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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Design and Technology: Product Design 5551/6551

PD1D Materials and Components

Mark Scheme

2007 examination - January 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.

Performance Criteria

	Marks
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.	4
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.	3
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.	2
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.	1

NB 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.

(low mark range)
The candidate has a basic but possibly confused grasp of the issues. Few correct examples are given to illustrate points made. Description may be unclear.
(mid mark range)
The candidate has some knowledge but there will be less clarity of understanding. Some correct examples given to illustrate points made. Description better but unclear or confused in parts.
(high mark range)
The candidate has a thorough understanding of the issues and has provided relevant examples to support the knowledge shown. This candidate's answer shows clear evidence of understanding.

1 (a) (i)

- **Wooden stool**
  Accept any suitable timber e.g. pine, birch, ash, beech, etc.
  Accept plywood or MDF (as it could be if covered with a veneer/laminate)

- **MP3 player (polymer case)**
  Accept any suitable thermoplastic such as:
  ABS-Acrylonitrile Butadiene Styrene
  HDPE- High Density Polyethylene / LDPE or simply polythene
  Silicone rubber or silicone
  High impact polystyrene (Hips)
  TPE Thermoplastic Elastomer
  PP- Polypropylene
  PC-Polycarbonate

  Not acrylic or PMMA

- **Metal bicycle frame**
  Accept suitable metals such as:
  Aluminium
  Duralumin
  Mild steel
  Aluminium alloy
  Titanium/titanium alloy
  Medium Carbon Steel

  Not stainless steel

Breakdown:

Material is correct but not specific e.g. 'steel'. (1 mark)

Correct specific material. (2 marks)

No marks for list with one or more incorrect materials *(2 × 2 marks)*

(ii) Candidates are expected to link the properties of the materials identified in part (i) to the function/use, manufacture, serviceability, environmental considerations, etc of their **two** selected products.

- **Wooden stool**

MDF / Plywood can be finished with quality veneer
Timbers such as ash, etc have attractive grain pattern/colour
Can be machined for K.D. fittings or traditional joints.
Can take a variety of finishes or can be left 'natural' for consumer to finish
Generally sustainable if grown in managed forests.
Etc

- **MP3 player (polymer case)**

Thermoplastic required for injection moulding process to mould intricate shapes.
Impact resistance of ABS, etc. Product likely to be dropped.
Polymers can include a colour for improved aesthetics (no need to paint, reducing manufacturing costs)
Thermoplastics can be recycled- important to meet environmental legislation.
Electrical insulator - product will be charged through a mains transformer (reduced risk of electric shock in event of a fault).
Etc

- **Metal bicycle frame**

Aluminium, aluminium alloy, titanium, etc have excellent strength to weight ratio. This keeps the bike lightweight but gives the frame good mechanical strength to withstand rigours of cycling.
Aluminium etc, doesn't corrode- essential to maintain long product lifecycle especially if used in all weathers.
Aluminium, titanium etc don't need to be painted (brushed or polished finish can save manufacturing costs).
Such metals can be fabricated / welded to make frame construction.
Polished aluminium has very good aesthetics
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.

Max 3 marks if generic list of properties. *(2 × 6 marks)*

(iii) Candidates will use notes and diagrams to explain the manufacture of **any two** chosen products from the list.

- **Wooden stool**

Accept suitable fabrication process using Knock Down (KD) fittings such as:

Cam lock and metal dowel
Captive nut and bolt
Wood screw and corner blocks
Wood screw and PVA
Leg/corner brackets
Traditional wood joints e.g. mortice and tenon, wood dowel, etc.
Etc.

Do not accept 'screw', or 'self tapping screw' but check notes and diagrams for any credit worthy, feasible answers.

- **MP3 player (polymer case)**

Accept **only** injection moulding.

Do not accept compression moulding, vacuum forming, etc.

- **Metal bicycle frame**

Accept **only** the following fabrication processes:

MIG - Metal Inert Gas welding
TIG - Tungsten Inert Gas welding
Oxy - Acetylene welding
Brazing - including Aluminium brazing / hard soldering,
accept drop forging or casting of component on end of forks.

