

Product Design and Development (315367)

Model Question Paper — Set B · Model Answers

Q.1

a) Types (variants) of products in product development.

2 M

- Market-pull products** (generic) — start from a market need, e.g. sporting goods, furniture.
- Technology-push products** — start from a new technology, e.g. a new display or battery technology.
- Platform products** — built on an existing technology platform, e.g. consumer electronics, printers.
- Process-intensive products** — process decided early, e.g. snack food, paper, chemicals.
- Customised products** — variations of a standard design, e.g. motors, switches, batteries.
- High-risk, quick-build and complex-system products** — e.g. medicines; software; aircraft and automobiles.

(Any four, $\frac{1}{2}$ M each)

b) Product architecture and its types.

2 M

Product architecture is the scheme by which the functional elements of a product are arranged into physical chunks and by which the chunks interact.

Types: (i) **Modular architecture** — each chunk carries out one or a few functions completely; interactions are well defined (e.g. desktop computer). (ii) **Integral architecture** — functions are shared by many chunks / one chunk does many functions; interactions are ill defined (e.g. high-performance racing car body, mobile phone mainboard).

(Definition 1 M, types 1 M)

c) Design by evolution vs design by innovation.

2 M

Design by evolution	Design by innovation
Gradual, small improvements of an existing design over a long time.	Sudden, radical new design based on a new idea, discovery or technology.
Low risk, low cost; based on experience and feedback.	High risk and high R&D cost; needs research.
Example: bicycle, plough, bullock cart wheel.	Example: transistor, jet engine, touch-screen smartphone.

(Any two points, 1 M each)

d) Factors affecting DFM.

2 M

- Number of parts and complexity of the design.
- Material selection and its machinability / formability.
- Manufacturing process capability and available machines.

4. Tolerances and surface finish required.
5. Production volume (quantity).
6. Use of standard components; ease of assembly; cost of tooling.

(Any four, ½ M each)

e) Value engineering and its objectives.

2 M

Value engineering is an organised, function-oriented approach to obtain the required functions of a product at the lowest total cost, without reducing quality, reliability, performance or safety (Value = Function / Cost).

Objectives: (i) to reduce unnecessary cost of a product; (ii) to improve value — better function at the same or lower cost; also to simplify the product and use better materials / processes.

(Definition 1 M, two objectives 1 M)

f) Symbols used in QFD.

2 M

Symbol	Meaning	Weight
●	Strong relationship	9
○	Medium (moderate) relationship	3
△	Weak relationship	1
(blank)	No relationship	0
++	Strong positive correlation (roof)	
+	Positive correlation (roof)	
—	Negative correlation (roof)	
--	Strong negative correlation (roof)	
▲	Larger is better (maximise)	
▼	Smaller is better (minimise)	
⊙	Nominal is best (hit target)	

(Any four symbols with meaning, ½ M each)

g) SLA vs SLS.

2 M

Point	SLA	SLS
Raw material	Liquid photopolymer resin	Polymer powder (nylon PA12/PA11, TPU); metal powders in metal versions
Support structure	Needed; removed after printing	Not needed — loose powder supports the part
Surface finish	Very smooth	Slightly grainy / matt
Strength	Brittle, lower strength	High — functional parts

(Any two points, 1 M each)

Q.2

a) Concept classification tree.

4 M

A **concept classification tree** divides the whole space of possible solutions of a sub-problem into several distinct **classes**, and each class is further divided, so that the team can compare and choose promising branches. It is used in step 4 (explore systematically) of concept generation.

