



General Certificate of Education

Design and Technology: Product Design 5551/6551

PD1D Materials and Components

Mark Scheme

2006 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.

Design and Technology: Product Design

3D Design Unit 1 (PD1D)

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
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

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.

Question 1

- (a) (i) • **Catamaran**

Accept Polypropylene (PP), High Density Polyethylene (HDPE), Acrylonitrile-butadiene-styrene (ABS), or Glass Reinforced Plastic (GRP) / Carbon Fibre Reinforced Polymer (CFRP).

Do not accept HIPS, Acrylic, PVC or PVCu.

- **CD Rack**

Accept laminated beech, birch or other suitable wood veneer.

Accept flexi-ply or laminated plywood.

Accept steam bent hardwood such as ash, etc

(1 mark for 'plywood')

(1 mark for ash, beech etc)

- **Shopping centre bench**

Accept mild steel/stainless steel or aluminium sheet for the seat.

Accept cast aluminium or cast iron for the leg section.

Breakdown

1 mark if material is correct but not specific e.g. 'steel'.

1 mark for list of correct materials.

1 mark if material would work but not entirely appropriate.

2 marks for correct specific material.

(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.

- **Catamaran**

Requires a thermoplastic that can be blow moulded or rotationally moulded such as PP, ABS, etc. or one suitable for lay-up techniques e.g. GRP.
Needs a polymer that is lightweight so that the boat can be carried.
Needs a material that is waterproof as the boat is immersed in water.
Needs a polymer that is impact resistant to take minor bumps misuse.
Needs a durable polymer that can withstand being left out in sunlight/weather.
Polymers are self-finishing, needs little maintenance, etc.

- **CD Rack**

Hardwood veneers such as beech are thin and pliable. They can be stretched over a former without splitting.
Hardwood veneers will absorb adhesive necessary for laminating.
Laminating veneers together gives good mechanical strength without the need for thick, heavy materials that would be costly and look unsightly.
Attractive grain pattern and colour giving aesthetic appeal.
Slots for CD can be machined and material doesn't split like some softwoods.
Can be finished by sanding and applying a polyurethane varnish/stain, etc.

- **Shopping centre bench**

Perforated mild steel plate etc is ductile and malleable. It can therefore be press formed into shape without tearing or creasing.
Steel sheet once bent will have the mechanical strength to support people sitting on the bench and withstand misuse such as people standing on it.
Perforated mild steel plate can be welded easily to the leg structure.
Mild steel plate is a hard material and will withstand misuse.
Perforations in the material deter graffiti and make it easier to spot suspect packages etc left underneath.
Mild steel is widely available and in sheet form is relatively inexpensive compared to other materials such as hardwoods or more exotic metals, etc.
If reference to cast legs, candidate will recognise suitable melting point for metals used e.g. aluminium has a low melting point of 650 to allow for ease of die casting, availability of metal, etc.
Stainless steel / aluminium resists corrosion

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 3 marks if generic list of properties.

(2 × 6 marks)

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

- **Catamaran**

Accept blow moulding or rotational moulding for PP etc.
Accept injection moulding (as some of the parts could be).
Accept lay-up/resin techniques for GRP etc
Do not accept vacuum forming.

- **CD Rack**

Accept laminating process similar to that described below:

Wood veneers are cut to size and a former is prepared.
Candidates may refer to wetting or steaming the veneers to make more pliable. (Plywood does not require steaming).
Inside surface of veneers is coated with an adhesive such as synthetic resin such as Cascamite or a waterproof PVA.
Veneers are sandwiched together and laid over the former.
A bag press or a split former is used to clamp the veneers.
The laminated veneers are allowed to dry for 24 hours or so and then the product is removed from the formers or bag press.
The slots for the CDs would be machined and the excess veneer trimmed off.
The finished item would then be sanded and a suitable finish applied.

- **Shopping centre bench**

Accept press forming of seat. Expect diagrams of simple male/female dies.
Possible reference to punching/piercing and blanking – perforations in plate.
Accept sand casting/die casting for manufacture of legs.
Possible reference to joining seat to legs e.g. with machine screws, welding, etc. Possible reference to finishing process.
Accept fabrication / welding of legs / frame

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) (i) Candidates will name **one** material that has **one** of the mechanical properties listed.

E.g. Malleability – Mild steel, copper, aluminium, tin, brass, etc.
(not polymers unless heated to soften)

Elasticity – Rubber, silicon-rubber, neoprene, plastazote, etc.

Hardness – Stainless steel, High Speed Steel, titanium, etc.

Breakdown

Material and property required for 2 marks

1 mark for material but unclear which property it relates too.

1 mark for list when one answer in list is incorrect.

(2 marks)

- (ii) Candidates will explain how the property affects the use of the material. They may refer to manufacturing or how the property affects the use of a product the material is made into.

- **Malleability**

E.g. Copper. Malleability in copper makes it an ideal material to shape by rolling, forging or extruding. The metal can be shaped under pressure without the surface cracking. Copper is often made into electrical wire. Its malleability is needed so that the wire can be coiled up and it will not fracture. Other malleable materials include mild steel, aluminium, gold, tinplate, etc.

