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| **1** | **Automation** | This is the use of control systems including those for design and manufacture, such as a computer numerically controlled (CNC) equipment, quality control and robotics. |
| 2 | Reduced labour costs, improved productivity and a faster time to market. | |
| 3 | Greater precision, greater control, consistency and quality. | |
| 4 | Flexible production as CNC machinery can be quickly reprogrammed. | |
| 5 | Greater job opportunities for engineers. | |
| 6 | High cost of buying, installing and repairing systems, risk of power failure and system. | |

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| **7** | **Robotics** | Is the use of machines to carry out complex tasks such as locating parts on an assembly line and welding car body parts |
| 8 | Ideal for tasks that are repetitive, require accuracy, or are hazardous. | |
| 9 | Can carry extremely heavy loads without tiring or lacking concentration. | |
| 10 | Can be programmed to do different tasks, and increase productivity. | |
| 11 | Cannot replace human judgement when making complex decisions. | |
| 12 | May lead to fewer jobs. | |

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| **13** | **Buildings and the place of work** | | As new technologies emerge, companies need to adapt the place of work in a variety of ways. |
| 14 | More flexible building design to improve performance and speed of product to market. | | |
| 15 | Automation and remote working, such as driverless vehicles managed centrally. | | |
| 16 | Smaller factory units needed as the automated ordering of materials (JIT) reduces storage space. | | |
| 17 | Automated Storage and Retrieval Systems (ASRS) may eliminate the use of manual handling. | | |
| 18 | JIT | Just in time is a strategy which increases efficiency by only accepting goods when they are needed in production, saving money on storage and levels of stock held | |

**1.1 Enterprise**

**1.1 Core technical principles**

**The workplace, automation and robotics**

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| **19** | **Tools and equipment** | Existing tools and equipment need to be adapted. |
| 20 | Multi-purpose equipment can increase operational flexibility. | |
| 21 | Equipment will be organised into flexible manufacturing cells to respond to changes in demand. | |
| 22 | Tools will be increasingly automated to improve safety, and space of manufacture. | |

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| **23** | **Enterprise** | Enterprises are important to the economy as they employ a large number of people. Companies need to take advantage of new and emerging technologies to help develop their enterprises. They also need to ensure that they work ethically**.** |

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| **33** | **Fairtrade** | * The Fairtrade Foundation protects the rights of farmers in developing countries. * It guarantees that they **receive fair prices for commodities** such as coffee, cocoa and tea. * Customers are often prepared to pay more for products that have met minimum social, economic and environmental requirements. |

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| **24** | **Crowdfunding**  **Sources of crowdfunding:** | Crowdfunding is a good way for businesses to get start-up financial assistance for an enterprise. Funding comes from a large number of people. Online platforms coordinate and administer the fundraising. |
| 25 | **Donation**: Money is given but not returned | |
| 26 | **Debt**: investors hope to receive their money back, sometimes with interest. | |
| 27 | **Equity**: Investors have the opportunity for a share in the business. | |

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| **34** | **Co-operatives** | A co-operative is an enterprise that is jointly owned and democratically controlled by its members**.** Members can employees, producers or consumers of the products and have a close interest in the success of the enterprise. |
| 35 | They can increase purchasing and marketing power | |
| 36 | Are easy to form with limited liability | |
| 37 | Often have limited resources or funding | |
| 38 | Can be hard to manage efficiently, which can reduce motivation. | |

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| **28** | **Virtual marketing and retail**  An online presence has pros and cons: | The internet has enabled new enterprises to reach a wider potential client-base. All companies will now have significant **virtual presence**. Marketing activities often use social networking sites to attract more customers. |
| 29 | Increased sales 30. Relatively cheap to set up and run | |
| 31 | Sometimes complicated/difficult to navigate. 32 Spam emails to advertise products are often not popular with customers. | |

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| **39** | **Sustainability** | Sustainability is meeting the needs of the present without compromising the needs of the future generations. New technologies are helping to protect our environment. |

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| **40** | **Finite resources**  **For example:** | **A finite resource is non-renewable or cannot be replenished at a sufficient rate to fulfil demand and will eventually run out.** |
| 41 | Fossil fuels used in the production of plastics | |
| 42 | Metal ores and minerals within the Earth’s crust. | |