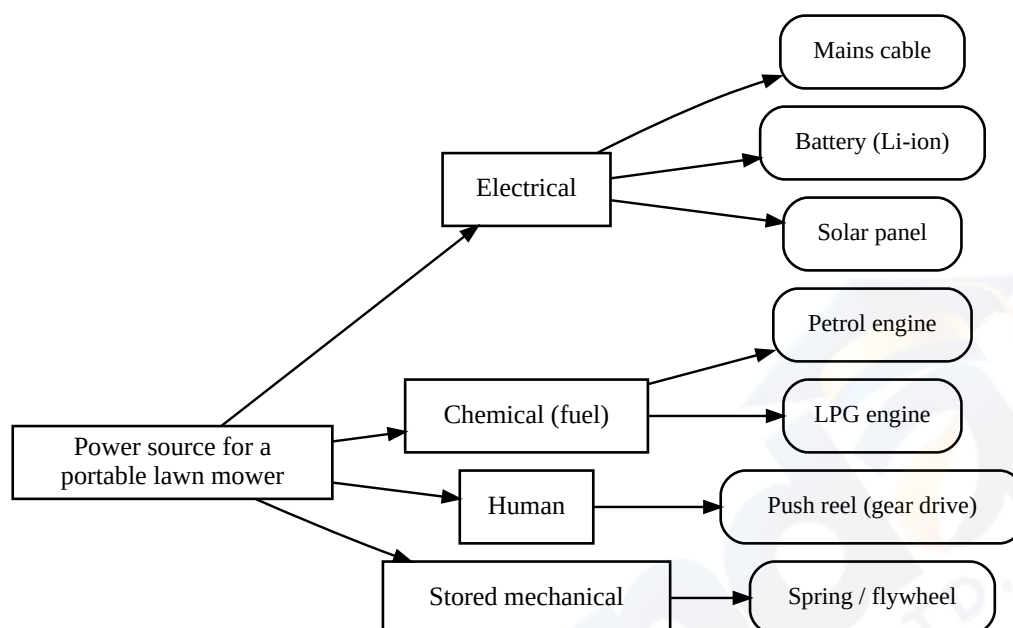


Fig.: Concept classification tree — power source of a lawn mower

Benefits: (1) pruning of less promising branches (e.g. spring / flywheel stores too little energy); (2) identification of independent approaches to the problem; (3) exposes wrong emphasis on some branches; (4) refinement of the problem decomposition for a particular branch.

(Meaning 1 M, example tree 2 M, benefits 1 M)

b) Modular vs integral architecture.

4 M

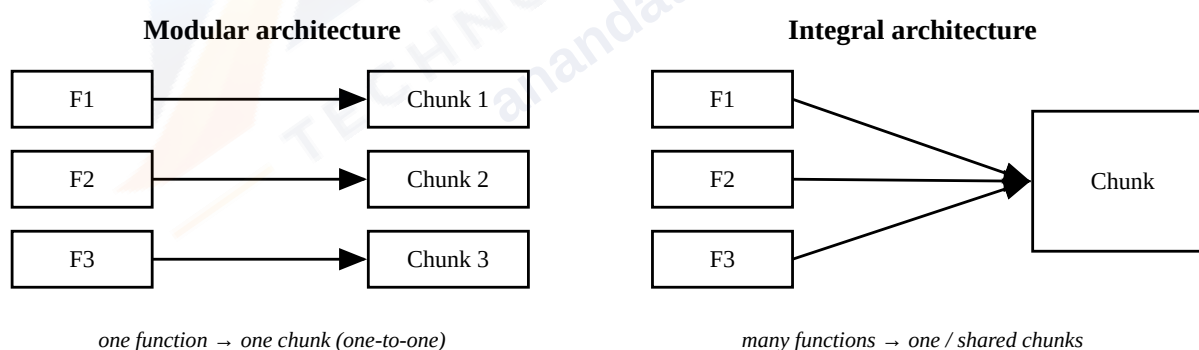


Fig.: Mapping of functional elements (F) to physical chunks

Modular architecture	Integral architecture
Each chunk carries out one or a few functional elements completely.	Functional elements are carried out by more than one chunk; one chunk may do many functions.
Interactions between chunks are well defined and simple.	Interactions between chunks are ill defined and complex.

A design change in one chunk does not affect other chunks; easy upgrading, repair and variety.	A change in one part affects many parts; difficult to upgrade or repair.
Allows standard components and parallel development of chunks.	Gives higher performance, lower size/weight and lower cost at high volume.
Example: desktop computer, trailer with separate box/bed/hitch, bicycle.	Example: Formula-1 car body, smartphone mainboard, aircraft wing.

(Any four points, 1 M each)

c) Design considerations for knob, lever and toggle switch.

4 M

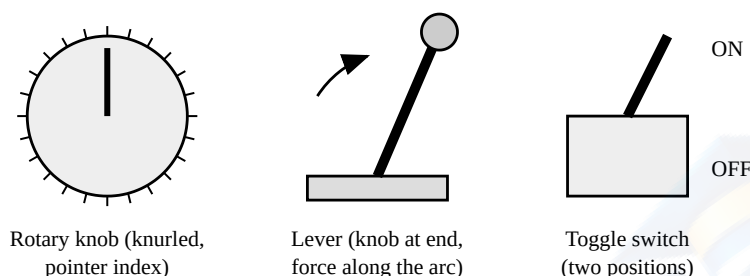


Fig.: Common hand controls

i) Rotary knob:

- Size (diameter) and shape suited to the torque — small for fingertip, larger for more torque; knurled or fluted edge for grip.
- Pointer / index line and scale for setting; detents (clicks) for discrete positions.
- Shape, size and colour coding to identify knobs by touch and sight; enough spacing between knobs to avoid accidental operation.
- Clockwise rotation to increase the quantity (movement compatible with the display).

ii) Lever:

- Length decided by force required — longer lever for higher force (mechanical advantage); knob or grip at the free end.
- Movement direction compatible with expectation: forward / up / right = increase or ON.
- Within normal reach and at elbow height; operating force within the limits of the hand / arm; locking device where needed.

iii) Toggle switch:

- Only two (or three) clear positions with positive snap action and visible / audible feedback.
- ON direction according to the accepted convention of the country or industry, marked with labels.
- Proper resistance and spacing; safety guard cover for critical switches to prevent accidental operation.

