A-LEVEL DESIGN AND TECHNOLOGY PRODUCT DESIGN (Year 12 and 13)

	Year 12 (Sept- Feb) NEA	Year 12 (Feb- July) Exam Component	Year 13 (Sept- Jan) NEA	Year 13 (Jan- May) Exam Component
Overview of Scheme of Learning	**Section A: Identify and investigate design possibilities** Central to the success of the NEA is the selection, by the student, of a context that will provide them with the opportunity to challenge themselves as a designer. Care should be taken, and guidance sought, to ensure that the context chosen offers the student the scope and complexity for a piece of work that is worthy of consideration for the award of an A-level. Having chosen their context and potential user(s) they then need to plan and carry out an extensive investigation into all aspects of the context in order that they might operate from a position of knowledge when making subsequent decisions. The student will be expected to employ a variety of both primary and secondary methods of investigation. These might include visits organised by themselves or others, surveys and questionnaires could be used to inform. Useful and relevant material can be gained from others via the internet, books, magazines or interviews. Students should also be	**Performance characteristics of metals** Students should be familiar with the following metals: • ferrous: • low carbon steel • stainless steel • high speed steel (HSS) • medium carbon steel • cast iron • non-ferrous: • aluminium • copper • zinc • silver • gold • titanium • tin • ferrous alloys: • stainless steel • die steel (tool steel) • non-ferrous alloys: • bronze • brass • duralumin • pewter **Characteristics of polymers** Students should be familiar with the following polymers: • thermoplastic: • low density polyethylene (LDPE) • high density polyethylene (HDPE) • polypropylene (PP) • high impact polystyrene (HIPS) • acrylonitrile butadiene styrene (ABS) • polymethylmethacrylate (PMMA) • nylon • rigid and flexible polyvinyl chloride (PVC) • Polyethylene terephthalate (PET) • thermosets, with specific reference to their: • urea formaldehyde (UF) • melamine formaldehyde (MF) • polyester resin • epoxy resin **Biodegradable polymers**	**Section D: Development of design prototypes** Design prototypes are just that, they need to be directly related to the design proposals and show consideration, at all stages, of how the design thinking continues to be developed and the prototype(s) refined. Given the level of this qualification it is expected that the student will demonstrate their practical skills to a high level using all of the potential resources, tools, machines and equipment at their disposal. During the development of their design prototype(s) the student should be encouraged to continue to experiment and adapt their design proposals as they progress. Constant testing and evaluation is expected to form part of this process. The use of CAM is encouraged, but this should not be the only form of manufacturing that is used. It should be noted that it is not expected that the assessment criteria be seen as a linear process and that aspects from	**Inclusive design** Students should be aware of, and be able to explain, the development of products that are inclusive in their design so that they can be used by a wide range of users including the disabled, children and the elderly. **Safe working practices** Students should be aware of, and able to explain, health and safety procedures related to products and manufacturing, including: • knowledge of the Health and Safety at Work Act (1974), and how it influences the safe manufacture of products • control of Substances Hazardous to Health (COSHH) and safety precautions that should be taken with relevant materials • safe working practices and identifying potential hazards for the school or college workshop and industrial contexts • safety precautions that should be taken with specific manufacturing processes

	encouraged to undertake, where relevant, practical experimentation and disassembly as methods for further understanding and exploring the context and its related issues. At this stage it is expected that the student will begin to explore their thinking on possible solutions by producing concept ideas that take into account the information collected. At this stage of the process these first concept ideas will merely demonstrate the student's initial thinking and should serve to stimulate later more considered thoughts regarding their design proposal(s) and design prototype(s). It should be noted that it is not expected that the assessment criteria be seen as a linear process and that aspects from this, and other assessment criteria, might be present throughout the student's portfolio. Wherever it takes place, it is expected that this work will be rewarded. **Section B: Producing a design brief and specification** The student is required to produce a clearly stated and challenging design brief that addresses the context and meets the needs of the intended	Students should be familiar with the following biodegradable polymers: • corn starch polymers • potatopak • biopol (bio-batch additive) • polyactide (PLA) • polyhydroxyalkanoate (PHA) • water soluble: lactide, glycolide (Lactel and ecofilm). **Composites** Students should be familiar with the following composites: • carbon fibre reinforced plastic (CFRP) • glass reinforced plastic (GRP) • tungsten carbide • aluminium composite board • concrete, including reinforced concrete • fibre cement • engineered wood, eg glulam (glued laminated timber). **Smart materials** Students should be familiar with the following smart materials: • shape memory alloys (SMA), eg Nitinol • thermochromatic pigment • phosphorescent pigment • photochromic pigment • electroluminescent wire • piezo electric material. **Modern materials** Students should be familiar with the following modern materials: • kevlar • precious metal clay (PMC) • high density modelling foam • polymorph.	this, and other assessment criteria, might be present throughout the student's portfolio. Wherever it takes place, it is expected that this work will be rewarded. **Section E: Analysing and evaluating** To gain marks for this section it is vital to remember that evidence for analysing and evaluating can take place in any part of the NEA. Students should be encouraged to be constantly analysing their work and recording their thoughts in order to explain their thinking. Ongoing evaluation should be seen to be informing the decision making process, particularly being used to bring about modifications to design proposals and prototype development. Central to this is the close and regular involvement of the proposed client/user(s) making sure that the prototype is both fit for purpose and meets the requirements of the client/user(s) rather than just meeting those of the student.	• the concept of risk assessment and its application to given manufacturing processes. **Manufacture, repair, maintenance and disposal** Students should be aware of, and able to explain, the need to modify designs to make them more efficient to manufacture, including: • reducing the number of manufacturing processes • how the choice of materials affects the use, care and disposal of products: • labelling of materials to aid separation for recycling • making products easy to disassemble or separate • application of the six Rs of sustainability: • reduce the quantity of materials, of toxic materials, of damaging materials and associated energy use • reuse components and parts • rethink by using eco friendly alternative materials • recycle materials and/or components into new products • maintenance: • temporary and integral fixings • use of standardised parts • allowing for service and repair/ replacement of parts • ability to upgrade with software downloads.

	user(s). The student should formulate a fully detailed design specification that is informed by their investigations and makes full use of the material collated. Statements in the specification need to be clear and unambiguous. There should be specific references to measurable outcomes as well as qualitative statements. Whatever format is chosen to present the specification it is expected that this will be a live and working document that will be constantly referenced throughout the process. The specification should also include details on how the student intends to organise their time and activities in order to ensure a successful completion of the process. It should be noted that it is not expected that the assessment criteria be seen as a linear process and aspects from this, and other assessment criteria, might be present throughout the student's portfolio. Wherever it takes place, it is expected that this work will be rewarded. **Section C: Development of design proposals** Design proposals should reflect on first concepts and take full account of the design brief and	**Polymer processes** They should be able to explain the suitability of the different forming methods for a range of specific products and scales of production. Specific process to include: • vacuum forming • thermoforming • calendaring • line bending • laminating (layup) • injection moulding • blow moulding • rotational moulding • extrusion • compression moulding. **The use of adhesives and fixings** • PVA • Contact adhesives • UV hardening adhesive • Solvent cements such as Tensol or acrylic cement • Epoxy resin **Scales of production** Students should be aware of, and be able to describe, the different scales of production giving example products and specific manufacturing methods. Specific scales of production to include: • one-off, bespoke • batch production • mass/line production • unit production systems (UPS) • quick response manufacturing (QRM) • vertical in-house production. **The use of computer systems** Students should be able to explain specific industrial manufacturing systems and their use in the production of given products.		**Design communication** Students should be aware of, and able to explain and demonstrate the skills, in a range of communication and presentation techniques for conveying proposals and intentions to clients, potential users and manufacturers, including: • report writing • the use of graphs • tables and charts • 2D/3D sketching • the use of mixed media and rendering to enhance drawings • dimensioning and details for manufacture. **Design styles and movements** Students should be aware of, and be able to discuss, key design styles and movements and their principles of design, including: • arts and craft movement • Art Deco • Modernism, eg Bauhaus • Post modernism, eg Memphis. **Designers and their work** Students should be aware of, and be able to discuss, the work of influential designers and how their work represents

	design specification. The aim should be that the development of their design proposal(s) leads to a prototype that can be manufactured by the student given their skills and experience. In developing their proposals the student will be expected to make constant reference to their design brief and design specification, to identify if further investigations are required and to carry these out. Design proposals can be demonstrated through a variety of different media, but whatever methods are chosen, they should be of a high quality befitting this level of qualification and show evidence of analysis and annotation (although these elements are not assessed in this assessment criteria). Modelling is seen as a key element of this assessment criteria, whether this be part modelling, practicing of manufacturing and finishing techniques, the production of scale models or material experimentation. There is also the expectation that students will produce working drawings, plans and patterns to enable successful prototype manufacturing to take place. The use of CAD is encouraged, but this should not be the only form of design communication that is used. It should be noted that it is not	Specific manufacturing systems to include: • modular/cell production • just in time (JIT) • quick response manufacturing (QRM) • flexible manufacturing systems. **Computer aided design (CAD)** Students should be aware of, and be able to describe, the following: • the advantages and disadvantages of using CAD compared to a manually generated alternative • the use of CAD to develop and present ideas for products, including: • the use of 2D CAD for working drawings • the use of 3D CAD to produce presentation drawings • how CAD is used in industrial applications. **Computer aided manufacture (CAM)** Students should be aware of, and be able to describe, how CAM is used in the manufacture of products. Specific processes to include: • laser cutting • routing • milling • turning • plotter cutting. **Virtual modelling** Students should be aware of, and be able to describe, how virtual modelling/testing is used in industry prior to product production. Specific processes to include: • simulation • computational fluid dynamics (CFD) as used for testing aerodynamics and wind resistance, and flow of liquids within/ around products • finite element analysis (FEA) as used in component stress analysis.		the principles of different design movements, including: • Phillipe Starck • James Dyson • Margaret Calvert • Dieter Rams • Charles and Ray Eames • Marianne Brandt **Major developments in technology** Students should be aware of, and able to discuss, how major developments in technology are shaping product design and manufacture, including: • micro electronics • new materials • new methods of manufacture • advancements in CAD/CAM. **Social, moral and ethical issues** Students should be aware of, and able to discuss, the responsibilities of designers and manufacturers, including: • products are made using sustainable materials and ethical production methods • the development of products that are: • culturally acceptable • not offensive to people of different race, gender or religious belief • the development of products that are inclusive • the design and manufacture of products that could assist with social problems, eg poverty, health

	expected that the assessment criteria be seen as a linear process and aspects from this, and other assessment criteria, might be present throughout the student's portfolio. Wherever it takes place, it is expected that this work will be rewarded.	**Rapid prototyping processes** Students should be aware of, and be able to describe, rapid prototyping processes, including 3D printing. Students should understand, and be able to explain, the benefits to designers and manufacturers.		and wellbeing, migration and housing • the impact of Fairtrade on design and consumer demand • designing products to consider the six Rs of sustainability. **Product life cycle** Design introduction, evolution, growth, maturity, decline and replacement. Students should be familiar with examples of how designers refine and re-develop products in the lifecycle of specific products.
Assessment Overview	**Section A: Identify and investigate design possibilities (20 Marks)** • Excellent rationale provided for the context selected, with continuous reference throughout the project to the end user and the constraints that need to be considered in formulating a final solution. • Student employs a comprehensive range of strategies and techniques, including both primary and secondary methods of investigation, practical experimentation and disassembly, to thoroughly explore design opportunities. All sources have been fully referenced.	**Paper 1** What's assessed Technical principles How it's assessed • Written exam: 2 hours and 30 minutes • 120 marks • 30% of A-level Questions Mixture of short answer and extended response. What's assessed Designing and making principles How it's assessed • Written exam: 1 hour and 30 minutes • 80 marks • 20% of A-level Questions Mixture of short answer and extended response questions. Section A: • Product Analysis: 30 marks	**Section D: Development of design prototypes (25 Marks)** • Excellent justification provided for selection of appropriate materials and components and proposed techniques and processes, demonstrating an excellent understanding of material properties to ensure excellent quality prototype(s) that are fit for purpose. • Significant complexity or challenge is involved throughout the production of prototype(s). The student demonstrates excellent manufacturing skills combined with an excellent understanding of the need for	**Paper 1** What's assessed Technical principles How it's assessed • Written exam: 2 hours and 30 minutes • 120 marks • 30% of A-level Questions Mixture of short answer and extended response. What's assessed Designing and making principles How it's assessed • Written exam: 1 hour and 30 minutes • 80 marks • 20% of A-level Questions Mixture of short answer and extended response questions.

	• First concepts are both fully relevant to the context and feasible for further development and are clearly communicated through a fully appropriate variety of methods and techniques. • All investigations relate directly to the design context, issues are identified and fully addressed and the student demonstrates a detailed and perceptive understanding of the information gathered. **Section B: Producing a design brief and specification (10 Marks)** • A comprehensive, clearly stated and challenging design brief resulting from a thorough consideration of investigations undertaken, that fully addresses both the context and the needs and wants of the intended user(s). • The student has produced a comprehensive, detailed and well explained design specification which will fully guide the student's design thinking. • A detailed project management approach to prototype development, including time management and determining quantities and costs of materials,	• Up to 6 short answer questions based on visual stimulus of product(s). Section B: • Commercial manufacture: 50 marks • Mixture of short and extended response questions	dimensional accuracy and precision. • The student has selected and used appropriate tools, machinery and equipment, including CAM where required, and worked with a high level of skill, precision and accuracy to produce their prototype(s). • Prototype(s) fully address the design brief, satisfying all major points of the specification and take into account all amendments/ modifications to their original design proposals as necessary. • Student makes all required modifications to the prototype in a fully considered manner in light of feedback from user trials and third party feedback and as a result of testing and evaluation carried out against earlier iterations of the prototype. • Quality assurance is evident throughout and it is clear where planned quality control checks have been applied throughout the process to ensure consistency and safety. • Clear evidence throughout the manufacturing process that appropriate health and safety processes have been both considered and employed.	Section A: • Product Analysis: 30 marks • Up to 6 short answer questions based on visual stimulus of product(s). Section B: • Commercial manufacture: 50 marks • Mixture of short and extended response questions

	has been fully integrated into the specification. **Section C: Development of design proposals (25 marks)** • The rationale for design decisions is clearly documented and fully justified with constant reference being made to the design brief, specification and investigations throughout the development of their design proposal. • In the development of innovative design proposals the student will demonstrate clear evidence of originality, creativity and a willingness to take design risks. • Excellent use of a variety of modelling techniques to support ongoing development work throughout. This is supported by the use of drawings, sketches, annotations and notes showing clear evidence of design thinking. • Excellent ongoing development of design proposals, achieved through exploration of and experimentation with different materials, techniques and processes leading to an excellent quality design of a prototype for manufacture. • Comprehensive and fully detailed manufacturing specification produced which		**Section E: Analysing and evaluating (20 Marks)** • Comprehensive evidence of analysis and evaluation throughout the process, which has clearly informed the chosen context, client or user and the subsequent development and manufacture of the prototype. • Testing is carried out in a focused and comprehensive way with clear evidence of how the results have been used to inform the design and any modifications to the prototype. • Student has provided a well reasoned critical analysis of their final outcome which links clearly to their design brief and specification and provides full justification for the extent to which the prototype is both fit for purpose and meets the needs of the client/user. • A comprehensive critical evaluation of their final prototype, clearly identifying how modifications could be made to improve the outcome, together with a full justification for these modifications and full consideration provided for how the prototype could be	

	makes specific reference to relevant quality control checks and allows fully accurate interpretation by a third party. • Project management for manufacturing allows for further development of design proposals in response to ongoing evaluation, testing and full consideration of contingency planning as prototype development takes place.		developed for different production methods.	
Link to detailed content (Knowledge Organiser)	Knowledge Organiser (Coursework)	Knowledge Organiser (Theory)	Knowledge Organiser (Coursework)	Knowledge Organiser (Theory)

A-LEVEL
DESIGN AND TECHNOLOGY: PRODUCT DESIGN
7552
NON-EXAM ASSESSMENT (NEA)

CONTENTS

DESIGN CONTEXT

Product design is driven by solutions to problems with existing products and methods. To come up with these solutions we must first generate problems to overcome.

Here are some everyday problems that I have identified:

1. Young **professionals** find the **balance** of **modern work life** and **family life stressful** so this can lead to **disorganisation**.
2. The morning **routine** for a **working family**.
3. Long-haul pilots **suffer** from **extreme jet lag**.
4. Day to day **struggle** of living with **diabetes**.
5. **Managing** an **effective** sleep **pattern** while in **education** and in part time **work**.
6. Some people are **indecisive** which affects their day to day **life**.
7. **Suffering** with **dyslexia** can affect **performance** and **confidence** in the **working life**.
8. Generating ideas in an **unsuitable** time (remembering something at 1am and then **forgetting** it the next morning)
9. **Losing** day to day items (phone, keys, wallet)
10. Use of **interfaces** (plug **switches**, **thermostat**, cooker **buttons**) with **diseases** such as **Alzheimer's**.
11. Child **safety** in busy **environments** such as an airport or theme park.
12. Overall **wellbeing** (**hygiene/safety**) at a festival.
13. Ensuring food/drink is at the optimum temperature for children/the elderly.
14. Personal safety in urban areas (mugging, pickpocketing, assault) especially at night.
15. Consumption of medication for people with conditions such as diabetes/ADHD
16. Repetitive Strain Injury from constant use of modern devices.
17. Keeping your car clean and organised both inside and out.

Conclusion:

After further consideration I have eliminated 14 of my 17 original problems leaving me with three everyday problems to further develop.

1. The day to day struggle of living with diabetes.
   Many diabetics have busy, professional lives, keeping on top of regular blood checks and medication can be a struggle for some diabetics, there are additional challenges that diabetics face such as: social stigma and diet and nutrition. This problem is particularly relevant as the number of diabetics being diagnosed in the U.K. continues to increase at a large rate.
2. Overall wellbeing (hygiene/safety) at a festival.
   Nearly all festivals have showering facilities however the facilities are often unhygienic, have long queues and are often extra on top of the ticket price. This is becoming even more necessary due to the gentrification of festivals.
3. Repetitive Strain Injury from constant use of modern devices.
   Modern life revolves around our phones and tablets and with the increasing use of these devices people are using them in more and more scenarios such as in bed, while commuting and at work or school. The instant access to infinite information and data has made these devices a necessity in the 21st century, however this necessity can also cause issues due to the constant exposure to the devices for long periods of time.

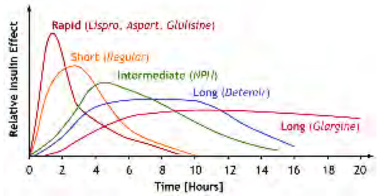
Nutrition

Daily insulin injections

Normal Life

DIABETES

Long Lasting/Fast Acting



Hypo can lead to Collapse

Materials Manipulation Research

	Oak	Pine	Plywood	MDF (Medium Density Fibreboard)	Hardboard	Acrylic	HIPS
Coping Saw 	Smooth cut, clean on entry and exit with no splintering overall a good choice for oak	Clean cut, easy bite and fast cute due to low density of pine. Very good choice for pine.	Splinters in backside of wood, easy to cut and good bite. Overall a good choice but care must be taken to minimise splintering.	Good bite and easy cut, some fluff-like shavings produced but overall good cut. 	Good bite and easy cut with little to no splintering produced and some fluff-like shavings	Lots of flexation while in vice, makes it difficult to cut. Despite this cut is quite fast. Lower chance of flexing/breakage by placing lower in vice.	Lots of flex, hard bite. Place low in vice to minimise flex 
Tenon Saw	Clean on entry and exit, no splintering but very slow progress. Fine powder-like sawdust produced. Overall a good choice for oak but cutting takes time	Easy bite, quick cut but lots of splinters produced along the cut. Not a good choice for pine 	Less splinters than the coping saw, good bite and relatively clean and easy cut. Good choice for plywood. 	Good bite, easy to cut but split veneer 	Easy to cut and good bite but lots of fluff like shavings produced 	Difficult to cut due to amount of flexation, the sample I cut broke very easily. Very bad choice for Acryllic. 	Hard bite, very difficult to saw and broke shortly after starting, very bad choice for HIPS 
Drill 	Relatively clean hole, little splintering occurred, minimise this risk with masking tape.	Some splintering at entrance hole, much more upon exit, masking tape could reduce this.	Clean hole on entry and exit, small risk of splinters mitigated by use of masking tape. Small shavings produced.	Clean exit, shavings on entry	Easy to drill, lots of fluff-like shavings produces	Chips of acryllic are produced from the surface when drilling. Use masking tape.	Split shortly after starting, very difficult to drill

Ergonomics/Anthropometrics

Primary Research

Ergonomics is the way in which a person interacts with an **objects design.** It is often studied in an attempt to maximise **efficiency** and **comfort.** It is needed in order to fit the needs of the **customer** and by including this in the **design** it makes the **product** more **comfortable** to the **users hands. Ergonomics** is **critical in design** as the better the **ergonomic** quality of a **product,** the more **satisfied customers** and **reviewers** will be. If a **design is ergonomic it will make the design easier to use** for longer periods of time for the user. To help me make my **design ergonomic** I will collect **data** (**span/length of male and female hands**) and use this data to **influence my design.**

Anthropometric Data Results

Male

A	220	221	193	211	192	250	219	220	190	198	195	202	210	210	200
B	195	196	190	191	194	180	190	200	175	184	197	200	215	196	202

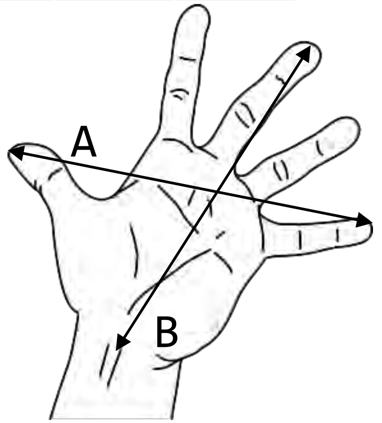
Average Male A: 197
Average Male B: 194
Average Female A: 179
Average Female B: 179
Average A: 188
Average B: 187

Female

A	190	180	210	186	172	160	175	190	170	190	155	185	160	176	180
B	175	185	188	191	173	175	180	180	160	185	179	180	173	181	177

Anthropometrics is the study of the **measurements** and **proportions** of the **human body,** this **data** is required when **ergonomic efficiency** is **desired** in a **design.** The **data** collected will be used to produce a **design** which is **compatible** with the largest possible **demographic** which will make the **product** available to the largest number of people.

In conclusion the average male hand has a larger span (by 18mm) and length (by 15mm) than that of the average female hand (A:179mm B: 179mm). The average hand for male and female combined is (A: 188mm B: 187mm). This data is very important as my wristwatch and base unit must be practical for a range of anthropometric data.



Ergonomics/Anthropometrics

Average Male: 178
Average Female: 163
Average: 171

Anthropometric Data Results

Male

184	175	170	190	178	177	182	175	180	170

Female

165	155	156	165	165	154	170	168	161	169

In conclusion the average male wrist has a larger circumference (by 15mm that of the average female wrist (163mm). The average wrist for male and female combined is 171mm. This data is very important as a watch is an everday item worn by men and women so the dimesnions must be appropriate for a wide range of wrist sizes. Some of the strap size issues will be negligible due to use of an adjustable strap, however it is still important to collect this data as excess strap material will be wasteful.

Most watch cases range in diameter from 38-46mm with the most typical sizes being 40mm or 42mm in size. The size of the watch is crucial as it is an everyday object that the user will likely not take off aside from sleep/showering. An overly large watch may cause difficulty with everyday use and the additional weight could cause a repetitive strain injury (RSI) in the wrist or hand. However too small a watch face could prove difficult when using the interface, especially for older users or users with restricted or affected movement. A watch that is overly light could give the impression of a cheap/fragile product which could in turn reduce product interest.

FOCUSED CLIENT INTERVIEW (PRIMARY)

The focused client interview aims to gain a more detailed picture of the clients needs and how they can be incorporated into a product and find inspiration from unidentified areas.

1. There are many products used to monitor blood sugar and keep them within a healthy range, what is the most inconvenient product of these?

I would have to say the finger prick can be incredibly annoying to use as the depth of penetration into the skin is a variable setting so sometimes I will set the depth too shallow and not enough blood can be drawn so I have to repeat the test which can be painful.

2. List some improvements to the products listed above.

A display of previous depth settings or the average depth setting would be very useful. One improvement that could be made on almost all products available for diabetics is the size and weight of items. Many items are bulky and heavy and to carry.

3. How does having diabetes affect your everyday life

You cant just pick up and eat a snack, everything has to be calculated. This is time consuming. Food is weighed during pregnancy and the body becomes more insulin resistant so your insulin ratios can change. Diabetes also affects exercise, often if I am going to exercise I will make sure my blood glucose is slightly high before I exercise to avoid a hypo.

4. How difficult was it to integrate medication/treatment into your life (work, family, social)

It was very difficult and there was a massive adjustment period. Before I was referred to Kings College London I was at a non specialist hospital that had a lack of counselling on diabetes treatment. This lead to me having many hypos due to poor diabetes management.

5. Referring to the products available to diabetics, how well is form balanced with function

Most products available are basic and focussed solely on form with no consideration for aesthetics. In my opinion this could lead to some diabetics being embarrassed at having to use a bland medical device in public.

6. Do you believe aesthetics should be considered in the design of diabetes products?

Definitely! More and more young people (even young children) are being diagnosed with diabetes and I feel that a more colourful and ergonomic product might not seem as daunting to a child and could help them adjust to being diabetic instead of being ashamed of it. While I don't want to trivialise diabetes by turning medical products into toys, I feel as if a more harmless looking product could help dispel the misconceptions some people have when they see diabetics checking blood glucose or injecting insulin in public.

7. Do you feel the general public has a lack of understanding with regards to diabetes; if so do you have any suggestions on how to improve this understanding.

In the past I have injected insulin on a public train, several people were staring and hearing judgemental comments is quite common, I think some people see a needle and assume the worst. While it would be difficult to incorporate diabetes awareness into the national curriculum I feel this is necessary to help reduce the stigma surrounding diabetes. More information should be available in GP surgeries and diabetes should be given more media attention. One thing that would improve awareness and QOL for diabetics would be to add carbohydrate units to food labels.

8. Do you feel that diabetic children would struggle to regulate their blood suagr?

Not necessarily, if proper advice is given to the child and their parents and they remain proactive about it there shouldn't be a problem, however I do feel a child friendly product would help a younger person to manage their diabetes. According to the latest research, on average, a child gets his or her first smartphone at 10.3 years old, if a child has access to a smartphone and can use it it would be beneficial if there was a product with smart technology capabilities as the child could use it alongside their phone.

FOCUSED CLIENT INTERVIEW (PRIMARY)

9. Do you feel the introduction of ‘smart’ technology has potential to improve the lives of diabetics through reminders/prompts etc?

Without a doubt. Why not integrate the product into the smartphone. I carry my smartphone everywhere with me, it is simple and convenient to use, so why cant I have something like that for diabetes. Perhaps a plug in blood meter that connects to an app and tracks your blood glucose levels.

10. How long can insulin be stored outside of the fridge before it becomes inactive?

Insulin must be used within 30 days of leaving a refrigerated environment, however I usually go through that amount within the allotted time.

