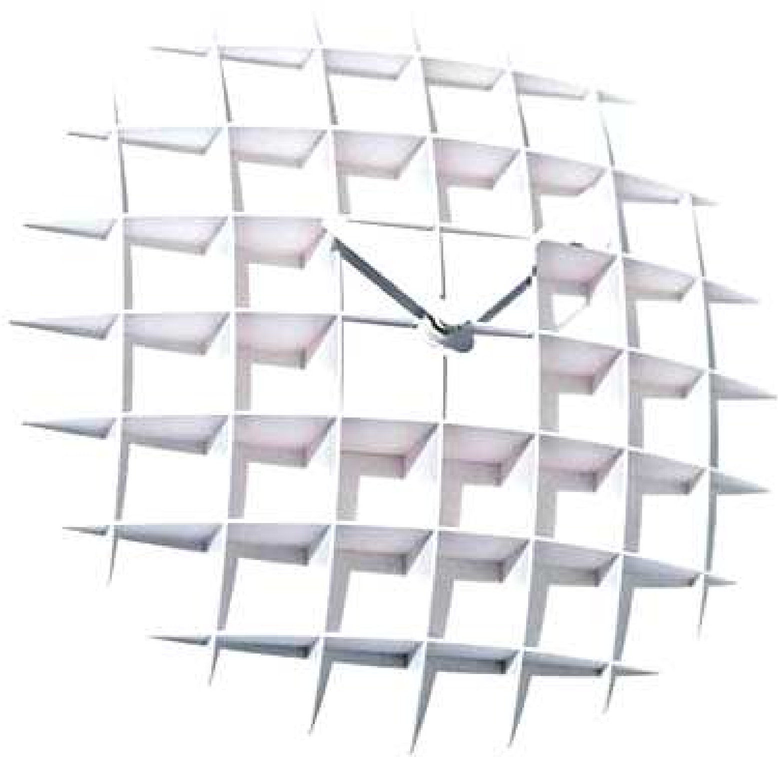
Core IB

Design Technology



International Baccalaureate Organization (IBO)

Student Name: **Tutor Group:**

Version 1.0

Welcome to the IBO course in Design and Technology

Contents of Coursebook: **Page(s)**

Foreword-

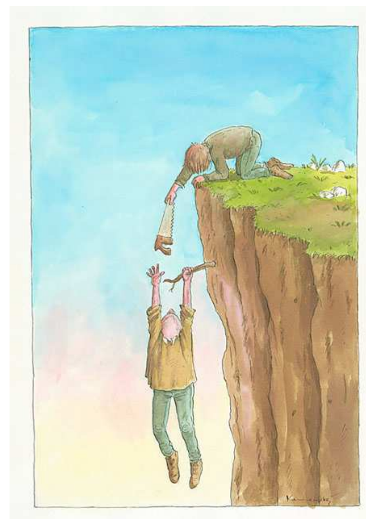
Congratulations! You have decided to enrol on a course that will stimulate, motivate, challenge and reward your interest in designing and making. This DT IB Coursebook is designed to:

- Help you understand what the course is about
- Show you how the course is organized
- Help you to understand and be involved in your own assessment
- Act as an activity and revision guide through your learning journey in the Core topics

Some common questions and answers when you start the course

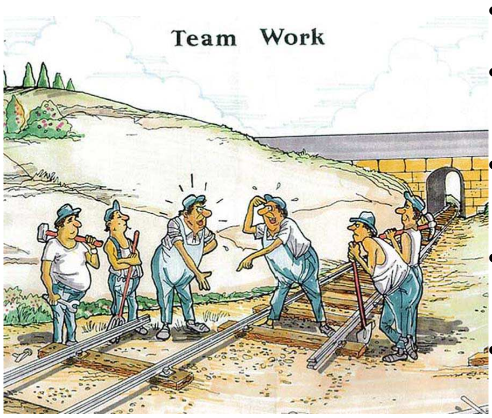
"I didn't get the grade I expected in D&T. Does this mean I will find the course too difficult?"
If you have studied a related GCSE D&T course at GCSE and achieved a grade B or higher, then you are suited for study at Higher level. It may be that some students have been accepted on to the course with lower grades due to individual circumstances; for example, a student may have not been able to complete coursework due to a personal situation and achieved a grade 'C'. However their capability is known to be strong.

"I haven't done D&T before. Will I be able to cope?"
Generally speaking if you achieved a grade 'C' or lower in a related GCSE Technology course, then study at Standard level is most appropriate. Students may be accepted onto the course that have not studied GCSE Technology but have a proven basic knowledge and/or interest in the subject. Students who have not studied Technology recently or who have no practical skills need to be aware that it will present significant challenges.



"Other people on the course seem to know more about D&T than me. Am I going to fall behind?"
Basic terminology such as 'brief', 'specification' and 'ergonomics' will be in frequent use as well as a presumed knowledge of basic designing and making principles. Students who are unfamiliar with these terms will need to do extra independent study. The staff here are very supportive and the materials produced can help with this, but essentially, students must recognize the particular challenges they may face from the beginning of the course and commit actively to overcoming them and have realistic expectations.

"What words of advice can you give me?"



- **Use your diary** and make sure you do your work on time
- **If you have any kind of problem, tell your teacher in advance** so that they have time to help you before the deadline
- **Don't try to work on your own.** DT is a collaborative course – you need to work together and support each other
- **Put your highest level of effort into all your work** because it all counts
- **Don't be put off by challenging work.** Do your best. We all learn and make progress when we face up to challenges. Why else would you be doing IB?

Basic equipment

You will be expected to provide the following things every lesson:

- Pens, pencils and colouring pencils
- Basic drawing equipment such as ruler, compass, eraser, etc.
- An A4 Folder with lined and plain paper for keeping notes
- A set of dividers so that you can easily check your work and find each section easily
- This DT IB Coursebook

Expectations

You can **expect us** to do the following:

- Provide you with the materials you need to prepare for your examinations
- Provide you with the materials you need for the production of project work & assignments
- Give you clear guidance about how your work is structured and assessed
- Provide written and spoken feedback on your progress
- Plan and deliver lessons which link directly to the topics you need to cover

We will **expect you** to do the following:

- Arrive to your lessons on time and with the correct equipment and materials
- Participate to the best of your ability in all lessons
- Dedicate the right amount of time to homework and revision
- Hand in assignments on time
- Ask in plenty of time if you need any guidance or advice
- Look after all your work in a well-organized way. **The responsibility for storing work safely and maintaining your projects and notes lies with you alone.** The department can provide places for you to keep work but it is not our responsibility to monitor its whereabouts.

If you understand the information so far and your expected commitment sign in the space below:

Name: **Date:**

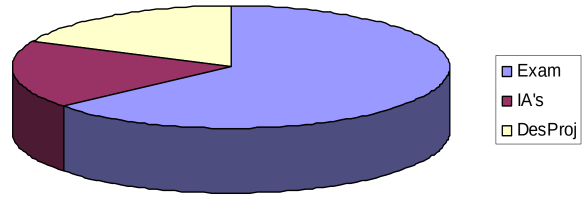
Signature:

Course outline

The course is part of **Group 4 'Experimental Sciences'.** Here is a really simple breakdown describing how your course is structured. Don't worry if it doesn't all sink in straight away, it is our job to make sure that you meet all the course requirements. Your job is to know **where you are now, where you are going next,** and **how to get there.**

This is your course in a nutshell:

- **Exams - 64%** Three papers based on CORE THEORY and OPTIONS in May of Year 13.
- **Internal assessments – 18%** Assignments over the whole course.
- **Design Project – 18%** Project of your choice started at the end of Year 12 and finished in January of Year 13.



The course explained in detail

You will be taught the following components and the recommended teaching time for each is also stated:

STANDARD LEVEL	HIGHER LEVEL
Theory (core and options) **95 hours** Practical work (Internal Assignments, Design project and Group 4 project) **55 hours** **TOTAL teaching time: 150 hours.**	Theory (core, options and additional higher level topics) **159 hours** Practical work (Internal Assignments, Design project and Group 4 project) **81 hours** **TOTAL teaching time: 240 hours**

You will actually get far in excess of this number of ***teaching*** hours over the course. You are expected to spend ***additional*** time on homework, assignments and private study; Standard Level students around **2 hours** additional time per week, Higher Level students around **3 hours** per week.

You will be expected to use the workshops in some of your private study time and after school to complete practical work. **Make sure you tell your teacher in advance if you need to do this.**

Looking at the 'theory' more closely

You all learn the following 7 topics. They are called CORE TOPICS. The number of hours spent on teaching and learning for each one is shown:

Topic 1: Design Process.	10 hours
Topic 2: Product Innovation.	7 hours
Topic 3: Green Design.	9 hours
Topic 4: Materials.	17 hours
Topic 5: Product Development.	11 hours
Topic 6: Product Design.	5 hours
Topic 7: Evaluation.	6 hours
Total for CORE THEORY:	**65 hours**

All Compulsory for both SL and HL

If you are a Higher Level student, you will study another five topics called ADDITIONAL HIGHER LEVEL TOPICS ('AHL'). They are;

Topic 8: Energy.	9 hours
Topic 9: Structures.	10 hours
Topic 10: Mechanical Design.	8 hours
Topic 11: Advanced manufacturing techniques.	10 hours
Topic 12: Sustainable development.	12 hours

Total for ADDITIONAL HIGHER LEVEL TOPICS ('AHL'): **49 hours**

To finish off your theory, you study **ONE** OPTION:

Option A: Food Science and Technology.
Option B: Electronic Product Design.
Option C: CAD/CAM.
Option D: Textiles. 30/45 hours.
Option E: Human factors design.

One Compulsory for both SL and HL

If you are a standard level student, your option teaching time is **30 hours.**

If you are a higher level student, your option teaching time is **45 hours.**

Coursework

You probably chose to do D&T because you like designing and making things. This is the part of the course where you can do just that. It all counts for 36% of you final assessment so it's worth a lot.

There are two types of 'coursework':

1. **Internal Assessments.** These are mini projects that show your skills in a number of key areas like drawing, research and manufacturing. You will be asked to do several different assignments over the whole of the course. They will usually be linked to the theory that you will be learning – so the two things go together. They are all worth 18% of your total assessment.

2. **Design Project.** In year 13, you will spend about a term doing a project of your own choice. This is worth 18% of your total assessment.

A word about coursework!
Remember, you don't just need your coursework at the end of the course – your coursework is your portfolio and you will need to finish it on time, look after it in your portfolio and have it ready to show people at any time. For example, when you are being interviewed for a place at University of you are applying for a job. Keep on top of your coursework.

Assessment criteria

There are 6 'internal assessment criteria' which are used to assess your work. **The following four are assessed twice**, one in your internal assessments and once in your design project:

- **Planning (PA)**
- **Research (RA)**
- **Development (DA)**
- **Evaluation (EA)**

- **Manipulative Skills (MS)** is assessed **once only** in your **design project**

- **Personal Skills (PS)** is assessed **once only** during the **Group 4 project**

Each criterion has three 'aspects'. The following section describes what you have to do for each aspect:

Planning (PA)
- ✓ Aspect 1: Defining the problem
- ✓ Aspect 2: Formulating a brief or a research question
- ✓ Aspect 3: Selecting variables or specifications

Research (RA)
- ✓ Aspect 1: Strategies
- ✓ Aspect 2: Data collection
- ✓ Aspect 3: Data processing and analysis

Development (DA)
- ✓ Aspect 1: Creativity
- ✓ Aspect 2: Techniques
- ✓ Aspect 3: Solution

Evaluation (EA)
- ✓ Aspect 1: Conclusion
- ✓ Aspect 2: Procedure
- ✓ Aspect 3: Recommendations

Manipulative skills (MS) ***ONLY USED FOR ASSESSING THE DESIGN PROJECT***
- ✓ Aspect 1: Procedures
- ✓ Aspect 2: Use of equipment and materials
- ✓ Aspect 3: Techniques

Personal skills (MS) ***ONLY USED FOR ASSESSING THE GROUP 4 PROJECT ***
- ✓ Aspect 1: Self motivation and perseverance
- ✓ Aspect 2: Working within a team
- ✓ Aspect 3: Self reflection

How are my internal assessments and project marked?

Each aspect can be awarded one of three levels:

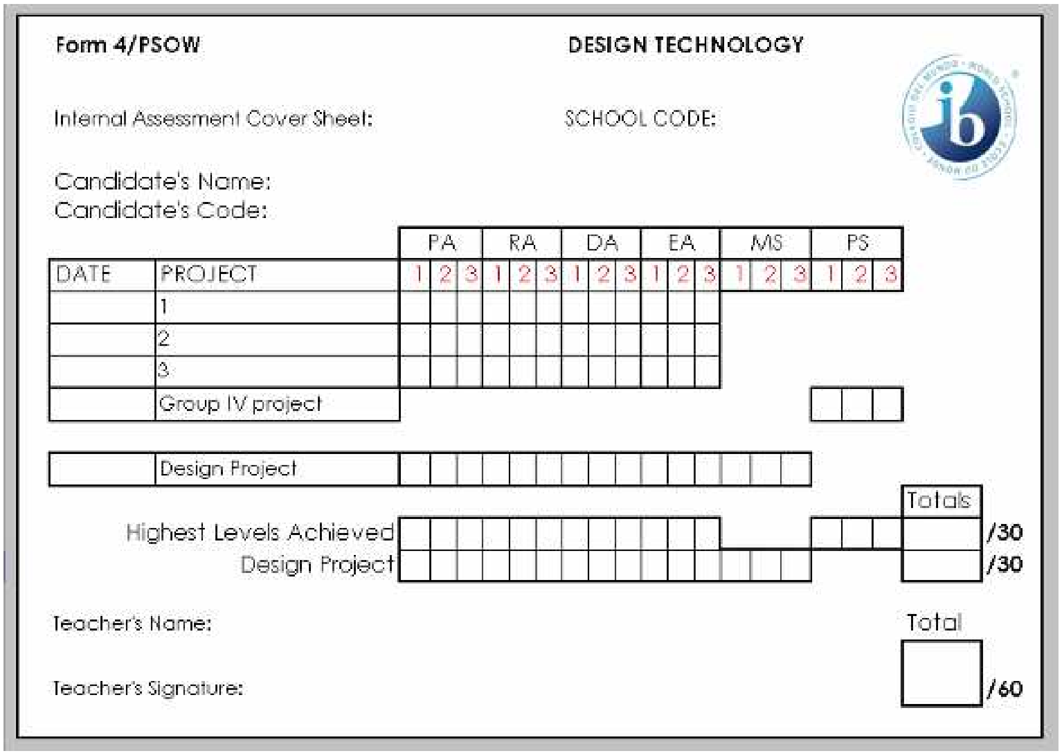
- **C**omplete – in other words you have met the criterion fully = **2 marks**
- **P**artial – you have met some but not the entire criterion = **1 mark**
- **N**ot at all – you haven't met the criterion at all = **0 marks**

The letters **C P N** are used to summarize these awards.

Because there are 6 criteria, you can get a maximum mark of 30 marks for your project, a maximum of 24 for all you internal assessments plus 6 marks for the Group 4 project. So the total for all of your 'coursework' is 60 marks.

The exam board changes this to a percentage and adds it to your exam results.

How do teachers judge my work?



Form 4/PSOW

DESIGN TECHNOLOGY

Internal Assessment Cover Sheet: SCHOOL CODE:

Candidate's Name:
Candidate's Code:

DATE	PROJECT	PA 1	PA 2	PA 3	RA 1	RA 2	RA 3	DA 1	DA 2	DA 3	EA 1	EA 2	EA 3	MS 1	MS 2	MS 3	PS 1	PS 2	PS 3
	1																		
	2																		
	3																		
	Group IV project																		
	Design Project																		

Totals

Highest Levels Achieved /30

Design Project /30

Teacher's Name: Total

Teacher's Signature: /60

It's important to remember that your work is **being judged all the time**; teachers will be recording all of your **assessments** and also noting your **organization**, **attitude** and **effort**. So assessment doesn't just happen when work is marked.

Remember also that your teacher will contribute to your **subject reference**, so it is important that they you give them every opportunity to praise you. However, you need to understand how teachers make a judgement about your work and your potential. This is how it is done:

You will be awarded a level at the end of your course. The levels range from **1-7**.
Level 4 is a pass **Level 5** is a good performance **Level 6** is very good **Level 7** is outstanding

It would be very rare indeed for a student to be awarded a level 7 in Year 12 as they would not yet have completed enough work to make a fair judgement, but in some exceptional cases, students do achieve level 7 in Year 12*. We have to decide what 'level' you are working at for each piece of work you do. This might be difficult if the work is a test for example and you get a percentage or mark. To help, we have produced the following guide:

%	IB Level	Descriptor
85+	7	Excellent
69-85	6	Very Good
56-68	5	Good
39-55	4	Satisfactory
28-38	3	Poor (Border fail)
16-27	2	Fail
0 -15	1	Fail

Please remember that teachers can only make judgments about your capabilities based on **evidence.** You need to do display the **right attitude** to your studies from the outset and remember that all of your actions contribute to our ability to assess your work and help you to do your best.

Your exams and assessment

Paper 1: 20%	**Standard level:** 45 minutes. 30 multiple choice questions on the CORE THEORY **Higher level:** 1 hour. 40 multiple choice questions on the CORE THEORY plus ADDITIONAL HIGHER LEVEL TOPICS

Paper 2: 24%	**Standard level:** 1 hour. Section A: Data based question plus several short answer questions – all compulsory based on CORE THEORY. Section B: One extended question from a choice of three based on the CORE THEORY. **Higher level:** 1 hour 45 minutes. Section A: Data based question plus several short answer questions – all compulsory based on CORE THEORY plus ADDITIONAL HIGHER LEVEL TOPICS. Section B: One extended question from a choice of three based on the CORE THEORY plus ADDITIONAL HIGHER LEVEL TOPICS.

Paper 3: 20%	**Standard level:** 1 hour. Several short answer questions and one extended response question based on the OPTION – all compulsory. **Higher level:** 1 hour 15 minutes. Several short answer questions and one extended response question based on the OPTION – all compulsory.

Internal Assessment: 18%	**Investigations** (coursework): A range of investigations and project work set by the teacher and conducted throughout the course. This will form the basis of your portfolio.

Design project: 18%	A project of your choice which represents the full design and make process, started at the end of Year 12 and concluded around January in Yr 13. Also a major item in your portfolio.

Your portfolio

You are expected to keep a well-organised portfolio of your work. This should be continuously added to as you go through the course. It should contain a **wide variety** of work that shows your **best designing** and **making skills** in a range of areas such as research, designing, CAD, CAM and evaluating.
It should also contain your GCSE work if you have it and any other work that relates to D&T such as competitions that you have entered or work that you have done as part of the CAS programme. This is incredibly important.
If you apply for a design-based University course or if you apply for a job, you will be expected to provide a portfolio that shows your talents in their best possible light. This is not something you should throw together just before an interview but is something that should be built up from the moment you start the course. Staff in the department can advise you on putting it together and keeping it updated. Remember that the portfolio is your responsibility.

The Group 4 project

What is it?

"…a collaborative activity where students from different group 4 subjects work together on a scientific or technological topic, allowing for concepts and perceptions from across the disciplines to be shared."

- Around 10 hours in total:
- Planning: around 2 hours
- Action: around 6 hours
- Evaluation: around 2 hours

You will work alongside students in other Group 4 subjects (Physics, Chemistry and Biology) on a collaborative project. You will be asked to produce a folio and / or display of evidence that documents your work.
The will be used to assess **'Personal Skills'**.

It usually takes place during the end of Year 12 and runs over a three day period. At the end of your project, you and the rest of your team will make a presentation to students and staff of the senior school. This will form part of the assessment.

You all have to take part in the Group 4 project and will receive specific details about the project nearer to the time.

Command terms

Command terms are used a lot in this course, and especially in examination questions. It is important to understand what they mean.

They are divided up into 3 'Objectives'.
Objective 1 verbs require a simple response and are worth 1 mark
Objective 2 verbs require a justified or explained response and are worth 2 marks
Objective 3 verbs require an interpreted or calculated response with explanation and are worth 3 marks.

If you learn them, they will help you to decide the **depth** of response that you give when you answer a question. These are all listed in the **appendix**.

Glossary

These words are used a lot in the course. The glossary is there to help you learn them and refer to them when answering questions, conducting research, etc. The glossary is shown in full in the appendix.

Mathematical Requirements

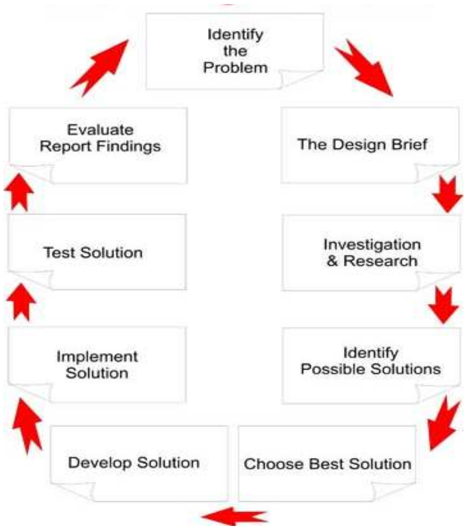
You need to be reasonably competent at Maths in this course. You will not be expected to learn equations but be able to carry out a basic range of mathematical calculations. The list in the appendix gives full details.

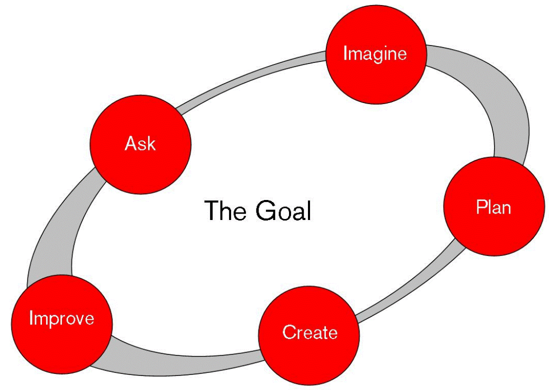
Appendix

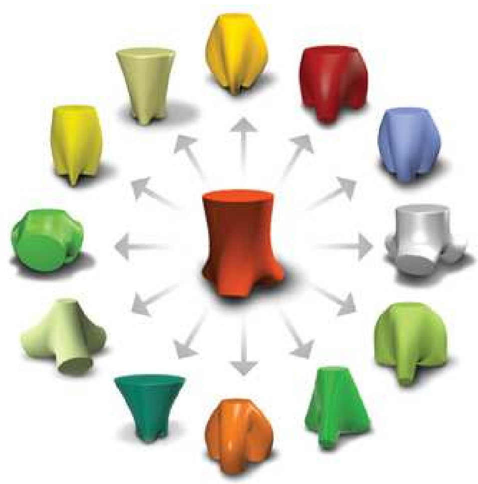
Appendix contains the Action verbs, Glossary, Mathematical Requirements and Course Map. You will find it at the back of this Coursebook.

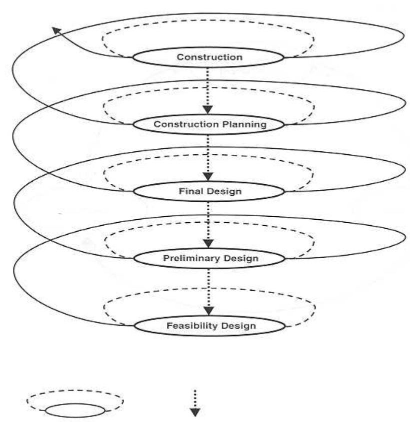
Topic 1

Design Process





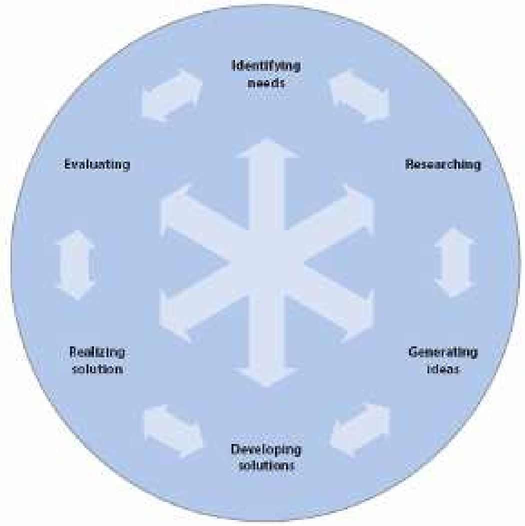




This topic introduces the design cycle model—a fundamental concept underpinning the design process and central to your understanding of design activities. Each element of the design cycle represents how designers progress through the design process to refine the design solution in increasing detail. The topic then moves on to focus on the strategies that designers use to arrive at solutions to problems and the varied nature of the skills and knowledge they need to carry out their activities successfully. The skills identified in this topic should be reflected in the internal assessment (IA) and reinforced throughout the course.

1.1 The design cycle model and the design process

1.1.1 Describe how designers use design cycle models to represent the design process
Design may be described in a variety of ways and degrees of complexity. Some design cycle models are simple and some are more complex. The design process usually consists of **successive stages** that can be arranged as a **systematic cyclical process** that eventually converges **to produce a solution to a problem**.



IB design cycle model

1.1.2 List the stages in the IB design cycle model (DCM)
The **DCM** comprises six stages, as follows:
• **identifying** or clarifying a **need** or opportunity
• analysing, **researching** and specifying requirements
• generating **ideas** and solutions
• **developing** the chosen solution
• **realizing** the chosen solution
• testing and **evaluating** the chosen solution.

1.1.3 Describe a design brief
The design brief is the formals starting point for a new design. It is a statement of the expectations of the design. The brief does not provide the design solution, but is a statement that sets out:

- the **design goal** (for example, a working prototype to be evaluated in terms of its feasibility for volume production)
- the **target market** for the product (for example, for children, disabled adults)
- the **major constraints** (for example, should comply with new legislation, have fewer working parts, be cheaper to manufacture) within which it must be achieved
- the **criteria** by which a good design proposal may be achieved (for example, increased value for money and/or cost-effectiveness for manufacturer)

Having explored the design context, students will need to formulate a brief for a project or a research question for an investigation. The **brief** or research question **needs explanation** or **justification**. A project brief will explain the nature of the intended outcome and the target market. A research question will be justified in relation to the design context. For example, a question that states that the investigation concerns testing a range of timbers to compare their properties is not as good as one that relates the question to the appropriate selection of timbers based on their properties for a floor covering, for which the criteria for selection of a suitable timber will be explained.

Task- The Design Process - What is a design brief?
The design brief is the formal starting point for the design of a new product. It is a statement of what the product is expected to do. The brief does not provide the design solution, but is a statement of the design problem.

Look at the example design briefs and for each list the design goal, the target market, the major constraints and the criteria by which a good design proposal may be achieved

The design brief	`North Face' is a company specialising in outdoor activities such as hill walking, trekking and climbing. You have been asked to design clothing suitable for these activities. The clothing must be suitable to be manufactured in quantity
The design goal	

The target market	
The major constraints	
The criteria by which a good design proposal may be achieved	

The design brief	Electronics are used extensively in the leisure industry and particularly in children's games. You have been asked to design, develop and make a prototype portable game for young children that is based on a popular movie
The design goal	
The target market	
The major constraints	
The criteria by which a good design proposal may be achieved	

The design brief	Luxury style ice cream is becoming increasingly popular as a dessert or snack. Design and make an imaginative ice cream aimed at families which can be batch produced.
The design goal	
The target market	
The major constraints	
The criteria by which a good design proposal may be achieved	

1.1.4 Describe the identifying or clarifying a need or opportunity stage of the IB design cycle model
The context of the problem is described and a concise brief stated. The design process can begin with a problem, an identified need, a market opportunity, a demand, a desire to add value to an existing product, or a response to opportunities presented by technological developments. The initial design problem is a loose collection of constraints, requirements and possibilities. From this, the designer has to make a coherent pattern. The design brief states the intended outcome and the major constraints within which it must be achieved.

1.1.5 Describe a design specification
The design specification justifies the precise **requirements of a design**. The specification will include **a full list** of the criteria against which the specification can be evaluated.

Having formulated you own brief or research question, you will select appropriate variables for an investigation or specifications for a project. **Variables** are factors that can be **measured** and/or **controlled**. **Independent variables** are those that are **manipulated**, and the result of this manipulation leads to the measurement of the dependent variable. A controlled variable is one that should be held constant so as not to obscure the effect of the independent variable on the dependent variable.

The initial design specification for a project needs to be explained in relation to the design brief, and priorities for research and development should be stated. The specifications should be justified as a list of requirements against which ideas will be evaluated and the final outcome assessed.

1.1.6 Describe the analysing, researching and specifying requirements stage of the IB design cycle model
Developing the specification from the brief is an evolving process beginning with an initial set of specifications and culminating in a final product design specification (PDS). A variety of sources for collection of suitable data should be identified and priorities made clear. Research for the project or investigation should anticipate the collection of sufficient data so that the brief or research question can be suitably addressed. Research may take many forms depending on the design context chosen.

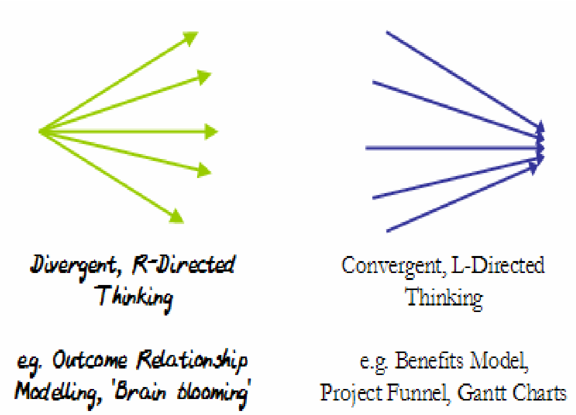
During an investigation or design project, there should be a balance between **qualitative** and **quantitative** data collection, and between **primary** and **secondary data**. Investigations may be focused on strategies for collection of one particular category of data, usually quantitative. Data may be presented in a variety of forms, for example, tables, graphs or photographs, and so on.

Issues for investigation	Primary data	Secondary data
Size of users	Measure a range of possible users	www.ergonomics4schools.co.uk Peoplesize 2000 (computer software) produced by Open Ergonomics Ltd. Pheasant, S. 1996. *Bodyspace: Anthropometry, Ergonomics and the Design of Work*. Taylor & Francis.
Materials and manufacturing methods	Photograph existing products	Norman, E, Urry, S, Cubitt, J, Whittaker, M. 2000. *Advanced Design and Technology*. Longman. Focus on plastics (computer software) produced by Focus Educational Software Ltd.

Research material will form the basis for generation of ideas. Analysis of data that has been suitably processed should relate the usefulness of the research material to the design brief or research question. Errors or uncertainties should be identified where appropriate, and the effect on the reliability of the data quantified. Students should show that they can take raw data, transform it and present it in a form suitable for analysis. IB Specification list includes **Function**, **Performance**, **Target Market Group, Cost**, and others depending on the project and the IA.

1.1.7 Describe the generating ideas and solutions stage of the IB design cycle model

Divergent thinking is used to consider ways in which a problem may be solved. The starting point for the generation of ideas should be the design specification, and proposals should be evaluated against this specification, with evidence of relevant research used to rate the ideas in terms of their usefulness. A variety of approaches should be used and different possibilities explored and analysed, before deciding on the most suitable solution.



1.1.8 Describe the developing the chosen solution stage of the IB design cycle model
A final concept is developed taking into account the conflicting needs of the manufacturer and the user, and the requirement of the design as set out in the specifications. A complete proposal is developed based upon the research and the designer's personal ideas. This stage involves detailed drawings (of a style relevant to the task).

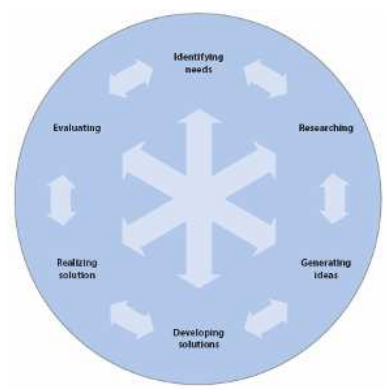
1.1.9 Describe the testing and evaluating the chosen solution stage of the IB design cycle model
The final outcome is tested and evaluated against the requirements set out in the specification. Recommendations for modifications to the design are made. A reiteration process should now begin.

The validity of **the solution** to the problem should be **evaluated** and **justified**. **Evidence** may be provided via **testing** of a designed product and expert appraisal or astute interpretation of data for an investigation, even if the conclusion appears contradictory to the accepted theories.

The **suitability of chosen strategies** at each stage of the investigation or project should be **assessed** taking into account available resources, including time. You must not only state weaknesses, but also indicate how significant the weaknesses are. For your Design Project, procedures will also relate to testing the solution in relation to the specifications stated at the planning stage and gaining user research.