**1.1 Sustainability**

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| **47** | **Disposal of waste** | Any waste generated in manufacturing is expensive to dispose of and can pollute rivers, harm habitats and cause global warming.  Companies need to act responsibly and use a **Life Cycle Assessment** with the aim of minimising waste and to keep the amount of waste going into landfill to a minimum. |

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| **43** | **Non-finite resources** | A non-finite resource can be replenished through natural methods and can sustain the level of demand. |
| 44 | Plants or algae are produced to manufacture fuels such as biodiesel. | |
| 45 | Oils from plants are used to produce environmentally-friendly plastics. | |
| 46 | Managed timber is used for building and furniture construction. | |

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| **48** | **Life cycle assessment ( LCA)** | **Life Cycle Assessment** (LAC) is way to measure and analyse the environmental impacts of a product at every stage of its life (from cradle to grave) |

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| **49** | **Strategies to minimise waster disposal** |
| 50 | **Reduce** the amount of waste produced, for example reducing packaging and size of products, improving quality control, and sending emails instead of letters. |
| 51 | **Reuse** products or materials that would otherwise become waste, for example using re-fillable ink cartridges. |
| 52 | **Recycle** materials to reduce the amount of new raw materials required for example recycling plastic and glass bottles. |
| 53 | **Recover** waste generated in factories for example using waste heat energy to heat factory. |

**1.1 People**

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| **54** | **Technology push and market pull** | The development of new products can be driven in two ways**.** |

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| **55** | **Technology push** | | Research and development departments use new technologies to manufacture products where there was no existing consumer demand. Products which were impossible to produce previously can now be made due to the development of. | |
| 56 | New materials with improved properties. | | | |
| 57 | New and improved manufacturing processes, making products more affordable. | | | |
| 58 | Advanced technology. | | | |
| 59 | The development of Apple products, such as the iPad, is a good examples of technology push as new products are developed regularly to make people want to buy them | | | |
| **60** | | **Market pull** | | Consumer demand can dictate how fast a product develops. There are several reasons**.** |
| 61 | | Consumers desire new and improved products. | | |
| 62 | | Manufacturers want to secure a larger part of the market. | | |
| 63 | | Manufacturers must respond to market trends. | | |
| 64 | | Competitors introduce improved or new products. | | |

**1.1 People cont ..**

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| **65** | **Changing job roles** | Some estimates predict that two-thirds of children who are about to begin their education will have jobs that do not exist. Job roles are already changing due to an increase in computer technology and artificial intelligence. |
| 66 | Some offices are now connected through virtual connection (conferencing) and mobile communication allows for home working or working while travelling. |
| 67 | Companies will need people with technological skills who can respond quickly to change. |
| 68 | People will need to become skilled in new technology such as in the film industry where CGI animation is increasingly used and automation is threatening the jobs of the less skilled. |

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| **69** | **The development of the digital camera** | This is a good example of market pull. There was demand to reduce the size of a camera and increase the number of images stored. So larger, bulky cameras have evolved into compact digital cameras, and then to cameras integrated into mobile phones with images stored in the cloud. |

**1.1Culture**

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| **70** | **Fashion** | Fashion is defined as the dominant style in a given time period. Fashion affects areas of society including clothing, makeup or furniture**.** |
| 71 | Fashion come and go relatively quickly, so new manufacturing technologies allow manufacturers to respond quickly to the latest fashion. | |
| 72 | Mobile communication and social media mean that the latest fashions can be found more easily and different brands are more accessible. | |
| 73 | Manufacturers can manage sales, marketing trends and stock more easily with **Product Data Management (PDM),** helping them analyse what is in or out of fashion in real time. | |

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| 74 | Product Data Management (PDM) is a computerised system accessible to all. It is used to manage all data about the design and manufacture of products. |

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| **75** | **Trends** | Trends reflect the general direction or development towards something new or different. |
| 76 | Technology can help companies to predict trends, helping them to respond quickly. | |
| 77 | Trends may have different lead times, so companies must have flexible manufacturing systems**.** | |

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| **78** | Lead time is the amount of time it takes for a company to deliver a product to market from the start of the design process. |

