

Answers to 'Exam-style questions'

Chapter 1

- 1 The six Rs are: Rethink, Refuse, Reduce, Reuse, Recycle, Repair.

Rethink: can this be done differently? Can a different process, material or method with less environmental impact or reduced waste and costs be used to achieve the same result?

Refuse: don't buy something if it is not needed. Are there better alternatives to things which are required?

Reduce: try to use less. Produce less waste, use less energy.

Reuse: are there ways which scrap can be reused, sold on, or repurposed?

Repair: can products in the organisation be repaired? Can the product being manufactured be repaired by the customer?

Recycle: recycle what cannot be reduced, reused or repaired.

The six Rs are important for the manufacturing process as increased environmental and sustainability legislation is driving how companies can manufacture items. The six Rs also provide an opportunity to reduce costs as producing less waste and using less energy is cost-saving for an organisation. [3]

- 2 When starting a design it is important to have good communication with the customer to ensure that your product will meet the customer's needs. The design brief is the initial customer request and should be discussed in detail with the customer as sometimes they may not fully understand the issues involved in their brief, or not be aware of what your organisation can do. A design brief that is too vague can lead to the wrong item being designed or to a solution being provided that does not fully meet the customer's requirements. A good design brief will clearly state the customer's needs and what the expected solution will achieve, so should lead to a better solution with less confusion during the design process. [2]

- 3 Sustainable design means that the product is manufactured in an environmentally friendly way and the resources for it are replenishable or available through recycling. The product itself should be able to be reused or recycled when it reaches the end of its life.

Sustainable design has the advantage of having a lower environmental impact. This can have advantages for the organisation because the design will meet new and upcoming legislation. Other advantages of sustainable design might include

reducing energy costs, reducing material costs, reducing parts used. [4]

- 4 Functional manufacture is where machines of the same type are grouped together to capitalise on the skill of the operators.

Cellular manufacture is where all the different machines and processes needed to make a product are grouped together, minimising the distance that products travel within the factory.

A production line is a high-volume equivalent of a manufacturing cell, that just manufactures a single (type of) product.

Matrix production systems are a combination of functional and cellular systems – machines of the same type may be grouped together, with some other machines needed to add features to specific products next to them. [2]

- 5 Testing in software allows tests to be made without having to manufacture the part or create testing jigs. This can save time and money and help to identify problems before a prototype needs to be manufactured. [2]

- 6 Mass production with a high level of automation would be suitable for manufacturing a ball point pen. SPC would be useful for control of quality. [1]

The ball point pen will be manufactured in large quantities, therefore automation will be required to produce the high volumes. The pens will all be same and only a small variation in the quality will be acceptable. Due to the large numbers of pens produced, individual checking would not be feasible so SPC would be a good method of controlling quality as it works well with large volume production. [3]

- 7 Sustainable design means that the product is manufactured in an environmentally friendly way and the resources for it are renewable or available through recycling. The product itself will be reused or recycled when it has finished being used.

As environmental concerns are growing and the effects of climate crises are becoming more apparent it is important that business adapt to new and upcoming legislation which will require stricter accountability for product life cycles, chemical usage, recycle and repairs of a product. Consumers are also more aware of environmental issues and thus providing an ecologically friendly product could give a competitive advantage. The impacts of this might include being subject to stricter rules on use of and disposal of waste, changes to energy infrastructure to provide low carbon electricity, changes to transport and car usage as fossil fuels are phased out, reduction of plastic use as the impacts of single use and microplastic pollution are becoming apparent. [4]

