TYPES OF PRODUCTION

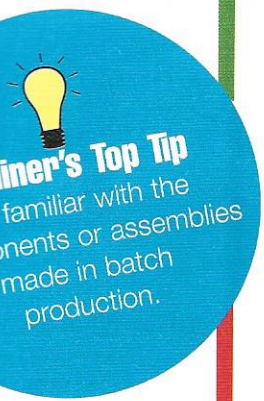
Industrial production methods can be divided into one of four general categories: job, batch, in-line and continuous flow production. Each category depends largely upon the numbers of products that are being manufactured and by the type of equipment being used. Computer-controlled manufacturing systems are now widely used, especially in the fields of batch, in-line and continuous production.

JOB PRODUCTION

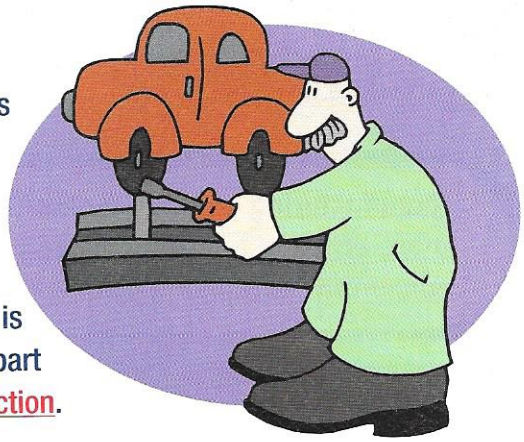
Job is used to manufacture one-offs or very small numbers. Examples include prototypes and tools for presswork equipment and assembly jigs. General-purpose machines such as lathes, milling machines and welding equipment are usually used. Machinery is not used on a continuous basis but only when required. Workers within this type of production need to be highly skilled in a range of areas and to able to work on a number of aspects of a project.

BATCH MANUFACTURE

Most industrial manufacture falls into this category. During batch production the operation is divided into a number of separate stages. A batch of sub-assemblies is made during each stage of the operation and the batches are advanced through the production system for completion. Individual components are added at appropriate stages. Batch sizes can vary from a few to ones numbering many thousands. It is much quicker to manufacture components using this method than trying to manufacture them one at a time. Jigs and fixtures are often used to speed up the process. Batch production is especially suited to computer-controlled manufacturing methods since the machines can be reprogrammed quickly for different batch sizes and batch types.



IN-LINE PRODUCTION



In-line production is used mainly for mass production of products such as cars, washing machines and fridges. The products are assembled as they flow down a production line. Semi-skilled operators tend to be used in the process. In-line production plants are very expensive to set up and thousands of products have to be made and sold to offset the capital costs. Production is often difficult to plan and breakdowns are costly. Many lines or part lines are controlled by computers which can also monitor production.

CONTINUOUS PRODUCTION

Continuous production refers to processes such as oil refining and chemical processing. Once production has started the plants tend to run continuously and automatically. Start-up times tend to be long since the process has to be started gradually. Continuous production plants tend to have sophisticated computer systems to monitor how the product is flowing through the system, and measures temperatures, liquid levels and other quality control quantities.

FLEXIBILITY

Examiner's Top Tip
Know how CNC machines and jigs and fixtures are used during batch production.

Manufacturing flexibility refers to how quickly a machine or manufacturing system can be changed to make a different type or different number of components or assemblies. Machines used in batch production are usually selected because of their flexibility. CNC machines are flexible because they can be programmed quickly and easily when different batch types and sizes are required. This is termed quick response. In-line and continuous production plants are less flexible because it is far more difficult to change them for different product types.

QUICK TEST

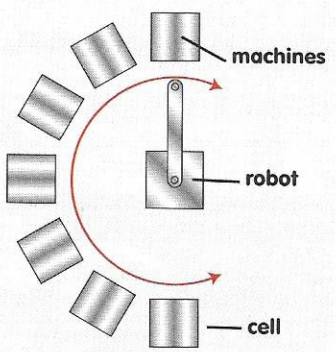
1. What is job production?
2. What attachments can be used to help speed up batch production processes?
3. What sort of products are made by in-line production?
4. What sorts of products are manufactured by continuous production plants?
5. What is meant by manufacturing flexibility?

