Answers to 'Now test yourself' questions

Chapter 1

1 Advantages of reactive maintenance are that it is simple to implement. For small, frequent problems (for example, a drill bit breaking or wearing out), it is easy to ensure that there are spares available to replace when needed. Putting petrol in your car could be seen as reactive maintenance.

Disadvantages of reactive maintenance are that it is not suitable for more complicated or expensive machinery or systems. It is better to regularly service your car so that costly breakdowns are less likely to happen.

2 Condition-based monitoring can be expensive initially to implement as the sensors and equipment can be expensive. Older machines may need to be modified to allow condition monitoring. There is also cost in training staff to use the new systems.

3 Reactive maintenance would be appropriate for small breakages which happen routinely and are easy to replace or repair. An example would be a drill bit breaking.

4 The six Rs are Rethink, Refuse, Reduce, Reuse, Recycle, Repair. They should be applied when looking at the lifecycle of a product, considering at each stage how they can affect the design. In the initial design stages, for example, changing the material or method of manufacture and reducing waste can all make savings for the organisation while helping to make the product more sustainable. Looking at the end of the product's life, questions should be asked about how easy it is to repair, dismantle or recycle the product, and also about the environmental impact of disposal, in order to maximise sustainability.

5 The six Rs and environmental legislation are becoming more important as increasing awareness of human impact on the planet and ecosystems drives governments to enact more legislation regarding carbon emissions and sustainability in an attempt to reduce climate change. Consumers want to buy 'greener' products so a company producing a sustainable product may have a competitive advantage.

6 The iterative design process is where the ideas, research and testing feed back into the design process. For example, an idea is discussed, modelled and tested, but found to not work correctly. An evaluation of why and how it is failing will allow the design team to redesign the part and try again. This process of design, test, change, can be applied throughout the design process.

Chapter 2

1 Automotive
2 For example, natural gas
3 Control
4 Plants, organic materials and animal waste
5 Water management
6 Light emitting diode
7 Organic
8 Combination of two or more technologies
9 Artificial intelligence
10 Robotics
11 Virtual reality

Chapter 3

1 Isometric drawings would be more suitable for communicating to a non-technical audience, such as showing a 3D representation of a product to a customer. Orthographic drawings are required for manufacture and assembly and communicate information to technical staff.

2 Parallel dimensioning takes dimensions from a datum so does not have tolerance build up across a part.

3 The main advantage that 3D modelling (CAD) has over hand drawing is that it is much quicker to edit. A change to a part might affect multiple other parts, for example, a shaft increasing in size would mean the hole in another part would also need to be changed. Depending on how the CAD model was created, this alteration might be carried out with just one dimension change; all the other relevant dimensions are then automatically altered to match. With hand drawings, this would be a slower process as all the affected drawings would need to be identified and each drawing then redrawn.

4 An assembly drawing shows how all the component 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. A number on the BOM matches the number of each part shown in the drawing.

A detail drawing is for manufacture and needs to contain all the information needed to make the part. This will include dimensions, materials, surface finishes and tolerances.

5 Each box shows a valve position, the arrows showing the inputs and outputs and where the fluid will flow to.

6 As few as necessary. The aim of an engineering drawing is to convey the needed information as efficiently as possible. If everything needed can be shown clearly in one view, then only one view is necessary. Typically three views are used.
7 BS888 for engineering drawing, IEC 61082-1 for circuit diagrams, ISO 1219-1 for hydraulic and pneumatic diagrams.

