to analogue using a DAC (analogue to digital converter); actuators are usually employed to operate devices like valves, heaters, etc.
- the device will be instructed to switch on or off (e.g. if controlling a central heating system, if temperature > set temperature a heater will be switched off and/or a cooling fan switched on; if the temperature is below the set point then the heating will be switched on and/or a cooling fan switched off)
- the computer/microprocessor system will continually monitor the data coming from the sensors
- in chemical and nuclear plants, there is often a combination of monitoring **and** control taking place. Information from sensors is often displayed on a control panel where operators can see key values and alarm conditions (e.g. if a system monitors temperatures and 110^0C is the normal temperature and 120^0C is the alarm temperature, the control panel will show normal, present and alarm values in the form of read outs – **either** the computer will automatically take action if necessary **or** the operator will take action (i.e. over-ride the system if necessary).

Why is this done?

Monitoring and control using computers/microprocessors is often done for the following reasons:

- it is safer (faster response to non-standard conditions and they don't get tired and miss key data)
- computers work 24/7 (even though humans can work in shifts there is always the danger of missing information at shift handover etc.)
- computers are more accurate and can take more frequent readings (e.g. if readings need to be taken every 30 seconds, humans can make mistakes or miss readings or even find it impossible to take readings at such short time intervals)
- data can be automatically displayed and analysed without the need to enter data manually (which in itself could introduce errors into the system)

1.4   Embedded Web Technology (EWT)

This is a new technology that uses the Internet in real time to control/interact with a device which contains an embedded system/microprocessor. The user needs to be authorised to do this and can control a device anywhere using a web browser (e.g. from a computer or even a mobile phone which is web-enabled).

Example: An oven contains an embedded processor. The owner can use a web-ready mobile phone anywhere to control the oven remotely. By accessing a web site he is able to send instructions to control the oven.

It is possible to control any device in this way if it contains an embedded processor e.g. television, DVD player/recorder, washing machine, scientific experiments in remote areas such as outer space.

1.5   Robotics

Robots can contain embedded processors or be linked to a computer system. They are pre-programmed to do a specific task or "taught" to remember instructions from a human operator carrying out the task manually e.g. teaching a robot to spray a car with paint. In summary:

- the robot is programmed with a series of instructions which enable it to carry out a series of tasks
- alternatively, an operator manually carries out a series of tasks which are relayed back to the robot; these instructions are remembered so that the robot can carry out the tasks automatically

Robots rely on processors and sensors. The sensors gather information so that the robot knows it is alright to do the task (e.g. is a car in position to be sprayed, is there an obstruction to prevent the robot doing its task, if the robot is spraying a car has the supply of paint run out, etc). They are capable of doing some pseudo-intelligent tasks (e.g. different sized cars to be painted) but essentially any non-standard routine is better dealt with by human beings.

Advantages of using robots

- they are capable of working in conditions hazardous to humans
- they can work non-stop; they don't need a break
- less expensive in the long run since robots don't need to be paid any wages
- generally more productive (can usually do a given task in a shorter time than a human)
- not necessarily more accurate than humans, but the standard of work is certainly more consistent
- removes the need to do boring, very repetitive tasks leaving humans free to do the more skilled work such as quality control etc.