11. Is there a contingency plan in the event of lost/stolen insulin (e.g. someone steals your handbag containing your epipen)

If I am in my town I will visit my GP or my pharmacy as they will have a record of my prescription. However if I was abroad or away from home I would visit the nearest hospital and go through triage.

12. How many weeks supply of insulin are you given at one time?

My prescription is 5x 10ml vials, this is meant to last 4 weeks but could vary slighty as no two days are the same or predictable as a diabetic.

13. Have you ever tried other treatments for diabetes such as the insulin pump?

I have never tried the pump and I would be hesitant to use it. There are a number of extremely serious health risks that become more probable with use of the pump such as Ketoacidosis (when your body produces a high number of blood acids and your blood becomes acidic). I also prefer to maintain completely manual control over my diabetes as I am accountable to myself.

15. How long does it take to for an insulin top up (adding up calorie values, calculating dosage and administration)?

It is a fairly time consuming process, especially if out and about. Values must be added up before eating and insulin dosage must be worked out according to your personal ratio (which can vary during the day). Overall I would estimate 10-15 minutes from calculation to injection.

Conclusion

The focused client interview has revealed problems with existing products. The main problem highlighted seems to be with ergonomics and aesthetics. I will take this into consideration when I am in the design phase, the product cannot be heavy or bulky and must have a sleek design with a range of colours but cannot become a status symbol. There are a number of different products that diabetics use so perhaps I could create a product that could eliminate the use of many products and combine the functions of several products. It would be foolish not to make use of smart technology such as touchscreens, Wi-Fi, Bluetooth and QR scanners. There is certainly the market for it and it has potential to greatly improve the quality of life for many diabetics.

FOCUSED CLIENT INTERVIEW (PRIMARY)

The focused client interview aims to gain a more detailed picture of the clients needs and how they can be incorporated into a product and find inspiration from unidentified areas.

1. There are many products used to monitor blood sugar and keep them within a healthy range, what is the most inconvenient product of these?

I really don’t like having to prick my finger so frequently, it can be painful, it isn’t a pretty sight in public and it takes time out of my working day.

2. List some improvements to the products listed above.

I know apple have brought out technology in their smartwatches that can detect certain things through the skin. If this same technology could be applied for use in diabetic products it would greatly improve the quality of life of the average diabetic.

3. How does having diabetes affect your everyday life

I travel a lot with work so making sure I always have the right thing on me in the right location at the right time can be a struggle, for example if I am going to be away while I am due to collect my prescription it must be organised to be collected in advance.

4. How difficult was it to integrate medication/treatment into your life (work, family, social)

When I was first diagnosed the advice I was given was to maintain a rigorous diet and calculate insulin based on my diet. This was difficult to do as a young man as it meant I coulnd’t eat or do the things I wanted to do sometimes.

5. Referring to the products available to diabetics, how well is form balanced with function

There is little in the way of variety in terms of visual and ergonomics. Most products are designed for maximum functionality (which is understandable) however it would be nice if there were more modern looking devices on the market.

6. Do you believe aesthetics should be considered in the design of diabetes products?

While I don’t think this should be the main focus (as these are medical products after all) however it would greatly increase the appeal of the product and could possibly help to reduce the negarive connotations with using a medical device in public.

7. Do you feel the general public has a lack of understanding with regards to diabetes; if so do you have any suggestions on how to improve this understanding.

Before I was diagnosed I had little knowledge of what diabetes was, I feel that is the same for most diabetics as there is little to no information about diabetes taught in schools so perhaps that would be a good place to start. I believe there are some charitable organisations in the USA dedicated to diabetes research and awareness so perhaps a sponsored program could hep funding and raise awareness at the same time.

8. Do you feel that diabetic children would struggle to regulate their blood suagr?

Definitely if they had a lack of parental monitoring or poor medical advice, this could be a struggle which could lead to complications or worsening of the condition.

FOCUSED CLIENT INTERVIEW (PRIMARY)

9. Do you feel the introduction of ‘smart’ technology has potential to improve the lives of diabetics through reminders/prompts etc?

Yes, certain technology such as skin sensors in patches are able to detect blood glucose levels in the blood.

11. Is there a contingency plan in the event of lost/stolen insulin (e.g. someone steals your handbag containing your epipen)

I would contact the nearest pharmacy or hospital if it was not urgent, however in an emergency any ER at a hospital will be able to provide an emergency supply.

13. Have you ever tried other treatments for diabetes such as the insulin pump?

I currently use the insulin pump as it allows me a greater deal of freedom than with daily injections, especially as I travel so often for work, it gives me one less thing to worry about. It also saves me time and allows more of a ‘normal’ lifestyle which is something a lot of diabetics desire.

Conclusion

The focused client interview has revealed problems with existing products. The main problem highlighted seems to be with ergonomics and aesthetics. I will take this into consideration when I am in the design phase, the product cannot be heavy or bulky and must have a sleek design with a range of colours but cannot become a status symbol. There are a number of different products that diabetics use so perhaps I could create a product that could eliminate the use of many products and combine the functions of several products. It would be foolish not to make use of smart technology such as touchscreens, Wi-Fi, Bluetooth and QR scanners. There is certainly the market for it and it has potential to greatly improve the quality of life for many diabetics.

RESEARCH ON EXISTING PRODUCTS

It is important to conduct research on existing products for diabetics. This helps to identify areas that can be improved and so gives guidance towards the areas to focus on the product's design.

Insulin Pump-The insulin pump is a device available to diabetics that allows for bespoke medical care to be given to each individual. For example it can be configured for use by a toddler, a pregnant woman or an elderly person to allow the correct doses to be automatically dispensed according to the individuals needs.

The insulin pump is made up of a continuous blood glucose sensor that continuously monitors the blood glucose levels and sends that data to the pump. The pump is the main unit that has a microprocessor which processes the data from the glucose monitor and uses that to dispense insulin from the built in insulin reservoir.

Advantages-The insulin pump allows a higher level of freedom as opposed to daily injections and allows the user to take a more relaxed approach to their diet and exercise regime. The pump is also more discreet than injections which could reduce the stigma surrounding diabetes.

Disadvantages-The pump is very expensive with some models costing upwards of £4500 and necessary supplies costing over £225. In the UK this will be available on the NHS but due to the expensive cost, doctors may hesitate to recommend use of the pump unless it is necessary to ensure the patients quality of life.

Daily insulin injections are another method of administering insulin to maintain blood sugar levels. Some injections are simply drawn from a cylinder into a syringe and then injected but some have a built in measurement function (humapen). There are also emergency version available that have a spring loaded needle to ensure the insulin is delivered into the bloodstream (epipen).

Advantages-This method is inexpensive (£50-70 for the pen and £20 for a pack of 5 insulin vials) and readily available in virtually every pharmacy.
This method is simple to use especially if using the humapen.

Disadvantages-This is more complicated to use than the insulin pump so may require more training to use effectively.
The wrong dosage could be administered which could be fatal.
Daily injections are extremely reliable and aren't prone to malfunction in the same way a pump is.

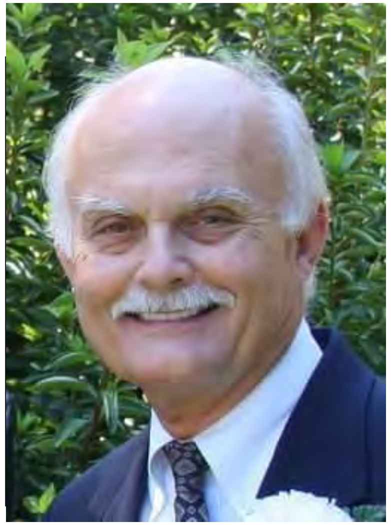
RESEARCH ON EXISTING PRODUCTS

Blood Meter-A blood meter is an electronic device that measures the glucose concentration and records this data in a way that allows the user to access it and adjust their insulin dosage accordingly. It is a key part of the HGBM (Home Glucose Blood Monitoring) process for most diabetics. Results are obtained by pricking the skin with a lancet to produce a drop of blood, the drop of blood is then placed on a disposable test strip where it is drawn into the meter and analysed. The resulting data is presented to the user in either mg/dm or mmol/l. Since the 1980s diabetes management has been aimed at achieving closer to normal levels of glucose in the blood, regular testing with the blood meter can be a massive help with this ias they are simple to use and highly accurate.
Positives: Low initial cost, simple to use, reliable technology, can simplify the process of calculating insulin dosages.
Negatives: Finger must be ‘pricked’ which can be painful if incision is too deep, repeated pricking in one area can result in build-up of scar tissue or callouses. Extremely high running cost, roughly £20-£30 a week for test strips alone (based on 10 strips a day)

Cost-£40-50 for meter, £15-20 for 50 test strips

Low Calorie Diabetes-Specific diet: Sometimes this method of blood glucose control is labelled as obsolete, however it it very popular among diabetics who are trying to lose weight. Having a pre-managed calorie intake can make things significantly less complicated. Often, diabetic foods are products with a lower than normal sugar content and fat content. This is because when a diabetic is trying to lose weight it is extremely hard as Insulin converts blood sugars into fat reserves; so it is important to ensure a hyper does not occur

POTENTIAL USER PROFILES



Name: Glenn Tomlinson
Age: 77
Gender: Male
Diabetic Type: Type 1
Date of Diagnosis: 1975
Personal Management of Condition (1-10): 4
Worst Experience with Hypo:
Products Used for Managing Diabetes: Pump/Patch
Status: Married
Mean Annual Income:
Disposable Income/Month:
Hobbies:
Interests:

Name: Cat Daniels
Age: 38
Gender: Female
Diabetic Type: Type 1
Date of Diagnosis: 2001
Personal Management of Condition (1-10): 7
Worst Experience with Hypo: When I was first diagnosed, I had a hypo, I woke up and there were two paramedics and four fire-fighters in my bedroom
Products Used for Managing Diabetes: Humapens and blood meter
Status: Married
Mean Annual Income: 13550 (part time before tax)
Disposable Income/Month: 50
Hobbies: Guitar, Blogging, Making Clothes
Interests: Music, Arts, Vintage Clothes

A Basic Outline of a Day in The Life of a Diabetic:

0530	Wake Up
0600	Check blood glucose and calculate fast acting insulin for breakfast. Administer fast acting insulin and then long acting background insulin
0645	Get children ready for the day
0700	Get myself ready for the day
1130	Prepare lunch (calculate carbohydrates and plan meal) and prepare meal for daughter not at school.
1200	Lunch, check blood glucose and administer insulin according to blood glucose levels.
1600	Prepare dinner (calculate carbohydrates and plan meal)
1700	Dinner, check blood glucose and administer insulin according to blood glucose levels.
1900	Bedtime routine for children
2200	Check blood glucose levels and administer long acting insulin accordingly before bed.

PRODUCT DISSASEMBLY

The humapen is made up of five main components: The cap, the needle, the canister, canister holder and the base of the pen which has the ability to adjust the dosage.
The cap is made of ABS with an anodised aluminium pen-style pocket-stay. ABS is chosen for this use as it has an incredibly high strength to weight ratio and high impact strength so it will protect the contents of the humapen. It is also durable and will not contaminate the contents which makes it suitable for medical use. Anodised aluminium is used as the anodised layer adds protection against corrosion, scratching and damage. The needle is made of titanium which has an extremely high strength to weight ratio so it will not bend or break in the body, titanium is commonly used in the medical industry as it is corrosion resistant and will not react with the medicine in the canister or any fluids in the body. The thread on the needle is most likely made of nylon as it has excellent abrasion resistance so the threads will not be worn down easily, ensuring a safe product over a long time.
The canister holder is made of PC as it has good impact resistance and a high strength to weight ratio so it will protect the canister. It can also be made crystal clear so the contents of the canister can be seen. PC also has very good chemical resistance; a good quality for medical applications. The canister itself is made of toughened glass which is inert and an atmospheric barrier so it will not contaminate the contents.

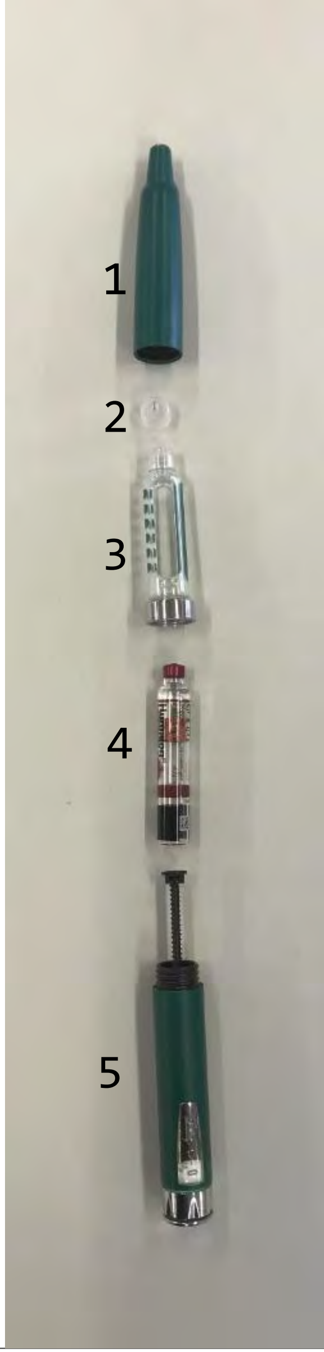
1-ABS Cap

2-Titanium needle and nylon thread

3-PC Canister case

4-Toughened glass insulin canister

5-ABS base



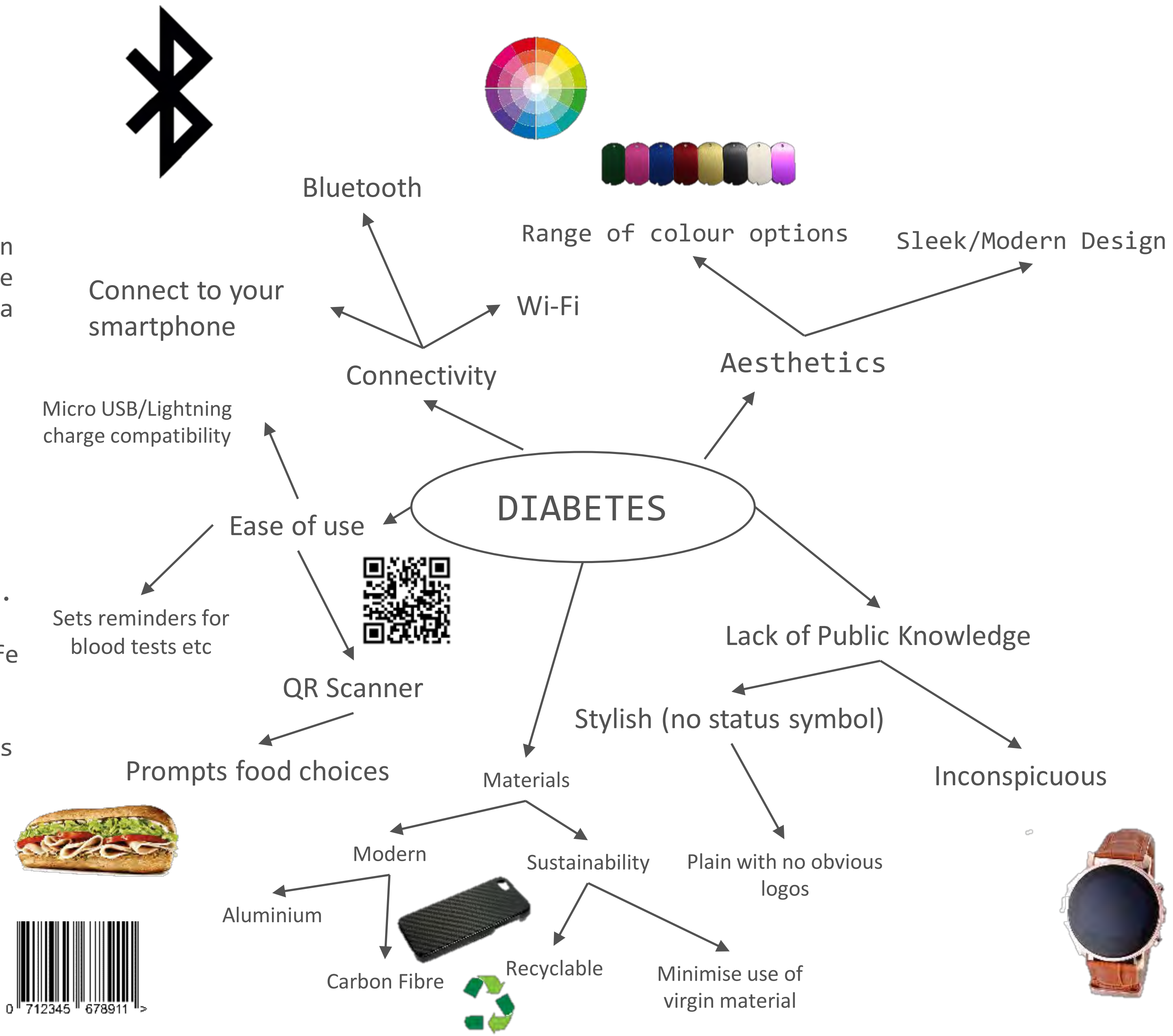
DESIGN PROBLEM AND DESIGN BRIEF

Design Problem:

Every day more and more people are diagnosed with diabetes at an increasing rate, including people who weren't born with it. This is due to a number of factors including genetics and lifestyle. Diabetics often require assistance during the initial adjustment following the diagnosis. After this initial adjustment diabetics will want to return to their normal lifestyle. Currently the products available for diabetics do not assist with inclusivity and enabling a more normal lifestyle but instead focus solely on reactive measures to avoid situations such as a hypo (dangerously low blood sugar level)

Design Brief:

I am an A-Level Product Design student, I am designing a product that will decrease the detrimental impact of diabetes on the ability of diabetics to live a normal life. The product must be able to function in a certain capacity that will enable it to conform to a 21st century way of life (apps/Wi-Fi/Bluetooth) and must be versatile enough to fit a wide demographic. The product must be aesthetically appealing, this will contrast almost all available diabetes products which often look dull. One way I will combat this will be to add an aspect of personalisation to the design, this helps with inclusivity and can instil a sense of personal pride in the product without creating a status symbol; this will make the user more likely to use the product.



SPECIFICATION

Introduction

I am an A-Level product design student in year 13, for my coursework I have chosen to design and manufacture a product that will help improve the quality of life of both type 1 and type 2 diabetics

Target Market

The potential target market for my product is all diabetics who want to live as mainstream and inclusive a life as possible. During my research I have understood my target market further by concentrating on two diabetics who are involved in my school or personal life, both work in a fast paced professional environment with rigorous stresses.

Function

My product will consolidate several diabetic products into one, this is because a reduction in the amount of products that must be carried and used would help a diabetic attain a better quality of life. My aim is to improve the quality of life of all diabetics who use this product. The product must be user friendly and have an instinctive, logical interface such as a touchscreen with an intuitive OS. I also aim to reduce the stigma around the use of diabetes products in public by improving the aesthetics of the product, however I do not want to create a product that is desired, rather a product in which the owner can take pride. My product will have a ‘cloud’ system that allows the hospital to download the users data via technology such as Wi-Fi or Bluetooth to avoid the regular trips to the hospital to download the users data. I would also like to include a less intrusive method of blood sugar monitoring such as above the skin sensors. There is also the possibility of having a docking station which could make use of wireless charging.

Ergonomics

My product must be designed in such a way that it is comfortable to be worn for long periods of time. Another ergonomic aspect to my design is that my design will have rounded edges which minimises discomfort while being used for long periods of time. The product must not be bulky or weigh too much as the product will be an integral part of the users life, 24/7/356. The screen will be large enough to be accessed by a range of users.

Costing

The product will be funded by either the NHS or privatized healthcare, it is a product of necessity and not desire so it is mandatory expenditure. The price range would be £800-1200, this is a high price but due to the nature of the product and the products lifespan (5+ years) the cost is not so expensive when compared to other products such as the insulin pump which can cost upwards of £4500.

Aesthetics

Aesthetics can be improved by selecting the appropriate materials for the product, such as carbon fibre or oak for their high aesthetic appeal. The designs will be clean and not overcrowded as the device is first and foremost a medical device. Aesthetics must be considered as this could help to reduce the stigma around using medical products in public, however aesthetics are not the main focus as function of this device is far more important. In simplified terms, this device is an example of function over form.

Materials

Form my actual product I would like to make use of modern, high performance materials such as carbon fibre as it is aesthetically appealing and is four times stronger than steel and a quarter of the weight so it would be ideal for this. Titanium would be a good material to use as it doesn’t react with medicines or the body so it is ideal for medical use. Nylon has a low friction coefficient and can be used to make small, intricate components. Polycarbonate has a high impact resistance so could be used as a screen protector. A hardwood such as oak could be incorporated into the docking station as it is aesthetically appealing and would contrast the more modern materials. For the prototype I will make use of readily available items that are easily obtained in a school workshop. Oak could be used for the docking station for the previously listed reasons. Pine, plywood and MDF could be used as they are inexpensive and are easy to manipulate. Acrylic could be used to simulate a screen and polymorph could be used as it can easily be shaped to fit the users wrist.

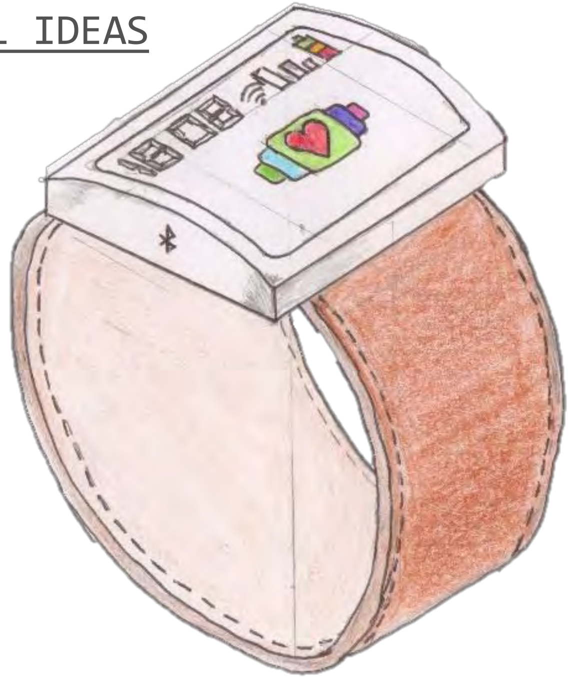
Manufacturing

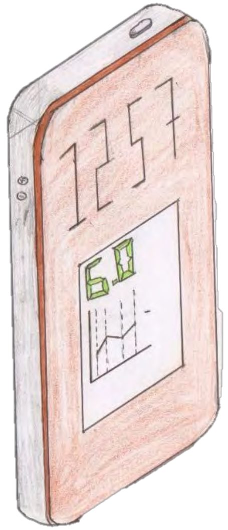
I will use a number of manufacturing processes in my design, for my product I will use line bending for acrylic. I will be able to use a scroll saw with most of my materials. When making the potential docking station I would like to hand cut dovetail joints (if appropriate to any of my designs) to add to the high-end craft aesthetic. CAD/CAM could be utilized to achieve a more realistic looking finish for certain design solutions generated.

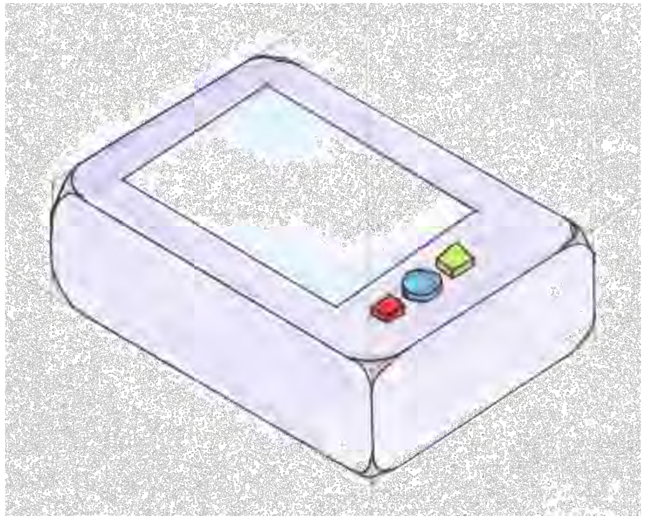
Sustainability

I would like to be as environmentally friendly as possible by working sustainability in to my design. I will use infinite renewable materials such as oak for my potential docking station, pine is another option and is preferable in terms of sustainability as pine can be renewed in as little as 20 years. The plastics I will use are finite and non renewable as they come from fossil fuels such as crude oil, however many of these plastics (thermoplastics) are recyclable as they can be heated and re-formed into another product. If this was manufactured in reality, ways of being more sustainable could include the introduction of solar technology to power the device. LED or LCD technology could be used as it uses less voltage than a traditional display which results in less power being used. I could also incorporate a power saver mode, very common on modern devices such as smartphones and tablets.

INITIAL IDEAS







Ergonomics: This product
Function: This product will function as a watch, this will assist the user in organisation and keeping track of meal times and when to test their blood sugar or top up insulin. The device helps to remove the stigma around diabetes as it is discreet and stylish. The device is styled as a watch so it is constantly attached to you. Putting a watch on is a morning ritual for those who wear watches so it will not be forgotten. The device monitors blood glucose levels through a sensor worn on the arm connected to the watch via Bluetooth
While leather is not recyclable, it is reusable. A non animal leather such as pleather or plant based leather could be used. Aluminium is nearly 100% recyclable and is already widely used in the personal electronics industry so would be appropriate to use for the main watch body.

https://www.freestylelibre.co.uk/libre/products/sensors.html

Ergonomics: this unit is a teardrop shape, the gentle curvature of the product complement the natural curvature of the hand, this makes the product more comfortable for use and reduces risk of repetitive strain injury. The buttons are large which reduces risk of accidental button pressing.

Form: there is a large display in the centre that is easy to read, the natural curvature of the design is aesthetically appealing

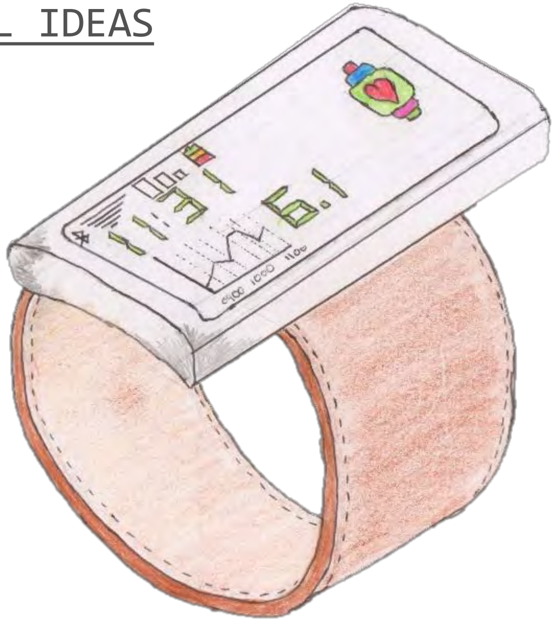
Function: the device will be WiFi and Bluetooth enabled to allow uploading of data to the cloud. This could reduce frequency of visits to the doctor. The device cap will be removable and will allow for direct testing of the blood with a single prick and no test strips required.

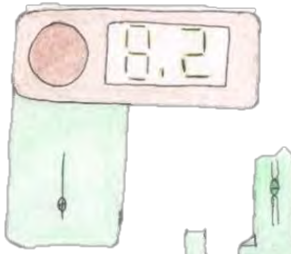
Materials, medical grade titanium, silicone rubber for the buttons, aluminium casing, possibly a high grade polymer such as HDPE. Wood, MDF/oak, foam prototype, laser cut components/CNC.

