Design technology Standard level Paper 2 Set B

1 hour 30 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- The maximum mark for the examination paper is [50 marks].

Answer all questions. Answers must be written within the answer boxes provided.

1. A student rides their bicycle to school and carries a backpack that must be worn on their back for the ride and carried between lessons. An IB design technology student designed a pannier that hooks onto a bicycle rack and converts into a backpack.



Figure 0: Examples of 'Panniers' which convert to backpacks on bicycles

Table 1: Extract from the student's design specification

Criterion	Essential	Desirable
1.1	Attaches and releases from the rack without tools	
1.2	Carries a 13 inch laptop, a lunch box and PE clothes	
1.3	Straps stow away completely when the bag is on the rack	
1.4	Conversion takes under 10 seconds	
1.5		Outer fabric made from recycled material

(a) State one user-centred research method the student may have used to understand how students carry bags to school, see Table 1. **[1]**

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(Question 1 continued)

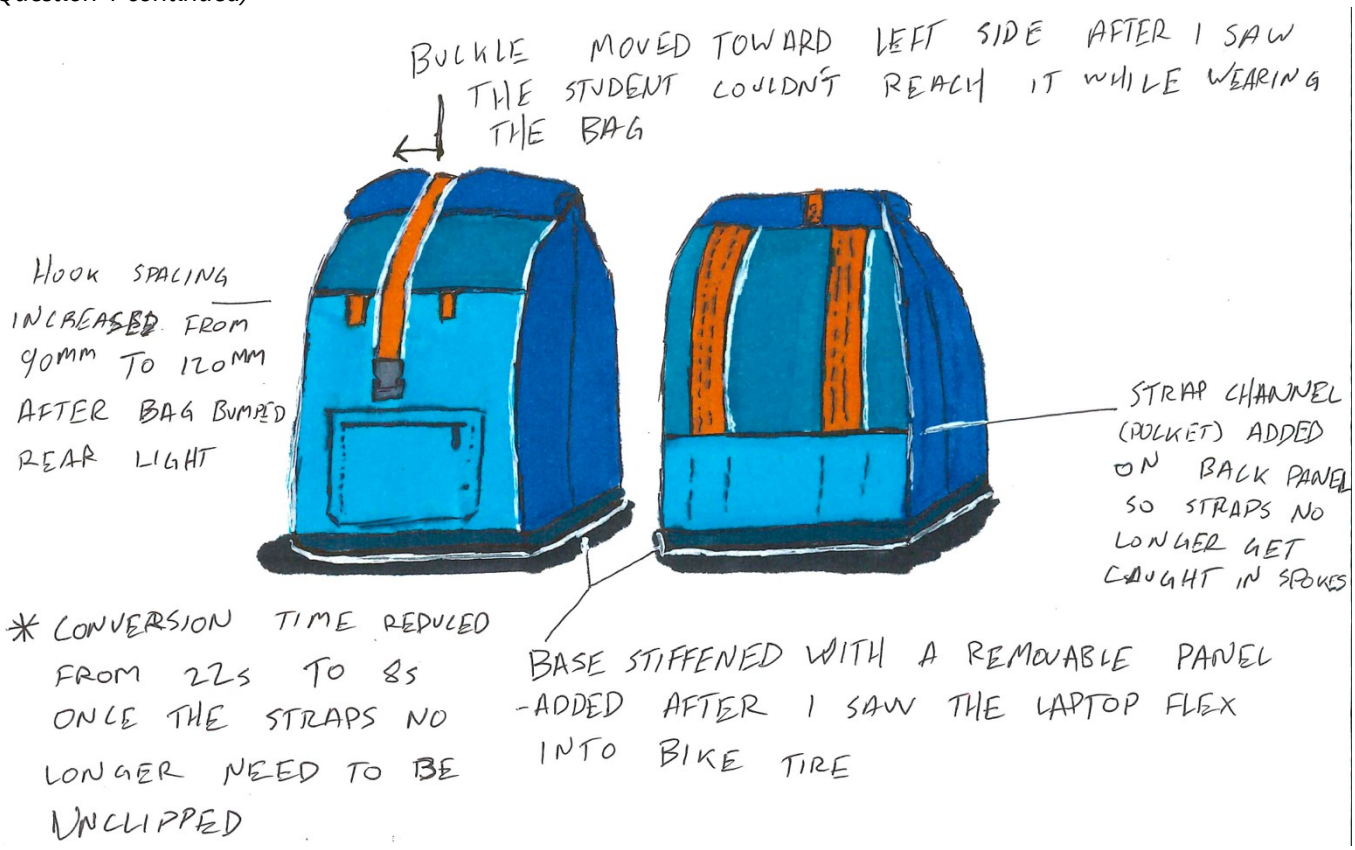


Figure 1: IB design technology student's CAD drawings produced during testing and refinement of the pannier

"Hook spacing changed from 90 mm to 120 mm after the bag bumped the rear light"
"Strap channel/pocket added behind the back panel after straps caught in the spokes"
"Buckle moved to the side after users could not reach it while wearing the bag"
"Base stiffened with a removable panel after the laptop flexed against the tyre"
"Conversion time fell from 22 s to 8 s once the straps no longer had to be unclipped"

(b) Describe one improvement to the pannier that resulted from the student's testing, see Figure 1. **[2]**

(c) Justify the student's decision to record the outer fabric requirement as desirable rather than essential, see Table 1. **[3]**

2. Alkaline batteries are sold by Duracell and Energizer in the same sizes to the same standard, so either brand fits any device. A rechargeable nickel-metal hydride cell fits the same sockets and can be recharged several hundred times.

Table 2: Three cells of the same size compared

	Alkaline, single use	**Rechargeable NiMH**	**Lithium, single use**
Nominal voltage	1.5 V	1.2 V	1.5 V
Purchase price	£0.50	£2.50	£1.60
Times usable	1	500	1
Self-discharge in storage	Low	Moderate	Very low
Performance below 0 °C	Poor	Moderate	Excellent
Mass	23 g	27 g	15 g

(a) State one chemical property that is relevant to the selection of a material for a battery casing, see Table 2. **[1]**