Disadvantages of using robots

- they can find it difficult to deal with "unusual" circumstances e.g. a door is missing from a car waiting on the paint spraying line
- tend to reduce labour requirements (therefore causing unemployment)
- since robots take over many of the tasks done by humans de-skilling is a real risk
- work can be done anywhere, therefore factories can be moved to anywhere in the world (again a cause for unemployment risks)
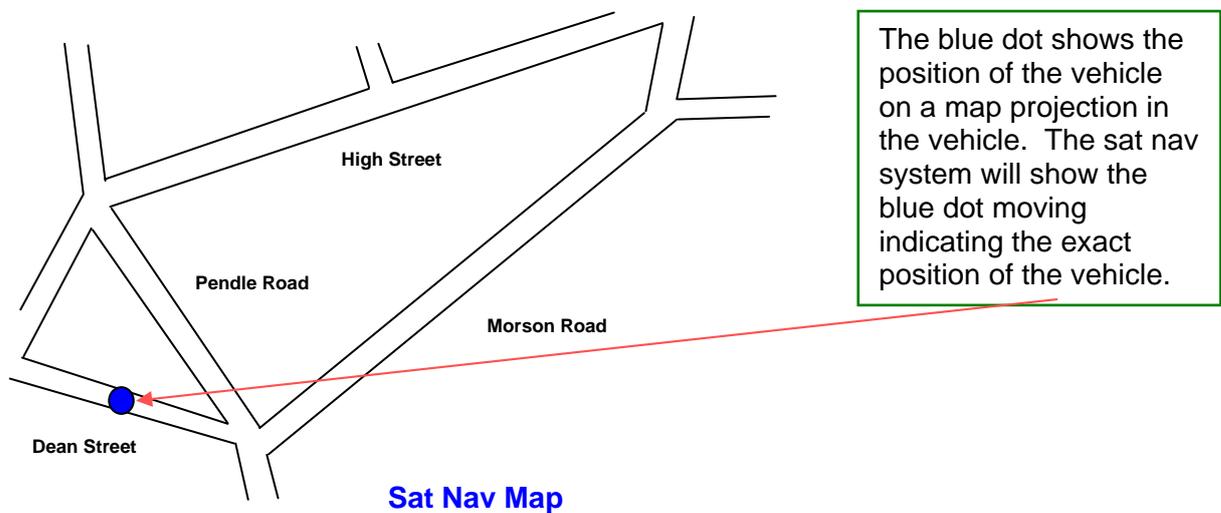
1.6   Global Positioning Satellites (GPS)
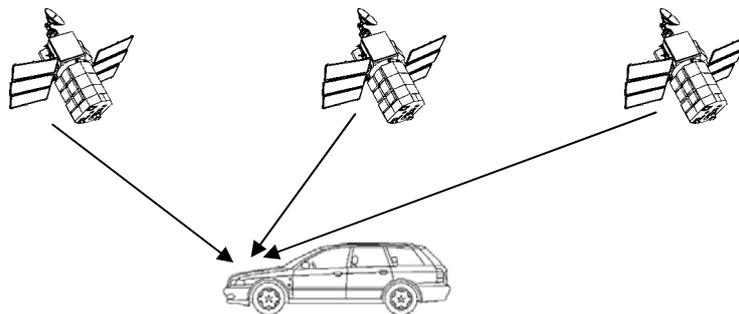
Global positioning satellite (GPS) systems are used to determine the exact location of a car, airplane, ship or any conveyance which travels from one place to another. In vehicles these systems are often referred to as satellite navigation systems (sat nav).

Satellites in outer space transmit signals to the Earth. Computers in vehicles (e.g. car, airplane or ship) receive and interpret these signals. Positioning depends on very accurate timing – atomic clocks are used because of their accuracy to within a fraction of a second per day. Each satellite transmits data indicating its position and time. The computer in the vehicle calculates its location based on the information from at least three satellites (in the case of airplanes, it is also possible to determine the height as well as position); this can be shown diagrammatically as:

satellite 1

Exact location
of vehicle

satellite 2
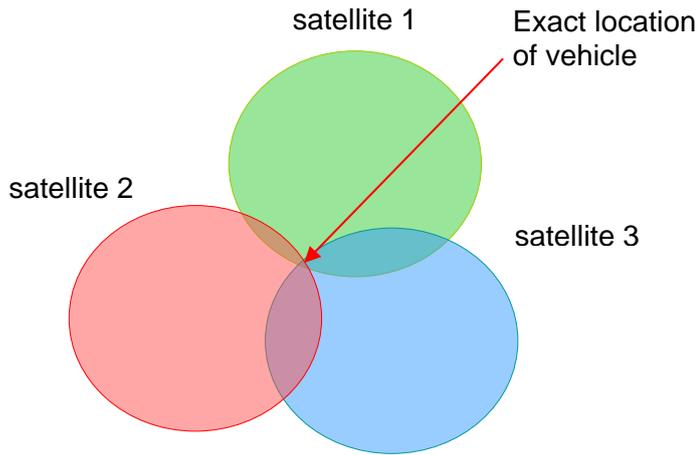
satellite 3

In motor vehicles the system is called satellite navigation (sat nav). The on board computer contains pre-stored road maps. The vehicle's exact location, based on satellite positioning, can be shown on the map; the driver can then be given verbal directions e.g. *"turn left into Pendle Road"* **OR** a screen output showing the vehicle moving on the map:

High Street

Pendle Road

Morson Road

Dean Street

The blue dot shows the position of the vehicle on a map projection in the vehicle. The sat nav system will show the blue dot moving indicating the exact position of the vehicle.

Sat Nav Map

This is far safer since a driver of a vehicle doesn't have to consult maps whilst driving. It also removes error (e.g. going the wrong way down a one-way street). Sat nav systems can also give additional information such as position of speed cameras, estimate time of arrival, etc. GPS can now be used to monitor a vehicle's position if it has broken down (additional safety feature) or has been stolen (known as vehicle tracking system).

In airplanes GPS can also pinpoint its exact location in case of an accident which enables search teams to quickly respond to the incident.

<u>What can go wrong?</u>

- maps not up to date therefore instructed to carry out an incorrect manoeuvre (e.g. turn into a road which no longer exists)
- unless the system is very sophisticated, road closures due to accidents or road works will cause problems to a sat nav system
- signal loss can cause problems with GPS systems
- potential interferences from external sources (major problem on aircraft)
- incorrect start and end point keyed into system (!!!)