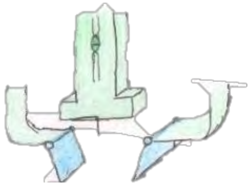
Use recycled aluminium. Al is nearly 100% recyclable. Titanium is recyclable. Thermoplastic elastomer for the buttons as it is recyclable.

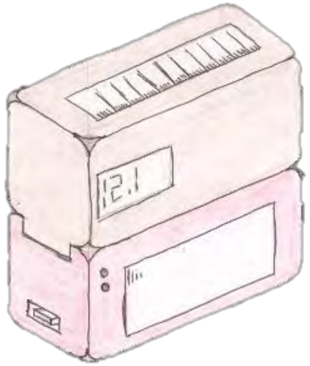
This product is designed to be a blood meter and insulin administering device as one. The device will be small enough to fit inside a trouser pocket so it is portable and can be carried anywhere. It will have cellular technology which will enable continuous uploading of data to the cloud which will reduce the need for frequent doctors visits.
The device has gentle curves to prevent the risk of strain while using. The product will send the data to the users phone via Bluetooth which can then upload to the cloud. The device could be made of a number of materials such as polymers like HIPS and the screen could be protected by a layer of polycarbonate. In the workshop I could utilise renewable materials such as MDF, Pine or oak. Also highly recyclable materials such as aluminium or titanium could be used

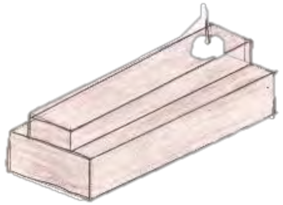
INITIAL IDEAS







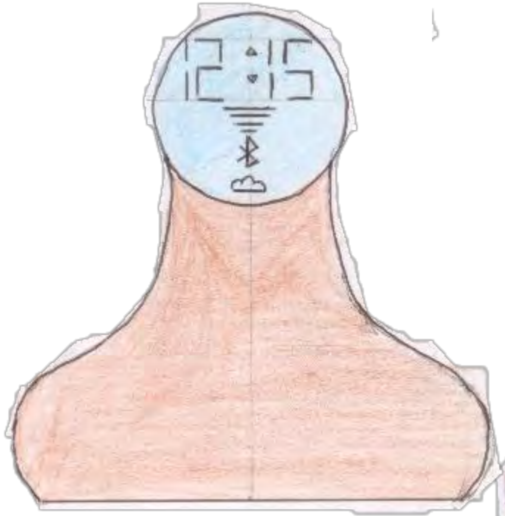


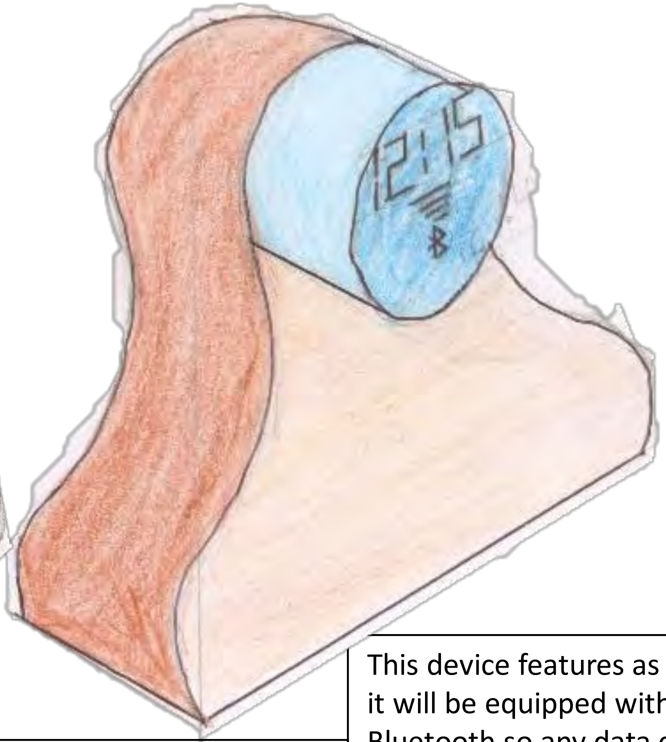


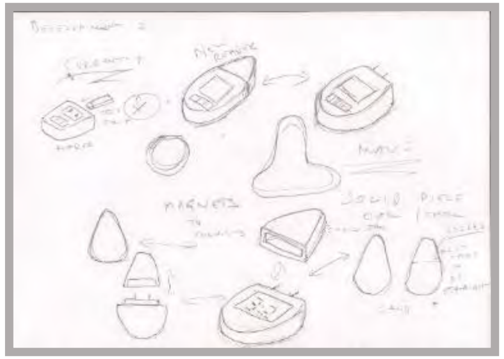
This product will function as a smart watch as it will set reminders and notifications for the user to check blood sugar or inject insulin. The product will have cloud connectivity which will decrease frequency of doctors visits, allowing the user to lead a more free and ‘normal’ life. This product looks stylish without becoming a status symbol which will help reduce the stigma around diabetes. As the item is worn like a watch, it will not be forgotten as for someone who wears a eatch, putting it on is a crucial component of their morning ritual.
The touchscreen will allow for personalisation and allows a wide demographic of users to access all functions of this device, the strap is made from leather so will be comfortable for the user to wear all day. The casing will be made out of a robust material such as medical grade titanium so it is inert and unreactive with the body. The leather strap will add to the aesthetic appeal of the watch and perhaps adding a brushed finish to the metal casing will further increase the aesthetic appeal. Materials for the device could include carbon fibre as it has 4x the strength of steel but is ¼ of the weight, it is also highly aesthetically appealing. Titanium is inert so it is appropriate if it will be in contact with the body all day. For the prototype, acrylic could be used for the screen, wood such as mdf or oak could be used for the casing and leather could be used for the strap. MDF is a manufactured board and is sustainable but non recyclable. Titanium and aluminium are almost 100% recyclable but non renewable.

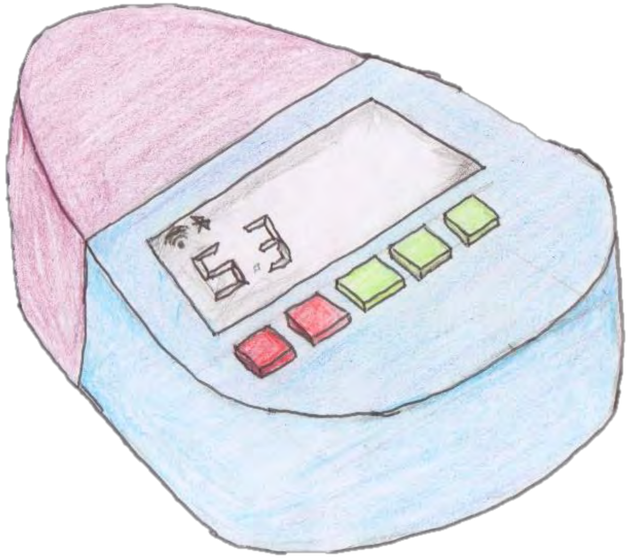
This product is designed to be a blood meter and insulin administering device as one. The device will be small enough to fit inside a trouser pocket so it is portable and can be carried anywhere. It will have cellular technology which will enable continuous uploading of data to the cloud which will reduce the need for frequent doctors visits.
The device has gentle curves to prevent the risk of strain while using. The device also makes use of a rotational hinge that allows the device to be used for multiple uses.
The device could be made of a number of polymers which would enable pigmentations which would increase the aesthetic appeal of the device and make the device appeal to a wider demographic.
The needle will be medical grade titanium as it is inert so it will not react with bodily fluids. The base of the needle could be nylon as it is impact resistant and an atmospheric barrier.

This device functions as a blood meter and insulin injection device. There is a viewing window in the top portion to remind you of how much insulin from the disposable cartridge you have left. The injection part of the device will function as a humapen. The device slides to bring these two functions into one compact, sleek product.
The device will have rounded edges so it will not hurt anyone or cause discomfort while in a pocket/handbag.
The device could be made of a number of materials such as polymers like HIPS and the screen could be protected by a layer of polycarbonate. In the workshop I could utilise renewable materials such as MDF, Pine or oak. Also highly recupyclsble materials such as aluminium or titanium could be used









The watches nightstand will have a high aesthetic appeal, while ensuring it isn't perceived as an aspirational product. This is difficult as the product must appear appealing for sales to be made and to defy the current designs for medical diabetes devices, but cannot be perceived as a prestigious product as it is not my intention to stylise diabetes.
To accomplish this effect, the nightstand features: flowing symmetrical curves, a dark hardwood finish, Wi-Fi connectivity, Bluetooth, wireless charging and a smooth façade featuring a clock face.

This device features as a nightstand for the watch, it will be equipped with wireless charging and Bluetooth so any data can be transferred from the portable unit into the base unit. The product will function as an alarm clock and radio as well. The stand has smooth curves which will match the natural aesthetic of the wood. The smooth curves will also make the device more appealing to a wider demographic.
A dark wood with a visible grain such as oak or teak would be excellent for this application as it is renewable and infinite and also highly aesthetically appealing.

The case is thin, will add very little bulk/weight to the phone. It will fit the ergonomic profile of the phone completely. This will reduces the chance of discomfort while in use

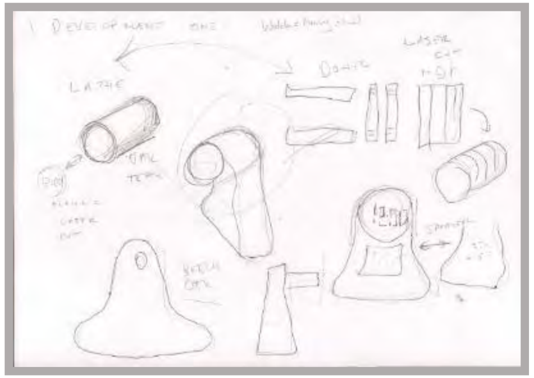
The product will send the data to the users phone which can then upload to the cloud. As we carry around our smartphones everyday we cannot live without them, for this reason we almost never forget our phones. This is why I have incorporated my design into a phone case.

Materials, carbon fibre, wood, aluminium, leather,

Wood, mdf, teak.

Most wood is renewable. Thermoplastics are recyclable as is aluminium

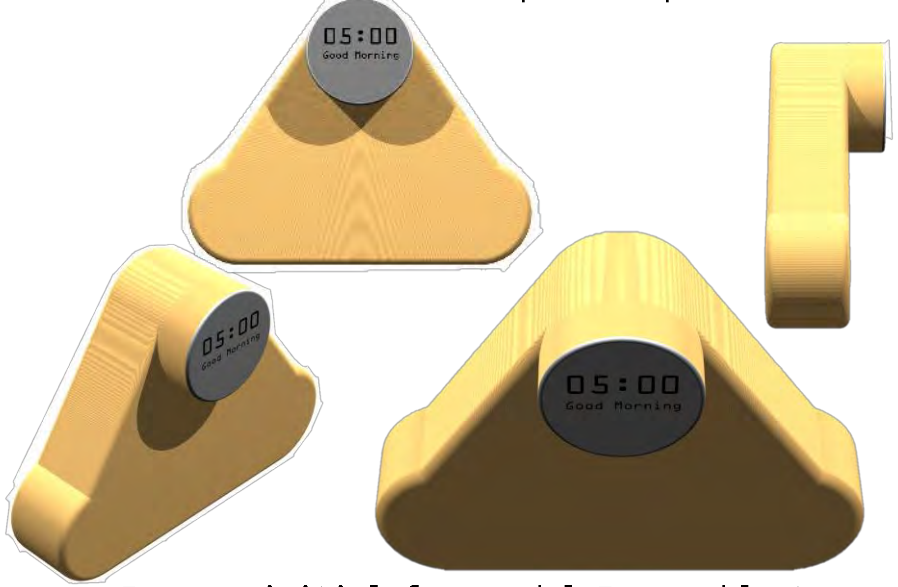
DEVELOPMENT STAGE A

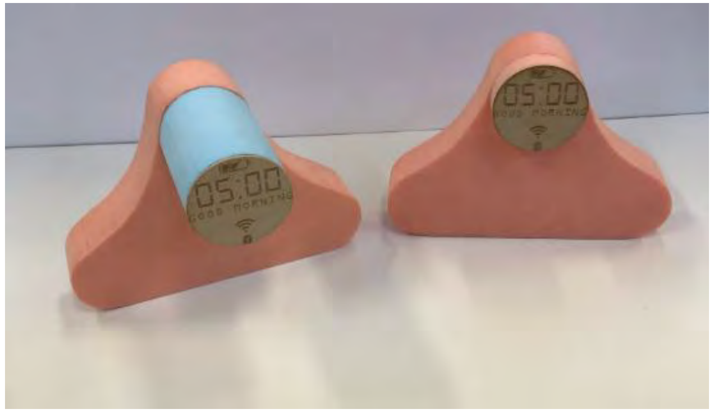


Before I created the foam model, I took my initial ideas and developed potential changes and variations which gave me a greater awareness of the 3 dimensional structures and shapes encompassed within the designs.

My design was not as stable as I had intended and would topple due to its centre of mass. This would be impractical for this design as it would require the addition of a base plate which would counter the smooth and free aesthetic of the design. I produced a redesigned foam model after designing it on prodesktop with a shorter protrusion on the face, this updated prototype will not topple on its own or with the watch in place.

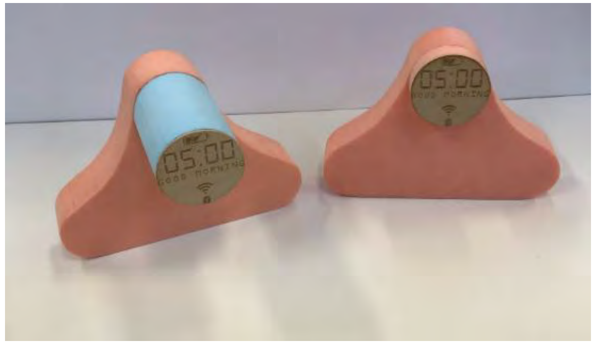
These 3D renderings of my design aid in visualisation of the potential dimensions and proportions. This allowed me to modify my design to conform with the desired aesthetic and anthropometric parameters.





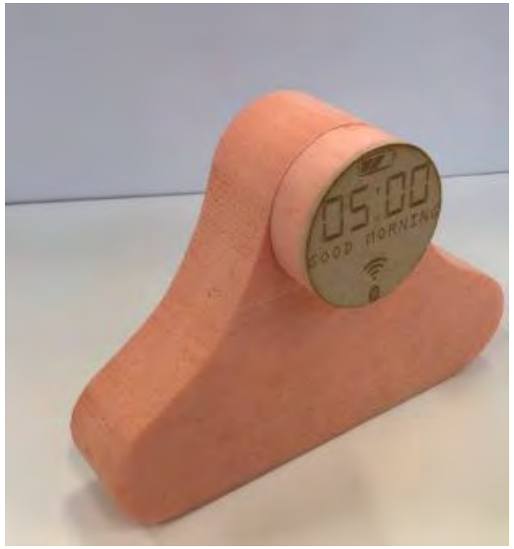
From my initial foam model I was able to acknowledge and understand the shortcomings of that particular design, having reviewed this I was able to modify and manipulate a digital version of this design to produce an improved version of the product that would not suffer the same flaws as my initial foam model. CAD allowed me to change details on the model instantly, it is much quicker than making another block model. CAD also allowed me to visualise the final product as I was able to add textures to the model. Using CAD alone I was able to determine the model was significantly more stable than the initial model and would not have the same liability to topple.

PRODUCT DEVELOPMENT



After examination if the initial design and realisation that it was not stable enough, I used CAD to produce schematics for another, redesigned prototype. I used 2D design to produce a template for the redesigned prototype. I took this scaled template and placed it over foamboard of the necessary thickness, I then used a jigsaw to cut around the template to produce the shape I needed for my design.

Once the design was cut, I used wet and dry to smooth the edges and then cut the face of the design (again using a CAD template and jigsaw) and used PVA glue to attach it to the main body of the prototype. Then I used 2D design to produce a design for the ‘clock face’ including: WiFi indicators, Bluetooth, the time and date and a greeting of the day. I then used a Laser Cutter to cut the design on to MDF which I then glued to the foam model

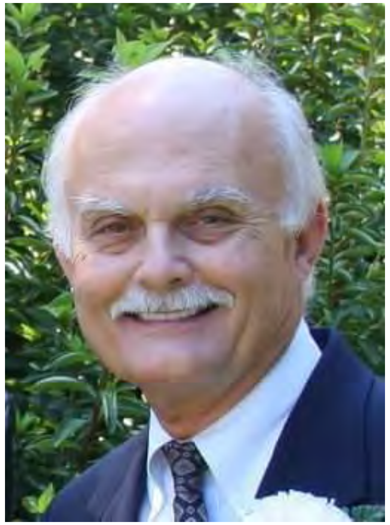


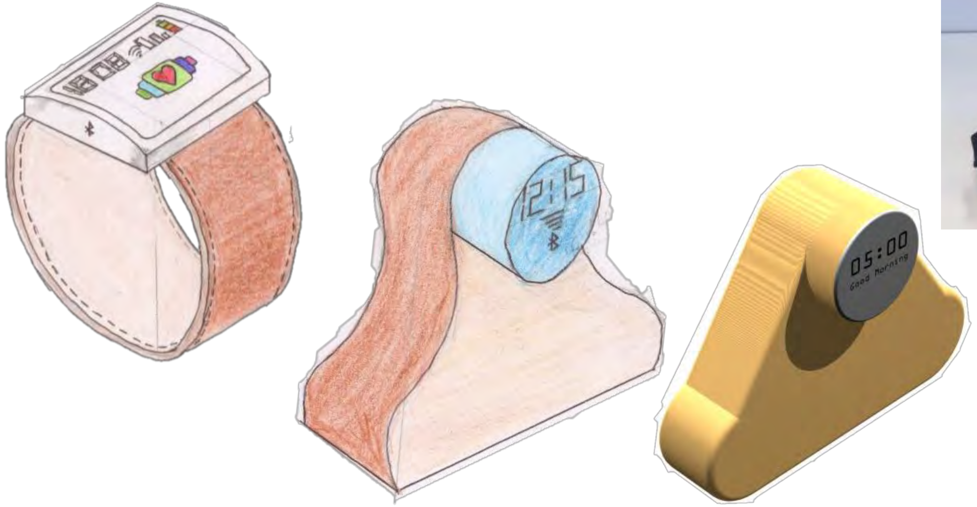
I took the final version of the prototype and evaluated it against the first, it will not topple even with the watch device placed on it, I achieved this by shortening the face of the design to shift the centre of gravity to a more stable position. This is critical to my design as a toppling design will not only be difficult to use but also a commercial failure.

I took the sketches from my initial watch design and created an initiaql prototype using laser cut pine and thin denim, I then used the CAD/CAM embroidery machine to embroider a lettered crest in the strap to add to the customisation of the watch. From this initial prototype I determined the placement of the embroidered crest was not optimal and that several modifications to the strap and face needed to be made. Using this information I then made a second model using oak (which I laser cut to produce the face) and denim which I embroidered differently to make the placement of the embroidery more visible and aesthetically appealing.

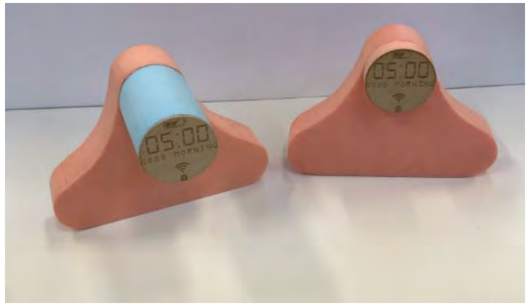
To ensure the engraving on the watch face and the base unit interface was optimal, I used a test piece of oak to determine the optimum speed and power of the laser cutter’s engrave setting for my oak prototype. I made a pine test piece on the lathe to further develop my wood lathe skills. This piece simulated the manufacture of the interface piece of my design. I was able to ascertain more information related to the engineering aspect of the design to ensure the male and female components fit together.

TARGET MARKET FEEDBACK (DESIGN PROCESS)





The sketches look promising, there is a lot of potential there. I especially like the curvature of the base unit, it contrasts with the modernity of the product and compliments it nicely. I like the screen layout, from the sketches it appears to be very intuitive and easy to use. The incorporation of smart technology into a medical device seems promising and could have wider implementation. The contrast of leather and metal in the watch design is very appealing (aesthetically), however I do not feel the colour blue fits with this product, I am aware this product is primarily a medical device but aesthetics must be considered if you are to destigmatise diabetes in everyday life. I feel a more neutral colour would be preferential as well as the use of metal or perhaps more wood as opposed to plastics, after all it will improve the aesthetics of the design and certain metals such as aluminium are highly recyclable and don’t require crude oil like plastic does. I feel that personalisation of the product would be a significant step in destigmatisation as the device would be more than just a medical device and more of a personal item, perhaps adding different metal colour options for the watch face and perhaps the strap could be embroidered or the face could be engraved to add a personal touch



The initial sketches show potential but there is always room for improvement. For example I feel it would be beneficial (both environmentally and medically) to use a metallic watch strap as no animal products are used and surgical grade titanium wont hold bacteria which will minimise the risk of infection (especially important in a medical device). It would also be much easier to clean and would last longer than leather. I also feel that giving the customer an option between leather or metal could increase the appeal for the product and could be marketed as a smartwatch for diabetics instead if as a medical device. You mentioned that ending the stigma around diabetes was one of your ‘mission statements’ and I think inclusion of personalisation or choice of colours could make a big impact with regards to this. The design of the base unit is contemporary yet not overly contemporary (it wouldn’t look out of place on an oak nightstand in the bedroom of a log cabin or in a modern cosmopolitan setting) this will definitely increase the breadth of the demographic this appeals to. In the annotations of your sketch you indicated that a hardwood such as oak could be used, this would add to the aesthetic appeal as oak is a high quality material that can achieve an aesthetically appealing finish. It is also renewable and reusable which could negate some environmental concerns.