(b) Outline why recycling alkaline cells is more difficult than recycling a single-material product, see Table 2. **[2]**

(c) Evaluate the selection of a rechargeable NiMH cell rather than an alkaline cell for a low-power consumption wall clock in a classroom, see Table 2. **[3]**

3. In 1989 a designer watched his wife, who had arthritis in her hands, struggling to hold a metal vegetable peeler. The peeler had a thin wire handle that pressed into the palm and required a firm pinch grip.

The OXO Good Grips peeler that followed has a large oval handle in a soft rubber-like material, moulded with flexible fins along the sides. It is held in the whole hand rather than pinched. It was sold to the general market at a higher price than an ordinary peeler, not as a medical aid.



Figure 2: The OXO Good Grips peeler and a conventional wire-handled peeler, shown together

(a) State the inclusive design strategy demonstrated by the OXO peeler, see Figure 2. **[1]**

(b) Describe how the large oval handle reduces the force a user must apply, see Figure 2. **[2]**

(c) Explain why a product designed for users with limited hand strength was sold successfully to the general market, see Figure 2. **[3]**

4. Patagonia makes outdoor clothing. In 2011 it placed a full-page newspaper advertisement headed "Don't Buy This Jacket", which set out the water, carbon and waste cost of making the jacket pictured and asked readers to buy only what they needed.

The company runs Worn Wear, which repairs garments, sells repaired second-hand garments, and publishes repair guides so that owners can mend clothing themselves.

On right, Figure 3: The "Don't Buy This Jacket" advertisement, 2011



(a) State the dimension of the triple bottom line that the water and carbon figures in the advertisement address, see Figure 3. **[1]**

(b) Identify two responsibilities of the designer that Patagonia is acting on through Worn Wear. **[2]**

(c) Analyse the tension between a company asking customers to buy less and a company that must sell garments to survive, see Figure 3. **[3]**

5. The Instant Pot, launched in 2010, is an electric pressure cooker that also slow cooks, steams and makes yoghurt. Earlier stove-top pressure cookers had a reputation for scalding their users, and many households avoided them.

The Instant Pot will not begin to build pressure until the lid is locked, and will not release the lid until the pressure inside has fallen. It sold in very large numbers, and then sales fell as households found that one appliance had replaced several they already owned and did not need replacing again.