1.7   **Expert Systems**

These systems have been developed to mimic the expertise and knowledge of an expert in a particular field. For example:

- prospecting for oil or minerals
- diagnosing a person's illness
- diagnostics (e.g. finding faults in a car engine, finding faults on a circuit board, etc.)
- tax and financial calculations
- complex "thinking" tasks such as *chess*
- route scheduling for delivery vehicles
- identification of plants, animals and chemical compounds (for example)

<u>The Basic System</u>

A basic expert system is made up of the following elements:
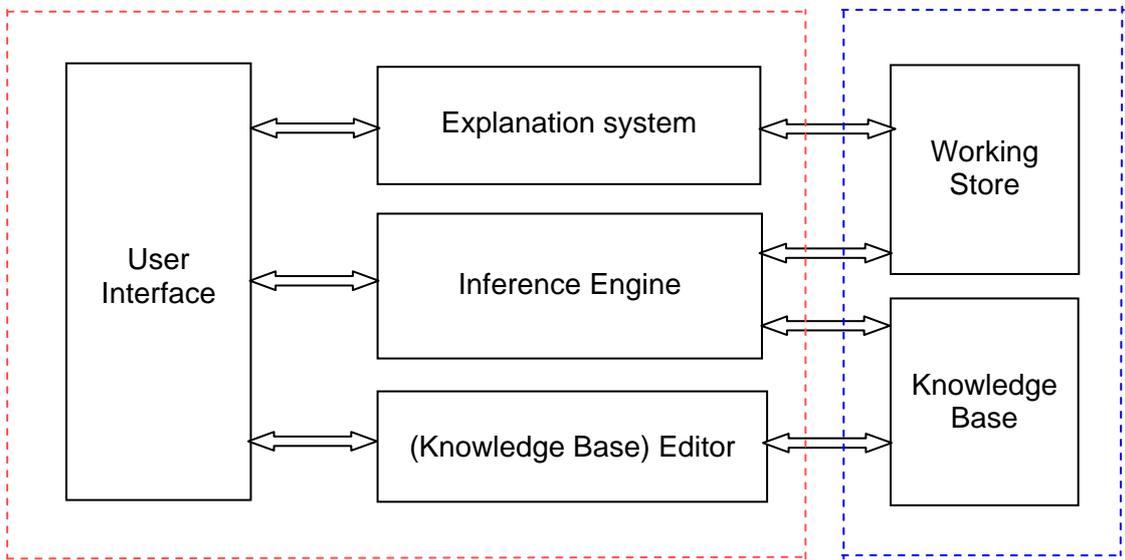
Expert System Shell

(Note: The *Working Store* contains the Facts and Rule Base)

Setting up an Expert System

- information is gathered from experts in the field
- the knowledge base is created
- information gathered from experts is added to the knowledge base
- the rule (base) is created
- the inference engine is created
- the user interface is designed/created (often use Yes/No options or multichoice)

The system, once set up, needs to be tested using data with known outcomes to see if it functions correctly.

If it is being used to diagnose faults, the expert system will output the probable fault and how to rectify/deal with the problem. Usually a % probability of the accuracy of the diagnosis will be given so the end user can decide whether or not to accept the recommendations.

How does it work?

Consider this set of questions?

Q: Do you know which car you want?
A: No
Q: Is there any make of car you would prefer?
A: No
Q: Do you want 2 doors?
A: No
Q: Do you want high performance?
A: Yes
Q: When you have a big engine, do you need a manual gearbox?
A: Why?

The system uses a *rule base* and an *inference engine* together to simulate human reasoning when analysing a problem and arriving at a conclusion. To simulate human processes it is necessary to have a vast amount of information stored in the knowledge base and the reasoning set out as a set of rules in the rule base.

In the above example, the response *Why?* came up since the user wanted to know the Expert System's thought processes.   The system would give the possible response "*I am trying to find the make of car you require. Up to now, coupes are not likely. It is possible that saloon cars are a likely option. I know that you like high performance which gives me strong evidence that the car should include a manual gearbox*".

The above is how an *Explanation System* might work where questions like *why* or *how* are dealt with. *Inference Rules* use an if-statement and a then-statement. This gives Expert Systems the ability to find solutions to diagnostic and prescriptive problems. For example:

If *the make of car includes high performance and you want Italian style*
Then *the car you want is probably a Maserati Quattroporte*

A *rules base* is made up of many such *inference rules* and the *inference engine* uses these to draw its conclusions.