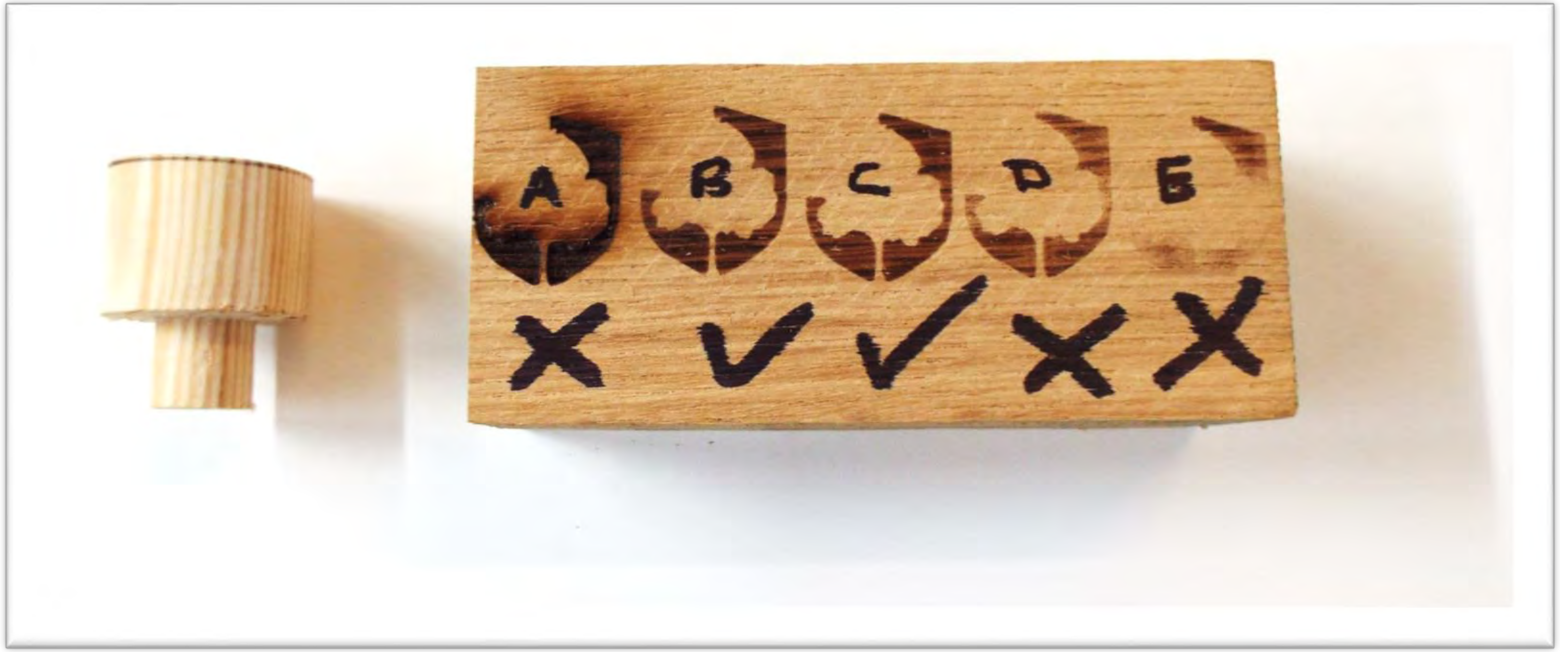
DEVELOPMENT STAGE-PHOTO DIARY

FINAL PROTOTYPE PICTURES


7.5
7.5
FW


00:00
Blood Glucose:
7.5


00:00
Blood Glucose:
7.5
00:00
Blood Glucose:
7.5
FW

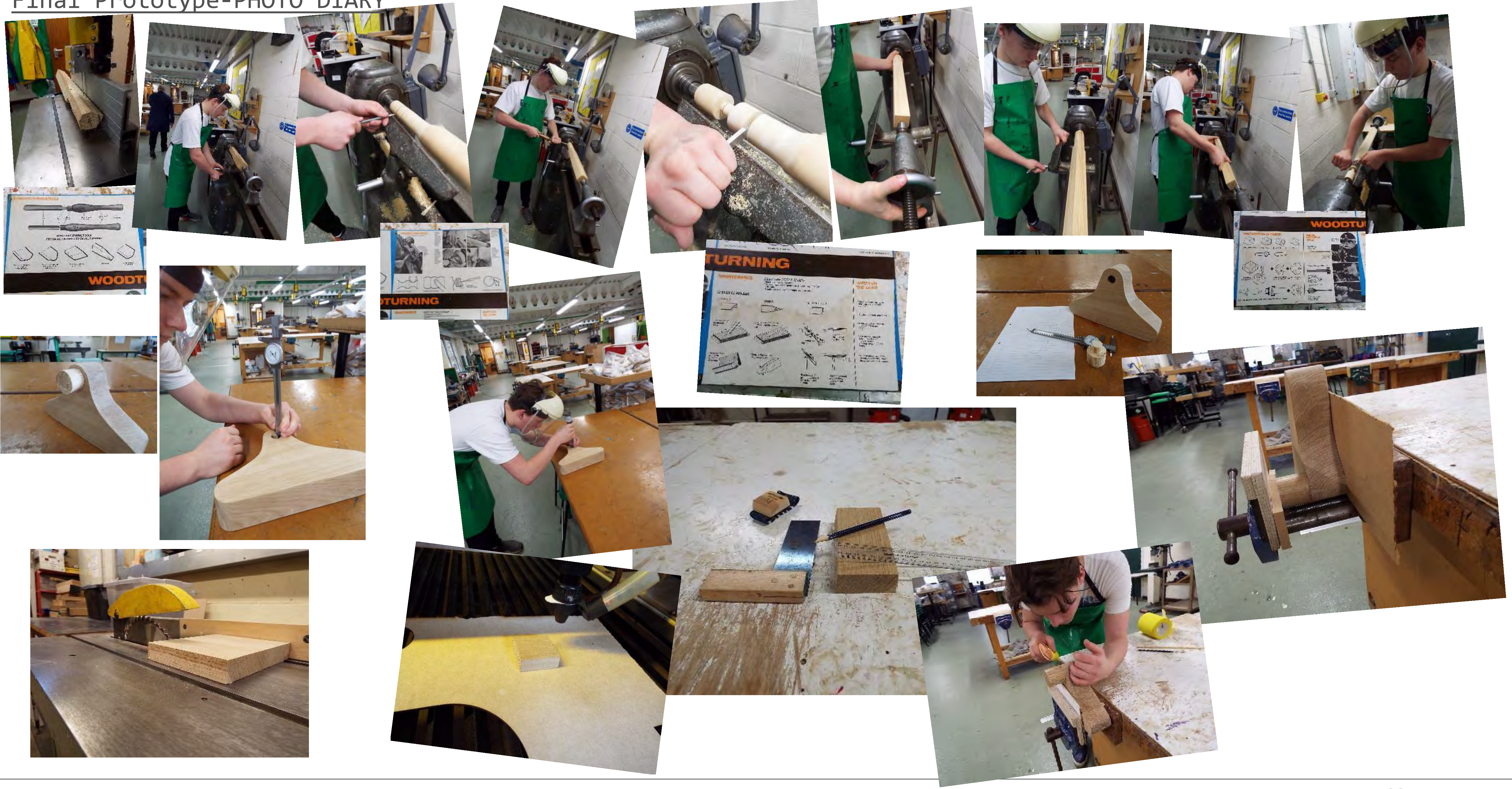

A
B
C
D
E

DIARY OF MAKING

Stage	Time	Task	Tools/Equipment	Health & Safety	Quality Control (QC)
1	Min	I will use the CAD program 2D design to produce and manufacture a template for my design, I will use CAD instead of hand drawing as it is faster, more accurate and exact duplicates can be produced with ease. The photocopier can provide a simple method for producing fast and accurate copies.	-2D Design -Computer -Mouse -Screen -Computer Chair -Metal Rule -Calculator -Pencil -Paper	I will turn on lights in the computer room to avoid eye strain, and adjust the brightness and contrast as well. The angle of the screen and the height of the chair will be adjusted to minimize risk of eye or back strain. I will take a break from looking at the monitor on a regular basis to avoid eyestrain/headaches caused by artificial light.	I will refer to my sketches to ensure the product is to scale and adheres to the ergonomic properties I want to achieve. Photocopiers can sometimes distort the image, so I will measure the dimensions of the copy to ensure no distortion has occurred.
2	30/40min	I will sand down a block of oak measuring (**X**X**mm) using a handheld belt sander and an orbital sander. I will use the handheld belt sander first as it is a less precise tool but will sand the oak to a finish that can be smoothed out by the orbital sander. The orbital sander is a finer tool and will achieve the desired smoothness of the oak.	-Oak block -Orbital Sander -Handheld Belt Sander -Face Mask -Goggles -Apron -Dustpan and Brush	I will ensure windows are open in the workshop to allow ventilation and prevent dust buildup and inhalation. I will wear an apron, goggles and a face mask to protect myself from the carcinogenic oak dust. I will periodically sweep up the dust to prevent accumulation of dust in the workshop.	I will periodically inspect the oak to ensure the surfaces are level and parallel with each other. I will also use progressively finer sandpaper to ensure a consistent finish.
3	20min	I will attach the template to my oak block using a non toxic adhesive and then cut around the template using the bandsaw	-Bandsaw -Non-Toxic Adhesive -Apron -Goggles	I will not use the bandsaw as you must be over 18 and have health and safety training, I will use a non-toxic adhesive to lower the potential hazards.	I will constantly ensure the cut adheres to the template. I will cut incisions along the template to ensure the blade does not overheat or distort which could damage the cut.
4	30min	I will use the orbital sander and handheld belt sander to remove the glued template and any adhesive residue. I will further sand the wood to produce an equally smooth finish on all sides.	-Orbital Sander -Handheld Belt sander -Orbital Sander -Mask -Goggles -Apron -Dustpan and Brush	I will ensure windows are open in the workshop to allow ventilation and prevent dust buildup and inhalation. I will wear an apron, goggles and a face mask to protect myself from the carcinogenic oak dust. I will periodically sweep up the dust to prevent accumulation of dust in the workshop.	I will check the sanding continuously to ensure an equal finish on all sides and ensure a symmetrical curve on the product.
5	30min	I will use a forstner bit to drill a 20mm hole in the surface of my design, this will allow for mounting of the ‘clock face’. I will then sand away any wough edges	-Goggles -Apron -Forstner Bit -Pillar Drill -Pencil -Ruler -Sandpaper	I will ensure the wood is securely in place when drilling by using a G-Clamp, I will use a sacrificial piece of MDF above and below the oak to ensure the high carbon steel of the machine does not scratch the oak.	I will slowly drill the wood to prevent charring of the wood. I will ensure the hole is being drilled in the right place with the use of a pencil and ruler. I will mark the exact spot is clearly marked.

Stage	Time	Task	Tools/Equipment	Health & Safety	Quality Control (QC)
6	Min	I will use the lathe to produce the circular clock face body. The lathe will allow me to produce a circular finish on my clock face much faster and more accurate than by hand.	-Lathe -Mask -Visor -Lathe Tools -Pencil -Turners Calipers -Verniers Calipers Dustpan and Brush	I will keep loose articles of clothing tied away or removed as the lathe could catch these and cause serious injury. I will wear a visor and mask at all times to protect against dust and high velocity wood chips. I will regularly pause and sweep up the shavings to reduce the slipping hazard.	I will refer to my sketches to ensure the product is to scale and meets the specified dimensions. I will use the turners (set to 21mm)to ensure an even diameter across the entire cylinder.
7	30/40min	I will use the laser cutter to engrave my clock face on to my product.	-2D Design -Computer -Mouse -Screen -Computer Chair -Metal Rule -Calculator -Pencil -Paper	I will turn on lights in the computer room to avoid eye strain, and adjust the brightness and contrast as well. The angle of the screen and the height of the chair will be adjusted to minimize risk of eye or back strain. I will take a break from looking at the monitor on a regular basis to avoid eyestrain/headaches caused by artificial light.	I will ensure the laser is properly aligned to ensure correct placement of the engraving. I will determine the best setting for speed and power of the laser cutter to give the desired effect. I first used the laser cutter on a test piece of oak and conduct multiple tests to determine the best settings for the laser cutter.
8	20min	I will laser cut the watch face from a block of oak. The material will first be machine cut by the technician using a circular saw.	-2D Design -Computer -Mouse -Screen -Computer Chair -Metal Rule -Calculator -Pencil -Paper	I will turn on lights in the computer room to avoid eye strain, and adjust the brightness and contrast as well. The angle of the screen and the height of the chair will be adjusted to minimize risk of eye or back strain. I will take a break from looking at the monitor on a regular basis to avoid eyestrain/headaches caused by artificial light.	I will ensure the laser is properly aligned at the correct height to ensure correct placement of the engraving. I will determine the best setting for speed and power of the laser cutter to give the desired effect.
9	30min	I will design, stitch and embroider a denim strap for my watch face. I will use a CAD/CAM embroidery machine to produce a custom strap design. I will also use a sowing machine due to the greater speed and ease of use than hand sowing. I will cut the design out of denim and then fold it over to give an aesthetically pleasing finish on both sides. I will then sow the two folds together to produce a tube of material which I will flatten with the iron and further stitch to create the strap.	-Sowing Machine -Denim -CAD/CAM Embroidery Machine -White Thread -Scissors -Iron -Ironing Board -Tailors Chalk -Ruler	I will ensure the denim is securely in place before using an machine as needle breakages can be costly and painful. I will Ensure any machine is set up safely to reduce risk of malfunction.	I will check the strap continuously to ensure adherence to my design. I will use a ruler and tailors chalk to ensure correct measurements before I cut the material.
10	30min	I will use a forstner bit to drill a (**mm) hole in the surface of my design, this will allow for mounting of the ‘clock face’. I will then sand away any wough edges	-Goggles -Apron -Forstner Bit -Pillar Drill -Pencil -Ruler -Sandpaper	I will ensure the wood is securely in place when drilling by using a G-Clamp, I will use a sacrificial piece of MDF as not to damage the oak.	I will slowly drill the wood to prevent charring of the wood. I will ensure the hole is being drilled in the right place with the use of a pencil and ruler. I will mark the exact spot is clearly marked.

Final Prototype-PHOTO DIARY



Evaluation Against the Specification

Introduction

I am an A-Level product design student in year 13, for my coursework I have chosen to design and manufacture a product that will help improve the quality of life of both type 1 and type 2 diabetics

Target Market

The potential target market for my product is all diabetics who want to live as mainstream and inclusive a life as possible. During my research I have understood my target market further by concentrating on two diabetics who are involved in my school or personal life, both work in a fast paced professional environment with rigorous stresses.

Function

My product will consolidate several diabetic products into one, this is because a reduction in the amount of products that must be carried and used would help a diabetic attain a better quality of life. My aim is to improve the quality of life of all diabetics who use this product. The product must be user friendly and have an instinctive, logical interface such as a touchscreen with an intuitive OS. I also aim to reduce the stigma around the use of diabetes products in public by improving the aesthetics of the product, however I do not want to create a product that is desired, rather a product in which the owner can take pride. My product will have a 'cloud' system that allows the hospital to download the users data via technology such as Wi-Fi or Bluetooth to avoid the regular trips to the hospital to download the users data. I would also like to include a less intrusive method of blood sugar monitoring such as above the skin sensors. There is also the possibility of having a docking station which could make use of wireless charging.

Ergonomics

My product must be designed in such a way that it is comfortable to be worn for long periods of time. Another ergonomic aspect to my design is that my design will have rounded edges which minimises discomfort while being used for long periods of time. The product must not be bulky or weigh too much as the product will be an integral part of the users life, 24/7/356. The screen will be large enough to be accessed by a range of users.

Costing

The product will be funded by either the NHS or privatized healthcare, it is a product of necessity and not desire so it is mandatory expenditure. The price range would be £800-1200, this is a high price but due to the nature of the product and the products lifespan (5+ years) the cost is not so expensive when compared to other products such as the insulin pump which can cost upwards of £4500. However for the prototype, my budget has been set at £20.

Aesthetics

Aesthetics can be improved by selecting the appropriate materials for the product, such as carbon fibre or oak for their high aesthetic appeal. The designs will be clean and not overcrowded as the device is first and foremost a medical device. Aesthetics must be considered as this could help to reduce the stigma around using medical products in public, however aesthetics are not the main focus as function of this device is far more important. In simplified terms, this device is an example of function over form.

Materials

Form my actual product I would like to make use of modern, high performance materials such as carbon fibre as it is aesthetically appealing and is four times stronger than steel and a quarter of the weight so it would be ideal for this. Titanium would be a good material to use as it doesn't react with medicines or the body so it is ideal for medical use. Nylon has a low friction coefficient and can be used to make small, intricate components. Polycarbonate has a high impact resistance so could be used as a screen protector. A hardwood such as oak could be incorporated into the docking station as it is aesthetically appealing and would contrast the more modern materials. For the prototype I will make use of readily available items that are easily obtained in a school workshop. Oak could be used for the docking station for the previously listed reasons. Pine, plywood and MDF could be used as they are inexpensive and are easy to manipulate. Acrylic could be used to simulate a screen and polymorph could be used as it can easily be shaped to fit the users wrist.

Manufacturing

I will use a number of manufacturing processes in my design, for my product I will use line bending for acrylic. I will be able to use a scroll saw with most of my materials. When making the potential docking station I would like to hand cut dovetail joints (if appropriate to any of my designs) to add to the high-end craft aesthetic. CAD/CAM could be utilized to achieve a more realistic looking finish for certain design solutions generated.

Sustainability

I would like to be as environmentally friendly as possible by working sustainability in to my design. I will use infinite renewable materials such as oak for my potential docking station, pine is another option and is preferable in terms of sustainability as pine can be renewed in as little as 20 years. The plastics I will use are finite and non renewable as they come from fossil fuels such as crude oil, however many of these plastics (thermoplastics) are recyclable as they can be heated and re-formed into another product. If this was manufactured in reality, ways of being more sustainable could include the introduction of solar technology to power the device. LED or LCD technology could be used as it uses less voltage than a traditional display which results in less power being used. I could also incorporate a power saver mode, very common on modern devices such as smartphones and tablets.

Evaluation Against the Specification

Introduction

Conducting an evaluation against the specification allows for a rigorous self evaluation as the product or design can be compared to the original goals and ideals to which the design was held. It allows for areas of further development and modification to be highlighted. It is a highly specific method of evaluation as there are eight separate aspects of analysis which results in a highly detailed response.

Target Market

My target market can be summed up as diabetics who want a streamlined work and home life with minimal interference from their diabetes. My design was a watch with a leather strap, as this is not gender or age specific it could be used by a wide demographic. As most people wear watches the design will not be intrusive as most people are already accustomed to putting on a watch as part of a morning routine. The design constantly monitors your blood glucose level meaning regular pricking of the skin to monitor levels is not required, this allows the user to continue their work day uninterrupted, this is especially useful in time critical careers such as surgeons, police officers, firefighters and many more.

Function

My product was able to consolidate several diabetic products into one through the use of smart technology. Using sensors on the bottom of the watch, the device will be able to monitor blood glucose levels without ever breaking the skin, while this technology is still in development and hasn't received approval from medical governing bodies such as the FDA or MHRA, it is likely to be approved in the near future due to the ever growing diabetic population of the planet and the demand for unobtrusive medical technology. Another key function of the design was to be user friendly and have an intuitive OS on the watch, I believe a simple layout on the touchscreen where the user can swipe through their apps (layouts incredibly popular in smartwatches) will streamline many diabetics lives. With regards to reducing the stigma around diabetes, the device is designed in such a way that it is unlikely to be noticed and recognized as a medical device as I will have the outward appearance of a smartwatch. This will eradicate the unwanted attention and reactions to diabetic products being used in public.

Ergonomics

My original ergonomic goals were to create a product that could be worn by the user all day, 365 days a year, and this was enabled with the 'smartwatch' design. I used anthropometric data obtained from peers to determine the average hand span/length and wrist circumference for both male and female peers. I used this data to determine the most appropriate dimensions for both the watch face and strap. The screen has more than sufficient surface area (at 2116mm^2 or 42X42mm) which enables it to be optimally utilised by a wide range of users all the way from elderly to child users. While large enough to fit a wide range of users the screen is simultaneously small enough not to cause any more noticeable effect than would be encountered with a normal wristwatch.

Costing

The device would be a very expensive product due to the nature of the device. There is cutting edge medical technology within the product as well as the high initial investment required for research and development, as well as this the product would have to meet stringent regulations set by the FDA (USA) and the MHRA(UK), this would also contribute to the cost of the product. Despite the high initial cost it would be a fraction of other products marketed at diabetics such as the insulin pump (£4500) and as this product would save the user both time and money it would certainly be a practical long term investment, as the user will no longer require blood testers or testing strips, the user will not have to attend as frequent medical appointments as the hospital will be able to access the user data via a cloud based system.

Aesthetics

Aesthetics were a priority as this device needed to have an appealing appearance to reduce stigma around use of medical devices in public. However function was more important than form to me, as the design was primarily a medical device. I used oak extensively in my prototype to add a high level of aesthetic appeal. I also used denim for the strap which is a durable material as well as aesthetically appealing. I used a CAD/CAM embroidery machine to embroider initials on to the denim strap to add a personal touch. I also used fine sandpaper to get a smooth and aesthetically appealing finish for my design. For my actual product I would likely use aluminium or medical grade titanium for the body as they are highly recyclable and aesthetically appealing. For the strap either animal or plant/synthetic leather, leather is a highly aesthetically appealing.

Materials

For production of my design I decided to use oak for the body of the docking station and oak for the watch face with a denim strap. I decided on a denim strap as it is available in different colours yet is a hardwearing material (similar to leather). It can also be embroidered with the tools I have access to. It could also be made of reclaimed denim which is in fashion right now (Companies such as Nudie Jeans uses reclaimed cotton for the manufacture of their denim)In the actual design I will use leather as it is a tough material and can achieve a high quality, prestigious aesthetic. I have used oak for the prototype watch face as it is a high quality material that can easily be obtained on a limited budget and manipulated in a school workshop. Oak can also achieve a variety of high quality finishes, it is currently in trend to use sustainable hardwoods. I have used HIPS (High Impact Polystyrene) this represents the speaker feature. HIPS can achieve a high quality finish after laser cutting. It is a cost effective material and looks like a realistic component. The particular HIPS I have used is layered, it is black on the top and bottom with a white centre section, this allows for another dimension of finishes as the top layer can be laser cut to reveal the white centre in places. I will incorporate the use of composites fore the body of the actual watch.

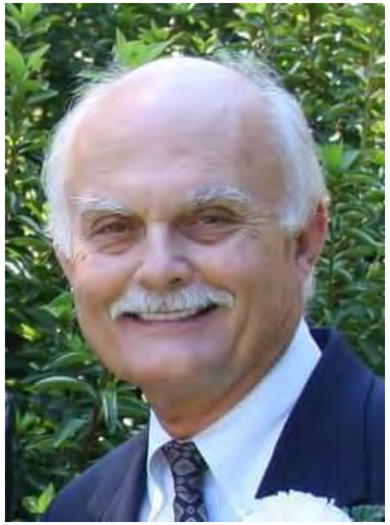
Manufacturing

I used a large number of techniques available to me as a student using a school workshop I utilized CAD/CAM technology in some aspects of my design such as: Using 2d design and a laser cutter to engrave the watch face and the docking station screen. I used Pro Desktop to create 3D renderings of the docking station. I used a number of hand tools such as sandpaper, tenon saws and I also used a number of machines such as a jigsaw, pillar drill, CAM embroidery machine, rotational sander, belt sander, orbital sander and handheld belt sander.

Sustainability

To ensure my design was as sustainable as possible while also being aesthetically appealing, I used materials such as oak which is both sustainable and renewable. After the products life, the product can be reused and repurposed or even burnt to release heat energy in an incineration plant which will produce electricity. This is conducted on an industrial scale but can also be conducted my small local businesses who have the capabilities.

Feedback From Final Prototype



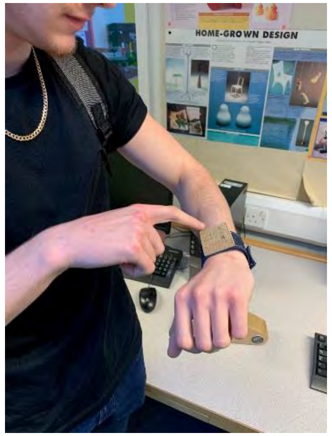
Name: Glenn Tomlinson
Age: 77
Gender: Male
Diabetic Type: Type 1
Date of Diagnosis: 1975
Personal Management of Condition (1-10): 4
Worst Experience with Hypo:
Products Used for Managing Diabetes: Pump/Patch
Status: Married
Mean Annual Income: 100000
Disposable Income/Month:
Hobbies: Fishing, Golf and Cigars Collecting
Interests: Politics, American History, Hank Williams Music, Cult Movies

Form: The sleek aesthetic compliments the oak very nicely, it is both classic and modern
Aesthetics: The mix of colours is not overly complicated yet is not dull like most diabetes products
Ergonomics: The base unit feels solid and well built. It has been finished nicely. The watch has an adjustable strap which is a nice touch as it will allow the device to fit a wide demographic.
Overview: The design is very nice and will certainly help to reduce the stigma surrounding diabetes.
Possible Modifications: I would like it if the speakers in the device were part of a removable unit so it could be used as a Bluetooth speaker as well. This would increase the functionality and increase customer intrest.

Name: Cat Daniels
Age: 38
Gender: Female
Diabetic Type: Type 1
Date of Diagnosis: 2001
Personal Management of Condition (1-10): 7
Worst Experience with Hypo: When I was first diagnosed, I had a hypo, I woke up and there were two paramedics and four fire-fighters in my bedroom
Products Used for Managing Diabetes: Humapens and blood meter
Status: Married
Mean Annual Income: 13550 (part time before tax)
Disposable Income/Month: 50
Hobbies: Guitar, Blogging, Making Clothes
Interests: Music, Arts, Vintage Clothes

Form: The design's curves and smooth finish are highly appealing
Aesthetics: The waxed finish is appealing to touch and is aesthetically appealing.
Ergonomics: The watch unit is comfortable to wear and is not intrusive. The base unit is easy to use and appears simple to use.
Overview: The design is not overly complicated and maintains a stylish minimalist aesthetic.
Possible Modifications: I feel that the design should be offered in different materials such as Teak or even a polymer such as HDPE, which would enable a range of colours to be used to further increase the personalisation of the product .

TESTING

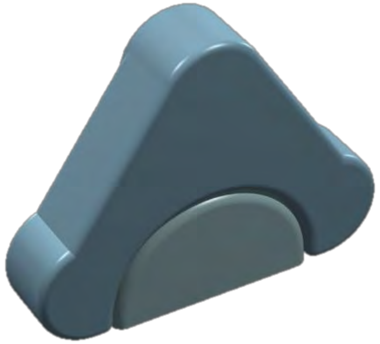


I really like the wood on the base unit, it adds a natural aesthetic yet it feels modern. I think this product would be complementary to the décor of both a rural cottage or a modern city apartment. I like the feel of the watch and the strap fits well, however the watch face is too thick and I think this would take some time getting used to. The watch face is large enough that it seems easy enough to use. I think there should be some way to ensure the watch does not fall off the base while charging, perhaps magnets could be used.

The watch seems easy enough to use, the face is large and the strap fits well so I doubt it will come off accidentally. I think it's a really good idea to have the watch charge on the stand overnight as sometimes I find myself searching for the correct wire to charge my phone or computer, this could certainly reduce the clutter of wires found by many peoples bedsides. One aspect of the design I really like is the curved shape of the design along with the symmetrical speaker placement and the snooze button in the middle.

My cousin is a diabetic and she often makes note of the inconvenience and poor design of currently available products, I think the ability to check vitals through an easy to use interface such as the smart watch would massively improve her quality of life. Another factor would be the facility for the hospital to access the information that the base unit uploads to the cloud. That could cut down on visits to the doctors saving both the patient and the medical facility time and money. I think the design is sleek in appearance which could make it aesthetically appealing in a number of environments. I like the stark contrast between the smooth curvature of the design and the completely flat back and front of the base unit.

MODIFIED IDEA

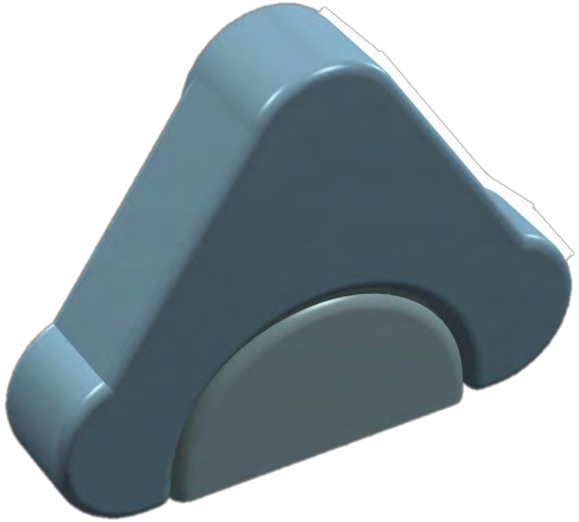


After reviewing customer feedback, I decided to move the two built in speaker units into one larger speaker unit that can be removed and used as a Bluetooth speaker. This will increase the appeal and functionality of the product. The cylindrical protrusion from the unit has been removed as it would offset the balance of the design. In the revised design the watch will rest on the apex of the base unit and though the implementation of wireless charging technology and Near Field Contact (NFC) will upload the data into an inbuilt memory in the device. I have included in my revised design two 'PANIC' buttons on the lower face of the design that will be customizable to contact an emergency contact or emergency services in the event of a hypo. Or any other health issue or incident.

This process uses the feedback and information obtained from my Client feedback and evaluation against the specification. This process is an essential part of any product development as it allows evolution of the product to take place by modifying the design to more closely mirror the specification and customer feedback. I employed the use of the CAD program (ProDesktop) to create a 3D model of the revised design. This enables me to render the design in a wide variety of materials, colours and finishes. I decided to include the use of polymers (such as HDPE) as the main material for my design as it can be finished in numerous ways to produce a retro or modern style. It can also be pigmented allowing for even further customisation of the product.

Modified Idea

This process uses the feedback and information obtained from my Client feedback and evaluation against the specification. This process is an essential part of any product development as it allows evolution of the product to take place by modifying the design to more closely mirror the specification and customer feedback. I employed the use of the CAD program (ProDesktop) to create a 3D model of the revised design. This enables me to render the design in a wide variety of materials, colours and finishes. I decided to include the use of polymers (such as HDPE) as the main material for my design as it can be finished in numerous ways to produce a retro or modern style. It can also be pigmented allowing for even further customisation of the product. After reviewing customer feedback, I decided to move the two built in speaker units into one larger speaker unit that can be removed and used as a Bluetooth speaker. This will increase the appeal and functionality of the product. The cylindrical protrusion from the unit has been removed as it would offset the balance of the design. In the revised design the watch will rest on the apex of the base unit and though the implementation of woreless charging technology and Near Field Contact (NFC) will upload the data into an inbuilt memory in the device.