Suggestions for **improvements** should be based on the weaknesses and limitations identified. Improvements may be presented in a variety of forms, such as **drawings**, a **modified design specification**, or a **new set of variables**. For investigations based on data collection, modifications should address issues of precision, accuracy and reproducibility of the results. The modifications proposed should be realistic and clearly described. It is not sufficient to state that more precise equipment should be used or more time allocated. Modifications for a designed prototype should consider changes to the design for scaling up production and to produce a design family of products.

1.1.10 Explain why the IB design cycle model is not linear and why it is iterative in practice, thus making it representative of design thought and action
The model emphasizes that designing is not a linear process. Evaluation, for example, will take place at various stages of the process, not just at the end. Similarly, ideas for possible solutions are not only generated the "generating ideas" at stage; some good ideas may develop even as early as the "identifying needs" stage. In practice, it is impossible to separate the stages of the design process as clearly as the model suggests.

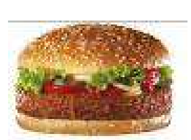
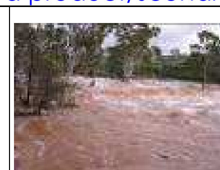


IB design cycle model

1.1.11 Explain the role of the designer in the design process
The designer's role varies depending on the complexity of the process and the intended outcome.

Task- Consider each section of the DCM listed below:
- identifying or clarifying a need or opportunity
- analysing, researching and specifying requirements
- generating ideas and solutions
- developing the chosen solution
- realizing the chosen solution
- testing and evaluating the chosen solution.

Write a short explanation about the role of the designer to a product/scenario for each part of the DCM

				
Spanner	Burger	Top hat	Flooding campsite	Toy car

1.1.12 Describe how designers interact with others and how the emphasis of the design process varies depending on the designer's role

Designers often work as members of a team.

Priorities will vary depending on the nature of the activity. For example, the information required by an architect will be different from that required by an engineer.

1.1.13 Explain why elements of the model may differ in importance according to the particular design context

Depending upon the nature of the problem, not all elements of the cycle carry the same weight in terms of time allocation and complexity. Points to consider include cost, resources, skills, time, original design specification and product modification.

Task- Answer these four questions in the space provided below

- Explain why the design cycle model is not a linear process.
- Describe the role of the designer in the design process.
- Describe how designers interact with other members of the design team. How does the emphasis of the design model vary depending on the designer's role?
- Explain why the importance of different elements of the design process may vary depending on the design context.

1.1.14 Define incremental design, radical design, convergent thinking and divergent thinking

Incremental design: small changes to the design of a product that seem trivial but the cumulative effect over a longer period can be very significant. These steps may have been influenced by changes in manufacturing technique or fashion and result in only superficial changes to the way a product looks or in how it performs.

Use this link- http://www.xtimeline.com/timeline/History-of-Mobile-Phones-Cell-Phones to see the full timeline and incremental design of the mobile phone and other product.

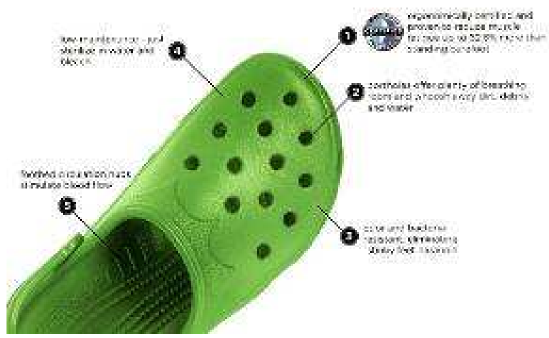
Radical design is where a completely new product is devised by going back to the roots of a problem and thinking about a solution in a different way.

Braun Products- http://www.youtube.com/watch?v=8sGnjEwazGc

Note: Design work often **combines** incremental and radical thinking. For example, the use of a new material for a product may be a radical leap forward but the product may look very similar to previous products—a tennis racquet made from carbon fibre is a radical development but the shape and form are similar to previous designs.

Radical? Guitar

Kevlar bicycle



Crocs shoes

Juicer

Task- Find a few more products and give reasons whether the product went through an incremental or radical development or is completely new and radical.

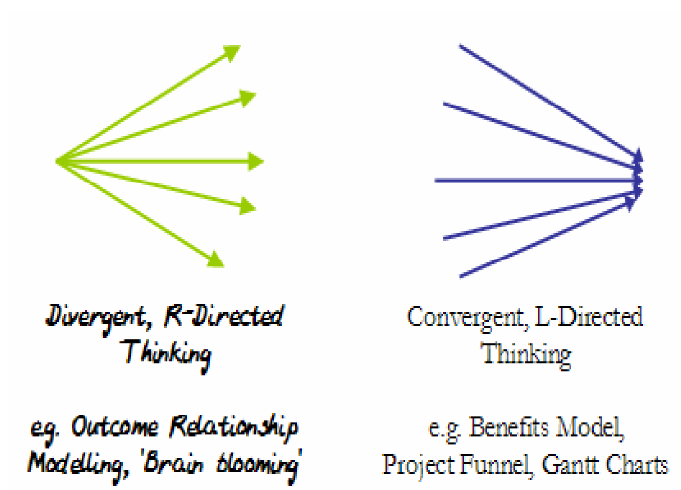
Incremental development	Radical development	Radical/new

Divergent thinking: using **creative ability** to produce a wide range of possible solutions to a problem. **Divergent thinking** is **conceptual and problem focused** e.g. used at the ideas generating phase and during development.

Convergent thinking: the ability to analyse information in order to select an answer from alternatives. **Convergent thinking** is **analytical and solution focused**, e.g. used at the research stage and during evaluation.

Note: The elements of the DCM that reflect convergent and divergent thinking.

The design process is a balance between divergent thinking and convergent thinking at different stages in the design process and in different design contexts.



Task- Watch the following video: Better by Design 04 Shopping Trolley

While you watch it, look out for key points when the designers use divergent and convergent thinking. Use the table to make notes as you watch; write down what the designers do, how they communicate and what each method achieves.

Divergent thinking:	Convergent thinking:

When the video is over, discuss your observations. Complete the following:

1. At what stages of the design process are divergent and convergent thinking likely to be used? Explain your answer.

2. What are the advantages and disadvantages of each method?

3. How successful has each process been in designing a better shopping trolley? What would you suggest needs to be done next? How would you do it?

1.1.15 Describe the relationship between incremental design and convergent thinking
As convergent thinking is analytical and solution focused it is extensively used through the research and evaluation stages of a product to develop the products feature.

1.1.16 Describe the relationship between radical design and divergent thinking
Divergent thinking enables creativity and is conceptual and problem focused.

1.1.17 Explain how elements of the design model reflect convergent and divergent thinking
Convergent thinking is analytical and solution focused, for example, during evaluation. Divergent thinking is conceptual and problem-focused, for example, used to generate ideas.

1.1.18 Explain how design work is often a combination of incremental and radical thinking
For example, the use of a new material for a product may be a radical leap forwards but the product may look very similar to previous products: a tennis racquet made from carbon fibre is a radical development, but the shape and form are similar to previous designs. Similar product that have gone through this development are skis and other sporting equipment.


Wood


Aluminium


Graphite


Carbon-Fibre/Kevlar

1.2 Generating ideas

1.2.1 Define constructive discontent
It is a **mechanical way** of generating ideas where a **detailed analysis** is made **of an existing design**.
Attribute listing identifies the key attributes of a product or process then enables designers to think of ways to change, modify or improve each attribute.
Creative designers can be dissatisfied with what exists and want to make the situation better, or designers may say, 'this is an excellent solution, but is it possible that there may be another solution that works even better or costs less'. Therefore, analysing a situation that would benefit from redesign, and working out a strategy for improving it.

For example a product that is entering the later stages of its life cycle may need to be redesigned to help lift sales. e.g. Car Design - the Mini

For years this was a very successful product and has attained the status of a design classic. However, BMW bought the mini brand and redesigned the car opening up new market opportunities.

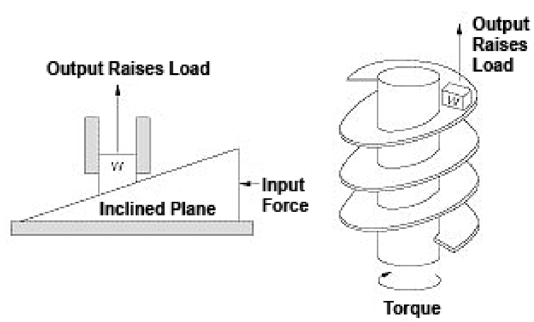
A new technology comes along that has the potential to enhance or change the way things have been done before e.g. CD technology is becoming less popular as more people get their music on-line.

1.2.2 Identify a design context where constructive discontent has been the primary generator of ideas
Designers use a wide variety of techniques and strategies to develop ideas during their designing activities. An example where constructive discontent has been the primary generator of ideas could be the car. Another example is the wheel. It is a great design but over the years it has gone from stone to pneumatic tyres!

1.2.3 Define adaptation
Adaptation - an existing technology or solution to a problem in one field is used to provide a new idea for a solution in another. The relevance of adaptation for designers; if a problem is in a new context a solution may be found by finding something similar from another context and adapting it.

1.2.4 Identify a design context where adaptation has been the primary generator of ideas

A solution to a problem in one field is used to provide a new idea for a design problem in another.
e.g. It is thought that Inclined Planes were used by the Ancient Egyptians to construct the pyramids.



Adapt this idea and the inclined plane wrapped round and round becomes a screw thread - try wrapping a right angled piece of paper around a pencil!!

1.2.5 Define analogy

The transfer of an idea from one context to another. Drawing on a similar situation for solutions, e.g. an ultrasonic focusing system for cameras was based on how bats navigate in the dark.

Camouflage kit in the military adapted from nature.

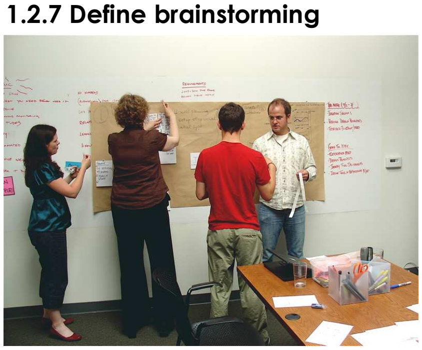
1.2.6 Identify a design context where analogy has been the primary generator of ideas

The relevance of analogies to designers; Odd, remote or strange analogies help to stimulate the mind in new ways, e.g. "cat's eyes" in the middle of the road or sonar based on communication between marine animals.

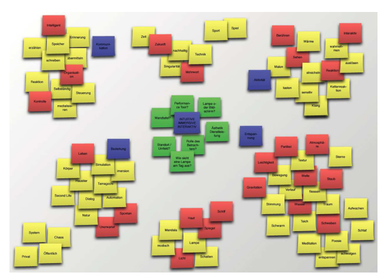
Another example is the Sea Harrier that when fully loaded had difficulties taking off on conventional aircraft carriers as their decks were too short. There was a serious operational problem. An analogy with a water ski jump was made which provided a breakthrough to the problem. Watch video http://www.youtube.com/watch?v=-kDb99ftPlY

The design idea for a laptop could have come from analogy i.e. Design a computer that resembles a book, or design a book that computes!

1.2.7 Define brainstorming



Participants use the ideas of others to spark off their own ideas and to build upon and combine ideas to produce new ones. No criticism is allowed, even of the most ridiculous ideas. Brainstorming may be amongst a group of colleagues, experts or focus groups.



1.2.8 Identify a design context where brainstorming has been the primary generator of ideas

A form of group think. A group with a recommended size of 10–12 people first devises wild ideas, all of which are written down. No criticism or evaluation is allowed until this is finished, as it is impossible to be creative and critical at the same time. The ideas are then criticized and evaluated.

Task- Find 101 uses for a paper clip! Brainstorm!

http://www.urban75.org/useless/bored.html

1.2.9 Define attribute listing
Attribute listing identifies the **key attributes of a product** or process and then enables designers to think of ways to change, modify or improve each attribute (Brainstorming).

1.2.10 Identify a design context where attribute listing has been the primary generator of ideas
Use Attribute Listing when you have a situation that can be decomposed into attributes - which itself can be a usefully creative activity. It is particularly useful with **physical objects**. You can use it elsewhere, too. Highly rational style. Suitable for people who prefer analytic approaches. Good for engineering-type situations.

Quick		X				Long
Logical	X	X				Psychological
Individual	X	X			X	Group

List attributes
For the object or thing in question, list as many attributes as you can. For example, a screwdriver has attributes of 'applies torque', 'metal shaft', etc.
It can also be useful to first **break the object down** into constituent parts and look at the attributes of each part in question. Thus you may break the screwdriver into the handle, the shaft and the tip. The tip then has attributes of 'fits screw', 'thin blade', etc.

Consider value of attributes
For each attribute, ask 'what does this give'? Seek the **real value** of each attribute. It is also possible that attributes have 'negative value' -- ie. They detract from the overall value of the object.
For example, the handle of a screwdriver being examined has attributes of 'hexagonal' which have the value of 'helps grip' and 'stops rolling on workbench', but has negative value of 'sharp corners'.

Modify attributes
Finally look for ways in which you can modify the attributes in some way. Thus you can increase value, decrease negative value or create new value. For example, you could modify the attributes of the screwdriver handle to be 'comfortable grip' by adding a rubber sleeve.

Another Example
The **attributes** of a **customer service desk** include opening hours, **friendliness** of **service** and **availability** of **literature**. You could change the opening hours to weekends (but closed during low hours during the week). Friendliness could be improved by keeping records of people asking for help and then asking them later how things went. And so on.

For your project work consider using SCUMPS analysis. This is a mechanism that is used to deconstruct the design of a product and lists its attributes or qualities.

1.2.11 Define morphological synthesis
Morphological synthesis is an elaboration of attribute listing for complex real world problems where there are many governing factors, most of which can not be expressed.

Imagine that you want to create a new lamp. The starting point for this might be to carry out a morphological analysis. Properties of a lamp might be power supply, bulb type, light intensity, size, style, finish, material, shade, and so on. You can set these out as column headings on a table, and then brainstorm variations. This table is sometimes known as a "Morphological Table".

Power Supply	Bulb Type	Light Intensity	Size	Style	Finish	Material
Battery	Halogen	Low	Very Large	Modern	Black	Metal
Mains	Bulb	Medium	Large	Antique	White	Ceramic
Solar	Daylight	High	Medium	Roman	Metallic	Concrete
Generator	Colored	Variable	Small	Art	Terracotta	Bone
Crank			Hand held	Industrial	Enamel	Glass
Gas				Ethnic	Natural	Wood
Oil/Petrol					Fabric	Stone
Flame						Plastic

Interesting combinations might be:
Solar powered/battery, medium intensity, daylight bulb - possibly used in clothes shops to allow customers to see the true color of clothes. Large hand cranked arc lights - used in developing countries, or far from a mains power supply. A ceramic oil lamp in Roman style - used in themed restaurants, resurrecting the olive oil lamps of 2000 years ago. A normal table lamp designed to be painted, wallpapered or covered in fabric so that it matches the style of a room perfectly. Some of these might be practical, novel ideas for the lighting manufacturer. Some might not. This is where the manufacturer's experience and market knowledge are important.

Key points:
Morphological Analysis, Matrix Analysis and Attribute Listing are useful techniques for making new combinations of products, services and strategies. You use the tools by identifying the attributes of the product, service or strategy you are examining. Attributes might be components, assemblies, dimensions, color, weight, style, speed of service, skills available, etc.

Use these attributes as column headings. Underneath the column headings list as many variations of that attribute as you can. You can now use the table or "morphological box", by randomly selecting one item from each column, or by selecting interesting combinations of items. This will give you ideas that you can examine for practicality.

Notes:
Attribute Listing focuses on the attributes of an object, seeing how each attribute could be improved.
Morphological Analysis uses the same basic technique, but is used to create a new product by mixing components in a new way.
Matrix Analysis focuses on businesses. It is used to generate new approaches, using attributes such as market sectors, customer needs, products, promotional methods, etc.

1.2.12 Identify a design context where morphological synthesis has been the primary generator of ideas
After completing the list of attributes, list them along two sides of a 2D grid. Think creatively about how the attributes can be developed through new ideas in each of the cells to improve the design.

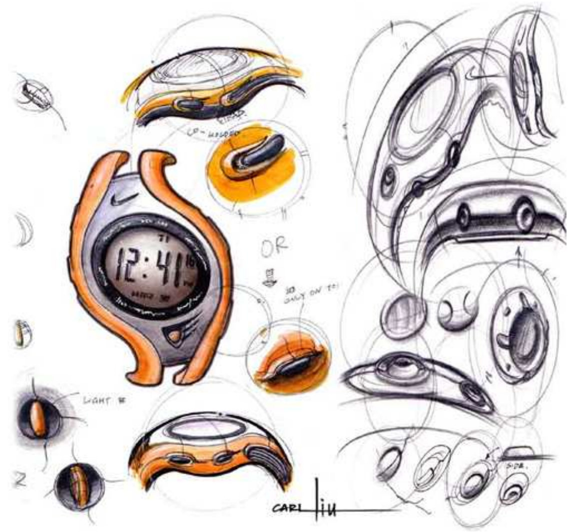
Size	Size	Colour	Uses	Material	Parts	Shape
Size			How can we reduce size but maintain functionality?		Can parts be removed to make it smaller?	What is dictating the size and shape of the product? Can this change?
Colour						
Uses		**The Next Big Idea??**				Is it shaped to allow the easiest possible use?
Materials		What other materials are available? What finishes might that provide?				**The Next Big Idea??**
Parts	**The Next Big Idea??**					
Shape				**The Next Big Idea??**		

1.2.13 Discuss why designers use a variety of techniques to develop ideas
Actual techniques selected depend upon:

- personal choice
- design context
- complexity
- time and resources available

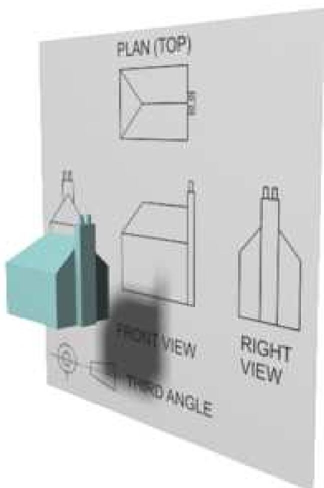
1.3 Communicating ideas

1.3.1 Define freehand drawing
The spontaneous representation of ideas on paper without the use of technical aids. Used early in the design process



1.3.2 Describe the importance of annotating freehand drawings
Annotations explain the thinking behind the visual image represented by the drawing. They allow the designer to communicate and consider the implications of the ideas for further development.

1.3.3 Explain the purpose of two- and three-dimensional (2D and 3D) freehand drawings
Designers use a range of freehand drawings in the early stages of developing ideas to explore shape and form (3D) and constructional details (2D).
Car concept drawings- http://www.youtube.com/watch?v=GXp1XcpVTpk

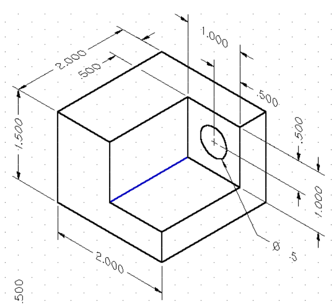


1.3.4 Define orthographic drawing
A series of flat views of an object showing it exactly as it is in shape and size.

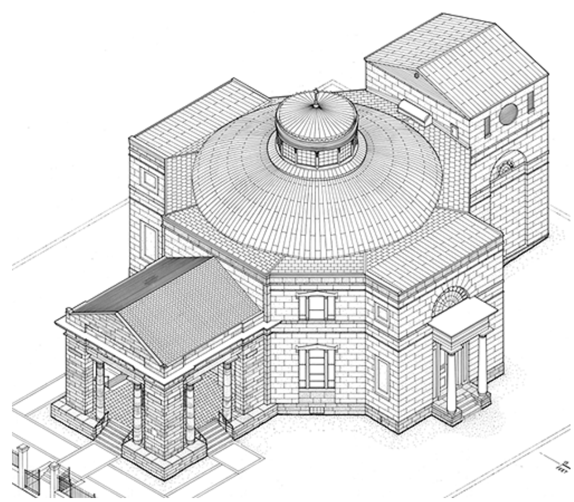
1.3.5 Explain the purpose of an orthographic drawing
An orthographic drawing shows details and dimensions and can be used as a production drawing.

1.3.6 Identify the stage of the design process where orthographic drawings are relevant
Orthographic drawings are produced at the final solution stage and are used as working drawings in the realization stage.

1.3.7 Define isometric drawing



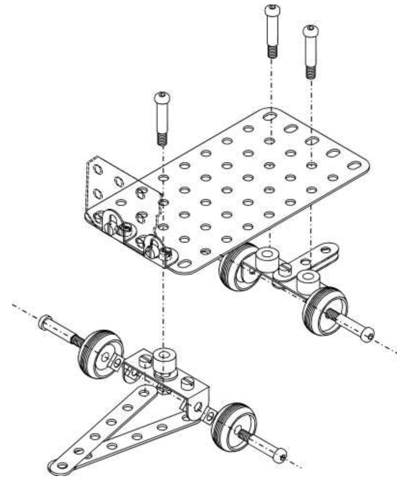
A 3D representation of an object drawn with the horizontal plane at 30° to the vertical plane.



1.3.8 Explain the purpose of an isometric drawing
An isometric drawing depicts the proposed solution in 3D showing shape and form. Isometric drawings are more formal (although when sketching it also common to try and sketch in isometric). Isometric drawings show the proposed shape and form of the idea.

Although a reasonable representation of the solution there is no sense of perspective.

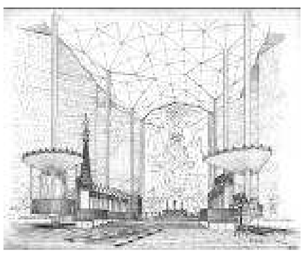
1.3.9 Define exploded isometric drawing
An isometric drawing of an object with more than one component that depicts how the parts of assemblies fit together



1.3.10 Explain the purpose of an exploded isometric drawing
The drawing is exploded to show component parts of a product and/or the sequence of assembly.
Here the drawing shows components separated along 1 axis. This helps to communicate both the component parts and the sequence by which something is assembled.

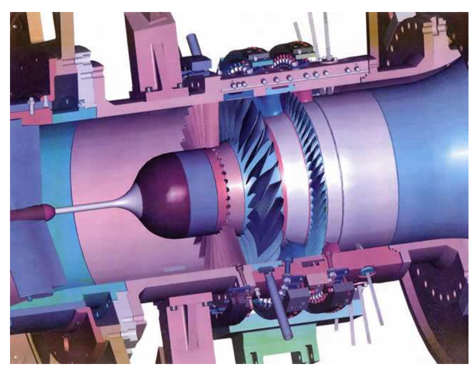
1.3.11 Define perspective drawing
A 3D drawing that realistically represents an object by utilizing foreshortening and vanishing points (usually imaginary ones).

1.3.12 Explain the purpose of perspective drawing
Compare perspective drawings with isometric drawings. Perspective drawings take into account spatial arrangements, for example, foreshortening, while isometric drawings are constructed to a set angle.



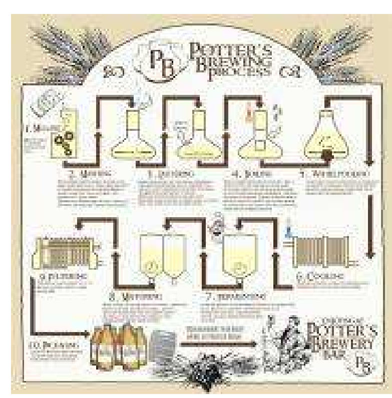

Perspective drawings produce a more visually accurate representation of an object and are often used to convey information to none technical people or to produce dramatic effects.
Perspective drawings take into account spatial arrangements, e.g. foreshortening, while isometric drawings are constructed to a set angle (60° to the horizontal) they are easier to construct but can sometimes look distorted particularly on large drawings.

1.3.13 Define computer-aided design (CAD) and computer modelling
The use of computers to aid the design process.



1.3.14 Outline two advantages and two disadvantages of using CAD instead of traditional drawing methods
Consider the skills required, storage, complexity and styles of the drawings, interfacing with other aspects of information and communication technology (ICT), time, cost and the purpose of the drawings.
These are realistic 3D models built on computer packages such as Prodesktop, Rhino and Solid Works.

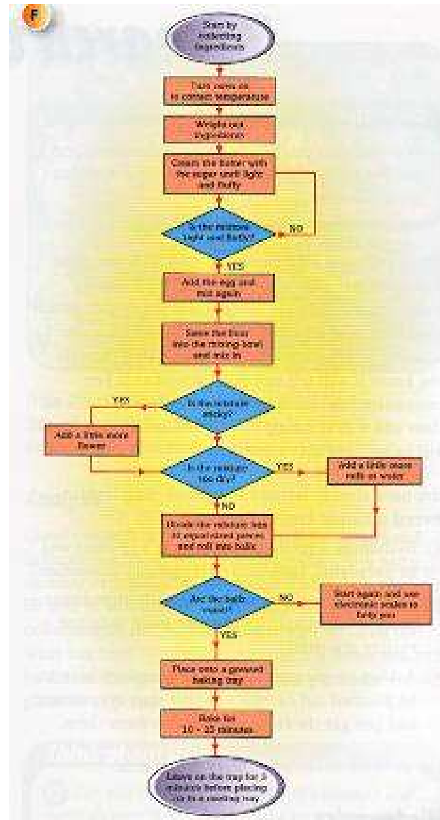
Task- What are the benefits of using CAD models over real world models?



1.3.15 Define algorithm
An algorithm is a set of instructions describing a sequence of events or actions.

1.3.16 Describe how an algorithm can be used to communicate a process
An example of using an algorithm to communicate a process is a labeled processing block diagram (PBD) sometimes refereed to as a schematic diagram may represent systems, processes and procedures.

In functional block diagrams, each block represents a specific part of the system and the arrows on the lines joining the blocks show the direction of information transfer. The name inside the block describes its function. A block diagram is a form of flowchart for a system – useful for analysing complicated electronic systems (correct sequencing is important). Another example, consider the operation of a lift. Correct sequencing is important, with input, process and feedback.



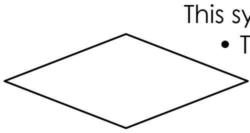
1.3.17 Define flow chart
A schematic representation of a process.

1.3.18 Draw a simple flow chart using symbols

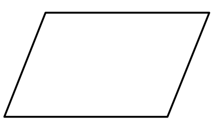
Flow charts
The symbols shown here for flow charts have been taken from BS 4058:1973 which includes all data processing symbols, computer use and management.

Start, restart, halt / interrupt, fault stop.

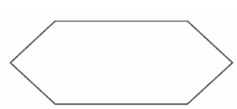
This symbol represents a general process without stating the method or equipment used. It serves the general progression without:
- Problem solving
- Extra equipment
- Introducing any changes



This symbol indicates a decision or a question and is included where there is:
- The need to test or check a process
- An alternative process
- A question arising from the flow chart



This symbol for input or output is used to show the addition or removal of fluids, materials, equipment etc



Changes, alternatives, extra preparation. This symbol normally follows a no answer from a decision point. It is also found where alterations are required Using the symbols produce a flow chart to show the sequence of tasks involved in repainting a badly weathered door.
- Burning off old paint, checking smooth surface, filling holes
- Scraping down with wire brush
- Smoothing down with glasspaper
- Priming with primer paint
- Checking that the door is dry and rubbing down to remove any unevenness
- Applying undercoat
- Leave door to dry
- Applying gloss coat

Task- Do a flow chart for making a cup of coffee.

1.3.19 Describe how a flow chart can be used to communicate a process
See diagram to the right.

1.3.20 Explain the differences between flow charts and algorithms
A flowchart is more specific and used to communicate a **process** and the **inputs**, **decisions** and **outputs** that occur during it. It communicates the whole system in detail where as an algorithm provides a quick overview/instructions. So to summarise, algorithm are codes and flowcharts are symbolic.

1.3.21 Describe models as representations of reality and representing selected features of a design.

Models are representations of reality. Crash testing can be carried out safely using different designs and materials. Dangerous procedures can be simulated safely. Hedonic aspects (personal taste or preference) can be considered.

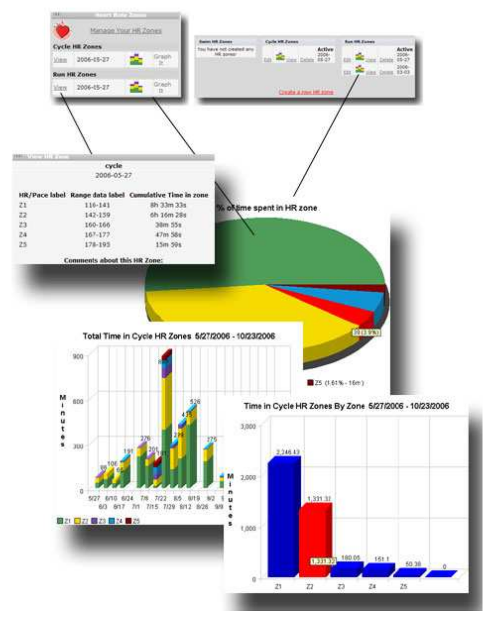
Modeling is the working through of ideas or hypothesis by using materials to construct physical models (e.g. TVR car designer), or using computers to generate mathematical, graphical or statistical models. Computer models of 3-D structures mean changes can be made that can be viewed.

These can be made for all sorts of applications and purposes.
It may be to show a proposed building design in its surroundings, or to show the form of a product for ergonomic considerations, or maybe to model a mechanism before manufacture. Models can be made out of a variety of materials. Popular choices are balsa, card, foam, clay, acrylic, fibreboard.

Task- What are some of the advantages and disadvantages of models to the designer and their clients?

1.3.22 Describe a range of physical models
Consider scale model, clay model and prototype. Refer to a range of modelling materials, for example, clay, card, foam, board, balsa and wood.

1.3.23 Explain the purpose of the various models described in 1.3.22.
A physical or iconic model looks like the intended outcome e.g. concept of a new school built to scale.



1.3.24 Define mathematical model
A mathematical or symbolic model is a 2D diagrammatic drawing or algebraic equation that can represent components or perform mathematical calculations e.g. force diagram for a bridge.
A model using mathematical symbols that can be manipulated numerically.

1.3.25 Describe the role of spreadsheet software in the development of mathematical models
Simple software can quickly calculate and present data.

1.3.26 Outline the advantages and disadvantages of graphical, physical and mathematical models
Some advantages to the designer of using physical modeling in a design context are: -
When designing a car, a model can help to establish proportions, judge people's reactions to the shape and be used for wind tunnel evaluations. It can also be used to establish the profiles for the pressing tools.

Some advantages to the designer of using mathematical modeling in a design context are: -

- Circuit design for a new radio etc. can be established using internationally recognised components and its success can be clearly evaluated because of its standard format.
- Time will be saved, as components will not have to be drawn as pictorial views.
- Computer modeling can cheaply model expensive processes such as crash testing.
- Some disadvantages of modeling are: -
- The simplicity of a model can lead to aspects being overlooked.
- The scale of a model can be misleading when the product is made larger or smaller.
- Mathematical modeling is only as good as the formula it relies on.
- Mathematical models rely on accurate data – "rubbish in rubbish out".
- Computer modeling can create delusions of infallibility.

