National
Qualifications
2022

2022 Design and Manufacture

Higher

Finalised Marking Instructions

These marking instructions have been prepared by examination teams for use by SQA appointed markers when marking external course assessments.

General marking principles for Higher Design and Manufacture

Always apply these general principles. Use them in conjunction with the detailed marking instructions, which identify the key features required in candidates' responses.

(a) Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.

(b) If a candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you must seek guidance from your team leader.

(c) The term 'or any other valid response' allows for possible variation in candidates' responses. Always award marks according to the accuracy and relevance of an answer.

(d) Where a question asks a candidate to **describe**, they must provide a statement or structure of characteristics and/or features. This should be more than an outline or a list. It may refer to, for example, a concept, process, experiment, situation, or facts, in the context of and appropriate to the question.

(e) Where a question asks candidates to **explain**, they must relate cause and effect and/or make relationships between things clear, in the context of the question or a specific area within the question.

(f) Where a question asks candidates to **discuss**, they must communicate ideas and information on a subject. It may be possible to debate two sides of the statement.

Marking instructions for each question

Question			Expected response	Max mark	Additional guidance
1.	(a)		Candidates' explanations should relate to the materials chosen for these products and/or their component parts. **Explanations are likely to include:** **Tubular stainless steel frame:** • corrosion resistant • tubular steel reduces weight (for lifting) • tubular saves on material • can be welded • ductile/malleable • hardwearing (durable) • tough (durable) • strength (hold weight of user) • aesthetic qualities. **Painted scoop and tubular mild steel frame:** • durable (paint resists corrosion) • tubular steel reduces weight (for lifting, both) • tubular saves on material • Strength (hold the weight of the user, frame only) • ductile/malleable • can be welded. **Polypropylene:** • chemical resistance for cleaning • good impact resistance • recyclability • durability • range of colours available • suitable for production methods.	**6**	**Six** valid explanations at **1 mark** each. **0 marks** awarded for repetition of properties, benefits or characteristics. It should include the properties or benefits of the materials related to this product. To achieve marks for lightweight/reduced weight, reference must be made to being tubular or hollow.

Question			Expected response	Max mark	Additional guidance
			ABS: • good chemical resistance (easily cleaned) • durable (can be used outdoors without deterioration) • scratch resistant (maintains aesthetic look) • impact resistant. **Rubber:** • easily formed • grip surface for holding • comfortable to hold. **Nylon:** • durable (wear resistant) • self-lubricating • chemical resistance. **Any other valid explanation.**		

Question			Expected response	Max mark	Additional guidance
	(b)		Candidates are expected to name and explain why the manufacturing processes are appropriate to the production of these diggers. **Explanations are likely to include:** **Playground sand digger:** • extrusion of tubular stainless steel • bending tubular frame • press forming for scoop • piercing to provide holes for assembly • drilling • blanking of component parts (brackets) • injection moulding of seat • welding of frame parts • use of jigs in assembly/welding. **Garden digger:** • extrusion of tubular mild steel • bending tubular frame • press forming for scoop • piercing to provide holes for assembly • drilling • injection moulding of seat • welding of frame parts • use of jigs in assembly/welding • Injection moulding for ABS wheels (accept rotational moulding) • injection moulding for rubber handles • painting • use of standard components (nuts/bolts).	**6**	Any **three** appropriate mass manufacturing processes and their relationships regarding suitability explained. **Maximum of 3 marks** for naming of processes, where related to part of product. (**1 mark** each process) **Maximum of 3 marks** for explanations of suitability. **1 mark** for each explanation of suitability; where more than one explanation is given to a process, **a maximum of 2 marks** per process should be awarded. **NB marks** can be awarded for correct explanation for the feature produced if an incorrect process is given. The wheels have been vacuum formed **(0 marks)** which is a low-cost production method. **(1 mark)**

