**M09 – Materials**

**Introducing and Classifying Materials**

**What are the General Groups of Materials?**

* Timber
* Metals
* Plastics
* Ceramics
* Composites
* Textiles

In each group there can be subdivisions;

* timber can be subdivided into natural wood and man-made
* metals can be subdivided into ferrous and non-ferrous
* plastics can be subdivided into thermoplastics and thermosets
* ceramics can be subdivided into earthenware, porcelain, stoneware, glass
* composites are the most difficult to subdivide because new materials are continually being developed with ever-changing properties
* textile fibres can be subdivided into natural or synthetic

**Alloy -**  a mixture that contains at least one metal. This can be a mixture of metals or a mixture of metals and non-metals.

**Composite -** A mixture composed of two or more substances (materials) with one substance acting as the matrix or glue.

**The Physical Properties of Materials**

**Density -** That is the mass of the object per unit of density.

**Electrical Resistivity -** This is a measure of a material’s ability to conduct electricity. A material with a low resistivity will conduct electricity well. A material with a high resistivity will be a good electrical insulator.

**Thermal Conductivity -** This is a measure of how well a material conducts temperature through it.

**Thermal Expansion** - This is a measure of the degree of increase in dimensions when an object is heated. This can be measured by an increase in length, area or volume. The expansivity can be measured as the fractional increase in dimension per kelvin increase in temperature.

**Hardness -** This is measured by the resistance a material offers to penetration or scratching.

An understanding of these properties is essential when selecting a particular material for use in a particular situation.

**Mechanical Properties**

Do not confuse MECHANICAL properties with PHYSICAL properties. Physical properties are the five properties listed above. Mechanical properties are;

**Tensile Strength -** The ability of a material to withstand pulling forces (Tension)

**Stiffness -** The resistance of an elastic body to deflection by an applied force (Young’s Modulus)

**Toughness -** The ability of a material to resist the propagation of cracks

**Ductility -** The ability of a material to be drawn or extruded into a wire or other extended shape. Do not confuse with malleability, the ability to be shaped plastically.

An understanding of the mechanical properties of materials is essential when selecting a material for use in a particular situation.

**Aesthetic qualities of materials**

A designer may also select a material to provide a particular cosmetic finish to a product. Polished metal finishes – oxidized finishes – tarnish resistant finishes – clear varnish/polyurethane finishes - natural wood finishes.

**Timber / Wood**

Wood is a natural product that is formed from cellulose fibres and water. The fibes run along the growth line of the tree. In softwood the fibres are not very densely grouped together so the wood is lighter, contains more water and is more likely to shrink and warp when the water between the fibres starts to evaporate. Softwood trees usually reach maturity in 30 to 40 years and are farmed like a crop. In hard wood the fibres are very compact, the wood is heavier and harder and it is less likely to shrink or warp. Hardwood trees take over one hundred years reach maturity.

**Trees and the environment**

Trees play a very important role in maintaining the environmental balance of the atmosphere. They are responsible for absorbing carbon dioxide from the atmosphere and emitting oxygen in to it. The large tropical rain forests can be regarded as the “lungs of the earth”. This is why the deforestation of large areas of rain forest in order to grow food crops is such a concern for the environmentalists.

**Composite timber products**

These are man-made wooden products that are made from mixing wood (usually wooden chips/particles/ dust with adhesives to create flat sheet materials. This will form products such and chipboard/hardboard/fiberboard and MDF (Medium Density Fiberboard).

There is another way the form sheet timber products such as plywood which is made by lamination. (Peeling thin slices of wood off a tree trunk like a toilet role and then cutting those sheets into panels and then gluing the panels together with the grain of each alternate panel running at 90° to the other.)

**Different wooden products have different Mechanical & Physical Properties**

A knowledge of these properties is required when selecting the most suitable type of wood product for a particular application.

**What type to use where?**

Solid timber (planks) is best used in structural load bearing situations. Composite man-made wooden products are best used where large sheets are required. Hardwoods are excellent for cosmetic finishes.