Chapter 4

1 0.0024
2 $\frac{9}{4}$
3 1.67%
4 60 kg
5 24
6 x = –1, y = 3
7 x = 2.637, x = –1.137
8 x = 1.2
9 $v = \sqrt{\frac{2\mathrm{KE}}{m}}$
10 $a_9 = 0.201$
11 $\frac{\mathrm{d}y}{\mathrm{d}x} = 10x$
12 $\frac{\mathrm{d}y}{\mathrm{d}t} = 15t^2 + 1$
13 $\frac{\mathrm{d}y}{\mathrm{d}x} = 4\sec^2(4x)$
14 $\int (15x^2 + 1)\mathrm{d}x = 5x^3 + x + C$
15 $\int \sin(3x)\mathrm{d}x = -\frac{1}{3}\cos(3x) + C$
16 $\frac{3\pi}{2}$ rad
17 11.004
18 15
19 $\begin{bmatrix} 10 & -27 \\ 25 & 69 \end{bmatrix}$
20 58
21 703
22 10011
23 range = 16, mean = 17.3, median = 16, mode = 24
24 median = 13.5
25 standard deviation = 3.07

Chapter 5

1 Metres per second ($\mathrm{m\,s^{-1}}$)
2 Mass
3 182.88 cm
4 A vector quantity
5 (r, θ)
6 A set of steps that provide a systematic and objective approach used to acquire knowledge
7 To gather experimental data to support or disprove the initial hypothesis
8 How close the measurement is to a known standard
9 ±0.01 mm
10 Atoms consist of a central nucleus, surrounded by one or more negatively charged electrons.
11 Salt and hydrogen
12 Oscillating motion
13 $p = \frac{F}{A}$
14 As the speed of a fluid increases, the pressure within the fluid decreases
15 Drag
16 Radiation
17 $pV = mRT$

Chapter 6

1 Physical property
2 Hardness
3 Electrical resistivity
4 Thermoplastic polymer
5 Glass-reinforced polymer (GRP), carbon-reinforced polymer (CRP), medium-density fibreboard (MDF)
6 Non-crystalline/amorphous
7 The presence of an atom of an alloying element or another dislocation
8 Brazing, welding
9 Polymers
10 High density products with optimum material properties
11 To refine the grain structure of metals
12 Painting, plastic coating, galvanising
13 For example, rusting of an iron component
14 For example, effects of the weather, exposure to pollutants, accumulated damage
15 σ (conductivity) = $\frac{l}{R \times A}$
16 Brinell test, Vickers test, Rockwell test

Chapter 7

1 That a body will remain at rest, or will continue moving at a constant speed in a straight line, unless a force is acting upon it.
2 $F = ma$
3 Uniformly distributed load
4 A measure of the bending effect that occurs when a force is applied to a beam or other structural component
5 9.81 $\mathrm{m\,s^{-2}}$
6 Work W = force F × distance moved d
7 Any two from solar, hydro, wind, geothermal, biofuel
8 Nuclear

Chapter 8

1 Electrical force
2 Energy

3 Output voltage of a potential divider
4 Capacitance
5 Potential difference
6 $R_{tot} = R_1 + R_2 + R_3 + \ldots$.
7 Kirchoff's voltage law
8 Digital
9 Signal processing
10 The number of inputs that a logic gate is capable of safely dealing with

Chapter 9

1 Linkage
2 To convert electrical, electronic or mechanical signals into physical movement
3 Microcontroller, microprocessor
4 Stepper motor
5 Programmable logic controller
6 Modular
7 To monitor and control industrial engineering processes
8 Pneumatic
9 Hydraulic
10 To control the direction of the fluid and hence the movement of other components.

Chapter 10

1 Any two from: light/temperature/flow/pressure sensors, switches
2 A latching system produces a signal that stays high or low until reset.
3 To represent system blocks mathematically, thus helping with system modelling, analysis and fault finding
4 PWM is a method of converting a signal into a format that is suitable for transmission, where the width of the pulsed carrier signal is varied according to the amplitude of the message signal.
5 Pneumatic systems use compressed air as the transmission and power medium, whereas hydraulic systems use a liquid, such as oil or water.
6 A digital sensor detects changes in the environment around it, by responding to and/or producing discrete signals (1s and 0s).
7 Active sensors send a signal into the environment around them and measure the responses that they get back, whereas passive sensors monitor changes in the environment around them without otherwise interfering with it.
8 Motor, solenoid
9 Measuring the volume of objects being processed, measuring different parameters within a production environment, etc.
10 Lifting/moving objects from one workstation to another, robot arms that assemble parts, etc.