(Sketch 1 M, considerations 1 M each control)

d) Main elements and need of industrial design.

4 M

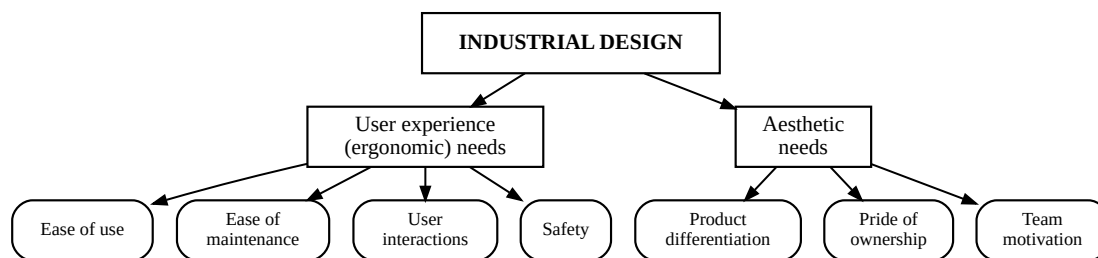


Fig.: Main elements of industrial design

A product needs industrial design (ID) when its success depends on **user-experience (ergonomic) needs** and **aesthetic needs**:

- **Ease of use** and **ease of maintenance** — features and controls must be easy to understand and service.
- **User interactions** — products with many or new interactions (e.g. a washing-machine panel) need more ID.
- **Safety** — all safety considerations must be seen from the user's point of view.
- **Product differentiation** and **pride of ownership** — appearance distinguishes the product in a crowded market and gives fashion / image value.
- **Team motivation** — an attractive design motivates the development team.

Thus ID improves usability, gives a corporate identity and increases sales.

(Block diagram 2 M, explanation 2 M)

Q.3

a) Characteristics of successful product development.

4 M

1. **Product quality:** how good is the product that results from development? Does it satisfy customer needs, is it robust and reliable? Quality is finally reflected in market share and the price customers will pay. Example: a refrigerator that cools uniformly and lasts 15 years.
2. **Product cost:** the manufacturing cost of the product (capital equipment, tooling and the cost of each unit). It decides the profit the firm makes at a given sales volume and price. Example: reducing the cost of a mixer motor by ₹100 at 1 lakh units saves ₹1 crore.
3. **Development time:** how quickly the team completed the development effort. Short time means quick response to competition and technology and faster economic returns. Example: mobile-phone makers launch new models every 6–12 months.
4. **Development cost:** how much the firm spent to develop the product (salaries, prototypes, testing, tooling). It is usually a significant part of the investment. Example: development of a new car model costs hundreds of crores.

(The fifth characteristic is **development capability** — whether the team and firm became better able to develop future products.)

(Each characteristic with example 1 M)

b) DFM with example of part-count reduction.

4 M

Design for Manufacturing (DFM) is a design approach in which the product is designed so that it can be manufactured and assembled easily and at low cost while meeting quality requirements. It is done by a cross-functional team throughout development. It mainly reduces the cost of components, the cost of assembly and the cost of supporting production.

Example — fan motor cover assembly:

Original design	DFM design
Sheet-metal cover in 2 halves + 6 screws + 6 washers + 2 brackets = 16 parts	One injection-moulded plastic cover with snap fits and moulded mounting bosses + 2 screws = 3 parts
Many operations: cutting, bending, drilling, painting; long assembly time	One moulding operation; colour in material (no painting); quick top-down assembly

Part count reduced from 16 to 3, i.e. by 81.2 %. Fewer part numbers mean lower assembly time, less inventory, fewer defects and lower cost.

(Explanation 2 M, example 2 M)

c) Roof ranking and body ranking in QFD.

4 M

Body ranking: the body of the House of Quality is the relationship matrix. Each relationship is given a weight ($\bullet$ 9, $\circ$ 3, $\triangle$ 1). The **technical importance** of each technical requirement = Σ (customer importance $\times$ relationship weight). The technical requirements are then **ranked** — the highest score shows where design effort and money must be spent first.

Roof ranking: the roof (correlation matrix) shows how the technical requirements affect one another: ++ / + (support each other) or - / -- (conflict). Negative correlations show **trade-offs**, which must be resolved by design decisions or new technology.

Electric iron (small example)

Direction of improvement		<div> <div>▲</div> <div>▼</div> <div>▲</div> </div>		
		Heater power (W)	Sole plate mass (g)	Thermostat accuracy
Customer requirements (WHATs) ↓ HOWs →	Importance (1–5)			
Heats quickly	5	●	○	
Light in weight	3		●	
Low electricity bill	4	○		●
Technical importance (absolute)		57	42	36
Relative importance (%)		42.2	31.1	26.7
Rank (body ranking)		1	2	3

Relationship: ● strong = 9, ○ medium = 3, △ weak = 1. ▲ maximise, ▼ minimise, ⊙ target.
 Roof: ++ strong positive, + positive, – negative, -- strong negative correlation.