Question			Expected response	Max mark	Additional guidance
			Justification statements could include: • repeatability of process • accuracy of process • economies of scale (mass/batch) • shape/form is suitable for process • surface finish/no further finishing required • uniform cross section for extrusion • intricate detail • hollow shape produced • suitability of process to material • thin sheet (suitable for piercing and blanking) • strength achieved through welding • easy assembly/maintenance using nuts/bolts. **Any other valid explanation.**		

Question			Expected response	Max mark	Additional guidance
	(c)		Candidates are expected to describe how anthropometrics and physiology have influenced the design of these diggers. **Descriptions are likely to include:** **Anthropometrics:** • diameter of handles • length of handles • height of seat above ground • width of seat • reach to handles • range of movements. Candidates **must** relate anthropometrics to the products. *(Ignore incorrect percentile range, if given.)* **Physiology:** • force required to operate levers, lift scoop (size of scoop/weight when full) • force required to rotate digger (smooth easy rotation) • posture issues (comfort) • limitations of dexterity • strength required to push garden digger (free rolling wheels) • weight of garden digger for lifting (storage). **Any other valid description.**	**4**	Four appropriate descriptions at **1 mark** each. The candidate must make reference to both anthropometrics and physiology to achieve full marks. **Maximum of 3 marks** for any single area **(3+1).** Candidate descriptions **must** relate to its appropriate area of ergonomics.

Question			Expected response	Max mark	Additional guidance
	(d)		Candidates are expected to describe how the design of these diggers have been influenced by function and safety. **Descriptions are likely to include:** • stability (span of wheels to prevent toppling) • finger traps minimised • appropriate length of levers allows easy operation • rubber grips for safety (non-slip) • textured seat prevents slipping • digger rotates for ease of use (commercial digger) • nylon bearings provide smooth action for ease of use (commercial digger) • grip on wheels • wheels allow product to be portable (garden digger) • weight of digger allows easy lifting for storage (garden digger) • strength of construction (appropriate materials/assembly) • material appropriate for outdoor use, water resistant • vandal proof bolts prevent bolts being loosened (commercial digger) • maintenance/ease of cleaning • digger secured to ground to prevent toppling (commercial digger) • scoop restricted (won't tip contents over user) • balls on end of handles prevent injury (commercial digger) • tools included makes easy assembly (garden digger) • self-assembly allows digger to be dismantled for storage if restriction on space (garden digger). **Any other valid description.**	**5**	**Five** appropriate descriptions at **1 mark** each.

Question			Expected response	Max mark	Additional guidance
	(e)		Candidates are expected to describe how production and planning systems can be used to improve efficiency during the manufacture of these diggers. **Descriptions are likely to include production and planning systems (with a related description on improving production efficiency) which could include:** • use of correct production type (one off/batch/mass/flow) • quality assurance (as part of a production/planning system) • Gantt charts • flow charts • use of CNC, CAD/CAM • automation • jigs/patterns/templates • JIT • standard components • sub-contracting • rapid prototyping. **Any other valid description.**	**4**	**Four** valid points at **1 mark** each. **Maximum of 3 marks** per planning and production system.

Question			Expected response	Max mark	Additional guidance
2.	(a)		The candidate is expected to give explanations of why a thermo-setting plastic is suitable for the utensils. **Explanations are likely to include:** • high impact strength • scratch resistance • heat resistance • chemical/stain resistance • range of colours available • hygienic • dishwasher safe • durable (resistant to wear) • tasteless/odourless. **Any other valid explanation.**	**2**	**2 marks** for each valid explanation. **0 marks** awarded for naming a plastic.
	(b)		The candidate is expected to give explanations of why compression moulding is suitable for the utensils. **Explanations are likely to include:** • economies of scale (do not accept just 'mass production') • components are a suitable form for the process • process is suitable for thermosetting plastics • little or no wasted material • very accurate with little shrinkage • it is a high-volume, high-pressure method suitable for moulding complex shapes • one piece production • relatively low-cost production method • quality surface finish/detail • repeatability. **Any other valid explanation.**	**2**	**2 marks** for each valid explanation.

