PRODUCT DESIGN AND DEVELOPMENT

DIPLOMA WALLAH

MECHANICAL

Unit - II Product Architecture

JHARKHAND UNIVERSITY OF TECHNOLOGY (JUT)

🔹 2.1 Definition of Product Architecture; Modular & Integral Architectures, Its Types, Component Standardisation, Steps for Establishing the Architecture (with examples such as trailers, spanners etc.)

📜 Definition :-

Product architecture is the scheme by which the functional elements of a product are arranged into physical components "chunks" or modules, and the way those components interact through defined interfaces. ProductPlan+2stuff.mit.edu+2 In other words: it's the mapping from functions → physical components + the specification of interfaces among them. CORE Architectures are often categorised into **modular** (components/modules operate relatively independently via defined interfaces) and **integral** (functions and components are highly interconnected, less clear modular boundary). MDPI+1 Component standardisation refers to using common parts or modules across product variants (or models) to achieve economy of scale, simplified manufacturing, easier servicing and variant management. Establishing architecture involves steps such as functional decomposition, component mapping, defining interfaces, deciding modules, and checking standardisation/variants.

🧩 Explanation (10 detailed points):

1. **Functional decomposition:** Break the product into its major functions and sub-functions (e.g., for a trailer: load carrying, towing, braking, lighting).

2. **Mapping to physical components:** Assign each function (or group of functions) to a physical component or module. This is the core of architecture. CORE+1
3. **Defining interfaces:** Specify how components/modules connect, interact — mechanically, electrically, hydraulically etc. A modular architecture has clear, standardised interfaces. Visure Solutions
4. **Modular architecture properties:** Each module performs one or a few functions, modules are interchangeable/reusable, interface defined, high flexibility. Wikipedia+1
5. **Integral architecture properties:** One component may handle multiple functions; interfaces may be informal or embedded; change in one part often affects many others. SpringerLink+1
6. **Types of architectures beyond just modular/integral:** Some literature mentions "open architecture", hybrid, platform architecture—variations exist. MDPI+1
7. **Component standardisation:** Using same parts, modules across a product family reduces cost, simplifies service/maintenance, supports variants. ResearchGate
8. **Steps to establish product architecture:** For example:
    - Identify functions
    - Cluster functions into modules or chunks
    - Map functions to physical components
    - Define interfaces among components/modules
    - Choose modular vs integral for each module considering strategy (cost, performance, variety)
    - Apply standardisation/variant planning
    - Validate architecture w.r.t manufacturability, serviceability, cost, upgrade path
9. **Example – Trailer/spanner:**

- Trailer: Could be modular—chassis module + deck module + axle module + hitch module, with standard interfaces so decks of different types fit on same chassis. Or integral if fixed structure optimized for one application.
- Spanner (wrench): A hand-tool may be integral (single piece forged) for strength and cost. Or modular: handle + interchangeable head module, standard attachment interface so you can swap heads for different sizes—supports variant widths/sizes.

10. **Strategic implications:** Architecture decision early heavily impacts cost, manufacturing, variant flexibility, serviceability, upgrade paths and product life-cycle. ProductPlan+1

⚙️ Applications:-

- Designing a family of trailers where different deck types (flatbed, tipping, container) use same chassis and axle modules (modular architecture).
- Designing a toolset of spanners where handles are standardised and heads are swapped (component standardisation) for different sizes or tasks.
- Consumer electronics (smartphones, laptops) where main platform is reused and modules (camera, battery, screen) are swappable.
- Automotive platform design: common platform chassis + modules for engine, transmission, body variants – supports many models with same architecture.
- Industrial equipment where high performance custom machine uses integral architecture for maximum compactness or integration of functions.