**Wood finishes and protection**

Wood is an organic material and as such will naturally decompose (rot). Finishes can be applied to the surface of the wood to slow down this process. Paint, varnish, lacquers and oils can be applied to the surface of the wood to repel water. Chemicals can be applied to the surface to kill/deter the organisms (funguses) and insects that will also damage the material.

**Wood for flooring**

There are three types of wood used for flooring;

**Softwood -** This is the most common, floor boards made from planks. This material is cheap and readily available because it easily slinters and does not wear well it is usually used as a base for carpets and other more durable surface products.

**Hardwood -**This is a very expensive product for flooring but it usually looks better and lasts longer.

**Composite -**Laminate flooring is a man-made product that uses thin slices of hardwood or plastics bonded to a base layer. This is much cheaper than hard wood but has all of the cosmetic qualities. It lasts longer than softwood and is a favorite compromise product for the mass market.

All of these three products usually have machined edges so that the individual planks can lock together to form a stable flat surface to walk on.

**Metals**

Metals come from ores which are mined from the ground. Metals fall into three main categories.

* Ferrous
* Non-Ferrous
* Alloys

**Ferrous metals** are those metals that contain iron. Ferrous metals are usually very strong, very heavy, prone to rust and usually need a protective coating to stop them rusting.

It is possible to produce ferrous metals which are resistant to rusting such as stainless steel. Rusting is a normal process and it happens when the iron starts to decay back into its original form of iron-ore. Rusting is caused by the oxygen in the air reacting with the iron and forming iron-oxide. To stop rusting you have coat the metal with a protective layer that excludes the oxygen. Such as, paint, lacquer or plastic.

**Examples of non-ferrous** metals are aluminum, copper, brass, gold, zinc, silver. These metals each have very different properties; aluminum is very lightweight but soft, brass is very hard but brittle, gold is very soft and very easily shaped etc.

**Alloys**

An alloy is a metal with one or more other materials added to it. In this way you can create a new material that has a mix of properties.

**Increasing Tensile Strength by Alloying**

To create an alloy requires the addition of one or materials to a metal. The addition of these other materials will create an alloy with a combination of all of the physical properties of the individual components. By the careful selection of which materials to add into the “mix” you can produce an alloy which will perform well in particular circumstances. An alloy with strong bonds at a molecular level will produce an alloy that performs better than one “pure” metal. E.g. Iron in its purest form is very brittle but by adding just the right amount of carbon to it during the smelting process you produce steel which has much better physical properties for use in situations where there are tensile forces in play.

**The effect of alloying upon Malleability and Ductility.**

Malleability means easy to shape. Ductility means easy to stretch into a long thin shape.

By adding these extra materials to the metal during the smelting process you enable the various materials to mix together. The extreme heating process of smelting breaks down the molecular bonds of the various materials and allows them to re-bond to each other in a different pattern/structure. By experimenting with various materials and a knowledge of the physical and mechanical properties of the component parts you can create a new material that has all or some or different properties. By carefully controlling the mix of materials you can increase or decrease properties such as ductility and malleability.

**Super Alloys**

Usually the strength of a metal decreases as it gets hotter. That’s because it normally gets softer as it heats up. Super Alloys do the opposite. Super Alloys are metals that are used in situations of extreme high temperature and they keep their hardness (mechanical properties) up to the temperature when they are just about to melt.

In addition to their ability to keep their mechanical properties they have enhanced physical properties and are particularly resistant to corrosion and metal fatigue. Metal fatigue is when small microscopic cracks start to form in a metal which weaken it.

**Applications for Super Alloys**

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

**Plastics**

Plastics are made from processing oil which is extracted from the ground by drilling.

Plastics are divided into two generic types:

* Thermosetting Plastics (These can only be cast /molded ONCE)
* Thermoplastics (These can be cast and remolded MANY TIMES)

Thermosetting plastic CANNOT be recycled. However, it is an excellent electrical and thermal insulator; this makes it an excellent material to use for the handles of saucepans and to encase electrical sockets and plugs.

Thermoplastic CAN be recycled and re-formed which makes it the perfect choice for products that are made by injection moulding, extrusion, blow-moulding and many other techniques where identical shapes are mass produced.

