



## **General Certificate of Education**

# **AS Design and Technology Product Design 5551**

**PD1D Materials and Components**

## **Mark Scheme**

*2007 examination - June series*

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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## Quality of Written Communication

The following marks are allocated to the quality of the candidate's written communication. Make a separate assessment of the candidate's overall ability as demonstrated across the paper using the criteria given below.

<i>Performance Criteria</i>	Marks
<p>The candidate will express complex ideas extremely clearly and fluently. Sentences and paragraphs will follow on from one another smoothly and logically. Arguments will be consistently relevant and well structured. There will be few, if any, errors of grammar, punctuation and spelling.</p>	4
<p>The candidate will express moderately complex ideas clearly and reasonably fluently, through well-linked sentences and paragraphs. Arguments will be generally relevant and well structured. There may be occasional errors of grammar, punctuation and spelling.</p>	3
<p>The candidate will express straightforward ideas clearly, if not always fluently. Sentences and paragraphs may not always be well connected. Arguments may sometimes stray from the point or be weakly presented. There may be some errors of grammar, punctuation and spelling, but not such as to suggest a weakness in these areas.</p>	2
<p>The candidate will express simple ideas clearly, but may be imprecise and awkward in dealing with complex or subtle concepts. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling may be noticeable and intrusive, suggesting weaknesses in these areas.</p>	1

This mark scheme is intended as a guide to the type of answer expected but is not intended to be exhaustive or prescriptive. If candidates offer other answers which are equally valid **they must be given full credit**.

Many responses at this level are assessed according to the **quality** of the work rather than the number of points included. The following level descriptors are intended to be a guide when assessing the quality of a candidate's response.

<b>(low mark range)</b>
The candidate has a basic but possibly confused grasp of the issues. Few correct examples are given to illustrate points made. This candidate does not have a clear idea of what s/he is writing about.
<b>(mid mark range)</b>
The candidate has some knowledge but there will be less clarity of understanding. Some correct examples given to illustrate points made. This candidate knows what s/he is writing about but is confused in part.
<b>(high mark range)</b>
The candidate has a thorough understanding of the issues and has provided relevant examples to support the knowledge shown. This candidate knows what s/he is writing about and provides clear evidence of understanding.

**No marks should be awarded for answers that simply state materials are “strong”, “cheap”, “easy to mass produce”, “easy to manufacture / cheap to manufacture” or “readily available”.**

### Question 1

(a) (i) Candidates will name specific materials for their chosen products.

- Plastic piggy bank

Accept any suitable thermoplastic, e.g. High Density Polyethylene (HDPE), Polypropylene (PP), High Impact Polystyrene (HIPS/PS), acrylic, polycarb, etc.  
1 mark for polyethylene or LDPE/PE.  
No marks for thermoset polymers.

- Metal torch

Accept aluminium, aluminium alloy, duralumin, titanium, mild steel, stainless steel, brass.  
1 mark for steel.

- Wooden table

Accept plywood, laminated plywood, flexi-ply, aeroply, 'Bendy wood', laminated wood veneer, beech/birch veneer, aspen, ash, beech or other hardwood that could be steam bent.

Breakdown:

1 mark if material is correct but not specific, e.g. 'steel'  
2 marks for correct specific material  
No marks for list with one or more incorrect materials  
2 marks for list of correct materials

*(2 × 2 marks)*

(ii) Candidates will explain why the materials are suitable for their chosen products.

- Plastic piggy bank

HDPE is a thermoplastic and can be blow moulded or rotationally moulded.

HDPE can be coloured with a pigment, removing need to paint product – reducing costs.

‘Flash’ or excess plastic from manufacturing can be recycled.

HDPE is non-toxic so safe for children to handle.

Impact resistant so won’t smash if dropped.

Etc

- Metal torch

Aluminium doesn’t corrode so torch can be used outdoors in damp conditions.

Aluminium can be anodised to colour the surface of the metal and protect it from tarnishing.

Aluminium is very lightweight (accept ‘light’) compared to steel. This keeps the weight of the torch down, making it easy to carry.

Aluminium can be machined easily with normal HSS cutting tools.

Aluminium can be threaded,

Etc

- Wooden table

Plywood is flexible and can be bent around a former.

Plywood has attractive surface veneer.

Can be finished with polyurethane varnish, stain or similar for good aesthetic qualities.

Stable material compared to natural timber won’t twist or warp.

Readily available in large boards – required for volume production.

Can be steamed to make more pliable.

Etc

Breakdown:

1 – 2 marks per relevant point (2 marks where point or statement is qualified, i.e. property is linked to product function etc)

Award additional mark for in depth explanation of a point.

Maximum 3 marks if generic list of properties.

*(2 × 6 marks)*

(b) Candidates will use notes and diagrams to explain the manufacture of **two** chosen products.