Fig.: House of Quality — Electric iron (small example)

Body ranking: heater power = $5 \times 9 + 4 \times 3 = 57$ (rank 1); sole-plate mass = 42 (rank 2); thermostat accuracy = 36 (rank 3). Roof: heater power and sole-plate mass are negatively correlated — a heavier sole plate stores more heat but makes the iron heavier, so a balanced value is chosen.

(Body ranking 2 M, roof ranking 2 M)

d) SLA 3-D printer.

4 M

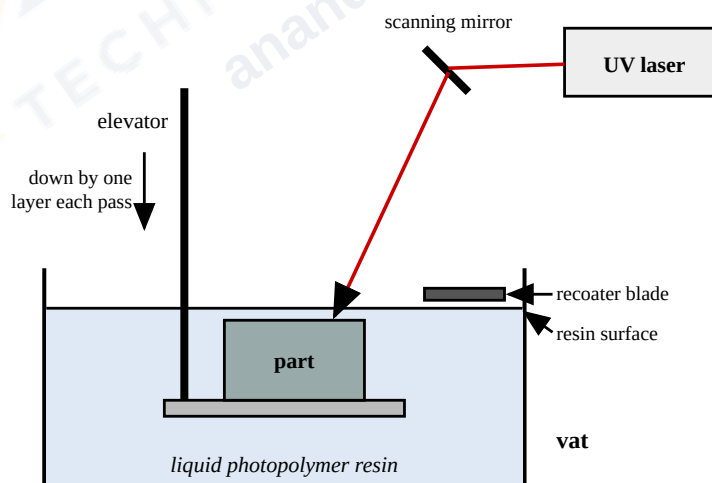


Fig.: Stereolithography (SLA) — schematic

Construction: a vat filled with liquid photopolymer resin, a perforated build platform on an elevator (Z-axis), a UV laser with galvanometer scanning mirrors, a recoater / wiper blade and a computer controller.

1. The CAD model is converted to STL and sliced into layers (0.025–0.1 mm); supports are added.
2. The platform is positioned just one layer below the resin surface.
3. The UV laser beam, steered by the mirrors, traces the cross-section on the resin surface; the resin **photopolymerises** (hardens) where the laser strikes.
4. The platform moves down by one layer thickness; the blade levels a fresh coat of resin over the part.
5. Steps repeat until the part is complete; the part is lifted out, washed in solvent (IPA), supports are removed and it is **post-cured** in a UV oven.

(In desktop SLA printers the part is built upside down — the laser cures resin from below through a clear vat bottom and the platform moves up.)

(Sketch 2 M, working 2 M)

Q.4

a) Concept combination table — electric bicycle.

4 M

A **concept combination table** is a systematic way of combining the solution fragments of the sub-problems. Each **column** is a sub-problem and its entries are the alternative fragment solutions found by searching. A complete concept is formed by selecting **one fragment from each column**.

Purpose: to explore combinations systematically so that no good combination is missed, and to stimulate new ideas; infeasible combinations are removed quickly.

Energy storage	Motor position	Power transmission	Rider control
Li-ion battery	Front-hub motor	Chain	Throttle
Lead-acid battery	Rear-hub motor	Toothed belt	Pedal-assist sensor
Super-capacitor	Mid-drive motor	Direct (hub)	

Number of possible combinations = $3 \times 3 \times 3 \times 2 = 54$. Example of a promising combination: **Li-ion battery + rear-hub motor + direct (hub) drive + pedal-assist sensor** (light, low maintenance). A combination such as super-capacitor + mid-drive is rejected because the super-capacitor stores too little energy for long rides.

(Meaning and purpose 1 M, table 2 M, combination 1 M)

b) Aesthetics: symmetry, colour, continuity, impression.

4 M

1. **Symmetry:** equal and balanced arrangement of parts about an axis. It gives a feeling of stability, balance and order (e.g. car front, ceiling fan, chair). Asymmetry is used deliberately for a dynamic look.
2. **Colour:** the most noticed aspect. Colours create mood and identity — red for danger and energy, blue for cool and trust, white for clean (medical equipment); colour contrast highlights controls; brand colours give corporate identity.

3. **Continuity:** smooth flow of lines and surfaces from one part to another without sudden breaks, so the product looks like one unit (e.g. continuous body lines of a motorcycle tank and seat).
4. **Impression:** the overall feeling the product creates in the mind of the user — strong, light, luxurious, modern, rugged. It results from form, colour, finish and proportion together (e.g. a rugged look for a site tool).

(Each aspect 1 M)

c) Four steps of planning for a prototype.

4 M

1. **Define the purpose of the prototype:** list the learning, communication, integration and milestone needs it must meet.
2. **Establish the level of approximation:** decide which features must be like the final product and which can be ignored; choose physical or analytical; the simplest prototype that meets the purpose is the best.
3. **Outline an experimental plan:** decide variables, test protocol, measurements and how data will be analysed.
4. **Create a schedule for procurement, construction and testing:** fix dates when parts are ready (“bucket of parts”), when testing starts (“smoke test”) and when results are expected.