Question			Expected response	Max mark	Additional guidance
	(c)		The candidate is expected to describe **two** idea generation techniques. **Descriptions should show how the technique is used to generate ideas and are likely to draw from the following:** • brainstorming • morphological analysis • analogy • lifestyle/mood board **Any other valid description.**	**4**	**A maximum of three marks** per technique described/illustrated. (**No marks** awarded for naming of the technique) **Candidates may refer to other idea generation techniques such as:** • lateral thinking • pencil for a walk • biomimicry • SCAMPER.

Question			Expected response	Max mark	Additional guidance
3.	(a)		Candidates are expected to outline **two** benefits to the consumer of using standard components. **Responses are likely to include:** • reduced purchase cost due to reduced production costs • supplied in common sizes/ratings • ease of replacement • easy to source • no specialist tools required. **Any other valid response.**	**2**	**1 mark** for each valid response.
	(b)		Candidates are expected to outline the benefits of using CAD to design products such as the bicycle. **Responses are likely to include reference to:** • making it easier to alter the design • a library of parts could be used to speed up the production of designs • carrying out stress analysis on parts/components before prototyping/manufacture • the design can be easily rendered to provide visuals for clients • easier to communicate design information with other members of the design team • create orthographic drawings for manufacture • increased accuracy • greater complexity of detail/parts • reduce waste. **Any other valid response.**	**3**	**1 mark** for each valid response.

Question			Expected response	Max mark	Additional guidance
	(c)		Candidates are expected to explain the impact that fully automated manufacturing has on the workforce. **Explanations are likely to include:** • reduced work force • retraining of skills • de-skilling of work force/reduced training costs • changed work patterns • economic migration. **Any other valid explanations.**	**2**	**1 mark** for each valid explanation.

Question			Expected response	Max mark	Additional guidance
4.	(a)		Candidates are expected to explain the advantages of using 3D printing over traditional manufacturing processes. **Explanations are likely to include reference to:** • flexibility of manufacturing • reduction in manufacturing costs • reduction in tooling costs • customisation is easier • can replicate mass-produced parts • no manufacturing skills required • reduction of labour costs • cost-effective at low volume • ability to create intricate designs not possible using traditional methods • reduced lead times (quicker to market) • accuracy of model • ability to edit and make changes to the design relatively quickly. **Any other valid explanation.**	**2**	**1 mark** for each valid explanation.

Question			Expected response	Max mark	Additional guidance
	(b)		Candidates are expected to describe methods of carrying out research into the needs of the end user and outline the information that would be gathered. **Descriptions for the research method are likely to include reference to:** • questionnaires/surveys • comparison (recurring features within existing products) • user trials • user trips. **Responses for the information gathered are likely to include:** • length of time in use (per day or lifetime) • user needs/wants • material durability • ergonomic data (anthropometrics/physiology) • material strength (weight of user) • specific use (sports, etc). **Any other valid response.**	**4**	The candidate must make reference to both the research method and the information gathered to achieve full marks. (**No marks** awarded for naming of the technique) **Maximum of 3 marks** for describing the research method **(3+1).**

Question			Expected response	Max mark	Additional guidance
	(c)	(i)	Describe the purpose of the following types of specifications and give an example of the type of information found in each one. **Product design specification.** **Descriptions are likely to include:** **Purpose:** • defines specific parameters • provides direction to the design process • used to evaluate changes in decisions. **Example:** • number to be produced • target market • cost • impact on environment • dimensions • information relating to design factors • environment it will be used in. **Any other valid description.**	**2**	**1 mark** for correct description of the purpose. **1 mark** for the example of type of information given.

Question			Expected response	Max mark	Additional guidance
		(ii)	Describe the purpose of the following types of specifications and give an example of the type of information found in each one. **Technical specification.** **Descriptions are likely to include:** **Purpose:** • provides specific technical detail required to manufacture product • produced after the product is designed and tested to provide specific technical information. **Example:** • materials • processes to be used • assembly methods • production costs • dimensions • weight • maintenance cycles • performance • power supply • comply with safety standards. **Any other valid description.**	**2**	**1 mark** for correct description of the purpose. **1 mark** for the example of type of information given.

