

Revision Notes for Standard Grade Computing Studies

(Revised Version)

Peter R May

**Principal Teacher of Computing
Inveralmond High School, Livingston**

Hugh McWhinney

**Principal Teacher of Computing
Alva Academy, Alva**

revision assisted by

Nicky Pasternak

**Principal Teacher of Computing
Douglas Academy, Glasgow**

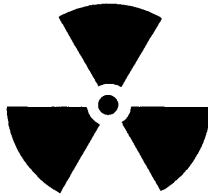
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The study of industrial applications provides an overview of the use of computers in control, production, design and simulation.

Need for Industrial Applications

- 1 The **speed** of an automated system is greater than that of a manual system. Automated processes can be completed in seconds whereas by hand the processes could take hours,
eg testing a new circuit board may involve hundreds of tests on each board.
- 2 **Hazardous environments** are dangerous for human operators,
eg nuclear power plants, ocean depths, poisonous areas.



Radioactive

Robots are ideal substitutes for humans since they can work effectively in hostile environments for long periods.

- 3 Robots are frequently used for **repetitive tasks**.

Machines perform these types of task exactly the same way each time. The quality of their work remains constant. Human operators can become tired and bored and as a result produce poor quality work.

- 4 Automated systems can increase output and hence **efficiency**, *eg a factory can operate 24 hours a day.*

Robots do not get tired or stop for breaks. Robots can be found in automated warehouses. A computer controls the "shelf" destination of container "bins". Using robots and computers allows stock levels to be maintained and items can always be located.

- 5 Automated systems repeat tasks with the same degree of **accuracy** time after time. Human operators on the other hand tend to perform less well at certain times of the day and the quality of their work can vary, *eg when they are tired.*

Robots can work to much closer tolerances than human operators. Their precision can be very high, *eg to test a silicon chip, probes must be connected to every gold wire on the circuit; robots can work to a tolerance of less than one thousandth of an inch whereas a human operator can not.*

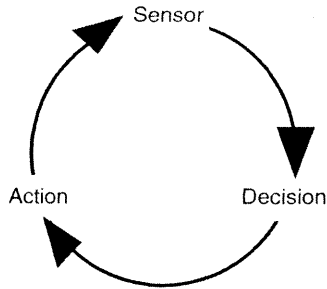
- 6 The **adaptability** of robots and computer controlled machines means that they can be programmed to perform a variety of different tasks depending upon the instructions issued. A robot can be reprogrammed to do different jobs, *eg paint spraying; once production of the current model ceases, the robot can be programmed to spray the new car shape.*

Hardware and Software

- **Sensors** are input devices which allow computer controlled machines to monitor their environment and provide control information for their programs. *eg a sensor may be a simple microswitch in a robot's bumper; this would allow the computer to respond as soon as the robot struck an object; other sensors may respond to infra red light.*

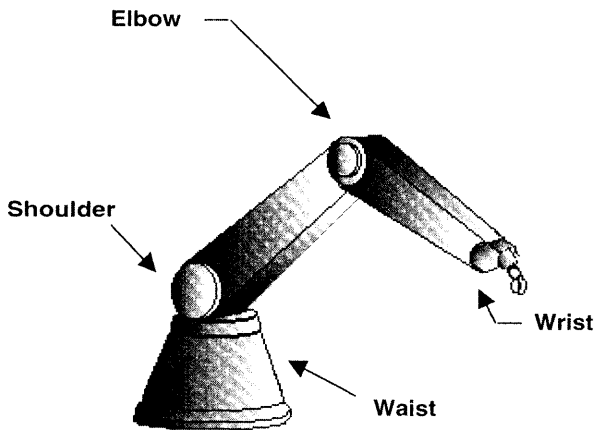
- A closed loop is a method of control which uses sensors to provide **feedback**.

The Closed Loop Cycle



A sensor detects changes in the environment and communicates what it senses to the processor. This feedback allows the processor to compare the actual situation with the desired situation and to modify an action and respond to changes as they are detected, *eg all traffic lights (including temporary lights) have sensors, these are either magnetic induction loops buried in the ground or infra red detectors which sense the heat from car engines.*

- **Robot anatomy** consists of the parts shown in the diagram.



