



Rewarding Learning

**ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2012**

Technology and Design

Assessment Unit AS 1

assessing

Product Design and Systems and Control

[AV111]

WEDNESDAY 13 JUNE, AFTERNOON

MARK SCHEME

General Marking Instructions

These mark schemes are intended to ensure that the AS/A2 examinations are marked consistently and fairly. The mark schemes provide examiners with an indication of the nature and range of candidate responses likely to be worthy of credit. They also set out the criteria which they should apply in allocating marks to candidates' responses. The mark schemes should be read in conjunction with these general marking instructions which apply to all papers.

Quality of candidates' responses

In marking the examination papers, examiners will be looking for a quality of response reflecting the level of maturity which may reasonably be expected of 17- and 18-year-olds which is the age at which the majority of candidates sit their AS/A2 examinations.

Flexibility in marking

The mark schemes which accompany the specimen examination papers are not intended to be totally prescriptive. For many questions, there may be a number of equally legitimate responses and different methods by which the candidates may achieve good marks. No mark scheme can cover all the answers which candidates may produce. In the event of unanticipated answers, examiners are expected to use their professional judgement to assess the validity of answers. If an answer is particularly problematic, then examiners should seek the guidance of the Supervising Examiner for the paper concerned.

Positive marking

Examiners are encouraged to be positive in their marking, giving appropriate credit for valid responses rather than penalising candidates for errors or omissions. Examiners should make use of the whole of the available mark range for any particular question and be prepared to award full marks for a response which is as good as might reasonably be expected for 17- and 18-year-old candidates. Conversely, marks should only be awarded for valid responses and not given for an attempt which is completely incorrect and inappropriate.

Types of mark schemes

Mark schemes for questions which required candidates to respond in extended written form are marked on the basis of levels of response which take account of the quality of written communication. These questions are indicated on the cover of the examination paper.

Other questions which require only short answers are marked on a point for point basis with marks awarded for each valid piece of information provided.

Quality of written communication

Quality of written communication is taken into account in assessing candidates' responses to all questions that require them to respond in extended written form. These questions are marked on the basis of levels of response.

Levels of response

Questions requiring extended written answers are marked in terms of levels of response. In deciding which mark within a particular level to award any response, examiners are expected to use their professional judgement. The following guidance is provided to assist examiners.

Threshold performance: Response which just merits inclusion in the level and should be awarded a mark at or near the bottom of the range.

Intermediate performance: Response which clearly merits inclusion in the level and should be awarded a mark at or near the middle of the range.

High performance: Response which fully satisfies the level description and should be awarded a mark at or near the top of the range.

In all cases, correct alternative responses will be given full credit.

AVAILABLE
MARKS

Section A

Product Design and Practice

- 1 When selecting a material for an outdoor product, designers need to consider the cost of materials and the available common forms and sizes of material.
- (i) Give **two** main reasons why the designer has to consider the cost of materials when making a selection for an outdoor product.
- Any **two** from the following:
- This will influence the overall final cost of the product and may make it too expensive
 - Costly materials may result in saving having to be made in the design or manufacture if the product is to remain competitive with similar products on the market
 - Very low cost materials may not withstand the lifespan of the product or equally very expensive materials may result in outlasting the lifespan of the product [2]
- (ii) Give **two** main reasons why the designer would use common forms and sizes of material for outdoor products.
- Any **two** from the following:
- Less expensive to purchase
 - More readily available supply
 - Be more suited to standard processes and equipment. [2]
- 2 The specific properties and characteristics of oak and ash make them suitable for a wide range of products.
- (i) State **one** specific application for the use of oak and briefly outline **one** main property which makes this wood suitable for your chosen application.
- Application – kitchen units
Any **one** main reason from the following:
- Hard strong and durable
 - Good aesthetic appeal
 - Stable material. [2]
- (ii) State **one** specific application for the use of ash and briefly outline **one** main property which makes this wood suitable for your chosen application.
- Application – Garden tools – handles
Any **one** main reason from the following:
- Tough and flexible
 - Good resistance to shock
 - Stable material. [2]
- (iii) Stains or oils may be used on oak or ash as a finish.
Briefly explain the main purpose of stains and the main purpose of oils.
- Stains change the colour of the wood whilst leaving the grain still visible. They do not provide protection against moisture. Oils provide a water-resistant, non-gloss finish. [2]