1. Where one-off or a small number of components are made.
2. Jigs and fixtures.
3. Cars, washing machines, fridges.
4. Oil, chemicals.
5. How quickly a machine can be changed to make a different type or number of components.

COMMERCIAL SYSTEMS

Manufacturing industry makes use of a range of business systems to help make them more efficient and to produce quality products. Common systems are production cells, concurrent manufacture, total quality management and just-in-time methods.

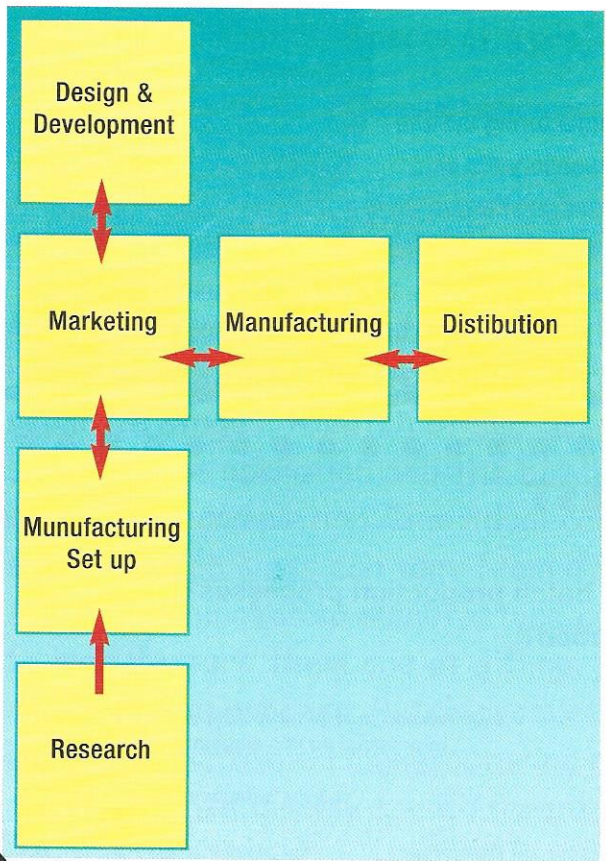
PRODUCTION CELLS



A production cell is a group of machines or a group of people and machines that work together to produce components or products. In the car industry, for example, robot cells are used to assemble, weld, spray and finish parts such as car door panels and floor panels. Other cells consist of people working as a team. Each person is not dedicated to a particular machine or role but will swap and change according to the tasks to be carried out. Team-working cells are widely used during batch production when a quick response to orders is required. Here the team will have responsibility for planning how the different batches will be made, decide which machines will be used and who will operate them and also be responsible for the quality control of the product.

CONCURRENT MANUFACTURE

Concurrent engineering is used to reduce the time it takes between the design stage and the manufacture of a product.



Examiner's Top Tip
Relate industrial processes to your own project designs.

In the traditional approach of manufacturing the tasks would have been completed in separate stages. This means that product design is carried out in the design department. The designs are then passed onto the production planning department for further work. Once completed, prototypes are made in the modelling shop and tested in the research and development department. Then manufacturing and finishing can commence. Finally the product can be field-tested and distributed. This approach is very time-consuming and leads to long lead times between the design stages and manufacture. In addition, potential manufacturing problems will not be identified until the manufacturing stage. Often these problems have to 'go back to the drawing board'.

In concurrent manufacturing, however, all departments are involved at the design stage and aspects of testing and manufacturing can be analysed prior to production starting. This cuts down the lead time between the design stage and full scale manufacture. It also reduces the risk of producing designs that cannot be manufactured properly or might fail in the field.

JUST-IN-TIME MANUFACTURING

Just-in-time manufacturing is used to reduce the stocks of goods that build up during manufacture. It also helps to ensure that companies are not left with too many unsold goods at the end of a production run. Just-in-time ensures that the minimum quantities of components are purchased and delivered and assembled at the right time with minimum waste.