Advantages of expert systems

- provides consistent answers
- never "forgets" to ask a question in determining the logic
- reduces the time taken to solve a problem
- less skilled work force needed, therefore potentially can save money

Disadvantages of expert systems

- lacks common sense in some of the decision making processes
- errors in the knowledge base can lead to incorrect decisions being made
- cannot adapt to changing environments unless the knowledge base is continually updated
- expensive system to set up in the first place
- needs considerable training to ensure system used correctly by operators

1.8   The internet

Web sites need to be set up to maximise information supplied to customers and to ensure they are as helpful and self-contained as possible. If customers are continually telephoning or contacting the company by email then the web site isn't being effective as it should. The following general features should be found on most web sites in one form or another (this list is by no means exhaustive):

- shopping basket
- secure site when using credit/debit cards
- "when customer bought X, they also bought Y" facility
- search facility for artist/tile/item ……
- drop down boxes to choose categories
- help facilities/how to get in touch with the company if a problem exists
- currency converters for international customers
- date/sales confirmation by automatic email
- saved customer details/customised pages
- ability to track status of orders
- ability to listen to/view/see video/see product ……..
- recognise customer as soon as they log on

When designing web pages it is necessary to supply the correct spacing for customer information (and/or use drop down menus), buttons to navigate to other web pages, etc.

Search Engines

The most effective way of finding information on the internet is to use a *search engine*. However, it is just as easy to use these inefficiently as well as efficiently.

When a search condition is entered, inclusion of statements such as AND (or + sign) and OR will help narrow down the search. Also, the use of quotes (" ") can also help. If these are not used, many irrelevant (and sometimes unwanted!!) results (known as *hits*) can be displayed by the search engine. For example:

Type in: *CIE*   and the search engine would return
                                             about 22 million hits

Type in: *CIE+sample papers*   and the search engine would return
                                             about 1.2 million hits

Type in: *CIE+sample papers+ICT*   and the search engine would return
                                             about 6,500 hits

Security

When using the Internet, security can be enhanced using *encryption*. Credit and
debit card transactions can also be protected by a special type of password control.
For example, if a user chooses the password **COMPUTE34** to protect their credit
card, when they buy something over the internet the card issuer will ask the user an
additional question such as: "Please type in the 2nd, 4th and 7th character of your
password in the following boxes:

☐ ☐ ☐   "

The user will then type in **O   P   E** and the card purchase will be authorised. This
additional protection is used as well as encryption.

Some of the new systems use a chip and PIN card which is slotted into the keyboard
and is used as additional security. The user slots the card into the side of the
keyboard and is required to type in a PIN before the Internet can be accessed. This
gives an additional level of security since it is necessary to have the card, know the
PIN associated with the card AND also know the user's log in id and password!!!

How society is affected

Buying goods and services (e.g. banking) over the internet has both positive and
negative aspects on society. These can be summarised below:

Positive aspects for society	Negative aspects for society
Shops and banks are open 24/7	Close down of shops/banks in city centres
Access to shops and banks is worldwide	Increased risk of fraud/hacking
Less pollution since less travelling	Less personal service/more impersonal
Disabled people are not disadvantaged (no need to travel)	Loss of jobs due to closures of shops/banks
Busy people can shop/bank when they want and where they want	Less social interaction between people – just sit at home using computer
If you live in a remote area, it is much easier to access shops/banks	Less activity for people – leads to a less healthy/overweight population
Less expensive (cost savings to shop/ bank + more competition – savings are passed on to the customer)	Less environmentally friendly since more goods sent out by post – waste from packaging significantly increases

In general, increased use of computers has led to many of the above affects . Other
aspects to consider include:

- deskilling of the work force (e.g CAD has taken over draftsman skills, word
  processors have taken over many office-based duties, etc.)
- the need to re-train the workforce in the use of new software/computers.

Computer systems have allowed companies to set up call centres in other countr
where potential cost savings can be made. This, of course, can lead to job losses in
the host country.   The main **advantages** to companies adopting call centres
overseas includes:

- if strikes or other problems occur in one country it is possible to transfer work
  elsewhere
- reduced costs in countries where labour costs are lower
- reduced costs due to incentives/grants by countries keen to set up call centre
  offices
- round the clock customer support (one of the **advantages** of time differences is
  the possibility of 24/7 cover)

There are, of course, **disadvantages** to having call centres overseas:

- language and culture problems
- animosity to overseas call centres (leading to loss of customers)
- need for extensive re-training which is time consuming and expensive
- time differences (can lead to health problems in call centre work force who need to
  work unsocial hours to target key markets)
- technology (does the infrastructure exist to service high tech equipment?)