**What is Extrusion?**

This is a method of production where an object is produced by squeezing and material, such as thermoplastic which has been softened by heating, through a former called a ‘die’. As the softened material is forced through the die it comes out of the other side in a pre-determined shape, then it is cooled so that it sets in that shape. Plastic pipes are an example of this method of manufacturing. This manufacturing process is perfect for mass production.

Watch this video <https://www.youtube.com/watch?v=Tp2Rdx69SSo>

**What is Injection Moulding?**

This is a method of production where an object is made by injecting a liquid material such as very hot thermoplastic into a hollow mould, cooling the material and then splitting the mould open to remove the final product. This method of production can produce very complicated shapes and is ideal for mass production.

**What is Vacuum-Forming or Thermo-Forming?**

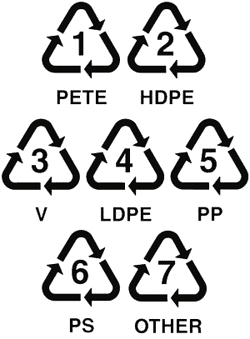
This is a method where an object is made from a flat sheet of plastic which is softened by heating and then it is clamped in a machine which forces a pre-formed mould into the sheet and then a vacuum sucks the soft plastic onto the mould to form a perfect copy. Then the plastic is cooled, the former/mould is pulled out and the finished object is cut out from the sheet.

Watch this video <https://www.youtube.com/watch?v=oxN70ktR0jg>

**What is Blow-Moulding?**

Blow-moulding is a manufacturing process used to make hollow products that have a very complicated shape such as plastic bottles and jars. It combines some of the features of injection moulding, extrusion and compressed hot air.

Watch this video <https://www.youtube.com/watch?v=ZfyPCujUPms>

**Recycling of Plastics**

Bottom of Form

The well-recognized “chasing arrows” symbol we see on plastic containers and products does not mean the product is recyclable. The little number inside the triangle tells the real story.

Within each chasing arrows triangle, there is a number which ranges from one to seven. The purpose of the number is to identify the type of plastic used for the product, and not all plastics are recyclable or even reusable. There are numerous plastic-based products that cannot break down and cannot be recycled.

Understanding the seven plastic codes will make it easier to choose plastics and to know which plastics to recycle. For example, water bottles that display a three or a five cannot be recycled in most jurisdictions in the US. A three indicates that the water bottle has been made from polyvinyl chloride, a five means that it’s been made of polypropylene, two materials that are not accepted by most public recycling centers.

***Here are the seven standard classifications for plastics, and the recycling and reuse information for each type:***

**1 - PET (Polyethylene Terephthalate)**

PET is one of the most commonly used plastics in consumer products, and is found in most water and pop bottles, and some packaging. It is intended for single use applications; repeated use increases the risk of leaching and bacterial growth. PET plastic is difficult to decontaminate, and proper cleaning requires harmful chemicals. Polyethylene terephthalates may leach carcinogens.

PET plastic is recyclable and about 25% of PET bottles in the US today are recycled. The plastic is crushed and then shredded into small flakes which are then reprocessed to make new PET bottles, or spun into polyester fiber. This recycled fiber is used to make textiles such as fleece garments, carpets, stuffing for pillows and life jackets, and similar products.

Products made of (PET) plastic should be recycled but not reused.

**2 - HDPE (High-Density Polyethylene)**

HDPE plastic is the stiff plastic used to make milk jugs, detergent and oil bottles, toys, and some plastic bags. HDPE is the most commonly recycled plastic and is considered one of the safest forms of plastic. It is a relatively simple and cost-effective process to recycle HDPE plastic for secondary use.

HDPE plastic is very hard-wearing and does not break down under exposure to sunlight or extremes of heating or freezing. For this reason, HDPE is used to make picnic tables, plastic lumber, waste bins, park benches, bed liners for trucks and other products which require durability and weather-resistance.

Products made of HDPE are reusable and recyclable.

**3 - PVC (Polyvinyl Chloride)**

PVC is a soft, flexible plastic used to make clear plastic food wrapping, cooking oil bottles, teething rings, children’s and pets’ toys, and blister packaging for myriad consumer products. It is commonly used as the sheathing material for computer cables, and to make plastic pipes and parts for plumbing. Because PVC is relatively impervious to sunlight and weather, it is used to make window frames, garden hoses, arbors, raised beds and trellises.