- Plastic piggy bank

Accept blow moulding / extrusion blow moulding or rotational moulding.

Do not accept vacuum forming.

Only accept injection moulding when candidate explains that it would be moulded in several parts using cores. The parts are then plastic welded or fixed with a suitable adhesive.

- Aluminium torch

Accept die casting.

Accept rolling and welding.

Accept extrusion for the main body.

Accept turning on a centre lathe (candidates may use the term 'lathing')

Give credit for drilling / boring operations to make cavities / holes for torch components and knurling for manufacture of grip.

Give credit for milling to make flats on end cap.

Give credit for finishing details, i.e. anodising/spray painting.

Accept spinning or press forming / deep drawing.

Credit for post assembly details, e.g. bulb fittings, etc.

- Wooden table

Process will include cutting to basic shape from stock sheets (possibly by laser or CNC router. Do not reward reference to generic CAM.

Sanding or router along edges.

Steaming to make more pliable (not essential).

Applying synthetic resin e.g. Cascamite to inside surfaces – not PVA.

Clamping in a former or use of a bag press and former.

Drying time. Removal from former. Final sanding to dimensions.

Give credit for staining and varnishing.

Breakdown:

- Basic diagram of a suitable manufacturing process with a few points labelled.  
(1 mark for stating correct process) (1 – 3 marks)
- Better diagram of a suitable manufacturing process with all points labelled and some explanatory notes. (4 – 6 marks)
- Detailed diagram with all points labelled and a good explanation of the process (7 – 9 marks)

(2 × 9 marks)

- (c) Candidates will describe how the manufacturer of the window frame would achieve accuracy and repeatability.

Answers may include:

- Use of a drilling or routing jig (a stencil like device used to guide drilling/routing for holes needed for catches, lock mechanism, etc). This removes the need to measure and mark out.
- Use of bench location fixture e.g. fixed clamps to 'zero', position of frame prior to CNC machining.
- Use of an assembly fixture, e.g. a frame/mitre jig for squaring up pieces to make a frame, keeping them parallel as they are plastic welded together.
- Use of 'stop-go' gauges to check parts for dimensional accuracy, prior to going to next stage of manufacture, e.g. length of pieces. Ensures consistent quality of end product.
- Use of 'machine stops' e.g. when cutting pieces to a set length, a stop on the band saw / dimension saw can be used.
- Etc

Breakdown:

- Basic answer with little understanding. Generic terminology used. e.g. 'use of CAD/CAM and clamps to cut the pieces out, this will keep them all the same size'. (1 – 2 marks)
- Better answer with more specific terminology and some reference to specific parts of the frame. Simple diagrams may be used to support answer. (3 – 4 marks)
- Full answer using specific terminology. Candidates may give more than one example and reference to specific parts of the frame. Candidates may do good supporting diagrams. (5 – 6 marks)

n.b. candidates may use sketches to support this answer. Give credit for this where relevant.

*(6 marks)*



## Question 2

(a) Candidates will explain why ABS is used in the games controller.

Answer may include:

- Can be printed on for logo / branding
- Good impact resistance – so will withstand being dropped
- High level of durability. Will withstand wear and tear from constant use.
- Electrical insulation so user is safe from mains electricity.
- Can be injection moulded into complex ergonomic shape required.
- Can be coloured with a pigment for brand identity/aesthetics and so on.
- Recyclable polymer – important to meet new environmental legislation, etc.
- Etc.

Breakdown:

1 – 2 marks per relevant point. (2 marks where point or statement is qualified i.e. property is linked to product function, etc)

Award additional mark for in depth explanation of a point..

**Maximum 3 marks if generic list of properties.**

*(6 marks)*

(b) Candidates will use notes and diagrams to explain the injection moulding process.

Breakdown:

- Basic diagram of injection moulding process with a few points labelled (or basic description with no diagram) (1 – 3 marks)
- Better diagram of injection moulding process with most points labelled and some explanatory notes. (4 – 7 marks)
- Detailed diagram with all points labelled and a detailed explanation of the injection moulding process. (8 – 10 marks)

(Reference to specific parts, e.g. hydraulic ram, Archimedean screw, ejector pins, watercooled mould, detail of mould with cavity matching product)

*(10 marks)*

(c) Candidates will explain in detail why the injection moulding process is suitable.

Answers may include:

- Fast method of manufacture required for high volume production
- Produces consistent quality product (each moulding is identical)
- Can be continuous fully automated – eliminating human error and reducing health and safety concerns
- Injection moulding uses high pressure injection of molten plastic – required to force polymer into intricately shaped mould needed for such a complex product
- Pigment can be added to polymer to colour the product (no need to apply paint, etc to the end product)
- Low unit cost with high volume production achieved with this process.