4

6

		AVAILABLE MARKS
<p>3 Injection moulding is a process which may be used to manufacture cases for hairdryers, vacuum cleaners and computer monitors.</p> <p>(i) Give two main reasons why the injection moulding process may be used to manufacture these cases.</p> <p>Any two from the following:</p> <ul style="list-style-type: none"> • Consistently accurate dimension produced • High quality finish • A wide range of complex forms can be produced • Fast production method when producing large numbers of products • Little waste generated <p>(ii) With the aid of an annotated sketch describe the injection moulding process.</p> <p>Suitable sketch of the injection process to include the hopper, screw, heater and mould</p> <p>Description of the flow of granules in the hopper to the opening of the split mould.</p>	<p>[2]</p> <p>[2]</p> <p>[2]</p>	6
<p>4 Knock down fittings and riveting are often used to join materials.</p> <p>(i) With the aid of annotated sketches explain how knock down fittings are used to join materials.</p> <p>Knock down fittings – annotated sketch showing blocks or brackets assembled with screws using screwdriver or allen keys.</p> <p>(ii) With the aid of annotated sketches explain how rivets are used to join materials.</p> <p>Riveting – annotated sketch showing the trapping together of two pieces of metal to be joined using rivets of the same material.</p>	<p>[3]</p> <p>[3]</p>	6
<p>5 Virtual imaging and rapid prototyping may be used in the design of products.</p> <p>(i) Outline two main characteristics associated with virtual imaging.</p> <p>Any two from the following:</p> <ul style="list-style-type: none"> • Three dimensional views of products on screen • Images can be manipulated on-screen to give sense of realism • Quick, interactive with client. <p>(ii) Outline two main characteristics associated with rapid prototyping</p> <p>Any two from the following:</p> <ul style="list-style-type: none"> • Like a 3D printer instead of ink it uses a solid material and ‘grows’ a three dimensional product. • Produces detailed products at relatively low cost • Relatively quick process compared to other 3 dimensional processes. • Spot errors in the design 	<p>[2]</p> <p>[2]</p>	4

6 Manufacturers of soft drinks bottles use statistical testing methods, Quality Control (QC) and Quality Assurance (QA) procedures in an effort to drive improvement.

(i) Explain how the manufacturer of the soft drinks bottles would use statistical testing methods.

Statistical Testing Methods is the use of statistics or data (e.g. 1 in 50 soft drinks bottles) to determine which bottles would be selected for testing purposes. [2]

(ii) Explain the difference between QA and QC procedures.

QA – is about setting standards and meeting them at every stage of design and manufacture. QC – is how you check if you are meeting these standards. This involves inspecting, sampling and testing. [2]

AVAILABLE
MARKS

4

7 Anthropometrics and ergonomics help determine the shape and profile of many products.

(i) With reference to **Fig. 7** explain how anthropometric data may have been used in the design of the product.

Anthropometrics data has been used to determine the most suitable length, thickness, grip location and size area of the brushing head for a specific target audience (e.g. adults or children). [2]

(ii) Select **two** aspects of the toothbrush in **Fig. 7** and explain how the designers may have incorporated ergonomics.

Any **two** from the following:

- Suitability for left and right handed people
- Texture for grip
- Grip position for thumb for cleaning action
- Overall size of the product in relation to function [2]

4

8 Scientific advances and cultural changes can have an influence on the design of products such as a television.

Selected product – e.g. television.

(i) With reference to any suitable product, outline **one** main scientific advancement and explain what influence this has had on its design.