Chapter 2

- 1 Any one from: petrol, diesel, antibiotics, vaccines, fertilizer and drinking water. [1]
- 2 Petrochemical [1]
- 3 Self-controlling with no human intervention [1]
- 4 Repeating long chain [1]
- 5 Global positioning system [1]
- 6 Plants and animals or hydrocarbon-based waste [2]
- 7 Digitalisation [1]
- 8 Small generation units [1] near to where they are used [1]
- 9 The stages of a product's evolution [1]
- 10 Augmented reality [1]
- 11 A system that reduces the impact of material use. [1]
It reduces waste and pollution by reusing and recycling materials. [1]
- 12 Two for a maximum of 2 marks from:
– connected appliances in the home
– autonomous farming equipment
– wearable health monitors
– wireless stock trackers
– smart factory equipment
– biometric cybersecurity scanners
– ultra-high speed wireless internet.
- 13 Maximum 4 marks. Allows the access of applications and data from any location worldwide and from any device with an internet connection. [1] More jobs could be created to allow people to work from home [1] therefore giving people more time for other responsibilities [1]. Money is saved as software is accessible over the internet and not required to be loaded onto individual computers [1]. People therefore have more money to spend in the economy [1]. Data exchange and networking can take place over the internet [1] therefore saving travel costs [1]
- 14 Possible discussion points to a maximum of 8 marks:
– Affordable virtual reality (VR) headsets could simulate manufacturing operations, identifying any issues that need to be addressed and potential opportunities for improvement.
– Could provide virtual environments for training.
– Could facilitate remote operation of robotic and mechatronic devices, for example in environments that are hazardous to humans.
– Immersive VR environments such as holoreums could allow designers to test and evaluate innovative product designs without the expense of making physical prototypes, reducing development costs for innovative products.

Chapter 3

- 1 Title, scale, material, company, name of creator, date of creation. Name of checker, date of check, company. 1st or 3rd angle projection, tolerances. [2]
- 2 -----
Centre line: used to show centre of circles and lines of symmetry.

Line used to show hidden detail on a view.



- Continuous line: used to show the visible lines on the part. [2]
- 3 To the left of the dimension line [1]
- 4 Threaded bolt [1]
- 5 An assembly drawing shows how all the parts fit together. Section views are often used to show how inside parts fit into the assembly. The assembly drawing contains a Bill of Materials (BOM) which lists the parts and the quantities needed. Each part in the BOM is numbered in the drawing. [3]
- 6 Geometric dimensioning and tolerancing (GD&T) can allow greater control over dimensions resulting in more accurate machining without increasing tolerances. For example, a flat rectangular part could have a bumpy surface, but still be in tolerance for length and width. GD&T would specify an acceptable flatness giving a better quality product and a more consistent finish. [Diagrams would be helpful when answering this question.] [4]
- 7 Limits and fits are a standard set of tolerances which help when designing parts which fit inside each other. They are used as they allow different types of fit and mean that the designer does not have to test or calculate what the tolerances might be. The standard set of tolerances are clearance, transition and interference. Clearance fits are a loose fit. Transition fits are where one part needs to slide against another. Interference is where the two parts are stuck together, and do not move. [3]
- 8 You would use a section view to add clarity to the drawing where it is helpful to see 'inside' the part or the assembly. [1]
- 9 For an experienced draughtsperson on a drawing board and an experienced CAD user the advantage is not in how long it takes to produce the engineering drawing, as this may be not very different for a complex part or assembly. The main advantage that CAD has over hand drawing is that it is much quicker to edit. A change to a part might affect multiple other parts, e.g. a shaft increasing in size would mean the hole in another part would need to be altered as well. Depending on how the CAD model was created, this could be carried out with just one dimension change which then changes all the other relevant dimensions automatically. By hand, this alteration would be a slow process identifying all the affected drawings and changing each one. [4]

Chapter 4

- 1 Identify use of cosine rule [1]
 $LM = \sqrt{2.6^2 + 3.1^2 - 2 \times 2.6 \times 3.1 \times \cos 40^\circ}$ [1]
 $LM = 2.01$ [1]
- 2 $1 + 2 + 4 = 7$ [1]