1.3.27 Describe three advantages of using models as part of the design process

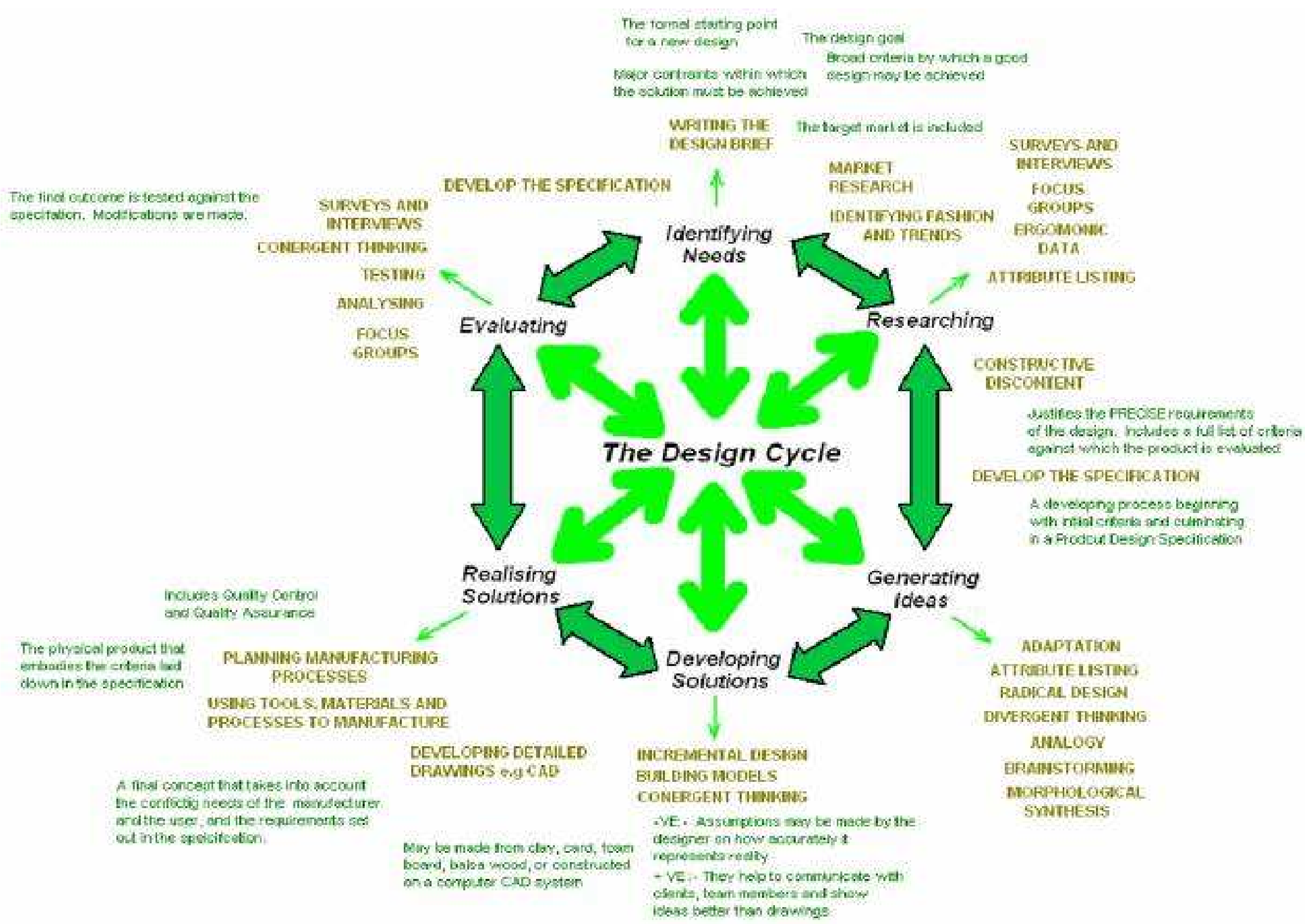
- communication with clients,
- communication with team members
- ability to manipulate ideas better than with drawings

1.3.28 Describe three limitations of the use of models in the design process

Designers can easily make assumptions about how **accurately** a model **represents reality**: it may **not work** like the final product or be made of the same **material**.

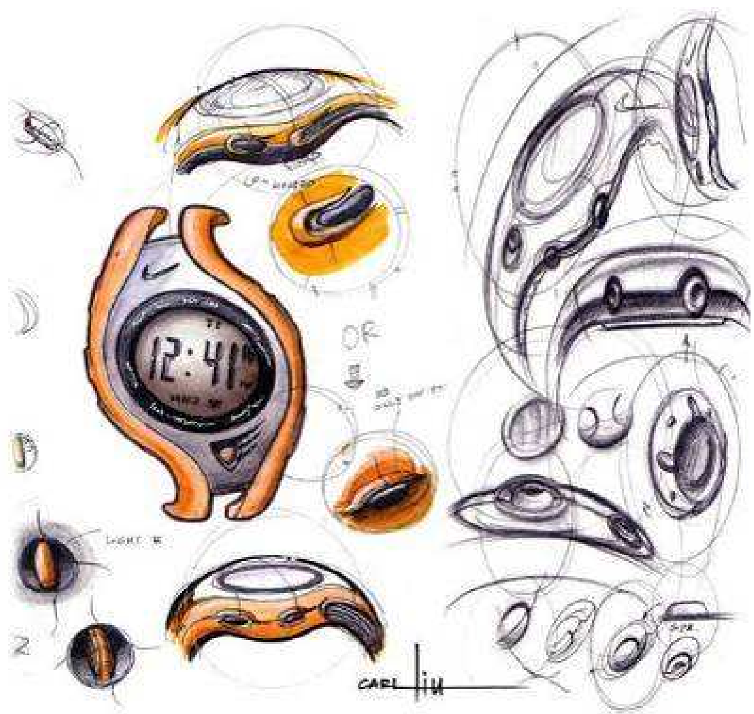
Topic 1 Language and Cognitive Scaffolds & Review

No	KEY WORD / PHRASE	Have seen/heard of it.	Can Use in a sentence	Can define	Can give a clear Example to explain	Never Heard of it!	Tick for: now I get it!
1	Design cycle model						
2	Design brief						
3	Design specification						
4	Incremental design						
5	Radical design						
6	Convergent thinking						
7	Divergent thinking						
8	Constructive discontent						
9	Adaptation						
10	Analogy						
11	Brainstorming						
12	Attribute listing						
13	Morphological synthesis						
14	Freehand drawing						
15	Orthographic drawing						
16	Isometric drawing						
17	Exploded isometric drawing						
18	Perspective drawing						
19	Computer aided design (CAD)						
20	Computer modeling						
21	Algorithm						
22	Flowchart						
23	Mathematic model						



Topic 2

Product Innovation



Innovation and the continuous development of new and improved products are key to the design process. This topic considers the relationship between the design cycle and the product cycle. It moves on to explore the role of invention in innovation and the impact of market pull and technology push on product innovation. Establishing and developing markets for products are a critical element of the product cycle.

2.1 Designers and the product cycle

2.1.1 Describe the product cycle
Designing is a part of the product cycle.
As a need is generated, a product is designed, made and sold, eventually becoming obsolete (out of use)..
This cycle is complicated as all these groups following are part of it:-

- Distributors
- Retailers
- Accountants
- Product Engineers - In CAD (computer aided design) and CAM (computer aided manufacture), the designer actually becomes part of the cycle by creating the prototype from a personal computer.

2.1.2 Discuss the role of the designer in the product cycle
Designing is part of the product cycle: as a need is generated, a product is designed, made and sold, eventually becoming obsolete. The cycle is complicated by distributors, retailers, accountants and production engineers, all of whom have an influence over the cycle. Although the designer is an integral part of the process, he or she is not necessarily in control (unlike in the design process). Computer-aided design (CAD) and computer-aided manufacture (CAM), where a prototype is produced by the designer from his or her personal computer (PC), blurs this distinction.

2.1.3 Outline the product cycle in terms of early, mature and late stages of development
In the early stages of the product cycle, many changes to the product take place until it develops to the mature stage, where it is diffused into the market, gains acceptance and sells well. In the late stage, the product begins to decline in need and therefore in sales.

Early stages of the design cycle- The product undergoes **many changes**

Identify 2 products which are in the early stage of the product cycle

Mature stages of the design cycle- No more changes, the product **gains acceptance** and **sells well**.

Identify 2 products which are in the mature stage of the product cycle

Later stages of the design cycle- Product **declines** in need and therefore in sales

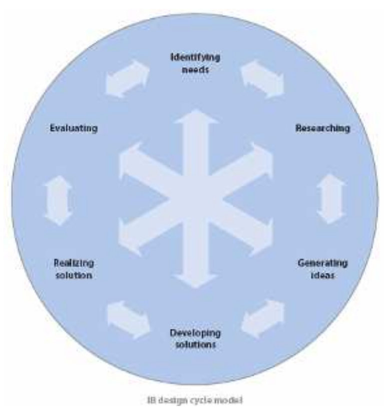
Identify 2 products which are in the mature stage of the product cycle

- The **Design Cycle** is aimed at producing a **suitable solution to a problem**.
- The **Product Cycle** is concerned with putting that solution into **commercial practice.**

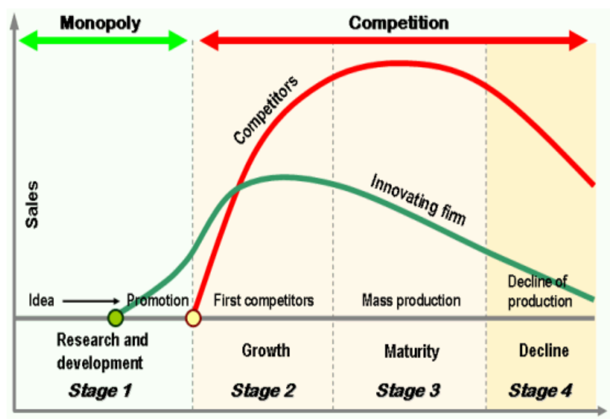
Identify why for many products the product cycle has shortened

2.1.4 Identify products that are at the early, mature and late stages of their product cycle
The ballpoint pen is in the **mature stage**, as it still sells well although the **design does not change much**. The cassette tape is in the **late stage**, as it has been **overtaken by successive generations of products**.

2.1.5 Compare the design cycle with the product cycle



Highlight how the design process is aimed at producing a suitable solution to a problem, and that the product cycle is concerned with putting that solution into commercial practice.



Design Cycle Model (DCM)

Product Cycle

2.1.6 Discuss why for many products the product cycle has shortened

Compare a laptop computer and a ballpoint pen.

Laptop computers are an **intensely competitive market**, with key issues around:

- size
- power
- materials
- weight
- function
- colour
- complexity
- style
- price

Task- Look at the products below and in small groups decide which part of the Product cycle they best suit


Vinyl LP


Blue Ray Disc


Apple I-phone


Light Bulb


Toilet Roll


Sony Mini-Disc Player

Some products don't go into decline. This is true of **mass produced food items** like bread and milk. Some branded products remain continuously popular such as Coke (although Coke products often undergo **extension strategies** – can you think of any?). Technological products tend to be the ones that do go into decline as new technology develops to replace them. This can be seen in the development of mobile 'phone technology for instance. However, some products use 'old' technology in innovative ways resulting in a new form of product. Here are some examples:

The Dyson vacuum cleaner.

The Baygen Freeplay radio

One laptop per child.

Swiss Army Knife

Task- In groups, examine each product. What 'old technology' is used? In what ways is the new product innovative? How might this product be developed in the future? What extension strategies might be used? Which scientific principles are used in the product?

Use the space below to write your suggestions.

2.2 Invention and innovation

2.2.1 Define invention and innovation

Invention- The process of discovering a principle. A technical advance in a particular field often resulting in a novel product.
Innovation- The business of putting an invention in the marketplace and making it a success.

We often like to talk about 'designers' and 'inventors' and we sometimes imagine that they work alone, thinking up new ideas for products. This is only true in a very small number of cases. Product design is very often the result of team work, not one individual person. Individuals who we might call 'inventors' or 'designers' actually do a lot more than just think of the idea. They also work hard to find innovative ways to get their products designed, manufactured and sold; the idea really is only a very small part of the process. Finally, thinking up new ideas is very hard, some would say impossible. So where do 'designers' and 'inventors' get their ideas from? To find out, we will have a look at some important pieces of product design.

Useful websites: http://inventors.about.com/

Task- In groups of two, see if you can find out what things were 'invented' by the following people:

Inventors:

Thomas Adams
Charles Babbage
John Logie-Baird
Alexander Graham Bell
Tim Berners-Lee
Edward Binney
Dr. Jacques Edwin Branden
Willis Carrier
Martin Cooper

Who or how were the following products invented?

Sinclair C5
Tetrapak
Sony Walkman
CD
Electric battery
Cling film
The sandwich
The microchip
Paper clips
The zip.

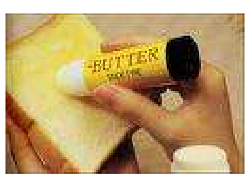
Have a look at the following page: The fifty greatest gadgets of the last 50 years.

Task- What features do these gadgets have in common?
What are their differences?
Why were they successful?

…and just for fun……

Have a look at these inventions:

http://www.chindogu.com/



Hopefully, you have begun to see that products do not all get 'invented' in the same way. Some don't have a known inventor, but evolve over time. Chopsticks are a good example of this. Others most definitely are the result of an innovative idea which then has to be made into reality using the skills of others like manufacturers, retailers and distributors.

The 'Chindogu' approach to invention is interesting. Even though the idea may seem ridiculous at present, future opinion and technological possibilities may change and what seems impossible or ridiculous now could be an acceptable product in the future.

2.2.2 Outline the stages of innovation

- Developing an idea into a viable product
- its production
- marketing and sales
- followed by redesign
- and the cycle or spiral continues.

Task- We can see that there is no single answer to the way products are designed, invented and developed. Let's add in some further detail based on what we know. Where would you add in the following terms? At what stages in the product cycle could these things have an effect?

Need is generated	**Product is designed**	**Product is made**	**Product is sold**
Product demand declines	**Product becomes obsolete (out of date/no longer useful)**	**Production engineers**	
Distributors	**Retailers**	**Accountants**	**Designers**
CAD	**CAM**	**Prototype**	

2.2.3 Discuss the importance of science to invention and innovation

Science and scientific understanding explains how the world is. Without this, the technology used in the product cannot be exploited. For example, the free-play radio uses a scientific principal to store and convert kinetic energy into electrical energy using a generator (or motor in reverse). Dyson also used a scientific understanding of centrifuges to develop his vacuum cleaner. It is important to remember that they did not invent this science. It already existed. They understood it and applied it to new contexts. This is sometimes called Transfer Technology.
http://www.bbc.co.uk/worldservice/people/features/mycentury/science.shtml

2.2.4 Discuss the importance of technology to invention and innovation

This is the application of science in order to make functional products. It is Technology that uncovers new possibilities for products. Technology also provides new materials, manufacturing techniques and process from which innovations can develop.

2.2.5 Explain why the majority of inventions fail to become innovations

This is dependant on the product and how it progresses through its product cycle. The majority of failures are from poor marketability, financial support, marketing, the need for the invention, price, resistance to change, and aversion to taking risks.

2.2.6 Explain the relevance of design to innovation

For continued innovations (re-innovation), products and processes are constantly updated (redesigned) to make them more commercially viable and to give consumers choice and improved products.
The mobile telephone is a good example of this as the product has become smaller and more complex.

2.2.7 Define dominant design, diffusion into the marketplace, market pull and technology push

- **Dominant designs** are products that meet manufacturers' and users' needs very well indeed and therefore, there is no need to change them. The design contains those implicit features of a product that are recognized as essential by a majority of manufacturers and purchasers.
- **Diffusion into the marketplace**- The wide acceptance (and sale) of a product.
- **Market pull**- The initial impetus for the development of a new product is generated by a demand from the market.
- **Technology push**-Where the impetus for a new design emanates from a technological development.

Task- Using the four areas described above- consider a product that is best suited to each heading

2.2.8 Describe a design context where dominant design is relevant

They tend to be products that we consume in large amount like the Tetrapak food carton, Coca Cola bottle, pencil sharpener, paper clip. However, occasionally, a dominant design is the result of innovation like the iPod, ballpoint pen ('Biro'), Coca-cola bottle or the Dyson vacuum cleaner.

Task- Make a list of products which are in your view dominant designs:

2.2.9 Explain the difficulties of getting a product to diffuse into the marketplace

Local, national and global competition can create problems of getting novel products to market include product launches and marketing. Market 'pull' and Technology 'push' – usually both are responsible for a successful product.

A good current example is the competition between mobile' phone manufacturers and service providers. Product launches and marketing- Consumers need to know that the product exists and where it can be purchased. If the target market does not have access to forms of advertising like the internet, billboards, TV, newspapers and magazines, they will be unaware of the product's existence. To make a big impact, a company may use a 'product launch' as a strategy to generate interest. This may be a high profile event like a film premiere. This generates interest in the product, especially if it is endorsed by celebrities. This in turn helps to get the product into the media through news channels and magazines. This strategy is used very effectively by games console manufacturers (Sony, Nintendo) when a new game is launched.

A final problem is that consumer tastes vary globally. You can see this with Trevor Bayliss' wind-up radio. Consumers in the West and Asia want products that are miniaturised to suit their lifestyle. However, the intended target group (African nationals) demand radios which are larger.

Food exemplifies this better than any other product. We are all attracted to and repulsed by different food products, sometimes due to personal taste, sometimes due to ethical and religious reasons. We like and dislike different flavours, textures, sights and smells. Coca-cola is one of the few food products that has broken through this cultural barrier to become the most globally recognised product in existence.

2.2.10 Explain why it is difficult to determine whether market pull or technology push is the impetus for the design of new products

Push and pull are present in most successful innovations. The explanation should apply only to the origin of the idea or where the idea seems to have been generated.

A Technology-push occurs, when internal development comes up with a patent or a technological device, which has a high novelty character for the enterprise in the absence of any specific need that customers may have. Often, such a break-through innovation is even unknown to the entire industry.

In technology push situations, innovations are created and then appropriate applications or user populations are sought that fit the innovation.

Did the market ask "please give me an ipod with download store" or a camera phone, most likely not. So this would be a **technology push,** when the market asks for better safety features in a car then this would be **market pull**. Technology advances often occur some time before the market knows about them so when the new products with the new tech hits the market the line between market pull vs technology push is blurred.

2.2.11 Define lone inventor
A lone inventor is an individual working outside or inside an organization who is committed to the invention of a novel product and often becomes isolated because he or she is engrossed with ideas that imply change and are resisted by others. Watch this quick video on the supersoaker developed by a NASA Engineer! http://www.youtube.com/watch?v=HpvEF_Glhmw

Task- Give a summary of these 2 projects below

- Trevor Bayliss and the clockwork radio

- '1 Laptop per child' project

2.2.12 Discuss why it is becoming increasingly difficult to be a successful lone inventor.
Most products are now extremely **complex** and **rely on expertise** from **various disciplines**.
Most designs are developed by multidisciplinary teams.

2.2.13 Explain why lone inventors often find it difficult to work in the design departments of large companies
This is exactly how Trevor Bayliss and James Dyson worked. It describes a person who is obsessed with the development of their product and who is convinced of its market potential. The innovation may be so advanced that it does not gain initial acceptance by others. This makes it very hard for the lone inventor to work as part of a team. They may be described as 'dogmatic' which means inflexible and determined to do things their own way. It is interesting to think that as we face the need to combat climate change by consuming less materials and less energy, both products are now looked upon very favourably.
Task- Can you explain why?

2.2.14 Define product champion
An influential individual who believes in the value of a product and works with teams in order to make that product successful. There are product champions behind every successful product.
Could you name the product champions behind the Apple I-Mac, the Dyson Vacuum cleaner or the Bayliss wind-up radio? They are the unsung heroes of successful design. Product champions need a range of qualities that far outstrips the qualities of the lone inventor.

You can see a big difference between the lone inventor and the product champion. The lone inventor is totally focused on the making their idea work.
The product champion is a project manager dealing with complex and variable needs. Their job is to bring together all of these variables to produce a well-marketed and sold product.
Task- Give a summary of James Dyson's Cyclone Vacuum Cleaner and how he could be classed as a product champion.

2.2.15 Compare the lone inventor with the product champion
The lone inventor may lack the business acumen to push the invention through to innovation. The product champion is often a forceful personality with much influence in a company. He or she is more astute at being able to push the idea forward through the various business channels and is often able to consider the merits of the invention more objectively.

2.2.16 Explain why innovators may have difficulty in obtaining financial support for an invention.
Most people with money to invest will be inclined to wait until it is clearer whether an invention is going to be successful before investing: the problem is to get them to take the risk.

2.3 People and markets

2.3.1 Define technophile, technocautious and technophobe
People **react** to technology in **different** ways. Here are three words that describe these variations:

- Technophile: Someone who immediately welcomes a technological change
- Technocautious: someone who needs convincing before embracing technological change
- Technophobe: Someone who resists all technological change

Which of these three words would you use to describe the following people?
Yourself:
Your friends:
Your parents/guardians:
Your grandparents:

2.3.2 Explain how people can be broadly classified according to their reactions to technological change.
People's reactions to technological change vary depending on their values and personal circumstances.

First-order effects and **second-order effects** should be taken into account, for example, personal gain in owning a car versus social and environmental considerations.

Imagine that you have been given a large sum of money and you wish to buy your first car. You are very keen but your parents less so and your grandparents are positively against it. Why is this? It is to do with our awareness of first and second order effects:
A first-order effect is the one which is felt immediately. If you buy a car, you feel the effects of personal gain, your **status and independence** have **improved**.

For your parents, **the second-order effects** are more apparent but not immediate to you the consumer: The cost of running the car, the risk of an accident, the difficulties in providing insurance. Your parents are able to consider second order effects because they **have experienced them themselves**. We all have to take account of second order effects more than ever due to the impact of technology on climate change. Buying a car adds to the congestion problem, contributes to air pollution and uses precious fossil fuels. We all have a responsibility to think beyond the first order considerations if we are acting as a designer or a consumer.

2.3.3 Define corporate strategy
This is simply the ways in which a company or organisation **decides how to meet its aims**. There may well be a product champion at the heart of this process. There are several forms of corporate strategies.

2.3.4 Describe the corporate strategy referred to as "pioneering"
Pioneering means **being ahead of the competitors** by introducing a new product first. It is the **most risky** (costly) strategy but one with the potential for the largest gains. A pioneering company requires a **strong research and development** (R&D) capability, which is expensive and needs to be financially secure and requires product champions to push new ideas. Consider the Sony or Apple companies and their various pioneering developments. Good market research can offset some risk, but is problematic for novel products.
Task- Identify 1 product which will have followed this strategy. Use http://www.xtimeline.com as a reference source,

2.3.5 Describe the corporate strategy referred to as "imitative"
The imitative strategy aims to develop a product similar to the "pioneered" product as quickly as possible. It takes advantage of R&D invested by others, and is less risky, but is based on a strong development capability.

2.3.6 Explain the benefits for a company of using a hybrid strategy
Companies that use a mixture of imitative and innovative strategies in order to maximize profit and sales and results in a quick turn around, and the benefits are there will be less disruption within the company should something go wrong...such as the counter-fit trade.

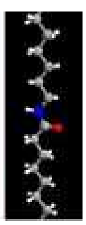
2.3.7 Define market penetration
Market penetration means increasing sales to existing customers or finding new customers for existing products.

2.3.8 Describe a strategy that a company would use to enhance market penetration
Product promotion through marketing-

2.3.9 Define market development
The strategy of market penetration might also use market development which means finding new applications for existing products, thereby opening up new markets. http://www.victorinox.ch/

Each part of the Swiss Army Knife or 'Multitool' is an existing piece of technology (scissors, saws, knife, tweezers, pliers, etc.)
Each element is re-packaged in a new form which appeals to a new market.
Task: List the various user groups that Victorinox (the manufacturer) is aiming to attract with its products

2.3.10 Describe how a company would undertake market development
The identification of new markets for products, for example, nylon was originally developed for parachutes.



Task- Find out about the market development of plastic Nylon and for what purpose was it originally developed? What other applications is Nylon used for now?

2.3.11 Define product development
Which is defined as the creation of **new, modified** or **updated** products aimed mainly at companies existing customers.

2.3.12 Describe one example of how a company undertakes product development.
For example is using blogs which examine the marketing strategies of leading companies such as Microsoft and compares them with Apple. This way the company can view the areas the product can be improved.

Adding variations to a product to develop a range of products building on an established brand, for example, ice cream, snack food products, chocolate products.

Task- See how many variations of the Kit Kat bar you can find? Which elements have been changed and which have stayed the same?

2.3.13 Define diversification

This involves a company both in the **development** of **new products** and in **selling** those products to **new companies.**

2.3.14 Describe one example of diversification

A manufacturer or business can **increase its market share** by considering diversification. Growth by creating new products or services to sell to existing or new customer bases is inherently risky, but handled well it can transform a business. By understand the risks diversification could be the biggest driver to growth and profitability. Mishandled, it could damage the productivity and relationships with existing customers.

An example of diversification is when a company manufacturing three-pin electrical plugs may consider producing them in a range of colours or from materials of different textures and/or material properties.

Task- Using a few samples of three pin plugs. The function of each plug is identical but their forms are different. List the ways in which the plug has been diversified and give a reason why this diversification has been made:

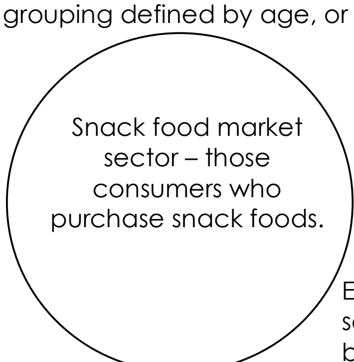
Diversification:	**Reason:**
(Example) Reduced volume	Less space taken up
(Example) Red colour	Can match colour of interior or product.

2.3.15 Define market sector and market segmentation

A broad way of categorizing the kinds of markets the company is aiming for.

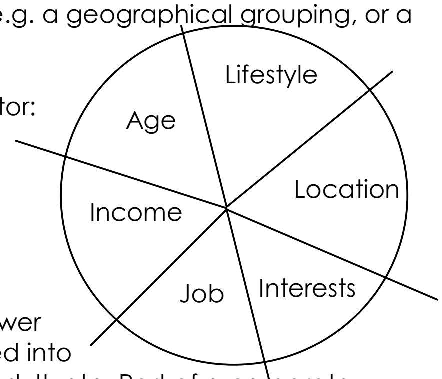
2.3.16 Outline two ways in which markets may be segmented

A part of the market that can be described, categorised and then targeted according to its own criteria and characteristics; sectors are often described as 'vertical', meaning an industry type, or 'horizontal', meaning some other grouping that spans a number of vertical sectors, e.g. a geographical grouping, or a grouping defined by age, or size, income, lifestyle, and so on.



Here is a visual example of a Market sector:

This market sector can be segmented into groups of consumers with similar characteristics



Each sector can be broken down into narrower sectors. For example; age may be subdivided into baby, toddler, pre-school, junior, teenage, adult, etc. Part of a corporate strategy may be to target a general sector such as those with a similar income or lifestyle, or a very specific sector, such a particular age group.

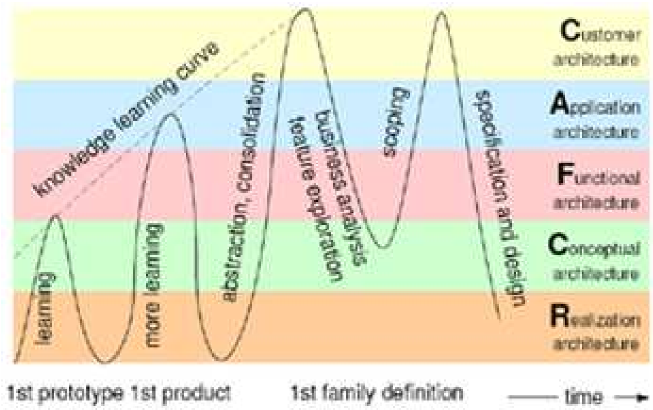
http://www.businessstudiesonline.co.uk/AsA2BusinessStudies/TheoryNotes/2874/PDF%20Non%20Print/02%20Market%20Planning.pdf

2.3.17 Define robust design and product family

- Robust design is a flexible approach that can be adapted to changing technical and market requirements. Design of a product so that its functionality varies minimally despite of disturbing factor influences.
- Product family can be a group of products having common classification criteria. Members normally have many common parts and assemblies. The set of products which have been derived from a common product platform.

2.3.18 Discuss an example of a robust design that evolved into a product family

An example of the application of robust design capabilities is Honda's success to be **adaptable** and to focus on leadership in the technology of internal combustion engines. For example, the high power-to-weight ratio engines Honda produced for its racing bikes provided technology and expertise which was transferable into mopeds. These values are consolidated into a core subassembly common across a product family.



HONDA
The Power of Dreams

http://www.youtube.com/watch?v=rYabfifhEPE

Task- Select a product which in your view is an example of a robust design that evolved into a product family

Test Yourself- Decide which of the following examples match the different markets above?

Different Markets	**Example**
Market Penetration	
Market Development	
Product Development	
Diversification	
Market sector/segmentation	
Robust Design	
Product Family	

- Marketing campaign to a different target group
- Developing a new colour range of the same product
- A low fat version of the same food product
- Using nylon for clothing rather than for parachutes which was what it was originally developed for
- Income; age; sex; lifestyle
- Products containing common parts and assemblies
- Flexible designs which can be changed

No	KEY WORD / PHRASE	Have seen/ heard of it.	Can Use in a sentence	Can define	Can give a clear Example to explain	Never Heard of it!	Tick for: now I get it!
1	Product Cycle						
2	Early product cycle						
3	Late product cycle						
4	Mature product cycle						
5	Invention						
6	Innovation						
7	Dominant design						
8	Diffusion into the market place						
9	Market pull						
10	Market push						
11	Lone inventor						
12	Product champion						
13	Market push						
14	Lone inventor						
15	Product champion						
16	Technophile						
17	Technophobe						
18	Technocautious						
19	Corporate strategy						
20	Pioneering strategy						
21	Imitative strategy						
22	Hybrid strategy						
23	Market penetration						
24	Market development						
25	Product development						
26	Diversification						
27	Market sectors						
28	Robust design						
29	Product family						

Topic 3

Green Design

This topic explores the impact of manufacturing processes and products on the environment. Clean technologies have emerged as a result of greater pressure for environmental protection and are supported by legislative frameworks.

Green products are designed using green design principles and adopt a 'cradle to the grave' approach to product design.

Strategies for green design include designing products so that they can be repaired, reused or recycled. Life cycle analysis offers a framework for evaluating the environmental impact of a product at all stages of its life cycle.

3.1 Principles of Green

3.1.1 Define green design, renewable resources and non-renewable resources.

Define Green Design

Designing in a way that takes account of the environmental impact of the product throughout its life.

Greening the federal government video from PBS and Autodesk

There are many examples of this, such as:

- To choose non-toxic, sustainable-produced or recycled materials which don't need as much energy to process
- To manufacture and produce products using less energy
- To produce products that are long lasting and better functioning so there is less replacement and use of products
- Design products using the concept of being able to recycle it when its use is done

http://www.youtube.com/watch?v=btePjTYkiKs

Define Non-renewable Resources

A natural resource that cannot be re-made or re-grown as it does not naturally re-form at a rate that makes its use sustainable, for example, coal, petroleum and natural gas.

These resources are:

- Natural Gas
- Petroleum
- Coal
- Gasohol
- Nuclear Energy
- Fossil Fuels

These resources are very useful and they are sources of energy. Of course this energy is needed to manufacture products. The bad aspect about this is that these resources are running out and the human dependency on them is very high. This is very bad because when they run out it will be a big problem in society.

Define Renewable Resources

Resources that are naturally replenished in a short time.

A natural resource qualifies as a renewable resource if it is replenished by natural processes at a rate almost the same as its rate of consumption by humans or other users. Renewable resources may also include things such as wood, paper, and leather. Wind is a renewable resources which is it is good to use wind for power.

3.1.2 Outline the reasons for green design.

Consider **consumer pressure** and **legislation**.

Green Design involves considering the effects of products might have on the environment at all stages of its life from design, through manufacture and use to ultimately disposal. In developing the product brief, formulating the product design specification and choosing the material and manufacturing process, the potential environmental impact of the product is assessed with the specific objective of reducing this impact and minimizing it over the longer term.

Consumer pressure
The public have become aware of environmental issues through media focus on issues such as the destructive effect of chlorofluorocarbons on the ozone layer; acid rain in Northern European forests and the nuclear accident at Chernobyl. Increased public awareness has put pressure on corporations and governments through purchasing power and voting power.

CFCs were the ideal and highly effective refrigerants during their time. They were nonflammable, non-corrosive, nontoxic, and odorless, compared to the toxic and flammable substances used before, such as sulfur dioxide and ammonia used in refrigeration units and air conditioners. Widely used consumer products during the 1970s and 1980s that contained CFCs, such as refrigerators, cleansing products, and propellants, were found to be very destructive to the Ozone layer. So in 1987, an international treaty: the Montreal Protocol, called for reducing CFC use by 50% by 2000. So what the companies did was replace the CFCs with HCFCs, which were considerably less damaging to the Ozone. HCFCs added Hydrogen to the Chlorine- and Fluorine Carbon compounds. But since it still contained chlorine, it was still damaging to the Ozone. By 2020, HCFCs are also to be phased out by this Montreal Protocol. HFCs are organic compounds that contain hydrogen, carbon and fluorine. HFC are suitable replacements of CFCs because there is no evidence of a potential hazard to the Ozone Layer.

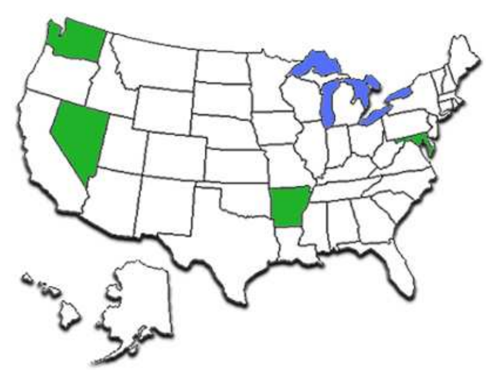
Legislation
Raised awareness of environmental issues is increasing legislation in many countries. This can lead to financial penalties on companies who do not demonstrate environmental responsibility. Many people will not behave responsibly unless forced to do so—legislation forces the issue.