Figure 4: The Instant Pot, with the lid interlock and pressure release valve indicated

(a) State the designer responsibility addressed by the lid interlock, see Figure 4. **[1]**

(b) Outline how the interlock improves the usability objective of errors, see Figure 4. **[2]**

(c) Explain why strong early sales were followed by falling sales, using product analysis. **[3]**

6. The Framework Laptop is sold by a company that publishes a repair guide and a parts shop for every component it makes. The screen, keyboard, battery, memory and ports can each be replaced by the owner with one screwdriver, which is supplied in the box.

Most laptops of comparable size are assembled with adhesive and proprietary fasteners, and a failed battery or a cracked screen is repaired by an authorised centre or not at all.



Figure 5: The Framework Laptop with the keyboard lifted out and ports visible on the table

(a) Identify two strategies for a circular economy that the Framework Laptop applies. **[2]**

Each port is a small module that slides into one of four bays. An owner chooses which ports to fit and can change them later. A port module costs about £15.

(b) Outline one responsibility of the designer that is served by selling individual parts to anyone who asks. **[2]**

(Question 6 continues on the next page)

(Question 6 continued)

The chassis (frame) is machined from aluminium rather than moulded in a polymer. The company states that a chassis is expected to outlast several sets of internal components.

(c) Describe why a component that is expected to outlast the rest of the product may justify a more expensive material, see Figure 5. **[2]**

A Framework Laptop costs more to buy than a comparable sealed laptop. A sealed laptop is typically replaced when its battery or screen fails.

(d) Explain how the Framework Laptop reduces waste over its life compared with a sealed laptop, see Figure 5. **[4]**

7. In the late 1970s a designer became frustrated that his vacuum cleaner lost suction as its bag filled. He adapted an industrial cyclone, which separates dust from air by spinning it, and fitted the principle to a domestic cleaner.

Between the first idea and a working product he built 5127 prototypes over five years.

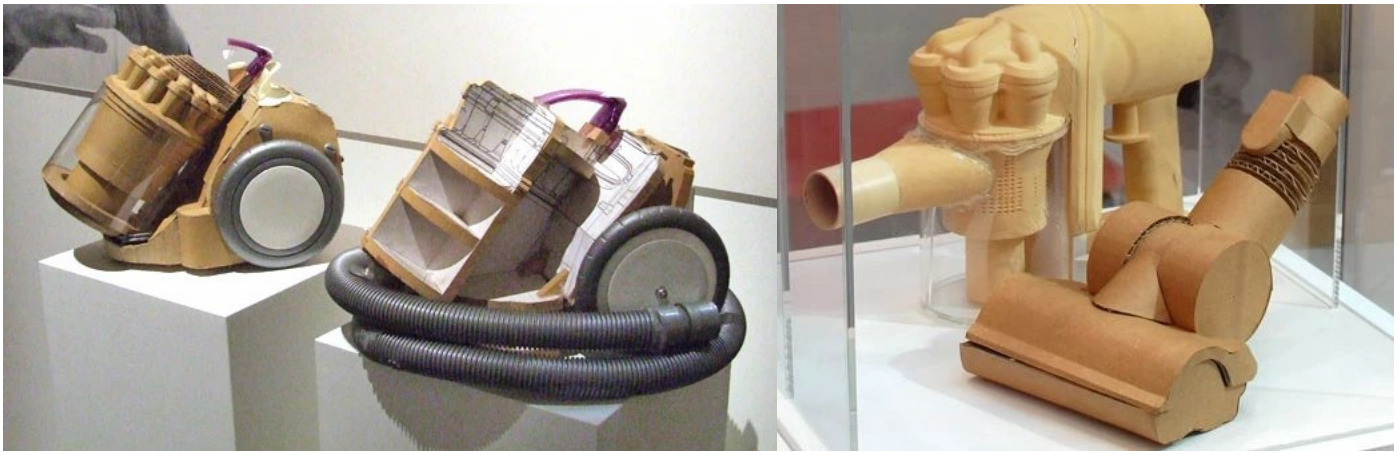


Figure 6: Dyson cardboard prototypes

(a) List two types of prototype the designer would have used across 5127 iterations. **[2]**

The problem was first written as "the bag clogs and the cleaner loses suction", and later rewritten as "the cleaner must maintain constant airflow as dust is collected".