Advantages of just-in-time	Disadvantages of just-in-time
Reduces stock piles in factory Reduces stock holding costs Eliminates unsold goods at end of production run Improves factory housekeeping Helps to strengthen relationships with suppliers Makes use of standard components, thus keeping costs down Demands tighter quality control	Possibility of products not reaching production stages on time Reliant on the quality standards of suppliers Reduces choice of suppliers

ELECTRONIC POINT OF SALE SYSTEM

The EPOS systems that are used in supermarkets and shops are good examples of how just-in-time works in practice. When a purchase is made the barcode reading system records that the stock level is lowered. This information is automatically computed and sent back to suppliers or warehouses over telecom links. The stock can then be topped up hourly or daily as required and always 'just in time'.

TOTAL QUALITY MANAGEMENT (TQM)

Total quality management emphasises the importance of product, process and procedure quality at every stage of management and manufacture. TQM does not rely solely on quality inspections at the end of the process. Total quality management relies on everyone in the factory being responsible for their own quality standards. Quality checks can be made at each stage of manufacture. If there are any problems these can be sorted out there and then. This helps to ensure that faults are found at early stages and not at the end of the manufacturing process. TQM helps reduce the number of rejected components.

QUICK TEST

1. What is a production cell?
2. Why is concurrent manufacturing used?
3. Give three advantages of just-in-time.
4. What is meant by EPOS?
5. What is meant by TQM?
6. Why is TQM important?

1. A group of machines or a group of people and machines working together to produce components.
2. To reduce the lead time between design and manufacture.
3. Reduction of stock piles, reduces stock holding costs, eliminates unsold goods, improves housekeeping.
4. Electronic point of sale.
5. Total quality management.
6. All workers are responsible for quality and quality checks are made at all stages of management and production.

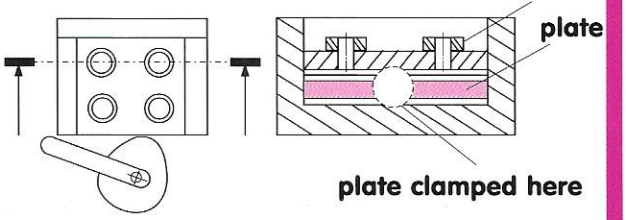
BATCH PRODUCTION

Most products are manufactured using batch production methods. Batch production involves producing a specified number of identical products in groups. The product to be made is usually broken down into a number of components or sub-assemblies which are then made in batches. Batch production needs to be well planned. Computer-aided manufacturing methods and jigs and fixtures are widely used to speed up the production process.

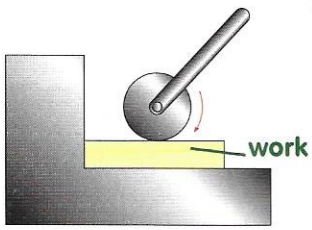
JIGS AND FIXTURES

When a number of identical components are to be made as a batch it is very time-consuming to measure and mark off each component individually before they are manufactured. Jigs and fixtures are used to speed up the production process. Jigs and fixtures are used to locate the workpiece quickly and clamp it into place so that measuring and marking out does not need to be carried out.

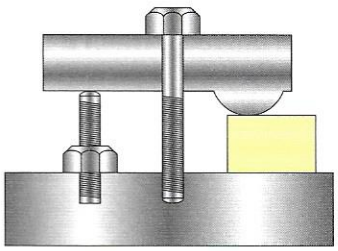
A jig is a device which locates and holds the work in place and also guides the tool for machining. This allows parts to be made accurately and quickly. Jigs used for drilling or reaming have hardened steel bushes to guide the tools.
As its name suggests, a fixture is a work-holding device that is clamped to the table. Fixtures can be used for operations such as milling, grinding and turning. Fixtures can also be used for welding and assembly work.