One problem in relation to the recycling of plastics is knowing what the plastic actually is. Labelling plastic products with the plastic type can help overcome this issue.

CFCs, or chlorofluorocarbons, are harmful greenhouse gases that erode the ozone layer, allowing UV rays to be absorbed and trapped into the Earth and causing global warming. CFCs could be found in Styrofoam, air conditioning coolants, and aerosol cans.
In response, McDonald chains in several MEDCs (more economically developed countries) were banned from using Styrofoam containers that contained CFCs and were forced to find alternatives to their old packaging. CFCs were also banned in aerosol cans, to the point where in 2002, CFC aerosol cans were sold for low prices on the black market and smuggled into Miami, Florida from places like Russia and India.

CFCs in that year were the second most imported illegal product after cocaine.

Green/High-Performance Building Legislation in the States
The following map displays states with legislation mandating the use of green/high-performance building standards for new state-funded building projects and renovations.
Green = States that have passed green/high-performance building legislation
White = States that have not passed green/high-performance building legislation



Activity 1: Choose one of the environmental issues above and write a small synopsis. Include a description of the problem and how is it being dealt with.

3.1.3 List design objectives for green products.

Objectives include:

- increasing efficiency in the use of materials, energy and other resources
- minimizing damage or pollution from the chosen materials
- reducing to a minimum any long-term harm caused by use of the product
- ensuring that the planned life of the product is most appropriate in environmental terms and that the product functions efficiently for its full life
- taking full account of the effects of the end disposal of the product
- ensuring that the packaging and instructions encourage efficient and environmentally friendly use
- minimizing nuisances such as noise or smell
- analysing and minimizing potential safety hazards.

Task- Describe why a particular green product of your choice is green using the above objectives as a guide.

3.1.4 Discuss the impact of "take back" legislation on designers and manufacturers of cars, refrigerators and washing machines.

Take back legislation is the legislation that holds manufacturers responsible for the environmentally safe recycling or disposal of their end-of-life products. They are expected to provide a financial and/or physical plan to ensure that such products are collected and processed.

In Maine in the U.S.A., Car manufacturers have back legislation in the sense that they have to pay the collection and recycling of mercury switches from old cars.

In March 2003 the UK government issued a legislation requiring that all car manufacturer's and vehicle importers of new cars into the United Kingdom take back vehicles from their previous owner and guarantee that they are treated environmentally friendly.

In Sweden, Producers and importers must take back for free a piece of old equipment (all electrical household appliance) when the customer buys a new product.

In Norway, Producers and importers are responsible for collection, transportation, recycling and safe disposal of any electrical appliance.

In Japan, the end users are obliged to pay fees for collection, take-back and recycling at the time of disposal. The government sets the fees to cover industry's actual costs for take-back, transportation, and recycling. They are (in U.S. dollars): washing machine, $24; air conditioner, $35; refrigerator, $46; and television, $27.

Any kind of take back legislation has great impact on both designers and manufacturers because, while designing and manufacturing, they have to be aware of these laws and their contents. For instance, if a product has to be taken back and recycled by the manufacturers, it would be most advantageous for them to be readily disassembled. Special care has to be taken with the choice of materials, costs, parts in order to optimize the collection and recycling.

Impact on the designer:
Cars, it would be advantageous to conceive a car model of which certain parts can be used over again, for example the glass, the seats, the board computer etc. The designer should also make sure to be aware of all costs involved because recycling and recollecting requires money. Therefore, the materials shouldn't be too expensive so that they cam be sold at a price in which recycling costs in a way should be included in order to minimalize the costs.

Refrigerators, one should be aware of the size of the appliance because recycling is paid per cubic meter, so the smaller the design the less recycling costs involved. In order not to make customers refuse a purchase based on the lack of capacity of the appliance, the designer should reduce the size of the engine, reservoir, cables etc, in order not to deprive the appliance of storage space. Also, the type of material should be cost effective and easy to recycle in order to re use as many parts as possible in the manufacturing of other appliances.

Washing machines, special care again has to be taken in order to keep the appliance as small as possible so the manufacturer's recycle costs can be limited. However, it should not deprive the washing machine of its capacity but should reduce the size of its motors, cables, and other parts. Also maybe it could be designed in such a way that certain parts could be used again by the manufacturer, eg. The rotator or door. As previously discussed, the designer should also do his best to use easy renewable and re usable materials to make it lucrative for his employer, the manufacturer.

Impact on the Manufacturer:
Cars, cost is an important issue. As ecologically friendly resources are becoming more popular, prices have lowered to become more affordable. Research into the actual manufacturing process should also take place: with the correct process the cost and efficiency of the product's production. This way, more money can be spent to better the product's ecological impact on the environment.

Refrigerators, insulation and heating should be taken into consideration. As a refrigerator becomes better insulated, the required electricity in order to lower the temperature inside lowers drastically. Manufacturers as well as designers should work closely together to ensure that the materials that are used in the product are properly assembled.

Washing machines, steps should be taken to ensure that the manufacturing process is efficient in which resources are used. Materials should be used which can be reused or completely recyclable. Not only would this allow the manufacturer's to save money by re-using previous materials, it would help the environment by reducing the amount of waste created during the manufacturing process.

3.1.5 Explain how people can be broadly classified according to their attitudes to green issues.
People's attitudes to green issues vary

Eco-warriors actively demonstrate on environmental issues. Eco-warriors protest anything that is damaging to the environment (such as animal cruelty and pollution). Greenpeace is an environmental organization that actively supports those protests and usually organize or join them. Examples of protests are members chaining themselves to trees and throwing red paint on fur coats.

Eco-champions champion environmental issues within organizations. The Eco Champion will lead a Taskforce', a team of councilors from all parties, and the local community to listen to ideas and work together to tackle these problems. The group will look into areas such as what we consume, what energy we produce and use up, how we get around and how we can reduce and dispose of our waste.

http://www.cf.ac.uk/news/articles/ecochampions-already-cutting-carbon.html

Eco-fans enthusiastically adopt environmentally friendly practices as consumers. An Eco-fan is someone who accepts all new technological advancements for green design on the current market. An eco-fan will buy almost anything that is environmentally friendly and will never buy a harmful product. Products include, dolphin friendly tuna, aerosol spray cans that so not contain CFC propellants, cosmetics that have not been tested on animals, products packaged in environmentally friendly materials (reusable/recyclable).

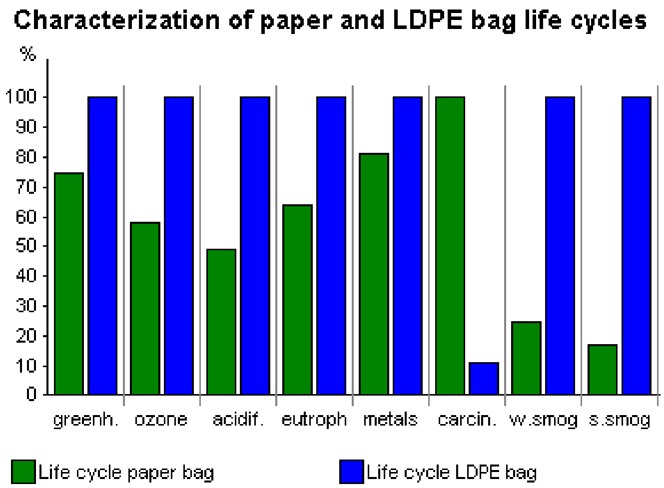
Eco-phobes actively resent talk of environmental protection –Eco-phobes are people who are against helping the environment and purposely go against the ecological movements. They believe that the environmental problems are irrelevant to their lives, and some even believe that it is a scam. If you told an eco-phobe about environmental problems such as global warming, he would probably respond by saying "Is the earth warming? Oh, you betcha. Is Mars warming? Yup. Jupiter? Uh-huh. Will this freeze-thaw cycle continue happening into whatever "eternity" there may be? I'd have to say so." There are many theories that eco-phobes believe are true against helping the environment, but many of these theories are skeptical and are suspicious of many people. Some suggest that an example of an eco-phobe is George Bush, who refused to sign the Kyoto agreement which is based on controlling the c02 output in a country to a limit in order to decrease global warming.

Google Video here
http://www.youtube.com/watch?v=qMPOrvHiRyo
http://www.youtube.com/watch?v=ov6GPTB4Tio
http://www.ruthtrumpold.id.au/designtech/pmwiki.php?n=Main.PrinciplesOfGreen

3.2 Life Cycle Analysis

3.2.1 Life Cycle Analysis definition: The assessment of the effect a product has on the environment from the initial concept to disposal (IBO 2001).

This graph compares a life cycle paper bag to a LDPE (or polyethylene) bag. The impacts mentioned in the graph are: greenhouse effect, ozone depletion, acidification, eutrophication (increase in chemicals), heavy metals, carcinogen, winter smog, and summer smog. The graph shows (for example) that a paper bags greenhouse impact is only about 75% of that of a polyethylene bag.

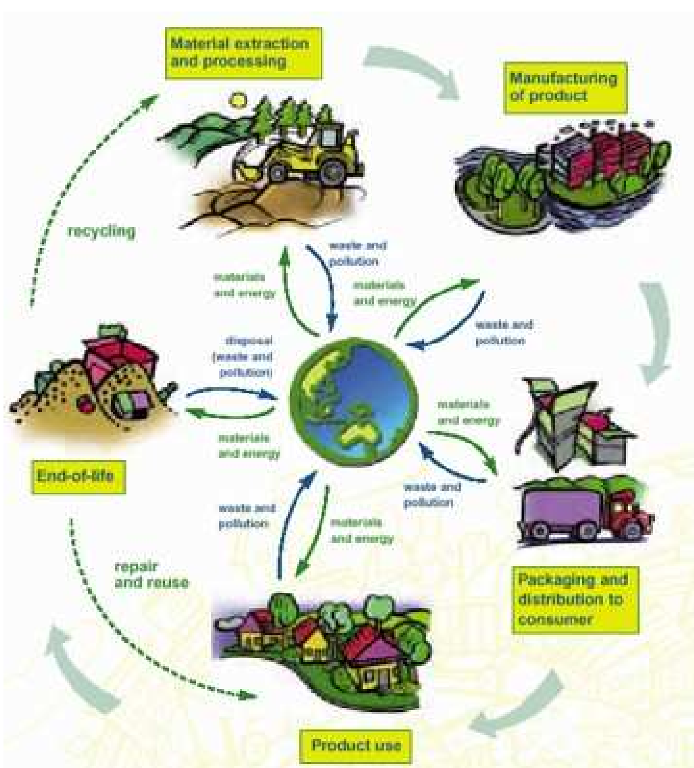


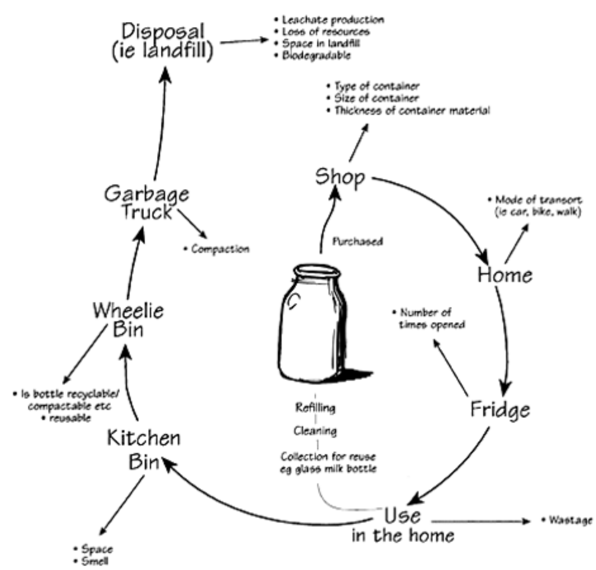
http://www.youtube.com/watch?v=qd9AZ3wn86k

This video explains how a seemingly simple and harmless object can have a big impact on the environment due its production process.

3.2.2 Describe how life cycle analysis provides a framework within which clean production technologies and green design can be evaluated holistically for a specific product.

Life cycle analysis provides the framework for a designer to assess the impact a product or the technology used to produce it will have on the environment. It allows green design to be evaluated for a given product.





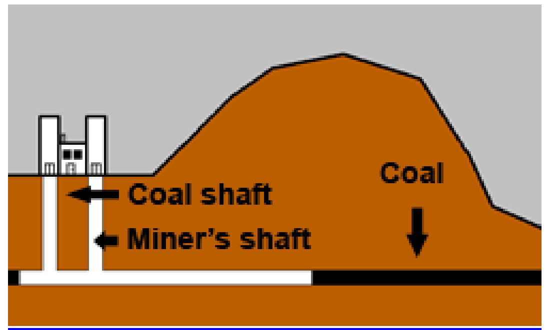
Life cycle of Milk Bottle

3.2.3 List the key stages in life cycle analysis.

In life cycle http://www.ilea.org/whatis.html analysis the life cycle stages are categorized as

- Pre- production
- Production
- Distribution including packaging
- Utilization
- Disposal (IBO 2007)

Pre- production is the obtaining of natural resources; it can be very polluting (strip-mining) or can have a small effect on the environment (shaft mining)



Production is the processing of the resources and shaping etc. to make the product. Once again it could be damaging to the environment (such as a large factory spewing out smoke) or have a small impact (a carpenter hand crafting children's toys)

Distribution and packaging includes taking the product from the factory to the warehouse, from the warehouse to the store, and the package. It could have a large impact (as is the case with an imported object from around the world in a Styrofoam box) or a very low impact (made and sold in the same place with a biodegradable box or no packaging)

Utilization is about the product's use and the effect that has on the environment. A diesel generator for example will pollute air and make noise pollution while a solar panel will make next to none.

Disposal depends on both the product and the method of disposal. Recycling one aluminum can will make less environmental problems than throwing one away even if they are identical. Biodegradable objects can be reused, recycled, or left to be broken down and add nutrients to the soil, depending on the object one or the other would be preferable. Paper is best recycled because of the chemicals used to make it and the logging of forests to obtain the pulp while a banana peel is completely useless for anything but compost.

3.2.4 List the major environmental considerations in life cycle analysis.
Life cycle analysis includes environmental considerations:

- Water
- Soil pollution & degradation
- Air contamination
- Noise
- Energy consumption
- Consumption of natural resources
- Pollution and effect on ecosystems (IBO 2001)

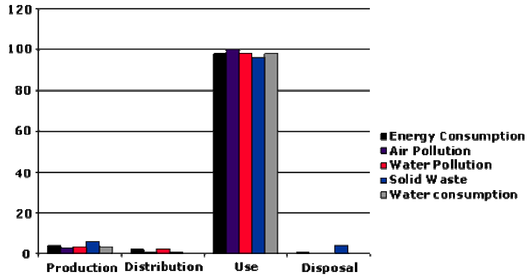
3.2.5 Both the environmental and life cycle stages can be organized into a matrix shown below.
This matrix is used to assess the impact of a particular product will have on the environment at all stages of its life cycle. This allows the designer to improve the product with the application of green design. The matrix will identify areas of action.

	Pre-production	Production	Distribution including packaging	Utilization	Disposal
Water Relevance					
Soil pollution and degradation					
Air contamination					
Noise					
Air contamination					
Energy consumption					
Effects on ecosystems					

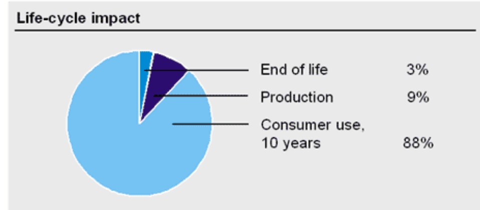
See also: http://www.youtube.com/watch?v=EBMpwrqxN7Y

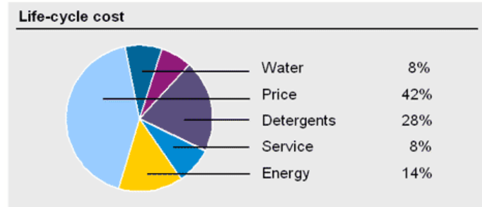
However, it should be born in mind that although different issues may arise, it may be necessary to prioritize their importance. For example, in many products energy will be consumed both during manufacture and during use. However, some products will use more during manufacture while others may use more during use. With a refrigerator, consideration of the consumption of energy is use is likely to be prioritized over consumption during manufacture since the product is designed for continuous operation. With other products the focus might be on operation. The importance of each category will therefore vary with the design context.

3.2.6 Analyse the environmental impact of refrigerators, washing machines and cars using an environmental impact assessment matrix.



Refrigerator LCA >





Using the Environmental impact assessment matrix to analyse the environmental impact of:

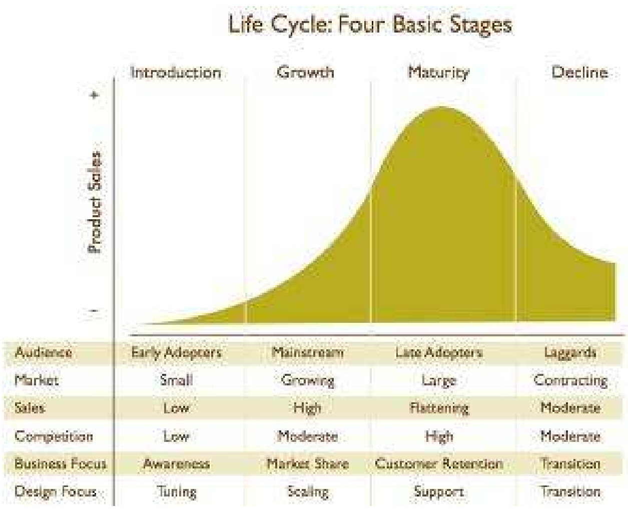
Refrigerators	Pre-production	Production	Distribution including packaging	Utilization	Disposal
Water Relevance	Low	Low	Low	Low	Low
Soil pollution and degradation	Low	Medium	Low	Low	Medium
Air contamination	Low	Medium	Low	High	Medium
Noise	Low	Low	Low	Low	Low
Consumption of natural resources	Medium	Low	Low	Low	Low
Effects on ecosystems	Low	Low	Low	High	Low

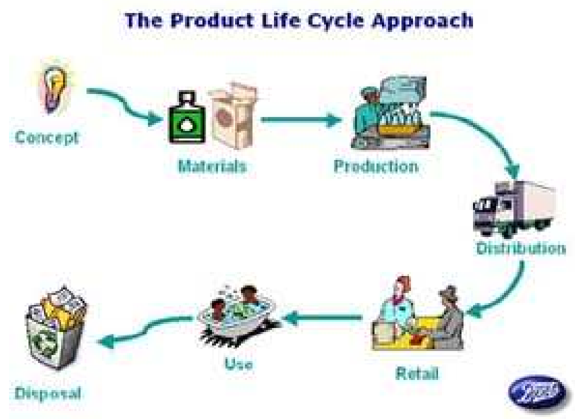
Washing Machines	Pre-production	Production	Distribution including packaging	Utilization	Disposal
Water Relevance	Low	Low	Low	High	Low
Soil pollution and degradation	Low	Low	Low	High	Medium
Air contamination	Low	Low	Low	High	Medium
Noise	Low	Low	Low	High	Low
Consumption of natural resources	Low	Low	Low	High	Low
Effects on ecosystems	Low	Low	Low	High	Medium

Cars	Pre-production	Production	Distribution including packaging	Utilization	Disposal
Water Relevance	Low	Low	Low	Low	Low
Soil pollution and degradation	Medium	Medium	Low	Medium	Medium
Air contamination	Low	Medium	Medium	High	Medium
Noise	Low	Medium	Low	High	Low
Consumption of natural resources	Medium	Medium	Low	High	Low
Effects on ecosystems	Low	Medium	Low	High	Low

3.2.7 Elements of the matrix may differ in importance according to a particular design context.
For example; in the case of the fridges and cars the larger part of energy consumption takes place in use rather than maintenance. There are five stages in the product cycle that all can result with a bad impact upon the environment. The amount of impact depends upon how the product was pre-production produced distributed utilized and Disposed. Follow this link http://dmst.aueb.gr/gr2/diafora2/DQE_Lectures/Lecture4_LCAM.ppt to a PowerPoint showing ways where designers and manufacture can minimize the impact of products on the environment.

3.2.8 Identify the roles and responsibilities of the designer, manufacturer and user at each life cycle stage of a product.





3.2.9 Describe one example of a situation where life cycle analysis identifies conflicts, which have to be resolved through prioritization.
The inventory step of the life cycle analysis is the description of the raw materials used as well as the emissions that occur in creating a product. The next step (impact assessment) is an evaluation of the consequences of the use of the raw materials and the emissions that occur during the production. During the inventory step, the manufacturers and designers will look at the raw materials and emissions, and then plan out which materials to avoid in the manufacturing process. For example, if using fiber optics in a product is more environmentally friendly and efficient, it will replace copper, which is a non-renewable resource that is not as efficient or eco-friendly.

3.2.10 Explain that life cycle analysis is targeted at particular product categories.
Life cycle analysis is targeted at products with a high environmental impact and in the global marketplace. It is then impossible for companies to argue that their products are being made uncompetitive. Life cycle analysis also targets companies with the resources to invest in R&D.

3.2.11 Explain why life cycle analysis is not widely used in practice.
Life cycle analysis is not used for many products. However, in the re-innovation of the design of a product or its manufacture, specific aspects may be changed after considering the design objectives for green products. Thus the materials selected may be changed to make them more environmentally friendly, for example, wood from sustainable forests or the selection of a less toxic varnish. A product may be distributed differently or its packaging may be redesigned.
While Life Cycle Assessment has been widely used, it continues to face challenges. First, the process is inherently complex, time consuming, and costly. It requires considerable data and relies on a variety of assumptions. Second, there are continuing questions about impact assessment, especially for "local" issues such as ecotoxicity, human health, or nutrient enrichment (eutrophication). Finally, communicating the results of a Life Cycle Assessment is a considerable challenge, given the complexity of the method.

http://www.youtube.com/watch?v=DL7KGbo_dPk
http://www.youtube.com/watch?v=qMyPSQybhUA

3.2.12 Describe the reasons for the introduction of eco-labelling schemes.

Eco labelling means that a legal organisation grants a special label, i.e. eco label to a product. This label means that the product in question is very environmentally friendly.
Many products now are labeled according to how environmentally friendly they are. Such labeling schemes have come about as a result of legislation and consumer pressure. They certainly enable the consumer to compare potential purchases and make an informed choice.

Task- What issues are considered when awarding an eco-label to a product?

3.2.13 Explain how eco-labelling reflects life cycle analysis of certain product categories.

Eco-labelling is when an unbiased legal organization (e.g. Ecotrust, Greenpeace) places a label on a product, certifying that the product under consideration is ecologically compatible. It is different from "green" stamps given or claims made by designers and manufacturers.

3.2.14 Compare the objectives of two different eco-labelling schemes.

Consider approaches to eco-labelling in Europe, Australia and the United States (US). The overall objective of the European eco-label is to contribute to sustainable development. It is based on the vision of greening non-food products all over Europe. The people who decide about the Eco label norms and to whom it is granted to is a group of stakeholders, together called the European Union Eco-labelling Board (EUEB). Every product group has to meet high environmental and performance standards. Ecological criteria for each product are depend on the basis of life cycle considerations (LCC) taken from a "cradle-to-grave" view of the environmental impacts of a product group. This LCC means that the complete life-cycle of a product will be investigated in detail, starting with the extraction of raw materials, the production, distribution and usage, ending with disposal after use.

In the United States, there are many types of eco-labels. For example, Energy stars, which is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy that promotes energy efficient products and practices. The Nutriclean label means that products are tested for pesticide rests and sets limits of detection for each specific pesticide remains. Green shield certified is an independent, non-profit certification program that promotes practitioners of effective, prevention-based pest control while minimizing the need to use pesticides. The Rainforest Alliance Certified is a certification granted by the Rainforest Alliance. It is a conservation tool whereby an independent, third party awards a seal of approval guaranteeing consumers that the products they are buying are the result of beneficial ecological, economic and social considerations. Probably the most famous eco label in the USA is Green Seal. It is an independent, non-profit organization which is dedicated to safeguarding the environment by transforming the market place with the promotion of the manufacture, purchase and use of environmentally responsible products.

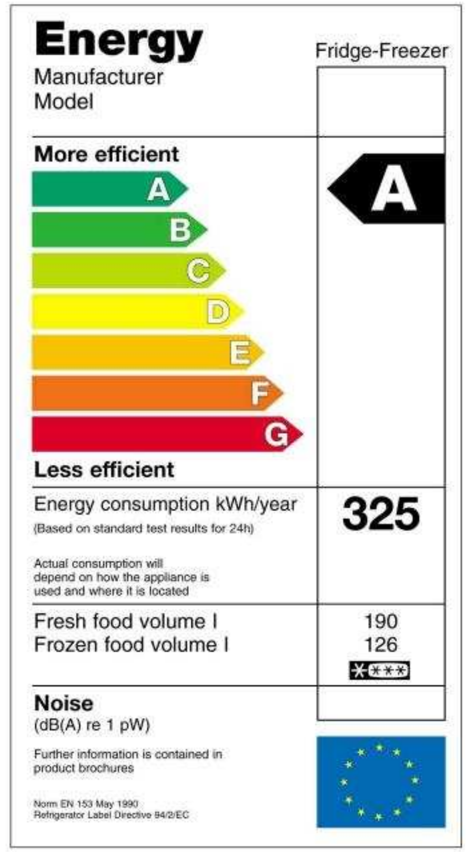
In Australia, Good Environmental Choice Australia (GECA) is committed to credible product information for sustainable development. The Good Environmental Choice Label is the only environmental labelling program in Australia which indicates the environmental performance of a product during its complete lifecycle. The label is awarded to products that meet voluntary environmental performance standards which have been created and assessed in comparison to international environmental labelling standards.

Task- How is the eco-friendliness of a product monitored subsequent to the award of the label?

Task- Why might a product lose its eco-label?

3.2.15 Explain how eco-labeling and energy-labeling schemes can help consumers to compare potential purchases.

If a company manufactures or sells household electrical equipment within the European Union, it must provide customers with the energy efficiency rating of your products by having a clear labelling on the product.



As a consumer, if you are buying a household electrical item the energy efficiency rating should be displayed clearly on the product to help you make a better informed decision. The energy labelling guidance applies to all electric mains-operated household appliances. This includes household appliances that businesses use.

http://www.energyrating.gov.au/appsearch/

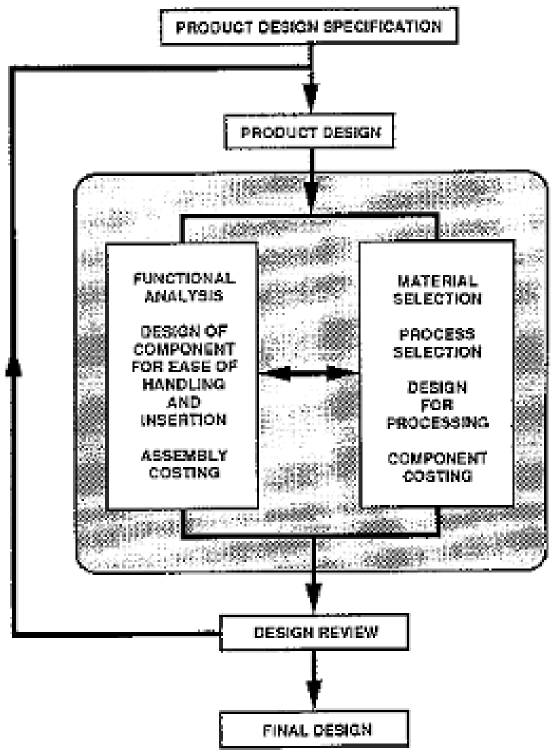
Task- What have been the benefits of the eco-labelling scheme?

Task- What have been some of the problems implementing the scheme?

3.3 Strategies for Green Design

3.3.1 Define design for manufacture (DfM),
Designers design specifically for optimum use of existing manufacturing capability. (DFM) is the process of designing products to improve the ease of manufacture, i.e. more manufacturability.

3.3.2 Describe why DfM can be a dominating constraint on the design brief and state that it can be conveniently split into design for materials, design for process and design for assembly.



Outline process for design for manufacture

<u>A Dominating constraint</u>
The designer's main objective is to design a product within given constraints (financial and specifications). It has been said that 70% of the product cost is determined by decisions made during the early stages of the design cycle, 20% during production and a further 10% on other aspects. Due to the high percentage of the product cost it is important that consideration be given in the design brief and thus being a major design constraint. When DfM the designer takes into consideration the existing production systems in order to maximize cost effectiveness.

It becomes a design constraint also when the designer must work within an existing production system that cannot be modified greatly.

DfM can be broken down into three parts: design for materials, design for process and design for assembly

3.3.3 Define design for materials, design for process and design for assembly.
<u>Design for materials</u>
- Designing in relation to materials during processing.
- Considers the availability of materials locally and thus can affect the manufacturing process.

<u>Design for process</u>
- Designing to enable the product to be manufactured using a specific manufacturing process, for example, injection moulding.

Design for assembly

- Designing taking account of assembly at various levels, for example, component (A part of a mechanical or electrical complex.) to component, components into sub-assemblies (An assembled unit forming a component to be incorporated into a larger assembly)and sub-assemblies into complete products.

Components

Sub-assemblies

Simply put, it's an approach to designing products with ease of manufacture in mind. By making things easier to assemble, one also makes the assembly process faster and more cost-efficient. This results in higher profit to the manufacturer, and can also add value for the customer.

If a product contains fewer parts it will take less time to assemble, also reducing manufacturing costs wikipeadia reference- (**Design for Assembly** is a process by which products are designed with ease of assembly in mind. If a product contains fewer parts it will take less time to assemble, thereby reducing assembly costs. In addition, if the parts are provided with features which make it easier to grasp, move, orient and insert them, this will also reduce assembly time and assembly costs. The reduction of the number of parts in an assembly has the added benefit of generally reducing the total cost of parts in the assembly. This is usually where the major cost benefits of the application of design for assembly occur). Take note of the Xerox saving millions and the Walkman product being one notable product produced this way.

3.3.4 Discuss three strategies that designers could employ for DfM.
Strategies include: minimizing the number of components, using standard components, designing components that are multifunctional or for multi-use, designing parts for ease of fabrication, minimizing handling, and using standard sub-assemblies.

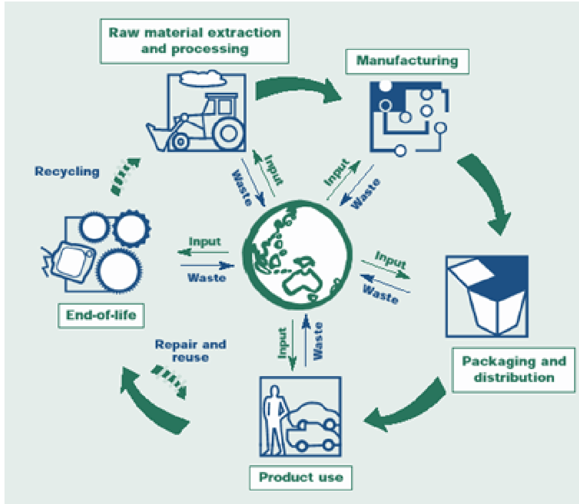
Design for materials
Designing in relation to materials during processing.

Design for process
Designing to enable the product to be manufactured using a specific manufacturing process, for example, injection moulding.

Design for assembly
Designing taking account of assembly at various levels, for example, component to component, components into sub-assemblies and sub-assemblies into complete products.

→ **Design for manufacture (DfM)**
Designers design specifically for optimum use of existing manufacturing capability.

3.3.5 Describe how designers can modify the environmental impact of the production, use and disposal of their product through careful consideration at the design stage.



- As with the above strategies early consideration during the design cycle is important.
- This strategy can be known as Design for the Environment (DfE) where stakeholders work to reduce the risk to people and the environment by reducing the environmental impact of a product during the product life cycle.
- Design for Materials: The use of recycled materials is increasingly important as more product take-back and producer responsibility legislations are mandated, product labelling programs are adopted, and sustainability goals are being promoted. Materials selection impact distribution, consumer use, repair and refurbishment, and other end-of-life activities.
- The Australian Environmental website http://www.environment.gov.au/settlements/industry/corporate/dfe.html mentions adopting strategies, for Raw materials, manufacturing, end of life, and distribution.
- This website- http://www.npd-solutions.com/dfe.html provides extra information.