Question			Expected response	Max mark	Additional guidance
5.	(a)		Candidates are expected to discuss the aesthetics of the kettles shown. **Reponses are likely to include reference to:** • shape • line • form • proportion • pattern • light • texture • colour • fashion/style • contrast (colour, shape or texture) • harmony • balance/symmetry • market trends • aesthetics for function • suitability for target market. **Any other valid response.**	**4**	**Four** appropriate comments at **1 mark** each. Candidates must refer to **four** different aesthetic aspects.

Question			Expected response	Max mark	Additional guidance
	(b)		Candidates are expected to name a method of protecting IPR and give an example of what it would be used to protect. **Responses are likely to include reference to:** **Copyright** • used to protect 'published materials' that is, literary works, art, photography, films, tv shows, music, web content. **Design rights** • used to protect the shapes of objects. **Registered designs** • used to protect the appearance of a product that is, shape, packaging, patterns. **Trademarks** • used to protect 'brand identity' that is, product names, logos, jingles, tag lines. **Confidentiality** • Used to protect secret formulas, ingredients, recipes. **Any other valid response.**	**2**	**1 mark** for naming a suitable alternative method of protecting IPR. **1 mark** for a valid example of what it would be used to protect. Abbreviations or symbols on their own do not attract any marks.

Question			Expected response	Max mark	Additional guidance
6.			Candidates are expected to describe the role of each of the named members of the design team. **Descriptions are likely to include reference to:** **Ergonomists** • advise on appropriate ergonomic information • ensure the product 'fits' the intended target market • advises on anthropometrics, physiology and psychology • can give information specific to target market in terms of age and gender. **Market Researchers** • can advise on target market wants and needs • advises on current trends • will have knowledge of competitor products • can predict sales volume and demand. **Project Managers** • ensures all aspects of the project are completed on time • plans activities and resources • organizes and motivates the project team • estimates cost and ensures project is completed within budget • monitors progress. **Any other valid description.**	**6**	**1 mark** for each valid description of the role of the named member. **Maximum of 3 marks** per named member **(2+2+2 or 3+2+1).**

Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	Candidates are expected to describe methods used to identify the materials used in a products manufacture. **Descriptions are likely to include reference to:** • flame test (only if colour of flame or smell of smoke is mentioned) • testing for magnetism (ferrous metals) • float test • scratch test • look for identification markings • drop test • cutting (looking for chips or slices) • grain pattern (wood only) • smell/odour • colour (wood and metal) • relative weight to a known material. **Any other valid description.**	**4**	**Maximum of 3 marks** per method described**.** **0 marks** awarded for simply naming a technique. Testing should relate to similar materials, i.e. metal to metal
		(ii)	Candidates are expected to describe how manufacturing features are used to aid accurate and efficient assembly. **Descriptions are likely to include reference to:** • bosses • location pins • raised edges • fasteners molded into components • Screw holes etc. all on one side (inserted from the same direction) **Any other valid description.**	**2**	**1 mark** for each valid response. **0 marks** awarded for simply naming the feature.

Question			Expected response	Max mark	Additional guidance
	(b)		Candidates are expected to describe steps that manufacturers can take to reduce the negative environmental impact of their products. **Descriptions are likely to include reference to:** • reducing the number of materials • reducing the number of parts • design for disassembly • increasing durability • markings to identify materials • reducing power consumption during manufacture • using renewable sources for energy • using recycled material • using recyclable materials • reducing transport distances • maintenance and repair issues • reducing waste/pollution from manufacturing processes • reducing packaging. **Any other valid description.**	**4**	**1 mark** for each valid description.