- $\frac{28}{7} = 4$ [1]
 $2 \times 4 = 8 \text{ kg}$ [1]
 3 $r = \frac{a_1}{a} = 3$ [1]
 $a_4 = 4r^{4-1}$ [1]
 $a_4 = 108$ [1]
 4 Probability of being defect free = $\frac{506-9}{506}$ [1]
 $= 0.982$ [1]
 for being arithmetically correct and [1] stated to 3 s.f.
 5 $A = a^{3+\frac{1}{2}-\frac{3}{2}}$ [1]
 $A = a^2$ [1]
 6 $15 = 30t - 4.905t^2$ [1]
 $0 = -4.905t^2 + 30t - 15$ [1]
 $t = 0.549 \text{ s}$ and $t = 5.567 \text{ s}$ [1]
 7 $12I_1 - 8I_2 = 20$ [1]
 $12I_1 + 15I_2 = 36$ [1 for both equations]
 $23I_2 = 16$ [1]
 $I_2 = 0.696 \text{ A}$ [1]
 $I_1 = 2.13 \text{ A}$ [1]
 8 $\frac{dd}{dt} = \frac{d}{dt}(3\sin(2t)) + \frac{d}{dt}5$ [1]
 $= 3\frac{d}{dt}(\sin(2t)) + \frac{d}{dt}5$ [1]
 $= 3 \times 2\cos(2t) + 0$ [1]
 $= 6\cos(2t)$ [1]
 When $t = 2$, $\frac{dd}{dt} = 5.99 \text{ ms}^{-1}$
 9 a 111001000 [1]
 b 1C8 [1]
 10 $\bar{x} = 16.39$ [1]
 $\sum (x - \bar{x})^2 = 9.389$ [1]
 $s = 1.021$ [1]

Chapter 5

- 1 1 gallon = 4.55 litres, 1 litre = 0.22 gallons [1]
 therefore 2500 litres = 549 gallons [1]
 2 $r = \sqrt{2^2 + 4^2} = \sqrt{20} = 4.5$ [1]
 $\theta = \tan^{-1} \frac{4}{2} = \tan^{-1} 2 = 63.4^\circ$ [1]
 The polar coordinates are (4.5, 63.4°) [1]
 3 The engineer could research similar manufacturing processes to see if this problem has been encountered before/how it was solved. [1]
 They could then form a hypothesis. [1]
 They could perform experiments to test the hypothesis/gather relevant data. [1]
 They could analyse the data to see if this supports the hypothesis. [1]
 4 The three-dimensional geometry of an object. [1]
 5 For example, plating [1], a finishing process where electrolysis is used to deposit a metal on the surface of material. [1]

Galvanic protection [1], a corrosion protection method that uses an electrolytic reaction to coat a metal with a more reactive metal. [1]

- 6 Pressure $p = \frac{450}{2}$ [1]
 $p = 225 \text{ Pa}$ [1]
 7 Thrust is the force that moves an object forwards through the air [1] whereas drag opposes this force. [1]
 8 $V_2 = \frac{p_1 V_1}{p_2}$ [1]
 $V_2 = \frac{101000 \times 6}{50000}$ [1]
 $V_2 = \frac{606000}{50000}$ [1]
 $V_2 = 12.121$ [1]

Chapter 6

- 1 Tensile strength is the ability of material to resist pulling stresses [1] whereas compressive strength is the ability of material to resist pushing stresses. [1]
 2 Its ability to resist indentations/scratches/abrasions. [1]
 3 Iron has good ductility [1] and malleability [1], but low tensile strength [1] and relatively low corrosion resistance. [1]
 4 A crystalline structure is a structure where the molecules are arranged in an ordered, well-defined arrangement [1] whereas an amorphous structure is a non-crystalline structure that does not follow an organised arrangement. [1]
 5 Any relevant point for a maximum of 3 marks, for example, too much temperature can cause discolouration [1] and burn marks [1] where trapped air has been compressed and overheated as the mould cavity fills. [1]
 6 Annealing reduces hardness, [1] eliminates internal stresses [1] and increases ductility. [1]
 7 Ageing occurs as a result of gradual degradation processes [1] which combine over a large period of time. [1] For example, effects of the weather/exposure to pollutants/accumulated damage. [1]
 8 Primary, [1] secondary, [1] tertiary [1]
 9 Necking leads to a decrease in the cross-sectional area of steel when supporting a test load, [1] and a corresponding increase in localised stress. [1] This increases the rate of localised deformation even further, [1] causing rapid failure. [1]

