MP482
PRODUCT DEVELOPMENT AND DESIGN

MODULE I

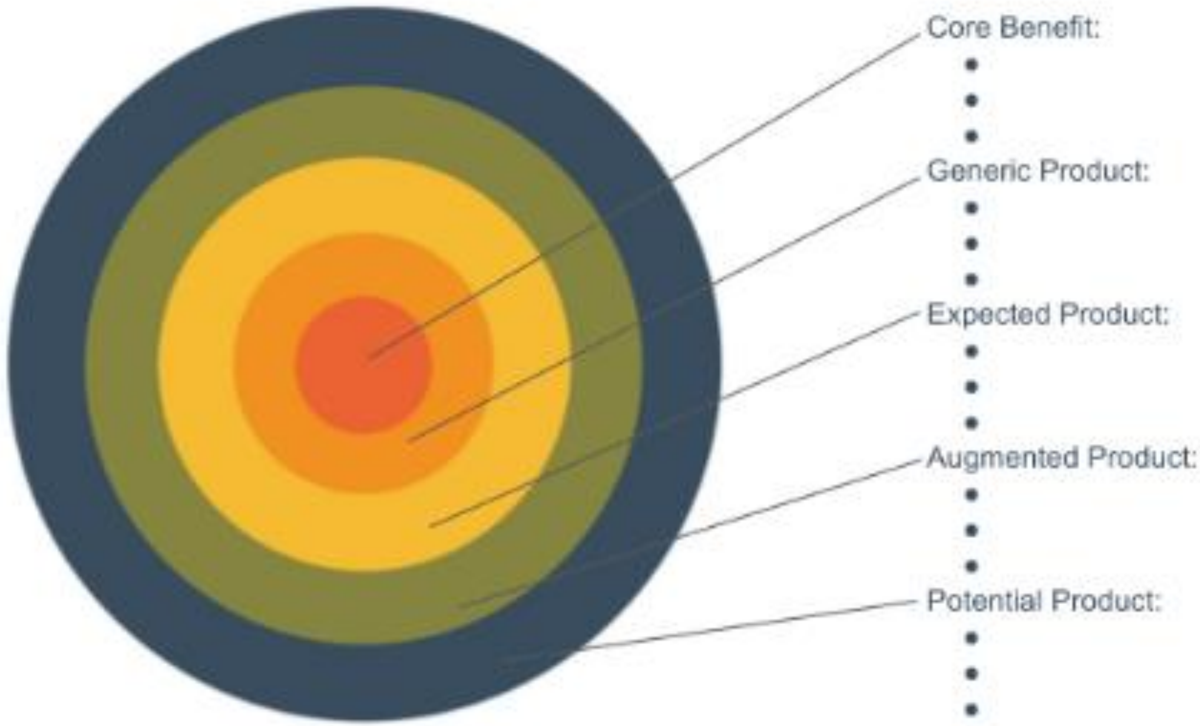
Introduction: Classification / Specifications of Products. Product life cycle. Product mix. Introduction to product design. Modern product development process. Innovative thinking. Morphology of design.

PRODUCT

- A product can be anything that can be offered to the market to satisfy a want or a need.
- A bundle of attributes, offering for use/consumption by the final customer
- **Products that are marketed include**
  - Physical goods
  - Services

LEVELS OF A PRODUCT

- 5 basic levels
- Each level adds more customer value
  - CORE BENEFIT
  - BASIC/GENERIC PRODUCT
  - EXPECTED PRODUCT
  - AUGUMENTED PRODUCT
  - POTENTIAL PRODUCT


Core Benefit:
Generic Product:
Expected Product:
Augmented Product:
Potential Product:

Levels of a Product

Core Benefit

- Explains what the buyer really buys
- The core benefit is the fundamental need or wants that the customer satisfies when they buy the product.
- For example, the core benefit of a hotel is to provide somewhere to rest or sleep when away from home.

Basic/Generic Product

- The generic product is a basic version of the product made up of only those features necessary for it to function.
- In our hotel example, this could mean a bed, towels, a bathroom, a mirror, and a wardrobe.

Levels of a Product

- Expected Product
  - The expected product is the set of features that the customers expect when they buy the product.
  - In our hotel example, this would include clean sheets, some clean towels, a clean bathroom.
  - Includes brand name, features, design, packaging, quality level, styling, styling, attributes, instructions manual
- Augmented Product
  - The augmented product refers to any product variations, extra features, or services that help differentiate the product from its competitors.
  - In our hotel example, this could be the inclusion of a concierge service or a free map or free wi fi of the town in every room.

Levels of a Product

- Potential Product
  - The potential product includes all augmentations and transformations the product might undergo in the future.
  - In our hotel, this could mean a different gift placed in the room each time a customer stays.
  - For example, it could be some chocolates on one occasion, and some luxury water on another.