General Security Issues

Many issues exist when linking a computer system to the Internet or indeed to any
external link via a network set up. There are ways of guarding against this. The
following is a list of potential problems and ways of protecting against the problems:

| Problem	Safeguard
Hacking	Use of passwords and ids to prevent illegal access to files. Also locking the computer itself or locking the computer room can help here. Encryption stops the information being read even if access has been gained to a file but won't stop hacking!!
Viruses (also see note 1 below)	Use of ant-virus software and firewalls to prevent viruses entering a computer. It is also sensible not to open emails/ attachments from "unknown" sources; it also helps to only load software from disks/cds which are originals
Corruption/Loss of Data can occur in a number of ways: - viruses - hackers - accidental damage - hardware faults - software faults - incorrect computer operation	 - viruses can be protected against as described above - as above (also see note 2 below) - accidental damage is best guarded against by keeping back up files or use the Grandfather-Father-Son (GFS) method; also use of passwords and ids can help by restricting access in the first place - protection against hardware faults could be to keep back ups or use GFS; use of UPS (in case of power loss) and parallel system also help - keeping back up files or using GFS would help here - backing up files would guard against problems caused by incorrect power down of the system

Note 1: Viruses don't just infect computers, they can also affect mobile phones, M players etc. – any device which can download files from a source such as the internet is potentially at risk.

Note 2: Backing up may allow files that have become lost/corrupted (due to hacking or viruses) to be reinstated; however, this would not recover the system nor would it prevent hacking/viruses affecting a system in the first place.

Note 3: Other problems such as spam, pop ups, cookies, etc. are more of a nuisance (although they can considerably slow down the operation of a computer system) and can be blocked or made inactive (since they can become active without the user's knowledge) using suitable software.

1.9   Simulations

To demonstrate how a simulation can be developed for use in a real situation the following example has been chosen. The scenario chosen is a series of traffic lights at two busy junctions:
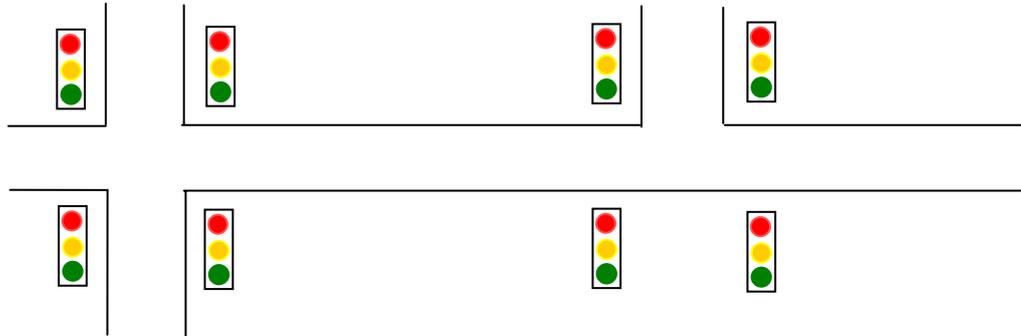
In this simulation it is necessary to consider:

(1)   how and what data is gathered
(2)   how the simulation is done
(3)   how the system would work in real life
(4)   why simulations are done
(5)   other examples of simulations

(1)   How and what data is gathered

To make this as realistic as possible, data needs to be gathered over a long period of time. This can be done by sensors in/near the road, using cameras or manual data collection. Data gathered includes:

- count the number of vehicles passing in all directions at each junction …..
- ….. at a particular time of day
- count how many cars build up at a junction before lights change
- is it a week day or weekend or bank holiday
- how long it takes to clear vehicles at a junction
- other data (e.g. pedestrian crossings)
- time for largest/slowest vehicle to pass through a junction
- other factors (e.g. filtering of traffic to the right or left)

(2)   How the simulation is done

The data is entered into the computer and the simulation is run. The following scenarios may be tried out:

- timing of lights varied to see how the traffic flow is affected
- build up number of vehicles stopped at a junction and change timing of lights to see how it affects the traffic flow
- increase/decrease traffic flow in all directions to see how the traffic is affected
- try out the impact of accidents
- consider passage of emergency vehicles
- effect of adding in pedestrian crossings
- once the simulation is run, the timing of the lights is determined and how they interact so that the maximum traffic flow is achieved; fault scenarios (e.g. an accident) and their impact are considered

(3)   How the system would work in real time

- sensors in/near the road gather data (these can be light/infra red sensors, induction loops, pressure sensors, etc.) – the data is usually number of vehicles passing a particular point
- the data is sent to a control box or computer system
- the gathered data is compared to data stored in the system (the stored data is based on simulation runs, how the number of vehicles at a junction at a particular time of day affects the traffic flow, etc.)
- the control box or computer "decides" what course of action to take and …..
- ….. sends signals to the traffic lights to change timing if necessary
- as with any system involving sensors, ADC and DAC interfaces may be needed

(4)   Advantages of carrying out simulations

- saves cost (rather than doing the real thing)
- safer (scenarios tried out on the simulation first before used in reality)
- possible to try out various scenarios in advance
- some environments make simulations the only way to carry out a task beforehand (e.g. outer space, under sea, chemical processes, nuclear reactors, crash testing cars, etc.)
- faster (no need to build and test real system, so it is possible to get results more quickly)

(5)   Other examples of simulations

- training (e.g. pilots, drivers, etc.)
- running/testing chemical plants and nuclear plants
- trying out equipment to be used under sea or in outer space
- crash testing cars
- financial simulations (e.g. stock market predictions based on various scenarios)
- population growth (i.e. predict how the world's population will increase based on a number of different scenarios)
- queues (e.g. simulating queues at supermarket checkouts for example)
- weather (refer to next section)

Another example of simulation is predicting weather (i.e. a weather forecaster). this case we will consider how/what data is collected, how the simulation is done and consider how it can be used in predicted possible climate changes. We won't consider stage (3) here (how the system works in real time) since this simulator doesn't control anything and stages (4) and (5) above will be the same.

