Student's Name: Date:

Manufacturing Systems

The way most things are made has changed considerably in the last 250 years. Up to the middle of the eighteenth century all products were individually made by highly skilled craftspeople. During the Industrial Revolution many of the jobs done by hand began to be done by machines instead. This meant that products could be made more quickly and in greater numbers, though they were not necessarily of such good quality.

During the early 1900s, the idea of making things on a production line was introduced. The idea was that each worker just made one part of a product as it passed down an assembly line.

One of the first successfully mass-produced items was the Model T car, made by Henry Ford between 1908 and 1916. It was assembled on a production line by workers who did the same job all day. Today robots carry out many of these repetitive tasks.

Production processes

Products are manufactured by different systems according to the volumes required.

One-off production *(Job Production)*: This is the most costly method but does allow for a personalized product, such as a made-to-measure suit of clothes. Workers in this system need to be highly skilled and to be able to work on a number of aspects of a project.

Batch production: This is used where a company needs to produce a limited number of the same product. It then changes its production line to make a different product. Using this method companies can respond quickly to market demand. 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. Production Cells are often used in batch production. They consist of a group of machines / people that work together to make products. For example in the car industry robot cells are used to assemble, weld, spray and finish parts such as door 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.

Mass production: Most common consumer products are made by mass production. Workers are organized to carry out individual tasks, where they become skilled. They are often rotated around a number of tasks to keep their interest. Production Lines are often used. The products are assembled as they flow down a 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 to cover the setup costs. Modern produciton lines are controlled by computers which can also monitor production.

Continuous Production: refers to processes such as extrusion. 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 need to have computer systems to monitor how the product is flowing through the system.

Manufacturing

Jigs

When a number of identical components are to be made as a batch it can be very time consuming to measure and mark off each component individually before they are manufactured. Jigs are used to speed up the process. Jigs can be used to locate the workpiece quickly and clamp it into place so that measuring and marking out does not need to be carried out. Jigs can also be used to guide cutting tools. This allows parts to be made accurately and quickly.

Jigs need:

- a method of quickly locating the component
- to be fool-proof so that the component can only be located the correct way.
- a method of positioning 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 component to 'sit' properly.

Flexibility

Manufacturing flexibility refers to how quickly a machine or manufacturing system can be changed to make a different part. Machines used in batch production are usually selected because of their flexibility. CNC machines are flexible because they can be re-programmed quickly and easily when different batch types and sizes are required. This is termed 'quick response'.

Just-in-time manufacturing

Just-in-time manufacturing is used to reduce the build up of stock at the factory. It also helps to ensure that companies are not left with lots of unsold goods at the end of a production run.
Just-in-time ensures that the minimum number of parts are purchased and then assembled at the right time with minimum waste.

Advantages of just-in-time:

- Reduces stock piles in factory
- Reduces storage costs / saves space
- Reduces waste - There are no unused parts left over at the end of the production run.
- Eliminates unsold goods at the end of the production run
- Improves factory housekeeping

Disadvantages of just-in-time:

- Possibility of products not reaching production stage on time
- Reliant on suppliers to meet tight delivery times

Standardised parts:

Many products make use of standard parts. Standard components, include nuts, bolts, screws, bearings, and gears. Cars from the same manufacturer use parts that are common across the model range. Examples are door handles and controls on the dashboard and steering wheels.
Standard components are normally bought in to reduce costs. Standard component suppliers are very important to just-in-time systems.

Parts are manufactured to international standards. 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).

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 updates the stock level. This information is then used to automatically order more stock. The stock can be topped up hourly or daily as required.

Total Quality Management (TQM)

Total quality management emphasizes the importance of quality control at every stage of the production process. 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 promptly. This helps to ensure that faults are found at an early stage and not at the end of the manufacturing process. TQM helps reduce the number of rejected components.

Q4U2do. (A)

1. What are the different Production systems we have looked at?
   - **a.**
   - **b.**
   - **c.**
   - **d.**

2. Give four examples of products which might be made using each of the different production systems (not the ones used in the notes).
   - *An example of a product made using **a.** would be..*
   - *An example of a product made using **b.** would be..*
   - *An example of a product made using **c.** would be..*
   - *An example of a product made using **d.** would be..*

3. List five things that companies can do to reduce their production costs.
   - ***a.***
   - ***b.***
   - ***c.***
   - ***d.***
   - ***e.***

4U2do (B)

Today we are going to be making pizzas (not real ones!!). The aim of the exercise is to help you understand that production systems can be made more efficient by identifying 'weaknesses' and then making the necessary adjustments.