PVC is dubbed the “poison plastic” because it contains numerous toxins which it can leach throughout its entire life cycle. Almost all products using PVC require virgin material for their construction; less than 1% of PVC material is recycled.

Products made using PVC plastic are not recyclable. While some PCV products can be repurposed, PVC products should not be reused for applications with food or for children’s use.

**4 - LDPE (Low-Density Polyethylene)**

LDPE is often found in shrink wraps, dry cleaner garment bags, squeezable bottles, and the type of plastic bags used to package bread. The plastic grocery bags used in most stores today are made using LDPE plastic. Some clothing and furniture also uses this type of plastic.

LDPE is considered less toxic than other plastics, and relatively safe for use. It is not commonly recycled, however, although this is changing in many communities today as more recycling programs gear up to handle this material. When recycled, LDPE plastic is used for plastic lumber, landscaping boards, garbage can liners and floor tiles. Products made using recycled LDPE are not as hard or rigid as those made using recycled HDPE plastic.

Products made using LDPE plastic are reusable, but not always recyclable. You need to check with your local collection service to see if they are accepting LDPE plastic items for recycling.

**5 - PP (Polypropylene)**

Polypropylene plastic is tough and lightweight, and has excellent heat-resistance qualities. It serves as a barrier against moisture, grease and chemicals. When you try to open the thin plastic liner in a cereal box, it is polypropylene. This keeps your cereal dry and fresh. PP is also commonly used for disposable diapers, pails, plastic bottle tops, margarine and yogurt containers, potato chip bags, straws, packing tape and rope.

Polypropylene is recyclable through some curbside recycling programs, but only about 3% of PP products are currently being recycled in the US. Recycled PP is used to make landscaping border stripping, battery cases, brooms, bins and trays. However, #5 plastic is today becoming more accepted by recyclers.

PP is considered safe for reuse. To recycle products made from PP, check with your local curbside program to see if they are now accepting this material.

**6 - PS (Polystyrene)**

Polystyrene is an inexpensive, lightweight and easily-formed plastic with a wide variety of uses. It is most often used to make disposable Styrofoam drinking cups, take-out “clamshell” food containers, egg cartons, plastic picnic cutlery, foam packaging and those ubiquitous “peanut” foam chips used to fill shipping boxes to protect the contents. Polystyrene is also widely used to make rigid foam insulation and underlay sheeting for laminate flooring used in home construction.

Because polystyrene is structurally weak and ultra-lightweight, it breaks up easily and is dispersed readily throughout the natural environment. Beaches all over the world have bits of polystyrene lapping at the shores, and an untold number of marine species have ingested this plastic with immeasurable consequences to their health.

Polystyrene may leach styrene, a possible human carcinogen, into food products (especially when heated in a microwave). Chemicals present in polystyrene have been linked with human health and reproductive system dysfunction.

Recycling is not widely available for polystyrene products. Most curbside collection services will not accept polystyrene, which is why this material accounts for about 35% of US landfill material. While the technology for recycling polystyrene is available, the market for recycling is small. Awareness among consumers has grown, however, and polystyrene is being reused more often. While it is difficult to find a recycler for PS, some businesses like Mailboxes Etc. which provide shipping services are happy to receive foam packing chips for reuse.

Polystyrene should be avoided where possible.

**7 – Other (BPA, Polycarbonate and LEXAN)**

The #7 category was designed as a catch-all for polycarbonate (PC) and “other” plastics, so reuse and recycling protocols are not standardized within this category. Of primary concern with #7 plastics, however, is the potential for chemical leaching into food or drink products packaged in polycarbonate containers made using BPA (Bisphenol A). BPA is a xenoestrogen, a known endocrine disruptor.

Number 7 plastics are used to make baby bottles, sippy cups, water cooler bottles and car parts. BPA is found in polycarbonate plastic food containers often marked on the bottom with the letters “PC” by the recycling label #7. Some polycarbonate water bottles are marketed as ‘non-leaching’ for minimizing plastic taste or odor, however there is still a possibility that trace amounts of BPA will migrate from these containers, particularly if used to heat liquids.