Chapter 7

- 1 For every action/force, there is an equal and opposite reaction. [1]
 2 $F = 1500 \times 2.5$ [1]
 $F = 3750 \text{ N}$ or 3.75 kN [1]
 3 The tool could overheat [1] leading to damage/breakage of the tool. [1]

- 4 A point load is a force applied at a single point on the beam [1] whereas a uniformly distributed load is applied evenly over the entire area or length of the beam. [1]
- 5 $W = 200 \times 15$ [1] = 3000J or 3kJ [1]
- 6 Power = $\frac{50}{20}$ [1] = 2.5W [1]
- 7 Low carbon emissions (1), so less damage caused to the ozone layer (1)
Freely available/replenished [1] so a sustainable/renewable resource. [1]
- 8 The fossil fuel is burnt, [1] creating steam. [1]
The steam turns the turbines that generate electricity. [1]
- 9 Advantage – reduces reliance on fossil fuels [1] so therefore also reduces carbon emissions. [1]
Disadvantage – nuclear waste can remain radioactive for thousands of years [1] so could significantly impact on the local environment. [1]

Chapter 8

- 1 A flow of protons from positive to negative [1]
- 2 The field strength is the intensity of the magnetic field [1] and magnetic flux is the total magnetic field that passes through a given area. [1] Magnetic flux density is the amount of magnetic flux that passes through a given area at right angles to the magnetic field. [1]
- 3 $R_{\text{tot}} = 12 + 12 = 24\Omega$ [1]
 $V = 1.5 \times 24$ [1]
 $V = 36V$ [1]
- 4 $\frac{1}{R_{\text{tot}}} = \frac{1}{10} + \frac{1}{10}$ [1]
 $\frac{1}{R_{\text{tot}}} = 0.2$ [1]
 $R_{\text{tot}} = 5\Omega$ [1]
- 5 To model the behaviour of more complex circuits [1] when it is not possible to use Ohm's law. [1]
- 6 Any three relevant applications for a maximum of 3 marks, for example electric generators, [1] transformers [1], computer hard disks, [1] maglev trains. [1]
- 7 As the pylon is tall and in an open space it would be susceptible to lightning strikes during stormy weather. [1] A lightning arrestor would divert the current from a lightning strike to earth, [1] thus protecting the pylon from damage. [1]
- 8 Forward bias is when current flows through a P–N junction from positive to negative when a positive voltage is applied to the P-type side of the junction. [1] Current cannot flow in the opposite direction in this case. [1]
With reverse bias this occurs when a positive voltage is applied to the N-type side of the junction. [1] No current flows until the electric field intensity is so high that the junction breaks down. [1]

Chapter 9

- 1 First class, [1] second class, [1] third class [1]
- 2 Gear ratio = $\frac{20}{60}$ [1] = 1: 3 [1]
- 3 Used to reduce the effort force needed when lifting loads [1] by increasing the mechanical advantage. [1]
- 4 Creates rotary motion through a precise angle or velocity. [1] The movement of the motor is controlled by a series of electronic pulses. [1]
- 5 Any suitable temperature sensor identified, e.g. thermistor. [1] This would function by detecting the changes in temperature level in the vehicle [1] and converting this physical signal into an electrical signal/voltage [1] so the system knows when to turn the heater/air conditioning on. [1]
- 6 Any four for a maximum of 4 marks, for example, robotic arms on production/assembly lines, [1] conveyor belt control systems, [1] automated packaging systems, [1] animatronic systems. [1]
- 7 Unitary PLCs have all the different parts and components contained within a single housing [1] whereas modular PLCs have different parts that are connected together to form a customisable device. [1]
- 8 Acts as an output device in a system, [1] turns hydraulic energy into mechanical energy. [1]