Any **one** from the following:

- Flat screen technology – televisions are slim and suitable for wall mounting.
- HD and resolution quality – resulting in high quality picture on large size screens. [2]

(ii) With reference to any suitable product, outline **one** main cultural change and explain what influence this has had on its design.

Any **one** from the following:

- Multi-cultural society – range of programmes/languages to reflect our changing society
- Culture change to be more inclusive – designed to be more interactive more young and old (subtitles, hearing loops, teletext, on line use) [2]

Quality of written communication [2]

Poor explanation using inaccurate English grammar.	[0]
Limited explanation using English grammar.	[1]
Clear and coherent explanation using good English grammar.	[2]

Section A

AVAILABLE MARKS

6

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Section B

AVAILABLE MARKS

9 (a) A circuit consisting of a reed switch and resistor is shown in Fig. 9(a).

(i) Describe the operation of a reed switch.

When a magnet is in the proximity of a reed switch, the contacts will close. [2]

(ii) The resistor R1 in the circuit shown in Fig. 9(a) is a pull down resistor. With reference to the voltage Vo, briefly explain the purpose of the pull down resistor.

The pull down resistor R1 ensures that Vo will always be 0 volts when the reed switch contacts are open. [2]

(b) Fig. 9(b) shows a circuit that utilises reed switches to detect if the emergency doors in a building have been opened.

(i) State the type of logic control achieved by the arrangement of reed switches in Fig. 9(b).

OR logic [1]

(ii) Describe the operation of the circuit shown in Fig. 9(b).

A trigger voltage of more than 2 volts at the gate of the thyristor controls the flow of current from the anode to the cathode. When a magnet passes momentarily over either switch A or B the trigger voltage will occur. Once the current flows from anode to cathode the thyristor remains 'latched' in this condition and the LEDs will continue to operate. [3]

Quality of written communication [1]

Poor explanation using inaccurate English grammar.	[0]
Clear and coherent explanation using good English grammar.	[1]

(iii) Explain with the aid of a labelled diagram how the circuit shown in Fig. 9(b) could be modified to incorporate a reset feature.

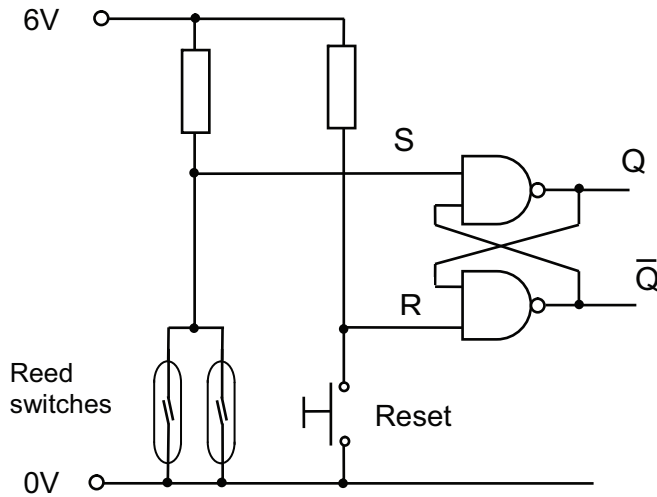
Labelled diagram showing either a push to break switch on the anode side or a push to make switch across the anode and cathode. [3]

(iv) Calculate the power dissipated in mW by the resistor R3 in Fig. 9(b) if the LEDs shown are each designed to operate at a forward voltage of 1.8 V and a current of 10 mA. Then select a resistor with the most appropriate rating from the following: 0.125 W, 0.25 W, 0.5 W and 1 W.

voltage drop across resistor = 6 V – 3.6 V = 2.4 V
 current = 10 mA × 2 = 20 mA
 therefore, power = 2.4 × 20 mA = 48 mW (0.125 W rated resistor) [3]

- (c) An alternative circuit for the emergency door detector shown in Fig. 9(b) could be constructed using an SR flip flop with input switches and pull up resistors.