Breakdown:

1 – 2 marks per relevant point (2 marks where the point is explained)

Award a further mark for in depth explanation of a point.

*(6 marks)*

(d) Candidates will use notes and diagrams to describe in detail how the two halves of the casing **could be** joined together.

Answers may include:

- Use of moulded snap fittings
- Use of self-tapping screws or similar in conjunction with internal screw posts and countersunk holes
- Use of machine screw and captive nut ‘fitted’ into moulded part on surface
- Use of ‘lipped’ edge and contact adhesives
- Use of shape memory fixings to facilitate recycling
- Etc

Breakdown:

- Basic diagram of joining process with a few points labelled (or basic description with no diagram) (1 – 2 marks)
- Better diagram of joining process with most points labelled and some explanatory notes. (3 – 4 marks)
- Detailed diagram with all points labelled and a good explanation of the joining process. (5 – 6 marks)

*(6 marks)*

**Question 3**

Candidates will explain why each of the materials is suitable for the products listed.

Answers may include:

<b>Material</b>	<b>Product</b>
(i) Expanded Polystyrene	<p><b>Cycle helmets</b></p> <ul style="list-style-type: none"> <li>• Softness related to comfort or impact absorbency ('gives')</li> <li>• Good impact absorbency – protects head from sudden impact</li> <li>• Can be injection moulded to form the shape with vents, etc</li> <li>• Waterproof – helmet will be used in all weathers</li> <li>• Inexpensive material when made in large volume. Help to keep cost of end product down</li> <li>• Lightweight – more comfortable to wear than denser materials</li> <li>• Etc</li> </ul>
(ii) Stainless steel sheet	<p><b>Electric kettle</b></p> <ul style="list-style-type: none"> <li>• Doesn't corrode so ideal when in contact with water</li> <li>• Non-toxic – vital in a product used with food and drink</li> <li>• Good aesthetic appearance with no need to paint, blends with contemporary style, etc</li> <li>• Can be pressed/spun into shape required as stainless steel is malleable</li> <li>• Etc</li> </ul>
(iii) Mild steel sheet	<p><b>Car body panels</b></p> <ul style="list-style-type: none"> <li>• Takes paint finishes readily</li> <li>• Mild steel is malleable and ductile so can be press formed into required shape without tearing</li> <li>• Widely available material – keeping costs down – necessary for volume production</li> <li>• Can be spot welded easily – main method of joining used</li> <li>• Easily sorted and recycled when car is disposed of</li> <li>• Etc</li> </ul>

(iv) Chipboard	<p><b>Flat-pack furniture</b></p> <ul style="list-style-type: none"> <li>• Flat, stable material ideal for base of laminates, etc</li> <li>• Can be drilled, etc, for various fittings needed in assembly</li> <li>• Inexpensive material when made in large volumes, therefore ideal for budget furniture</li> <li>• Generally uses waste material from timber industry. Good for sustainability issues</li> <li>• Etc</li> </ul>
(v) Aluminium	<p><b>Alloy wheels</b></p> <ul style="list-style-type: none"> <li>• Can be machined for custom designs</li> <li>• Low melting point metal – necessary for die casting</li> <li>• Lightweight compared to steel. Reduces fuel consumption of car</li> <li>• Doesn't corrode – maintains good aesthetic appearance</li> <li>• Etc</li> </ul>
(vi) High Impact Polystyrene	<p><b>Blister packaging</b></p> <ul style="list-style-type: none"> <li>• Can be printed on for graphics</li> <li>• Food safe – important in food packaging</li> <li>• Available in transparent so contents can be seen</li> <li>• Absorbs impact to protect item in transit</li> <li>• Colours to increase consumer appeal</li> <li>• Thermoplastic – necessary for vacuum forming/thermoforming</li> <li>• Can be recycled – important in short lifecycle product for sustainability issues</li> <li>• Can be heat welded to seal package preventing tampering</li> <li>• Etc</li> </ul>
(vii) Beech	<p><b>Kitchen utensils</b></p> <ul style="list-style-type: none"> <li>• Can be machined, sanded into shape</li> <li>• Non-toxic so safe to use with foods</li> <li>• Close grain that does not harbour dirt</li> <li>• Hard – resists scratching which would harbour dirt</li> <li>• Resistant to water – product constantly washed, etc.</li> <li>• Can be steam bent into shape</li> <li>• Straight grain, knot free, which good for manufacture</li> </ul>

Breakdown:

1 – 2 marks per relevant point (2 marks where property is clearly linked to product function, manufacture, etc)

**Zero marks if very generic list of properties given**

1 mark for factually correct, relevant points (up to a max 2 marks)

*(7 × 4 marks)*

#### Question 4

(a) Candidates will name a specific material that could be used to make a 3D block model of the design.