✅ Advantages:-

1. Modular architecture allows reuse of modules, faster development of product variants, lower cost per unit in volume.

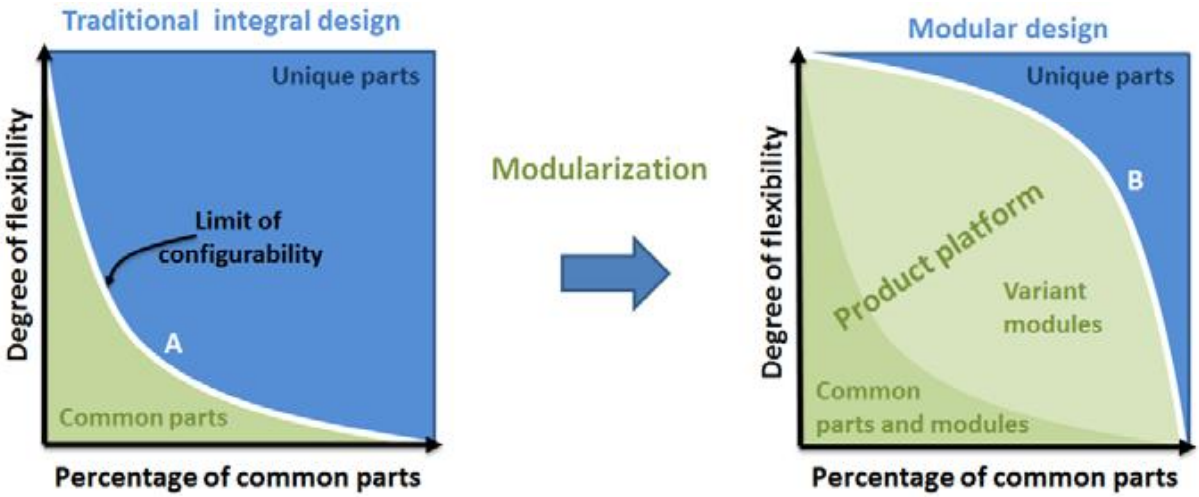
2. Standardisation reduces inventory, simplifies supply chain, improves serviceability and maintenance.
3. Good architecture means easier upgrades, maintenance, service and product life-cycle management.
4. Integral architecture can lead to higher performance, compactness, fewer modules/interfaces means fewer failure points.
5. Making architecture decisions early helps align design, manufacture, service and marketing, reducing downstream costs and risks.