Design an SR flip flop based circuit (using NAND gates) to perform the same function as the circuit in Fig. 9(b), showing how the reed switches could be connected and label any additional switches.



[5]

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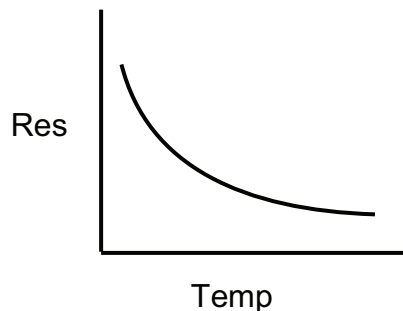
- 10 (a) Fig. 10(a) shows a prototype op amp based circuit for a system to keep newly hatched chicks warm. The system controls a 12 volt bulb that will produce sufficient heat to maintain room temperature.

- (i) State whether the comparator based circuit shown in Fig. 10(a) is an open loop or closed loop control system and briefly justify your answer.

The system can be considered as closed loop because the heat from the bulb (output) is a form of feedback to the thermistor (input). [2]

- (ii) The component R_{th} has a negative temperature coefficient. With the aid of a labelled graph explain what is meant by the term negative temperature coefficient.

As the temperature increases the resistance decreases.



[3]

- (iii) Calculate the voltage V1 in the circuit shown in Fig. 10(a) and calculate the voltage V2 when the resistance of the thermistor Rth is 4.2 kΩ at 15 °C

$$V1 = 6V$$

$$V2 = 12 \times 4.2/4.2 + 10 = 3.6 V \quad (3.55) \quad [3]$$

- (iv) If the transistor TR1 in Fig. 10(a) has a current gain (h_{FE}) of 60 and a V_{be} of 0.6 V, calculate the required value of Rb that will allow the bulb to operate with a current of 120 mA. (Assume that the output voltage of the op amp matches the supply voltage.)

$$Rb = 12 - 0.6/2 \times 10^{-3} = 5.7 k\Omega \quad [3]$$

- (v) With reference to V1 and V2 describe the operation of the circuit shown in Fig. 10(a) under both hot and cold conditions.

The voltage at the inverting input (V1) will be fixed at 6 volts. Under hot conditions the resistance of the thermistor will be low causing a low voltage at the non-inverting input (V2). The output of the comparator will therefore be -12 volts. The transistor will not switch on under these conditions and the bulb will remain off. Under cold conditions the resistance of the thermistor will be high causing a higher voltage at the non-inverting input (V2). The output of the comparator will therefore be 12 volts. The transistor will switch on under these conditions and the bulb will illuminate. [3]

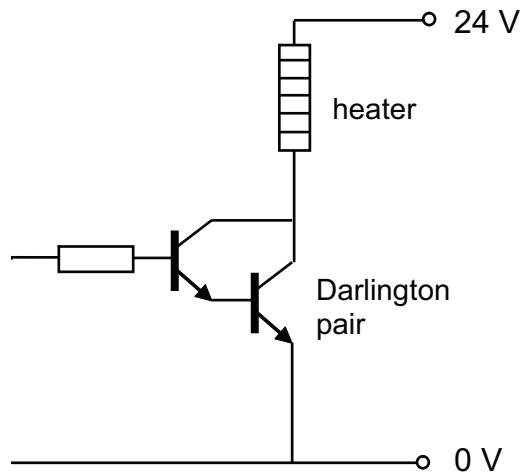
Quality of written communication [1]

Poor explanation using inaccurate English grammar.	[0]
Clear and coherent explanation using good English grammar.	[1]

- (b) A modification has been suggested for the circuit shown in Fig. 10(a) where the transistor and 12 volt bulb are to be replaced with a 24 volt heater and suitable driving circuitry.

With the aid of an annotated circuit diagram, show how this modification could be achieved.