Chapter 10

- 1 AND, [1] OR, [1] NOT [1]
- 2 Produces a signal that stays high or low [1] for a set period of time. [1]
- 3 Compares two different signals [1] and indicates which is the highest. [1]
- 4 A signal that is continuous/shown as a sinusoidal wave. [1]
- 5 Shown as an \times in a circle on a systems diagram [1] with signal polarity indicated. [1] Produces the algebraic sum of different input signals [1] thus producing a single, unified output. [1]
- 6 Marking scheme: 1–2 marks – general, mainly descriptive response. 3–4 marks – response superficially relates to the context, some explanation. 5–6 marks – detailed explanation relating directly to the specific context.
Indicative content: The schematic would give the details of the specific individual components, the wiring and connections needed for the security lighting, with components shown as symbols to aid understanding (for example, any sensors, the main control device and the lamp). This would also aid with any future maintenance or repairs to the lighting system.

The wiring diagram would show the components as they will be arranged in situ on the outside of the building as pictorial representations joined together by wires. This would show exactly where each

part of the system is to be placed outside and the necessary connections, that is, where the lamp and sensors would be physically fitted and how it would be connected to main control device.

- 7 An output device that produces physical movement in response to continuous signals received. [1]
- 8 Solenoid/motor [1] – when a current flows through the actuator it would produce the locking movement [1] through electromagnetism. [1]
- 9 The sensor sends a signal into the environment around it [1] and measures the response that it gets back. [1]
- 10 Marking scheme: 1–2 marks – general, mainly descriptive response. 3–4 marks – response superficially relates to the context, some explanation. 5–6 marks – detailed explanation relating directly to the specific context.

Indicative content: Programmable logic controllers (PLCs) would allow automation of the robot arms so they could continue 24/7 without any human intervention, thus allowing the required demand to be met.

PLCs are rugged and reliable so there would be less downtime due to maintenance or breakdowns. Dedicated integrated circuits are more prone to damage, especially in a manufacturing environment.

PLCs can be reprogrammed so that the robot arms can produce the new designs when they are introduced to the factory. Dedicated integrated circuits cannot be reprogrammed so would have to be replaced, costing time and money.

Chapter 11

- 1 Either 100% sampling [1] or SPC sampling [1]
- 2 British Standards Institution [1]
- 3 An agreed set of norms for the characteristics of a material or product. [1]
- 4 Prevention of defects and mistakes in manufactured products [1]
- 5 Institute of the Motor Industry (IMI) [1]
- 6 The 80/20 rule [1]
- 7 A cause and effect diagram is used to explore the possible causes of a certain event. [1]
- 8 ISO develops and publishes an internationally agreed set of norms for the characteristics of a material or product [2]
- 9 Offers a wide range of courses to assist building services engineers to attain professional registration and membership [2]
- 10 Traceability is the ability to trace all processes from the procurement of raw materials [1] to production and disposal [1] to clarify 'when and where the product was produced by whom'. [1]
- 11 1 mark for any of the following to maximum of 2 marks:
 - to identify acceptable lots from unacceptable ones
 - to determine whether the process is changing

- to determine whether the process is approaching the specification limits
- to determine the quality of a product
- to assess inspectors' accuracy
- to determine the accuracy of the measuring instrument
- to measure process efficiency.

- 12 Keep track of changes [1] identify when important decisions were made [1]

- 13 1 mark for any of the following to maximum of 2 marks:

- create a list of processes
- identify the audience
- define the objectives
- choose a format
- write the SOP.

- 14 1 mark for an example and 1 mark for an explanation to maximum of 2 marks:

- make processes more efficient [1] and reduce manufacturing time [1]
- ensure that fewer defects are present in products [1] to reduce wastage [1]
- avoid variations in the manufacturing process to produce identical products [1] that meet the needs of customers [1]

- 15 1 mark for an advantage and 2 marks for two disadvantages to a maximum of 3 marks.