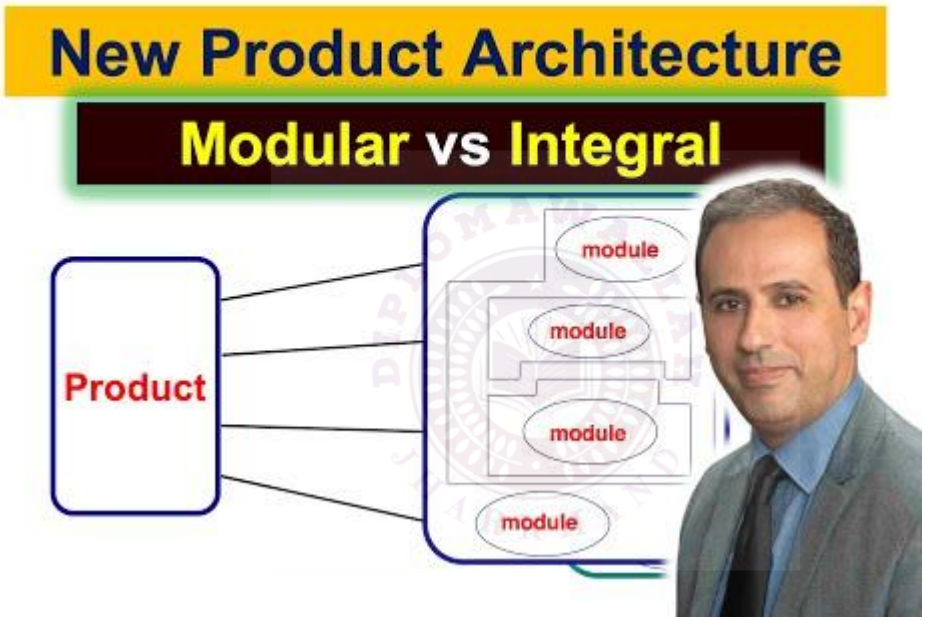
❌ **Disadvantages:-**

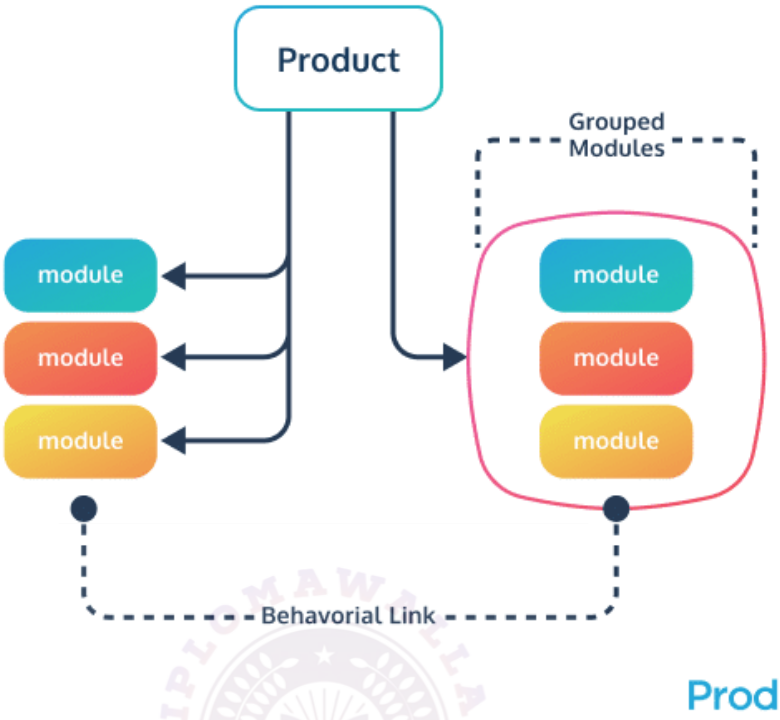
1. Modular architecture may incur more interface overhead, possibly higher cost or reduced performance compared to fully integrated design.
2. Integral architecture is inflexible; changes or upgrades require redesign of many components; poor for quick variants.
3. Too much standardisation may reduce differentiation or innovation in product design.
4. Establishing architecture demands upfront investment (analysis, mapping, tooling) and careful cross-functional alignment.
5. If wrong architecture chosen (e.g., modular when performance is critical, or integral when variety is needed), product may suffer in cost/performance/market fit.

🗣️ **Summary:-**

Product architecture ka matlab hai product ka structure—functions ko parts/modules me baantna aur unka interface define karna. Modular ya integral architecture ka decision business strategy, cost, performance aur variant-management pe depend karta hai. Agar architecture sahi ho, to product development aur service dono smooth hote hain.


Traditional integral design
Unique parts
Limit of configurability
A
Common parts
Degree of flexibility
Percentage of common parts
Modularization
Modular design
Unique parts
B
Product platform
Variant modules
Common parts and modules
Degree of flexibility
Percentage of common parts


New Product Architecture
Modular vs Integral
Product
module
module
module
module



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🔹 **2.2 Ergonomics – Definition; Necessity of Ergonomics in Product Design; Design Considerations for Qualitative & Quantitative Displays; Design Considerations for Controls like Knob, Levers, Handwheel, Toggle Switch**

📜 **Definition :-**

Ergonomics (also called human factors engineering) is the scientific discipline concerned with understanding the interactions among humans and other elements of a system, and applying theory, data and methods to design in order to optimise human well-being and overall system performance. ITCILO Training In product design context, ergonomics means designing products, systems, displays and controls so that they fit the human body, cognitive capabilities and usage context,

making them safe, efficient, comfortable and easy to use. Poor ergonomics can lead to discomfort, fatigue, inefficiency or errors—so its necessity in product design is high.