- **Elasticity**

E.g. Natural rubber (NR). Elasticity allows a material to be stretched in tension but will return to its original shape when the force is released. Polyisoprene used in tyres, fenders etc or styrene-butadiene rubber (SBR) also used in tyres. Rubber used in tyres will flex as the tyre goes over curb stones and bumps in the road and it will stretch over a wheel rim to allow the tyre to be fitted to a wheel but return to its original shape, preventing the tyre coming off. Polychloroprene rubber (CR) or Neoprene used in diving suits, etc. Neoprene used in diving suits allows the diver to swim easily because the material stretches with the movement of limbs.

- **Hardness**

E.g. Stainless steel. Hard materials resist scratches and indentations from surface impacts. Hard materials such as stainless steel are difficult to machine with standard HSS cutting tools. Hardness in stainless steel makes it ideal to make kitchen sinks, cooking utensils etc as scratches in such products make them difficult to keep clean. Hardness of some metals can be increased by heat treatment. Other hard materials include: High Speed Steel, Diamond, Tungsten-Carbide, Oak, etc.

Breakdown

1 – 2 marks per relevant point. **Maximum 4 marks**

If three properties described mark all three and award highest mark for one of the answers (Rubric Rules).

(4 marks)

Total 40 marks

Question 2

- (a) Definition of a composite material e.g.

“Composites are produced by combining or bonding together two or more different materials in order to enhance and utilise the properties of each in a new material”

Breakdown

Basic definition. Maybe incomplete . (1 – 2 marks)

Better definition with reference to mixing or bonding two or more materials, possible reference to improved properties. (3 – 4 marks)

(4 marks)

- (b) Suitable reasons given for composites being better than parent material e.g.

“Composites often have a higher strength and less weight than their traditional parent materials alone. Composites can often be formed or moulded into useful products, difficult to make from traditional materials”.

(3 marks)

- (c) Candidates are expected to give reasons why each material is suitable for the products listed. Better answers will link the material properties to product function/use, manufacturing method, etc.

- (i)
- Kevlar**
- body armour/protective clothing.

Kevlar is a polymer based material that has a tightly woven structure that under a microscope resembles a goal keeper’s net. This structure gives it very good ballistic resistance. It has good tensile strength and high tear resistance making it resistant to knife cuts, etc. Kevlar has a high resistance to heat making it excellent for use in fire fighter’s clothing, etc. Kevlar, weight for weight is many times stronger than steel making it a lightweight material ideal to manufacture body armour, gloves, jackets etc from. It can be combined with other polymers to make solid objects such as military helmets, etc.

- (ii)
- CFRP**
- racing bikes.

CFRP is available in a woven mat or ribbon and can be laminated with epoxy or polyester resin to make monocoque frames. Such frames can be made thinner and more aerodynamic than tubular frames. It is much lighter than steel or aluminium traditionally used in bike frames but has similar mechanical strength. Can take mechanical fixings e.g. screws, bolts etc. CFRP frames can be custom made as it is easy to change the moulds to suit individual riders. Does not require expensive tooling up. CFRP can be joined using adhesives (easier than welding with metals).

(iii) **Laminated chipboard** – kitchen work surfaces.

Chipboard laminated with a paper printed with a design and encapsulated in melamine formaldehyde (MF) resin. MF is a thermoset so is heat resistant – ideal for hot saucepans etc. MF is a hard material so will withstand impacts and abrasions from equipment used in kitchens. MF is waterproof so protects the chipboard from spillages etc. Laminated paper is coloured and printed with a design to give effects such as stone, beech blocks and so on in order to match desired interior. Can be cut easily with jig-saw to fit sink, etc. More readily available and less expensive than genuine hardwoods or stone worktops. Easier to cover a large surface area than joining pieces together.

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 3 marks if generic list of properties.

(3 × 7 marks)

Total 28 marks

Question 3

- (a) Suitable applications include: (not exhaustive)
- (i) Furniture e.g. table tops, shelves, interior design projects, mould making, model making etc.
- (ii) Blister packs e.g. for screws, nails etc. Food packaging, drinks cups, toys etc.
- (iii) Nails, screws, hinges, etc for outdoor applications. Gates, farm equipment, barbed wire fences, buckets, security fencing, etc.
- (iv) Model making, mould making, thermal insulation etc (not packaging). (4 × 1 mark)
- (b) Properties of each material should be linked to the function/use/manufacture of the products given by the candidate.
- (i) **MDF**
- Flat stable material. Does not warp, twist, cup, split like natural timber providing a good platform for veneers, paints etc.
 - Relatively soft – can be shaped easily with hand tools, sanded, etc.
 - Inexpensive compared to natural timber.
 - Available in long, wide boards, ideal to cover large areas such as table tops.
 - Machines well, e.g. can be routed or cut with jig-saws etc without splitting.
 - Etc
- (6 marks)
- (ii) **HIPs**
- Thermoplastic necessary for vacuum forming, thermoforming, blow moulding or injection moulding used in packing etc.
 - Recyclable – important environmental factor for packaging industry.
 - Can be transparent so products can be displayed through blister pack, etc. Or opaque colour to enhance aesthetics.
 - Food grade polymer – so safe to drink from or contain foodstuffs.
 - Widely available polymer and when manufactured in bulk, products can be very inexpensive.
 - Impermeable – necessary to contain drinks, etc.
- (6 marks)

(iii) **Galvanised mild steel**

- Mild steel widely available ferrous metal – therefore inexpensive compared to stainless steel etc.
- Suitable mechanical strength, hardness etc for applications such as nails, hinges, etc.
- Mechanical barrier formed by zinc prevents corrosion of mild steel.
- Mild steel can be cast, machined, fabricated etc to form a wide range of products.