Activity One: ***Production Cells***

You are going to start by working with a partner to make a 'pizza'.
After your teacher has 'trained you' (shown you what to do), spend a few minutes deciding who will do what.
Your teacher will tell you when to start. As you are working you should be thinking about how you could improve the quality of your product / the speed of your production system.
When you finish put your hand up to let your teacher know. He/she will tell you how long it took you - make a note of the time below;

Time taken (1): ☐ ***(mins)***

Your teacher will now carry out a *Quality Control* check.

Pass ☐ ***Borderline*** ☐ ***Fail*** ☐

Now discuss your ideas for how to imrove your production system with your partner (don't let anyone else know!)

Record your ideas below;

Having identified possible improvements to your system you are now going to make another pizza. Your teacher will tell you when to start. Record your new time in the space below

Time Taken (2): ☐ ***(mins)***

Your teacher will now carry out a second Quality control check.

Pass ☐ ***Borderline*** ☐ ***Fail*** ☐

Manufacturing

Activity Two: *Production Lines*

Your teacher will now put you into two teams and appoint a 'Production Manager' for each team.
Working together *(The production manager is in charge)* decide how to set up a production line to manufacture pizzas.
You are going to have a competition to see which team can make the most pizzas in a set time with prizes for the winners. *(Remember that each pizza must pass the quality control checks. If a pizza fails the QC checks it will not count and you will also lose one from your total!)*

Good luck!

As your teacher adds up the totals spend a few moments to reflect on the success of your team.
In the space below write down what you think went well

In the space below write down what did not go well

Use of CAD/CAM in industry

Computers are used widely in industry for both designing and manufacturing. CAD refers to computer-aided design, CAM refers to computer-aided manufacturing operations and CNC refers Computer numerical control. These are machines which are used to cut out the CAD drawings.

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 modeling 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. Some CAD programs can be used to determine how the product will work.



CAD packages can be linked to rapid prototyping equipment such as 3D printers. Rapid prototyping equipment has become much more affordable recently and allows a prototype to be made quickly at a relatively low cost.

Advantages of CAD:

- The design process can be speeded up.
- Allows 'solid modeling' of the product.
- Enables design changes to be made quickly.
- Information can be stored digitally and be easily emailed to other parties.

Computer-aided manufacturing

Computer-aided manufacturing (CAM) is 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 CAM:

- Can be re-programmed easily for different batch sizes
- Can work continuously without the need to stop for breaks
- Gives consistently high quality levels
- Can be used in hazardous conditions
- Can be linked to CAD systems
- Can be linked to a factory-wide computer system

CNC Machinery

Computer numerically controled (CNC) machines include lathes, milling machines, routers, sheet metal presses and welding equipment. On some CNC machines the tools can be changed automatically to speed up processing speeds.



Robots

Industrial robots are computer-controlled devices that can be programmed for many different operations. They can be quickly reprogrammed with new sequences of movements and can be very

versatile. Robots usually have interchangeable gripping devices. Typical uses are spot welding, paint spraying, component handling and difficult assembly operations.

Computer Integrated Manufacturing (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.

CIM systems consists of:

- computer-aided design
- computer-operated machinery
- computer-controlled production systems
- computer-controlled material handling systems

CIM systems are very expensive to set up. They tend to be installed in industries such as automated car production and aerospace manufacturing. They very often have a central computer which controls a range of operations.

Advantages of CIM:

- Can integrate a factory so that all sections are controlled centrally.
- Can use CAD to quickly download information to CNC equipment.
- Production can be monitored constantly.
- Allow companies to have more effective links with their suppliers.
- Can produce data on many aspects of the production process.

Disadvantages of CIM:

- Expensive to install.
- Failures can cause expensive problems.
- Difficult to maintain.

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 needed ordering. The computerised system is able to re-order components and parts from supplies.