Do not accept the term 'soldering' but give credit if notes and diagrams actually describe the correct **welding or brazing** process and equipment.

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)

(b) Suitable health and safety measures might include:

Ensure employees are trained in standard operating procedure.
Extraction of wood dust from machining manufactured boards etc to prevent irritation to respiratory system.
Provision of personal protective clothing such as dust masks, safety specs, overalls to protect eyes etc from debris..
Provision of fume extraction for welding process to protect respiratory system from toxic substances in fluxes etc.
Provision of welding mask to protect eyes from welding flash.
Provision of health and safety training on the process to prevent accidents
Risk assessment carried out to check level of risk and control hazard.
Use of automation to reduce human input-removing worker from dangerous process.
Use of guards, barriers etc to prevent entrapment in machinery.

Accept Health and Safety measures that an individual employee might take.
Etc

Breakdown

1-2 marks per relevant point.
(2 marks where point or statement is qualified i.e. health and safety measure linked to hazard).
Award **1 mark only** for list of personal protective clothing e.g goggles, gloves, mask, overalls, etc. *(6 marks)*

2 (a) Suitable definition of a thermoplastic e.g.

A thermoplastic is a polymer that can be changed into a different form by applying heat. Thermoplastics can be reformed several times in this way and so are recyclable.

Breakdown:

- Incorrect or no definition given
  (0 marks)
- Definition is incomplete e.g. no reference to changes in the material by applying heat, but partly correct "thermoplastics can be recycled"
  (1 – 2 marks)
- Definition is correct with reference to changes in material by applying heat.
  Further detail used to explain term such as recycling or reference to manufacturing e.g. "thermoplastics can be injection moulded".
  May include diagrams. (3 - 4 marks) *(4 marks)*

(b) Suitable definition of a thermoset e.g.

A thermoset polymer is formed into a product by application of heat & pressure but once 'set', it cannot be changed by further application of heat.

Breakdown:

- Incorrect or no definition given
  (0 marks)

- Definition is incomplete e.g. the term left unexplained but a relevant property given, such as "thermoset plastics can not be recycled"
  (1 - 2 marks)

- Definition is correct with the term explained.
  Further detail used to explain term such as reference to "cross linking of polymer chains" or manufacturing e.g. "thermosets can be compression moulded".
  (3 – 4 marks) *(4 marks)*

(c) (i) **Low Density Polyethylene (LDPE) - carrier bags**

- Thermoplastic which can be recycled. Important for short lifecycle product/sustainability issues.
- LDPE is flexible so bag will stretch around contents dropped into bag.
- LDPE has good tensile strength, required to take load on handles.
- LDPE can be made into a thin film using the calendaring process- required to make the bag
- LDPE can be printed on- required to display corporate graphics, etc.
- Etc

(ii) **Polyethylene Terephthalate (PET)- Plastic drinks bottles**

- Food grade, non-toxic polymer. Required to contain a drink.
- Thermoplastic which can be blow moulded into the bottle shape.
- Can be recycled which is important in short lifecycle product to protect the environment.
- Flexible and won't smash if dropped (unlike glass)
- Can be transparent so the contents of the bottle can be seen
- Impermeable so the contents won't leak and can be pressurised for carbonated drinks
- Etc

(iii) **Urea Formaldehyde (UF)- Electric light switch**

- Thermoset polymer, which cannot deform in the event of an electrical fault causing heat through sparking.
- Electrical insulator so no risk of electric shock from using the switch.
- Can be compression moulded into complex shape of light switch.
- Accept reference to colour.
- Accept 'can be injection moulded'.
- Etc.

(iv) **Melamine Formaldehyde- Kitchen work surfaces.**

- Heat resistant- useful with hot saucepans etc
- Can be used over paper laminate to simulate timber/stone, etc.
- Waterproof.
- Relatively scratch resistant- important for hygiene.
- Accept easy to clean.
- Accept reference to colour
- Easier to cut / shape than natural materials.
- 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).
Give additional mark where point is explained in detail.