A- Level Product Design
Knowledge Organiser

Polymers

Table 1 *Common polymers*

Common name	Working name	Characteristics	Common uses
Thermoplastics			
ABS	Acrylonitrile Butadiene Styrene	High impact strength, giving good toughness with good strength, scratch-resistant, lightweight and durable	Kitchen products, mobile telephone cases, PC monitor cases, safety helmets, toys, some car parts and domestic telephones
CA	Cellulose Acetate	Tough and rigid, lightweight with good strength, transparent and non flammable	Photographic film, handles for cutlery, cupboard door knobs, frames for glasses
Nylon	Polyamide	Hard, tough, resistant to wear with a low coefficient of friction	Bearings, gears, curtain rail fittings and clothing
PMMA (PolyMethyl MethAcrylate)	Acrylic	Food-safe, tough, hard, durable, easily machined	Light units, illuminated signs, lenses for car lights
PP	Polypropylene	Lightweight, food-safe, good impact resistance even at low temperatures, good chemical resistance	Kitchen products (food containers), medical equipment, string and rope
HIPS	High Impact Polystyrene	Good impact resistance, good strength and stiffness, lightweight	Toys and refrigerator linings
PS	Polystyrene	Lightweight, rigid, colourless, low impact strength	Packaging, disposable cups/plates and containers
	Expanded polystyrene	Floats, good sound and heat insulator, lightweight, low strength	Packaging, disposable cups, sound and heat insulation
LDPE	Low Density Polyethylene	Low density (lightweight), low stiffness and rigidity, good chemical resistance	Detergent bottles, toys and carrier bags
HDPE	High Density Polyethylene	High density, good stiffness, good chemical resistance	Crates, bottles, buckets and bowls
uPVC	Polyvinyl Chloride	Good chemical resistance, good resistance to weathering, rigid, hard, tough, lightweight, can be coloured	Pipes, guttering, bottles and window frames
PVC (un-plasticised, flexible)	Polyvinyl Chloride	Good chemical resistance, good resistance to weathering, rigid, hard, tough, lightweight, can be coloured	Flexible hose, e.g. hose pipes, cable insulation
PET	Polyethylene Terephthalate	Moderate chemical resistance	Fibres used to make a wide range of clothing, blow-moulded bottles for beers and soft drinks, electrical plugs and sockets, audio and video tapes, insulation tapes
PC	Polycarbonate	Good chemical resistance, expensive material	Very tough – used for protective shields, e.g. safety glasses, safety helmets, hairdryer bodies, telephone parts, vandal-proof street-light covers

Thermosets		
Epoxy resins	High strength when reinforced with fibres (GRP – glass-reinforced plastic), good chemical and wear resistance	Surface coating, encapsulation of electronic components, adhesives
Melamine formaldehyde	Rigid, good strength and hardness, scratch-resistant, can be coloured	Tableware, decorative laminates for work surfaces
Polyester resins	Rigid, brittle, good heat and chemical resistance	Casting, used in glass re-inforced plastic (e.g. boat hulls and car body parts)
Urea formaldehyde	Rigid, hard, good strength, brittle, heat-resistant, good electrical insulator	Electrical fittings, adhesives

Improving the properties of plastics: additives

A variety of materials can be incorporated into the polymer powder prior to processing. Some of these, e.g. fillers, can be used to give the material bulk, while others are used to condition the material (i.e. increase the mechanical properties of the material) in a similar way to **heat treatments** for metals. For example, particular additives give the material anti-static properties, make the material flame-retardant or resistant to ultraviolet light.

Fillers

Fillers are used to reduce the bulk of the plastic. They are generally cheaper than plastics and so help reduce costs. Examples of fillers include: sawdust, wood flour, crushed quartz and limestone. Some fillers can increase strength and hardness of the polymer by removing brittleness.

Flame-retardants

Flame-retardants are used to reduce the risk of combustion. Their main role is to create a chemical reaction once combustion has begun; they release agents that will stifle the combustion. An example of the use of flame-retardants is in the foams used to fill seating cushions.

Anti-static agents

Anti-static agents reduce the effects of static charges that could build up on a product, e.g. from walking on a carpet made from synthetic materials.

Plasticiser

Plasticisers are added to plastics to improve the flow properties of plastics when being moulded. They also reduce the softening temperature and go some way to making the material less brittle.

Stabilisers

Stabilisers are used to reduce the effects of ultraviolet light, i.e. by making the plastics more resistant to being 'broken down' by sunlight. This is important both from a structural and an aesthetic point of view. Stabilisers are used in products that are exposed to a lot of sunlight (such as windows, doors and conservatory components).

Biodegradable plastics

Conventional oil-based plastics do not break down easily and, since the main bulk of domestic waste is made up of plastics, they have a significant effect on the environment. **Biodegradable** plastics however a designed to be degradable under the right conditions, i.e. in a biological rich environment.

Applications

Applications for biodegradable polymers vary widely: packaging – shopping bags, food trays and some soft drinks bottles; catering – disposable pots, bowls and cutlery; gardening; and medical and sanit products such as disposable gloves.

The majority of biodegradable plastics are derived entirely from **renewable** raw materials. For example, starch-based polymers are produced from wheat, corn and potatoes and are used in the manufact of capsules for medicines.

Polylactides (PLA) is another type of polymer derived from natural resources. This polymer is transparent and has similar properties to polyethylene and polypropylene and, as such, can be processed in simila ways to these conventional thermoplastics. Applications include packag in the form of bottles and films for carrier bags and gardening products such as plant pots. They are also used in the manufacture of disposable nappies. Certain types of PLA have been used successfully in medical implants and in sutures, because of their ability to dissolve over time.

PHAs and PHBs

Biodegradable plastics can also be produced naturally by using bacteria to aid in fermenting plant sugars. These polymers are called polyhydroxyalkanoate (or PHA), also known as **Biopol**. The plastic is harvested from bacteria grown in cultures.The most popular of this type of polymer is PHB (poly-beta-hydroxybutyrate) and variations of this polymer are used in packaging since it has similar properties to polypropylene. PHAs have wide-ranging applications in the area of medicine in the form of dispersible fixatives such as films, screws, and bone plates and are also used for applying slow-release medication. Although stable in the environment these polymers are fully compostible, i.e. they will break down completely when in contact with micro-organisms in the soil.

Oxo-degradable polymers

Oxo-degradable polymers have additives that promote short **degradation** times, e.g. less than five years. These additives will help the polymer break down into a fine powder from the effects of heat, oxygen, moisture and even mechanical stress, making it more readily digestible by micro-organisms.

Photo-degradable polymers will break down when exposed to ultraviolet (UV) light making them more readily biodegradable.

It is possible to help conventional polymers break down more readily by including an additive such as 'bio-batch'. This additive can be used with polymers such as PE, PP, PVC, PET or PS and its inclusion will enable the material to degrade in a much shorter period of time (again fewer than five years) rather than the possible 100 years predicted for conventional oil-based products.

Injection moulding

This process is most commonly associated with thermoplastics and is used to produce complex three-dimensional (3-D) shapes.

Stages of the process:

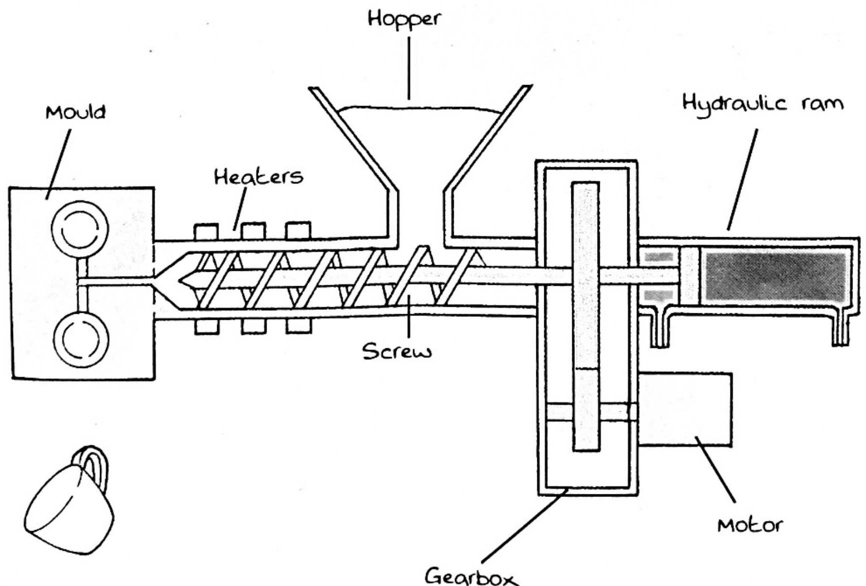
Step 1 Plastic granules (plus any other additives and colours mixed with them) are placed in the hopper. The granule mixture falls through the hopper onto the Archimedean screw.

Step 2 The screw is rotated via the motor and gearbox. This action forces the polymer forwards towards the heaters, where it becomes softened to the point where it is ready to be injected into the mould.

Step 3 The hydraulic ram forces the softened polymer through the feedhole into the mould. Pressure from the ram ensures the mould cavity has been filled.

Step 4 When sufficient time has passed to allow the polymer to cool and solidify (a matter of seconds), the mould halves are opened. As they open, ejector pins are activated to release the product from the mould.

Step 5 Once emptied, the mould is then closed ready to begin another cycle.



Advantages and disadvantages of injection moulding

Advantages

- Very complex 3-D shapes can be produced.
- High volumes can be produced with consistent quality.
- Metal inserts can be included in the item being produced.

Disadvantages

- Initial set-up costs are high.
- Moulds are expensive.

Blow moulding

This process is used in the manufacture of bottles and other containers. Objects produced are usually hollow and have a narrow neck.

Stages of the process:

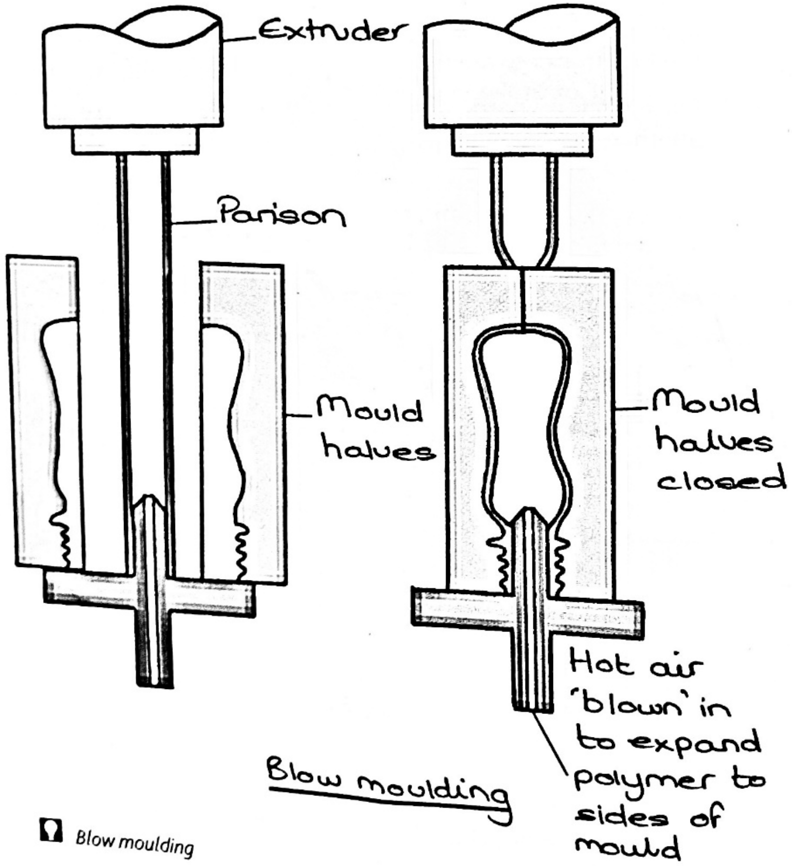
Step 1 A tube of heated and softened polymer is extruded vertically downwards. This tube is called a **Parison**.

Step 2 The mould halves close, trapping the upper end of the Parison, effectively sealing it.

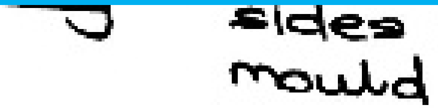
Step 3 Hot air is then blown into the Parison forcing it out to follow the shape of the mould.

Step 4 The mould effectively cools the polymer allowing it to be released from the mould.

Step 5 The mould halves are opened and the product is extracted.



Blow moulding



Blow moulding

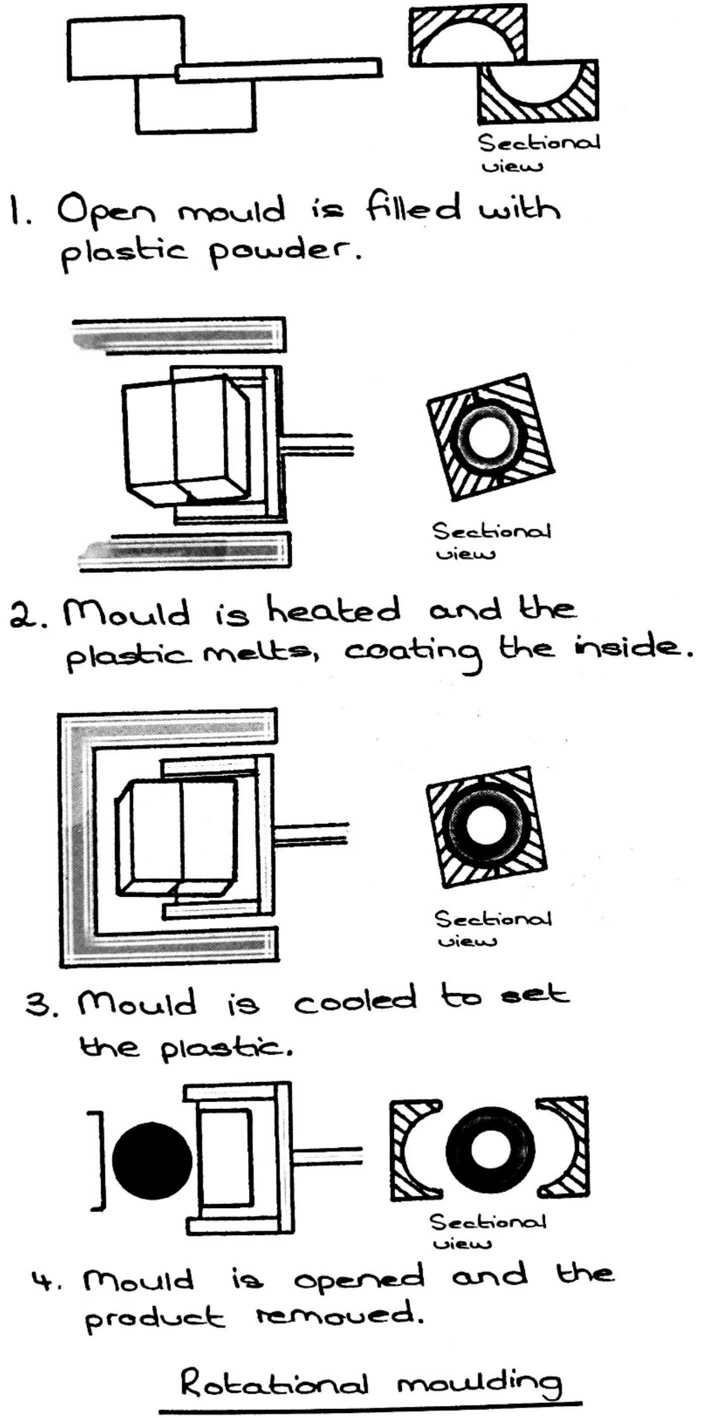
Advantages and disadvantages of blow moulding

Advantages

- Once set up, blow moulding is a rapid method of producing hollow objects with narrow necks.
- Non-circular shapes can be produced.

Disadvantages

- Moulds can be expensive.
- It's difficult to produce re-entrant shapes, i.e. shapes that do not allow easy extraction from the mould (e.g. a dovetail joint).
- Triangular-shaped bottles are difficult to produce.



Rotational moulding

Rotational moulding is used in the manufacture of 3-D hollow products, such as footballs, road cones and large storage tanks (up to 3 m^3 capacity).

Stages of the process:

The machines used have a number of arms that rotate about a fixed central point. Moulds are attached to the end of each arm and are rotated continuously. The only time the moulds do not rotate is when they are at the starting point and end point of the process.

Step 1 Once the moulds have been loaded with a precise weight of thermoplastic powder (e.g. polyethylene) the mould halves are clamped together.

Step 2 The moulds are then rotated about the arm spindle and the whole arm is rotated towards a heated chamber where the thermoplastic material is heated to its melting point. The continuously rotating mould ensures that the thermoplastic covers all of the mould.

Step 3 The next stage of the process is the cooling chamber where the material is cooled ready to be extracted from the mould.

Step 4 The mould is then returned to the starting point where the mould halves are separated and the product removed.

Cycle times vary as they depend on the required wall thickness of the material.

Advantages and disadvantages of rotational moulding

Advantages

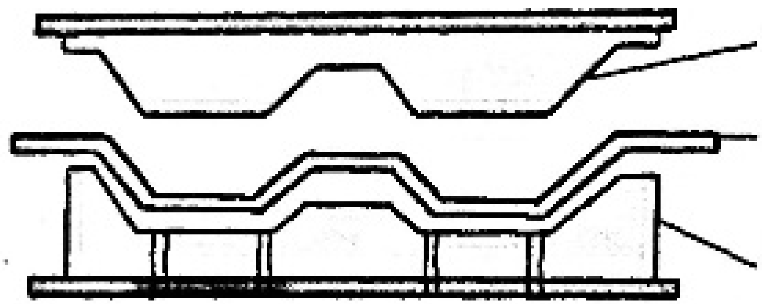
- One-piece mouldings can be produced.
- It is ideal for both rigid, tough shapes and flexible shapes.
- A large range of sizes is possible, from small medical components to large storage tanks.
- Surface **textures** can be applied to the finished products from textures applied in the mould.
- Moulds tend to be cheaper than those for injection or blow moulding, since high pressures are not required.
- Cheaper moulds allow lower production runs.

Disadvantages

- Only hollow shapes can be produced in this way. More complex 3-D shapes would either be blow moulded or injection moulded.

Thermoforming and vacuum forming

Thermoforming is a relatively new process, but is very closely related to **vacuum forming**. Where vacuum forming relies solely on a vacuum to 'pull' the softened polymer around a mould, thermoforming uses an outer mould to help in the process – this allows a greater level of detail, such as lettering, symbols and sharp edges, to be achieved.



Thermoforming

Thermoforming

The thermoforming process

Sheet material is heated to just above its softening point and then held securely in a frame between the two mould halves. The mould halves close and at the same time a vacuum is applied through the lower mould. The upper mould ensures the required amount of detail is achieved.

Advantages and disadvantages of thermoforming

Advantages

- It's a low-cost process.
- It's good for smooth shapes with additional detail.

Disadvantages

- Deep moulds result in a thinning of the wall thickness where it has been stretched.
- It's limited to simple designs.
- Trimming is usually needed.

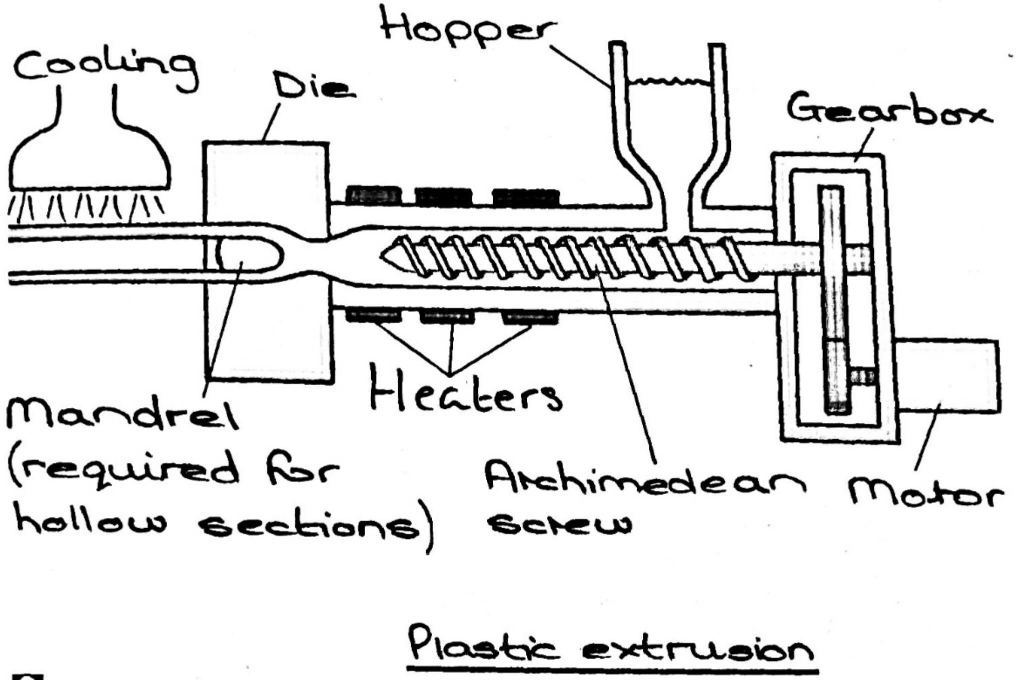
Extrusion

Extrusion is the process used where products with a continuous cross-section are required.

In essence, the process forces molten plastic through a die that has the required cross-sectional shape.

Stages of the process:

Step 1 Thermoplastic powder is placed in the hopper; this powder then falls onto the rotating Archimedean screw, which in turn pushes the material towards a heated section of the extruder.



Plastic extrusion

Step 2 The heaters soften the plastic, which is then forced through the die by the rotating screw.

Step 3 On exiting the die, the plastic product is then cooled using a water jet.

Step 4 Further along the transfer table, the product is cut to the required length.

Wires can be insulated with the aid of a special mandrel arrangement that allows the wire to pass through.

Advantages and disadvantages of extrusion

- Extrusion has the advantage of generally being a low-cost process that requires only simple dies.
- Its main disadvantage is that it can only produce continuous cross-sectional shapes.

Calendaring

Calendaring is used for the manufacture of thermoplastic film, sheet and coating materials. In the main, materials such as PE, PVC, ABS and cellulose acetate would be processed in this way. Shopping bags made from LDPE would have been calendared.

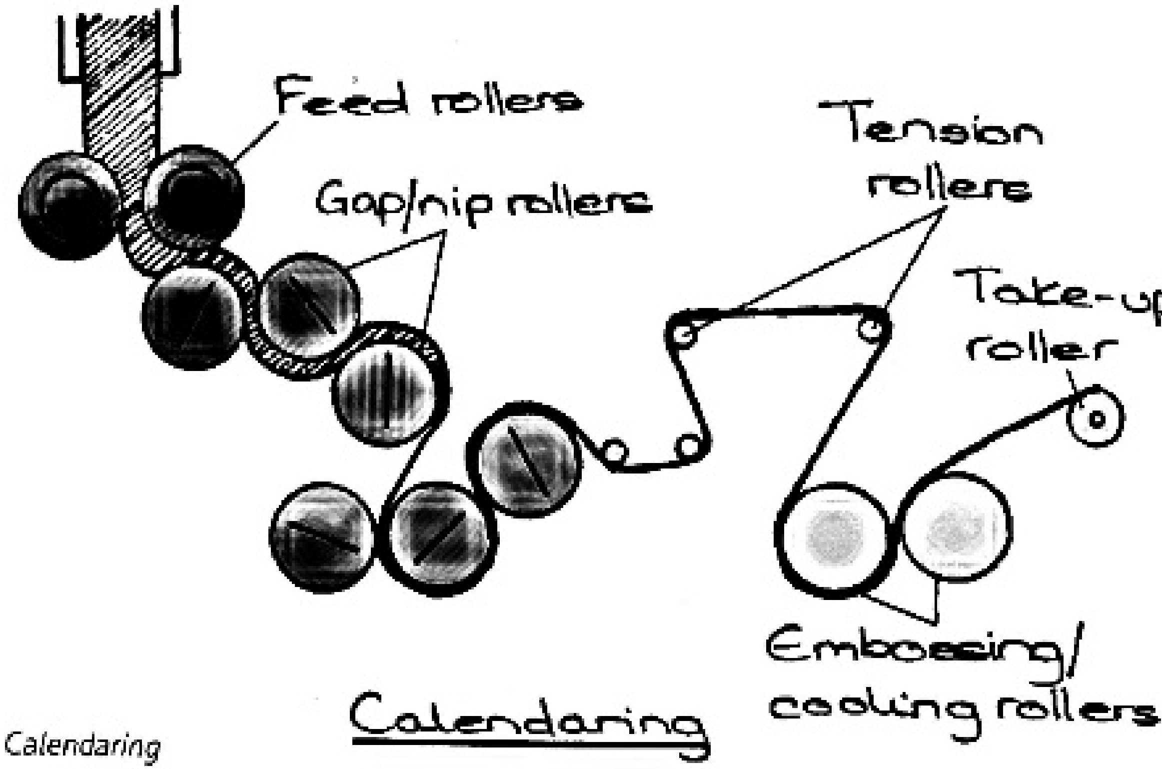
Stages of the process:

Calendaring involves rolling out a mass of pre-mixed plastic material between large rollers to form a continuous film of accurate thickness.

Step 1 The rollers are heated to just above the softening point of the thermoplastic.

Step 2 During the rolling process, the plastic 'dough' is forced through the gap roller. These rollers determine the thickness of the material.

Step 3 The final roller is the 'chill' roller that cools the material.



Calendaring

Key terms

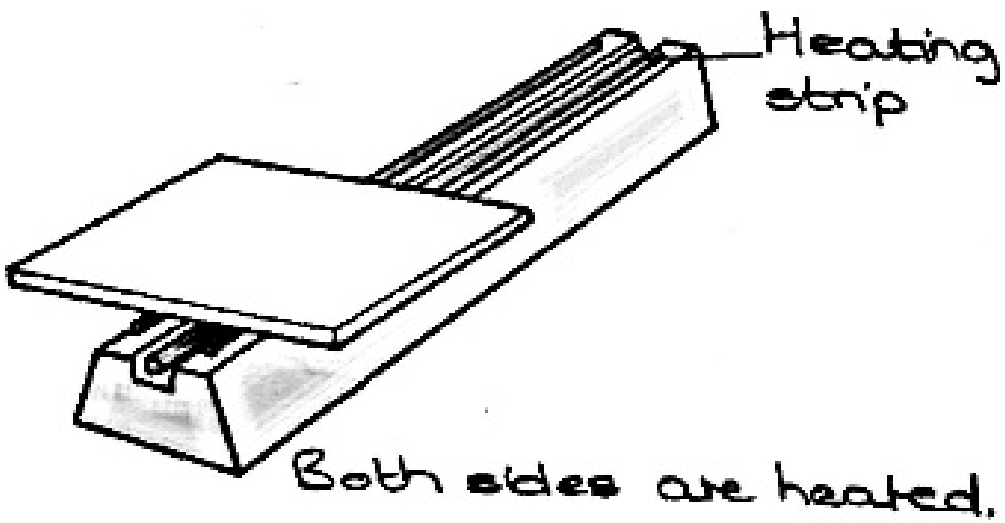
Line (or strip) bending: a method of processing sheet materials, in particular thermoplastics; limited to producing simple shapes.

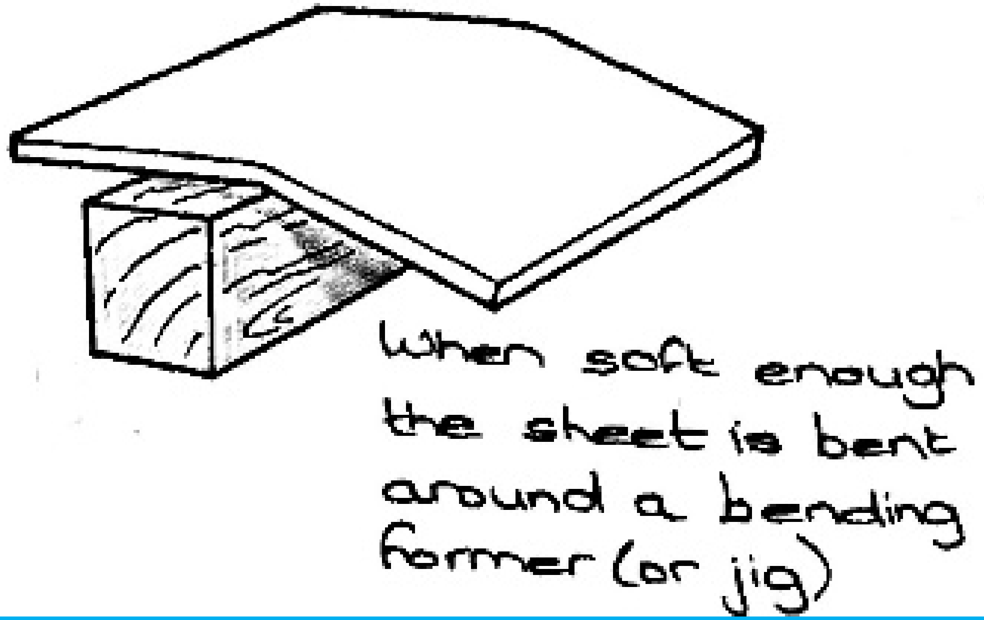
Line bending

Line (or strip) bending is used to form straight, small curved bends in thermoplastic sheet material.