Q4U2do. (C)

4. What do the letters CAD, CAM and CNC stand for?

5. What advantages does CAD have over traditional drawing methods?

6. What advantages does CAM have over traditional manufacturing processes?

7. What does CIM stand for?

8. Use CAD to draw a workshop tool.

9. Design an information sheet about the tool you drew for Q5 using the CAD drawing you produced.

Manufacturing

Industrial Manufacturing processes

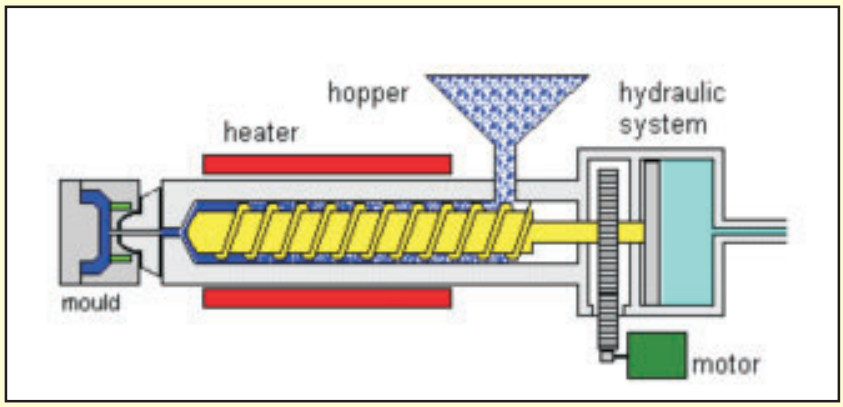
Materials can be shaped in a variety of ways. These can be separated into three groups of processes which are **(WAR)**;

- **Wasting** - these processes involve the removal of material using a cutting process such as sawing or drilling.
- **Addition** - these processes involve joining materials together such as gluing, screwing, soldering, brazing or welding.
- **Redistribution** - these process involve reshaping materials such as casting/ moulding, forging and pressing.

Some of the major processes used in industry for forming materials are as follows;

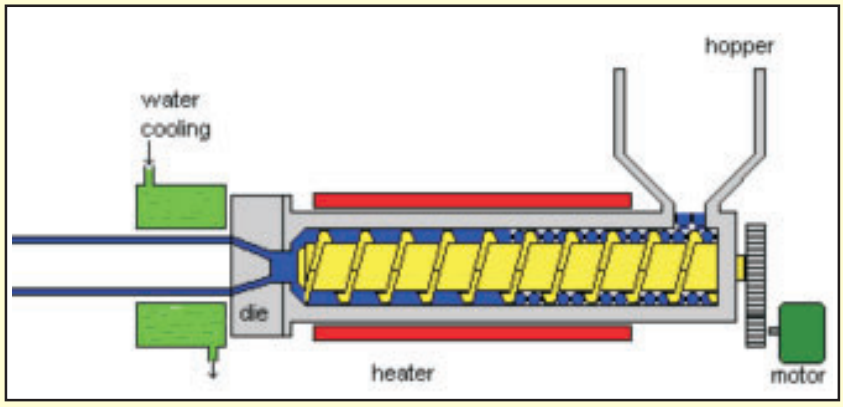
Injection Moulding

This is one of the most common manufacturing processes and is used for shaping thermoplastics.



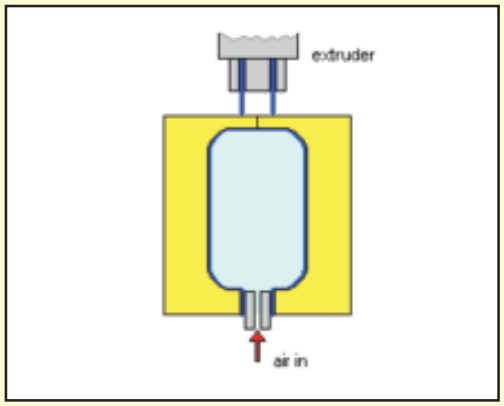
Extrusion

This process is used for producing long lengths of material with a uniform section such as drain pipes or guttering.



Blow moulding

This process is used for producing simple shell structures such as bottles form thermoplastic.