3.3.6 Define reuse, repair, reconditioning and recycling.

- Reuse of a product in the same context or in a different context.
- Repair The reconstruction or renewal of any part of an existing structure or device.
- Reconditioning a product so that it is in an "as new" condition, and is generally used in the context of car engines and tires.
- Recycling refers to using the materials from obsolete products to create other products.

3.3.7 Describe how reuse, repair, reconditioning and recycling contribute to the optimization of resource utilization.

They promote use of fewer raw materials

Toshiba has on its website the following:
Optimization of resources pursued from the product design stage
"Development of lighter products and robust products with longer lives saves resources. At Toshiba Group, as well as resource-saving design, we are emphasizing greater use of modules so that repairs and upgrades of products are performed simply by replacing modules. Reduction of the number of parts to facilitate disassembly and recycling is another priority." "Also, we are promoting use of recycled resources in products. For example, 1,800 tons of recycled plastics were used in the manufacture of Toshiba washing machines, Multi-Function Peripherals (MFPs), and other products in fiscal 2006." (http://www.toshiba.co.jp/env/en/products/resource.htm)

Task- List three examples of products that are designed with ease of maintenance in mind and justify your choices.

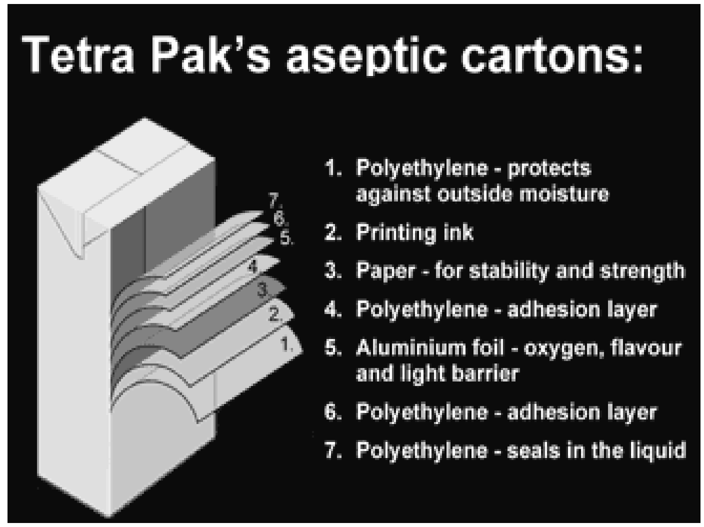
Task- Read through the following information about Tetra Pak packaging.

77% paper – to provide strength and stiffness from renewable forests

18% polyethylene – to make packages liquid tight and to provide a barrier to microorganisms

5% aluminium foil – to keep out air, light and prevent flavour changes – all the things that can cause food to deteriorate

A family consuming 300 litres of milk a year carries home 7.7 kg of disposable packages. Packages are constantly losing weight: A carton package weighs 20 per cent less today than it did 20 years ago.
When you go shopping, you carry home more liquid food and less packaging compared to a couple of years ago.



Describe the environmental problems that arise from using Tetra Pak packaging.
http://www.tetrapakrecycling.co.uk/

3.3.8 Describe how the strategies of reuse, repair and recycling can be applied to the design of products, including packaging.
For example, consider disposable cameras, vacuum cleaners and car tires.

Task- The strategies of reuse repair and recycle can be applied to the design of products. For the following examples, indicate which strategies you would advocate as a designer with explanatory notes as to show such a strategy might be implemented.

Product	**Strategy(s)**	**Explanation**
Disposable Camera	Reuse and recycle	Design Camera such that it has to be taken to photographic shop for recovery of film for processing. Camera body can then be returned to manufacturer for re-use. If made from thermoplastic it can be recycled many times over.
Refrigerator		
Car tires		
Packaging for liquids e.g. milk, juice		
Packaging for confectionery e.g. Easter Egg		

Task- List in the table below three materials that can be easily and economically recycled along with the products where each material might be used. An example is given for you:

Material	Application
Copper	Electrical wiring

3.3.9 List three material groups that can be easily and economically recycled.
Consider thermoplastics, metals and glass.

Thermoplastics

- Thermoplastics make up 80% of the plastics produced today.
- It is one of the easiest materials to recycle as it can be reheated and reshaped due to the weak secondary bonds between the long polymer chains.

Metals

- A few statistics about recycling Aluminium and steel.
- Precious metals are rarely thrown away. All metals can be reheated and reshaped easily and efficiently.
- The savings from recycling metals

Glass

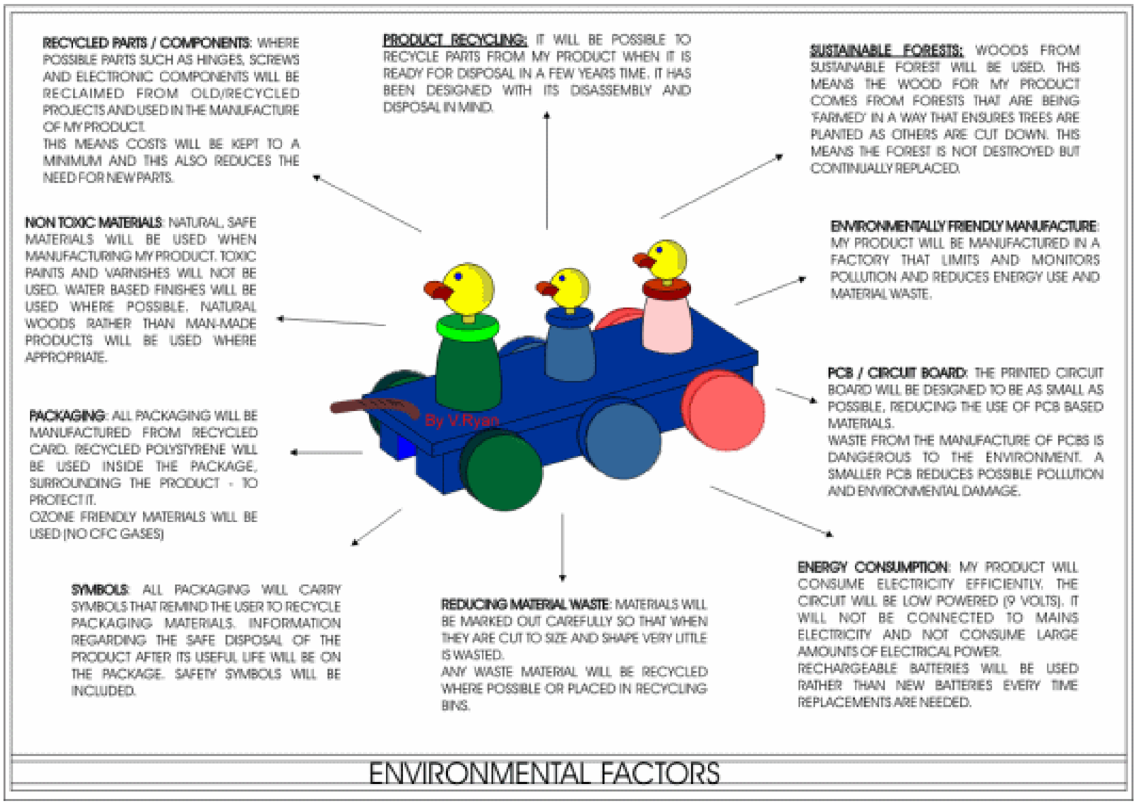
- A few statistics about recycling glass.
- wasteonline.org.uk stats and info.
- Glass can be recycled over and over again without loss of quality.
- Reduces the cost of producing glass enormously.

Task- Many materials can be easily and economically recycled. However, many cannot either because it is too expensive or difficult to recycle or because they cannot be recycled at all. In the table below give two examples of specific materials that are not recycled along with reasons. Again, an example has been provided for you.

Materials	Reason for not recycling	Application
Urea Formaldehyde	Thermosetting Plastic	Electrical fittings such as plugs and light switches

3.3.10 Describe how many products comprise several different materials, and state that these materials have to be separated to enable recycling.

Identify the materials that are in the book that can be recycled.
Often products (such as the binder shown) will be made of two or more different materials. If they happen to be easily recycled then they should be separated and disposed of into the appropriate recycling bins.



3.3.11 Discuss the issues underpinning the economic recycling of materials.
Consider collection, energy and processing considerations, redistribution.

Collecting, transporting, separating and processing used materials takes time and inputs of yet more resources

Collection

- Recycling attitudes of the consumer, willing separate materials.
- plastics or metals and glass need to be sorted and currently can only be done by hand so to reduce costs collection systems at point of disposal are needed, i.e tubs or large bins
- People actually out the right coloured glass or plastic in the right collection bin
- Collection is costly; an Australian study stated that the cost for recycling collection was greater waste collection per household.

Energy and processing considerations
Plastics (including types) or metals and glass need to be sorted o the same types can be recycled
Products that other materials that need to be removed beforehand both are done by hand so it is slow and costly
Glass production is costly and energy intensive using recycled glass reduces the energy needed thus the costs

Some materials need to be reprocessed first before recycling

- Plastics need to be made into pellets.
- Glass needs to ground into fine granules
- Paper needs chemicals and water to be broken down before being recycled
- Naturally, reprocessing and cleaning materials for recycling will require energy, some materials more than others, e.g. plastics

Redistribution

Once made into a material that is ready for manufacture it will need to be stored, transported to its new location thus increasing costs and use of recourses.

3.3.12 Define design for disassembly.

Designing a product so that when it becomes obsolete it can easily and economically be taken apart, the components reused or repaired, and the materials recycled.

3.3.13 Explain that design for disassembly is one aspect of design for materials and will facilitate recycling of products on disposal.

"Designing products in order to minimise their impact on the environment is becoming increasingly important. Many designers are beginning to recognise this fact and are therefore demanding tools and techniques which enable them to design more responsibly. One technique which can be used is Design for Disassembly - this enables the product and its parts to be easily reused, re-manufactured or recycled at end of life. This paper not only presents this technique but also illustrates its use with a case study. It is hoped that this will encourage designers to consider product disassembly early in the product's design stage". (http://www.co-design.co.uk/design.htm)

3.3.14 Discuss two strategies that designers could employ to design for disassembly.

Designing components made from one material. Using thermoplastic adhesives that lose their properties when reheated. Designing snap fittings instead of welding and gluing.

http://www.nrdc.org/reference/glossary/a.asp

Green Design- a design, usually architectural, conforming to environmentally sound principles of building, material and energy use. A green building, for example, might make use of solar panels, skylights, and recycled building materials.

Choice of Products & Services: Bottle of shampoo, Old Ipod, W/b Marker, Paper from recycle bin, Chartwells lunchbox, Wisachino cup, airconditioning services, leaking water taps or those left dripping,……

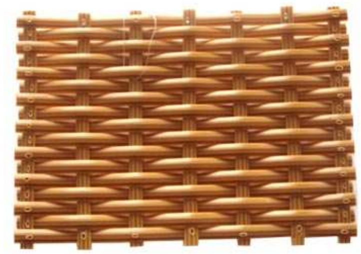
Prompt Question: What is the environmental impact of this product throughout its life cycle? What is a Product Life Cycle?

No.	KEY WORD / PHRASE	Have ard of it.	Can Use in a sentence	Can define	Can give a clear Example to explain	Never Heard of it!	Tick for :now get it!
1	Clean Technology						
2	'cradle-to grave'approach						
3	Product Life Cycle						
4	Non-toxic / Toxic waste						
5	Sustainable						
6	Non-renewable resource						
7	Renewable resource						
8	Environmental Impact						
9	Chlorofluorocarbons CFCs						
10	Environmental legislation						
11	Consumer Pressure						
12	Safety hazards						
13	Take back legislation						
14	Eco Warriors						
15	Eco champions						
16	Eco Fans						
17	Optimum resource utlization						
18	Environment friendly product						
19	Acid Rain						

Topic 4

Materials





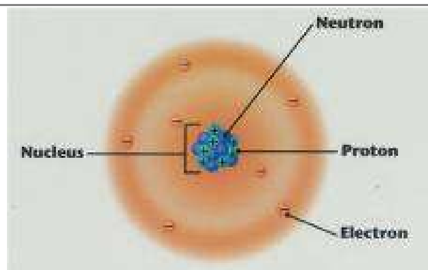
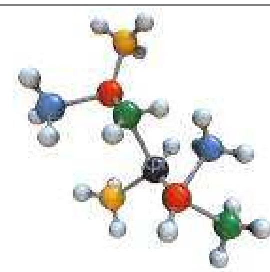




4.1 Introducing and classifying materials

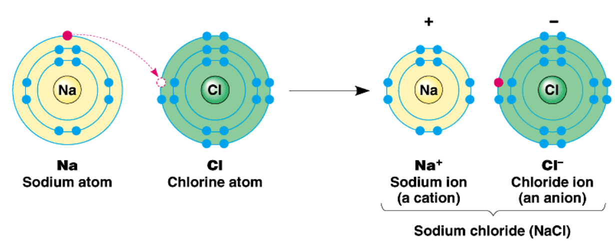
4.1.1 Define atom, molecule, alloy and composite

- **Atom** The smallest part of an element that can exist chemically.
- **Molecule** Two or more atoms that are normally bonded together covalently.
- **Alloy** A mixture that contains at least one metal. This can be a mixture of metals or a mixture of metals and non-metals. An example of an alloy is brass, an alloy of copper and zinc.
- **Composite** A mixture composed of two or more substances (materials) with one substance acting as the matrix or glue.

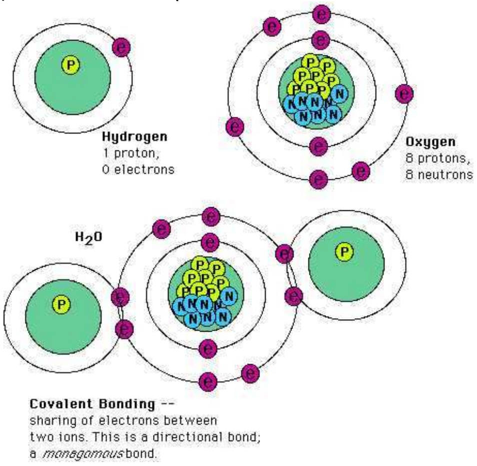
Atom	**Molecule**
	
An atom is the smallest particle characterizing a chemical element. An atom consists of an electron cloud surrounding a dense nucleus. This nucleus contains positively charged protons and electrically neutral neutrons, whereas the surrounding cloud is made up of negatively charged electrons. When the number of protons in the nucleus equals the number of electrons, the atom is electrically neutral; otherwise it is an ion and has a net positive or negative charge. An atom is classified according to its number of protons and neutrons: the number of protons determines the chemical element and the number of neutrons determines the isotope of that element.	A molecule is as a sufficiently stable electrically neutral group of at least two atoms in a definite arrangement held together by strong chemical bonds. Basically it is composed of a group of atoms covalently bonded to form an element such as Water (H2O).
Alloy	**Composite**
	
* An alloy is a homogeneous mixture of two or more elements, at least one of which is a metal, and where the resulting material has metallic properties. The resulting substance usually has different properties (sometimes substantially different) from those of its components. * Unlike pure metals, most alloys do not have a single melting point. Instead, they have a melting range in which the material is a mixture of solid and liquid phases. * Alloying one metal with others usually improves on the properties of other elements.	Composite materials (or composites for short) are engineered materials made from two or more constituent materials with significantly different physical or chemical properties and which remain separate and distinct on a macroscopic level within the finished structure. For example the most primitive composite materials comprised straw and mud in the form of bricks for building construction. One way to form composites is using many moulding methods.

4.1.2 Describe a bond as a force of attraction between atoms

There are three types of inter atomic bonds. **Ionic**, **covalent** and **metallic**.

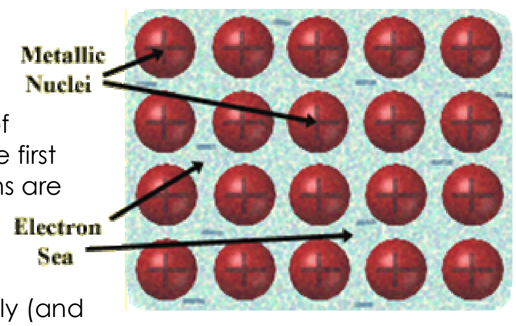


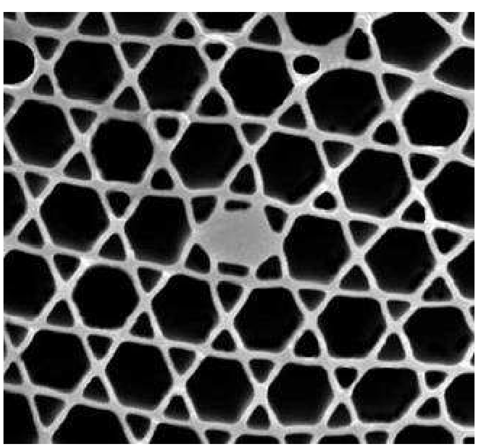
Ionic bonds occur **between a metal and a non metal**; all atoms strive for a full outer shell of electrons. The metal has a nearly empty outer shell with a full shell beneath it and a non-metal has a nearly full outer shell. To fill their shells, the metal gives its extra electrons to the non metal leaving it with an overall positive charge and the nonmetal with an overall negative charge. Since opposite charges attract the ions (charges atoms) stay connected through electrostatic forces. Ionic bonds are brittle because a small bump could easily change the positions of the ions relative to each other causing the electrostatic forces to be between two like charges and repel. when the ions dissociate (separate), whether in a solvent such as water or through melting, they can conduct electricity because the positive ions accept electrons while the negative ions provide them (but this transforms them back into elements).



Covalent bonds are formed when **two nonmetals bond**. They form because both have a more than half full outer shell; therefore, by sharing some electrons, they can have a full shell. Covalent bonds are the strongest type of bonds because the outer electron shell of two or more atoms overlap and create a completely new shell around both of them. There are two main types of covalent bonds, molecular and network. molecular, like water, makes molecules that are not very well bonded to each other and are usually in the gaseous or liquid state at room temperature for lack of large charges (like ions). Network covalent bonds, like diamond, can make crystals of virtually any size. They are usually hard because of the strength of covalent bonds.

In a **metallic bond**, the valence electrons from each atom form a 'sea' of electrons that works as glue to keep the metal together because the lattice ions (the rest of the atoms making up the metallic crystal) are attracted to the electrons. the sea of valence electrons gives the metals two important properties, the first being malleability, metals are malleable because the lattice ions are still attracted to the electrons even after being moved. The second property is conductivity. The electrons have enough freedom to move, which is exactly what electricity is. The electrons' freedom also means that they can start vibrating easily (and so can the lattice ions because they have quite a bit of freedom too) and that makes them good heat conductors because temperature is a measure of the average kinetic energy of the substance.





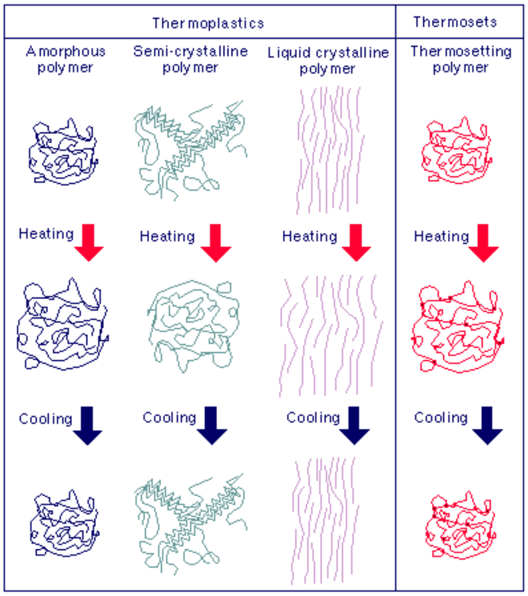
4.1.3 Describe how materials are classified into groups according to similarities in their microstructures and properties

The microstructure of a material is its structure when perceived through a microscope. Materials are classified depending on their **crystal structure**, their **size**, **composition**, **orientation**, **formation** and **interaction**.

When materials are not viewed microscopically, they are perceived and classified **macroscopically**. This means they will be classified in terms of their **physical properties** such as **strength**, **toughness**, **ductility**, **hardness**, **corrosion resistance, high / low temperature behaviour, wearability,** etc… In the case of metals, the microstructures can be seen with the blind eye. Each polygon, usually hexagons, represents a single crystal of zinc remain to the surface of the steel beneath.

4.1.4 Explain that several classifications are recognized but that no single classification is "perfect"

It is convenient to be able to classify materials into categories (albeit crude in nature) that have characteristic combinations of properties.

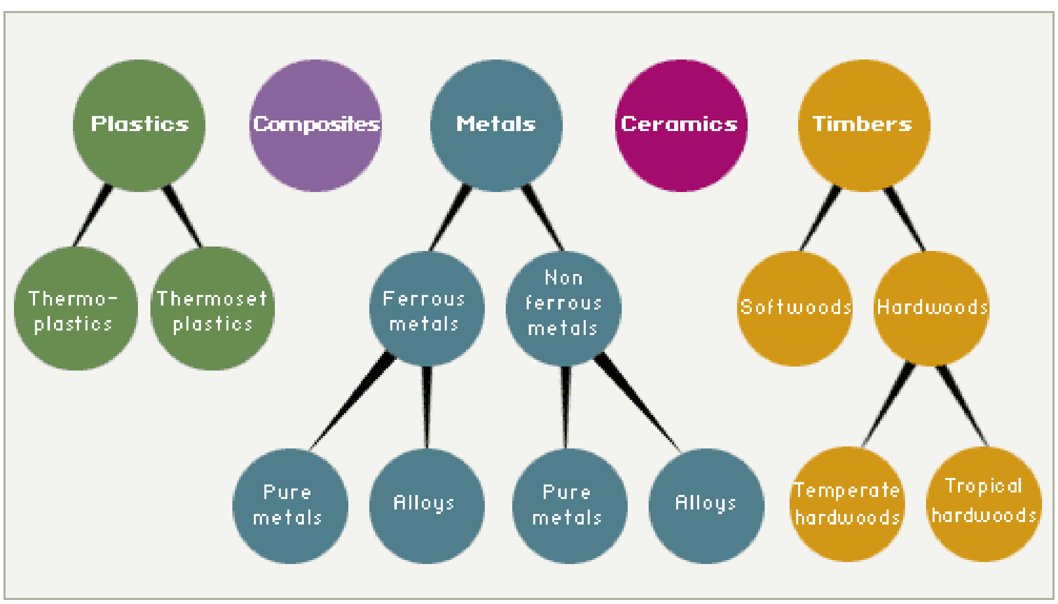


Classification of different materials is not considered perfect due to the variance of different material's microstructures. For example, the microstructure of different plastics, thermoplastics and thermoset plastics have distinct differences. The microstructure of a thermoplastic is composed of strings or threads of plastic particles. This gives it special characteristics such as being easily reformed or malleable. On the other hand, thermoset plastics are composed of stronger covalent bonds, which make them stronger but less malleable. It is for reasons such as this, that classifications of materials can not be considered perfect.

4.1.5 Describe that, for this course, materials are classified into groups: timber, metals, plastics, ceramics, food and composites; and that some of these groups have subdivisions

In each group there can be subdivisions, for example:

- **Timber** (natural wood and man-made)
- **Metals** (ferrous and non-ferrous)
- **Plastics** (thermoplastics, thermosets)
- **Ceramics** (earthenware, porcelain, stoneware, glass)
- **Textile fibres** (natural or synthetic)
- **Food** (vegetable or animal origin)
- **Composites** (difficult to classify due to variability and continual development of new composite materials)



4.2 Properties of materials

Physical properties

4.2.1 Define density, electrical resistivity, thermal conductivity, thermal expansion and hardness

- **Density-** The mass per unit volume of a material
- **Electrical resistivity-** This is a measure of a material's ability to conduct electricity. A material with a low resistivity will conduct electricity well.
- **Thermal conductivity-** A measure of how fast heat is conducted through a slab of material with a given temperature difference across the slab.
- **Thermal expansion (expansivity)-** A measure of the degree of increase in dimensions when an object is heated. This can be measured by an increase in length, area or volume. The expansivity can be measured as the fractional increase in dimension per kelvin increase in temperature.
- **Hardness-** The resistance a material offers to penetration or scratching.

4.2.2 Explain a design context where each of the properties in 4.2.1 is an important consideration

- **Density** is important in relation to product weight and size (for example, for portability). Prepackaged food is sold by weight or volume, and a particular consistency is required.
- **Electrical resistivity** is particularly important in selecting materials as conductors or insulators.
- **Thermal conductivity** is important for objects that will be heated or must conduct or insulate against heat.
- **Thermal expansion** (expansivity) is important where two dissimilar materials are joined. These may then experience large temperature changes while staying joined.
- **Hardness** is important where resistance to penetration or scratching is required. Ceramic floor tiles are extremely hard and resistant to scratching.

Task- Find a few products or context where a physical property is crucial to the design and explain why.

Density	Electrical resistivity	Thermal conductivity	Thermal expansion	Hardness

Mechanical properties

4.2.3 Define tensile strength, stiffness, toughness and ductility

- **Tensile strength-** The ability of a material to withstand pulling forces.
- **Stiffness-** The resistance of an elastic body to deflection by an applied force.
- **Toughness-** The ability of a material to resist the propagation of cracks
- **Ductility-** The ability of a material to be drawn or extruded into a wire or other extended shape.

4.2.4 Explain a design context where each of the properties in 4.2.3 is an important consideration

- **Tensile strength** is important in selecting materials for ropes and cables, for example, for an elevator.
- **Stiffness** is important when maintaining shape is crucial to performance, for example, an aircraft wing.
- **Toughness** is important where abrasion and cutting may take place.
- **Ductility** is important when metals are extruded (not to be confused with malleability, the ability to be shaped plastically).
- **Aesthetic characteristics** are the properties that products have that make them appealing or unattractive to us. Aesthetic properties depend completely on your own personal point of view – this means they are **subjective.** Your tastes depend as much on your **mood** as they do on your **beliefs** and **values.**

Task- Find some products or context where a mechanical property is crucial to the design and explain

Tensile Strength	Stiffness	Toughness	Ductility	Aesthetics

4.2.5 Outline the characteristics of taste, smell, appearance, texture and colour

4.2.6 Explain a design context where each of the characteristics in 4.2.5 is an important consideration

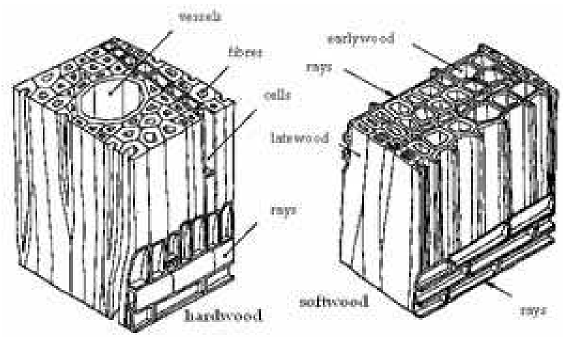
Some of these properties are only relevant to food, while others can be applied to more than one material group. Although these properties activate people's senses, responses to them vary from one individual to another, and they are difficult to quantify scientifically, unlike the other properties.

Task- Watch this video Design 4 life 02 The Colour of Emotion - the importance of colour & light

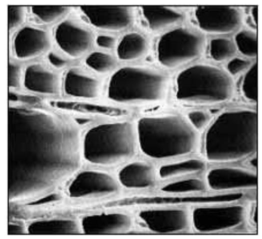
4.3 Timber

4.3.1 Describe the structure of natural timber

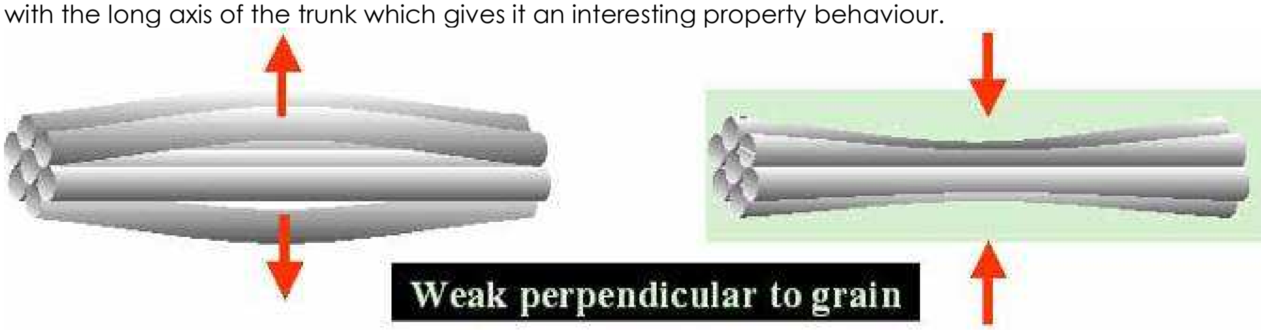
Natural timber is timber that is used directly from the tree. Natural timber is a natural composite material comprising cellulose fibres in a lignin matrix.



The tensile strength of timber is greater along the grain (fibre) than across the grain (matrix).



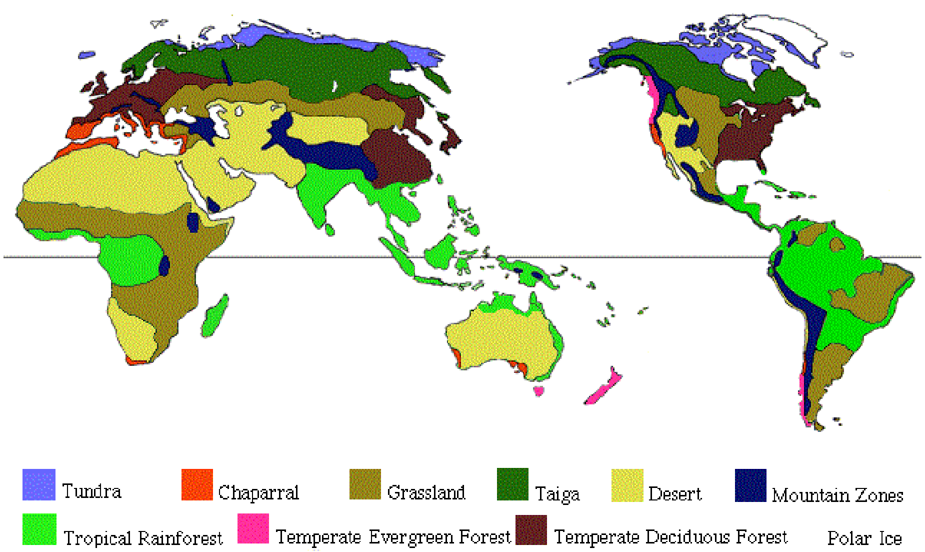
Wood is a fibrous material. The structure of wood similar to a bunch of parallel straws (**the cellulose fibres**), which are bonded together with a glue (**lignin matrix**). The fibres are long and slender and are aligned with the long axis of the trunk which gives it an interesting property behaviour.



When load is applied parallel to the axis of the fibres, they are very strong in tension and have reasonably good compressive strength until they start to buckle.
When the load is applied perpendicular to the axis of the fibres, they will tend to crush under compression and are weakest in tension, where the "glue" bond fails and the straws literally tear apart.

4.3.2 Outline that timber can be classified according to the conditions needed for tree growth

Study the distribution of forest map of the world below. **Temperate forests** tend **top** be in **cooler regions** and **tropical forests** tends to be between **the Tropic of Cancer and Capricorn** in **warmer climates**.



4.3.3 Outline that conifer trees are referred to as softwoods and that these grow only in temperate regions

Conifers- Any of various mostly **needle-leaved** or scale-leaved, chiefly **evergreen**, **cone-bearing** trees or shrubs such as pines, spruces, and firs.

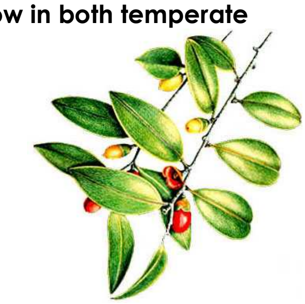
Characteristics of softwood trees are:

- They take around **30 years** to reach **maturity**
- The wood from these trees is generally **softer** (That's where the name comes from) due to the **faster growth** of the tree and therefore producing a **less dense cellulose fibres and lignin matrix**
- Softwoods reproduce by **cones**
- Softwoods have **needles**
- They do not lose their needles in the fall They are sometimes called **evergreens** because the needles are green year round
- Examples included are **pine, cedar**, and **cypress**

4.3.4 Outline that deciduous trees are referred to as hardwoods and that these grow in both temperate and tropical regions

Decidiouos- Hardwood trees **shed their leaves** and other characteristics of hardwood trees are:

- The wood from these trees is generally **harder**. (That's where the name comes from) as they take around **100 years to mature** and therefore ore have a much **denser cell structure**
- Hardwoods **reproduce by flowers**.
- Hardwoods have **broad leaves** and are **fruit bearing**
- Many lose their leaves every **autumn** and are dormant in the winter
- Some examples of hardwood trees includes **eucalyptus, elm, maple, oak,** and **beech**



4.3.5 Discuss the issues relating to the consideration of timber as a renewable resource

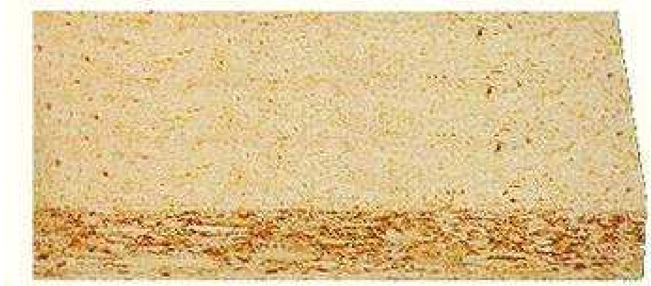
issues should be placed in local, national and international contexts.