The equipment used in this type of process is known as a 'strip heater' and comprises an electrical heater – usually a tensioned resistance wire – that is enclosed in a channel within a table. The sheet of thermoplastic material is clamped accurately over the heating element, so that the heater softens the part of the sheet that requires bending. In some line bending arrangements heating elements can be placed on both sides of the sheet, avoiding the need to turn the material over.

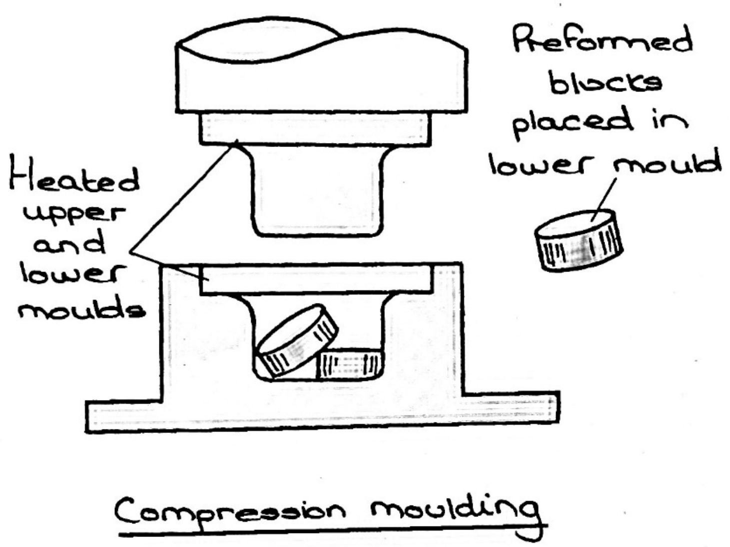
Once heated to the required temperature, the material can be bent. Accurate bends are achieved using bending jigs that ensure the correct angle is consistently being achieved.





Compression moulding

Compression moulding is probably the most important moulding process for manufacturing with thermosetting plastics. A combination of heat, pressure and time is needed to ensure all of the material's form and structure changes.



Compression moulding

Stages of the process:

Step 1 A preformed 'slug' (compressed powder) of material is placed between the two halves of the mould.

Step 2 The mould is heated to a temperature that will allow the **cross-links** to form within the material.

Step 3 The mould is closed onto the preform and the pressure used will force out any excess material. The moulds are held closed under pressure at the required temperature for a period of time that is sufficient to allow all of the material to be 'cured', i.e. all cross-links formed.

Step 4 When the mould is opened, the product can be ejected while it is still hot (it does not have to be cooled) and the process can begin again.

Advantages and disadvantages of compression moulding

Advantages

- Moderately complex parts can be produced over long production runs.
- Although there is some heavy machinery involved, start-up costs are relatively low; moulds are less expensive than those used in injection moulding.
- There is little waste material.

International symbols

Look at any modern plastic product and somewhere on it will be a symbol that identifies the type of plastic material that has been used in its manufacture (see Table 3).

Table 3 *International symbols for polymers*

SPI code	Type of polymer	Common uses
1 PETE	PETE (or PET), polyethylene terephthalate	Soft drinks and water bottles; deli and baking trays; oven-safe film and food trays; carpets and fibre filling
2 HDPE	HDPE, high density polyethylene	Milk, juice, shampoo, butter and yoghurt containers; grocery, rubbish and retail bags; cereal box liners; heavy-duty pipe; bottles for laundry products, oil and car washing fluid
3 V	V (or PVC), polyvinyl chloride	Pipes, film, clear packaging and carpet backing; containers for non-food items
4 LDPE	LDPE, low density polyethylene	Bread, frozen food and dry cleaning bags; carrier bags; squeezable bottles
5 PP	PP, polypropylene	Yoghurt and margarine containers; medicine bottles; car parts, carpets, industrial fibres
6 PS	PS, polystyrene	Meat trays, cups, plates, cutlery and compact disc sleeves; video- and audio-cassette cases
7 OTHER	Other (any polymer or combination of polymers not covered by categories 1-6), includes ABS, acrylonitrile butadiene styrene	Reusable water bottles, trays for the microwave; mobile telephone outer cases, computer parts, monitors, keyboard parts

Case study 1: Plastics

Plastics used in detergent packaging: bottled detergents

Detergent bottle

With the invention of liquid washing detergents, bottle packaging was required. The type of bottle shown in the photograph is commonly used in the storage and retail of such liquid detergents.

It is made from a tough plastic, such as polypropylene, with the top being made from high density polyethylene. Detergent bottles like these are made from durable plastics, so that they can be kept by the consumer for some time and refilled using the sachet-style packaging shown below. As HDPE and PP are thermoplastics, it is possible to recycle the bottles. They can also be made from a percentage of recycled plastics. This is an important consideration for manufacturers, as they are required by legislation to meet ecological targets.

The main body The main body of the bottle is made using blow moulding. This is a relatively fast process that is important in the manufacture of a mass-produced bottle. It is possible to mould in ergonomic features such as a comfortable handle used to carry the bottle and to pour the liquid.

The bottle top The bottle top and pouring spout are injection moulded. This process uses molten plastic injected at high pressure into precision-made dies. It enables the manufacture of accurate components such as the bottle top, complete with textured grip to help in undoing and tightening the lid, and an internal thread for joining the top to the bottle.

Refill packaging

Advantages of using plastics The durability of HDPE and PP has obvious benefits to both the manufacturer and the consumer. The main benefit is that the bottles are less likely to burst, either in handling during warehousing and transport or in transit from the shops to home. This is an important functional aspect of bottle packaging.

As plastics are 'self-coloured' by adding a pigment to the polymer, the packaging can be coloured to meet aesthetic requirements. This is very important as colour is a key feature to brand identity.

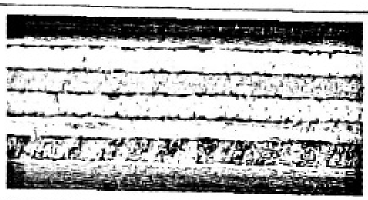
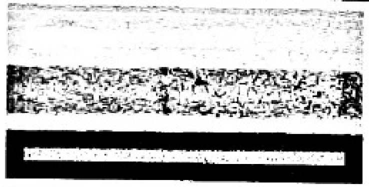
Disadvantages of using plastics If the consumer does not refill the bottle, the plastics used would be wasted. If the consumer does not recycle the bottle, it would have to go to incineration or landfill. Polypropylene and polyethylene are not biodegradable; therefore landfill is not a particularly good option. The bottle shape is awkward to store, transport and display. This is why this type of bottle is often made with flat sides to minimise such problems.

Sachet detergent packaging This type of packaging was developed shortly after the bottle as a method of refilling bottles. The sachet is retailed at a slightly lower price than a bottle, therefore encouraging consumers to buy these instead of new bottles each time they need more detergents.

The sachets are made from a low density polyethylene film, using the calendaring process. The graphics, branding etc. are applied to the film using offset lithographic printing methods,

Composites

Table 4 *A range of man-made boards*

Type of board		Common uses
Plywood		Backs of furniture, e.g. cabinets, bottoms of drawers, panelling; can be flexible for producing curved shapes
Block board		Generally used for tabletops and furniture carcasses
Stirling board		Flooring for sheds and workshops; also used for roofing and shuttering for casting concrete
Chipboard		Knockdown furniture, kitchen cupboards and worktops; usually veneered or laminated for furniture; also used for flooring
Medium Density Fibre board (MDF)		Furniture sides acting as a base for veneers; pattern making for castings
Hardboard		Backs of cupboards and drawer bottoms of kitchen units; can be supplied pre-coated

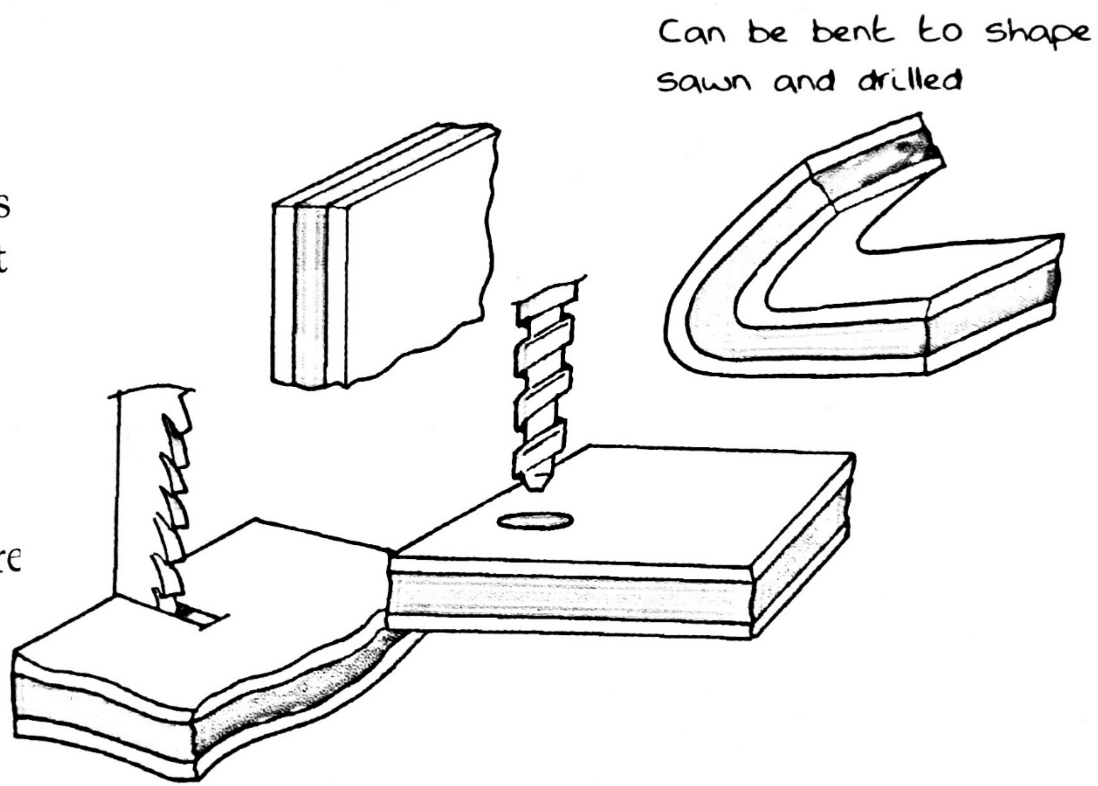
Sheet-based composites

We have touched on sheet-based composites in the introduction to this section by discussing man-made boards, such as plywood, block board, and their applications.

Metal/polymer composites

More recent developments have seen the introduction of metal/polymer composites. An example of this type of material is ALU composite. This material is a **laminate** of, generally, 0.3 mm thickness **aluminium** sheet sandwiching a polyethylene core. The overall thickness is about 3 mm. This results in a lightweight material that has excellent rigidity along with good impact resistance.

The material can be shaped by sawing, drilling or milling and cut with shears, and can be formed by rolling without distorting the polymer core



Cross section of ALU composite

Advantages of this type of material include good sound and vibration damping qualities along with good thermal insulation characteristics combined with good strength. Applications can be found in the automotive industry where it is used for vehicle skins. This results in a much reduced level of road noise for the occupants. Other applications include partitions as well as uses in boats.

Concrete is thoroughly mixed while it is dry. Water is then added. Mixing continues until every particle of aggregate and sand is coated in cement paste (this is the bonding agent). Once cast, the concrete is left to harden. During hardening, the temperature of the mix will rise; this is due to the chemical reactions that take place.

Advantages and disadvantages of concrete

Advantages

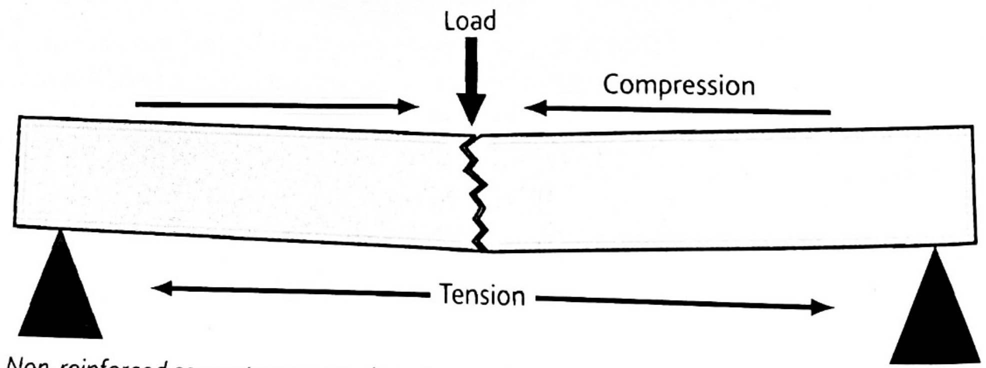
- It can be moulded into complex shapes.
- It has properties similar to stone.
- Components are more readily extracted than stone.
- It can be cast in situ (on site), whereas stone has to be quarried and cut to shape.
- It is good in compression.

Disadvantages

- It is poor in tension, making it necessary to reinforce the concrete when spanning large distances.

Reinforced concrete

Concrete is classed as a particle-based composite. Concretes are generally very good when subjected to compressive loads, e.g. foundations for a building, but very poor when in tension, e.g. when used as a beam that spans a distance.

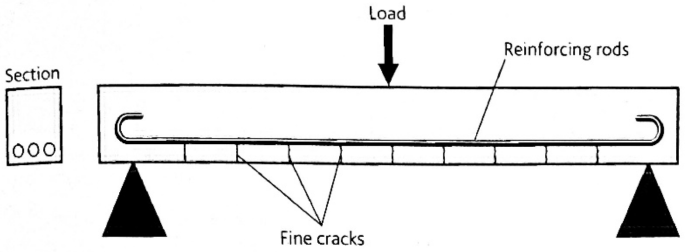


Non-reinforced concrete may crack under tension

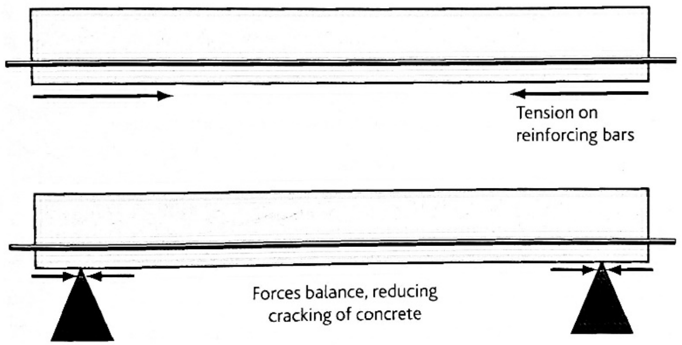
We are looking at this material in the fibre-reinforced composites section because, in order to combat the possibility of failure under tension, reinforcing bars can be placed in the concrete shuttering prior to casting the concrete. These reinforcing bars will then become surrounded by, and gripped by, the concrete.

The inclusion of reinforcing bars has led to the design of longer spans in bridges and buildings. However, there is still some potential for cracking in places where the beam/structure is under tension, i.e. on the underside of the beam. This has led to a process where the reinforcing bars are put under tension prior to and during the casting of the concrete structure.

Once set, the tension is released on the bars having the effect of placing that part of the structure under compression. This means that the beam/structure is better able to withstand heavier loads or bridge longer spans. The diagram below shows the effect of the use of high-tensile reinforcing bars in concrete.



Surface cracks may still be evident with ordinary reinforced concrete



Pre-tensioned reinforcing bars greatly reduce surface cracks

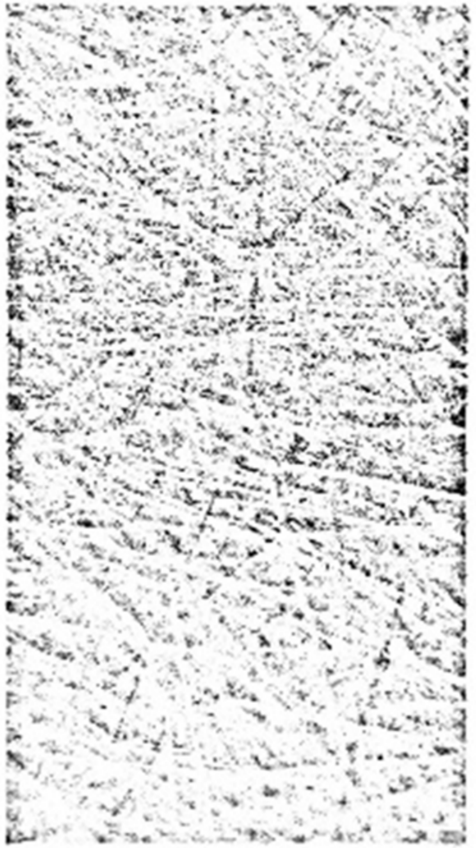
Particle-based composite materials

The general characteristics of particle-based composites are:

- They have a high strength in compression, as in the case of concretes; less so in tension.
- They have good stability.
- They have a uniform structure ensuring consistent strength.
- They are generally free from surface defects.

Concrete

Concretes are made up of materials known as aggregates, as well as sand and cement. The characteristics of the final concrete material are determined by the ratio of the constituent parts.

Name	Appearance	Image	Characteristics	Uses
Glass reinforced plastic (GRP)	Glass fibre matting is covered with smooth plastic resin (gel coat) which sets hard with high gloss finish. It is easily coloured and complex shapes can be formed		Lightweight, good strength-to-weight ratio, good corrosion, chemical and heat resistance, waterproof, high VOCs / resins used. Can be trimmed with rotating blade. Labour intensive to produce	Boat hulls, car and truck body parts, liquid storage tanks, pipes, helmets, seating

Name	Appearance	Image	Characteristics	Uses
Carbon-fibre reinforced plastic (CRP)	Carbon-fibre is a cloth woven from individual strands, the interlacing provides an interesting and modern aesthetic, available in different patterns, can be coloured but frequently left natural, vinyl decals can be added for decoration		Very high strength-to-weight ratio, good tensile strength but not good compressive strength, stiff and rigid, very expensive, high VOCs / resins used, waterproof and resistant to chemicals. Manufacture is a labour-intensive and skilled process	Supercars and sports cars, top-end sports equipment, bespoke boats and musical instruments, increasingly developed for prosthetic uses

echnical textiles

Kevlar®

Kevlar® is a fibre developed by DuPont™ that has high tensile strength, has great heat resistance and is extremely hard-wearing. It is a flexible and lightweight synthetic fibre from the class of fibres known as **aramids** which are modified polyamide (nylon) fibres. Kevlar® is used for many applications including body armour and personal protective equipment for use in hazardous situations. It has also been found to have useful acoustic properties and is used in the production of quality loudspeakers and some musical instruments.

Name	Appearance	Image	Characteristics	Uses
Kevlar® by DuPont™ Poly-paraphenylene terephthalamide	Natural yellowish-gold material which also comes dyed in many colours. Woven texture from fine to course weave		Extremely strong and hard-wearing, excellent cut and tear resistance, high thermal protection, non-flammable, good chemical resistance	Personal armour, helmets, bullet-proof vests, motorcycle safety clothing, extreme sports equipment, audio equipment, musical instruments

Metal and Processes

Table 7 *Types of steel*

Base material	Additional element, carbon	Type of steel	Ductility	Hardness	Toughness
Iron	<0.3%	Low carbon steel (mild steel)	↑	↓	↑
	0.3–0.6%	Medium carbon steel			
	0.6–1.7%	High carbon steel			
	3.5%	Cast iron			Brittle

Table 8 *Typical uses for steels and cast irons*

Name	Common uses
Mild steel	Nuts, bolts, washers, car bodies, panels for cookers and other white goods
Medium carbon steel	Springs, general gardening tools
High carbon steel	Hand tools, scribers, dot punches, chisels, plane blades
Cast iron	Machine parts, brake discs, engines

Table 9 *Non-ferrous metals*

Metal	Melting temperature	Common uses and properties
Aluminium	660 °C	Kitchenware, such as saucepans; when drawn into wire, used in overhead power cables – it is an excellent conductor of electricity
Copper	1083 °C	Electrical contacts, domestic pipe work for central heating and water; in wire form, it is used for electrical cable and wire; also used in jewellery
Gold	1063 °C for fine gold	Primarily thought of as a metal for jewellery, but also has applications in electronics in the form of contacts for switches and credit/telephone SIM cards
Lead	330 °C	A very soft but heavy metal used for flashing between roofs and adjoining brickwork; very durable

Platinum	1755 °C	Used as a precious metal in the manufacture of jewellery; is also used in wire form to produce thermocouple cables
Silver	960 °C for fine silver	Used for many years in the manufacture of expensive cutlery and various decorative items; also used in the processing of photographic film
Tin	232 °C	Rarely used in its pure state, but applications include food wrapping (foil) and coating for steel plate in the manufacture of food cans
Titanium	1675 °C	Has a good strength/weight ratio and is a very clean material, making it suitable for surgical applications such as hip replacements; also used for spectacle frames
Zinc	419 °C	Used as a coating for steels, i.e. galvanised steels; used for the manufacture of products such as buckets, and casings for electrical units; can be die-cast to produce high detail products, such as lock mechanisms and small gears

Benefits of alloying

In general, the benefits of alloying metals are that it:

- changes the melting point
- changes the colour
- increases strength, hardness and ductility
- enhances resistance to corrosion and **oxidation**
- changes electrical/thermal properties
- improves flow properties, producing better castings.

Alloying steels

Alloying steels with elements such as chromium and nickel will produce stainless steel – a well-known group of metals with good corrosion resistance, hardness, strength and toughness.

Most metals, steel included, will become less hard and more ductile when heated. By alloying with tungsten, chromium and cobalt, a range of 'high speed steels' can be produced, which do not lose their cutting edges when working at high temperatures (Table 11).

Key terms

Oxidation: when a material comes into contact with oxygen (e.g. in the air) the result is an oxide layer that forms over the surface of the metal. In most metals this serves to protect the material from further oxidation, but in the case of steels this oxide layer is porous and so allows further contact with air and therefore further oxidation.

Activity

List the benefits of using brass for the 'pins' on a 3-pin domestic plug. Why would copper be less suitable?

Table 11 *The effects of alloying steels with other elements*

Alloy steel	Alloyed with	Characteristics	Common uses
Stainless steel	Chromium, nickel, magnesium	Tough and wear-resistant; corrosion-resistant	Sinks, cutlery, sanitary-ware,
High speed steel (HSS)	Tungsten, chromium, vanadium	Very hard, will cut while at red heat	Cutting tools, such as drills
Tool and die-steels	Chromium, manganese	Very hard and tough, with excellent wear-resistance	Fine press tools, extruder dies, blanking punches and dies, some hand tools
High tensile steels	Nickel	Good tensile strength and toughness, generally corrosion-resistant	Car engine components

Alloys and alloying

In the same way that composite materials (p20) take the best from both materials for the proposed application, the alloying of metals achieves a similar result, producing materials with enhanced properties.

Individual metals have a limited range of properties that can only be enhanced by heat-treating them in some way. To obtain a better range of properties and characteristics two (or more) metals can be mixed together to produce an alloy.

For example, the addition of zinc to copper produces a much harder and stronger material than pure copper. Alloying changes other characteristics of the material. Mixing copper with zinc to make brass, for example, changes the colour of the metal to a yellow/gold making the material attractive to purchasers.

Table 10 *Common alloys*

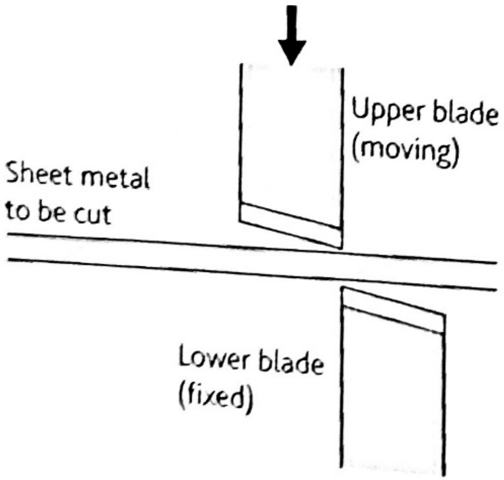
Name	Base metal	Composition	Common use
Duralumin	Aluminium	4% copper 1% manganese 0.1% magnesium	Structural components for aircraft
Brass	Copper	35% zinc	Cast valves and taps, boat fittings and ornaments
Bronze	Copper	10% tin	Statues, coins, bearings
Nitinol	Nickel	Nickel, Titanium	Smart metal alloys for making springs and muscle wires

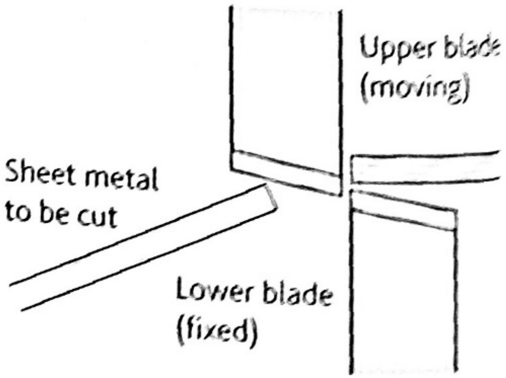
Wasting processes (relating to metals)

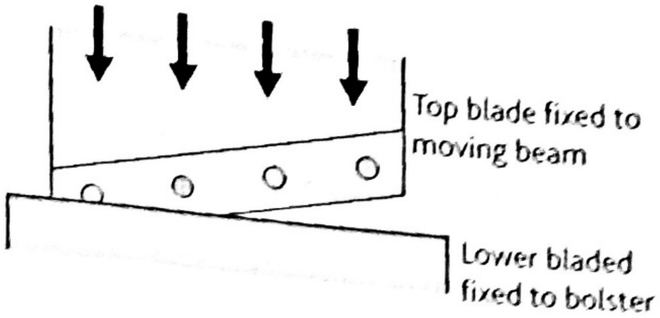
Blanking and piercing

Sheet metals can be cut to a required shape using punches. These cut through the material using a shearing action, much in the same way that scissors cut through paper.

A guillotine is usually used to cut sheet metal off a roll into useable sheet sizes. These sheets are then passed into either manually operated or automatic machines that will cut the material to shape and/or punch holes into it.