- Most automated systems use a **motor** to allow movement.
- Robots are **programmable** and can be programmed in two ways.
 - 1 A programmer writes a program at a computer and the robot follows these instructions. The robot does not need to be connected to the computer while the program is being written. This has the advantage that a new program can be developed while the robot is still working on another task.
 - 2 The teach and repeat method involves a human operator leading the robot through the sequence of movements required to complete the task. Sensors built into the robot detect the movements, allowing the sequence to be stored by the computer, *eg a robot spraying a car.*

This sequence can later be re-played over and over again.

- **Stationary** robots are fixed in one location. **Mobile** robots can move around to different places.
- Robot arms can use a variety of different **tools** (end effector), *eg magnet, gripper, paint spray, welding torch.*

These allow the robot to undertake different tasks.

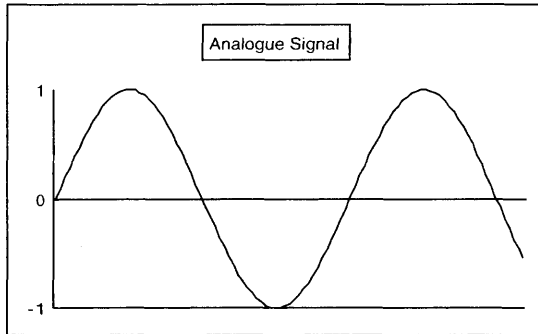
- Computer Aided Design (CAD) software allows engineers and designers to create and manipulate images on the screen. Designers are then able to visualise their ideas. Time is saved creating images and designers can experiment with changes and see the alternatives straight away. Previously, it would have taken several days for a skilled craftsman to construct a 3D image or accurate scale model.

Computer Aided Manufacture (CAM) involves the use of the computer to control a machine being used to make parts.

When both CAD and CAM are integrated, the system is called **CAD/CAM**. The computer used at the design stage can pass details directly to the CAM section which then controls the manufacture of the final product.

- Most sensors supplying information to a computer controlled machine provide an analogue signal.

An analogue signal is produced by a constantly changing quantity,
eg voltage from sensor.



An example of an analogue input signal would be from a temperature sensor. An example of an analogue output signal would be sound from a speaker.

Analogue input and analogue output is usually referred to as **analogue I/O**.

- An **interface** is an item of hardware which allows two items with different operating properties to communicate with each other. An interface is essential if the processor is to interact with the outside world.
- Moving robots operate in an environment with set boundaries. **Guides** can be used to mark the operational area for a robot. The robot is programmed with an internal plan of the building and routes.
 - 1 Magnetic guides outline a route which the robot detects from cables buried in the floor. This is an example of a magnetic guidance system.
 - 2 Reflected light from painted white lines outline a route which the robot detects with sensors. This is an example of a light guidance system.

Extending the robot's working area involves laying down new guides and reprogramming the robot's internal plan.

The addition of new paint is simpler than burying more wires in the floor.

- Most CAM systems and robots will use specialised **high level instructions** to make programming the device easier. *eg move arm up, move arm down.*
- A **simulation** is a computer model of a real life situation. Certain situations are extremely dangerous. Simulations allow humans to gain experience in a safe environment. *eg controlling a plane after engine failure, responding to a nuclear power core meltdown.*

It is not feasible to train new pilots to deal with engine failure by taking a plane to altitude and turning the engines off.

Computer simulations allow pilots to gain experience of what to do in an emergency without any of the dangers. Training is provided, safety is increased and savings may be made.



A nuclear power station can be modelled to simulate specific problems. Operators can then experience the dangers and learn how to respond in the safe environment of a computer simulation.

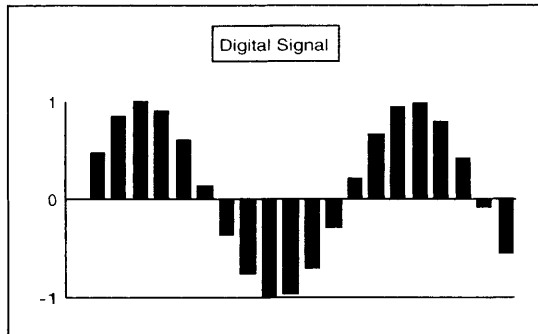
- **Virtual reality** systems can be used in a simulation. *eg surgeons may practice new procedures and complex operations on VR simulators.*
- **Real-time processing** reacts/responds to events in real time, as they happen.