(6 marks)

(iv) **Styrofoam**

- Very soft so can be shaped with simple hand tools, glass paper etc.
- Available in a denser form to enable machining e.g. by CNC router.
- Available in a variety of thicknesses, useful to build up moulds etc.
- Can be cut with hot wire cutter for model making.
- Can be glued with PVA to enable joining together of parts.
- Can be sealed with polyfiller/car body filler and then spray painted.
- Good thermal insulation properties.

(6 marks)

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 3 marks if generic list of properties

(Do not double penalise)

(4 × 6 marks)

Total 28 marks

Question 4

- (a) Expect description of materials used in sun sculpture and ornamental cat and their method of manufacture. Best answers will link properties to the product function/use, manufacturing method, finishing, etc rather than just a description of what candidates see. Answers may be bullet pointed.

Sun sculpture

- Made from close grained hardwoods, good for carving e.g. cherry.
- Made from a suitable timber such as cedar, oak, teak, etc which have good durability qualities. (Withstand weathering processes).
- Hardwood such as oak etc tend to have an attractive grain pattern, giving the sculpture good aesthetic qualities.
- Hardwoods can be cut and carved with hand tools to the desired shape. Expensive specialist equipment is not required.
- Generally hardwoods such as oak etc, can be cut, carved etc more successfully than softwoods which tend to split and break off with short grain, knots, etc.
- Hardwoods can be sanded, stained and treated with oils and preservatives to enhance the aesthetics of the product and prevent decay. A better finish is achieved with hardwoods which are less resinous and have a finer grain than many softwoods.
- Reference to use of gouges, chisels.
- Round face could be turned on lathe
- Face glued to a back with sun rays cut using coping saw, bandsaw, files, etc

Ornamental Cat

- Made from sheet metal such as mild steel, 'tin plate' or aluminium, and wire.
- Sheet metals are of thin section or gauge which can be bent easily to form the shape of the cat.
- Sheet mild steel, etc are malleable and ductile so they can be bent over formers, beaten with a mallet and sandbag etc to form the shape.
- Edges of the sheet are rolled over to make a safe edge. Properties of ductility and malleability allow this.
- If mild steel or tin plate is used, it can be spot welded or seam welded together to fabricate some of the parts.
- Such sheet metals are widely available, (potential for recycling waste sheet off-cuts, tin cans etc into ornament).
- Finished with acrylic paints, possibly primed first to give better paint adhesion. Colour adding value to the product but an expensive and time consuming process if done by hand.
- Use of tin snips, files etc to cut shape out.
- Use of formers, stakes etc to shape sheet
- Brazing or welding. Accept soldering.

Breakdown

- Basic answer with reference to generic materials and or properties.
1 – 4 marks
- Better answer with reference to specific materials and properties and some details of manufacture.
5 – 8 marks
- Good answer with specific materials, reference to properties linked to function, manufacture etc. Good reference to manufacturing process.
9 – 12 marks

(2 × 12 marks)

(b) Suitable description of a finish used on the sculpture or ornamental cat.

E.g. Sculpture – Teak Oil or similar to “feed” the wood, prevent it drying out, maintain colour of the timber, etc but will allow timber to swell and contract with changes in humidity. Teak oils soaks in, protecting the timber and doesn’t flake off. Applied with a cloth to rub into grain. Accept polyurethane varnish/yacht varnish or trade named wood preservative. Could be scorched and wire brushed.

E.g. Cat – Enamel or acrylic paints. Possibly primed with a suitable acrylic primer to provide a key/base colour and prevent corrosion. Top coats applied with brush or spray for speed. Fine brush for detail. Maybe coated with a lacquer to give a clear, hard coat which protects the paint. Possible reference to spirit or oil based paint. Cellulose based paint, etc. Accept enamelling.

Breakdown

Specific finish named e.g. polyurethane varnish
(1 – 2 marks)

Specific finish named with some description of application method or how / why it enhances aesthetics/protects product.
(3 – 4 marks)

Zero marks for “paint”, “varnish”. However candidate may pick up marks for description of application or explanation of how it enhances/protects product. (4 marks)

Total 28 marks

Question 1:		40 marks
Question 2:	28 marks	
Question 3:	28 marks	
Question 4:	28 marks	
2 question 28 marks each		56 marks
Quality of written communication		4 marks
Paper total:		100 marks