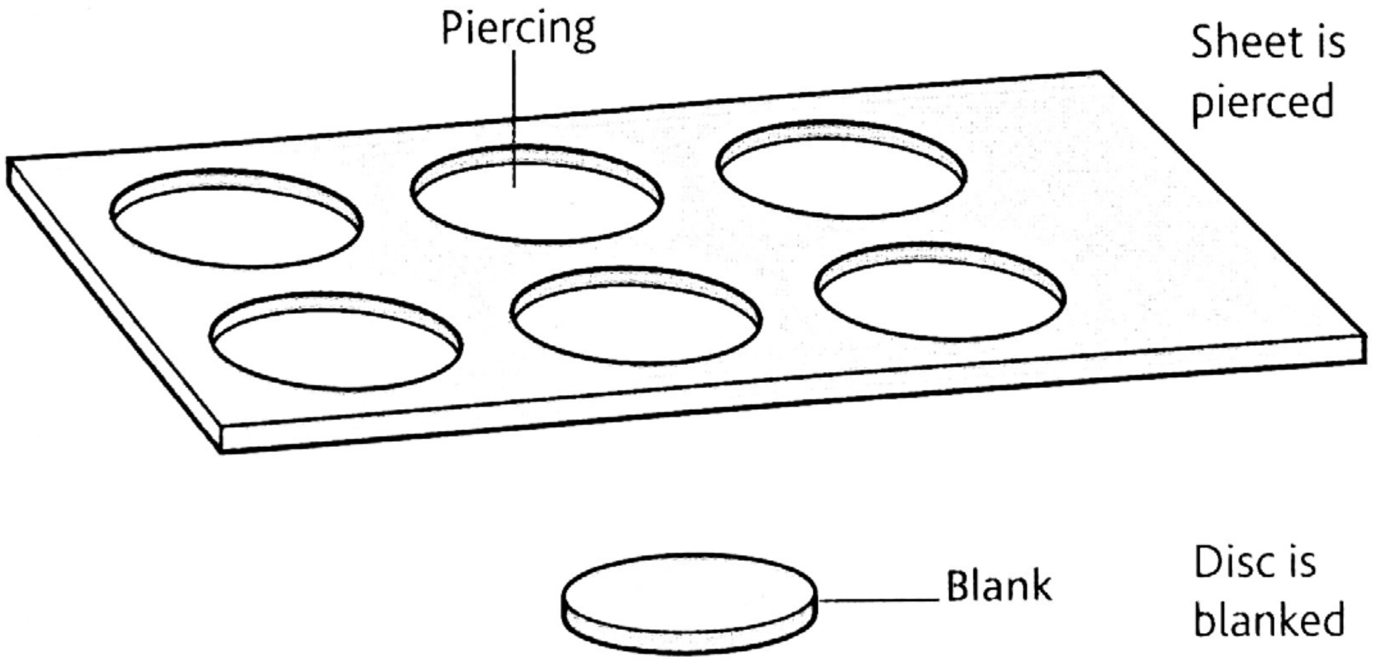


Shear action

When a sheet of metal has a hole punched into it, it has been pierced. When the piece that has been punched out of the sheet is to be used, it is called a 'blank'.

Products, such as soft drinks cans, are made by punching disc-shaped blanks from the sheet material. The process is set up to maximise efficiency with as little waste metal left as possible.

Some products require both blanking and piercing, e.g. casings for desktop computers.



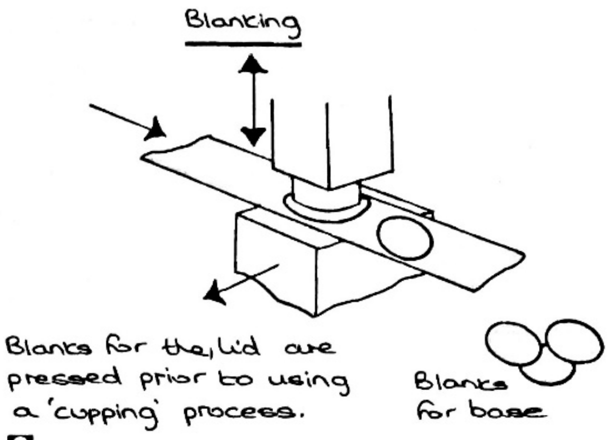
Blanking and piercing

Press-forming

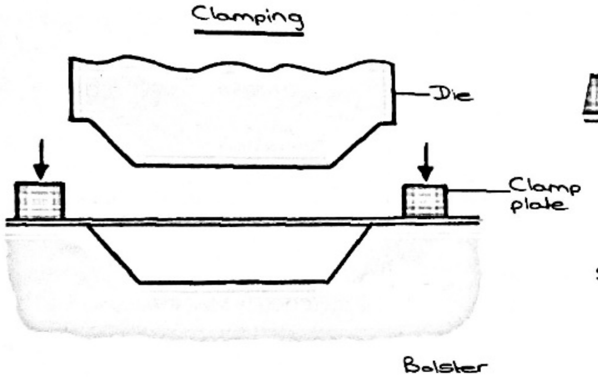
Press-forming is carried out with the material at room temperature. The process relies heavily on the ductility of the material being pressed. If insufficiently ductile, the material may have to be annealed to increase its ductility.

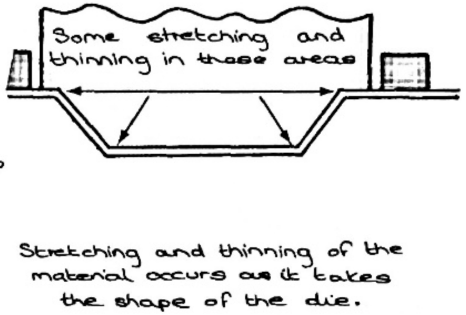
Press-forming is carried out using a punch and a die which are both manufactured from toughened die-steel; this makes them resistant to impacting loads, and wear from contacting the material being pressed.

Car body panels are pressed from mild steel sheet to produce the vehicle's overall shape once assembled. The complex shapes produced require the generation of very high stresses to overcome the resistance of the material being pressed.



Blanking prior to press-forming





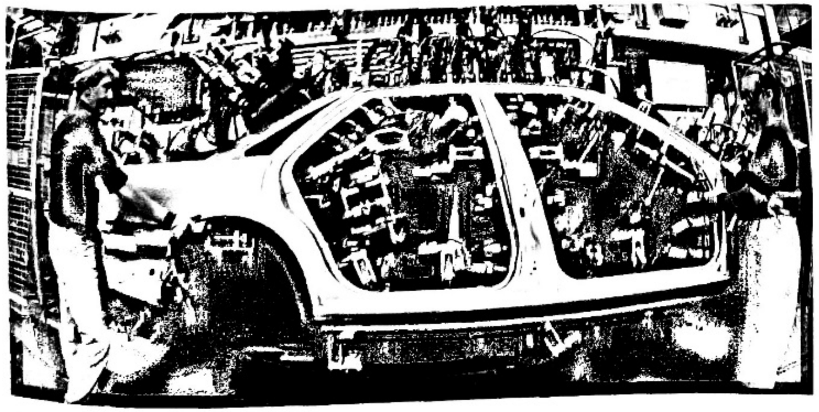
Bolster

Sheet metals being pressed

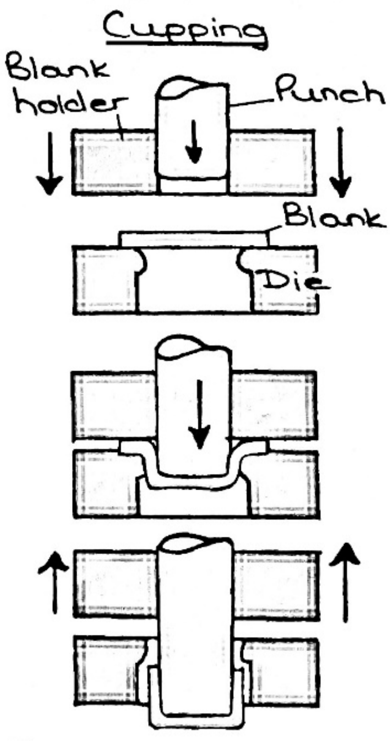
There are advantages of pressing a sheet material to a more 3-D shape, including that of greatly increased stiffness. This, in effect, has the benefit of reducing the amount of material necessary to build the vehicle to a good safety standard.

In addition to forming to shape, press tools can also incorporate shears to cut sections away. If we look again at the completed car body panel, we can see the holes have been cut to form door pillars and windows.

Other examples of press-formed sheet materials include domestic radiator panels, kitchen products such as meat trays, and cooker tops.



Press-formed car body panel



Cupping

Table 18 *Eco-design improvements to a mobile phone*

Design strategy	Ideas for improvement
Use low-impact materials	Use recycled polymers for the casing.
	Use recycled copper for the electronic components.
	Do not use aluminium in the casing or internal parts (aluminium uses energy in its production).
	Do not use materials banned under RoHS.
Reduction of materials used	Make the phone smaller to reduce the materials needed.
	Reduce the functions on the phone to reduce the number of components needed.
Reduce impact of distribution	Provide human powered or solar powered charger to charge batteries.
	Use recycled materials in packaging.
Reduce energy consumption in use	Provide human powered or solar powered charger to charge batteries.
	Provide a device that switches off chargers when the battery is charged or when the phone is unplugged from the charger.
Optimisation of product life time	Design the phone with classic styling that will not 'date' the phone too quickly.
	Provide downloadable software upgrades to update the functions of the phone.
	Provide interchangeable casings to refresh the appearance.
	Make the phone repairable.
Optimisation of end of life	Make the phone using smart shape memory alloy fastenings and actuators that will loosen and pop the casing and parts open when heated and aid the separation of parts for recycling and reuse.

Joining wood

A variety of both temporary and permanent joining methods can be used with woods, depending on the intended application.

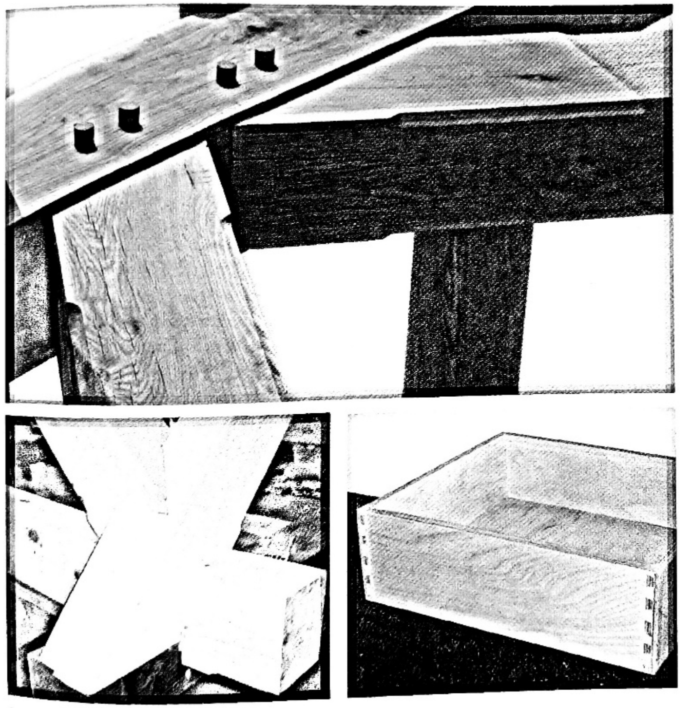
When large sections of timber are used – for example, the oak framework for a house – the beams and posts can be joined together by a combination of **traditional wood joints** and pegs.

When large section beams are used for temporary support, a more temporary joining arrangement may be used. In the case shown above, a barn wall is being supported by a framework that is bolted together.

A modern roof truss is produced in a different way, i.e. without the use of traditional joints. Each of the timbers is cut to the correct size and shape and, once set up in a jig, plates with spikes (effectively nails) are forced into both sides of the joints.

For traditional household furniture, more traditional wood joints would be used. The type of wood joint again depends on the application.

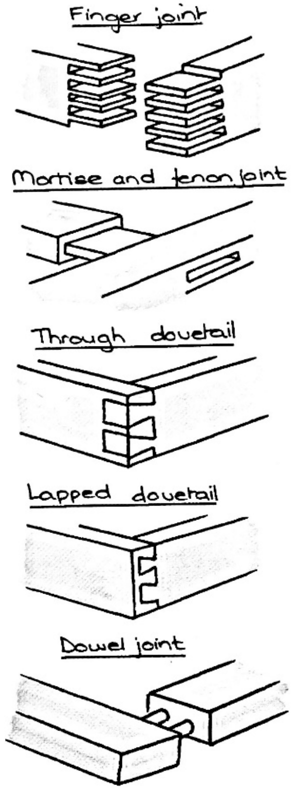
Note: All of these joints would be secured with an adhesive, such as PVA (Poly Vinyl Acetate), making them permanent.



Examples of different wood joining methods

Self-assembly furniture

Self-assembly furniture is produced in high volume, being supplied to the consumer as a flat-pack of component parts. In order to accommodate self-assembly, a range of fixings has been developed specifically for use with this type of furniture. With every flat-pack there



Wood joining methods

Key terms

Traditional wood joints: wood joints that require machining to make interlocking parts and often combined with adhesive.

Study tip

You should develop an understanding of the traditional wood joining techniques and be able to give examples of where they would be used.

	Type	Examples	Uses
Natural adhesives	Animal glues	Animal hide, bones, hooves	Used to glue woods, fabrics and leathers
	Natural resins	Gum arabic	Used for papers and fabrics, and binders in watercolour paints
	Inorganic cements	Portland cement	Used in the building industry for bonding bricks and blocks
Synthetic adhesives	Synthetic resins	Cascamite (powder mixed with water)	For bonding woods; is waterproof and can fill slight gaps
	Epoxy resins	Araldite Two (part adhesive, hardener and resin)	Joins most materials
	PVA	Poly Vinyl Acetate (water-based)	Used for gluing woods; generally not waterproof
	Contact adhesives	Evo-Stik (works by evaporation of solvent)	Used for bonding sheet materials on contact
	Hot glue sticks	(Work on application of heat)	For rapid bonding of papers and cards
	Acrylic cement	Tensol	For gluing acrylics only

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Products designed specifically for the elderly would focus on making life easier and more comfortable. Generally very elderly people might have reduced mobility or motor skills. They might also have reduced physical strength. As the very elderly are more immobile than the average consumer, it is very important that furniture such as seating and beds are designed and made to be as comfortable as possible.

Examples of products specifically designed for the very elderly include things like:

- lever tap tops (to make turning taps on and off easier)
- kettle cradles (to aid the pouring of kettles)
- universal jar openers (to facilitate jar lid opening)
- elasticated and Velcro-fastening clothing
- seating with memory foam cushions.

As the population is generally living to an older age, design activity for this age group is becoming more and more significant. Indeed, in some parts of the United States and Japan, whole supermarkets and shopping malls are devoted to products that appeal to the elderly.

Designing for other groups in society

In addition to designing for disabled people and the elderly, 'inclusive design' can also include designing for children and those in the lower percentile group, (5th percentile or lower) and the upper percentile group (95th percentile and above).

Designing for children (or the 5th percentile), means designers must take into account smaller body sizes and different physical abilities. Many products are already specifically designed for children such as furniture, car seats, baby products, tableware, e.g. cutlery and plates, and clothing.

Products designed for people in the 95th percentile group need to accommodate their large body sizes. This has already resulted in the design and manufacture of XXL-sized clothing, fully adjustable car seats, steering wheels and seat belts.

CE

Consumer safety

There are many European and international safety standards that influence the safety measures that designers and manufacturers have to adhere to when developing new products. Many products sold in the UK and Europe must comply with standards set by the British Standards Institute and the European Community. For example, toys must meet the European Community Directive 88/378 and (Community law) for Toy Safety and British/European standard BS EN 71. Toys meeting these standards would be labelled with the 'CE' mark and Kitemark.

The British Standards Institution (BSI)

The **British Standards Institution** is an organisation that documents UK national standards for quality and safety in products and services. BSI also represents the UK in European (CEN) and International (ISO) standards production. Companies can pay to have their products tested against national or international standards, and if they meet the standard requirements, and their production processes have been assessed and comply with regulations, they can be awarded the BSI Kitemark. The company is issued a licence to use the Kitemark on its products. This symbol of quality and safety helps to assure consumers they are buying a safe and consistent product. Companies registered with BSI have their product and their production process regularly tested.

A British Standard example

An example of a British Standard is BS EN 71. This means that the standard is both British (BS) and European (EN) and this particular standard is for toys.

BS EN 71 has eight parts as follows:

Part 1 Mechanical and physical properties covers toys to ensure that they have no parts that can stab, trap, mangle or choke.

Part 2 Flammability concerns toys such as Wendy houses, fancy dress costumes and soft toys. It limits the materials used to prohibit some of the more flammable ones, and ensures that if the toy does catch fire the child can drop it, or get out of it and get away.

Part 3 Migration of certain elements concerns limiting the 'release' of harmful substances such as lead, cadmium or mercury from toys, if they are swallowed or chewed by a child.

Part 4 Experimental sets for chemistry and related activities gives safe limits for the amount of chemicals that can be sold in such sets.

Part 5 Chemical toys (sets) other than those used for experiments controls the substances and materials used in toy sets such as water-based paints, modelling clay, etc.

Part 6 Graphical symbol for age warning labelling sets the standard for labelling toys unsuitable for children under three years old.

Part 7 Finger paints controls the chemicals used in finger paints and minimises the risks associated with ingesting paint or prolonged skin exposure to paint.

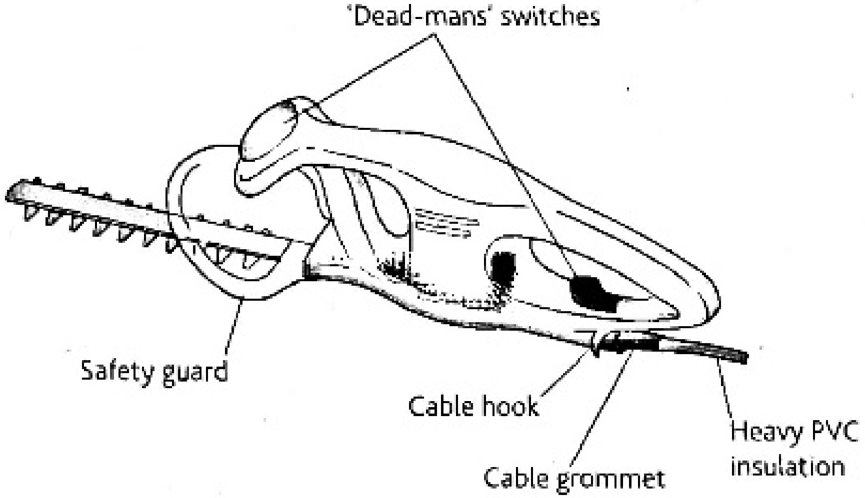
Part 8 Swings, slides and similar activity toys for indoor, family and domestic use limits the height of such play equipment, reduces protruding parts, requires that a child or a child's clothing cannot be trapped, and ensures stability.

The BSI Kitemark

Safety features in a garden hedge trimmer

A 240 volt electric hedge trimmer can be a very dangerous power tool. Designers and manufacturers have devised a number of features to ensure consumer safety:

- *Electrical wire*: this is coated in thick, heavy duty PVC insulation which is orange coloured. This makes it stand up to wear and tear and stand out against a green/brown hedge.
- *Cable grommet*: this is a thick rubber sleeve that reinforces the cable where it enters the body of the tool. This area is weak and the cable could break leaving exposed wires.
- *Cable hook*: this is a small recess in the handle or casing of the trimmer which feeds the cable down, away from the blades.
- *Double switches*: with one positioned on the top handle and one on the trigger grip, this means that the consumer has to have both hands on the handles where they will be safe.



240-volt electric hedge trimmer

Patents

Protecting designs (patents and intellectual property)

From the point of invention to the release of products into the market and their continued diffusion, ideas are at risk of being copied. To prevent this happening, inventors need to use a form of legal protection.

If an inventor or designer can prove that an invention is theirs, they can be granted a patent. This gives the designer the intellectual property rights of ownership of the design and legal action can be taken against anyone trying to use their invention without their permission.

Patents are granted by the state exclusive rights to make, use or sell a new invention for a set period (normally up to 20 years) in most countries. In exchange, patent holders must allow the details of their invention to be made public. This allows the state to build up a knowledge base that can encourage further invention and advance technological development for the benefit of everyone.

Patent applications contain the details of a product sufficient for it to be made by a third party. This will be a detailed description including drawings and technical detail that may be used by manufacturers actually making the product or seeking to improve upon it in the future.

Once a patent is granted, the invention becomes the legal property of the inventor. The owner can sell it, or they may authorise others to make, use or sell the invention in exchange for royalties.

1. It must be new. It must not have been shown or discussed publicly anywhere prior to the patent application being filed.
2. It must involve an inventive step. The idea must not be obvious to someone with reasonable prior knowledge of the subject.
3. It must be capable of being industrially made. It must take the physical form of a substance, product or an industrial process.
4. It must not be excluded. An invention is not patentable if it is on the excluded list issued by the Patent Office.

These lists vary but generally, in the UK, exclusions include things such as discoveries, mathematical methods or scientific theories, art, literary

Analogy

This is where designers use similar situations, either in the natural or man-made world to inspire ideas. The Wright brothers observed how birds twist their wings to balance in flight. They adapted their aircraft wings to do likewise. George Carwardine used the principles of the human arm to design the 'Anglepoise' lamp. Alexander Graeme Bell made the analogy of the human ear when designing sound receiver apparatus for his experimental telephones. These analogies went on to become major innovations and inspired many more.

Combination

This is where two or more devices or products are combined into one to produce a new product. For example, power tool manufacturers are currently making a range of multi-functional tools combining a drill, circular saw, light or other tool with an interchangeable handle and battery.

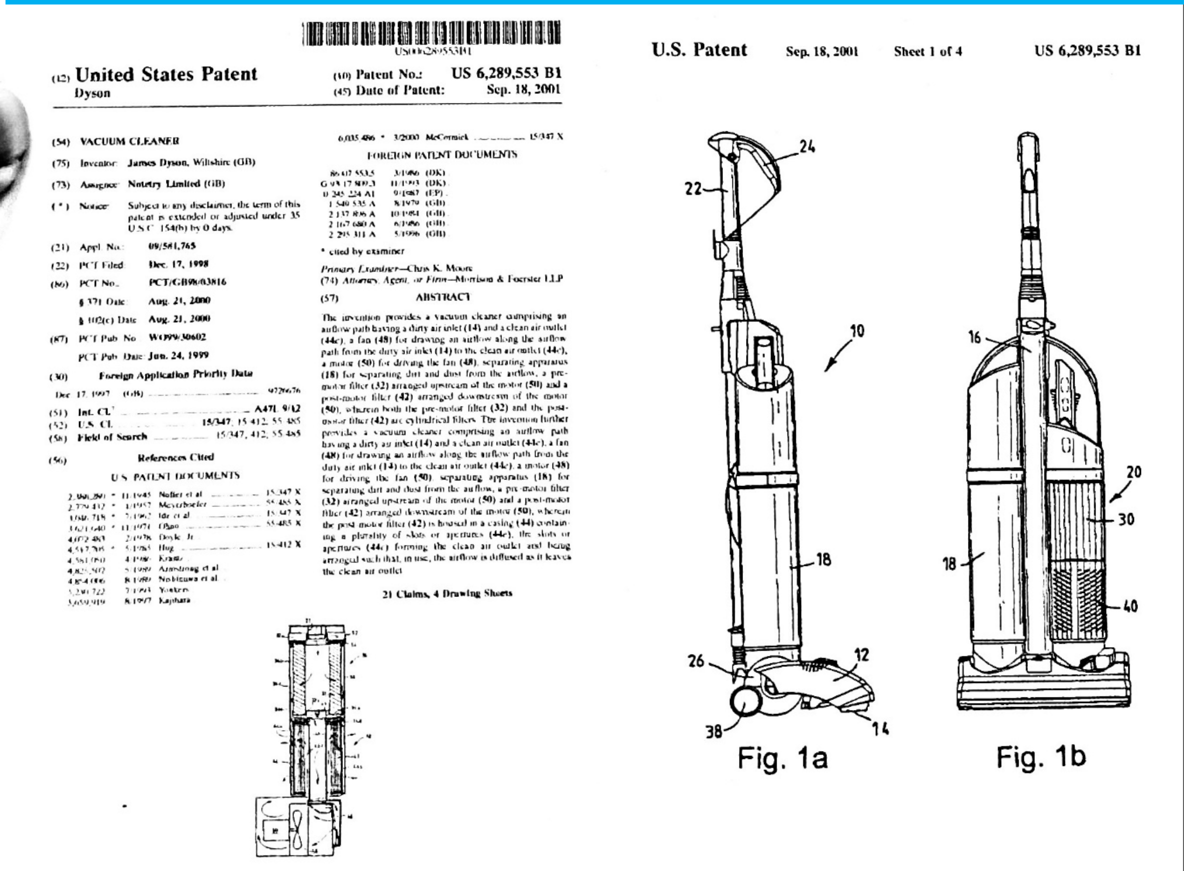
and dramatic work, computer programs or other areas that don't include a physical product.

There are other methods of protecting intellectual property. Where designers or manufacturers have similar products but they each have different design features, the different features can be protected as registered designs.

When designers produce drawings of new ideas, these drawings can be protected under design right. This is similar to copyright which protects the work of artists or authors.

Product brand names, slogans, logos and other branding material can be protected by trade marks.

Patenting a design can be expensive, especially if worldwide patents are required. This can be very difficult for lone inventors who often need initial investment in a product in order to afford the patent process. This puts them in a vulnerable position as their designs are at risk of being copied after presenting their ideas to potential backers. The only way to challenge an infringement of a patent is through the courts. This can be hugely expensive. In 2000, James Dyson, famously took Hoover to court over infringements of his 1980 patent for his bagless vacuum cleaner using cyclones. At the time, Hoover was manufacturing a Triple Vortex bagless cleaner, using the same cyclone invention. Dyson had to put everything he had into paying for legal action. He eventually won the case and with the proceeds was able to set up his own UK factory to build the DC01.



Sustainability and environmental concerns

Introduction

Manufacturers and retailers are becoming increasingly concerned with the impact that the products they make may have on the environment. The main reasons for this are, first, government and international law, and, second, that consumers are much more environmentally aware and will choose greener brands.

Environmental legislation and regulation

The following is intended as a brief summary of recent legislation and regulations concerning products and the environment.

Ecolabel

The EU Ecolabel is a voluntary scheme which was established in 1993. Manufacturers are encouraged to label products that have a reduced impact on the environment over their life cycle. European consumers can identify such products with a flower symbol.

Packaging Directive

The EU Packaging Directive, introduced in 1994 and amended in 2004, sets targets for the reduction of packaging waste by means of designing out waste in the initial package design, recycling, and re-use. It also sets limits for the amount of toxic metals used in packaging. EU member states have to meet the following targets: by 2008, 60 per cent of all packaging waste is to be recovered and a minimum of 55 per cent of this waste is to be recycled.

Energy Labelling Directive

This EU directive was introduced in 1996. All electrical appliances such as refrigerators and washing machines are labelled with a rating from A to G to indicate their energy use for consumers to refer to when making a purchase. The directive also aims to phase out inefficient appliances.

End-of-Life Vehicle Directive (ELVD)

This directive was introduced in 2003 to encourage the reuse and recycling of waste from vehicles when they reach their end of life. It restricts the use of toxic metal in new cars and requires manufacturers to label plastic parts to aid recycling. Manufacturers also have to publish information on how to dismantle the vehicles.

Waste Electrical and Electronic Equipment Directive

This EU directive known as the WEEE Directive was implemented in 2006. It encourages manufacturers to develop electrical and electronic products that can be dismantled and the parts reused or recycled. Manufacturers have to include instructions to consumers not to discard the old product but take them to WEEE collection points. The directive also requires manufacturers to arrange collection of WEEE.