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| 79 | | **Culture** | Culture is the shred general beliefs or customs of a specific group of people. | | |
| 80 | **Faiths and beliefs** | | People from different cultures may have very different faiths and beliefs (which can be based on factors like religion, politics, vegetarianism, age or gender). People follow the rules of these faiths and beliefs as it is their measure of what they feel is right or wrong. Manufacturers must be careful to research their market to ensure that: | | |
| 81 | Their products do not give offensive images or messages. | | | 83 | They are aware of their workers’ needs such as breaks for worship or particular clothing requirements. | |
| 82 | Their products do not use materials which are against the market’s beliefs. | | | 84 | A culture can be any group of people that shares specific beliefs or faiths | | |

**1.1 Society**

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| **86** | **Design for the disabled** | The one billion people around the world living with disabilities can benefit from technology to help them live a long, healthy, independent and engaging life. This includes designs for. |
| 87 | Assistive technology, which covers small speech readers to large lifting devices and all-terrain wheelchairs that can scale uneven surfaces. | |
| 88 | Prosthetic limb technology where the electrical activity in the body can be harnessed, providing the user with a new degree of control. | |

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| **89** | A **prosthetic** is any artificial body part, such as a limb, or retina implant. |

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| **98** | **Continuous improvement** | Technological change is continuously improving quality, efficiency and processes involved in product design and reducing costs and environmental impact. This may include changes to |
| 99 | Information services | |
| 100 | Manufacturing systems (machinery) | |
| 101 | Manufacturing scheduling (flow) | |
| 102 | Product redesign | |
| 103 | Materials technology | |
| 104 | Improved products can have reduced carbon footprint. | |
| 105 | Early replacement of existing products, leading to increased use of transport, finite resources and landfill. | |

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| **90** | **Design for the elderly** | The average age of the population is increasing due to the age structure (1960s baby boom) and rising life expectancy. It is important that we address the needs of this sector of the population so that elderly people have a purpose and sense of wellbeing. This includes designs for. |
| 91 | Communication and accessible social media or monitoring devices. | |
| 92 | Mobility including transportation for short distances. | |
| 93 | Independence with mechanical / electronic aids for normal activities at home and away from home. | |

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| **94** | **Design for different religious groups** | Designing must consult with members of religious groups to consider their beliefs and to ensure that the design is suitable as otherwise they could lose potential customers. |
| 95 | Some manufacturers will have a range of designs for a product that addresses the needs for each group and will not standardise the needs of religious groups. | |
| 96 | Technology can aid religious groups through improved communication. For example, followers of individual faiths can download prayer schedules or have a digital call to prayer. | |

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| **97** | The simple use of the wrong wording colour or certain animal products in designs may offend some religions but will acceptable in others. |

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| **106** | **Efficient working** | Efficiency is the ratio of time it takes to make a unit against the theoretical time needed to do it. Improvements in efficiency will save on cost and energy used. This can be achieved by developing: |
| 107 | Lean manufacturing | |
| 108 | Just in time (JIT) production | |
| 109 | Improved transport infrastructure | |
| 110 | Redesigned factory layout Better quality assurance and control systems. | |
| 111 | Better quality assurance and control systems. | |
| 112 | Fewer mistakes, lower stock and storage, products made to order. | |
| 113 | Relies on efficient supply chains, as breaks in supply chain affect production. | |

**1.1 Environment**

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| 114 | **Pollution** | Pollution is the release of contaminating substances into the natural environment. As new technologies develop, companies will carry out Life Assessments (LCAs) to find ways to reduce pollution, which would include. |
| 115 | Using renewable energy sources to reduce carbon dioxide released into the atmosphere. | |
| 116 | Ensuring that its waste can be reduced, reused or disposed of easily. | |
| 117 | Making production energy efficient. | |
| 118 | Governments can also help by providing regulations including a carbon tax or subsidies to encourage companies to use alternative energy resources. | |

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| 119 | **Global warming** | Increases in global manufacturing are also increasing the carbon emissions from burning fossil fuels, causing the Earth’s surface temperature to rise. This is global warming.  Effects of global warming may include. |
| 120 | Rise in sea levels | |
| 121 | More unpredictable weather/ storms | |
| 123 | Widespread extinction of some species | |
| 124 | Massive crop failure | |