CLAMPING



cam type clamp



bridge type clamp

Clamps for jigs and fixtures need to release and tighten up quickly. Two types that are often used are bridge clamps and cam type clamps.

Examiner's Top Tip
Practise the design of simple jigs for making products in batches.

JIG & FIXTURE DESIGN

Jigs and fixtures need:

- a method of quickly locating the component
- to be foolproof so that the component can be only located the correct way round
- a method of positioning the tools accurately
- to allow guards to be used properly
- to allow swarf, wood or plastics cuttings to be cleaned quickly after each operation
- to allow the component to seat properly in the jig or fixture.

COMPUTER-AIDED MANUFACTURE

Computer-aided manufacturing is used widely in batch production processes. The way in which computer-aided machines can clamp and machine components has largely replaced the need for jigs and fixtures in many applications. The machines can be programmed easily for a particular batch of products. Computer control allows identical products to be made quickly and to a high degree of accuracy. Programs often allow complex shapes to be machined. The tools on computer machines are often changed automatically.

COSTING

Manufacturing costs can be broken down into direct and indirect costs.
Direct costs depend upon how many components are made in the batch.
They include the cost of labour and the cost of materials and the cost of other supplies.
Indirect costs include the costs of heating and lighting, wages for office staff, rents, rates and the cost of sales and marketing. Indirect costs do not generally change with the number of components being manufactured in the batch.
Computer-aided machines may be more expensive to buy in the first place. However, once programmed the direct costs can be lower due to minimal labour costs and wastage.

PRODUCTION COSTING

The cost of producing a batch of components is an important business factor.
In addition to the cost of buying the machine (capital cost) the following costs need to be calculated.

Computer machines	*Machines using jigs and fixtures*
Cost of initial programming	*Cost of making jigs and fixtures*
Material costs	*Material costs*
Overhead costs	*Overhead costs*
Supervisor costs	*Operator costs*
Running costs	*Running costs*
Cost of changing programs	*Cost of setting up the machine*

PLANNING

Planning is an essential business activity to ensure that batches are manufactured in the most appropriate sequence and on time to meet orders. Network charts can be used to help show the production route. Gantt charts can be used to indicate the sequence of operations and the time they will take.

QUICK TEST

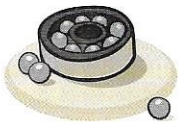
1. What is meant by batch production?
2. What is meant by a jig?
3. What is meant by a fixture?
4. What type of tasks are carried using jigs?
5. What is meant by a direct cost?
6. Why are computer controlled machines used in batch production?

Examiner's Top Tip
Know the advantages of using jigs in batch production

1. Where a number of identical components are made in batches.
2. A device that locates and clamps the work and guides the tool.
3. A work-holding device which is clamped to the machine.
4. Drilling, reaming.
5. A cost that depends upon how many components are made.
6. Do not need jigs and fixtures, can make identical components quickly and easily.

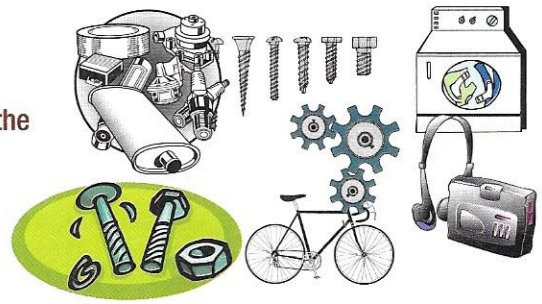
USE OF STANDARD COMPONENTS

THE DEMAND FOR STANDARD COMPONENTS



There are very few designs that do not use standard components.
Examples where they are used are bicycles, cars, tumble driers and personal stereos.
Standard components include nuts, bolts, set screws, bearings, and bushes and gears.
Standard components are normally bought in to reduce costs.
Standard component suppliers form the backbone of parts of just-in-time systems.