Example — plastic coupling of a food-processor drive:

Step	Plan
Purpose	Select coupling material and tooth profile that transmit motor torque without wear or cracking.
Level of approximation	Correct tooth geometry and material; colour, mould method and appearance ignored; 3-D printed and machined samples.
Experimental plan	3 materials × 2 tooth profiles = 6 couplings; run on test rig at full load for 50 hours; measure wear and temperature.
Schedule	Week 1: designs; week 2: parts ready; week 3: tests; week 4: analysis and selection.

(Four steps 3 M, example 1 M)

d) SCAMPER technique.

4 M

SCAMPER is a checklist-based creative-thinking technique: the designer asks seven types of questions about an existing product to produce new ideas.

Letter	Question	Example — conventional bucket
S – Substitute	What material / part can be replaced?	Steel → HDPE plastic (lighter, no rust)
C – Combine	What can be combined?	Bucket + mop wringer = mop bucket
A – Adapt	What idea can be adapted from elsewhere?	Wheels from trolley → wheeled bucket
M – Modify / Magnify / Minify	Change shape, size, colour?	Collapsible (foldable) silicone bucket
P – Put to other uses	Other uses?	Bucket as planter / storage bin

E – Eliminate	What can be removed?	Separate handle clips eliminated (moulded handle)
R – Reverse / Rearrange	Reverse order or layout?	Spout at bottom (tap) for easy draining

(Meaning 1 M, seven steps with example 3 M)

e) Patent, rights and importance.

4 M

Patent: an exclusive right granted by the Government to an inventor for a new invention (product or process) for a limited period — **20 years** from the filing date in India — in exchange for full public disclosure of the invention.

Rights of the patent holder:

- To exclude others from making, using, offering for sale, selling or importing the patented product/process in India without permission.
- To assign (sell) the patent or grant licences and earn royalty.
- To take legal action against infringement.

Importance:

- Protects the invention from copying and gives market advantage.
- Earns money by licensing; increases the value of the firm.
- Encourages research and innovation.
- Disclosed knowledge helps further development in society.

(Definition 1 M, rights 1½ M, importance 1½ M)

Q.5

a) Identifying customer needs — electric kettle.

6 M

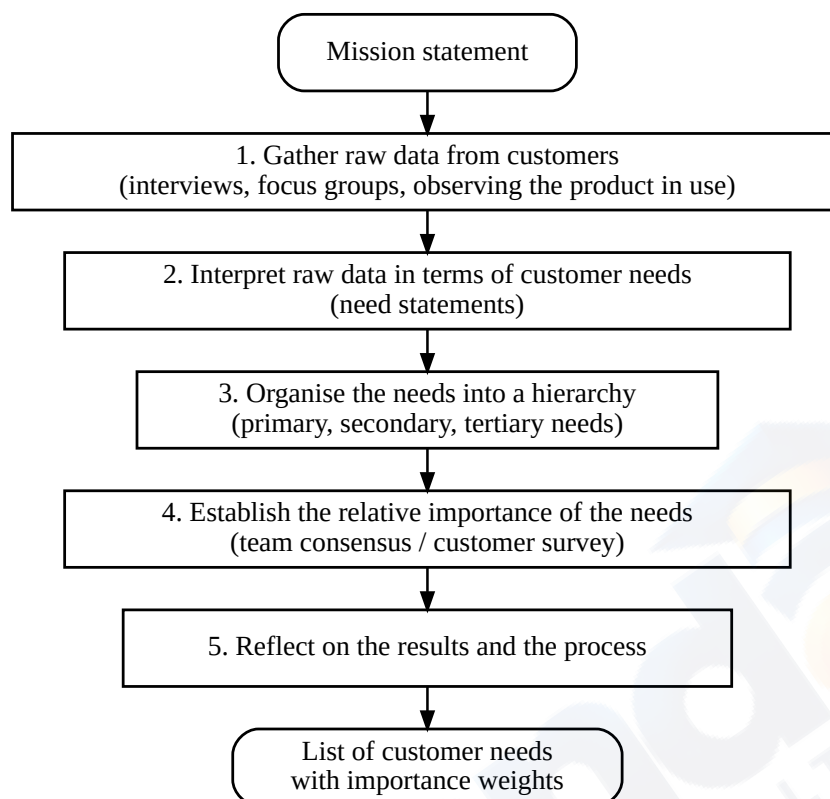


Fig.: Five steps of identifying customer needs

1. **Gather raw data from customers:** interviews with users at home, a focus group of housewives / students, and observing the kettle in use. About 10 interviews per segment are enough to find most needs.
2. **Interpret raw data in terms of customer needs:** each customer statement is written as a need statement — in terms of *what* the product must do, positively, as an attribute of the product, and without “must/should”.
3. **Organise the needs into a hierarchy:** group similar needs under primary needs (safety, performance, ease of use, maintenance) with secondary needs under them.
4. **Establish the relative importance of the needs:** by team consensus or a customer survey, rate each need (1–5).
5. **Reflect on the results and the process:** check that all important customers were contacted and latent needs were captured.