Advantages: achieves greater productivity, increases the quality of products, employee morale boosted, makes use of the skills of all workers

Disadvantages: lack of interest from management, training provided may be inadequate, the purpose of the project is unclear, quality circles do not have the authority to make decisions

- 16 Discussion points to a maximum of 6 marks.

	100 per cent sampling	SPC
Cost	Expensive to perform	Less expensive to perform
Time	A greater amount of inspection time is required	Process can be automated at high speeds
Fatigue	There is the possibility of fatigue in operators	In most cases, operator fatigue is eliminated
Staff	Staffing requirements need to be increased	Automation reduces the need for staff
Damage	Due to increased handling, products are damaged	Minimal handling means fewer damaged products
Destructive testing	Components or products cannot be destroyed	Destruction is possible for components or products
Product lot	As each piece is inspected, it may be possible to save the lot	In the event that a piece is defective, the whole lot may be rejected

- 17 Possible discussion points up to a maximum of 4 marks.
- To ensure consistency [1] and reduce errors [1], resulting in increased customer satisfaction. [1]
 - To ensure that all workers follow the identified best practice. [1]
 - To provide detailed instructions [1] so that tasks are carried out safely [1] and to train staff. [1]
 - To ensure that regulatory requirements/ specified standards are met. [1]

Chapter 12

- 1 mark for any one of the following answers:
 - undertake a risk assessment and record significant findings if there are five or more employees
 - appoint competent people to support health and safety measures
 - establish emergency procedures.
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations [1]
- Control of Substances Hazardous to Health [1]
- Improvement or Prohibition notice [1]
- 1 mark for each correct answer, total 3 marks:
 - protect people's health, safety, and welfare at work
 - ensure the safety and health of people outside the workplace (for example, visitors or the general public)
 - be in control of explosives, highly flammable substances, or other potentially hazardous materials
- Ear muffs [1] or earplugs [1]
- Any two from the following for maximum 2 marks:
 - inadequate manual handling
 - machines that are not guarded
 - tool and equipment noise and vibration
 - non-isolated equipment that stores energy
 - electrical equipment that is not maintained or is defective
 - the misuse of electrical equipment
 - inhalation of harmful substances
 - poor housekeeping resulting in slips, trips, and falls
 - dangerous working conditions (e.g. working in confined spaces)
- Asphyxiation is when the body does not have a sufficient supply of oxygen. [1] It can lead to unconsciousness, brain damage and death. [1]
- The Clean Air Act 1993 regulates smoke emissions. [1] Industrial premises are prohibited from emitting dark smoke from chimneys or flues. [1]
- To ensure electrical equipment has controlled isolation [1]
- Control of Substances Hazardous to Health (COSHH)
- A safe system of work is a set of procedures designed to eliminate [1] or minimise the risks [1] involved in specific operations.

- E.g. bend at the knees, assess the load before lifting, get assistance if necessary, only lift weights within the specified limits [1]
- To protect employees and other members of the public who may be at risk due to workplace activities [1]
- Benefit: reduces single-use items and waste. [1]
Limitation: products that are re-used often have a lower quality. [1]
- Any from the list for maximum 2 marks:
 - moving parts of machinery or ejected materials can strike and injure people
 - body parts can get caught between rollers, belts, or pulleys
 - severe injuries can result from sharp edges
 - sharp-pointed parts can stab or puncture the skin
 - abrasion or friction injuries can occur as a result of rough surfaces
 - a machine, wall, or other object can crush a person, either between moving parts or against a fixed part.
- A health and safety culture in the workplace are the shared values / beliefs / expectations and attitudes [1] about how to behave safely within an organisation. [1]
- One mark for each correct stage to a maximum of 3 marks.
 - 1 Identify hazards.
 - 2 Evaluate risks.
 - 3 Implement control measures.
- Possible discussion points to a maximum of 6 marks:
 - implementing ISO 14001 can help an organisation reduce waste [1] thereby reducing the cost of materials [1] or the cost of removal of waste [1]
 - it can reduce potential local environmental damage [1], reducing potential longer term liabilities/risk of prosecution [1]
 - it can help the organisation reduce power consumption [1] such as fuel and electricity [1], further reducing costs [1]
 - it can give the organisation greater credibility with stakeholders [1] making it easier to access funding [1]
 - it can give the organisation a positive image with customers [1] supporting sales growth/ brand loyalty [1].