🧩 **Explanation :-**

1. **Human anatomy and anthropometry:** Product design must accommodate body sizes, reach, posture, movement capabilities (e.g., hand reach for levers, comfortable wrist angles). ITCILO Training
2. **Display design (qualitative vs quantitative):**
    - *Quantitative displays* show numerical or measurement values (e.g., speedometer, temperature gauge) – must have legible numbers, clear scale, good contrast, placed in line of sight.
    - *Qualitative displays* use indicators, lights, colours (e.g., green/red LEDs) to show status or discrete states – must be clear, unambiguous. www.slideshare.net
3. **Control design – Placement & Reach:** Controls (knobs, levers, hand-wheels, toggle switches) must be placed within comfortable reach for the user's typical posture, frequency of use, movement. ITCILO Training
4. **Control design – Motion and feedback:** Controls should follow logical mapping (turning clockwise increases, etc.), provide feedback (tactile, visual) and allow safe, correct operation without undue effort. www.slideshare.net+1
5. **Control design – Shape, size, materials:** Knobs should allow easy grip, levers require correct pivot lengths, hand-wheels sized for required torque; surfaces should be non-slip and comfortable.
6. **Control–Display relationship:** Good design ensures consistency between control movement and display action (C/D ratio), direction of motion must be intuitive, avoid user confusion. Your Article Library

7. **Visibility and legibility:** Displays must be readable under different lighting and distances; controls must have clear function labels or symbols; safe grouping of controls. www.slideshare.net
8. **Minimising cognitive load & error:** Simplify layouts, avoid clutter, group frequent controls, differentiate emergency controls clearly. ITCILO Training
9. **Accessibility and variation:** Design must cater to different user types (left/right handed, varying strength, age) and usage contexts (sitting, standing).
10. **Iterative testing and adjustment:** Ergonomic evaluation (user testing, simulation) should be part of design to refine displays and controls based on real user interaction.

⚙️ **Applications:-**

- Designing a vehicle dashboard: frequently used controls (speed dial, emergency stop) placed within easy reach; display that shows speed/engine status in large clear numbers.
- Designing a hand tool (e.g., spanner or hand-wheel) whose handle is sized for comfortable grip, material is non-slip, torque control easy, control surface visible.
- Designing a machine control panel: toggle switches for emergency are coloured red and raised; levers for less frequent use are longer and placed at comfortable height.
- Consumer appliance: a knob controlling temperature on a microwave, with clear numbers (quantitative) and indicator light (qualitative) for power state.
- Medical device interface: touchscreen display with large text for quantitative values (heart rate), plus visual icons (qualitative) for alarm states; controls sized for gloved hands.

✅ **Advantages:-**

1. Improves user comfort, reduces fatigue, errors and risk of injury.

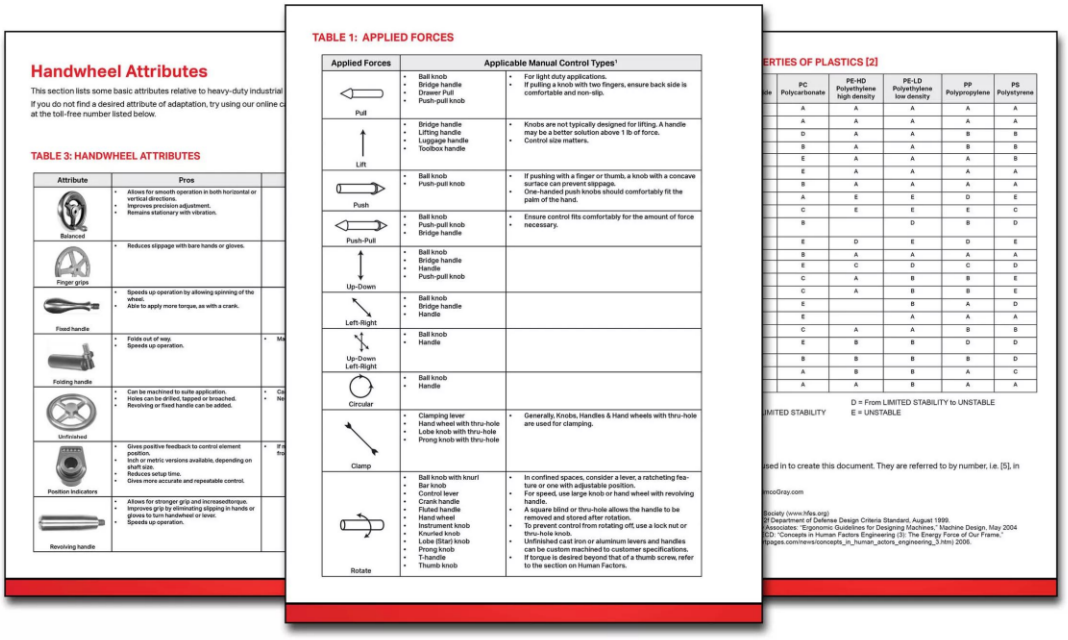
2. Enhances usability and efficiency — users operate faster and with fewer mistakes.
3. Broadens accessibility — good ergonomic design serves more users including those with limited strength/mobility.
4. Helps product adoption, satisfaction and brand reputation (users feel good using the product).
5. Supports safety and regulatory compliance (especially in industrial/medical equipment).