A new generation of compostable plastics, made from bio-based polymers like corn starch, is being developed to replace polycarbonates. These are also included in category #7, which can be confusing to the consumer. These compostable plastics have the initials “PLA” on the bottom near the recycling symbol. Some may also say “Compostable.”

#7 plastics are not for reuse, unless they have the PLA compostable coding. When possible it is best to avoid #7 plastics, especially for children’s food. Plastics with the recycling labels #1, #2 and #4 on the bottom are safer choices and do not contain BPA. PLA coded plastics should be thrown in the compost and not the recycle bin since PLA compostable plastics are not recyclable.

The plastics industry has conformed to regulations by applying the required codes to consumer products, but it is up to individuals to read and understand the codes. BY understanding these simple classifications, we can best use plastics to our advantage while minimizing the health and disposal issues that may otherwise arise.

**Ceramics**

Ceramics are silicon based materials. Silicon is an ore and is mined out of the ground.

**The composition of and production of glass**

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

Glass is created in a furnace. The silicon is heated up to a very high temperature where it reacts and bonds with the other materials mixed with it to form glass. Glass production requires considerable amounts of heat and this process used considerable amounts of energy.

**The Characteristics of Glass**

* Brittleness
* Transparency
* Hardness
* Un-reactivity (Does not react with chemicals – acids or alkalis)
* Electrical Insulator
* Aesthetic properties.

**Heat Proof Glass (Pyrex Glass Cook Ware)**

The particular characteristics of glass can be altered if you alter or change the amounts of other materials added to the silica in the making process.

Borosilicate glass is a type of glass with the main glass-forming constituents’ silica and boron oxide. Borosilicate glasses are known for having very low coefficients of thermal expansion (~3 × 10−6 /°C at 20°C), making them resistant to thermal shock, more so than any other common glass. Such glass is less subject to thermal stress and is commonly used for the construction of reagent bottles.

**Toughened and Laminated glass**

Glass can be made less likely to break if you toughen it or laminate it.

**Toughened** or **Tempered Glass**

This is a type of safety glass processed by controlled thermal or chemical treatments to increase its strength compared with normal glass. Tempering puts the outer surfaces into compression and the inner surfaces into tension. Such stresses cause the glass, when broken, to crumble into small granular chunks instead of splintering into jagged shards. The granular chunks are less likely to cause injury. As a result of its safety and strength, toughened glass is used in a variety of demanding applications, including passenger vehicle windows, shower doors, architectural glass doors and tables, refrigerator trays, as a component of bulletproof glass, for diving masks, and various types of plates and cookware.

**Laminated Glass**

This is a type of safety glass that holds together when shattered. In the event of breaking, it is held in place by an interlayer, typically of polyvinyl butyral (PVB), between its two or more layers of glass. The interlayer keeps the layers of glass bonded even when broken, and its high strength prevents the glass from breaking up into large sharp pieces. This produces a characteristic "spider web" cracking pattern when the impact is not enough to completely pierce the glass. Laminated glass is normally used when there is a possibility of human impact or where the glass could fall if shattered. Skylight glazing and automobile windshields typically use laminated glass. In geographical areas requiring hurricane-resistant construction, laminated glass is often used in exterior storefronts, curtain walls and windows. The PVB interlayer also gives the glass a much higher sound insulation rating, due to the damping effect, and also blocks 99% of incoming UV radiation.

Watch this video <https://www.youtube.com/watch?v=fg3moEI9V5g>

**Other uses for Glass**

Plate glass and glass bricks are frequently used as wall and flooring materials. This is because glass has particular physical properties that are desired by builders and architects.

* resistance to tensile and compressive force
* thermal conductivity and transparency
* aesthetic properties
* allows natural light into buildings

**Composites**

**Definition of Composites**

Composites are a combination of two or more materials that are **bonded** together to improve their mechanical, physical, chemical or electrical properties. Carbon-fibre is an example of a composite material.