Real-time systems allow the computer to react instantly to any changes in the input. *eg a central heating system, a system controlling a mixing process in a chemical plant, aircraft control systems (fly by wire).*

There would be little point in using a system which detected a cooling fault at a power station and which then took 3 hours to respond.

- Analogue/Digital convertors permit a digital computer to communicate with an analogue device.

Digital signals contain a definite value which may be precisely measured.



A computer can only process digital information.

An **analogue to digital (A to D)** converter allows the computer to sample an analogue signal and produce a corresponding digital equivalent.

Some computers have a built-in analogue port to allow the computer to be connected to peripherals which detect analogue signals.

This simply means the computer has a built-in **A to D** converter and the users can directly connect to this port.

A **digital to analogue (D to A)** converter is an interface which converts a digital signal into analogue form.

- A **control language** is used to write a program for robots. This is usually a high level language which has been designed for use with a particular robot. The commands in the language should make it easy to use all the features of the robot, eg *TURN wrist LEFT 89°*.

The disadvantage with this is that the programmer may have to learn a new language for each different robot, although the languages should be similar.

- Instructions may be stored on a ROM chip as **ROM software**. Instructions stored on ROM can not be altered by the user.
eg instructions for washing machine, microwave.
- An **embedded system** is designed for a specific appliance, *eg car engines, mobile phones etc.*

Some are programmable and some are fixed in ROM.

- **Intelligent robots** are autonomous and have extended capabilities because of their powerful processors, large main memory and numerous sensors.

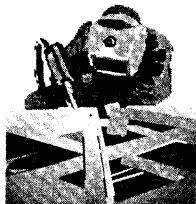
They can make complex decisions, on their own (autonomous), without human input.
eg in space exploration, remote inspection, mining, oil and gas exploration.

Social Implications

- Automated systems can often take over jobs which used to be done manually by humans. This may lead to unemployment for some and fewer opportunities for employment for those beginning work. Workers have to be prepared to retrain, to learn how to use new technology or to move to a different job in the company. Automated systems tend to remove the repetitive, boring and poorest paid jobs.

As with many computer related jobs, **retraining** is required at frequent intervals to keep pace with changing technology.

Automated systems may lead to unemployment for some manual workers.



- The **nature of jobs** may be **changing**, moving away from manual labour towards more skilled work.

As the use of automated systems expands there is an increase in opportunities for installation engineers to setup equipment and for maintenance engineers to repair the equipment.

- Many authors suggest the increased use of automated systems will lead to an **increase in leisure time**. However, it should be remembered that a person must have sufficient income to enjoy increased leisure time.

Technical Implications

- **Industrial automation** involves automating a factory. This often involves making major changes to the building to make it suitable for the new equipment.
- **Safety precautions** must ensure that computer controlled machines are able to sense obstructions and take the necessary action to safeguard human operators.

Automated warehouses must cater for unexpected situations, *eg broken tracks, human operators moving around, liquid spillage*.

Static robots are surrounded by guard rails and fencing to prevent people from accidentally entering their work area.

- The **design of the workplace** has to take account of the equipment and the safety of the employees working in the area. It is sometimes cheaper to build a new factory rather than convert an existing one.
- **Modern factories** rely on computerised systems and robotics. Minimum human supervision is required. Human input is only necessary for reprogramming or maintenance.

Factories are designed around the equipment rather than the operator.

The computerised systems provide management with increased flexibility in the manufacturing process, *eg reprogramming the machines to do a different job*.

- Industrial automation creates the **need for systems analysis**. Systems analysis in the design process ensures that manual tasks can be transferred to a computerised system.

One technique often used in systems analysis is observation, *eg observing a traditional manual process prior to computerisation*.

The aim of the systems analyst is to make the computerised process efficient.

Economic Implications

- The purchase of robots and automated equipment has a **high initial cost** as this type of equipment is generally very expensive to buy.

This may involve complete rebuilding of the factory to accommodate the new equipment. Old buildings may not be capable of adaptation to modern equipment.

- Companies will buy robots and automated equipment only if they can make **long term savings**, *eg on wages and increased productivity*.
- The robots and equipment do not last forever and will eventually have to be upgraded or replaced.

Competitive companies will have a planned replacement programme for robots and automated equipment. These **replacements costs** must be considered by management.