(b) Outline why the second statement of the problem is more useful to a designer than the first. **[2]**

Most of the 5127 prototypes differed from the one before by a single change, such as the angle of a cone or the diameter of an inlet.

(c) Describe the advantage of changing only one feature between prototypes, see Figure 6. **[2]**

(Question 7 continues on next page)

(Question 7 continued)

No established manufacturer would licence the design, so the designer eventually manufactured and sold it himself. The cleaner reached market at roughly twice the price of a conventional cleaner and became the best selling cleaner in its market within two years.

(d) Evaluate the decision to bring the cleaner to market at twice the price of a conventional cleaner. **[4]**

Markscheme

Design technology Standard level Paper 2 Set B

Marking annotations

Annotation	Meaning	Annotation	Meaning
✓	Correct point (awards 1 mark, up to the maximum for the question part)	NAQ	Not answered question
✗	Incorrect point	NBOD	No benefit of the doubt
0	Incorrect response, awards zero	OC	Off course
A+	Analysis	REP	Repetition
B+	Balanced argument	SEEN	Point noted, no credit given
BOD	Benefit of the doubt	TV	Too vague
D	Description	WTTE	Words to that effect
EVAL	Evaluation	^	Caret, omission
GEXP	Good explanation		

Make sure you have looked at all pages. Put the SEEN annotation on any blank page to indicate that you have seen it.

Question		Answers	Notes	Total
1.	**a**	• Interviews ✓ • User observation ✓ • Surveys / questionnaires ✓ • Focus groups ✓ • Field research ✓ • Task analysis ✓	Award [1] for one relevant user-centred research method that may have been used to understand how students carry bags to school up to [1 max].	1
1.	**b**	• Hook spacing changed from 90 mm to 120 mm ✓ because the bag fouled the rear light ✓ • Strap channel added behind the back panel ✓ because loose straps caught in the spokes ✓ • Buckle moved to the side ✓ because users could not reach it while wearing the bag ✓ • Base stiffened with a removable panel	Award [1] for each detail, leading to an account of one improvement resulting from testing and refinement up to [2 max]. Credit the change and the reason for it. Do not award [2] for naming two changes with no reason.	2

Question		Answers	Notes	Total
		✓ because the laptop flexed against the tyre ✓ • Conversion time reduced from 22 s to 8 s ✓ by removing the need to unclip the straps ✓		
1.	**c**	Design specifications communicate the essential and desirable success criteria of a product. • An essential criterion must be met or the design has failed, so it constrains every later decision ✓ • Recycled fabric is not required for the pannier to perform its function ✓ • The function criteria 1.1 to 1.4 all affect whether the bag works; the fabric source does not ✓ • Recording it as essential could force the student to abandon an otherwise successful design ✓ • Supply of a suitable recycled fabric may be outside the student's control at school ✓ • Separating the two allows the student to prioritize when criteria conflict, for example between cost and material source ✓ • A desirable criterion still records the intention and can be met if circumstances allow ✓ • Testing against a desirable criterion is still possible, so the ambition is not lost ✓	Award [1] for each valid reason / piece of evidence justifying the classification of the fabric requirement as desirable up to [3 max]. Credit responses arguing from function, from feasibility, or from both. Award a maximum of [2] where the response does not distinguish essential from desirable criteria.	3
2.	**a**	• Corrosion resistance ✓ • Reactivity with the electrolyte ✓ • Resistance to oxidation ✓ • Chemical stability ✓	Award [1] for one relevant chemical property up to [1 max]. Due to wording, accept **flammability.** Do not credit physical or mechanical properties such as density or strength.	1
2.	**b**	A circular economy aims to recover and restore products, components and materials. • A cell contains several materials sealed together: steel, zinc, manganese dioxide and an electrolyte ✓ • The materials cannot be separated by hand, so the cell must be processed	Award [1] for each relevant brief point explaining why alkaline cells are harder to recycle up to [2 max].	2