**The Structural Strength of Composites**

Composites are a mixture of materials that get their physical strength from the matrix/weave/lattice nature of their combined structure. E.g. Carbon fibre is woven into a fabric type cloth and then a resin and resin catalyst hardener is poured onto the carbon fibre, allowed to permeate into the fabric and then to set. The hardened resin locks the carbon fibres together creating a strong and lightweight material.

**The Development of new Composites**

The science and technology to create more new composites is rapidly increasing. The rate at which new techniques for the combination of various materials together is increasing. Research into Nano-Technologies and other new materials are being developed new composites are being developed to me the design expectations for new multi-functional products.

Watch this video <https://www.youtube.com/watch?v=J1psr8xTRPA>

**Smart Materials**

The term Smart Material is a misleading phrase. Smart materials are not cleaver or smart or intelligent - they are just materials that react to an environmental change in a particular way. What is smart is - the way that designers include these materials in a product to get a desired outcome. Scientist have conducted extensive investigations into these materials to predict how they will react in particular circumstances. Designers have used this information to design products that include these materials to create products that can react in a predictable way to environmental changes.

Smart materials have one or more properties that can be dramatically altered, for example, viscosity, volume, conductivity. The property that can be altered influences the application of the smart material. Smart materials have properties that react to changes in their environment. This means that one of their properties can be changed by an external condition, such as temperature, light, pressure or electricity. This change is reversible and can be repeated many times.

**Smart Materials in everyday products**

**Piezoelectric materials** – these have two unique properties which are interrelated. When a piezoelectric material is deformed, it gives off a small but measurable electrical discharge. Alternately, when an electrical current is passed through a piezoelectric material it experiences a significant increase in size (up to a 4% change in volume) Piezoelectric materials are most widely used as sensors in different environments. They are often used to measure fluid compositions, fluid density, fluid viscosity, or the force of an impact. An example of a piezoelectric material in everyday life is the airbag sensor in your car. The material senses the force of an impact on the car and sends and electric charge deploying the airbag.

**Electro-rheostatic (ER) and magneto-rheostatic (MR)** **materials** - are fluids, which can experience a dramatic change in their viscosity. These fluids can change from a thick fluid (similar to motor oil) to nearly a solid substance within the span of a millisecond when exposed to a magnetic or electric field; the effect can be completely reversed just as quickly when the field is removed. MR fluids experience a viscosity change when exposed to a magnetic field, while ER fluids experience similar changes in an electric field. The composition of each type of smart fluid varies widely. The most common form of MR fluid consists of tiny iron particles suspended in oil, while ER fluids can be as simple as milk chocolate or corn starch and oil. MR fluids are being developed for use in car shock absorbers, damping washing machine vibration, prosthetic limbs, exercise equipment, and surface polishing of machine parts. ER fluids have mainly been developed for use in clutches and valves, as well as engine mounts designed to reduce noise and vibration in vehicles.

**Shape memory alloys (SMA's)** - are metals, which exhibit two very unique properties, pseudo-elasticity, and the shape memory effect. Arne Olander first observed these unusual properties in 1938 but it was not until the 1960's that any serious research advances made in the field of shape memory alloys. The most effective and widely used alloys include NiTi (Nickel - Titanium), CuZnAl, and CuAlNi. The two unique properties described above are made possible through a solid state phase change, which is a molecular rearrangement, which occurs in the shape memory alloy. In most shape memory alloys, a temperature change of only about 10°C is necessary to initiate this change.

Information sources for Smart Materials

[**www.bbc.co.uk/schools/gcsebitesize/design/electronics/materialsrev5.shtml**](http://www.bbc.co.uk/schools/gcsebitesize/design/electronics/materialsrev5.shtml)

Watch these videos <https://www.youtube.com/watch?v=R6qHY1H6piE>

<https://www.youtube.com/watch?v=i6n8cpLKzHE>

<https://www.youtube.com/watch?v=SBXQ-6uI8GY>

<https://www.youtube.com/watch?v=qD37iLWRdD4>

<https://www.youtube.com/watch?v=O-8POr_0RJA>

<https://www.youtube.com/watch?v=8MPh2yhhqEc>

**Nano-Technology**

This is the manufacture of products that utilize structures that are microscopically small. These nano-structures have existed in nature for thousands of years but have only recently been discovered using very powerful microscopes. These structures have been discovered by scientists investigating how existing natural phenomenon work or happen. It is Designers and Technologists who have taken these discoveries and built them into new products.