Max 3 marks if generic list of properties. *(4 × 5 marks)*

3 (a) Candidates will explain why each material is suitable for the products listed:

(i) **Unbleached recycled paper pulp- egg boxes**

- Unrefined material is inexpensive to manufacture. Important in a mass-produced item such as an egg box.
- Will degrade naturally if disposed in landfill (won't damage the environment)
- Lack of processing produces less harmful bi-products that could damage the environment
- Can be moulded into the egg shape required with the addition of a water-based adhesive.
- Accept references to recycling (can be recycled)
- Etc

(ii) **Corrugated card- fragile glass packaging**

- Corrugations provide some shock absorbency. Protects from minor impacts.
- Will flex so can be 'moulded' around product.
- Will biodegrade or burn easily (important in a short lifecycle product that could damage the environment)
- Can be printed on e.g. recycling logo
- Etc

(iii) **Expanded polystyrene- Fast food packaging**

- Insulation properties so food can be kept warm.
- Food grade, non -toxic polymer so safe to eat from.
- Can be **injection** moulded into a suitable shape to hold food.
- Can be recycled- important in a short lifecycle product.
- Will crush-minimising space in bins, etc.
- Etc

(iv) **Laminated card- drinks carton**

- Will crush so minimises space in bins, etc after disposal.
- Uses less material than bottles so cheaper to manufacture and better for the environment.
- Lamination makes the card waterproof so it can contain the liquid
- Can be printed on easily- good for aesthetics/brand identity etc.
- LDPE film used to laminate card is non toxic- so safe to use with drink.

(v) **Glass- Drinks bottles**

- Available in a variety of colours or transparent so contents can be seen.
- No taste to glass so flavour of contents not spoiled
- Non toxic- safe to contain drinks
- Can be blow moulded into shape
- Recyclable
- Can be sterilised for re-use.

(vi) **Aluminium- baking foil**

- Reflective surface protect food from heat, prevents burning.
- Insulates and keeps food warm or conducts heat to speed up cooking
- Can be made in a very thin gauge so that it can fold easily for food wrapping.
- Very malleable- can be wrapped around food easily.
- Non toxic

Breakdown:

1-2 marks per relevant point.
(2 marks where point or statement is qualified i.e. property is linked to product function etc).
Max 2 marks if generic list of properties. *(6 × 4 marks)*

(b) Candidates will give **two** reasons why manufacturers are trying to reduce packaging in products

Reasons include:

- To reduce manufacturing costs
- To reduce volume of waste to landfill
- To reduce transportation costs
- Government legislation regarding packaging waste
- To portray a greener image for the company.
- Etc *(2 × 2 marks)*

Breakdown:

1-2 marks per relevant point
2 marks when explained

4 (a) Suitable metal for the sculpture include:

- Mild steel
- Stainless steel
- Galvanised steel
- Aluminium
- Cast iron
- Bronze
- Copper
- Brass
- Cor-Ten (Weathering Steel)
- Etc

Breakdown:

Material would work but not quite suitable (1 mark)

Correct suitable material (2 marks) *(2 marks)*

(b) Candidate will explain why the material is suitable, linking properties of material to function, aesthetics, manufacture, etc.

e.g. Mild steel

- Available in thick plate form- ideal for manufacture of sculptures, which will need to resist weathering/vandalism, etc.
- Inexpensive material compared to stainless steel. Large-scale sculpture could be expensive to make.
- Can be flame cut/laser cut to make the design & lettering

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

Max 3 marks if generic list of properties. *(6 marks)*

(c) (i)

- Candidate will describe how the silhouette pattern on the sculpture is manufactured

- Possible methods include:

- Flame cutting

Using oxy-acetylene bottles with flame cutting torch.
Design can be drawn out with chalk and then cut using the flame-cutting torch. The mixture of acetylene and oxygen generates heat in excess of 1200°C-sufficient to burn steel plate. The fine nozzle on the torch allows for fine detail to be cut.
Following Oxy-acetylene flame cutting, the edge would be rough and so it would need grinding to finish it and remove burrs.