Chapter 13

- Efficiency in the context of commercial operations is how well a company makes its product compared with the amount of time and money expended making the product. [1]
- Supply is how much of a thing a business has available to sell, demand is how many customers want to buy that thing. High demand can enable a company to charge higher prices and oversupply can drive prices down. [2]

- 3 For example: assembling the product from its components; machining a part to the required shape. [1]
- 4 Research and development of new products and ideas can be costly and time consuming, for example META is spending billions of dollars on developing virtual reality (VR) and augmented reality (AR) solutions with limited results so far for the money, time and effort involved. Thus research and development can be risky as it is uncertain whether it will result in a successful solution or product. However, research and development can pay large dividends in developing new and innovative products, for example, the iPhone. [4]
- 5 Financial responsibility means being able to manage any debts, liabilities and bills that the organisation has. [1]
- 6 Cash flow is the money coming into the company (for example, from other companies paying for goods they have bought) and the money leaving the company (for example, paying for supplies). If the organisation is not paid for the goods it has sold on time, it may have a cash flow problem and be unable to pay its debt. It is therefore important for an organisation to manage spending to ensure good cash flow. [3]

7 Three ways of raising finance:

I Equity financing

Advantages:

- a Access to expertise: equity investors often bring valuable industry knowledge, experience and connections with them, which can benefit the firm.
- b No repayment obligation: equity financing does not require regular repayments, which can ease the financial burden on the firm, especially in the early stages.
- c Shared risk: investors share in the financial risks and rewards, which can provide a buffer for the firm during difficult times.

Disadvantages:

- a Loss of control: giving up equity means relinquishing some control over the firm's decision-making and operations.
- b Sharing profits: equity investors are entitled to a portion of the firm's profits, potentially reducing the owner's share of earnings.

Appropriateness: equity financing is suitable for small engineering firms with high-growth potential and founders willing to give up some control in exchange for capital and expertise.

II Debt financing:

Advantages:

- a Retain ownership: borrowing through loans or lines of credit allows the firm to retain ownership and control.
- b Predictable repayment: loan terms typically have fixed repayment schedules, making financial planning more predictable.

- c Interest tax deductions: the interest on business loans is often tax-deductible, reducing the overall cost of borrowing.

Disadvantages:

- a Debt repayment: regular debt repayments can strain cash flow, especially if the business faces challenges.
- b Collateral requirements: many lenders require collateral, which may put personal or business assets at risk.
- c Limited financing amounts: the amount of debt a small engineering firm can secure may be limited, and high interest rates may apply.

Appropriateness: debt financing is suitable for small engineering firms with stable cash flows and a preference for retaining ownership and control.

III Crowdfunding:

Advantages:

- a Access to a wide audience: crowdfunding allows firms to access a diverse pool of potential investors, including customers and supporters.
- b Validation and marketing: a successful crowdfunding campaign can validate the product or service and serve as a marketing tool.
- c Minimal equity dilution: crowdfunding campaigns may not require giving up equity, allowing founders to maintain control.

Disadvantages:

- a Time-consuming: running a crowdfunding campaign can be time intensive, from planning and marketing to fulfillment.
- b Risk of failure: if a crowdfunding campaign falls short of its funding goal, the firm may receive none or only a portion of the required funds.
- c Public disclosure: crowdfunding campaigns may require disclosing sensitive information to the public.