❌ **Disadvantages:-**

1. Considering ergonomics thoroughly may increase design time, cost (anthropometric studies, user testing).
2. Ergonomic improvements may require sacrifice in other areas (e.g., aesthetic, compactness, cost).
3. Variability among users (body sizes, abilities) makes "one-size-fits-all" hard; compromises needed.
4. Over-engineering ergonomic features may add bulk or unnecessary complexity.
5. If ergonomics are ignored or done late in design, implementing changes can be costly and reduce design flexibility.

🗣️ **Summary:-**

Ergonomics ka matlab hai product ko insaan ke hisaab se banana — displays, controls, handles sab aise hone chahiye ki user use bade aasani se aur comfortably use kare. Agar display/control theek design ho, to user ka experience better hoga aur product zyada reliable banega.



Handwheel Attributes

This section lists some basic attributes relative to heavy-duty industrial

If you do not find a desired attribute of adaptation, try using our online c
at the toll-free number listed below.

TABLE 3: HANDWHEEL ATTRIBUTES

Attribute	Pros
Balanced	• Allows for smooth operation in both horizontal or vertical directions. • Improves precision adjustment. • Remains stationary with vibration.
Finger grips	• Reduces slippage with bare hands or gloves.
Fixed handle	• Speeds up operation by allowing spinning of the wheel. • Able to apply more torque, as with a crank.
Folding handle	• Folds out of way. • Speeds up operation.
Unfinished	• Can be machined to suite application. • Holes can be drilled, tapped or broached. • Revolving or fixed handle can be added.
Position indicators	• Gives positive feedback to control element position. • Inch or metric versions available, depending on shaft size. • Reduces setup time. • Gives more accurate and repeatable control.
Revolving handle	• Allows for stronger grip and increasedtorque. • Improves grip by eliminating slipping in hands or gloves to turn handwheel or lever. • Speeds up operation.