Sample answer



[5]

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Section B

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Section C

AVAILABLE
MARKS

11 (a) Fig. 11(a) shows an incomplete sawing system powered by a motor **M**. The motor **M** turns shaft **K** and the **cutting blade** is intended to move forwards and backwards in a straight path.

(i) State the types of motion at **Shaft K** and the **cutting blade**.

Ans = Shaft K = Rotary

Blade = Reciprocating.

[2]

(ii) During testing when the sawing system is fully functional it is recorded as having a mechanical advantage of 4 and a velocity ratio of 5. Calculate the efficiency of the sawing system.

Ans = Eff = MA/VR × 100%

$$= \frac{4}{5} \times 100\%$$

$$= 80\%$$

[2]

(iii) On the pro forma provided (Answer No. 11(a)(iii)) name and draw a suitable mechanism to allow the **cutting blade** to move forwards and backwards as **Shaft K** rotates.

Ans = Crank and slider.

[1]

Sketch of crank and slider mechanism.

[2]

(b) Fig. 11(b) shows another incomplete mechanical system powered by motor **N**. The rack moves when the motor **N** rotates.

(i) State the direction of rotation at **F** if **X** rotates in a clockwise rotation.

Ans = Clockwise

[1]

(ii) Calculate the output speed of pulley **X** if the motor **N** rotates at 440 rev/min.

Ans = VR = DN/DR = 300/150 = 2

[1]

$$OS = IS/VR = 440/2 = 220$$

$$OS = 220 \text{ rev/min}$$

[2]

(iii) Calculate the velocity ratio between pulley **A** and gear **E**.

Ans = VR A – B = 50/200 = 0.25

[1]

$$VR C – E = 96/96 = 1$$

[1]

$$\text{Total VR} = 1 \times 0.25 = 0.25$$

$$VR A – E = \frac{1}{4}$$

[1]

(iv) Calculate the linear movement of the rack if gear **E** makes **four** rotations. Assume a 180 degree rotation of the pinion gear moves the rack 148 mm.

Ans = VR F – G = 120/60 = 2

[1]

$$4 \text{ rotations of F} - 2 \text{ rotations of G}$$

[1]

$$4 \times 148 = 592 \text{ mm.}$$

[1]

- (v) Describe **two** safety procedures which should be used when working with mechanical systems.

Ans = When working with moving parts make sure that fingers, hair or any loose clothing does not get trapped as a serious accident could occur.

Ensure that all necessary safety guards and signs are in place and meet all relevant health and safety requirements. [2]

Quality of written communication [1]

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Poor explanation using inaccurate English grammar.	[0]
Clear and coherent explanation using good English grammar.	[1]

12 Fig. 12 shows part of an incomplete pneumatic circuit.

- (a) (i) Name the activation method at **A**.

Ans = Solenoid [1]

- (ii) State the purpose of the symbol shown on **port 5** on the double acting cylinder.

Ans = Exhaust port to allow expelled air to escape. [1]

- (iii) Name the activation method at **B**.

Ans = Lever set/reset [1]

- (b) (i) On the pro forma provided (Answer No. **12(b)(i), (ii)** and **(iii)**), complete the circuit to enable the double acting cylinder to instroke following an outstroke from the single acting cylinder.

Ans = 3PV at outstroke identified as component suitable for use. [1]

Correct piping to instroke port of 5PV [2]

See sample answer.

- (ii) On the pro forma provided (Answer No. **12(b)(i), (ii)** and **(iii)**), complete the circuit to enable the single acting cylinder to outstroke once **A, B** and **C** have been activated.

Ans = Main Air Supply [1]

Connection method A–B [1]

Connection method B–C [1]

C to SAC [1]

See sample answer.

- (iii) On the pro forma provided (Answer No. **12(b)(i), (ii)** and **(iii)**), complete the circuit to enable the double acting cylinder to outstroke following an instroke from the single acting cylinder or **Q** being activated.