- time to reach maturity, e.g. Mahogany trees takes about 100 years to mature
- soil erosion ... the roots of the tree hold the soil in

- greenhouse effect ... less trees to remove the greenhouse gases
- extinction of species ... destroying animal, insect and plant life

http://www.youtube.com/watch?v=HfQgmlwzRXg

4.3.6 List two examples of composite timbers



Chipboard

Plywood

4.3.7 Compare the characteristics of particle board, laminated woods (for example, plywood), pine wood (a softwood) and mahogany (a hardwood)
Consider composition, hardness, tensile strength, resistance to damp environments, longevity and the aesthetic properties of grain, colour and texture. The ability to produce sketches showing cross-sectional views of the structure of the materials is expected.

Task- Comparing particle board, plywood, pine and mahogany.
Resources needed: Testing timber samples of particle board, plywood, pine and mahogany

	Chipboard	Plywood	Pine	Beech
Composition				
Grain				
Colour				
Texture				
Hardness				
Tensile strength				
Resistance to dampness				
Longevity				

You will be given a sample of each material. Use the samples to make **observational comparisons** between each material. Here are the categories that you need to use:

- Composition (show the structure of the material as a hand-drawn cross-sectional view)
- Grain
- Colour
- Texture

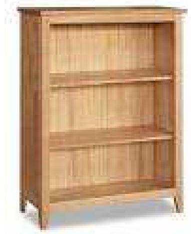
Now carry out some **comparative testing** to add to your sheet. In groups, devise and carry out a **test** to compare the following properties of each material:

- Hardness
- Tensile strength
- Resistance to dampness
- Longevity

For example; hardness is the ability of a material to withstand scratching. Can you design and make a simple test rig that will provide a comparison of each material's hardness?
Take digital photographs of your test rig and testing procedure. Present this with your sketches above on NO MORE THAN 2 sides of A3 paper.

4.3.8 Outline criteria for the selection of timber for different structural and aesthetic design contexts
As a designer and manufacturer consideration of timber for buildings, bridges, furniture and children's toys must be carefully considered. This is mainly due to the various properties and characteristics of timber and the product specifications.
E.g. Beech (Hardwood) is very hard and is therefore ideal for children's toys. As it is quite expensive it would not be suitable for building a house with and a different timber could be selected.

Task- Investigate the following products and identify a suitable timber for its use.

					
	Children's Toys	**IKEA Flat pack bookshelf unit**	**Modern Chair**	**Outdoor Garden chair**	**Indoor Book Shelf**
Timber choice					
Reason					

4.3.9 Describe the reasons for treating or finishing wood.
Consider reducing attack by organisms and chemicals, enhancing aesthetic properties and modifying other properties.

4.3.10 Explain three differences in the selection of timbers for flooring if it were made of a hardwood, a softwood or a composite material.
Consider durability, ease of maintenance and aesthetics.

4.4 Metals

4.4.1 Draw and describe a metallic bond

Metals are often described as positively charged nuclei in a sea of electrons. The outer electrons of the metal atom nuclei are free and can flow through the crystalline structure. The bonding is caused by attraction between the positively charged metallic atom nuclei and the negatively charged cloud of free electrons. Specific arrangements of metal atoms are not required.

4.4.2 Explain how the movement of free electrons makes metals very good electrical and thermal conductors

4.4.3 State that metals (pure or alloyed) exist as crystals

Crystals are regular arrangements of particles (atoms, ions or molecules). Details of types of crystals are not required.

4.4.4 Draw and describe what is meant by grain size

4.4.5 Explain how grain size can be controlled and modified by the rate of cooling of the molten metal, or by heat treatment after solidification

Reheating a solid metal or alloy allows material to diffuse between neighbouring grains and the grain structure to change. Slow cooling allows larger grains to form; rapid cooling produces smaller grains. Directional properties in the structure may be achieved by selectively cooling one area of the solid.

4.4.6 Define plastic deformation

4.4.7 Explain how metals work-harden after being plastically deformed

4.4.8 Describe how the tensile strength of a metal is increased by alloying

4.4.9 Explain the effect of alloying on malleability and ductility

The presence of “foreign” atoms in the crystalline structure of the metal interferes with the movement of atoms in the structure during plastic deformation.

4.4.10 Describe a superalloy

The strength of most metals decreases as the temperature is increased. Superalloys are metallic alloys that can be used at high temperatures, often in excess of 0.7 of their absolute melting temperature.

4.4.11 List two design criteria for superalloys

Consider creep and oxidation resistance.

4.4.12 Identify applications for superalloys

Superalloys can be based on iron, cobalt or nickel. Nickel-based superalloys are particularly resistant to temperature and are appropriate materials for use in aircraft engines and other applications that require high performance at high temperatures, for example, rocket engines, chemical plants.

4.5 Plastics

4.5.1 Describe a covalent bond
In a covalent bond the outer electrons of some atoms come close enough to overlap and are shared between the nuclei, forming a covalent bond. Each pair of electrons is called a covalent bond. Mention of sigma (σ), pi (π), double or triple bonds is not required. Covalent bonds are strong bonds and examples of primary bonds (as are metallic and ionic bonds).

4.5.2 Describe secondary bonds as weak forces of attraction between molecules

4.5.3 Describe the structure and bonding of a thermoplastic
Thermoplastics are linear chain molecules, sometimes with side bonding of the molecules but with weak secondary bonds between the chains.

4.5.4 Describe the effect of load on a thermoplastic with reference to orientation of the polymer chains
Deformation occurs in two ways:

- elastic, in which initially coiled chains are stretched and the material returns to its original size and shape when the load is removed
- plastic, when at higher loads the secondary bonds between the chains weaken and allow the molecular chains to slide over each other, and the material does not return to its original size and shape when the load is removed.

Creep and flow are important. No quantitative details are required.

4.5.5 Explain the reversible effect of temperature on a thermoplastic, with reference to orientation of the polymer chains
Increase in temperature causes plastic deformation.

4.5.6 Explain how the reversible effect of temperature on a thermoplastic contributes to the ease of recycling of thermoplastics

4.5.7 Draw and describe the structure and bonding of a thermoset
Thermoplastics are linear chain molecules but with strong primary bonds between adjacent polymer chains. This gives thermosets a rigid 3D structure.

4.5.8 Explain the non-reversible effect of temperature on a thermoset
Heating increases the number of permanent crosslinks and so hardens the plastic.

4.5.9 Discuss the properties and uses of polypropene and polyethene thermoplastic materials

4.5.10 Discuss the properties and uses of polyurethane and urea–formaldehyde (methanal) thermoset materials

4.5.11 Discuss the issues associated with the disposal of plastics, for example, polyvinyl chloride (PVC)
Although PVC disposal is problematic, PVC is still widely used as a structural material, for example, in windows and for guttering and drainpipes.

4.6 Ceramics

4.6.1 Describe the composition of glass
Glass is composed primarily of silicon dioxide together with some sodium oxide and calcium oxide and small quantities of a few other chemicals.

4.6.2 Explain that glass is produced from sand, limestone and sodium carbonate, and requires large quantities of energy for its manufacture
Scrap glass is added to new raw materials to make the process more economical.

4.6.3 Describe the characteristics of glass. 2 Consider brittleness, transparency, hardness, unreactivity and aesthetic properties

4.6.4 Explain that the desired characteristics of glass can be accurately determined by altering its composition
Consider soda glass and Pyrex®.

4.6.5 Outline the differences between toughened and laminated glass
Consider their responses to being deflected and to impact.

4.6.6 Explain why glass is increasingly used as a structural material
Consider the use of plate glass and glass bricks as wall and flooring materials. Consider material properties, for example, resistance to tensile and compressive forces, thermal conductivity and transparency. Consider aesthetic properties and psychological benefits: allows natural light into buildings and can visually link spaces, creating more interesting interiors.

4.7 Composites

4.7.1 Describe composites
Composites are a combination of two or more materials that are bonded together to improve their mechanical, physical, chemical or electrical properties.

4.7.2 Define fibre

4.7.3 Describe the matrix composition of composites

4.7.4 Explain that new materials can be designed by enhancing the properties of traditional materials to develop new properties in the composite material.

4.7.5 Describe a smart material
Smart materials have one or more properties that can be dramatically altered, for example, viscosity, volume, conductivity. The property that can be altered influences the application of the smart material.

4.7.6 Identify a range of smart materials
Smart materials include piezoelectric materials, magneto-rheostatic materials, electro-rheostatic materials, and shape memory alloys. Some everyday items are already incorporating smart materials (coffee pots, cars, the International Space Station, eye-glasses), and the number of applications for them is growing steadily.

4.7.7 Describe a piezoelectric material
When a piezoelectric material is deformed, it gives off a small electrical discharge. When an electric current is passed through it, it increases in size (up to a 4% change in volume). They are widely used as sensors in different environments. Specific details of crystalline structure are not required.

4.7.8 Outline one application of piezoelectric materials
Piezoelectric materials can be used to measure the force of an impact, for example, in the airbag sensor on a car. The material senses the force of an impact on the car and sends an electric charge to activate the airbag.

4.7.9 Describe electro-rheostatic and magneto-rheostatic materials
Electro-rheostatic (ER) and magneto-rheostatic (MR) materials are fluids that can undergo dramatic changes in their viscosity. They can change from a thick fluid to a solid in a fraction of a second when exposed to a magnetic (for MR materials) or electric (for ER materials) field, and the effect is reversed when the field is removed.

4.7.10 Outline one application of electrorheostatic materials and one application of magneto-rheostatic materials

- MR fluids are being developed for use in car shock absorbers, damping washing machine vibration, prosthetic limbs, exercise equipment, and surface polishing of machine parts.
- ER fluids have mainly been developed for use in clutches and valves, as well as engine mounts designed to reduce noise and vibration in vehicles.

4.7.11 Describe shape memory alloys (SMAs)
SMAs are metals that exhibit pseudo-elasticity and shape memory effect due to rearrangement of the molecules in the material. Pseudo-elasticity occurs without a change in temperature. The load on the

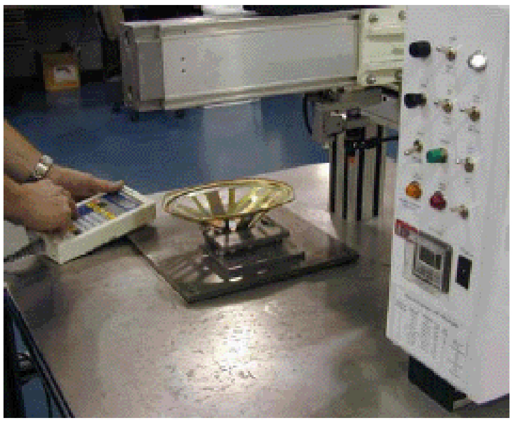
SMA causes molecular rearrangement, which reverses when the load is decreased and the material springs back to its original shape. The shape memory effect allows severe deformation of a material, which can then be returned to its original shape by heating it.

4.7.12 Identify applications of SMAs

Applications for pseudo-elasticity include eye-glasses frames, medical tools and antennas for mobile phones. One application of shape memory effect is for robotic limbs (hands, arms and legs). It is difficult to replicate even simple movements of the human body, for example, the gripping force required to handle different objects (eggs, pens, tools). SMAs are strong and compact and can be used to create smooth lifelike movements. Computer control of timing and size of an electric current running through the SMA can control the movement of an artificial joint. Other design challenges for artificial joints include development of computer software to control artificial muscle systems, being able to create large enough movements and replicating the speed and accuracy of human reflexes.

Topic 5

Product Development




5.1 Manufacturing techniques

5.1.1 Define manufacturing technique

A specific manufacturing term, sometimes relating to one material group only. Manufacturing is the making of goods by **physical labour** and machinery. It generally involves the conversion of raw materials into a finished product. Raw materials can include such items as fruit, cloth, wood and plastic. They are supplied from industries such as agriculture and mining.

Finished products include: Books, jeans and compact discs and are supplied to customers.

Cotton fields to Jeans

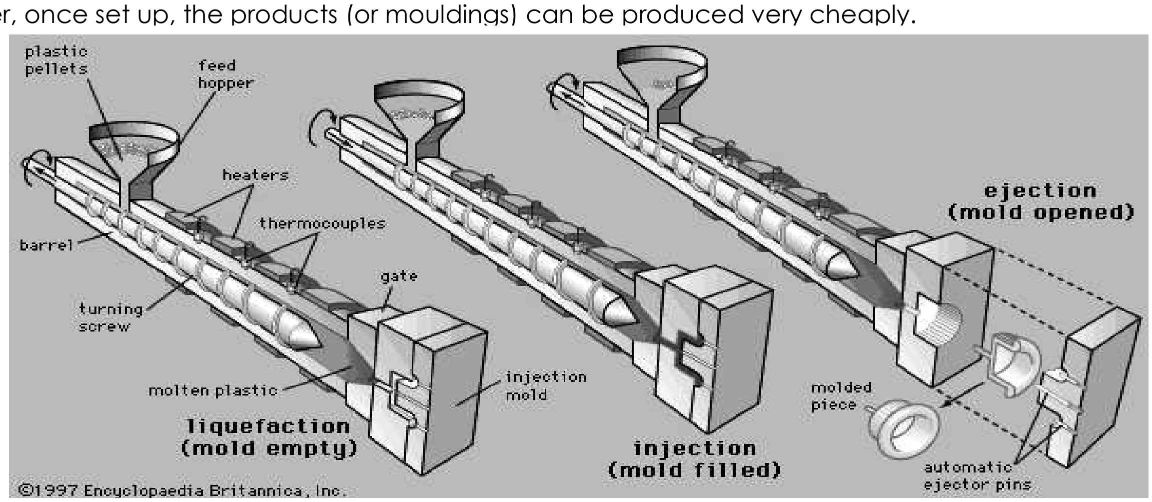
Trees to Books

5.1.2 Outline the techniques of moulding, casting, weaving, fusing, stitching, cutting, machining, abrading, using adhesives and using fasteners

Injection Moulding

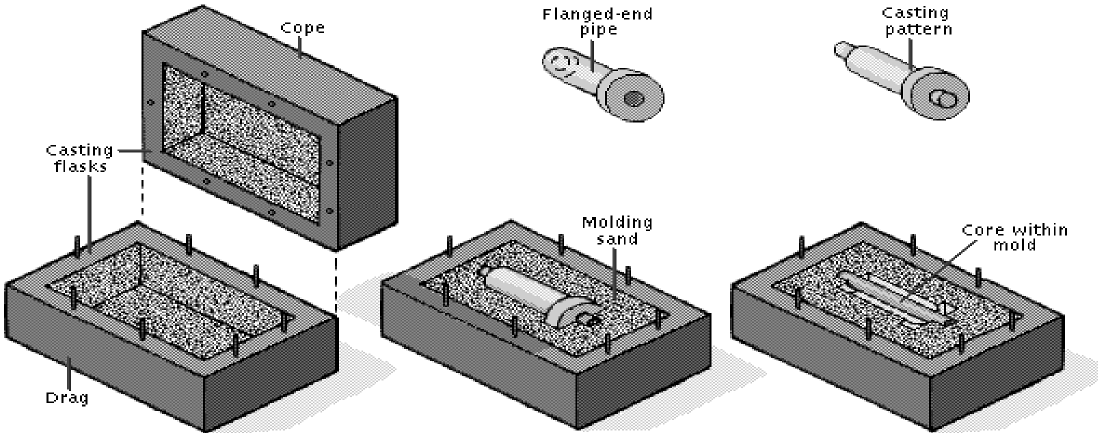
Injection moulding as its name suggests involves injecting molten thermoplastic into a mould under great pressure. The moulds can be very intricate and are often made in several pieces. Radio housings, computer casings, vacuum cleaners and watches are all made with injection moulding.

Injection moulding is widely used process for making products in volume. It would never be used for one-off or small batch production. This is because the tooling cost for the machines is very expensive. However, once set up, the products (or mouldings) can be produced very cheaply.



Casting

Casting is a method of shaping an object by pouring a liquid into a mould and letting it harden. The shaped object is called either a cast or a casting.

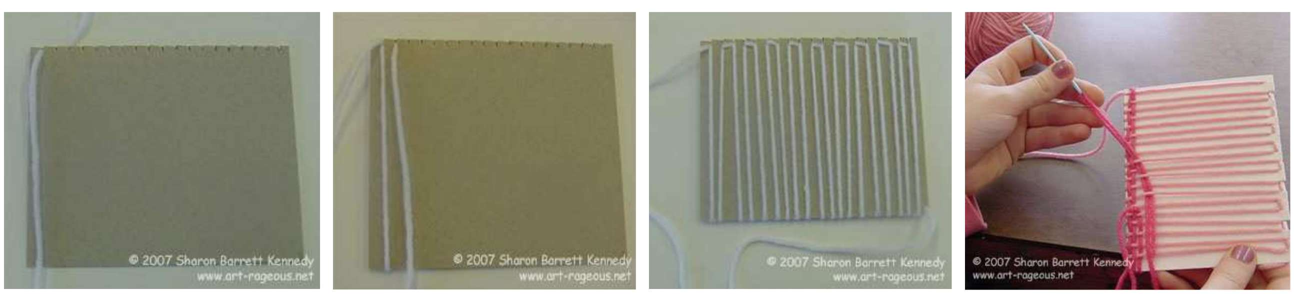


Casting is used to make thousands of articles, including tools, machine parts, toys, and art objects such as statuary. The Egyptians cast bronze in moulds over 3,500 years ago. Today, plastics, aluminium, ceramics, and many other materials are used in casting.

Weaving

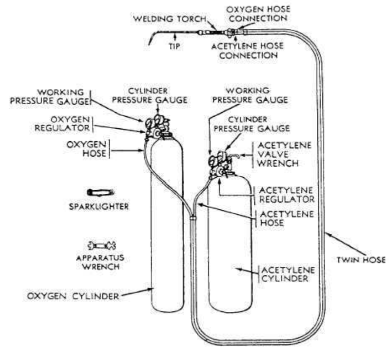
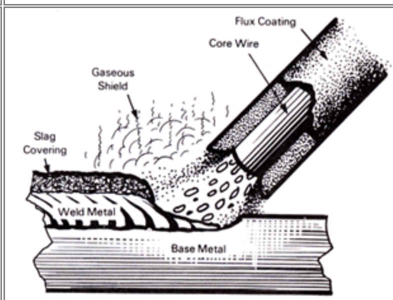
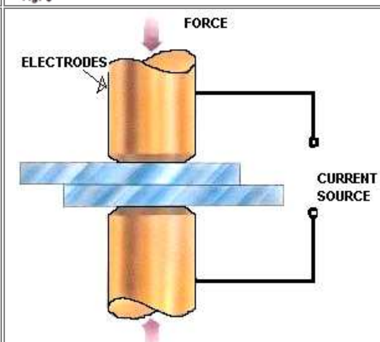
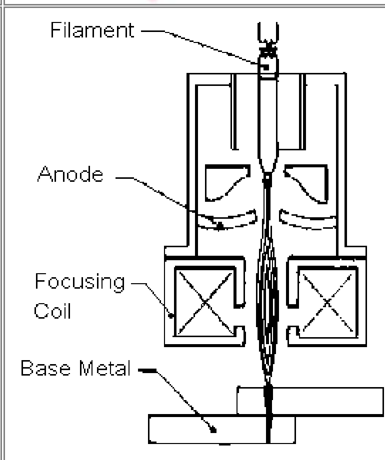
Weaving is the process of making cloth, rugs, blankets, and other products by crossing two sets of threads over and under each other. Weavers use threads spun from natural fibers like cotton, silk, and wool and synthetic fibers such as nylon and Orlon. But thin, narrow strips of almost any flexible material can be woven. People learned to weave thousands of years ago using natural grasses, leafstalks, palm leaves, and thin strips of wood.

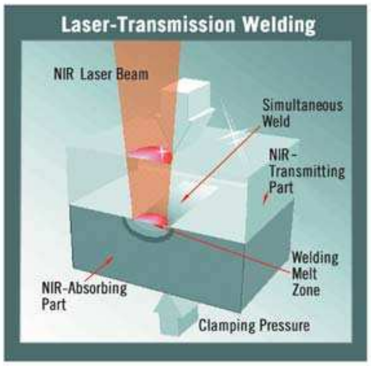
In general, weaving involves the interlacing of two sets of threads at right angles to each other: the warp and the weft. The warp are held taut and in parallel order, typically by means of a loom, though some forms of weaving may use other methods.



Task: Attempt a weave of your own using the above technique, how would you describe the process to a year 6 using pictures alone.

Fusing
Fusing involves the melting of metal by the application of heat.

Gas Welding		Mixed gases in the proper Proportions, directed against the parts to be welded. The molten edges of the parts then literally flow together, after cooling, form one solid piece.
Arc Welding	 Fig. 6	Arc welding electrode combines a central current carrying "core wire", which acts also as the filler rod, and a flux covering.
Spot Welding		Spot welding is used to weld various sheet metal products. The process uses two shaped copper alloy electrodes to concentrate welding current into a small "spot" and to simultaneously clamp the sheets together.
Electron Beam		Electron Beam Welding (EBW) is a fusion joining process that produces a weld by impinging a beam of high energy electrons to heat the weld joint. Raising electrons to a high energy state by accelerating them to roughly 30 to 70 percent of the speed of light provides the energy to heat the weld.

<table>
<tr>
<td>Laser</td>
<td>
</td>
<td>Laser Beam Welding (LBW) is a modern welding process; it is a high energy beam process that continues to expand into modern industries and new applications because of its many advantages like deep weld penetration and minimizing heat inputs.</td>
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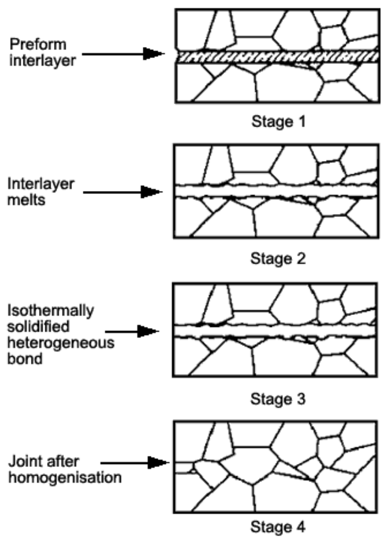
<tr>
<td>Diffusion Bonding</td>
<td>
</td>
<td>Diffusion bonding involves holding pre-machined components under load at an elevated temperature usually in a protective atmosphere or vacuum. Times at temperature can range from 1 to 60+ minutes, but this depends upon the materials being bonded.</td>
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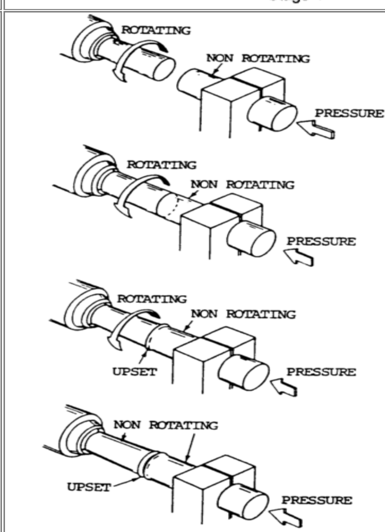
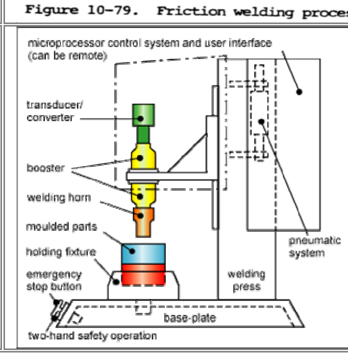
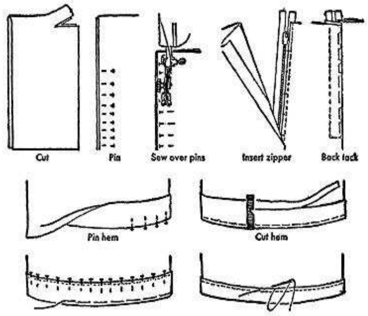
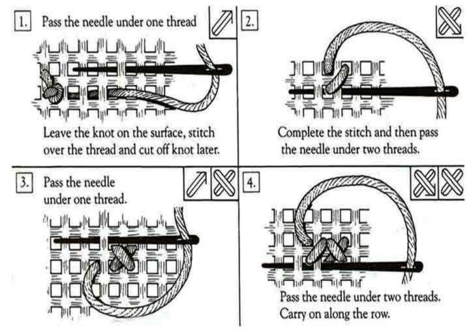
<tr>
<td>Friction Welding</td>
<td>

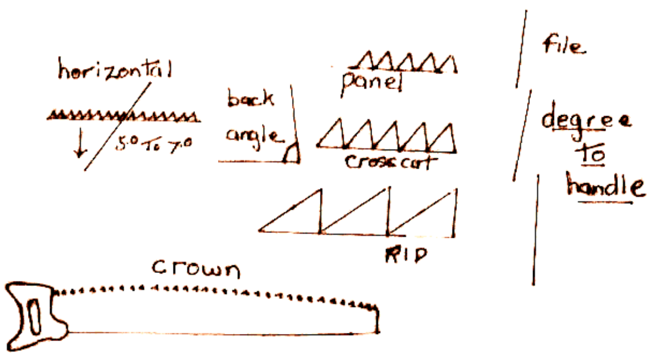
Figure 10-79. Friction welding process.</td>
<td>Friction welding (FW) is processes that generates heat through mechanical friction between a moving work piece and a stationary component. Technically, because no melt occurs, friction welding is not actually a welding process in the traditional sense, but a forging technique. Friction welding is used with metals and thermoplastics in a wide variety of aviation and automotive applications.</td>
</tr>
<tr>
<td>Ultrasonic Welding</td>
<td>
</td>
<td>Ultrasonic welding is an industrial technique whereby high-frequency ultrasonic acoustic vibrations are locally applied to work pieces being held together under pressure to create a solid-state weld. It is commonly used for plastics, and especially for joining dissimilar materials. In ultrasonic welding, there are no connective bolts, nails, soldering materials, or adhesives necessary to bind the materials together.</td>
</tr>
</table>

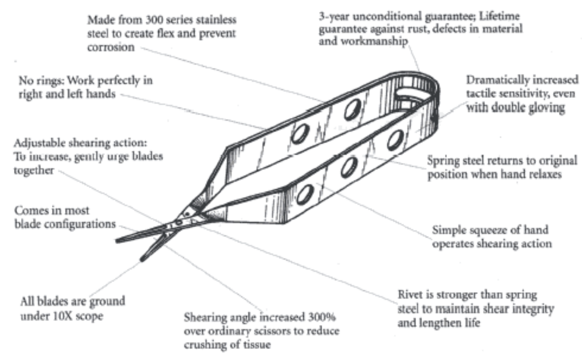
Stitching
Joining of cloth, leather, furs, bark, or other materials, using needle and thread. Its use is nearly universal among human populations and dates back to 30,000 BC. Stitching predates the weaving of cloth.



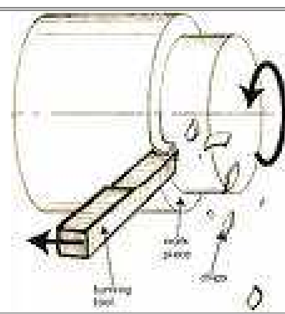



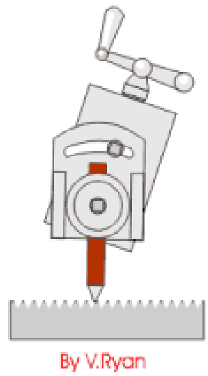
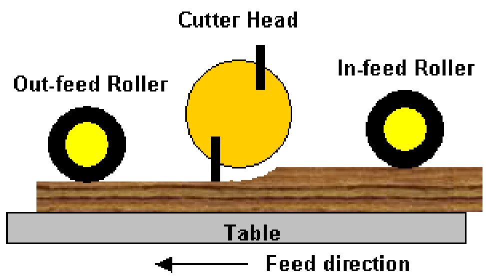
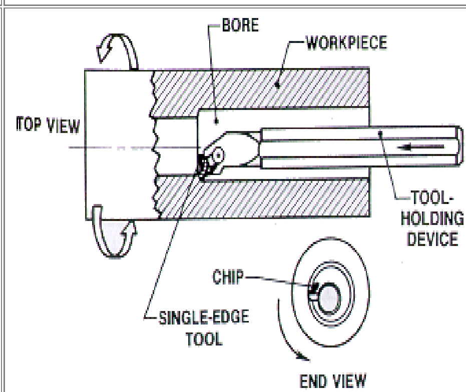
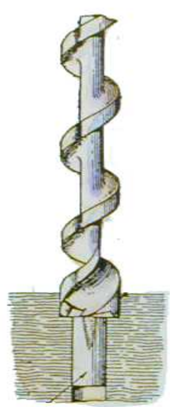
Cutting
Cutting is the separation of a physical object, or a portion of a physical object, into two portions, through the application of an acutely directed force. For an object to be capable of cutting it must have a hardness sufficiently larger than the object being cut, and should be applied with sufficient force. Cutting also describes the action of a saw which removes material in the process of cutting.

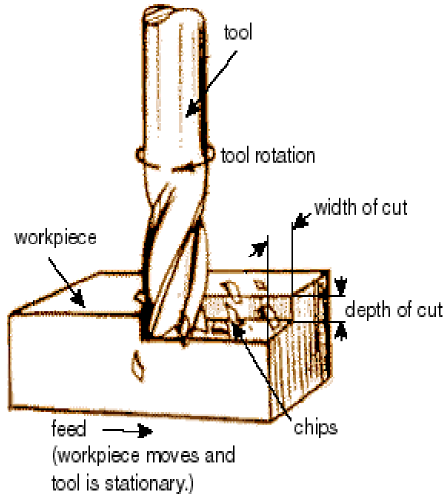
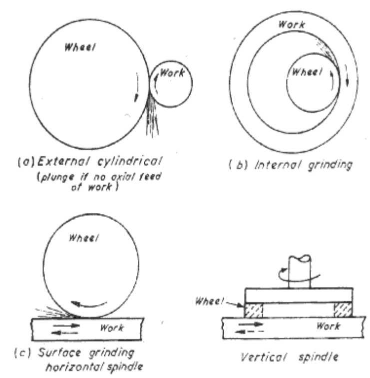




Machining
Powered machines that shape metals and other materials through a variety of cutting or grinding processes, machine tools operate on unfinished metal parts, such as rough metal castings o forgings, and perform shaping and finishing operations that produce precisely dimensioned parts.
Most machine tools function in one or more of several basic categories: turning, shaping and planing, boring, drilling, and milling and grinding.

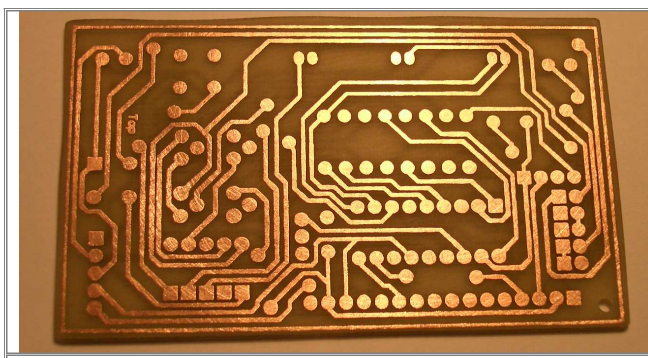
Turning		The engine lathe is the oldest and most common turning machine. It is used for shaping the external surface of a cylindrical part by rotating the work piece against a cutting tool. The turret lathe carries a number of cutting tools that can be used in sequence to shape, drill, bore, ream, and cut threads on both exterior and interior cylindrical surfaces.

Shaping		In shaper operations the cutting tool moves against a stationary work piece, which is usually held on a horizontal table.
Planing		These machines remove metal from flat surfaces. In the planing machine the work piece moves beneath a stationary cutting tool. Planers can shave even layers off a metal surface or cut multiple grooves and channels.
Boring		Boring is the process of enlarging a hole that has already been drilled (or cast), by means of a single-point cutting tool, for example as in boring a cannon barrel. Boring is used to achieve greater accuracy of the diameter of a hole, and can be used to cut a tapered hole.
Drilling		Drilling is the process of using a drill bit in a drill to produce cylindrical holes in solid materials.