WHY STANDARD COMPONENTS ARE USED



It is more expensive to make standard parts than to purchase them from a supplier.
The supplier may be making them in their thousands and therefore the cost of each component – the unit cost – will be kept low.
If the parts are made 'in house' special machines and tools have to bought. The unit cost will be high.
Many standard part manufacturers are specialists in their own field. They will have extensive experience in making reliable parts. This will ensure that good-quality components are bought in.
Standard component manufacturers often have good testing facilities to test for reliability and safety. This helps to make sure that the safety requirements have been met.

Suppliers' catalogues give the types and prices of parts that are available. In most cases the more that are bought the cheaper will be the unit price.
Many of the parts are manufactured to national standards, ensuring high quality and safety standards.

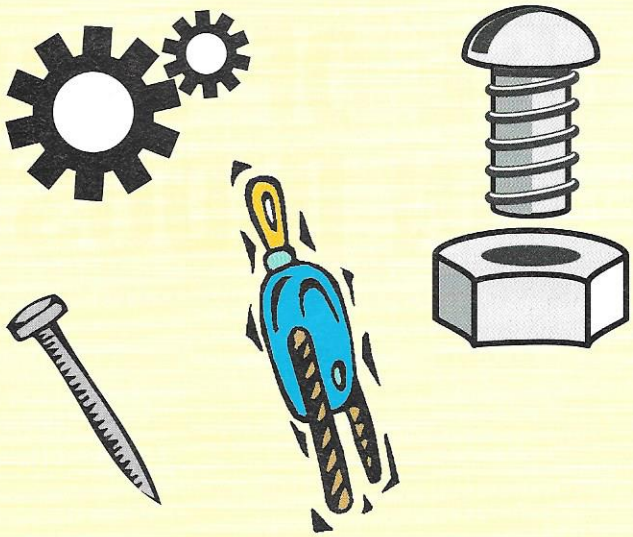
SOME NATIONAL STANDARDS

BS	British Standards
JIS	Japanese Industry Standards
ANSI	American National Standards Institute

INTERNATIONAL AND COMPANY STANDARDS

World trade has created the need for international standards. The International Standards Organisation has created a number of ISO standards for a wide range of products.
Many companies have their own systems for standardising components. These include design specifications and part numbering procedures.

STANDARD SIZES



Standard components are manufactured in a range of standard sizes and dimensions. Metric coarse threads for example have the range M2, M2.5, M3, M4, M5, M6, M8, M10 and M12 (where M2 refers to a 2 mm diameter thread).

In a similar way bearings have a range of standard inside and outside diameters.

Component sizes can be found in manufacturers' catalogues. The actual dimensions of a component can be used in the design of a product with confidence that it will fit.

Common standard components used in schools include gears, bearings, pulleys, round bars and dowels used for shafts, nuts, bolts and wood screws.

Examiner's Top Tip

Use suppliers' catalogues to understand the range of components that are available.

STANDARD PARTS AND JUST-IN-TIME MANUFACTURE

Standard parts' manufacturers make large numbers of just-in-time deliveries. When parts are required orders can be made using computerised stock control systems which speed up the ordering process. Standard components' manufacturers who supply companies on a just-in-time basis have to be well-organised.

QUICK TEST

1. Why do manufactures buy in standard components?
2. Name three standard components.
3. What does the term BS stand for?
4. Where can details and sizes of standard components be found?

1. Cheaper than making them in house
2. Nuts, bolts, set screws, bearings, bushes and gears
3. British Standard
4. Manufacturers' catalogues

USE OF CAD/CAM IN INDUSTRY

Computers are used widely in industry for both design and manufacturing operations. CAD refers to computer-aided design operations. CAM refers to computer-aided manufacturing operations. Computerisation allows designs to be easily downloaded to computer-controlled machinery. This can reduce the time between design and manufacture.

COMPUTER AIDED DESIGN

Computers are used in the design process in a number of ways. They are used to make accurate 2-D and 3-D drawings of components and products. Solid modelling is used to show how the product will look when made. Different colours and textures can be added to the model and the product can be rotated to show different views. Many CAD programs can determine how the product is likely to fail when in service using finite-element software packages.