Question			Expected response	Max mark	Additional guidance
8.			Within their answer candidates are expected to link **type of model** to **area of design process**, discussing purpose of modelling and **information gained**. (How the creation of the model advances the design) **Descriptions are likely to make reference to some of the following aspects.** Variety of models likely to be included: • physical models — sketch modelling — scale model — block model — test rigs — prototypes — rapid prototype. • computer generated models and simulations. Models can be used at various stages in the design process to: • generate and explore • test and refine • communicate. **Sketch modelling** Sketch models are simple physical models made of low cost, easy to work materials. • generation of ideas (initial ideas stage) • help visualisation (ideas stage or ideas development) • test concepts/explore user interaction (ideas stage or ideas development).	**8**	This question is set to test the candidate's ability to present a reasoned discussion about the variety of models which can be used to gain information during the design of products. Although there is an underlying body of design knowledge required to answer it, there is a very wide range of possible answers. **Therefore, the question is marked holistically.** The features which are looked for are knowledge of the subject matter, and ability to comprehend the question and construct an answer which uses clear examples to support the points made. The table below is designed to assist with the placing of answers within the full mark range.

Question			Expected response	Max mark	Additional guidance
			Block models Block models are commonly used to communicate and develop the form, dimensions and surface details of the product. • help visualisation (ideas stage or ideas development) • check aesthetics, proportion, ergonomics etc (idea development) • feedback from client (idea development). **Scale model** Scale models are used to communicate the size and proportion of the ideas/concepts. • checking ergonomics (idea development) • check aesthetics (idea development) • feedback from client (idea development). **Test/working model** Test/working models are used when determining functionality to allow accurate components to be manufactured. • test functional aspects (idea development) • check durability (idea development) • test efficiency (idea development) • check for flaws (idea development) • health and safety compliance (idea development) • material properties (idea development).		

Question			Expected response	Max mark	Additional guidance
			Computer generated models Computer generated models have become commonplace within the design industry due to their ability to be fully integrated with the CAD/CAM workplace, reducing the tooling development cost and speeding up the development stage. • various colour schemes can be analysed, aesthetics, finishes, textures etc (idea development) • show how the product will fit together, functional aspects, moving parts etc (idea development/manufacture/final proposal) • stress analysis of materials (idea development) • creation of working drawings from model (manufacture) • could be used for direct manufacture (manufacture) • used for promotional purposes (final proposal) • simulations for presentation to client (final proposal). **Prototype** Prototypes are used to physically show or simulate the final design in terms of aesthetics, materials and functionality. • promotional purposes (final proposal) • check for any flaws (final proposal) • test efficiency (final proposal) • identify and/or overcome performance issues (final proposal) • testing market opinion (final proposal) • discussing with client (final proposal).		

Question			Expected response	Max mark	Additional guidance
			Rapid prototype Rapid prototyping is a method of making a model directly from CAD data. • discuss with client (final proposal) • direct manufacture (final proposal) • used for testing factors such as aesthetics, ergonomics, functional/moving parts etc (idea development/final proposal) • check for flaws (idea development/final proposal).		

0—2 marks	3—4 marks	5—6 marks	7—8 marks
An answer which falls into this category may do so for a number of reasons. • **limited** knowledge or understanding of the types of models used at certain stages of the design process and the information that can be gained • little or no reference to types of models • very few points are made • much of the response does not answer the question • the answer is simply too thin.	An answer which falls into this category may do so for a number of reasons. • **adequate** knowledge or understanding of the types of models used at certain stages of the design process and the information that can be gained • the answer will be relevant to the question • some reference is made to different modelling types, stages and the Information that can gained • although examples are used, points made are unclear.	An answer which falls into this category may do so for a number of reasons. • **secure** knowledge or understanding of the types of models used at certain stages of the design process and the information that can be gained • the answer will be relevant to the question and demonstrate a good level of comprehension • clear reference is made to different modelling types, stages and the information that can be gained • several points made are clear and examples are used to support them.	An answer which falls into this category may do so for a number of reasons. • **extensive** knowledge or understanding of the types of models used at certain stages of the design process and the information that can be gained • the answer will be relevant to the question, demonstrating a high level of comprehension • detailed information is given about different modelling types and the information that can be gained • all points made are clear and examples are used to support them.

[END OF MARKING INSTRUCTIONS]