Appropriateness: crowdfunding is suitable for small engineering firms with innovative ideas that may or may not be successful [12]

Chapter 14

- 1 For example: IMechE (Institute of Mechanical engineers) and IEEE (Institute of Electrical and Electronics Engineers) [1]
- 2 For example: working safely, being punctual, professional appearance [1]
- 3 Insufficient training and fatigue [1]
- 4 Ongoing CPD ensures that you are aware of the latest developments in your industry and keep up to date with new legislation, rules and regulations. It is important so that you can apply knowledge and develop new skills and competencies. [3]
- 5 For example:
 - Ensure that breaks are taken regularly. [1]
 - Ensure that overtime is managed and that any limits on working time are followed. [1]

- 6 Assuming that the annual membership for a professional membership is manageable, the potential opportunities in terms of CPD and being able to network with other engineers and resources available, the possible use of the institute's headquarters, access to libraries and legal support provide potentially provide more than the cost of membership. However, it is also very possible to be a member of an institute and not take advantage of the resources available. [4]
- 7 Bad workplace practice or behaving in an unprofessional manner can lead to disciplinary measures and eventual dismissal from a job. Depending on the context it can also be unsafe and lead to injury or death in hazardous environments. [2]

Chapter 15

- 1 To avoid ending up with too much or too little of each resource throughout the manufacturing process, [1] to avoid bottlenecks [1] that would slow production, [1] so they can make a profit.
- 2 Tools, [1] machines, [1] desks/chairs [1], factory buildings [1] or any other appropriate response.
- 3 To ensure the assets are let go of in accordance with company procedures [1] and relevant statutory regulations. [1]
- 4 Depreciation is the reduction in value of an asset over time. [1]
- 5 Through wear and tear on parts and components [1] for example the lifting mechanisms, [1] through damage cause by falling stock/driving into objects [1] resulting in its value getting less over time [1] or becoming obsolete as new models are released [1].

Chapter 16

- 1 Any two relevant examples described, for a maximum of 4 marks, for example: storage needed [1] for unsold products left in the warehouse [1]; lost money/profits [1] from products made but not sold [1]; wasted raw materials [1] that could have been used in other products [1]
- 2 Plan [1] do [1] check [1] act [1]
- 3 Any three relevant examples for a maximum of 3 marks: machine changeover time, [1] capacity utilisation, [1] on-time delivery percentage [1]
- 4 Any one benefit explained for a maximum of 2 marks, for example: improves communication of key information [1] as visual medium can be more easy to understand [1]

- 5 Any two benefits for a maximum of 2 marks, for example: increased ownership of maintenance processes, [1] reduced downtime, [1] increased efficiency, [1] training of engineers in different skillsets. [1]
- 6 To reduce changeover times when making products. [1]
- 7 Any two benefits explained, for a maximum of 4 marks, for example: better management of the flow of work [1], reduced inventory [1], tracking of production [1] due to use of card/board system [1]; reduced waste [1] due to increased efficiency of production. [1]

Chapter 17

- 1 To provide a short summary of the problem to be solved [1] so that everybody involved understands what they will be doing. [1]
- 2 The desired outcomes of a project. [1]
- 3 Evaluation of the project against the success criteria [1] where improvements for future projects are identified. [1]
- 4 To check the progress of the project against the plan [1] to ensure it is meeting the desired/required outcomes. [1]
- 5 Email [1], online/instant messaging [1], video conferencing software [1]
- 6 To ensure that work is being completed in a way that satisfies the requirements of legislation [1] and to enforce compliance/punish non-compliance where necessary. [1]
- 7 To initiate the project [1], ensuring that their needs and wants are fully understood by the project team [1] so that they can be successfully addressed. [1]
- 8 Consideration of the staffing required for the project [1]
- 9 The amount of money available for the project [1] over the time taken to complete it [1]
- 10 A chart that shows each project task as a shape [1] along with the estimated time needed to complete it. [1] The tasks are linked together in dependencies. [1]
- 11 Management by stages is where the manager makes checks at defined points of a project [1], whereas management by exception is where checks are only made at stages where there is deviation from the norm. [1]
- 12 A benefit of management by exception: it saves time for managers [1]; a limitation: it is corrective rather than preventative. [1]