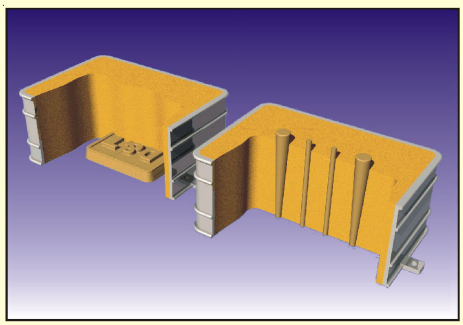


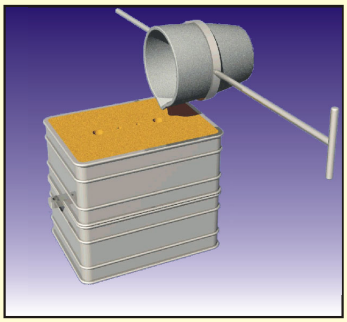
Rotational Moulding

This process is used for producing simple shell structures with thick walls. It involves partially filling a mould with liquid plastic and then revolving it in every direction. A layer of solidified plastic gradually builds up on the walls of the mould. When the plastic has all set the mould can be opened and the product removed.

Casting

Used for forming parts from molten metal. Sand casting involves making a wooden 'pattern' which is then put into a frame which is filled with sand. The frame is then turned over and the pattern is removed. A second frame which has air holes, a 'runner' and 'riser', is then placed on top. Molten metal is then poured into the runner, filling the cavity created by the pattern and then overflowing out of the riser. The The metal is then left to cool before being removed. (The sand mould is destroyed when the casting is taken out of it.)

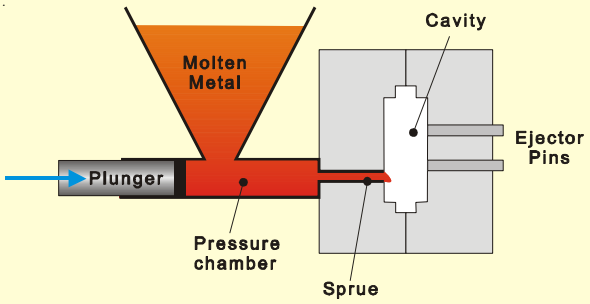






Die Casting

Die casting is a very similar process to the injection moulding of plastics. The metals used are often zinc and aluminium alloys because they melt at relatively low temperatures.



Pressing

Cold pressing is used to form sheet metals into irregular shapes such as car body panels. The sheet is placed between two shaped 'dies' which are pressed together under high pressure. When the dies are separated the sheet retains its new form.

Drop forging

Drop forging is used for squeezing metal 'blanks' into simple solid shapes. This process involves putting a heated piece of metal of the correct shape and size into a 'die' and then 'dropping' a second die onto the top of it with a great force. The metal blank is squeezed into the shape of the cavity.

Spindle moulding

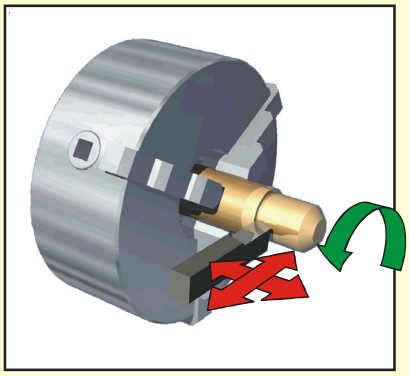
A spindle moulder is used to put a 'profile' along the edge of a piece of timber.
This process is used for putting the mouldings along the edges of wooden skirting boards, architrave etc.
A hand held machine called a router can be used in a similar way to make small mouldings around the edges of decorative pieces of wood.

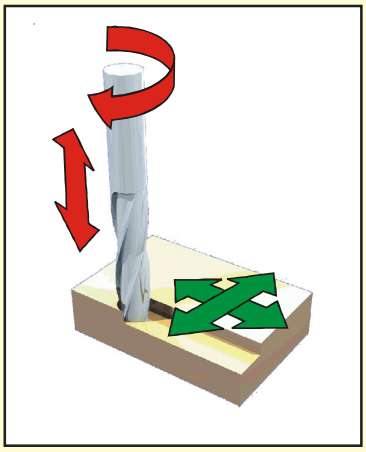


Manufacturing

Turning

The process of turning can be carried out on woods, metals and plastics. It involves holding the material in a set of jaws. (Depending on the length of the work piece it may need to be supported at both ends.) The work is then spun round and a cutting tool is then offered up to the work. By moving the tool in /out and along, different profiles can be achieved. The machines can either be hand operated using rotary handles or Computer Numerically Controlled. An example would be the wooden spindles for a stair case.