Milling		The rotating cutting tool in a milling machine is usually toothed and is used to cut a variety of shapes, from flat-planed surfaces to slots, grooves, shoulders, and dovetails. Milling machines are used to cut gears.
Grinding	 GRINDING OPERATIONS	In grinding, metal is removed from the surface of a work piece to make it smooth. A grinding machine has a grinding wheel that spins at high speed against the work piece. This wheel is made of an abrasive material similar to that on sandpaper.

Abrading

To wear down or rub away by friction, also known as a wasting process because the piece that is removed is usually referred to as 'waste'. Using this forming process you create a new form or component by removing or cutting away any surplus material. This can be achieved by several means, such as:

	
Chemical (etching)	Mechanical

5.1.3 Describe how the techniques in 5.1.2 relate to different materials

Task: Using ticks or crosses (√ or x) complete the Materials/ Manufacturing Techniques below

For example, casting relates to metals, plastics, food, ceramics and some composites, but not to timber or textiles.

	Metals	Plastics	Food	Ceramics	Textiles	Timber
Moulding						
Casting	√	√	√	√	x	x
Weaving						
Stitching						
Fusing						
Cutting						
Abrading						
Fasteners						
Adhesives						
Machining						

5.1.4 Discuss advantages and disadvantages of using the techniques to manufacture products

The manufacturing technique depends on the material to be processed, the amount of components needed and the type of component required. Other factors contributing to the advantage or disadvantage of technique selection would be production location and environmental issues concerned.

5.2 Craft production

5.2.1 Define craft production and one-off production.

Craft production (or One-off Production) is the process of manufacturing by hand with or without the aid of tools. The term Craft production refers to a manufacturing technique applied in the hobbies of Handicraft but was also the common method of manufacture in the pre-industrialized world.

5.2.2 Describe why most products were manufactured by craft techniques prior to the Industrial Revolution

Prior to the Industrial Revolution most products were manufactured by craft techniques. The processes, techniques and materials that were used were restricted by the technology and energy sources that were available at the time. The development of skills were slow; sources of materials and energy were few and would depend on the immediate surrounding areas; sales and distribution were workshop and market based; the craftsman was also the designer as was the the client also the consumer.

5.2.3 Explain the advantages and disadvantages of craft production

Task: Which of the following are advantages and which are disadvantages?

- Variable production costs are high, particularly labour costs, but fixed costs are low.
- Expensive form of production.
- Difficult to organise if production is technically complex.
- Worker motivation enhanced. Each new job presents a different challenge, so they need to be adaptable.
- Workers gain satisfaction from being responsible for the complete product.
- Skilled workers needed with a high degree of technical expertise and the ability to adapt. Can be large workforce if a technically complex project is involved.
- Very flexible system, enables large variety of products to be manufactured, geared to customer specification.
- Manufacture of a single product or small quantity.
- Selling aimed at particular customers or firms in specialised markets

5.2.4 Discuss the importance of craft production for developed and developing countries

In pre-industrial cities, craftsmen tended to form associations based on their trades, confraternities of textile workers, masons, carpenters, carvers, glassworkers, each of whom controlled secrets of traditionally imparted technology, the "arts" or "mysteries" of their crafts. Usually the founders were free independent master craftsmen.

Before a new employee could rise to the level of mastery, he had to go through a schooling period during which he was first called an apprentice. After this period he could rise to the level of journeyman. Apprentices would typically not learn more than the most basic techniques until they were trusted by their peers to keep the guild's or company's secrets.
In a developing country a guild can be said to some aspects of the modern corporation. They have control over the materials and tools, needed to produce goods. They are early forms of small business associations.

5.3 Mechanization

5.3.1 Define mechanization

Watch this: Chocolates http://www.youtube.com/watch?v=wQppu2jkIwE

Mechanization is defined as: *"A volume production process involving machines controlled by humans"*.

In other words, machinery is used to carry out some or all of the repetitive tasks in a production process. Mechanization might involve the following elements:

- Using jigs and templates to ensure *quality control*.
- Using conveyor belts to control the *rate of production* and to keep components flowing from one process to the next.
- Using Robots to assemble complex machinery such as a car.

Task: Why is mechanization well suited to volume production and not to one-off or small batch production?

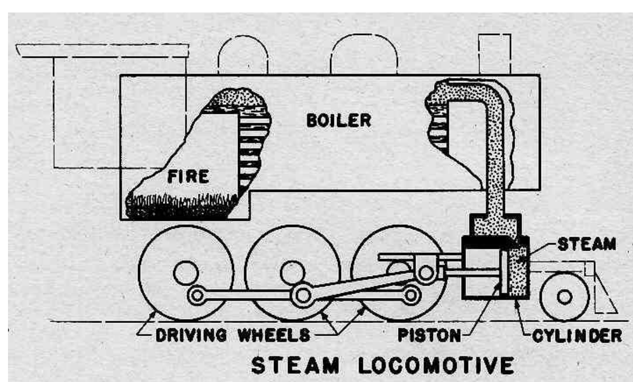
5.3.2 Describe how the availability of new sources of power in the Industrial Revolution led to the introduction of mechanization

The only source of portable energy prior to the Industrial Revolution was human muscle power and animal power. Tools were designed to be used only with these energy sources. Even though it was possible to harness heat energy from fire (for example to forge metal), the limitation is that **the energy source** (timber and coal) **depended upon local availability**.

The water wheel enabled the harnessing of energy for batch production. However, the water wheel had a **fixed location** next to a fast-flowing river and so **lacked adaptability**. However, the energy from water could be harnessed at many points along the river, resulting in the first batch and mass- manufacturing developments in textiles and ironwork. Because the wheel creates **rotary motion**, the motion could easily be converted into linear, oscillating and reciprocating forms to carry out a variety of tasks. An oscillating hammer could be used to forge metal for example.

Steam engines.

A real breakthrough came in 1712 with the manufacture of the world's first steam engine. The principle is very simple: Water is heated until it boils and becomes steam. The steam is contained in a cylinder and creates pressure. The pressure can be used to make a cylinder reciprocate (move backwards and forwards in a straight line). This motion is converted to rotary motion using mechanisms. You can see this principle in action on a steam locomotive.



This meant that for the first time, power could be transported (you did not need to be next to a river, timber or coal source to create energy). This really was the beginning of the mass production age and unfortunately, the source of many of today's global energy and environmental problems.

5.3.3 Define assembly-line production
Assembly-line production is defined as: *"The mass-production of a product via a flow line based on the interchangeability of parts, pre-processing of materials, standardization and work division."*

Put more simply, it means the following:

- Each manufacturing **task** is **divided up** into basic stages.
- Each stage is carried out using specialist labour and equipment (**work division**).
- A flow line (like a conveyor belt) moves each part from one stage to the next. This controls the **rate of production** (how fast it is made).

This makes *each individual task repetitive*. These repetitive tasks are increasingly carried out using control technology (robots).

Charlie Chaplin made a great movie in 1936 about the impact of assembly line production on society called 'Modern Times'. Watch this clip: Modern Times http://www.youtube.com/watch?v=qDnDaDYZ2AQ

Task: Was Charlie Chaplin's vision of the future correct? Discuss.

5.3.4 Explain the relevance of assembly-line production to mechanization.

and

5.3.5 Outline two advantages and two disadvantages of mechanizing a production process

Hopefully you can see how assembly-line production and mechanization are related. You can't have one without the other! This table summarizes this relationship:

	Assembly line	**Mechanization**
Which came first?	First	Second
Why?	This split tasks into stages (work division)	Specialist machinery can then carry out the repetitive tasks.
Economics	More efficient. Products are manufactured at a controlled rate and with increased quality.	Even more efficient. Less labour Intensive, production can be continuous.
Design of products	Less adaptable. Changes to product design are harder to implement.	Products become identical. Less flexibility to adapt to new designs (this is now changing with the development of 'mass customization'.
Effect on the work force	Tasks are repetitive. Workers Become skilled in a single process. Labour is used more efficiently. Health and safety issues arise (repetitive strain etc.)	Minimal labour required. Labour is used mainly to oversee automated processes. Higher unemployment.
Consumer choice	Reduced. Products become similar.	Minimal. Your products are identical. Note that 'mass customization' is changing this.
Summary:	**Advantage 1**	Reduced cost of product for consumer.
	Advantage 2	Increased reliability and product quality.
	Disadvantage 1	Reduction in labour needed leading to unemployment.
	Disadvantage 2	Re-skilling of workers needed to maintain mechanized processes.

5.3.6 Define batch production and mass production.
Batch production: *"Limited volume production (a set number of items to be produced)"*

Mass production: *"The production of large amounts of standardized products on production lines, permitting very high rates of production per worker"*

5.3.7 Compare batch production and mass production in a mechanized production system
Watch the following movie clips. Decide whether each is an example of **batch production** or **mass production.** What evidence is there to support your choice?

Magnum http://www.youtube.com/watch?v=7hXfFfGMT_M
Shoelaces http://www.youtube.com/watch?v=8HHluPK9zWg
T-shirt http://www.youtube.com:watch%3Fv=HVZh07CfJSw%0D
Surfboard http://www.youtube.com/watch?v=FR8SndoR2RQ

Summary:

Task: Complete the following table to show how batch-production and mass-production compare:

	Batch production	**Mass production**
Market need (explain which types of markets demand which scale of production).		
Consumer choice (how does each system affect consumer choice?)		
Product differentiation (in what ways Are products similar and different?)		
Economies of scale (how does each System affect costs for manufacturer and consumer?)		

5.4 Automation

5.4.1 Define automation
The term automation refers to a wide variety of systems and processes that operate with little or no human intervention. In most modern automation systems, control is exercised by the system itself, through control devices that sense changes in such conditions as:

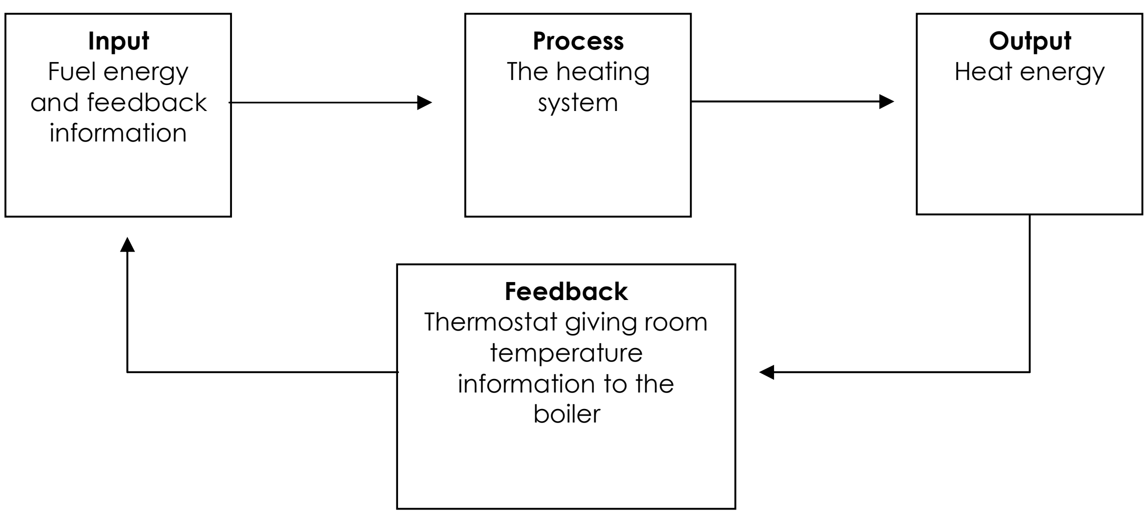
AC Temperature controls

Automatic water bowl for a Pet

Auto Volume Control

These devices then command the system to make adjustments to compensate for these changes. Most modern industrial operations are too complex to be handled manually or even with simple machines under manual control.

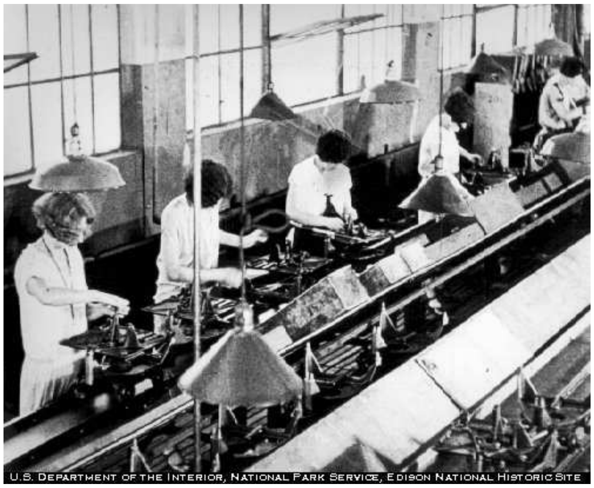
All automated systems depend on feedback to control their performance. The basic elements of feedback can be illustrated by a home heating system.



Essential to all automatic-control mechanisms is the feedback principle, which enables a designer to endow a machine with the capacity for self-correction. A feedback loop is a mechanical, pneumatic, or electronic device that senses or measures a quantity such as position, temperature, size, or speed.
It compares the measurement with the previous measurement and takes whatever preprogrammed action is necessary to maintain the measured. Using feedback devices, machines can start, stop, speed up, slow down, count, inspect, test, compare, and measure.

5.4.2 Describe how the development of computer and information technology in the "technological revolution" led to the introduction of automation

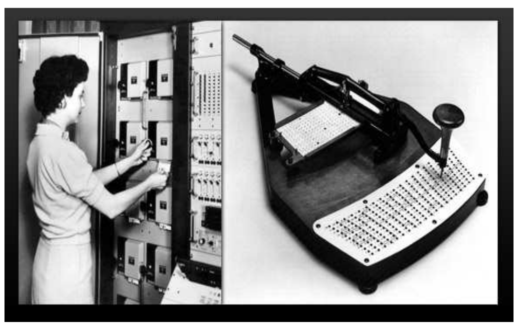
The development of computer and information technology in the Technological Revolution led to the introduction of automation via computer controlled electrically powered assembly line procedures. Automation has made a major contribution towards increases in both free time and real wages enjoyed by most workers in industrialised nations.

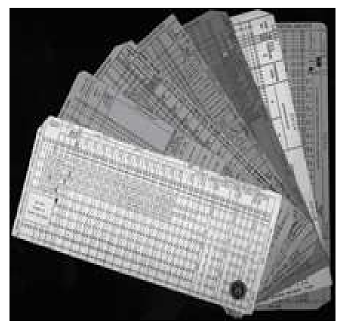


Mechanised Assembly Line


Automated Assembly Line

Computers and feedback loops have promoted the development of numerically controlled machines (the motions of which are controlled by punched paper or magnetic tapes) and machining centres (machine tools that can perform several different machining operations).


A punch card reader and writer


Punch cards

Applications

- The chemical industries developed the technology of automation to regulate variables such as pressure and temperature that are involved in the production of chemicals.
- The food industries found that packaging, bottling, and sealing operations, as well as the production of food products, could be accomplished more efficiently by the use of automated systems.
- The methods of automation were refined with the development of aircraft guidance systems and automatic pilots.
- The development of digital computers, which can monitor external conditions and make appropriate adjustments to a system, added further impetus to the applications of automation.
- An entire oil refinery can be operated by just four persons.
- Industrial robots perform numerous functions on assembly lines, and automated spacecraft on deep-space probes are programmed automatically to make adjustments in operations.
- In our homes, thermostats control the temperature in automated heating and air-conditioning systems, in refrigerators, and in water heaters.
- In medicine, cardiac pacemakers regulate the heart rate of people with heart disorders.

5.4.3 Define computer-aided manufacture (CAM) and computer numerical control (CNC)

When CAD systems are linked to manufacturing equipment which is also controlled by computer, they form an integrated CAD/CAM (**Computer-Aided Manufacture**) system. CAM equipment relies on a series of numeric codes, stored in computer files, to control manufacturing operations This Computer Numeric Control (CNC) is provided by describing machine operations in terms of the special codes and component shape geometry, and building specialised computer files or “part programs”. The development of these part programs is a skilled task, now largely superseded by specialised computer software, which forms the link between CAD and CAM systems.

5.4.4 Explain how CAD, CAM and CNC contribute to an automated production system

Consider the wide variety of systems available.

CAM offers significant advantages over more traditional approaches by controlling manufacturing equipment with computers instead of human operators. CAM equipment is usually associated with the elimination of operator error and the reduction of labour costs. However, the consistent accuracy and predicted optimum use of the equipment lead to even more significant advantages. For example, cutting blades and tools will wear more slowly and break less frequently, reducing manufacturing costs still further. Against these savings should be set the higher costs of capital equipment or the possible social implications of maintaining productivity with a reduced workforce.

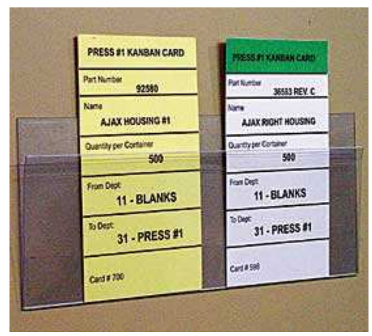
5.4.5 Define just-in-time (JIT) and just-incase (JIC)

History

Toyota's most famous discovery; just in time (JIT).

To reduce the space occupied, and money tied up, by high buffer stocks of materials and work in progress, Toyota devised a card ordering system known as kanban.

The rule was that no components would be made, or supplies ordered, unless the instruction was given by the kanban. If an assembly worker fitted eight left-hand car doors, a kanban would be sent to the door production team, which would produce another batch of eight.



Kanban Cards in use

In theory these would arrive, just in time before the assembly worker's remaining stock ran out. At first, the new system caused chaos, as parts arrived late and suppliers complained about making frequent deliveries of small batches.

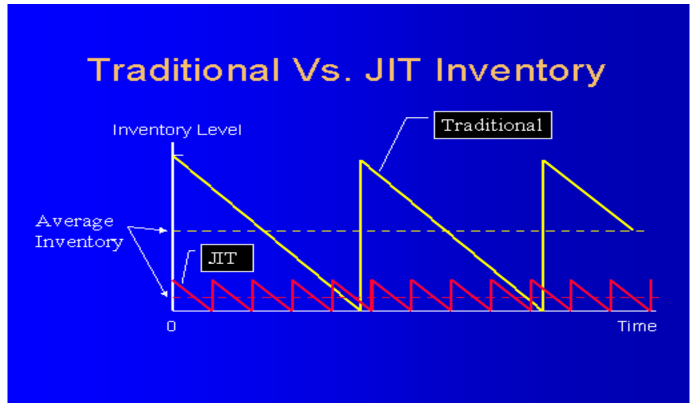
DD = Daily demand (units)
LT = Replenishment leadtime (days)
SS = Statistically calculated safety stock (units)
SQRT = Square root
TB = Time bucket of the safety stock data points (days)
KB = Quantity per kanban (units)
EPEI = Supplier’s replenishment interval (days)

No. of kanban = (DD*LT+SS*SQRT(LT/TB))/KB+(DD*EPEI)/KB

Kanban Card and Calculation

Yet, Toyota soon realised that the knife-edged nature of this system was its very strength. If a faulty batch of components to the door production team caused a halt to the final assembly line, the supplier was soon threatened with quality improvements or paying for the lost output. Existing with only an hour's worth of buffer stock ensured that every production, supply or quality fault would be acted on quickly, or else be clear for all to see.

Once Toyota applied all aspects of the just-in-time process, they realized that change would constantly be needed. Therefore, the concept of "Kaizen," continuous improvement, was put into the process as well. For almost a decade, Toyota and its suppliers were alone in the use of the Toyota Production System. By the late 1970's, other Japanese automobile manufacturers began to take Toyota's ideas and put them to practical use. Mazada, Honda, and Nissan all adopted the concept of just-in-time to continue



Inventory level chart of JIT and traditional

By 1990, Toyota was producing over four million cars a year, far outstripping any European or Japanese producer and rival the American giants, Ford and General Motors.

Definition

JIT (Just in time) is the most used and recognized lean manufacturing technique. The correct definition of just-in-time is having the right part at the right place in the right amount at the right time. This technique shortens cycle times, decreases the amount of inventory that a company carries, leads to low work-in-process (WIP), and creates a flexible atmosphere for the type or amount of product that a company would like to run and most of all streamlines work flow through a manufacturing facility.

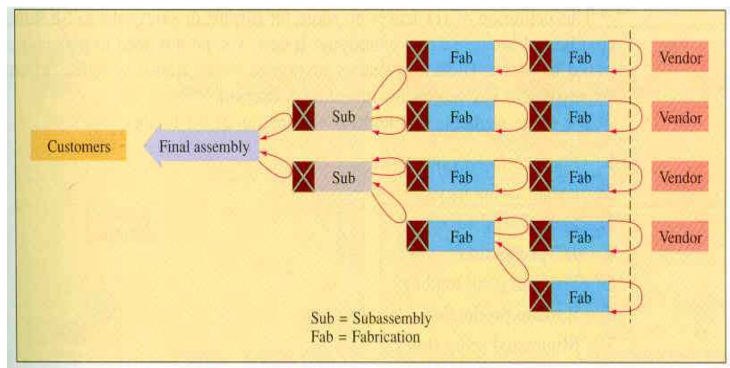


Illustration of the JIT process

Companies will adopt a modular/ cellular production approach, where each cell will produce it's component when it is required. More cells equals more safety.

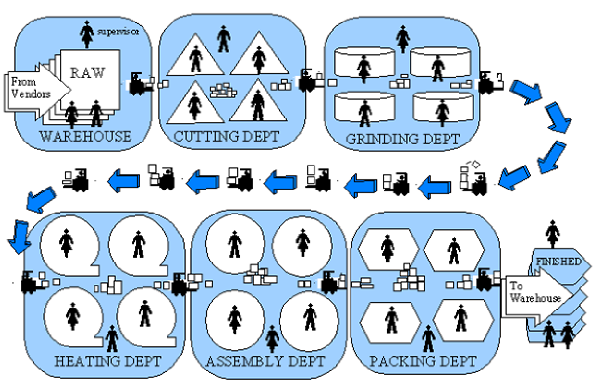


Illustration of traditional production process

JIC (Just in case) is very different from the previously defined JIT system, companies using the JIC technique carry spare stock 'just in case' they need them. Stock would usually consist of main problematic components, components known to need replacing, some will stock components that are very difficult to come by, they are timely to import or manufacture. In the traditional sense JIC practices keep a lot of inventory.

5.4.6 Explain the advantages of JIT and JIC to manufacturing
As most companies use an inventory system best suited for their company, the Just-In-Time Inventory System (JIT) can have many benefits resulting from it. The main benefits of JIT are listed below.

Advantages of JIT
1. Set up times are significantly reduced in the factory.
2. The flows of goods from warehouse to shelves are improved.
3. Employees who possess multiple skills are utilized more efficiently.
4. Better consistency of scheduling and consistency of employee work hours.
5. Increased emphasis on supplier relationships.
6. Supplies continue around the clock keeping workers productive and businesses focused on turnover

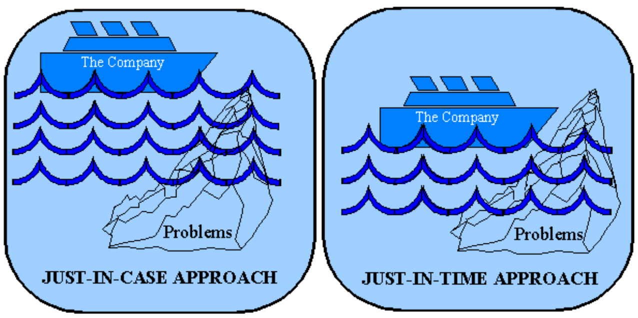


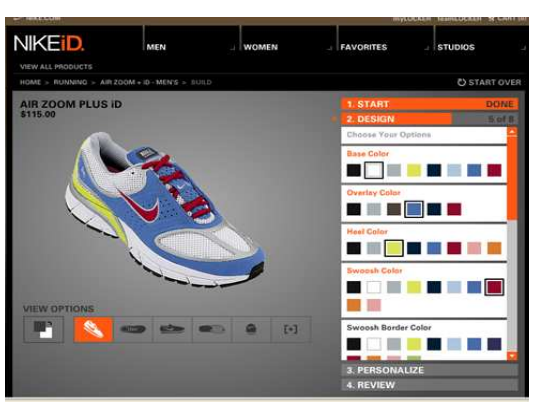
Illustration showing Ohno's Analogy

Ohno's analogy of JIT and JIC;
There the company (the boat) floats on a sea of inventory, lurking beneath the sea are the rocks, the problems that are hidden by the sea of inventory.
if we reduce the inventory level then the rocks become exposed, Now the company can see the rocks (problems) and hopefully solve them before it runs aground!

Advantages of JIC
1. Company can rely on safety stock
2. No problems with the implementation of JIT (Japanese and Western culture differences)
3. No loss of individual autonomy, workers work as a whole entity not as part of a cell
4. No Loss of team autonomy This is the result of increasing buffer inventories lead to a higher flexibility of the workers to solve problems as a team.
5. Relationship between management and employees is closer than with JIT
6. Employee motivation is to complete not to compete.
7. Production level JIC works best for low to medium range of production volume.

5.4.7 Define mass customization
"producing goods and services to meet individual customer's needs with near mass production efficiency"
Tseng and Jiao (2001, p. 685)

A sophisticated CIM (Computer Integrated Manufacturing) system that manufactures products to individual customer orders. The benefits of economy of scale are gained whether the order is for a single item or for thousands.



5.4.8 Outline how mass customization is changing the relationship between the manufacturer and the consumer
The relationship is akin to craft production, where the individual requirements of the consumer dominate.

Today's turbulent markets and the internet *Mass Customization* is the new paradigm that replaces mass production, which is no longer suitable growing product variety, and opportunities for e-commerce. Mass customization *proactively* manages product

variety in the environment of rapidly evolving markets and products, many niche markets, and individually customized products sold through stores or over the internet.[1]
Many industries have found that lengthy supply-chains, and the economics of configurability do not allow them to economically offer mass customization.

Famously, some of the early businesses attempting mass customization (e.g. in bicycle production) went out of business. In 1999 boosters of the mass customization trend proffered Cannondale as the exemplar of the new model. "Cannondale [...] for example can configure over 8 million different frame and colour variations in its bicycles."

Although the company's subsequent bankruptcy in 2003 was blamed on other causes (including a failed attempt to enter the motorsports market) the mass customization "revolution" certainly failed to save it, and it was dropped as a role model by some business gurus

5.4.9 Discuss the impact of automation on working conditions
Consider nature and type of employment, health and safety issues, social interaction and job satisfaction.

Automation raises several important social issues. Among them is automation's impact on employment. English textile workers in the early 1800s who protested against Jacquard's automated weaving looms destroyed automated textile machines because they felt their jobs threatened.
Some argue automation leads to *higher* employment. One author made the following case. When automation was first introduced, it caused widespread fear. It was thought that the displacement of human workers by computerized systems would lead to severe unemployment. In fact, the opposite has often been true, e.g., the freeing up of the labor force allowed more people to enter higher skilled jobs, which are typically higher paying. One odd side effect of this shift is that "unskilled labor" now benefits in many "first-world" nations, because fewer people are available to fill such jobs.
It appears that automation does devalue labour through its replacement with less-expensive machines; however, the overall effect of this on the workforce as a whole remains unclear.

Advantages
- Automation has greatly increased production and lowered costs, thereby making cars, refrigerators, televisions, telephones, and other goods available to more people.
- It has allowed production and wages to increase, and at the same time the working week has decreased in most Western countries from 60 to 40 hours.
- In an automated system, health and safety can be monitored with more efficiency due to the repetitive nature of the work process. The 'human error' is reduced.
- Provides opportunities for the "unskilled" labour force.

Disadvantages
- Workers will have little variety in their job and could result in low job satisfaction.
- Social interaction during work times will be cut, lunch and break may be at different times for each worker so as to keep production at an efficient level.

5.4.10 Outline how automation has improved the type and range of products available to consumers
Many products require such precision in their manufacture that, without automation, it would not be possible to produce them at an affordable price.

To meet increasing demands for productivity gains, manufacturers continually ask factory workers to do more with less equipment, and in less factory floor space. The most automated assembly lines make factory floors as efficient as possible, boosting the bottom line in highly competitive manufacturing markets.

Adding the latest in robotics and assembly line conveyor systems can help manufacturers meet the stiff challenges they face. With smaller robotic cells, toploading robots mounted on gantries, new vision-based robots, simulation software for visualizing robotic cells, and more efficient assembly line equipment, manufacturers can boost productivity and remain competitive.

Manufacturing Engineering, Feb 2004 by Waurzyniak, Patrick

Automation has greatly increased production and lowered costs, thereby making cars, refrigerators, televisions, telephones, and other goods available to more people.

Automation within society

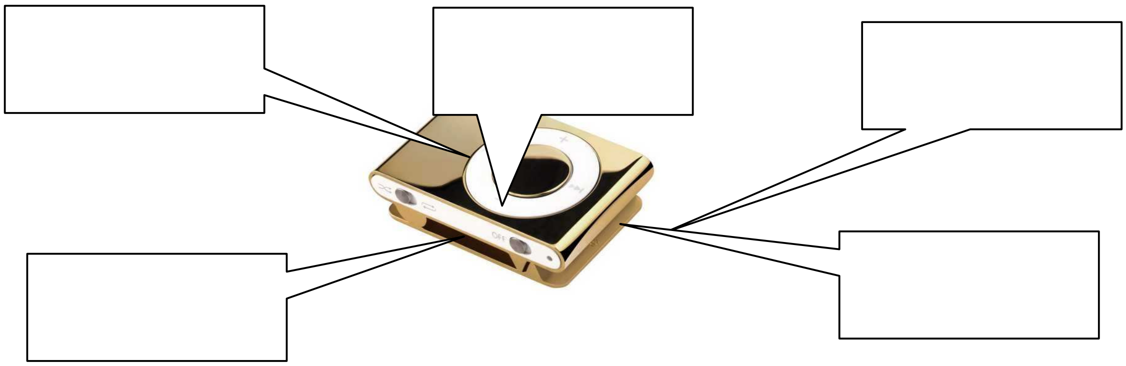
Millions of human telephone operators and answerers, throughout the world, have been replaced wholly (or almost wholly) by automated telephone switchboards and answering machines. Thousands of medical researchers have been replaced in many medical tasks from 'primary' screeners in electrocardiography or radiography, to laboratory analysis of human genes, sera, cells, and tissues by *automated systems*. Even physicians have been partly replaced by remote, automated robots and by highly sophisticated surgical robots that allow them to perform remotely and at levels of accuracy and precision otherwise not normally possible for the average physician.

5.5 Economic considerations

5.5.1 List the costs that contribute to the final cost of a product.

***** When you buy any product, you are not just paying for the materials that it is made from. *****

Apart from the material costs, can you think of five other costs? Write them in the spaces provided.



Task: Are there any others?

Task: See if you can define the term for each of the costs below. The first has been done for you as an example. You can **click and drag over the empty cells and change the font** colour to reveal the correct answers.

Definition:	Cost term:
1. Whether the product is a one-off, batch, mass or volume produced.	**Scale of production**
2. Whether the product has simple or advanced features	
3. All the energy, materials, labour, etc. that are needed to make the product.	
4. The abilities of the people involved in manufacture.	
5. The systems that are used to maintain standards.	
6. The physical mass of the product.	
7. Space required for the product, materials, components to be kept.	
8. Moving the product to where it will be sold.	
9. Making target markets aware of the product's existence.	
10. Matching the product and potential target market.	
11. The amount of money left after costs have been subtracted.	
12. Money paid to the government after products have been sold.	
13. Ensuring that the product is easily accessible to a target market.	
14. Getting the right materials at source.	
15. Creating new ideas for future products.	
16. The employment of individuals.	
17. All aspects of assembly and production.	
18. Money invested in land, buildings, machinery, etc.	
19. The indirect costs of running a business i.e. rent, administration, etc.	
20. Getting the product from its place of manufacture to place of sale.	
21. Products and services given in exchange for money	

5.5.2 Define fixed costs and variable costs.
Fixed costs: "The costs that must be paid out before production starts, for example, machinery. These costs do not change with the level of production."

Variable costs: "Costs that vary with output, for example, fuel or raw materials."

5.5.3 Identify the factors in 5.5.1 as fixed costs or variable costs
Task: Go back to the table on the previous page. For each of the costs listed, indicate whether it is fixed or variable by adding F or V to the first column.