TABLE 1: APPLIED FORCES

Applied Forces	Applicable Manual Control Types[1]	
Pull	• Ball knob • Bridge handle • Drawer Pull • Push-pull knob	• For light duty applications. • If pulling a knob with two fingers, ensure back side is comfortable and non-slip.
Lift	• Bridge handle • Lifting handle • Luggage handle • Toolbox handle	• Knobs are not typically designed for lifting. A handle may be a better solution above 1 lb of force. • Control size matters.
Push	• Ball knob • Push-pull knob	• If pushing with a finger or thumb, a knob with a concave surface can prevent slippage. • One-handed push knobs should comfortably fit the palm of the hand.
Push-Pull	• Ball knob • Push-pull knob • Bridge handle	• Ensure control fits comfortably for the amount of force necessary.
Up-Down	• Ball knob • Bridge handle • Handle • Push-pull knob	
Left-Right	• Ball knob • Bridge handle • Handle	
Up-Down Left-Right	• Ball knob • Handle	
Circular	• Ball knob • Handle	
Clamp	• Clamping lever • Hand wheel with thru-hole • Lobe knob with thru-hole • Prong knob with thru-hole	• Generally, Knobs, Handles & Hand wheels with thru-hole are used for clamping.
Rotate	• Ball knob with knurl • Bar knob • Control lever • Crank handle • Fluted handle • Hand wheel • Instrument knob • Knurled knob • Lobe (Star) knob • Prong knob • T-handle • Thumb knob	• In confined spaces, consider a lever, a ratcheting feature or one with adjustable position. • For speed, use large knob or hand wheel with revolving handle. • A square blind or thru-hole allows the handle to be removed and stored after rotation. • To prevent control from rotating off, use a lock nut or thru-hole knob. • Unfinished cast iron or aluminum levers and handles can be custom machined to customer specifications. • If torque is desired beyond that of a thumb screw, refer to the section on Human Factors.

ERTIES OF PLASTICS [2]

	PC Polycarbonate	PE-HD Polyethylene high-density	PE-LD Polyethylene low-density	PP Polypropylene	PS Polystyrene
	A	A	A	A	A
	A	A	A	A	A
	D	A	A	B	B
	B	A	A	B	B
	E	A	A	A	B
	E	A	A	A	A
	B	A	A	A	A
	A	E	E	D	E
	C	E	E	E	C
	B		D	B	D
	E	D	E	D	E
	B	A	A	A	A
	E	C	D	C	D
	C	A	B	B	E
	C	A	B	B	E
	E		B	A	D
	E		A	A	A
	C	A	A	B	B
	E	B	B	D	D
	B	B	B	B	D
	A	B	B	A	C
	A	A	B	A	A

D = From LIMITED STABILITY to UNSTABLE
LIMITED STABILITY E = UNSTABLE

sed in to create this document. They are referred to by number, i.e. [5], in

ncoGray.com

Society (www.hfes.org)
of Department of Defense Design Criteria Standard, August 1999.
Associates: "Ergonomic Guidelines for Designing Machines," Machine Design, May 2004
CD: "Concepts in Human Factors Engineering (3): The Energy Force of Our Frame."
tpages.com/news/concepts_in_human_actors_engineering_3.html 2006.

Qualitative dimensions	Quantitative dimensions
Words, understanding	Numbers, explanation
Purposive sampling, inductive reasoning	Statistical sampling, deductive reasoning
Social sciences, soft, subjective	Physical sciences, hard, objective
Practitioner as a human instrument to gather data, prescriptive, personal	Researcher, descriptive, impersonal
Inquiry from the inside	Inquiry from the outside
Data collection and analysis intertwined	Data collection before analysis
Creative, acknowledgement of extraneous variables as contributing to the phenomenon	Predefined, operationalised concepts stated as hypotheses, empirical measurement and control of variables
Meanings of behaviours, broad and inclusive focus	Cause and effect relationship
Discovery, gaining knowledge, understanding actions.	Theory/explanation testing and developme

🔹 2.3 Aesthetics Principles – Definition; Necessity of Aesthetics in Product Design; Consideration of Aesthetics in Product Design; Aspects of Aesthetics in Product Design – form, symmetry, color, continuity, proportion, contrast, impression, surface finish

📜 Definition :-

Aesthetics in product design refers to the sensory and perceptual qualities of a product — how it looks, feels, and appeals emotionally to users beyond just functional performance. It involves the visual form, colour, texture, finish and overall impression of the product. Aesthetics are necessary because in a competitive market users often choose products not only for what they do but how they look and feel, and strong aesthetic design contributes to perceived quality, brand identity and user satisfaction.