Answer may include:

- Card (if used in layered object modelling)
- Clay
- Styrofoam
- Jelutong
- MDF
- Balsa
- Model board
- ABS or similar (as in rapid prototyping/3D printer, etc)
- Etc

Breakdown:

2 marks for list of correct materials

1 mark if material would work but not entirely appropriate e.g. Pine (as the grain would show)

No marks for list with one or more incorrect materials

2 marks for correct specific material.

*(2 marks)*

(b) Candidates will explain why this specific material is suitable.

Answers may include (some examples given here)

#### **Styrofoam**

- Styrofoam can be cut on hot wire cutters
- Styrofoam can be easily shaped with hand tools and glass paper for model making
- Styrofoam is available in thick, wide boards, removing need to glue pieces together
- Dense varieties of Styrofoam can be machined with CNC routers, etc to make an accurate model
- Styrofoam can be painted after filling the surface with Polyfilla or body filler (accept simply can be painted)
- Etc

#### **Jelutong**

- Easily shaped with hand tools, machine tools, etc
- Close grain, no knots, and very little resin gives a very smooth finish when sanded
- Provides an excellent base for applied paints
- Available in thick sections to produce depth of model required
- Gives a similar weight to plastic product – helps to simulate ‘feel’ of the real product
- Etc

**Rapid Prototype plastics, e.g. ABS ‘Starch’, etc**

- Gives similar weight and ‘feel’ to injection moulded polymer
- Liquid/powder nature of material gives accurate detail e.g. of switches, controls, etc. Similar quality to final moulding.
- Can be printed in colour or sanded, primed and sprayed with a variety of paint finishes.
- Etc

Breakdown:

1 – 2 marks per relevant point (2 marks where property is linked to product function, manufacture, etc)

Award additional mark where further in depth explanation of a point is given.

**Maximum 3 marks if generic list of properties is given.**

*(6 marks)*

(c) Candidates will use notes and diagrams to explain how the model could be made.

Possible answers include:

- Use of manual or CNC milling machine to cut screen detail/profile, etc
- Use of manual or CNC router to cut screen detail/profile, etc
- Layered Object Modelling (Rapid prototype process similar to a plotter cutter, cut out pieces of self-adhesive paper, layer by layer, which are stuck together on a jig to build up 3D model)
- 3D printer – product made in a rapid prototype machine that fuses powdered starch/plastic together. Powder is then ‘set’ with a resin similar to super glue
- Stereo lithographic prototyping – similar to above except lasers fuse liquid polymer, layer by layer into a solid model.
- Fused deposition modelling – works like a glue gun, extruding molten plastic, (commonly ABS) building up the model layer by layer
- Etc

Breakdown:

- Basic diagram of modelling process with a few points labelled (or basic description with no diagram)  
No marks for simply CAD/CAM (1 – 3 marks)
- Better diagram of modelling process with most points labelled and some explanatory notes. (4 – 7 marks)
- Detailed diagram with all points labelled and a good explanation of the modelling process. (8 – 10 marks)

Credit specific reference to tools, equipment, software, e.g. Art Cam, Prodesktop, etc.

Do not credit details for finishing in this part.

*(10 marks)*

(d) Candidates will explain in detail how the model could be finished to a high standard.

Answers may include:

- Sanding the model with glass paper / wet & dry abrasive
- Applying a filler to seal the surface, cover imperfections, etc followed by re-sanding
- Applying a cellulose or acrylic filler primer spray paint – covers minor imperfections and provides a key to surface for top coat paints
- Use of fine wet & dry to remove high spots
- Apply cellulose or acrylic spray paint primer to match top coat (white for light coloured top coats)
- Drying time – 3-4 coats. Drying in between.
- Apply lacquer for high gloss finish.
- Use of dry transfer graphics/printed graphics for screen.
- Coloured powders/resins could be used in RPT but some further work needed for high quality finish
- Etc

Breakdown:

- Basic description with little or no reference to specific finish/finishing method  
(0 – 1 mark)
- Better description with reference to specific finishes. Several stages described with some accuracy  
(2 – 3 marks)
- Detailed description with reference to specific finishes and most of the stages described with accuracy  
(4 – 5 marks)

*(5 marks)*

(e) Description of the health and safety precautions you would take when making and finishing the model.

Answers may include:

- Use of personal protective clothing, dust masks, goggles, etc when machine/sanding
- Use of extractor to remove dust/spray fumes
- Use of guards on machines e.g. milling machine/router to protect from flying debris etc
- Specific health and safety training on equipment used
- Risk assessments to assess hazard, level of risk and control measures
- Etc

Breakdown:

1 – 2 marks per relevant point (2 marks when point explained)

Award additional mark for further in depth explanation of a point.

1 mark for simple list of personal protective equipment.

*(5 marks)*