Ans = 3PV at instroke of SAC [1]

Connection method from Q to new 3PV [1]

Shuttle valve [1]

Connection to outstroke port on 5PV [1]

See sample answer.

(c) Describe a main safety issue and procedure used for Pneumatic control systems.

Ans = Issue – Pneumatic piping not being properly secured into the ports of the pneumatic components. This can cause the piping to release itself from the port and thrash around and possibly cause personal injury to the operator. [1]

Procedure – Make sure all piping is secured properly to the ports before the main air supply is turned on. [1]

Or other suitable issues and procedures

Quality of written communication [1]

Poor explanation using inaccurate English grammar.	[0]
Clear and coherent explanation using good English grammar.	[1]

(d) A single acting cylinder is required to produce a force during the outstroke of 212 N using an air pressure of 0.4 N/mm². Select one of the following single acting cylinders which could best meet the requirement:

- Cylinder L – piston radius 6 mm
- Cylinder M – piston radius 9 mm
- Cylinder O – piston radius 13 mm
- Cylinder P – piston radius 15 mm
- Cylinder Q – piston radius 17 mm

Please assume $\pi = 3.14$

Ans = $F = P \times A$

$$212 = 0.4 \times ?$$

$$3.14 \times 13 \times 13 = 530.66 \quad [1]$$

$$530 \times 0.4 = 212 \text{ N} \quad [1]$$

Cylinder O is required. [1]

Section C

AVAILABLE MARKS

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Section D

AVAILABLE
MARKS

Product Design

- 13 (a) With reference to Fig 13(a), (b), (c) and (d) on the insert sheet;
- (i) Briefly outline **three** specific functional criteria that a designer would need to include in the design specification for this product.
 - Allow the user to brush dust and food spoils into the dustpan
 - Brush shaft to be able to attach to dustpan handle for storage
 - Be able to be hooked onto a wall. [3]
 - (ii) Briefly outline **three** main criteria that would influence the selection of the material to be used for the tubular shaft of the dustpan (Fig 13 (b)).
 - Tough and rigid material
 - Can be flexed and has a high impact strength
 - Suitable for moulding. [3]
 - (iii) Briefly outline **three** main reasons why folded boxboard is the material used for the packaging of the dustpan and broom (Fig. 13(a)).
 - Produces a strong durable board for the package
 - Cost effective material
 - Suitable for printing graphics on [3]
 - (iv) Under the Intellectual Property Rights (IPR) for the product the designer registered the design. Outline **two** characteristics associated with registered designs.
 - A registered design protects the appearance of a product (the lines, contours, colours, shape, texture and materials)
 - A registered design covers two-dimensional as well as three-dimensional products
 - A registered design must be new and have individual character [2]
- Quality of written communication. [1]

Poor explanation using inaccurate English grammar.	[0]
Clear and coherent explanation using good English grammar.	[1]

(b) With the aid of detailed annotated sketches, using the blank A3 proforma answer page (Answer No. **13(b) (i)** and **(ii)**), suggest for each of the following:

(i) An appropriate handle for the broom which will be more ergonomically suited to the user whilst minimising the use of material (**Fig. 13(d)**). [4]

Level of response not worthy of credit.	[0]
Vague sketches lacking detail and appropriate annotation. Difficulties in disseminating if the ideas are appropriate and represent improvements.	[1]
Both the sketches and annotation are limited. The ideas represent improvements but lack the finesse appropriate for the product.	[2] or [3]
Detailed annotated sketches representing an appropriate improvement to the overall design.	[4]

(ii) An appropriate end for the tubular shaft which would enable the user to quickly remove the brush head and replace it with other attachments (**Fig. 13(c)**). [4]