Customer statement (raw data)	Interpreted need statement	Primary need	Importance (1–5)
“The handle gets hot when the water boils.”	The kettle handle stays cool to touch during boiling.	Safety	5
“Water spills when I pour the last cup.”	The kettle pours without dripping or spilling.	Ease of use	4

“It takes too long to boil for tea in the morning.”	The kettle boils water quickly.	Performance	5
“I forget it on and it keeps boiling.”	The kettle switches off automatically after boiling.	Safety	5
“I cannot see how much water is inside.”	The user can see the water level easily.	Ease of use	3
“Lime deposits are hard to clean.”	The kettle is easy to clean inside.	Maintenance	3

Needs with importance 5 (cool handle, quick boiling, auto cut-off) become the most important targets for the design.

(Steps 4 M, example table 2 M)

b) Determining PLC of an electric two-wheeler.

6 M

Procedure to determine the product life cycle of a product:

1. Collect sales (units) of the product for several years — from company records, dealer data or industry reports (e.g. vehicle registration data).
2. Calculate the yearly growth rate of sales; also study profit, price trend, number of competitors and customer type.
3. Plot sales against time and compare the shape with the standard PLC curve.
4. Decide the present stage using the growth rate and market behaviour, and plan the strategy for that stage.

Example — e-scooter (assumed sales data for illustration only):

Year	Sales (lakh units, assumed)	Growth over previous year	Stage
2018	1.2	—	Introduction
2019	1.5	+25.0%	Introduction
2020	1.7	+13.3%	Introduction
2021	2.3	+35.3%	Introduction
2022	6.3	+173.9%	Growth
2023	8.6	+36.5%	Growth
2024	10.2	+18.6%	Growth
2025	12.1	+18.6%	Growth
2026	14.3	+18.2%	Growth

Rule used to fix the stage: sales still below 20 % of the peak and rising → Introduction; growth $\geq$ 15 % per year → Growth; growth between –5 % and +15 % (sales levelled) → Maturity; sales falling more than 5 % per year → Decline.

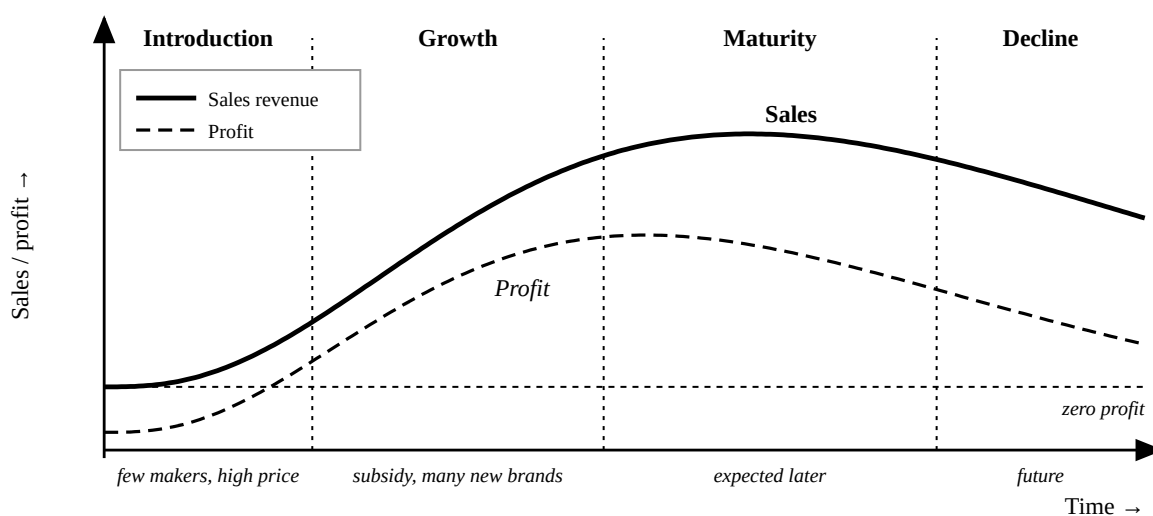


Fig.: PLC of e-scooter (present position: growth stage)

Result: the last years are classified as **Growth** (latest year growth 18.2 %), so the e-scooter is in the **growth stage** — sales rising, many new brands entering, improving charging network and falling battery prices. Strategy: add models and features, expand dealer and service network, reduce cost. As growth slows towards about 5–15 % per year it will enter maturity.

(Procedure 2 M, data/curve 3 M, conclusion 1 M)

c) VEJP phases — table lamp.

6 M

Value Engineering Job Plan (VEJP) is the systematic, phase-wise plan of work followed by a value engineering team to identify unnecessary cost and increase the value of a product.