(1)   How and what data is collected

- sensors measure pressure, temperature, relative humidity, wind speed and wind direction
- sensors are placed in weather balloons and/or weather stations
- information is also got from satellites
- pilots also send in information regarding weather conditions during long flights

(2)   How the simulation is done

- information from the sensors/satellites sent to computer
- this data is compared to information stored on files …..
- ….. which contain known weather patterns from the past
- ….. predictions are made based on these comparisons
- produces weather maps showing isobars, temperatures, etc.
- computer can show graphically how weather (e.g. cloud formations) will change with time (i.e. predict weather patterns) – this is often presented as a computer-generated video showing how clouds build up, how temperature and pressure changes over, for example, the next 7 days, wind speeds etc.
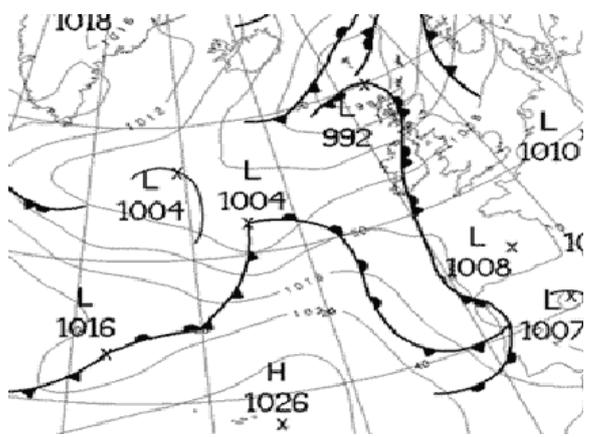
This shows isobars tracking across part of Europe. A computer simulation will show how areas of pressure change with time so it is possible to predict rainfall, strong winds etc. in advance

This shows clouds tracking across the Earth. A computer simulation will show how the clouds patterns will change with time so it is possible to predict rainfall etc.

- it is also possible to do statistical analysis and predict the percent probability that certain weather conditions will occur.

(3)   How future environment/climate changes can be predicted

- information over time is fed into a climate/weather model
- based on changes in weather patterns, carries out a statistical prediction
- model is able to change parameters to see how future climate can be affected
- needs to review a lot of previous data over a number of years to check if changes are genuine or just cyclical
- over, for example 20 years, predictions compared to actual climate conditions to validate/further refine the model
- can make use of spreadsheets and statistical software packages

1.10   **Training and Entertainment**

Music

Computer hardware and software advances have changed how music is generated and produced. Some of the key reasons for this have been summarised below:

- actual musical notes can be generated from the music itself by software
- music samplers and mixers give an almost limitless ability to alter the original tracks recorded in a studio
- software can automatically correct notes
- don't need to understand music notation to write a musical score
- electric instruments (such as guitars and organs) play back through electronic effects machines
- synthesisers combine simple wave forms to produce more complex sounds
- electric organs can now mimic almost any instrument (including a full orchestra!!)
- automatic rhythm
- music notes automatically printed out in the correct format

There are many other software and hardware developments; the above is just a summary of the more common elements.

Animation/Cartoons in Films and Video/Television

Computer animation is the art of creating moving images via computer hardware and software.

For 3D animation, objects are designed on a computer and a 3D skeleton is produced. The limbs, mouth, eyes, etc. are moved by the animator using key frames (these define the start point and end point of a smooth transition to make the animation as realistic as possible).

The differences in appearance between key frames are automatically calculated by the computer – this is called TWEENING or MORPHING. The animation is finally RENDERED (i.e. turned into a realistic image).

Computer animation uses a technique called *avars* (animation variable) where the starting point is usually a series of stick figures; e.g. *Toy Story* used over 700 *avars* (1 avar = position of each feature e.g. the mouth). Successive sets of *avars* control all movement of the animated character. Once the stick model is moving in the required way, *avars* are incorporated into full wire frame models. Finally, surfaces are added requiring a process called *rendering* (i.e. turned into a realistic image).