- Plasma cutting

Plasma cutting uses an electric arc to generate heat. This is combined with either compressed air or an inert gas such as argon to blast through the material. Operator may use a pattern to run the gun around to ensure accuracy.

- Laser Cutting

Laser cutting uses a highly concentrated light beam to generate heat. This is combined with an inert gas such as carbon dioxide to blast through the metal.(The design would be drawn on CAD/CAM software and converted into a CNC programme to guide the laser).

- Cutting individual parts using CNC Milling machine and fabricating

- Casting e.g. aluminium or iron, etc.

Preparation of sand moulds. Possible reference to cope/drag. Use of runners and risers. Melting of metals in a crucible, de-gassing, etc.

- Accept cutting individual parts with ‘nibbler’ metal cutting jigsaw, etc. then welding.

Do not accept ‘punching’ or piercing and blanking of the whole sculpture as one piece but accept punching for individual parts

Breakdown:

- Basic description of a suitable manufacturing process with a limited number of points. Basic diagram or no diagram at all but reasonable notes. **(1 mark for stating correct process)**

(1 – 3 marks)

- Better description of a suitable manufacturing process with several points but not fully explained. Good diagrams used to describe process, possibly one or two details missing.

(4 – 6 marks)

- Detailed description of a suitable manufacturing process supported with good quality, correctly labelled diagrams.

(7 – 9 marks) *(9 marks)*

(ii) Candidates will explain why the process described in part (i) is suitable.

E.g.

Flame cutting

Can be done by hand or CNC controlled.
Can be done in a craft workshop without need for expensive CNC or dedicated equipment- ideal for one- off sculpture. **Or…**

Plasma cutting

Easy to follow a pattern clamped over work piece.
Uses a 'gun' which will not arc until the trigger is pulled. This allows for accurate placement of the gun. A fine cut is achieved so little or no finishing/de-burring is required. Plasma cutting can be done by hand or CNC controlled. CNC would allow for repeatability. **Or…**

Laser cutting

Produces a very fine cut so fine detail can be achieved. Laser cutting is done by CNC machines for consistent quality.
Laser can be programmed to cut/engrave a variety of materials and any number of different designs.

Casting

Allows for creation of intricate shapes that are difficult to cut.
Repeatability with the use of wooden/ GRP patterns. etc

Breakdown:

1-2 marks per relevant point.
(2 marks where point is qualified).
Give a further mark for in depth explanation of a point *(3 marks)*

(d) Candidates will use notes and diagrams to give suitable description of the finishing materials and the method of application. process E.g.

- Sharp points/burrs etc are removed with an angle grinder and files
- All metal parts are chemically cleaned (e.g. in an acid pickle) to remove grease, carbon deposits and oxidisation.
- All metal parts are then galvanized by dipping them in a molten bath of zinc (approx 450 to 460 ˚C). This forms a mechanical-barrier with a non-ferrous metal, helping to prevent the mild steel-corroding.
- Once cooled, the metal can then be primed with a zinc/metal oxide based primer. This can be applied by air gun spray method, dipping or by brush.
- After drying top coat(s) of colour are applied. This might be a suitable exterior grade paint such as 'Hammerite' or other oil or cellulose based paint. This would be applied by spray or brush.
- 2 - 3 coats of paint are required.

Alternative finishing methods might include:

- Powder coating (Product given an electric charge. Paint is also charged and sprayed onto product. Followed by low temperature bake to harden paints)
- Dip coating with LDPE powder, etc.
- Sheradizing (Electric spray transfer of zinc based coating)
- Etc.

Breakdown:

- Very basic diagram and description e.g. "sculpture dipped in zinc and then painted with paint using a brush".
  (1 – 3 marks)

- Better diagrams with some attempt to describe the process in a logical order. Some errors or detail missing.
  (4 – 6 marks)

- Good diagram & description of the process given using the correct terminology.
  (7 – 8 marks) *(8 marks)*