Question		Answers	Notes	Total
		industrially ✓ • A single-material product can be identified, sorted and reprocessed directly ✓ • Mixed materials require shredding and chemical or thermal separation ✓ • Separation is energy intensive and recovers lower-value material ✓ • The electrolyte is hazardous, so the cell cannot enter a general waste stream ✓ • Cells are small and dispersed, so collection is harder than for a large product ✓		
2.	**c**	Materials are selected for specific applications based on their properties and on additional factors including cost. Strengths of the rechargeable cell: • 500 uses against one, so a single cell can serve the clock for many years ✓ • Cost per use is far lower than £0.50, so it is cheaper over the clock's life ✓ • Far fewer cells enter the waste stream ✓ • A classroom has mains power available for charging ✓ Limitations: • 1.2 V against 1.5 V, so the clock runs at a lower voltage than specified ✓ • Moderate self-discharge means a cell loses charge while the clock runs slowly over months ✓ • A wall clock draws very little current, so an alkaline cell may last a year or more anyway ✓ • The £2.50 purchase price is five times higher and must be paid up front ✓ • The cell must be removed and recharged, which requires someone to notice and act ✓ Judgment: • The low current draw weakens the usual case for rechargeables in this specific application ✓ • The environmental case remains, since a single rechargeable still displaces several alkaline cells ✓	Award [1] for each distinct strength / limitation, leading to an appraisal of the selection of a rechargeable cell for a classroom wall clock, up to [3 max]. Award a maximum of [2] where only strengths or only limitations are given. Credit responses that use values from Table 2.	3
3.	**a**	• Design for extremes ✓	Award [1] for the correct inclusive design strategy up to [1 max]. Do not credit adjustability, range of	1

Question		Answers	Notes	Total
			sizes or designing for the average user.	
3.	b	Physiology is the study of systems and biomechanics within the human body, their responses, limitations and capabilities. • A large oval handle spreads the reaction force over a larger area of the palm ✓ • Lower pressure at any one point reduces pain and allows a longer grip ✓ • A whole-hand power grip recruits more and stronger muscles than a pinch grip ✓ • The wire handle concentrated force on a narrow line across the palm ✓ • The soft material deforms to the hand, increasing the contact area further ✓ • The flexible fins increase friction, so less grip force is needed to stop slipping ✓ • A larger diameter needs less closing force to hold securely ✓	Award [1] for each detail, leading to an account of how the handle reduces the force the user must apply, up to [2 max]. Credit either the increase in contact area or the change from a pinch grip to a power grip.	2
3.	c	Designers often use a design for extremes strategy to develop solutions suitable for those with impairments which are also appropriate for the general population. • A solution for the hardest case is usually easier for everyone else ✓ • A peeler that needs less grip force is more comfortable for any user over a long task ✓ • The fins and soft grip reduce slipping when hands are wet, which affects all users ✓ • Fatigue affects everyone, so lower required force benefits the whole population ✓ • It was sold as a better peeler rather than as a medical aid, so no user is marked out ✓ • Buyers do not have to identify themselves as needing an adjustment in order to benefit ✓ • The higher price was accepted because the product was visibly better, not because it was specialized ✓ • The design is now the normal form for a peeler, which shows the mainstream market accepted it ✓	Award [1] for each relevant reason / cause explaining the general-market success of a product designed for limited hand strength up to [3 max]. Award a maximum of [2] where the response does not identify the design for extremes principle.	3