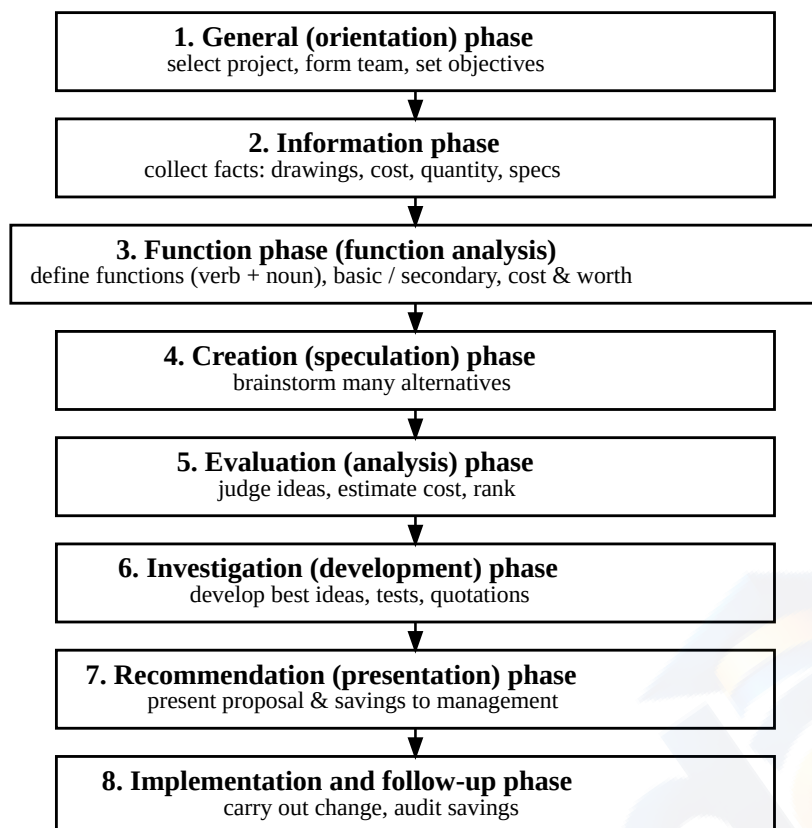


Fig.: Value Engineering Job Plan (VEJP) — phases

1. **General / orientation phase:** select the product or part (high cost, high volume, many complaints), form a team, fix objectives and target saving.
2. **Information phase:** collect all facts — drawings, specifications, quantities, cost break-up, customer complaints; ask “What is it? What does it cost?”.
3. **Function phase:** define each function in two words (verb + noun), separate basic and secondary functions, find the cost and worth of each function (value index).
4. **Creation (speculation) phase:** generate many alternative ways to perform the function — brainstorming, SCAMPER; no criticism at this stage.
5. **Evaluation phase:** screen and rank the ideas for cost, feasibility and performance; select the best few.
6. **Investigation (development) phase:** develop the selected ideas in detail — drawings, tests, supplier quotations, cost estimates.
7. **Recommendation (presentation) phase:** present the proposal with savings, investment and benefits to management for approval.
8. **Implementation and follow-up:** carry out the approved change, monitor the actual savings and quality.

Example — table lamp (cost and worth assumed):

Component	Function (verb + noun)	Basic / Secondary	Cost ₹	Worth ₹	Value index = Worth / Cost	Saving potential ₹
Cast-iron base	Support lamp	Secondary	120	50	0.42	70

Stem (tube)	Position bulb	Basic	60	50	0.83	10
Shade	Direct light	Basic	70	60	0.86	10
Switch	Control current	Basic	40	35	0.88	5
Decorative ring	Improve look	Secondary	30	10	0.33	20

Total cost = ₹320; total worth = ₹205; overall value index = $205/320 = 0.64$. The component with the lowest value index (**Decorative ring**, 0.33) is the first target for value improvement.

Creation / evaluation: replace the cast-iron base by a pressed-steel base with a moulded weight pocket, and the separate decorative ring by a moulded groove in the shade. **Recommendation:** estimated cost of base + ring reduces from ₹150 to about ₹70 with the same function and look.

(Meaning 1 M, phases 4 M, example 1 M)

Q.6

a) Generic product development process.

6 M

Product development process is the sequence of steps or activities which an enterprise uses to conceive, design and commercialise a product. The generic process has six phases:

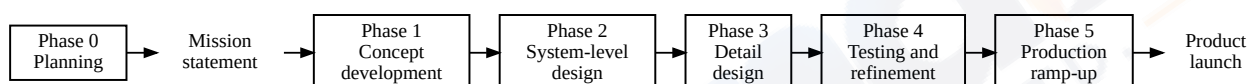


Fig.: Generic product development process (six phases)

- 1. Planning (Phase 0):** identify the opportunity, assess technology and market, set project objectives; output is the *mission statement*.
- 2. Concept development:** identify customer needs, generate and evaluate alternative concepts, select one or more for further development.
- 3. System-level design:** define product architecture, break the product into sub-systems and components, preliminary layout.
- 4. Detail design:** complete geometry, materials and tolerances of every part; select standard parts; prepare drawings and process plans (control documentation).
- 5. Testing and refinement:** build and test alpha and beta prototypes for performance, reliability and customer acceptance.
- 6. Production ramp-up:** make the product with the intended production system, train workforce, remove remaining problems, then launch.