Milling

This process can also be applied to woods, metals and plastics. It involves holding the work piece in a vice or set of jaws which is mounted on the bed of the machine. A rotating cutter is then lowered down to the work from above. The bed of the table is then moved to produce slots or grooves. By moving in all three axis, more complex shapes can be produced.

Q4U2Do.(D)

10. What are the three means by which materials can be shaped? (WAR)

11. What is the mass production method by which most thermoplastic products are manufactured?

12. Draw a labelled drawing of the method you mentioned in Q11.

13.What is the name of the manufacturing process usually used for making plastic bottles?

14. Name a suitable manufacturing process for making large numbers of small metal products such as toy cars.

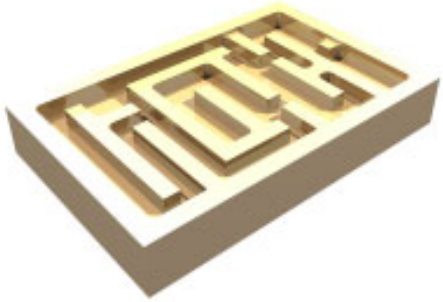
15. What type of alloys are usually used for the process mentioned in Q14. Why is this?

16. Name the process used to manufacture car body panels.

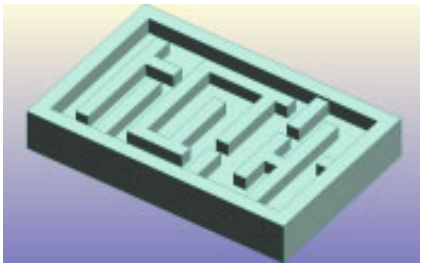
17. What manufacturing process would you use to make the part shown below.



18. What process could be used to machine the shape below from a solid block of material?



19. The CAD drawing for the part in Q18 is shown below. What is different about the drawing and the final piece? Why is this?



Manufacturing

AQA General Certificate of Secondary Education

Design and Technology: Product Design

Unit 1 Written Paper

To help you prepare for the written exam

Q. 1 Which one of the following is a production method based on providing stock as it is needed? [1 mark]

A Computer Aided Manufacture
B Flexible Manufacturing
C Integrated Manufacture
D Just in Time Manufacturing

Q. 2 Choose one product or component from the list below and describe two features that make it suitable for mass production.
Polymer toy musical instrument, Steel car door, Newspaper, Cotton T-Shirt, Printed Circuit Board, Flat pack furniture [2 x 2 marks]

Q. 3 Explain the purpose of 'quality control'. [2 marks]

Q. 4 Describe one method of 'quality control' that is used when making prototype products. [2 marks]

Q. 5 Name one process used to remove waste material to make different parts of a prototype. Describe the process you have chosen. [3 marks]

Q. 6 Select one product in the table below. Explain why the given commercial process is used in its manufacture. [3 marks]

Toy car	Casting
Tea towel	Printing
Toothbrush	Injection moulding
Pop up card	Die cutting
Wooden fruit bowl	Turning
House alarm.	Flow soldering

Q. 7 Name one industrial process used in the manufacture of the product or component you have chosen for the question above. Use notes and/or sketches to explain this process in detail. [5 marks]

Q. 8 Explain two ways how just in time (JIT) production can help manufacturers improve efficiency. [4 marks]

Q. 9 Computer based tools are helpful to designers when modelling. Discuss how a designer might use computer based tools in the development of aproduct. [6 marks]

Q. 10 Choose one of these addition processes- Lamination, Printing, Sewing, Soldering, Welding. Use notes and sketches to describe your chosen process. Identify the equipment used in your chosen process. [6 marks]

Q. 11 Analyse how different production aids are used in the manufacture of products. Evaluate how the use of such production aids improves the quality, accuracy and speed of manufacture. [8 marks]

Exam Advice

You are very likely to be asked to describe how you would make a 'batch' of a product.
You should make reference to how you would use jigs and templates.
You should also be able to select appropriate tools for different tasks and describe how they are used.
You should be able to use simple diagrams to describe processes such as vacuum forming and strip heating.

You may well be asked to describe an industrial mass production process such as Injection Moulding (include diagrams).

List of CGP Revision questions:

A1 Technology in Manufacturing
A2 Production Systems CAD CAM
C3 Scales of Production
C4 Quality Control
C5 Production Aids
D2 Stock Forms and standard components
E10 Manufacturing Specs