There are several ways of generating *avar* values to get realistic movement. One way is to use *markers* on a real person (or whatever is being animated) acting out a part and track the movements by video camera. Alternatively, *avars* can be set manually using a joystick. Software produces a level of quality for movie animation that would take many years to produce by hand and would employ several cartoonists/animators. This all saves considerable time and money to the film and television producers.

Avatars are another example of animation. These are often used to represent people either in 3-D (as used in computer games) and in 2-D (as used in internet message boards). Some avatars are animated consisting of a sequence of images played one after the other.

Ultimately, animators want to create a human image which moves and interacts with its background in such a away that the viewers can't tell if a particular scene is computer generated or produced by real actions in front of an actual movie camera.

Special effects in many modern films (televisions) all use computer animation to produce fantasy worlds.

1.11   Computer Based Training

CBT makes use of a computer system to train people in a number of applications. It makes use of multimedia and self-assessment with minimum input needed from a human trainer.

The advantages of training people using computer systems (such as CBT) include:

- trainees can work at their own speed
- trainees can learn when they want
- it is possible to re-run sections of the training program if necessary
- possible to come back at any time/pause training program at any point
- user gets immediate assessment of performance
- possible to include multi-media elements in the training package
- no need to have a teacher/classroom – potential cost savings therefore possible
- it is easier to keep up to date/amend

1.12   Communications

Video Conferencing

Video conferencing continues to grow in popularity. Why is this? Some of the reasons are listed below:

- communication links are now much faster therefore images, sound quality etc. are now far better
- safety reasons (increase in world-wide terrorist activity, frequent travelling, etc. are all risks to company employees if they have to travel to meetings)
- costs (the money saved on not having to travel, accommodation costs, lost time to the company whilst employees are out of the office travelling to meetings, etc.)
- improvements to the work/general environment (employees can work from home, less travel means less stress to employees but also means less pollution, disabled employees are no longer disadvantaged, etc.)
- because of the above, it is possible to hold a meeting at short notice

The hardware and software needed to run video conferencing is very sophisticated. Apart from the obvious items (i.e. large screen, computer and devices such as mouse, etc.) the following briefly describes what is needed to have a video conference:

- delegates speak into a central microphone
- webcam takes a video image
- delegates hear speech through loud speaker system at each venue
- the system uses internet/WAN/modem to transmit data
- requires use of compression software for video/audio signals
- systems may use CODEC (which converts and compresses analogue data into digital data for sending down digital lines)
- requirement for echo cancellation software (this allows talking in real time and keeps communications synchronised)
- video images and audio are seen/heard in real time on large monitors/through loud speakers

Electronic Mail (email)

Another form of communication is through email. This has the following advantages over video conferencing:

- there are no language problems (systems can translate messages sent)
- it is possible to read emails whenever you want – there are no issues of time differences as would be the case with video conferencing.   If some delegates lived in the USA and the others lived in India, for example, the time difference is 10 to 14 hours which could be a problem)
- it could be argued that the email system is cheaper since there is no need to buy webcams, special software, etc.

The following is a simple description of how the email system works:

- the sender composes a message (and attaches a file if required) and sends it
- this message is sent to an ISP (Internet Service Provider) mail server
- the mail server examines the address associated with the message and decides how to route the message
- the message travels over the internet arriving at the recipient's ISP mail server
- the message is then held in the recipient's electronic mail box
- to read the message, the recipient logs on to their mail server
- the message is then retrieved and sent to the recipient's computer

Wireless Technology (WiFi) and Broadband

Most areas in the world now offer broadband rather than dial up for connecting to the internet. The advantages of broadband over dial up include:

- the system is always "on"/no need to dial into ISP every time you want access
- the connection rate/data transfer rate is much higher (for example broadband operates at 11 000 kbps compared to the dial up rate of 60 kbps)
- there is a flat monthly rate with broadband (dial up is charged per hour of usage)
- it is possible to use the telephone at the same as the internet with broadband/the line isn't tied up
- broadband permits other facilities such as "skype"/VOIP

Wireless technology (WiFi) allows connection of a computer to the Internet without the need for connecting cables. A router (containing a modem and external aerial) is connected to a telephone line and it is then possible for any computer within range to communicate with the router and allow Internet access – the link between computer and router is completely wireless.. The main advantage of doing this is clearly the portability (i.e. can go anywhere within range since no wires are needed).