The output of planning is the *mission statement*, and the output of the whole process is the *product launch*. After concept development the process is often managed as stage-gates (reviews) where management decides to continue or stop.

(Flow chart 2 M, six phases 4 M)

b) House of Quality — mixer grinder (complaints → technical requirements).

6 M

In QFD, customer **complaints** are converted into positive customer requirements; these are linked to measurable technical requirements in the House of Quality, which shows which engineering characteristic must be improved first.

Step 1 – Voice of customer (complaints → requirements):

Customer complaint	Customer requirement (WHAT)	Importance (1–5)
“Very noisy, children wake up.”	Low noise	4
“Liquid leaks from the jar bottom.”	No jar leakage	5
“Motor gets hot and trips in 10 minutes.”	Motor does not overheat	5
“Too costly compared to other brands.”	Reasonable price	3

1. List customer requirements (WHATs) on the left wall and give each an importance rating (1 = low, 5 = very high).
2. List measurable technical requirements (HOWs) on the ceiling with the direction of improvement (▲ / ▼ / ⊙).
3. Fill the relationship matrix (body): ● strong = 9, ○ medium = 3, △ weak = 1.
4. Fill the roof (correlation matrix) to show how technical requirements support (+) or conflict (–) with each other.
5. Compare our product with a competitor (customer rating 1–5) in the right wall.
6. Body ranking: technical importance of each HOW = Σ (importance $\times$ relationship weight); convert to % and rank.

Mixer grinder

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Relationship: ● strong = 9, ○ medium = 3, △ weak = 1. ▲ maximise, ▼ minimise, ⊙ target.

Roof: ++ strong positive, + positive, – negative, -- strong negative correlation.

Fig.: House of Quality — Mixer grinder

Calculation of technical importance (body ranking):

Technical requirement	Σ importance $\times$ weight	Relative %	Rank
Noise level (dB)	$4 \times 9 = 36$	16.2	4
Jar seal (gasket) leak pressure	$5 \times 9 + 3 \times 1 = 48$	21.6	2
Motor winding temp. rise ($^{\circ}\text{C}$)	$5 \times 9 = 45$	20.3	3
Motor rating (W)	$4 \times 3 + 5 \times 9 + 3 \times 3 = 66$	29.7	1
Manufacturing cost (₹)	$3 \times 9 = 27$	12.2	5

Result: the design team should give first priority to **Motor rating (W)** (rank 1), then **Jar seal (gasket) leak pressure**.

Roof ranking (trade-offs): negative correlations exist between Motor winding temp. rise ($^{\circ}\text{C}$) $\leftrightarrow$ Motor rating (W); Motor rating (W) $\leftrightarrow$ Manufacturing cost (₹); Noise level (dB) $\leftrightarrow$ Motor rating (W); Jar seal (gasket) leak pressure $\leftrightarrow$ Manufacturing cost (₹). For each such pair, improving one makes the other worse, so a balanced target value must be chosen (or a new technology used).

(Complaints $\rightarrow$ requirements 1 M, HoQ with matrix and roof 3 M, ranking 2 M)

c) Advantages, disadvantages and applications of rapid prototyping.

6 M

Rapid prototyping builds a physical model directly from 3-D CAD data by adding material layer by layer (e.g. FDM, SLA, SLS).

Advantages:

1. Shorter development time and lower cost of prototypes (no tooling).
2. Complex shapes and internal features possible.
3. Design errors found early; easy design changes (iterations).
4. Better communication with customers and team (physical model).
5. Customised / one-off parts economical; less material waste.

Disadvantages:

1. Limited choice of materials; properties may differ from production material.
2. Lower strength and accuracy; layer marks need finishing.
3. Limited build size; slow and costly for mass production.
4. High cost of some machines and materials (SLA resin, SLS powder).

Applications:

- Automobile and aerospace: concept models, ducts, brackets, fit checks.
- Medical and dental: surgical planning models, implants, aligners, crowns.
- Jewellery patterns, consumer products (housings, toys), architectural models.
- Tooling: jigs, fixtures, patterns for casting and moulds; education and research.

(Advantages 2 M, disadvantages 2 M, applications 2 M)

Note: This is a **model question paper prepared by Ananda Technologies** only for practice and exam preparation, based on the pattern of previous MSBTE question papers and the K-scheme syllabus. It is **not an official MSBTE paper**, and it does **not** mean that these questions will come in the exam. Answers follow standard textbook points; marks shown are indicative. Free for students — anandatechnologies.in