Some CAD packages can be linked to rapid prototyping equipment. This builds up a 3-D wax or resin model of the product designed on the computer. Rapid prototyping equipment is expensive to buy. However, it allows a prototype to be made quickly without having to use expensive machinery and materials.

ADVANTAGES OF USING CAD PACKAGES

The design process can be speeded up.
Allows solid modelling of the product.
Enables design changes to be made quickly.
Information can be stored easily on disk.
Data can be easily transmitted to other design and manufacturing areas.

COMPUTER-AIDED MANUFACTURING

Computer-aided manufacturing (CAM) is used to describe the way in which components and products are made with the aid of computerised equipment. Computers allow new information to be programmed into the computer relatively easily and changes to be quickly carried out.

ADVANTAGES OF USING CAM

- Can be reprogrammed easily for different batch sizes.
- Can work continuously without the need to stop for breaks.
- Gives consistent quality levels.
- Can be used in hazardous conditions.
- Can be linked to computer-aided design facilities.
- Can be linked to a factory-wide computer system.

Examiner's Top Tip
Know the advantages and disadvantages of using CAD/CAM in industry.

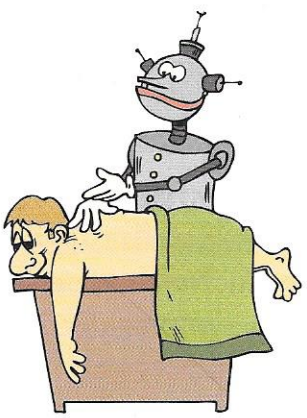
CNC MACHINERY

Computer numerical control (CNC) machines form the most widely used class of computer-aided manufacturing equipment. A CNC machine uses a dedicated program which has been programmed into a process control unit. Machines can be programmed using special key pads, floppy discs or smart cards.

Industrial applications include CNC lathes, milling machines, routers, sheet metal presses, welding equipment and materials - handling equipment. CNC machining centres are machines which are able to be programmed to carry out a range of operations on the same machine such as turning, milling and drilling. On many CNC machines the tools can be changed automatically and measurements can be carried out automatically using sensor probes.

ROBOTS

Industrial robots are computer-controlled devices that can be programmed for many different operations. A robot can be reprogrammed with a new sequence of movements and can be easily adapted to new conditions. The original program need not be lost since it can be re-used for operations at a later date. Robots usually have interchangeable gripping devices. Typical uses are spot welding, paint spraying, component handling and difficult assembly operations.



QUICK TEST

1. What is solid modelling?
2. Give three advantages of using CAM in industry.
3. Give two examples of industrial CAM machines.
4. State two advantages of using CAD packages.
5. What is meant by an industrial robot?
6. What useful processes do robots perform in industry?

1. A computer model of how the product will look when made.
2. Reprogrammed easily, works continuously without breaks, consistent quality levels, concurrent design.
3. Computer Numerical Control (CNC) machines (such as lathes and milling machines), and Robots.
4. Can be linked to CAD and factory-wide systems for automatic assembly and machining.
5. An industrial robot is a computer-controlled device that can be programmed to carry out many different functions.
6. Can be used in hazardous conditions, processes which are difficult to control.

COMPUTER INTERGRATED SYSTEMS

WHAT IS CIM?

CIM stands for computer-integrated manufacture.
A CIM system is one which has a large part of its production process operated and controlled by computers.

PARTS OF A CIM SYSTEM

A CIM system consists of:

computer-aided design

computer-operated machinery

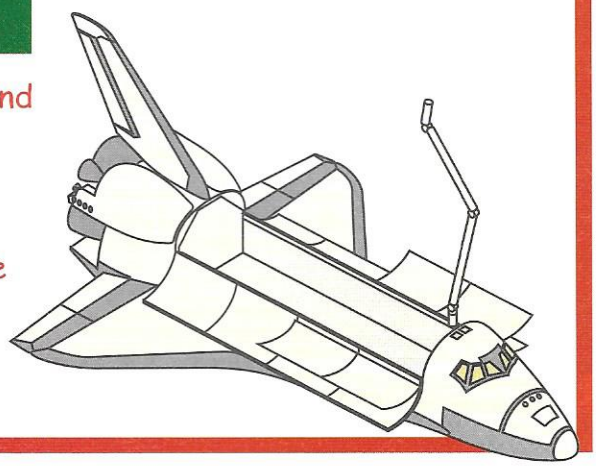
computer-controlled production systems

computer-controlled material handling systems.