Question		Answers	Notes	Total
4.	a	• Planet / environmental ✓	Award [1] for the correct dimension of the triple bottom line up to [1 max].	1
4.	b	A designer has a responsibility to the needs of clients, their community and the environment. • Responsibility to the environment, by keeping garments in use ✓ • Responsibility to the user, by making repair possible after purchase ✓ • Responsibility to the community, by publishing repair knowledge freely ✓ • Responsibility to reduce consumption of materials and energy ✓ • Responsibility to design products that can be repaired at all ✓	Award [1] for each relevant designer responsibility identified up to [2 max]. Do not credit two statements of the same responsibility.	2
4.	c	Designers make decisions by considering the balance between the three Ps of the triple bottom line. • The advertisement reduces sales of the item pictured, which is a direct commercial cost ✓ • A company with no revenue cannot fund repair programmes or environmental work ✓ • The two aims are in genuine conflict, not merely in apparent conflict ✓ • The message builds trust, and trust raises long-term sales, so the conflict is partly resolved commercially ✓ • Selling fewer but more durable garments at a higher margin is a different business model, not a smaller one ✓ • Repair and resale generate revenue from garments already sold ✓ • The company is credible only while it accepts some real cost; a costless gesture would be greenwashing ✓ • The tension is permanent and is managed rather than removed ✓	Award [1] for each distinct guiding element / structure identified in the tension between reducing consumption and remaining viable up to [3 max]. Award a maximum of [2] where the response treats the conflict as fully resolved by increased brand loyalty.	3
5.	a	• It is a designer's responsibility to ensure their products are safe to use ✓	Award [1] for the correct designer responsibility up to [1 max].	1
5.	b	The five usability objectives are learnability, efficiency, memorability, errors and satisfaction. • The user cannot start the cycle with the lid unlocked, so the error cannot be	Award [1] for each relevant brief point on how the interlock serves the errors objective up to [2 max]. Credit responses that distinguish	2

Question		Answers	Notes	Total
		made ✓ • The user cannot open the lid while pressure remains, so the scalding error is prevented ✓ • The error is designed out rather than warned against ✓ • The protection works regardless of the user's experience or attention ✓ • It does not depend on the user reading or remembering an instruction ✓ • A user who has made no error has no error to recover from ✓	preventing an error from warning about one.	
5.	**c**	Product analysis and evaluation examines product performance to determine strengths and weaknesses and identify improvement opportunities. • The product replaced several appliances, so one purchase removed the need for further purchases ✓ • A durable appliance is not replaced until it fails, and it does not fail quickly ✓ • The market reached saturation once households that wanted one had bought one ✓ • Early sales were driven by households switching from stove-top cookers, a one-time transfer ✓ • There was no consumable or subscription to generate repeat revenue ✓ • Later models offered little reason for an existing owner to upgrade ✓ • A product that succeeds by lasting and by replacing other products limits its own repeat market ✓	Award [1] for each relevant reason / cause explaining the pattern of sales up to [3 max]. Credit responses that identify the conflict between product durability and repeat sales.	3
6.	**a**	Designers can eliminate waste through longevity, upgradability, disassembly and dematerialization, and recover value through reuse, repair, recondition and recycling. • Design for disassembly, since every part is removable with one screwdriver ✓ • Design for repair, since parts are sold to any owner ✓ • Design for longevity, since the chassis outlasts several sets of components ✓ • Design for upgradability, since components can be improved rather than replaced wholesale ✓	Award [1] for each relevant circular economy strategy identified up to [2 max]. Do not credit recycling alone, which the case does not describe.	2

Question		Answers	Notes	Total
		• Reuse, since a removed part remains usable ✓		
6.	b	A designer has a responsibility to the needs of clients, their community and the environment. • Responsibility to the user, who can keep a product working rather than replace it ✓ • Users are not dependent on an authorised repair centre or its pricing ✓ • Independent repairers can work on the product, which supports local employment ✓ • Responsibility to the environment, since a repaired product is not discarded ✓ • It removes the manufacturer's ability to end a product's life by withholding parts ✓ • It anticipates right-to-repair regulation rather than resisting it ✓	Award [1] for each relevant brief point on the responsibility served by an open parts supply up to [2 max].	2
6.	c	Materials are selected for specific applications based on their properties and on additional factors including cost. • The chassis is used across several generations of internal components ✓ • Its cost is therefore spread over a much longer service life than a component's ✓ • Cost per year of service is low even though purchase cost is high ✓ • Aluminium resists the repeated opening and closing that a repairable product receives ✓ • A polymer chassis would wear at screw bosses and hinges before the chassis was due for replacement ✓ • A chassis that failed early would end the life of all the working parts inside it ✓ • Aluminium is itself recyclable at end of life, unlike a filled polymer ✓	Award [1] for each detail, leading to an account of why a long-lived component justifies a more expensive material, up to [2 max].	2
6.	d	A circular economy is a closed-loop system where resources are continuously repurposed. Component replacement rather than product replacement: • A failed battery or screen ends a sealed laptop and is a £15 to £100 part on a Framework ✓ • The remaining components stay in use rather than being discarded with the	Award [1] for each relevant detail / reason / cause relating to how the Framework Laptop reduces waste over its life up to [4 max]. Award a maximum of [3] where the response does not compare the two products over a full service life. Credit	4