🧩 Explanation

1. **Form/Shape:** The basic outline or silhouette communicates not only aesthetics but also function (e.g., ergonomic curves imply comfort, straight edges imply precision) LearnPick
2. **Symmetry & Balance:** Symmetrical forms often feel stable and trustworthy; controlled asymmetry can be used to create interest and dynamism. LearnPick
3. **Colour:** Choice of colour influences mood, brand identity, usability (visibility/contrast) and emotional appeal. Correct palette contributes to product attractiveness. LearnPick
4. **Continuity:** Smooth flow of lines/surfaces, logical integration of elements – ensures product looks coherent and unified.
5. **Proportion:** Good relation among sizes of parts (e.g., handle to head of spanner) creates harmony; the "golden section" is a famous proportional guideline. LearnPick
6. **Contrast:** Differences in colour, texture, shape, size draw attention to key features, create visual interest. LearnPick

7. **Impression & Character:** The overall "feel" or "character" of product – elegant, rugged, playful, premium – which should align with target user and brand promise.
8. **Surface Finish & Texture:** Material finish (glossy, matte, brushed), texture (smooth, patterned) influence how the product is perceived (quality, durability) and how it feels to touch.
9. **Necessity of Aesthetics in Product Design:** Since functional differences among many products tend to narrow, aesthetic differences often drive consumer choice; good aesthetics enhance brand image and product value.
10. **Consideration of Aesthetics in Design Process:** Aesthetics should be integrated early, alongside function and ergonomics—not just added at the end; trade-offs between aesthetics and manufacturability, cost must be managed.

⚙️ **Applications:-**

- Designing a premium smartphone: form (slim, curved), symmetry in body, colour options (Midnight Blue, Graphite), continuity (glass body wrap), surface finish (matte metal or glossy glass) to give premium look.
- Home appliance like mixer or refrigerator: aesthetic choices (colour, finish) match modern home interiors; form and finish make product commodity into design object.
- Hand tools (spanner/wrench): handle shape, surface finish (chrome plating), contrast colour size markings, proportion suited for grip & strength—appearance influences perception of quality.
- Industrial equipment: colour coding, contrast and surface finish used to improve user perception and safety (e.g., bright coloured machine parts, textured surfaces).
- Packaging and consumer electronics accessories: Aesthetics drive purchase decision; form, colour, finish align with brand and user lifestyle.

✅ **Advantages:-**

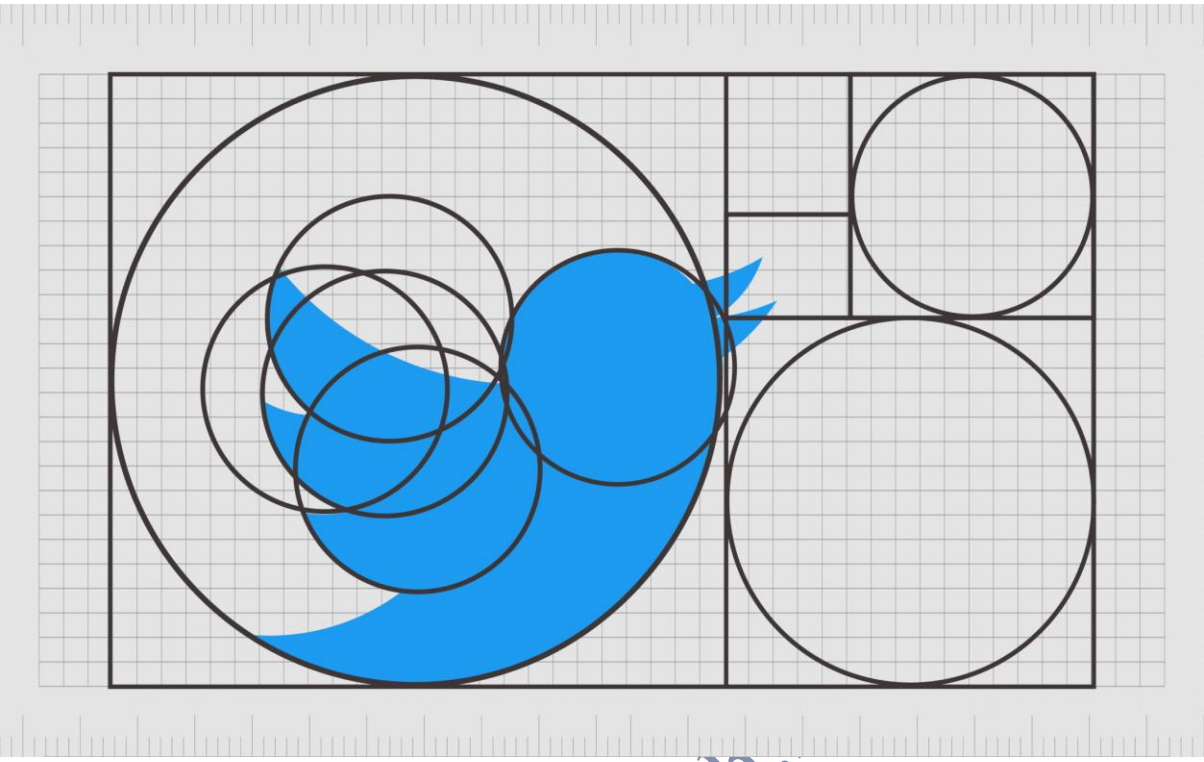
1. Attractive aesthetics increase user desire, brand value, product differentiation and market success.
2. Good form, finish and design create perception of higher quality, reliability and prestige.
3. Integrated aesthetics with function and ergonomics leads to better overall user experience.
4. Aesthetic consistency across a product line builds brand identity and recognition.
5. Attention to surface finish, material and proportion contributes also indirectly to usability (e.g., easier to clean, better perception of grip).