Examiner's Top Tip
Learn the meaning of CIM and know the advantages and disadvantages.

INSTALLING CIM SYSTEMS

CIM systems are very expensive to install. They tend to be installed in industries such as automated car production and aerospace manufacturing.
CIM systems are integrated systems where the various parts of the company and its operations are linked together by computer.
They very often have a central computer which can controlled a range of operations.



PRODUCTION CONTROL

Companies can use computers in a number of ways. These include stock control, checking maintenance requirements, monitoring where products are in the system.
Computers are used for just-in-time systems to check whether parts need ordering. The computerised system is able to re-order components and parts from supplies.

CONTROLLING EQUIPMENT

Computer-aided machinery and computer-aided drawing systems are networked to the central system. Orders can be sent to the appropriate machines and equipment. CIM systems can also have automatic handling equipment to speed up the movement of goods through the factory.

ADVANTAGES OF CIM

- Can integrate a factory so that all sections are controlled from a central point.
- Can have CAD quickly download information to computer equipment.
- Production can be monitored constantly.
- Companies can have effective links with their suppliers.
- Can produce data on many aspects of the production plant.

DISADVANTAGES OF CIM

- Expensive to install.
- Not all companies can afford it.
- Failures can cause expensive problems.
- Difficult to maintain.

QUICK TEST

1. What does CIM stand for?
2. What sort of equipment may be linked to a CIM system?
3. What sort of industries might have a CIM system?
4. What types of operational control are linked to a CIM system?
5. What are some of the disadvantages of CIM?

1. Computer-integrated manufacture.
2. Production control, maintenance, CAD, CAM.
3. Car industry, aerospace industry.
4. Just-in-time, stock control, parts control links with suppliers.
5. Expensive to install, not all companies can afford it, computers might fail, difficult to maintain.

CONTROLLING THE QUALITY

QUALITY CONTROL AND TQM

- Quality systems are important to ensure that parts and products are manufactured to the required standards and specifications.
- Inspection methods are often used to check the quality of parts either at the end of the manufacturing process or at specific points during the process.
- Quality control using purely inspection methods can lead to a large number of rejects because faults may not be found until the end of the manufacturing process.
- The total quality management (TQM) approach can improve the quality of processes and procedures and products because quality systems are introduced at every stage of production and within the organisation.
- TQM seeks to make the product right first time, every time.

QUALITY DEFINITIONS

Quality means:

- Conforming to the design specification.
- Ensuring that the product performs the task it was intended for.
- Ensuring customer satisfaction.
- Ensuring that products meet the criteria laid down in British or other standards.

Examiner's Top Tip
Know how to use templates and simple gauges to check measures for small batches of components.

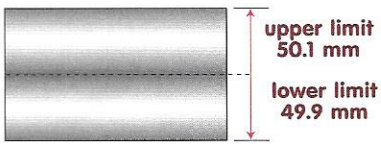
VARIABLES AND ATTRIBUTES

There are two types of quality characteristics:

- Variables are characteristics which can be measured and must lie between a range of values. These include lengths, widths, heights, diameters and weights.
- Attributes are not measurable quantities but are yes/no decisions that are either acceptable or unacceptable. Examples are correct colour or missing parts.