Question		Answers	Notes	Total
		failed one ✓ • A laptop contains a mainboard, display, metals and a cell, all of which survive one failure ✓ Longevity: • The chassis outlasts several sets of components, so the largest single part is reused ✓ • Upgrading rather than replacing extends the life of a product that still works ✓ Access to repair: • Parts sold to anyone means repair does not depend on an authorised centre ✓ • A supplied screwdriver and a published guide remove the skill barrier ✓ • Adhesive and proprietary fasteners in a sealed laptop defeat repair even by someone willing ✓ Comparison over a life: • A sealed laptop replaced on first failure consumes a second complete product ✓ • The Framework consumes one chassis and a succession of small parts ✓ Limits: • The benefit depends on parts remaining available for the chassis's whole life ✓ • A higher purchase price must be recovered through actual repair, not merely the option of it ✓ • Machined aluminium has a higher manufacturing impact than a moulded chassis ✓	responses that identify a limit or a condition.	
7.	**a**	Prototypes can be developed at a range of fidelity for different purposes. • Low fidelity prototype ✓ • High fidelity prototype ✓ • Sketch model in card or foam ✓ • Working or functional prototype ✓ • Virtual or CAD prototype ✓ • Scale model ✓	Award [1] for each relevant type of prototype up to [2 max]. Do not credit two descriptions of the same type.	2
7.	**b**	The first step in solving a problem is to define it. • The first statement names a part, the bag, and so assumes a bag is present ✓ • A problem written around an existing component can only produce a better version of it ✓ • The second statement describes the	Award [1] for each relevant brief point explaining why the second statement is more useful up to [2 max]. The response must identify that the first statement embeds a solution for full marks.	2

Question		Answers	Notes	Total
		required performance, not the mechanism ✓ • Any solution that maintains airflow is admissible, including one with no bag ✓ • It states a measurable condition, constant airflow, which a solution can be tested against ✓ • It separates the symptom from the requirement ✓ • A wrongly framed problem limits the outcome however good the ideation that follows ✓		
7.	**c**	The design process is iterative, using repeated model-test-refine cycles. • A single change means any difference in performance has a single known cause ✓ • Changing several features at once makes the effect of each impossible to isolate ✓ • A failed change can be reversed without losing the gains already made ✓ • Each prototype builds on a known-good previous version ✓ • It produces a record of which variables actually matter ✓ • Each iteration is fast and cheap to build, so many can be made ✓ • It allows the designer to approach an optimum by steps rather than by guessing ✓	Award [1] for each detail, leading to an account of the advantage of a single change between prototypes, up to [2 max].	2
7.	**d**	Product analysis and evaluation examines product performance to determine strengths and weaknesses. Strengths of the decision: • The cleaner offered a benefit no competitor had, so it was not competing on price ✓ • A high price signals quality and performance to a buyer who cannot test the claim ✓ • Five years of development and self-financed manufacture had to be recovered ✓ • Higher margin on each unit funded the marketing needed to explain a new idea ✓ • No bags to buy meant the lifetime cost to the owner was closer to a cheaper cleaner than the purchase price suggests	Award [1] for each distinct strength / limitation, leading to an appraisal of the pricing decision, up to [4 max]. Award a maximum of [3] where only strengths or only limitations are given. Credit responses that reach a judgment supported by the market outcome.	4

Question	Answers	Notes	Total
	✓ Limitations: • It excluded buyers for whom price was the deciding factor ✓ • It invited established manufacturers to produce a cheaper competing version ✓ • An unknown brand asking a premium price carries a high risk of rejection ✓ • Retailers may be unwilling to stock an untested product at that price ✓ Judgment: • Becoming the best selling cleaner within two years indicates the price was accepted ✓ • The decision was sound because the product was genuinely different; the same price on a conventional cleaner would have failed ✓ • Pricing follows from the strength of the differentiation rather than from the cost of development ✓		
			50