Chapter 11

1 International Organization for Standardization
2 IAgrE (Institution of Agricultural Engineers)
3 British Standards Institution
4 European Union
5 ISO 9001
6 Total Quality Management
7 Prevention of defects and mistakes in manufactured products
8 Keeps track of documents and key decisions made
9 To decrease waste
10 The 80/20 rule. 80% of the effects come from 20% of the causes.
11 It is a graphic tool used to explore and display the possible causes of a certain effect
12 Upper control limit
13 Either flowchart, hierarchical or step-by-step
14 Statistical process control

Chapter 12

1 PUWER (Provision and Use of Work Equipment Regulations 1998)
2 Improvement and prohibition
3 MHOR (Manual Handling Operations Regulations 1992)
4 Control of substances hazardous to health
5 Health and Safety Executive
6 Hazard, risk and control
7 Respirator/face mask
8 Employer
9 Hazard identification
10 Lock out tag out
11 Clean Air Act 2022
12 An internationally agreed environmental management system

Chapter 13

1 Force majeure is a defence for not fulfilling a contract due to circumstances which could not have been foreseen or prepared for. For example, being unable to complete a delivery of parts due to the COVID outbreak.
2 Companies need to make a profit in order to stay in business. If they are publicly traded they need to be able to pay their shareholders a dividend. A company that makes a loss will soon not have sufficient money to pay its bills or its workforce.
3 Direct costs can be directly set against the product, for example the wages for machine operators. Indirect costs, or overheads, are not related directly to the manufacture of the product, for example the cost of the receptionist's computer, but are still essential business costs.
4 Assets are items that the organisation owns, for example machines and computers. Liabilities are

items for which the company owes money, for example a loan for a machine.

5 Value Added Tax (VAT) is applied to most UK manufactured goods.

6 Methods of raising capital might include investment from friends and family for a small start up. Other methods used by larger businesses include raising capital from venture capitalists (VC), corporations, government, private loans, work or business operations, or raised from the business being floated on the stock exchange.

7 A verbal contract relies on the memories of the parties involved as to what was agreed. A written contract states what has been agreed and can be checked by all parties; it is more formal and constitutes a legal document.

8 In a contract there must be an offer, acceptance, consideration, an intention to create legal intentions. Both parties should be clear about the terms of the contract.

Chapter 14

1 Ethics is the idea that you behave responsibly and treat other people with respect. Engineering ethics is about behaving to high professional standards and working with integrity, ensuring that the work you produce is of a high quality and you honestly state how the product performs.

2 A knowledge of how people perceive things might inform where you place important feedback information for a machine. For example, where the controls are located on a machine so that the operator can easily get to them.

3 Some common workplace behaviours expected are punctuality, carrying out your job to a high standard, working well with others, following company rules and procedures, and working safely.

4 Training courses, industry placements, academic study

Chapter 15

1 Obsolete

2 A 'write down'

3 Made to stock

4 Lack of machine capacity, lack of staff

5 Planning, acquisition

6 Wear and tear

Chapter 16

1 Key performance indicators

2 Small, regular changes that over time move the business forward.

3 Transportation, inventory, motion, waiting, excess production, overprocessing, defects, unused talent

4 Value stream mapping

5 Single minute exchange of dies

6 (Total number of good products produced × ideal processing time/planned production time) × 100

7 Total productive maintenance (TPM)

8 Kanban

Chapter 17

1 Initiation, planning

2 The limitations put on a project

3 Sharing of different skills/knowledge/expertise, increased involvement/feedback from stakeholders

4 Project brief

5 Project goals

6 Client, regulators

7 To take overall responsibility for the project, manage the budget/resources/staff involved, monitor progress

8 Team member

9 Regulators

10 The client (but could also be the engineering company themselves)

11 Human resources, communication, facilities required

12 To determine the minimum time necessary to complete the project

13 Project evaluation review technique

14 Contingency plan