There are, however, a number of disadvantages:

- the range can be very limited
- possible interference from nearby electronic devices
- security issues (i.e. tapping illegally into WiFi networks)
- access speed/transfer rate is often slower using wireless systems

It isn't just computers that can be linked without wires, various peripheral devices can be linked to a computer system without the need for a physical, wired connection. For example:

- printers
- keyboards
- mouse
- digital cameras

1.13   Intranets

Many companies use intranets as well as the internet. The simple definition is "An intranet is a computer network based on internet technology, that is designed to meet the internal needs for sharing information within a single organisation/company". The main reasons for doing this include:

- safer since there is less chance of external hacking or viruses
- it is possible to prevent employees from accessing unwanted web sites
- companies can ensure that the information available is specific to their needs only
- it is easier to send out "sensitive" messages to remain within the company only

Some comparisons between internet and intranet include:

- the INTERNET is INTERnational NETwork
- an INTRANET is INTernal Restricted Access NETwork
- the intranet only gives local information relevant to the company/organisation
- it is possible to block access to certain sites using the intranet
- it is not always necessary to have external modems when using intranets
- information for use on intranets is stored on local servers
- the internet can be accessed from anywhere
- the internet is available to anyone, whereas the intranet requires password entry
- the intranet is behind a firewall

1.14   Other applications

The notes in sections 1.1 to 1.13 cover a number of computer applications. These are by no means exhaustive since the list of possibilities is almost endless. The following section chooses a sample of another application which is useful to study. It considers how supermarkets use bar codes in their automatic stock control systems. It would have been equally valid to consider library systems, administration systems (e.g. in a hospital), banking systems, burglar alarm systems or passports/id cards. Centres would be advised to consider all of these as a knowledge of computer systems is built up.

Sample Application – Automatic Stock Control System in a Supermarket

- bar codes are attached to all goods/items sold by the supermarket as a means of identification
- each bar code is associated with a stock file on a computer database
- the customer takes their basket/trolley to the POS terminal
- the bar code on the product is scanned at the point of sale (POS) terminal
- if the bar code can't be read, the POS operator has to key in the bar code number manually using a keyboard/key pad
- the bar code is searched for on the database
- once the bar code is identified/found, the appropriate file/record is accessed
- the price of the good/item is found and sent back to the POS
- the stock level of the item is reduced by 1
- if the stock level is less than or equal to the re-order/minimum stock level then the system automatically re-orders goods/items from the suppliers
- this procedure is repeated until all the items in the customer's basket/trolley have been scanned
- when all items/goods have been scanned, the customer is given an itemised bill showing a list (with prices) of everything they have bought

- the computer also updates the files containing the daily takings
- if the customer has a loyalty card, the system automatically updates their points total
- when new goods arrive, the bar codes are used to update the stock files
- some newer supermarkets now allow customers to scan their own basket/trolley and pay for the items/goods using credit card or cash (essentially the stock control system is the same for both methods)

1.15   Problems

A list of examination-based problems now follow. These can be used as revision questions or centres can use the questions to make up their own assessments to give candidates practice under examination conditions.

(1)   (a)   Give **three** features you would expect to see in a typical Computer Aided Design (CAD) package.

        (b)   A company uses CAD to design a child's toy. Give **two** advantages of using CAD in this application.

(2)   (a)   What is meant by *virtual reality*?

        (b)   A hotel decides to offer a *virtual tour* of its facilities on a web site.

                (i)   Describe how images are created and processed for use in the *virtual tour*.

                (ii) What features would you expect to see on the *virtual tour* web site?

        (c)   Give **two** other applications of *virtual reality.*

(3)   (a)   A large house with eight bed rooms is to be protected by an intruder surveillance system (burglar alarm).

                Describe how sensors and a microprocessor would interact to monitor for intruders and sound an alarm if a break in occurs.

        (b)   Describe the main differences between a computer being used in a monitoring application and a computer used in a control application.

(4)   Robots are being used to spray some metal parts.

        (a)   Describe **two** problems the robot might encounter and how these could be overcome.

        (b)   In general, what are the advantages of using robots rather than human workers in manufacturing industries?

(5) A bus has been fitted with a *Global Positioning Satellite (GPS)* navigatisystem (*sat nav*).

   (a)   Describe how the *sat nav* computer calculates the exact location of the
         bus.

   (b)   How does the *sat nav* system indicate to the bus driver the correct
         route that needs to be taken to reach the required destination?

   (c)   What are the advantages to the bus driver of having GPS installed?

(6) An *expert system* is to be created to identify chemical compounds.

   (a)   Describe how the *expert system* would be set up and made ready for
         use.

   (b)   Explain the function of the *Explanation System* which forms part of the
         expert system.

(7) (a)   Describe **four** security issues associated with linking a computer to the
         internet. How is it possible to guard against **each** of these security
         issues?

   (b)   Describe the differences between the *internet* and an *inranet.*

(8) A supermarket has decided to model queues at the check outs using
   simulation software.

   (a)   Describe how data is collected for the simulation/model.

   (b)   Describe how the simulation/modelling is carried out.

   (c)   Describe the advantages of using a simulation.

   (d)   Give **two** other uses of simulations.

(9) Describe how computer hardware and software are used to create animation
   effects in films and television programmes.

(10) (a)   Describe how it is possible to have a video conference between
          delegates in two different countries.

    (b)   Give the main reasons why video conferencing has become
          increasingly popular.