TOLERANCE

It would be very time-consuming and almost impossible to make every product in a batch to exactly the same size.
In practice limits and tolerances are used to give the largest and smallest size permitted for a dimension:



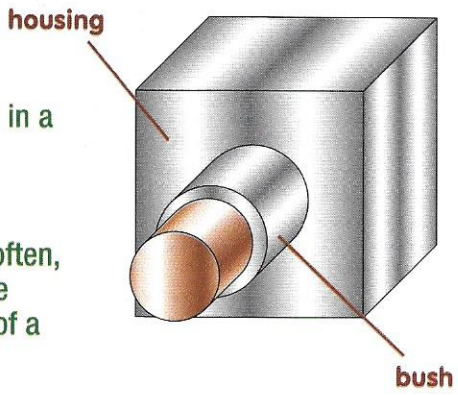
tolerance = 50.1 - 49.9 = 0.2mm

- The upper limit is the largest dimension that is acceptable.
- The lower limit is the smallest dimension that is acceptable.
- The tolerance is obtained by subtracting the lower limit from the upper limit.

INSPECTION PROCEDURES

There are two basic types of inspection: 100% inspection and sample inspection.
100% inspection is where every product is examined.
It is often impractical to check every component during manufacture. Instead, a sample of components are checked. If an unacceptable number of rejects are found in the sample then the whole batch may be rejected and subjected to 100% inspection. Adjustments are then made to the faulty production process.

TYPES OF FIT



Tolerances are often used in conjunction with types of fit.

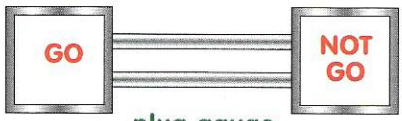
- A clearance fit occurs, for example, when a shaft can rotate freely in a hole. A clearance fit occurs when the shaft is smaller than the hole.

- An interference fit occurs when the shaft is larger than the hole. Interference fits are used when two parts have to be held in place, often, by the frictional forces between the two materials. Examples include location dowels in jigs and fixtures and the fit between the outside of a bearing and its housing.

LIMIT GAUGES

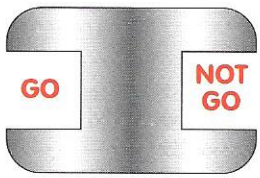
Measuring each component in a sample using rules, callipers, micrometers and verniers would be time-consuming. In practice, gauges are used to speed up the process. A gauge can be used to check whether component dimensions are satisfactory or not satisfactory.

The size of a hole can be checked using a plug gauge. The GO end will enter the smallest hole the NOT GO end will not enter the largest acceptable hole.



plug gauge

Gap gauges are used to measure the dimensions of shafts. A shaft within limits will enter the GO end but will not enter the NOT GO end.

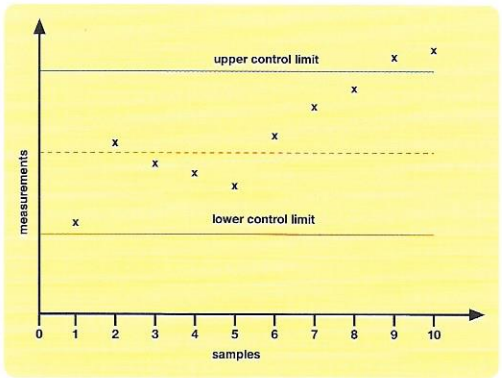


gap gauge

Taper plug gauges are used for checking the accuracy of tapers.

CONTROL CHARTS

- ***Control charts can be used to monitor the quality of a process. Component sampling is carried out and recorded on a control chart. The chart indicates whether the products are within the quality limits. If not, the machines or processes must be stopped or adjusted.***
- ***ISO 9000 is an internationally agreed set of standards for the operation of quality management systems. ISO 9000 specifies the procedures that manufacturers have to comply with in order to reach the quality standard. Complying with the standards indicates that a company has good quality procedures and is producing good-quality goods.***



QUICK TEST

1. What is a variable?
2. What is an attribute?
3. What is meant by a tolerance?
4. Name two types of fit.
5. What is a plug gauge used to check?
6. What ISO code is an international standard?

1. A characteristic which can be measured.
2. A characteristic which can only be acceptable or unacceptable.
3. The difference between an upper and lower limit of acceptability.
4. Interference and clearance.
5. The size of holes.
6. ISO 9000.