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| 125 | Renewable energy sources have been developed to slow down global warming. |

**1.1 Production techniques and systems.**

**1.1 Environment Cont …**

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| **133** | **Computer AIDED Manufacture (CAM)** | CAM uses computer soft and hardware to translate CAD models into manufacturing instructions for **Computer Numerical Controlled (CNC)** machine tools. |
| 134 | CAM offers greater reliability and quality as well as flexible production and improved productivity. | |
| 135 | Machine tools are faster, more accurate and can be quickly reprogrammed and linked to demand. | |
| 136 | Costs are reduced. | |
| 137 | Workers are guarded from potentially dangerous processes. | |
| 138 | Morale may be affected due to less human involvement and fewer ‘machine minding’ job roles. | |
| 139 | High set-up costs. | |

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| 140 | **Lean Manufacturing** | This is a method to eliminate waste in a manufacturing system in key areas. |
| 141 | Minimal storage, as stock materials are delivered just when needed and products are made only to order. | |
| 142 | Production is carefully set up to eliminate delays and reduce material / component movement. | |
| 143 | Rigorous quality assurance systems are established. | |
| 144 | Labour is used efficiently. | |

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| 126 | **Computer Aided Design (CAD)** | CAD combines software and hardware to create, develop, modify, test, communicate and record design information. |
| 127 | CAD designs can be shared electronically. | |
| 128 | Ideas are tested, evaluated and modified on screen. | |
| 129 | Parts can be expanded for detail and complex calculations carried out. | |
| 130 | Processes are simulated, reducing the expense of producing prototypes | |
| 131 | Workers need retraining. | |
| 132 | There is a risk that electronic files can be lost or sent to the wrong place. | |

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| 145 | **Just in time (JIT)** | **146. Just in time (JIT) helps companies meet quality orders quickly, and minimise time and resources using information and Communication Technology (ICT). New stock is only ordered when needed, which means no over-ordering better use of space and increased efficiency.** |
| 147 | Materials / components are in the right place at the right time. | |
| 148 | Storage costs are reduced as stock is not stored unnecessarily. | |
| 149 | Small batches of products can be produced cost-effectively. | |
| 150 | A break in the supply chain may cause delays. | |

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**1.1 Critical evaluation**

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| 151 | **Planned obsolescence** | Some products are designed to have a specific, often short, life span.  Companies may **plan** for their products to become **obsolete** in a certain timeframe by: |
| 152 | Choosing appropriate parts to suit the predicted life span. | |
| 153 | Deciding on the frequency of upgrading elements of the design or a full re-launch. | |
| 154 | Launching new products using new technologies, or to meet new trends, to maintain their market share. | |
| 155 | Obsolescence increases demand by encouraging purchasers to buy again sooner. | |
| 156 | Companies can use cheaper components, which need only last as long as the planned life of the product. | |
| 157 | Consumers may complain about having to buy more regularly. | |

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| 158 | **Design for maintenance** | Designers need to consider whether they would want their products to be repaired by the user at a much lower cost than it could be replaced. |
| 159 | The product has an extended life span, which is perceived to save customers money. | |
| 160 | The idea of saving money improves the reputation of the business. | |
| 161 | Technical support is expensive. | |
| 162 | The company must carry stock for repairs which takes up valuable storage space. | |
| 163 | Consumers will not want to buy new products. | |
| 164 | Home repair may lead to safety issues. | |

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| **170** | **The environment** | Companies must balance the demand for new products against the needs of the environment, and will use a **Life Cycle ASSESSMENT (LCA)** to review: |
| 171 | Materials processing, separation and use. | |
| 172 | Energy consumption and emissions (pollution). | |
| 173 | Wastes and by-products of manufacturing. | |
| 174 | Transport for production distribution and use. | |
| 175 | Packaging, construction and disposal. | |

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| 165 | **Ethics** | Companies must act fairly and honestly. They **must not:** |
| 166 | Exploit host countries, workers or suppliers. | |
| 167 | Damage the environment, so they need to use sustainable materials, reduce energy consumption and manage any impact form waste. | |
| 168 | Forget to look at the needs of the end user and the impact of the products. | |