Watch this video <https://www.youtube.com/watch?v=gzm7yD-JuyM>

**Sustainability**

Essentially this is being aware of the importance of not wasting your resources. In the past, sustainability was never considered to be an issue because the pace at which we consumed our resources was not that great. However, as the global human population has grown and the culture of “throw away consumerism” has spread around the world natural resources are being consumed faster than nature can replace them.

It is generally agreed that the industrial revolution marked the start of the problem. This is the point in history at which the consumption of fuel sources and other raw material sources significantly increased. That consumption of raw materials rapidly increased over the next 100 or so years to the point where some had been completely used up. This was the time when it was finally realised that if mankind did not start to manage the world’s natural resources carefully the human race would suffer the same fate as the Easter Islanders two hundred years previously.

Designers are now producing products which are based on the 6 R’s. These are;

* **Re-use**: This refers specifically to producing designs for products that lend themselves to being re-used for another purpose when they can no longer be used for their original purpose. The original purpose of a reused product can still be easily identified when it is being used for a second or third time. For example, used printed paper can easily be shredded and reused for packaging or insulation. Old textile products can be shredded and reused for building insulation. The waste fuel & ash from coal fired power stations can be used to make building blocks for the construction industry. The debris from a demolition site and be crushed and re-used as hard-core in the foundations of new buildings and roads.
* **Recycle**: This refers to a product being disassembled into its various component raw materials and those raw materials being reprocessed into another product. Metals and plastics are common examples of this process. For example, scrap cars are broken up and then melted down to produce new products. Glass can be processed in a similar way as can certain types of plastics.
* **Repair**: This refers to products that can be repaired when they breakdown. Such a product can have an expected working life 5 to 10 times longer than a similar product that cannot be easily repaired. For example, a Desktop Computer is more easily repairable that a laptop computer. The costs of repairing a desktop computer is far lower than that for a laptop. The replacement cost of a laptop computer might be less than the replacement costs.
* **Recondition**: This is where the user returns the old product to the manufacturer in exchange for a replacement one which the manufacturer stripped down and rebuilt using new components to replace the old worn-out ones. The reconditioned product performs like a brand new one but costs far less. For example, this practice is common with printer toner cartridges. Garages offer a similar facility when replacing the engine or gearbox unit on a car.
* **Re-engineer**: This is where a product is radically redesigned in order to work more effectively and efficiently. Genetic engineering of food crops is a very modern example of this concept. Food crops like wheat, corn and grass can be genetically modified to be more resistant to drought, fungal attack or insect attack. Aircraft can be reengineered to use less fuel or carry a greater payload using smaller and more efficient engines. Hybrid cars can use the capture the energy previously wasted when braking by harvesting it to charge on-board batteries which can then be used to power the vehicle using an electric motor. New electronic products can be multifunctional and thereby reduce the use of valuable construction materials and costs for the user.
* **Refuse**: This is where the consumer’s ecological awareness is raised to a level where they will only purchase products that are environmentally friendly or fair-trade products. They refuse to use products that are made with no consideration to environmental or social impact.

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**Now answer the questions on the next page**

**Materials - Unit Assessment**

Referring to the information contained in this booklet answer the following 10 questions.

Q1. Why is a hardwood more expensive than a soft wood?

Q2. Name the two main classifications of plastic, state which type can be formed and re-formed many times.

Q3. In your own words define the term ‘smart material’.

Q4. How can you stop ferrous metals from rusting?

Q5. Explain why laminated glass is so strong.

Q6. In your own words define what is an alloy?

Q7. In your own words describe how is a composite material made?

Q8. In no more than three sentences describe why it is our interests to know about sustainability.

Q9. In your own words explain the difference between the terms recycling and re-using.

Q10. a) Name an everyday wooden product and state which type of wood it is made from.

b) Name an everyday metal product and state which type of metal it is made from.

c) Name an everyday plastic product and state which type of plastic it is made from.

d) Name an everyday product that utilises a smart material and state what the “Smart” characteristic is and what the smart material is likely to be.