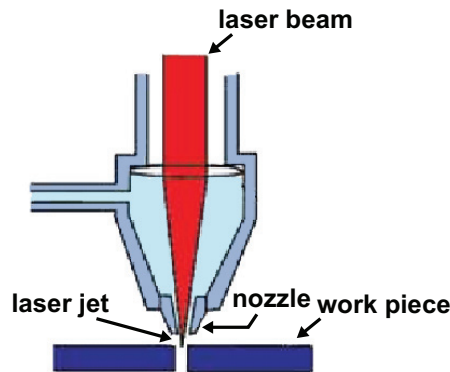
Level of response not worthy of credit.	[0]
Vague sketches lacking detail and appropriate annotation. Difficulties in disseminating if the ideas are appropriate and represent improvements.	[1]
Both the sketches and annotation are limited. The ideas represent improvements but lack the finesse appropriate for the product.	[2] or [3]
Detailed annotated sketches representing an appropriate improvement to the overall design.	[4]

20

14 Fig. 14 on the insert page shows a photograph of an electric shaver designed for a mature male target audience.

(a) The electric shaver could be produced in model form using a laser cutter and a range of workshop processes such as drilling, cutting, filing and polishing.

(i) With the use of an annotated sketch describe the process of laser cutting.



Sketch [2]

Laser cutters work by directing a very powerful laser beam at a precise focal length onto a material which can either be cut or etched

Explanation [1]

(ii) The table below shows an incomplete five stage risk assessment for the vertical pillar drill, used when drilling plastic, wood or metal.

Briefly outline the appropriate content for stages 2, 3, 4 and 5 in the answer booklet.

[4]

E.g.

Stage	Vertical pillar drill.
1. Hazard identified	Drilling plastic or metal – rotating material.
2. Who is at risk and how?	User – injury as a result of rotating material with possible sharp edges.
3. Precautions	Ensure material is adequately clamped use guard and ensure appropriate drill is fitted and the feed/ speed is appropriate for the material.
4. Record findings	Record any finding or observations on the process, keeping them simple and not too elaborate.
5. Review your assessment	Review over a set time period and make any improvements, changes as needed.

(b) For promotional purposes it is planned to manufacture a number of large scale models of the electric razor using carbon fibre reinforced plastic (CFRP).

Briefly outline **two** main characteristics associated with carbon fibre reinforced plastic (CFRP) which make it suitable for production of such models.

Any **two** from the following:

- Excellent strength-to-weight ratio
- Resistant to many chemical solutions which may be used for cleaning
- Suitable for applying graphics to represent elements of the product [2]

(c) To assist in the planning for manufacture of the electric shaver shown in **Fig. 14** a Gantt chart is to be used. Explain **two** main characteristics associated with a Gantt chart.

Any **two** from the following:

- A Gantt chart is a chart that shows a project schedule.
 - Gantt charts illustrate the start and finish dates/timings of the elements of a project
 - Some Gantt charts also show the dependency or relationships between activities. [2]
- Quality of written communication. [1]

Poor explanation using inaccurate English grammar.	[0]
Clear and coherent explanation using good English grammar.	[1]

(d) As a designer you have been asked to consider the problem of re-designing the casing of the electric shaver shown in **Fig. 14** for a target audience of males of all ages who may be frequent travellers. On the blank A3 pro forma answer page (Answer No. **14(d)**) provide a response for each of the following:

- Sketches of a remodelled shape for aesthetic. [3]

Level of response not worthy of credit.	[0]
Sketches lacking detail and no explanation. Difficulties in disseminating if the design is appropriate for the target audience.	[1]
Sketches and explanation are limited. The design is appropriate for the target audience.	[2]
Detailed sketches and an appropriate explanation. The design is very appropriate for the target audience.	[3]

Any three main requirements, e.g.

- rechargeable batteries
- reduction in size
- weight
- ease of cleaning [3]

Suggest a suitable specific material and manufacturing process for the casing. Select a suitable material – e.g. thermoplastic elastomer and manufacturing process – e.g. injection moulding [2]

Section D

Total

AVAILABLE MARKS

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80

Answer No. 12(b)(i),(ii) and (iii)