Restriction of Hazardous Substances Directive (RoSH)

Introduced in 2006, this EU directive bans the use of some hazardous materials and chemicals such as lead, mercury and cadmium in electrical and electronic equipment. This is to safeguard human health when electrical equipment is disposed of and recycled.

Green design, ecodesign, sustainable design and sustainable innovation: what's the difference?

Green design

This is an approach in design to reduce impact on the environment.

It focuses on one or two areas such as conserving materials through using recycled materials in the manufacture of a product or by conserving energy in the use of the product. For example, the Dyson contra-rotating washing machine uses a water jet system to reduce the amount of water used and the agitation caused by the two tubs turning in opposite directions reduces the time taken to wash clothes, thus saving energy.

Ecodesign

This is an approach to design that goes further than green design. In this approach, designers and manufacturers will try to reduce the impact of a product through its entire lifecycle from raw materials extraction to final disposal. For example, a company developing a new washing machine might take the following areas into consideration:

- selection of low impact materials
- reduction in materials useage (both in manufacture and packaging)
- reduction of impact during use and optimisation of initial lifetime
- optimisation of end-of-life systems (for recycling and recovery of materials and components).

Sustainable design

In this approach, the main function of a product is analysed and a more environmentally sound method of performing the same function is sought. In addition to lessening the effect on the environment, sustainable design often has wider socio-economic benefits such as improved welfare and safety for workers producing the product, fair trade schemes and so on. For example, instead of using tumble dryers to dry clothes, it may be possible in some homes to use an alternative such as a cabinet that is heated by solar energy.

Sustainable innovation

This is a radical approach that goes beyond sustainable design to look for new ways of doing things using a mix of products and services. For example, instead of each home having a washing machine to clean clothes, a community based laundry services could collect your washing at the same time as your recycling waste (using biodiesel powered vehicles), then clean your clothes using efficient washing machines powered by alternative energy systems such as solar, wind or micro CHP (Combined Heat and Power). Your clean clothes could then be returned with your weekly grocery shopping.

Green design products

Examples of green design include clothing made from organically grown, naturally coloured cotton (reducing the need for pesticides and chemical dyes), sandals made from recycled denim (most waste denim would go to landfill), folding bicycles (encouraging commuters to conserve fuel and reduce carbon emissions), condensing gas central heating boilers (with over 90 per cent efficiency, saving much more energy than traditional boilers at around 50–60 per cent efficiency), coffee machines that utilise reuseable plastic filters instead of paper, biodegradable carrier bags, pencils made from recycled polystyrene cups and so on.

Table 19 *Life cycle assessment and eco design approaches for a polymer jug kettle*

Life cycle phase	Environmental impact	Design approach
Raw materials extraction and processing	• Polymers processed from crude oil (exhaustible material). • Copper and zinc used in wire and metal parts (exhaustible materials). • All polymers and metals used in the kettle consume large amounts of energy in extraction and processing (greenhouse gas emissions). • Mining or metal ores and oil exploration can have an impact on the site of extraction (toxic waste).	• Minimise the quantity of material required in each kettle, e.g. a reduction in weight by 15 per cent. • Use a significant percentage by weight of recycled polymer. • Use a cordless design to minimise the use of copper cable. • Reduce the number of different materials and components used.
Manufacture	• Material wastage. • Injection moulding and final assembly. • Consumption of energy (greenhouse gas emissions).	• Efficient mould design to mould as many parts in one cycle as possible. • Snap fittings and ultrasonic welding to replace adhesives and screws (speeding up manufacture and reducing toxic materials found in adhesives). • Elimination of wasteful steps in manufacture to speed up 'tac time' (saving energy).
Distribution	• Transport from point of manufacture to distribution centre and onto retail outlets (greenhouse gas emissions and consumption of fossil fuels). • Packaging material waste, e.g. expanded polystyrene (EPS), LDPE film and printed card.	• Efficient box design to maximise number of units to a pallet. • Moulded card insert to replace EPS. • Bio-additive included in LDPE film to biodegrade.
Use	• High amount of energy consumed in the life time of a kettle (significant greenhouse gas emissions) and solid waste/ash from coal fired power stations.	• Easy to read filler gauge positioned on the top to aid precise filling. • Thermochromic patch to show if it is necessary to reboil the kettle or not. • Use an insulating double wall with an air gap to keep the water hot. • Use a water reservoir that dispenses the correct amount of water onto the heating element for one or more cups as desired.
Disposal	• Polymers could take several hundred years to degrade in landfill. • Electronics are difficult to separate from a circuit board.	• Design the kettle in a form that is 'classic' or timeless to extend its useable life. • Use the international identification code on polymer parts to aid recycling. • Use one type of thermoplastic polymer to facilitate recycling. • Use surface mount components that can be separated from a circuit board when passed through an infra-red oven.

Safety

Before reading this section, you should refer back to Chapter 3 which introduces safety standards and legislation in Product Design. You will need to have an understanding of British, European and International standards that affect safety in products and their safe manufacture.

Risk assessments

You need to understand the concept of **risk assessment**. Risk assessments can be applied to both the design and manufacture of products, and the outcome of these risk assessments can determine things such as the physical appearance, the materials, components and finishes used, the method of manufacture and consumer advice issued with products.

The example in Table 20 is a risk assessment applied to a child's sit and ride plastic car

Table 20 *Child's sit and ride plastic car*

Hazard	Level of risk	Control measure (design)	Control measure
		Hazards in use	
Entrapment in mechanisms or moving parts	Low	• Design out potential areas for entrapment such as door hinges by removing doors altogether. • If pedals are used these would be direct drive to the front wheel(s) so there is no chain or gears to guard. • Sufficient space between the pedal crank and the wheel to prevent entrapment.	
Tipping over	Medium	• Design car with wide wheel base and thick wheels. • Add seat belt/straps to keep rider in. • Add a parental handle.	
Toxic materials and finishes	Low	• Specify non-toxic materials, pigments and additives from suppliers. • Applied finishes are designed out; colour pigment to be added in moulding process.	• Random testing of materials to ensure hazardous materials are not present or fall below safe limits.
Accident through use, e.g. road traffic incident	Medium to high	• Give clear instructions about adequate parental supervision and safe use of the product.	
		Manufacturing hazards	
Toxic fumes			• Protect employees by using fume extraction and fully automated moulding processes.
Molten polymer			Fully guarded machines (guards are safety interlocked and machine will not operate without guards in place).
Hot products (post moulding)			• Fully guarded machines (guards are safety interlocked and machine will not operate without guards in place).

Safety legislation and the user

There is a range of consumer protection laws determined and enforced by the Department of Trade and Industry (DTI) and the European Union.

The Trading Standards Agency is responsible for the day to day enforcement of consumer safety law. Trading Standards officers have the power to remove unsafe products from the market and prosecute offenders. Supplying an unsafe product can result in a £5000 fine and/or imprisonment for up to six months.

One piece of important legislation concerns the safety of electrical consumer goods. This is influenced by the Electrical Equipment (Safety) Regulations 1994. This requires mains voltage items to be well insulated and contain measures to protect consumers from electric shock or fire. If used with 240 volts mains power, electrical plugs have to be fitted. These, in turn, must conform to the Plugs and Sockets etc. (Safety) Regulations 1994.

The European Union (EU) have put in place a number of Product Directives, covering a wide range of product areas such as:

- General product safety.
- Machines.
- Toy safety.
- Noise emission from domestic products.
- Low voltage electrical equipment.

Products that meet the relevant EU directives can display the CE mark. This mark is a statement by the manufacturer that it conforms to the directive that is applicable to it. It means that the product can be sold in the EU. Manufacturers wishing to display the CE mark on their products usually have them tested by the British Standards Institute. The BSI tests the products against agreed standards. On passing the tests, the product can also display the BSI Kitemark. Both the CE and Kitemark reassure consumers that they are buying a safe product.

ICT and the internet

The internet was developed from US military research in the 1950s and 1960s to devise a computer system that could maintain communication in the event of a nuclear missile attack. This research, together with the advancements in technology already discussed allowed a number of users to access a computer at the same time. This early work enabled the development of email and conferencing systems. A source code that allows information to be shared was developed and this enabled the internet to become a method of mass communication. Linux is one operating system code for the internet used by about a quarter of the market. Microsoft Windows is used by most home users.

The web is the 'public face' of the internet. It was invented by English physicist Tim Berners-Lee in 1989 while he was working at the European particle physics lab in Geneva. In his role, he needed to communicate with a wide number of scientists working on different projects and they all needed access to complex information on a range of subjects. He designed a searchable linked information system using hypertext. This allowed any user to access data using searches that would be able to find documents stored in other servers and across networks. There are now over 600 million internet users worldwide and over 20 million users in the UK.

users worldwide and ...

Radio Frequency Identification Tags (RFID)

RFID tags are an example of a product developed through advancements in microelectronics and software development. They are electronic tags that can be attached to products and can contain information about the product such as ingredients, batch number, date of manufacture, price, use by date and so on. This technology is set to make bar codes obsolete.

RFID tag systems are made up of three main components:

- A tag that contains an electronic circuit and an antenna. The tag stores the data on the product and will act as a transponder, sending the information when scanned by an electronic reader.
- A reader that sends a signal to the tag and receives the information.
- A computer database that receives the information from the reader and processes it.

RFID tags have several advantages over traditional bar codes. They are robust and can withstand rain, and other damage and still function. They can be scanned from several metres away and don't have to be in direct line of sight with the readers, for example, they can be read through obstructions such as the walls of containers, vehicles and so on.

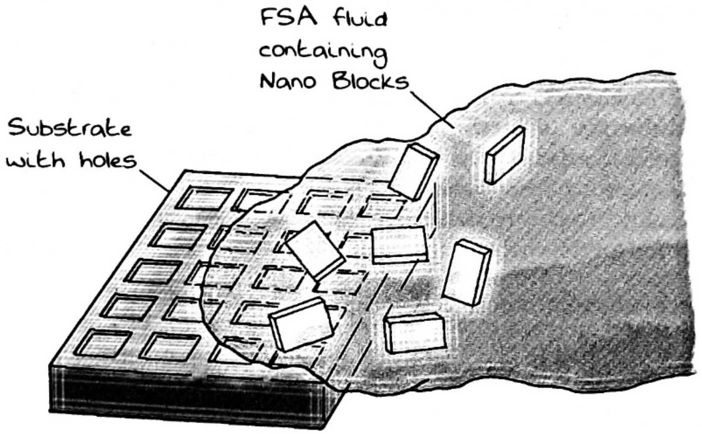
RFID tags are available in two forms; passive and active. Active tags have their own power supply and can have the information modified. They can also transmit information over a greater distance.

Common applications for RFID tags include stock control. They are used in Kanban systems that control the flow of components and products as they move through a factory to a store room and then onto despatch. The progress of products as they are being made can be tracked as the tag passes by readers along a production line.

In some stores, RFID tags are used on individual products and 'smart shelves' read the tags as the product is removed from them. The system then automatically re-orders the product to maintain stock levels. The technology is also used in pet identification chips implanted under the skin, door control identity cards, hospital patient identity bracelets and in new UK passports.

Fluidic self assembly (FSA)

Fluidic Self Assembly (FSA) is a new manufacturing technique developed to manufacture very small integrated circuits like those used in RFID tags on a large scale at a low cost. The technique devised by the American company Alien Technology Corp, uses its 'NanoBlocks' which are tiny circuits floated in a suspension liquid. This is spread over a substrate that has holes in its surface matching the shape of the circuits. These settle and self-align into the holes making the electrical connection. This technique allows the placement of millions of NanoBlocks with a high degree of accuracy on a range of materials within minutes. It makes it possible to manufacture flat screen PC monitors, high definition TV screens and flexible polymer film.



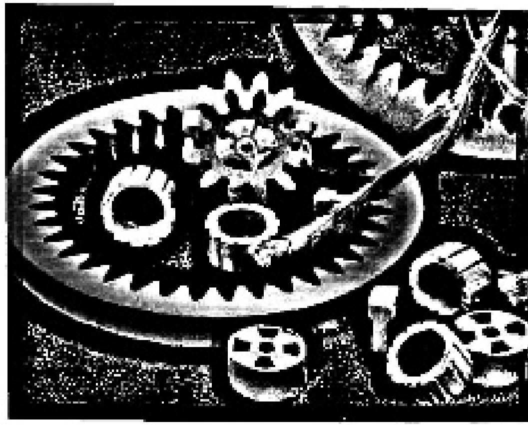
NanoBlocks settling into a substrate in FSA process

Nanotechnology

The previous section discusses the miniaturisation of electronics – putting millions of transistors onto a microprocessor. This involves working in measurements of micrometres (one thousandth of a millimetre). Nanotechnology involves working on materials at the atomic level. Here, scientists and engineers are using measurements in nanometres (one thousandth) of a micrometre which is some 40,000 times smaller than the width of an average human hair.

Nanotechnology can be defined as the manipulation and rearrangement of individual atoms to create useful materials, systems and devices.

Scientists hope that in the future, the scale can be reduced to the molecular level known as molecular nanotechnology. This may allow the manufacture of machines a few nanometres big such as robots, motors, and other devices that would be smaller than a cell.



Electron micrograph showing nanotechnology gears next to a fly's leg.

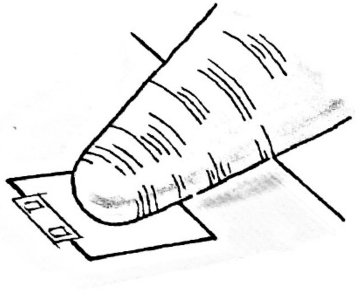
Currently highly accurate mechanisms can be made so small that they can only be seen clearly through an electron micrograph.

With nanotechnology, materials can have the physical and mechanical properties of their constituent parts modified. This means that the resulting material could be made far superior to the original. Typical properties that could be improved might be: stiffness, strength, flame resistance, electrical conductivity, permeability or impermeability and optical clarity.

Products using nanotechnology

Vehicles

Car manufacturers such as Toyota have used nanocomposites in the manufacture of car bumpers and other vehicle components. Nanotechnology can make these parts 60 per cent lighter and increase resistance to denting by 100 per cent. This again has benefits for the environment because it will allow cars to be made with reduced weight (using less fuel), and more durable so they will not need to be changed as frequently.



A pressure sensor used in air bags (pencil point shows scale)

Tiny pressure sensors made from nanomaterials can be used in airbags. These are small plates embedded into a circuit board that move under rapid deceleration to make an electrical circuit, triggering the rapid inflation of the air bag.

Carbon nanotubes can be embedded into plastic car body parts to make the surface electrical conducting. This can be used in powder coating where paint particles can also be electrically charged to improve adherence and remove the need for a primer coat.

Clothing

Nanotechnology is currently used in clothing to increase stain resistance. Embedded nanoparticles can be bonded to the fabric so that liquids simply run off the surface rather than soaking in. Companies such as Gap and Dockers are using this technology in making stain resistant khakis. The use of this technology means that the clothes won't need washing as much which has benefits for the environment as energy, water and detergent are saved.

Electrical consumer goods

Flexible, organic light emitting diode display

Kodak has developed colour screens made from nanostructured polymer films. These films combine organic light-emitting diodes (OLEDs) which enable them to be made into lightweight, flexible displays for use in mobile phones, PDAs, laptops and other applications. OLEDs also give very good brightness and consume extremely low levels of energy in use.

Companies such as Hewlett-Packard and IBM are experimenting with nanotechnology in computer chips. These chips will allow the manufacture of computers that boot up instantly. Known as NRAM chips (non-volatile random access memory), the chips remember how to run programs and so don't need to go through the usual installations sequences as computers boot up when switched on. Improved conductivity in these chips will make computers run faster and use less energy.

Medical

By manipulating calcium and phosphate at the molecular level, scientists have developed a substitute for natural bone. This can be used to make synthetic bone replacements for bone that has become too damaged to repair or has been removed.

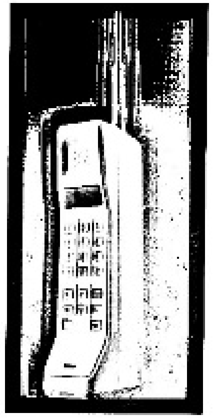
Nanofilters have been produced which are so small that they can stop viruses and other biological agents. This makes it possible to filter even the most contaminated water to make it drinkable. Such products may have applications in emergency survival situations or in developing countries in times of drought.

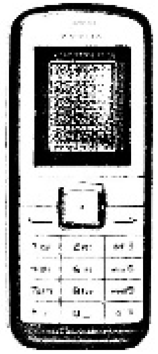
Scientists have suggested that in the future, nanotechnology will allow the manufacture of tiny machines small enough to be used inside the human body. These might be able to carry out operations, remove tumours or deliver medicines to specific parts of the body.

Product analysis exercise 6: Major developments in technology

Mobile phones

Study the photographs that show a 1980s 'brick' mobile phone and a contemporary mobile phone.





1 Make notes under the following headings, explaining what advancements have been made in technology to enhance the performance and function of mobile phones.

a Batteries.

b Visual displays.

c Microelectronics.

2 Explain how developments in technology have led to improvements in the ergonomics of mobile phones.

3 Explain how developments in smart materials can make electrical products easier to recycle.

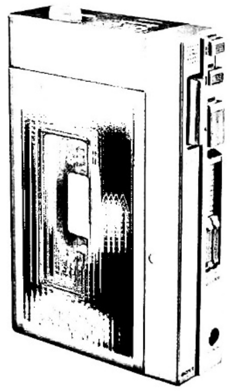
Technology push and market pull

So far we have discussed examples of how advancements in technology can drive product development. We have also seen that the design process often starts with the recognition of a need or a market for a product. These two drivers in invention are often referred to as the 'technology push model' and 'market pull model'.

The technology push model is a linear process where a scientific or technological advancement – often conducted in a research and development department (R&D) – is passed to a design and development team to design a useful product using the technology. In turn, these designs are passed to manufacturing to build the product, and marketing and sales to promote and retail the finished item. This approach is often called the 'over the wall model' as departments may work in isolation from each other and the end user. The finished item is metaphorically thrown over the wall to the consumer who the team believes will want the product, and will understand how to use it. This is a high risk strategy that can have its successes and failures.

Basic science drives invention | Design and development | Manufacturing | Marketing | Sales

Linear technology push model



The first Sony Walkman

A 'technology push' success

An example of a success is the Sony Walkman first designed in 1979 and manufactured from 1980. Akio Morita, president of the Sony Corporation and other Sony colleagues complained that their existing portable stereo and standard headphones were too big for personal use. Company engineers removed the recording circuit from their small cassette recorder (the Pressman) and then replaced it with a stereo amplifier. They also developed a lightweight headphone set. The development of the headphone set required a number of technological innovations but the remainder borrowed existing technology. The Walkman did not have a specific market need and many thought it might fail to diffuse into market. However, Morita pushed the project forward and with some aggressive marketing, the Walkman achieved almost instant success. Sony managed to convince consumers to buy a product that they hadn't known they wanted.

A 'technology push' failure

An example of a technically sound and inspirational product that failed to become successful, is the Sinclair C5. This is an electrically assisted vehicle invented by Sir Clive Sinclair and launched in the UK in January 1985. Financed personally by Sir Clive Sinclair (famous for development of the first pocket scientific calculator and early home PCs such as the Sinclair Spectrum and ZX81), the C5 was a battery driven tricycle, steered by two handles either side of the driver's seat. It had a top speed of 15 mph (low enough for the driver not to need a driving licence), and was made in the Hoover factory at Merthyr Tydfil. It cost over £12 million to develop and put into production. Unfortunately, when it was launched it was perceived by the public as being impractical for the British climate (it being an open design and close to the ground), and perhaps a little unsafe in terms of visibility to other vehicles.

In addition to these perceived problems, there were several serious design flaws such as the weight of the vehicle, the lack of gears, the short pedal cranks and lack of adjustability of distance from seat to pedal. In use on long hills, the rider had to pedal to assist the motor which was prone to burning out.

By August 1985, fewer than 17,000 C5s had been sold. Production ended and Sinclair Vehicles Ltd went into receivership in October 1985. The C5, like many other products is an example of a product that was developed without careful consideration of user needs and even with promotional campaigns using ex-Formula One racing champion Sir Stirling Moss, the C5 failed to capture the imagination of the consumer.

Market pull

This model describes how the stimulus for new products comes from the needs of society or a specific section of the market. Detailed analysis of market research would identify what needs exist, how existing products might meet these needs and how a new product might be better.

Having conducted this research, the product that is subsequently developed should be successful because the product has been specifically designed to meet a need.

Market pull model

The market pull model can be criticised. Consumers are good at identifying weaknesses in existing products and can voice their demand for new ones. However, they can't demand products that don't exist, where the technology or science isn't available. Just because a need exists, there is no guarantee that a new product can be developed to meet that need.

Coupling model

This is an alternative model to technology push and market pull. It suggests that successful design can emerge by getting the balance right between technology and market considerations. The coupling of market needs and state of the art technology is vital in all of the stages of the design process. In other words, from the first spark of inspiration, the designer would consider both market needs and existing technology, through to design and development, manufacture, marketing and sales.

Product life cycles and historical influences

The term life cycle can have several different meanings. First it can be used to describe how long something will last before it wears out. Second, it can be used to discuss the environmental impact of a product through the stages of its life from raw materials extraction, to manufacture, use and disposal. Finally, it is used to describe the stages that a product goes through from its introduction to its eventual **obsolescence**. It is the latter that will be discussed here.

The life cycle of a product can be divided into several stages. These are:

- introduction
- growth
- maturity
- decline.

How long a product's life cycle lasts depends on several factors:

- changes in materials and technology (often known as the 'technology push')
- changes in consumer demand (often known as the '**demand pull**')
- sales (is the product selling?)
- what the product is
- how technically complex the product is.

Introduction and launch

The introduction stage of a product's life cycle is the period when a product is newly released onto the market. At first sales can be slow, as consumers may not recognise the benefits of a new product. At this stage, there are many costs associated with launching a new product and very little profit if any will be made.

Growth

As advertising takes effect and consumers see the benefits of new technology, sales start to rise, the product begins to diffuse and there is a steady increase in profit. During this stage of a product's life cycle, competitors may start to introduce their own brand of the product. This can be seen in the MP3 player market with many brands being launched, each with slightly different features.

Maturity

At this point in the life cycle, sales begin to level off. The market becomes saturated with competitor designs that may have different or improved features. Major companies, such as Sony, monitor the market very carefully and have new designs ready – in order to maintain their market share. Alternatively, companies have to market their product aggressively to stay ahead.

Decline

This stage begins when the market is completely saturated and sales start to drop off. Profits fall. At this stage companies have to decide whether to accept reduced profits or stop making the product and launch a new one. This might be accelerated by changes in technology.

As new technology develops, products can be made obsolete. This is clearly illustrated with the replacement of vinyl records and audiocassette tapes with the compact disc. More recently, Sony developed the minidisc, reducing the size of personal stereos. Then they developed the MP3 player, making a personal stereo truly pocket size. The introduction of internet marketing of music and the MP3 player has the potential to make CDs obsolete. 'Consumer pull' is clearly contributing to this as a whole new generation routinely downloads music from the internet, rather than purchasing CDs.

Planned obsolescence

Some companies deliberately plan to keep the lives of their products short. They produce new or improved products at short intervals choosing not to wait until the current product reaches maturity or decline. Such companies aim their advertising at convincing consumers that they must have the latest version of their product. This system of updating designs is known as 'product churning'. This strategy can be seen clearly in consumer electronics products where new versions of a product are released each year.

There are several reasons why companies 'product churn':

- to maintain a steady volume of sales
- to maintain a market advantage over competitors
- as a result of technological advancement, e.g. developments in microelectronics.

Some products need to have a built-in obsolescence for safety or hygiene reasons, for example, the hypodermic syringe or disposable razor. Others, such as cars, may have a shorter life cycle than is actually possible, in order to keep the overall cost of the vehicle at an affordable level. It is possible, of course, to make cars from very durable materials, such as stainless steel, but it is very expensive.

The influence of fashion

Consumer fashions, trends and the demand to keep up with the latest technology, all help to contribute to obsolescence. Many people change their wardrobe on an annual basis, and their home interiors every three to five years, and this therefore feeds the demand for new products.

The influence of fashion and trends on product design cannot be over-estimated. Manufacturers today employ agencies to predict what the latest fashions will be. Such agencies will advise on colour and fabric trends for interiors and for the fashion industry. This results in seasonal colours and fabrics being manufactured together with a full range of coordinating accessories.

Printing Processes

Offset Lithography

Applications:

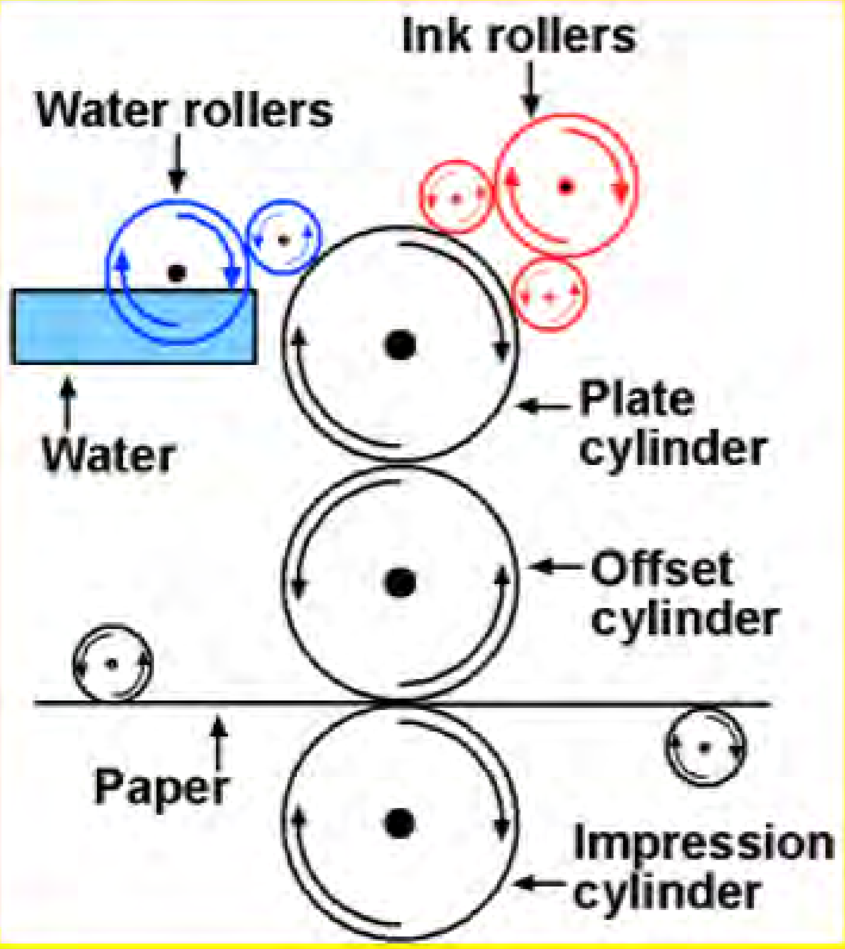
Business stationery;
Brochures;
Magazines;
Newspapers.

Offset Lithography

How it works:

Plates (aluminium or polymer) are made up with the images & type. Water covers the blank areas to repell the inks. The plate rolls against the rubber blanket cylinder (offset). This then transfers from the cylinder to the stock (paper).

This is known as indirect or offset printing.



Advantages

- Good reproduction quality, especially photography.
- Inexpensive.
- Able to print on a variety of papers and stocks.
- High printing speeds.
- Widely available.