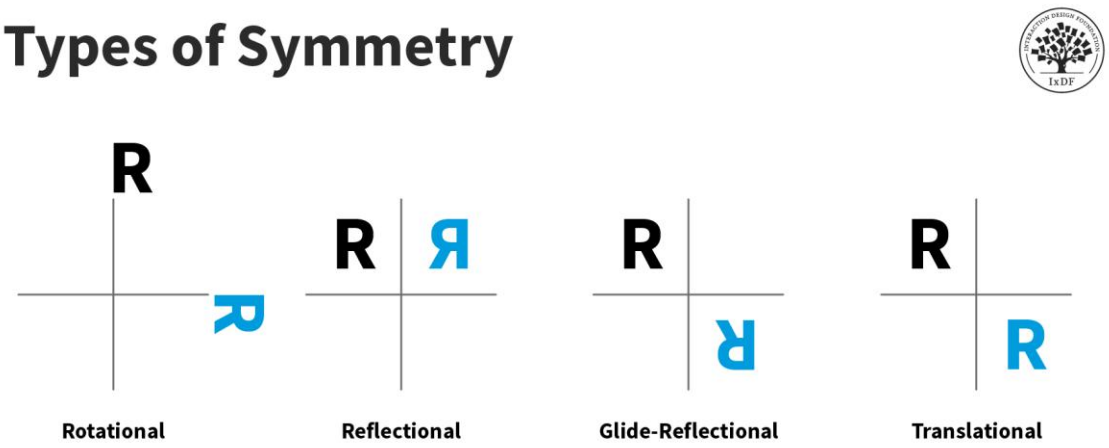
❌ **Disadvantages:-**

1. Focusing too much on aesthetics may compromise function, cost or manufacturability (e.g., expensive finishes).
2. Premium finishes, complex forms may increase manufacturing cost and time.
3. Aesthetic trends change quickly — product may look outdated sooner than its functional life.
4. Over-designing (too many aesthetic features) may distract from usability or ergonomics.
5. If aesthetics are treated as an afterthought (rather than integrated early), design may become inconsistent, increase rework and cost.

🗣️ **Summary**

Aesthetics ka matlab hai product ka "look & feel" — shape, colour, finish sab milkar user ko pehla impression dete hain. Agar ye design accha ho, to product attractive banega, brand strong hoga aur market me alag dikhega.




Types of Symmetry
R
R
R
R
R
R
Rotational
Reflectional
Glide-Reflectional
Translational
Interaction Design Foundation
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