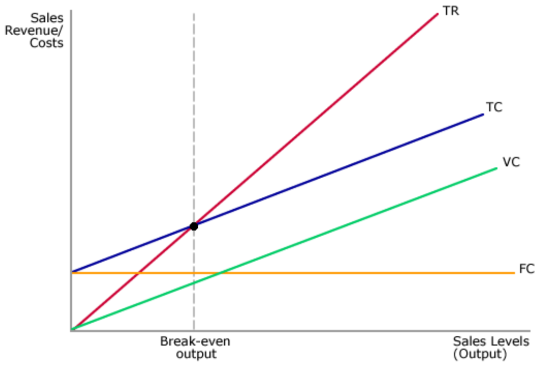
5.5.4 Explain how the costs in 5.5.1 relate to craft production, mechanization and automation
Task: Let's take another look at the list of costs. For each cost, you need to state whether it will be relatively **HIGH, MEDIUM,** or **LOW** for each scale of production.

Example:

i. A **hand-crafted table** will have **HIGH material costs** and **labour costs** and the **capital costs would be LOW.**
ii. A **mechanized production** system for a table would have **MEDIUM material** and **labour costs** and the **capital costs would be MEDIUM**.
iii. An **injection-moulded (automated) table** will have **LOW material and labour costs** but the **capital costs would be HIGH**. These have been added in to the table.

Cost term:	Craft production	Mechanization	Automation
Scale of production			
Complexity of product			
Resources			
Skills			
Quality control			
Size and weight of product			
Storage			
Distribution			
Advertising			
Marketing			
Profits			
Taxes			
Availability			
Procurement of materials	**HIGH**	**MEDIUM**	**LOW**
Research &Development ('R&D')			
Labour	**HIGH**	**MEDIUM**	**LOW**
Manufacturing costs			
Capital costs	**LOW**	**MEDIUM**	**HIGH**
Overheads			
Distribution			
Sales			

5.5.5 Explain the concept of "break-even point" in relation to fixed and variable costs



FC = Fixed costs (these do not change).

VC = Variable costs (these change and are likely to increase such a fuel price, material price, etc.).

TC = Total cost (FC + VC)

TR = Total revenue (the amount of money that comes back into a company by selling its products).

The important lines to look at are **TC** and **TR** (TC is simply FC and VC added together). Imagine you have decided tom start a small business that prints T shirts. Before you can start production, you need to spend some money on your premises, machinery, fabric etc. You have already made a loss! However, once you start to sell your T shirts, you begin to bring some money back in to the business (revenue – shown by the line TR). At some point, **the revenue will equal the total costs** and this is called the **break even point** (shown by the black dot). After this point, your revenue is more than your total costs and you start to make a **profit**.
Remember that the profit will be subject to taxation!

A good business plan will calculate its costs, revenue and break even point very carefully. However, it can change unexpectedly if there are dramatic changes in variable costs (like fuel price) or if there is no longer demand for the product and revenue begins to decrease. This happens for example when products have saturated the market.

If your production rates increase (you start making more T shirts) then you need to realize that your variable costs will increase too (you need more material, energy, labour, etc.). That why the VC line continues to rise on the graph.

5.6 Clean manufacturing

Clean technology is defined as 'an approach to manufacturing or production which uses less resources and causes less environmental damage (by reducing the exploitation of natural resources, minimizing waste and preventing pollution) than an alternative means with which it is economically competitive'.

What does this mean and how does it impact the way that products are designed, manufactured, used and disposed of?

5.6.1 Explain why the introduction of mass production increased damage to the natural environment
A historical perspective is important. Environmental considerations were not an issue in the 18th and 19th centuries. Little quantitative data was available, and all governments encouraged the growth of industry.

We are all very aware that many examples of technology cause environmental damage.

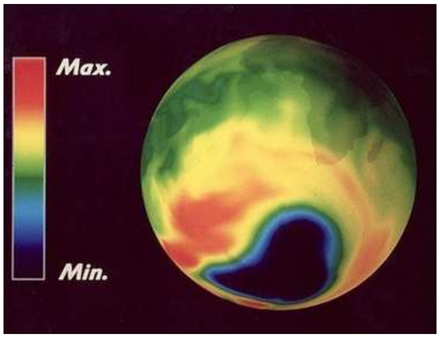
- The burning of fossil fuels which leads to the production of 'greenhouse gases' such as carbon dioxide that, in turn, has lead to global warming and other climatic changes.
- The production of sulphur dioxide, again from burning fossil fuels, leading to acid rain. A good example is the destruction of Scandinavian forests as a result of the sulphur dioxide produced by British power stations.
- The use of chlorofluorocarbon (CFC) gases as aerosol propellants, refrigerants and in the manufacture of plastic foams leading to he destruction in the ozone layer. This thinning of the ozone layer reduces protection from the suns harmful UV rays, increasing the incidence of skin cancer.
- The large-scale destruction of tropical rainforests to satisfy the Worlds demand for timber.
- The cost of landfill sites

Task: Think of two more examples
1.
2.

Carbon Dioxide

One impact that the burning of fossil fuels has had on the Earth's environment has been the increase of carbon dioxide (CO_2) in the Earth's atmosphere. The amount of atmospheric CO_2 apparently remained stable for millennia, but over the past 100 years it has increased. The significance of this change is its potential for raising the temperature of the Earth through the process known as the greenhouse effect.

Acid Deposition
Also associated with the burning of fossil fuels is acid deposition, which is caused by the emission of sulphur dioxide and nitrous oxides into the air from power plants and motor vehicles. These chemicals interact with sunlight, moisture, and oxidants to produce sulphuric and nitric acids, which are carried with the atmospheric circulation and come to Earth in rainfall and snowfall, commonly referred to as acid rain.



Ozone Layer Destruction
During the 1980s, scientists began to find that human activity was having a detrimental effect on the global ozone layer, a region of the atmosphere that shields the Earth from the Sun's harmful ultraviolet rays. Without this gaseous layer, which is found at about 40 km (25 mi) above sea level, no life could survive on the planet. Studies showed the ozone layer was being damaged by the increasing use of industrial chemicals called chlorofluorocarbons (CFCs, compounds of fluorine) that are used in refrigeration, air-conditioning, cleaning solvents, packing materials, and aerosol sprays.

Chlorinated Hydrocarbons
Extensive use of synthetic pesticides derived from chlorinated hydrocarbons in pest control has had disastrous environmental side effects. These organo-chlorine pesticides are highly persistent and resist biological degradation. Relatively insoluble in water, they cling to plant tissues and accumulate in soils, the bottom mud of streams and ponds, and the atmosphere.

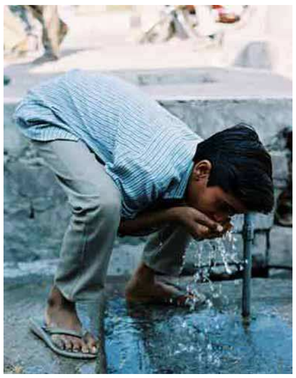
Other Toxic Substances
Toxic substances are chemicals and mixtures of chemicals the manufacturing, processing, distribution, use, and disposal of which present an unreasonable risk to human health and the environment. Most of these toxic substances are synthetic chemicals that enter the environment and persist there for long periods of time. Major concentrations of toxic substances occur in chemical dump sites.

Radiation
Although atmospheric testing of nuclear weapons has been banned by most countries, eliminating a large source of radioactive fallout, nuclear radiation still remains an environmental problem. Power plants always release some amount of radioactive waste into the air and water, but the main danger is the possibility of nuclear accidents, in which massive amounts of radiation are released into the environment—as happened at Chernobyl, Ukraine, in 1986.

Loss of Wild Lands
Increasing numbers of human beings are encroaching on remaining wild lands—even in those areas once considered relatively safe from exploitation, degradation, and pollution. Insatiable demands for energy are forcing the development of Arctic regions for oil and gas and threatening the delicate ecological balance of tundra ecosystems and their wildlife.

Soil Erosion

Soil erosion is accelerating on every continent but Antarctica and is degrading one fifth to one third of the cropland of the world, posing a significant threat to the food supply. For example, erosion is undermining the productivity of approximately 35 per cent of all cropland in the United States. In the developing world, increasing needs for food and firewood have resulted in the deforestation and cultivation of steep slopes, causing severe erosion.



Demands on Water and Air

The world is experiencing a steady decline in water quality and availability. Human beings already use 55 per cent of available freshwater run-off. This level of consumption will be an increasing problem as the population rises. About 75 per cent of the world's rural population and 20 per cent of its urban population have no ready access to uncontaminated water.

Massive air pollution occurs over much of Eastern Europe and the former Soviet Union. As much as 15 per cent of the former Soviet Union is so badly polluted that there are significant and widespread threats to human health and agriculture.

5.6.2 The reasons for cleaning up manufacturing

Reasons include promoting positive impacts, ensuring neutral impact or minimizing negative impacts through conserving natural resources, reducing pollution and use of energy, and reducing wastage of energy and resources.

Obviously something has to be done to prevent irreversible damage to the planet and its valuable resources. World population growth continues at a relentless pace and the demands each of us place on the planets resources are increasing rapidly and at a rate that is not sustainable.

Clean technologies and green design are strategies that can assist us in protecting the planet. Clean technologies have emerged as a result of greater pressure for environmental protection and are increasingly being supported by legislative frameworks (laws). As a general principle though, the reasons for this are to:

- reduce pollution and waste
- adopt more efficient use of energy and materials
- promote positive impacts
- ensure neutral impact or minimize negative impacts through conserving natural resources

In the case of the more traditional 'smokestack industries' like iron and steel manufacture the adoption of such principles is quite a challenge given that they are heavy consumers of raw materials and energy and are heavy polluters.

5.6.3 How an initial response to reducing emission of pollutants is adding clean-up technologies to the end of the manufacturing process

The addition of clean-up technologies to the end of the manufacturing process is termed the "end of-pipe" approach.

Initially clean technology was aimed mainly at developing cleaner manufacturing processes. However there are a number of ways in which this can be done as we shall see. The addition of clean-up technologies to the end of the manufacturing process is termed the' end of pipe' approach. This is how companies initially dealt with the problem of reducing pollutants. As opposed to the 'cradle to grave' Green Design approach which takes into account the environmental impact o the product throughout its product life cycle.

Repair, Reuse, Recycle and Recondition

Green design is all about developing a product, design specification and choosing materials and processes that are environmentally friendly. In doing so the specific objective is to reduce any impact and minimise any effects over the longer term.

5.6.4 Explain how legislation provides an impetus to manufacturers to clean up manufacturing processes.

and

5.6.7 Explain that targets for reducing pollution and waste from industry are agreed internationally, but not all industrial nations agree to the targets.

Legislation means 'law'. One of the difficulties in dealing with global problems is that each country has its own laws and it is very difficult to apply the law globally. Who will police it? What organization will take responsibility? There are several organizations who attempt to put pressure on countries to conform to global good practice – but the real challenge is enforcing it!

Have a look at Greenpeace's China website: http://www.greenpeace.org/china/en/

See if you can find out about the impact that the **manufacture of PVC** has on the environment (look in the 'what we do' section). If you can't find this, see if you can locate another example of the manufacturing industry's impact on the environment.

The issue is complex: Here is an example from Greenpeace's website:

"Stricter environmental regulations in developed countries have led to many polluting industries transferring their toxic technologies to the developing world. We are fighting to ensure an end of toxic trade to regions of the world least equipped to deal with inevitable pollution and accidents, such as the Electronic waste trade in China, Bhopal disaster in India, and ship-breaking in Asia."

It is a good example how a law in one country creates problems in another. So legislation (law) provides an impetus (pressure) but cannot be strictly enforced around the world. Real improvements are made when **consumers** demand changes to the way products are manufactured and this is where the real power to make a difference lies. This pressure is often as a result of campaigning organizations or pressure groups like Greenpeace who raise public awareness of these issues. Here are some examples of where this kind of pressure has resulted in positive change:

http://www.greenpeace.org/china/en/about/greenpeace-victories

You can read in more detail about the variety of initiatives to set international targets to tackle environmental issues and the difficulties in reaching agreement with all participating countries:

Global strategies for sustainable development

Task: Which countries did not sign the Kyoto Protocol? Why not? (you will need to do some wider research to answer this question – the links on the website will help you).

5.6.5 State that the legislation can be policed by monitoring through the collection of quantitative data

Quantitative data is **information that is represented by statistics** (numbers). Greenpeace uses data like this to expose practice which is harmful to the environment. Here is a really good example:

Guide to greener electronics

Task: Read the report and then answer the following questions:

1. Which **three** companies are the lowest ranking on the scale?

2. What **two** demands do Greenpeace make for the electronics industry?

3. What **four** criteria do Greenpeace set for dealing with their discarded products?

5.6.6 Explain that strategies for cleaning up manufacturing are mainly reactive, and that more radical approaches require a rethink of the whole system and may result in significant product and/or process modification or radically new technologies.

Legislation and pressure alone are nowhere near enough to deal with our environmental problems. What is needed is a complete change of attitude to all aspects of consumerism which considers a **Life Cycle Analysis** of the product (see Topic 3 – Green Design).

Pressure and legislation are reactions to situations that have already developed. They are examples of a **reactive response.**

A better approach is to be **proactive**; that means to address those problems before they arise. For proactivity to succeed, consumers and manufacturers will need to develop new attitudes to how they select and dispose of products. For example; consumers will need to feel a responsibility for disposing properly of unwanted electrical products. Manufacturers will need to recycle used parts more thoroughly and make their materials more easily and precisely identifiable. Consumers will need to achieve a better balance between consuming what they want and need (there's a difference – can you explain it?).

End of Topic discussion:

To what extent are you prepared to change your habits in order to protect the planet?

Some starters: Will you…

…keep using your old mobile even if a smarter model becomes available?
…walk more and use cars less?
…not put on the air conditioning even if you are hot?
…repair your clothes, recycle all your rubbish and re-use plastic knives and forks?
...refuse to buy water in a PET bottle?
…reduce your use of plastic?
…stop traveling abroad for your holidays?
…check the sustainability levels of materials used in products that you buy?
…give your unwanted clothes, books and toys to others?
…wear clothes that are handed on to you?

No	KEY WORD / PHRASE	Have seen/ heard of it.	Can Use in a sentenc e	Can define	Can give a clear Example to explain	Never Heard of it!	Tick for: now I get it!
1	Manufacturing Technique						
2	Moulding						
3	Casting						
4	Weaving						
5	Fusing						
6	Stitching						
7	Cutting						
8	Machining						
9	Abrading						
10	Adhesives						
11	Fasteners						
12	Craft Production						
13	One-off Production						
14	Industrial Revolution						
15	Mechanization						
16	Assembly-line Production						
17	Batch Production						
18	Mass Production						
19	Automation						
20	CAD, CAM & CNC						
21	JIT & JIC						
22	Mass Customization						
23	Economic Considerations						
24	Fixed & Variable Costs						
25	Break-even point						
26	Clean Manufacturing						
27	End-of-pipe Approach						

Topic 6

Product Design

6.1 Ergonomics

6.1.1 Define ergonomics, anthropometrics and percentile range

6.1.2 State that ergonomics is multidisciplinary, encompassing anthropometrics, psychological factors and physiological factors

6.1.3 Describe a design context where the 5th–95th percentile range has been used
For example, mass-produced clothing.

6.1.4 Describe a design context where the 50th percentile has been used
For example, height of a desk.

6.1.5 Explain the limitations of using the 50th percentile as a means of designing for the "average" person
The 50th percentile refers to one particular dimension. For example, someone may be average in height but not average in other dimensions.

6.1.6 Identify specific design contexts where the designer would use percentile ranges for particular user groups.
For example, toys for young children.

6.1.7 Outline the significance of psychological factors (smell, light, sound, taste, texture and temperature) to ergonomics
Individuals react differently to sensory stimuli. Efficiency and comfort are affected by such factors.

6.1.8 Outline physiological factors that affect ergonomics
For example, bodily tolerances such as fatigue and comfort.

6.1.9 Discuss the influence of perception when collecting data relating to psychological factors
Quantitative data may be used in a design context relating to psychological factors, but individuals vary in their reaction to the data. For example, one person will find a room temperature comfortable while another person will find it uncomfortable, though the temperature is constant.

6.2 The designer and society

6.2.1 Discuss moral and social responsibilities of designers in relation to green design issues
Consider issues relating to waste, pollution, resources, market forces and wealth creation.

6.2.2 Define planned obsolescence

6.2.3 Outline how planned obsolescence influences the design specification of a product
Consider materials and construction, durability and ease of maintenance.

6.2.4 Describe the advantages and disadvantages of planned obsolescence to the designer, manufacturer and consumer
Refer to consumer choice, value, R&D and product life cycle.

6.2.5 Define fashion

6.2.6 Compare the influence of fashion and planned obsolescence on the product cycle
Planned obsolescence has a definite timescale; fashion is less predictable. Both may be present. For example, a certain colour may be fashionable for a car but this does not affect materials or technological obsolescence.

6.2.7 Evaluate the influence of fashion and planned obsolescence in relation to the quality and value of a product
Consider whether "designer" products are better quality than cheaper brands of the same product, and also question the values of a "throw-away society".

6.2.8 Explain how aesthetic considerations affect the design of products
Refer to shape and form, texture and colour.

6.2.9 Discuss the conflict that a designer faces when attempting to balance form with function in the design of products
Examples should be used, for example, a car or domestic products.

6.1 Ergonomics

Ergonomics and Anthopometrics.

www.design-technology.info/anthropometrics/
www.designandtech.com

Define Ergonomics and Anthropometrics

Ergonomics
Anthopometrics

www.technologystudent.com/designpro/ergo1.htm

Activities

- Set up an A4 sheet to collect your anthropometric data.
- Collect your data

What is the significance of a 'percentile range' when using anthropometric data?

- Identify on your sheet your 90^{th} percentile range.
- Identify on your sheet your 50th percentile range.

Factors affecting anthropometric data.
Psychological Factors – smell, light, sound, taste, texture, and temperature

Physiological Factors- Fatigue, comfort, and physical differences

6.2 The Designer and Society

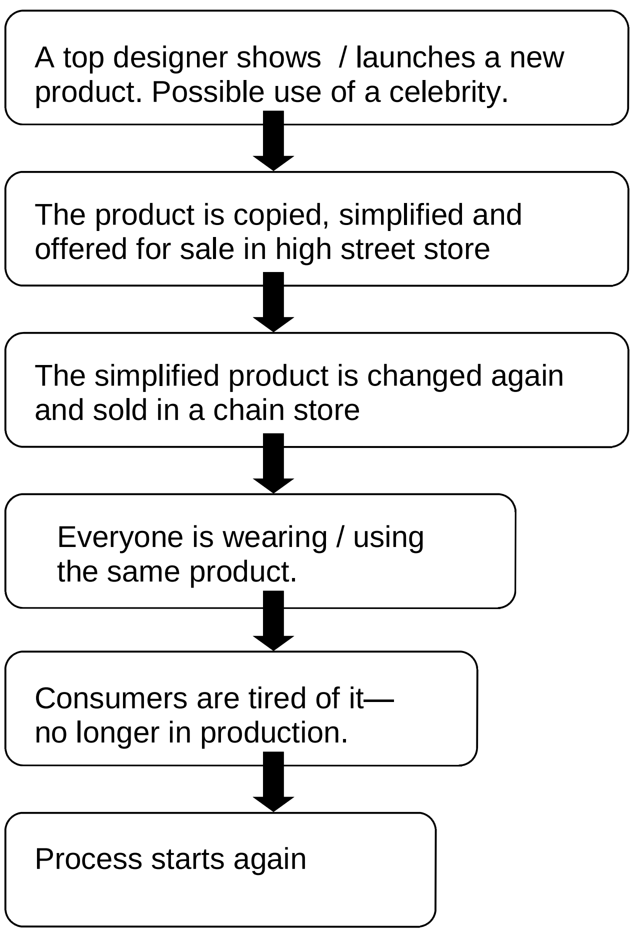
Moral and social responsibilities
Reducing waste; reducing emissions; using renewable energy; recycling; reusing; Fair trade;
http://news.bbc.co.uk/2/hi/business/4660410.stm

Planned Obsolescence
Covers 3 areas

- Obsolescence of function – an existing model becomes outmoded by a new and better model
- Obsolescence of quality- a product breaks down in a given time (built-in obsolescence)
- Obsolescence of desirability- a product performs the same but it's styling is outdated.

Think of 3 products that you own, which have become obsolete in different ways.

Fashion
A style or trend



Give some examples of products which have evolved in this way – try to get a mixture of material areas in your examples – 1 example is completed for you

Straight legged jeans

3.

2.

4.

Aesthetics – **Shape**, **form, texture** and **colour.**

How do these considerations affect the design of products?

Look at the different items below. See the differences in the 3 products.

Form Vs function – wikipedia

What is the great debate all about?

Examples of where form and function are important factors of a product :-

Examples of where only form is the important factor :-

Examples of where only function is the important factor :-

Key Vocabulary for Topic 6

Ergonomics

Anthropometrics

Percentile range

Planned Obsolescence

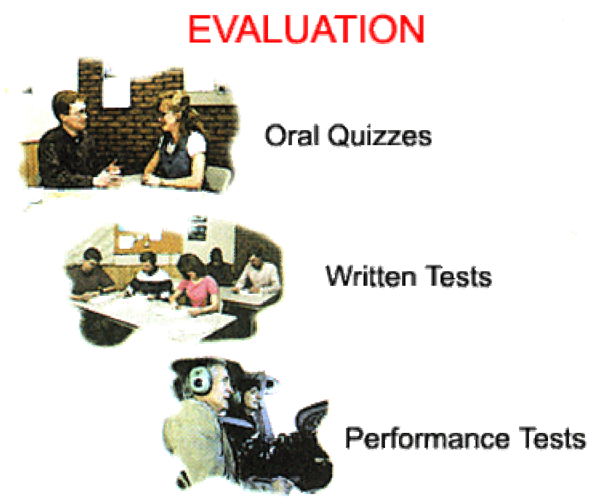
Fashion

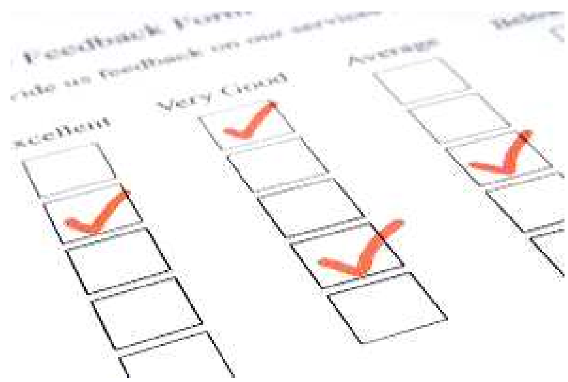
Aesthetics

Form Vs Function

Topic 7

Evaluation





7.1 Evaluation and designing

7.1.1 Outline the general criteria used to evaluate products
The general criteria used to evaluate products:

- performance
- reliability
- ease of use
- safety
- aesthetics
- materials
- construction
- cost

7.1.2 Explain how the criteria used to evaluate products will vary depending on the purpose of the evaluation
The criteria used to evaluate products will vary depending on the purpose of the evaluation. For example, crash-testing cars is done in relation to safety only, a change in manufacturing techniques may affect the cost of a product.

7.1.3 Apply the general criteria to evaluate products
Task- Product Analysis- using the general evaluation criteria of 5 products.

7.1.4 Explain the use of qualitative and/or quantitative tests, models and experiments used to evaluate ideas at the design development stage (developing chosen solution) of the design cycle
Qualitative and/or **quantitative tests**, **models** and **experiments** are used to evaluate ideas at the design development stage (developing chosen solution) of the design cycle. For example: Testing how much a car fractures when colliding a 300mm brick wall at 30 km/h.

Models can be used to evaluate shape, form and proportion; materials tests; construction technique tests, and so on. For example: CAD modeling.

7.1.5 Define literature search
Literature search is the use of **consumer reports** and **newspaper** items to **follow historical development**. Useful sources of information could include CD-ROMs, such as encyclopedias and newspapers and subject-specific magazines and manufacturer's information.

7.1.6 Describe one advantage and one disadvantage of literature search for data collection
One **advantage** of literature search for data collection is that **many sources of information are available**, but a **disadvantage** is that there may be an a**bundance of data**, which can be **too time-consuming** to process.
ICT aids literature search by easier access to information, speed, costs, however storage and security needs to be considered.

7.1.7 Evaluate the importance of ICT in aiding literature searching
Consideration to evaluate the importance of ICT should be based on **access** to information, **speed**, **costs**, **storage** and **security**.

7.1.8 Define user trial
A user trial is the **observation of people** using a product and collection of comments from people who have used the product.

7.1.9 Describe one advantage and one disadvantage of a user trial to collect data
One **advantage** of a user trial is that the "user" is a **non-specialist**, which makes trials **easier and cost-effective**. However, a **disadvantage** may be that users may **carry out tasks in different ways** from those expected and be inexperienced.

7.1.10 Define user research
User research is obtaining **user responses**, usually through questionnaires or interviews.

7.1.11 Describe one advantage and one disadvantage of user research to collect data
An advantage of user research is that data is relatively easy and cheap to obtain but a disadvantage is that data is largely qualitative.

7.1.12 Compare user research with user trial
The difference between user research and user trial is that with user research, data is collected by obtaining users' responses to questions. User trial data is collected by observing users' behaviour.

7.1.13 Define expert appraisal
Expert appraisal is the reliance on knowledge and skills of an **expert** in the operation of a product.

7.1.14 Describe one advantage and one disadvantage of using expert appraisal to collect data
An advantage is that expert knowledge and advice are gained (compared to a user trial), but a disadvantage may be the expert may be biased. It may also be difficult to locate an expert. The data collected is usually qualitative.

Task- Fill in the table with what you have learnt.

What are the following examples of?	**Literature search, User Trail, Expert Appraisal, performance test**
Observation of adults folding prams and lifting them into a car boot.	
2 hour test flight of a jet fighter	
Usability - Ergonomists judging how easy a product and the instructions are to install and use. They can also give advice on how to improve it.	
Testing the user interface (UI) of mobile phones using potential end users.	
Benchmark the speed of your PC computer hardware, and then compare the result to other machines.	
Getting feedback from experienced race drivers on how well certain tyres handle at their performance limit.	
How well a car stops in wet weather using different tyres	

Task- Watch the case study of a new Toyota Camry –
List all the methods of Evaluation and research techniques used.

7.2 Evaluation and manufacturing

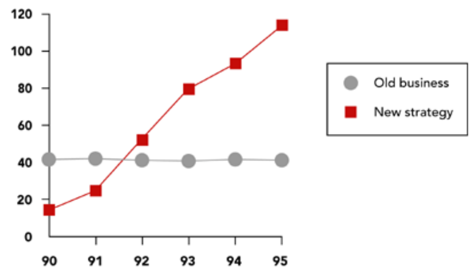
7.2.1 Identify the nature of evaluation at different stages of the product cycle

Provides feedback to the company. The use of different types of market research, for example, evaluating **competitive products**, evaluating the **success** of a new product and **evaluating for redesign**.

7.2.2 Define cost-effectiveness

Cost effectiveness is the most efficient way of designing and producing a product from the manufacturer's point of view.

7.2.3 Explain the importance of cost effectiveness to manufacturers



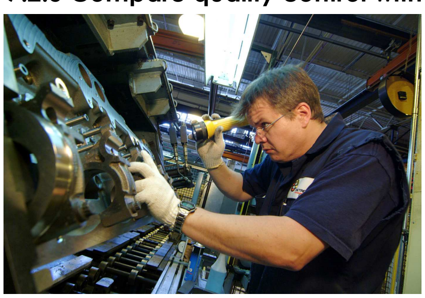
Cost effectiveness is important to manufacturers because in order to maximize profit, manufacturers require the most cost-effective production system. This is often the major aim of the brief for designers.

Example of cost effectiveness would be determining the most efficient method of manufacture for a part or component in order to maximize profit. E.g. Weld several parts together or produce a casting incorporating all the parts

7.2.4 Define quality control and quality assurance

Quality assurance **covers all activities from design to documentation**. It also includes the regulation of quality of raw materials, assemblies, products and components, services related to production, and management and inspection processes.

7.2.5 Compare quality control with quality assurance for manufactured products



Quality control involves the **development systems** to ensure that products or services are designed and produced to **meet or exceed customer requirements** and expectations.

An example of quality control would be checking components are to within dimensional tolerance or meet recognized standards using skilled workers. Quality control gauge used for checking the dimensions of finished components.

The International Organisation for Standards is an example of quality assurance
http://www.iso.org/iso/about/discover-iso_meet-iso.htm

Key Factors of a Quality Assurance System

- Organization of the workforce
- Control of design
- Control of production systems
- Manufacture to specification
- Standards

LLOYD'S REGISTER QUALITY ASSURANCE
LR
ISO9001

Product testing at Toys'R'us-
http://www.reuters.com/article/consumerproducts-SP/idUSN1040588720070910

Task- Use the following pictures to help discuss the role and importance of quality assurance.





TASK - Compare quality control and quality assurance.

7.2.6 Define performance test
Performance test is an evaluation of the **actual performance of the task** or learning objective using the conditions under which it will be performed and the **absolute standard for acceptable performance**.

7.2.7 Describe one advantage and one disadvantage of using a performance test to collect data
With a performance test it is possible to collect **quantitative data,** but the test **may be time-consuming and costly**. It can be used where a user trial is not feasible, for example, crash-testing cars.
Example of crash testing cars. [http ://www.youtube.com/watch?v=FXm_-5RgFm4](http://www.youtube.com/watch?v=FXm_-5RgFm4)

7.2.8 Define field trial
Field trial is a test of the performance of some new product under the conditions in which it will be used.

7.2.9 Describe one advantage and one disadvantage of using a field trial to collect data
Field trials are usually quite extensive exercises, so can be expensive, but the product is tested in the **marketplace**, which **provides data** that is different from laboratory-based evaluations.

7.3 Evaluation and the consumer

"Sales Research shows it's too big for them to carry home, sir."

7.3.1 Define value for money
Value for money is the relationship between what something, for example, a product, is **worth** and the **cash amount spent on it**.

7.3.2 Compare price with value when assessing a product for value for money
If the price is too high, there may not be enough potential purchasers who can afford it or think the product is value for money. If the price is too low, consumers may think the product is too cheap to have much value. Demand for a product will generally establish the maximum price that can be charged, and the costs of production will determine the minimum price that is acceptable. However, a company may choose to set its price in relation to its competitors, or it may choose to set the price in accordance with the perceived value of the product.

7.3.3 Explain how consumers apply criteria to evaluate a product for value for money, referring to before purchase, purchase, initial use and long-term use
Before purchase: advertising, manufacturer's specification, list price, product image, and evaluation by experts and consumer groups.
- Purchase: aesthetics, performance, build quality and purchase price.
- Initial use: actual performance, safety and ease of use.
- Long-term use: reliability, ease of maintenance, durability and running costs.

7.3.4 Discuss how the criteria in 7.3.3 are assigned different weightings depending on the design context
The importance of the above criteria depends on the design context.
Value judgments play a part in product analysis, and they vary according to the individual, the time (era) and the circumstances. Consumers often value utility, security, availability, rarity and aesthetics, while designers may consider function, reliability and ease of maintenance more important.

7.3.5 Explain the relevance of quality assurance to consumers
Quality assurance means that consumers do not have to carry out their own research when considering purchasing products, and they have a means of redress if a product fails to match expected standards, for example, via a guarantee.

7.3.6 Discuss the role of consumer associations for product evaluation
Consumer associations are independent organizations. They carry out tests on products to see if manufacturers' claims are justified, and they provide published data for consumers. They compare similar products within a target market and recommend the best value-for-money products. Consumer associations therefore have a role in product evaluation. Examples of consumer associations:

- http://www.which.co.uk/ — Product testing and evaluation
- http://www.case.org.sg/ — Singapore Consumers Association
- http://www.organicconsumers.org/ — Labeling GM foods

7.3.7 Explain the contribution of the media and education to product evaluation
The media and education also make a contribution to product evaluation. There are consumer and lifestyle programmes on television, the weekend sections of newspapers and consumer journals, and they focus on new products. Also curriculum development and design education in schools encourages product evaluation.

No	KEY WORD / PHRASE	Have seen/ heard of it.	Can Use in a sentenc e	Can define	Can give a clear Example to explain	Never Heard of it!	Tick for: now I get it!
1	Performance						
2	Reliability						
3	Ease of Use						
4	Safety						
5	Aesthetics						
6	Construction						
7	Cost						
8	Qualitative Tests						
9	Quantitative Tests						
10	Models						
11	Experiments						
12	Literature Research						
13	User Trials						
14	User Research						
15	Expert appraisal						
16	Cost-effectiveness						
17	Quality Control						
18	Quality Assurance						
19	Performance Test						
20	Field Trial						
21	Value-for-money						

-End of Coursebook-