TYPES OF PRODUCT

- Can be done in a variety of perspectives
- Consumer-Goods Classification
  - Classified on the basis of shopping habits
    - Convenience products
    - Shopping Products
    - Specialty Goods
    - Unsought Goods
  - Durability and Tangibility
    - Durable Goods and Non durable goods
    - Tangible and intangible goods
- Industrial-Goods Classification
  - Classified in terms of their relative cost and how they enter the production process
    - Materials & parts
    - Capital Items
    - Supplies and Services

Consumer-Goods Classification

- **Convenience products**
- Bought frequently, immediately with minimum comparison and buying effort.
- Inexpensive, frequently purchased.
- Staples, Impulse and emergency goods.
- Are low priced
- Available in many locations

- *e.g. Soap, candy, newspapers, fast food*

Consumer-Goods Classification

- **Shopping Goods**
  - Not as frequently as convenience products
  - Costly
  - Consumer does research before purchase.

Consumer-Goods Classification

- Specialty Goods
  - Unique features
  - Consumer is prepared to pay a premium price.

- Has unique characteristics or brand identification for which a significant group of buyer is willing to make a special purchase effort.

Consumer-Goods Classification

- **Unsought Product;**
- Consumer either does not know about/ knows about but does not normally think of buying it.
- Require a lot of advertising, personal selling and marketing efforts.
- *e.g. Life insurance, Encyclopedia.*

Industrial Products:

Industrial Products:

- Distinguished from consumer products on the basis of usage
  - **Materials & parts**
  - **Capital Items**
  - **Supplies and Services**
  - *e.g. A lawn mower.*

Industrial Products:

Materials & parts

i. ***Raw materials & parts:***

- \- Farm products, (wheat, cotton, livestock, fruits, vegetables)
- \- Natural products (fish, lumber, crude oils, iron ore)

ii. ***Manufactured materials & parts:***

- \- component materials (iron yarn, cement, wires)
- \- Component parts (small motors, tires, castings)

Industrial Products

- ***Capital items***

Aid in buyer’s production or operations

i. *Installations:*

- Major purchases (factories, offices)
- fixed equipment (generators, elevators, computer systems)

ii. *Accessory equipments:*

- - Portable factory equipments and tools (hand
- tools, lift trucks)
- - Office equipments (computers, fax machines, desks)

Industrial Products

c. ***Supplies and Services:***

Are convenience products

i. Supplies

- Operating supplies (Lubricants, coal, paper, pencil)
- Repair and maintenance (paint, nails, brooms)

ii. Services

- Maintenance and repair services (window clearing, computer repair)
- Business advisory services (legal, management, consulting, advertising)

BASED ON DURABILITY AND TANGIBILITY

- **Nondurable Goods**
  - Tangible goods consumed in one or few uses
  - Purchased frequently
  - Strategy : availability , low priced , heavily advertised

BASED ON DURABILITY AND TANGIBILITY

- **Durable Goods**
  - Tangible goods that survive many uses
  - Require more personal selling and service
  - Higher margins and requires seller guarantee

BASED ON DURABILITY AND TANGIBILITY

- Services
  - Intangible product
  - Requires more quality control and credibility

PRODUCT LINE

- **Product Line :** A group of products that are closely related because they function in a similar manner, are sold to the same customer groups, are marketed through the same types of outlets, or fall within given price ranges.
- A product line is that combination of products which;
  - Belongs to a single manufacturer
  - Shares similar Attributes
  - Serves the common general purpose but;
  - Targets different market segments

PRODUCT MIX

- A Product Mix is the set of all products and items a particular seller offers for sale.
- **A product mix has certain width, length, depth and consistency**
- The width of a product mix refers to how many different product lines the company carries.
- Product Length refers to the total number of items the company carries within its product lines.
- The depth of a product mix refers to how many variants are offered for each product in the line.
- The consistency of the product mix describes how closely related the various product lines are in the end use.

Product Mix of ITC

FMCG	Hospitality	Paperboard & Speciality Papers	Packaging	Agri Business	Information Technology
Cigarettes & Cigars	Hotels	Coated Boards	Carton Board Packaging	Agri Commodities and Rural Services	ITC Infotech
Foods	Branded Accommodation	Graphic Boards	Flexible Packaging	Agri Business-ILTD	
Personal Care	Restaurants	Fine Papers	Tobacco Packaging	E-Choupal	
Education & Stationery		Thin Printing Papers			
Lifestyle Retailing					
Agarbatti					
Safety Matches					

Product Mix of ITC

Cigarettes	Foods	Personal Care	Stationery	Lifestyle Retailing	Safety Matches	Agarbatties
Insignia	Aashirvaad	Essenza Di Wills	Classmate	Wills Lifestyle	Aim	Mangaldeep
India Kings	Sunfeast	Vivel	Paperkraft	John Players	I Kno	
Wills Navy Cut	Bingo	Fiama DI WIlls				
Classic Regular	Kitchens of India	Engage				
Gold Flake	Yippee	Superia				
Navy cut	B Natural Juices	Vivel Cell Renew				
Bristol	Mint -o	Savlon				
	Candyman	Shower to Shower				

Product Specifications

- Customer needs are generally expressed in the “language of the customer.”
- Customer needs are typical in terms of the subjective quality of the expressions.
- For this reason, development teams usually establish a set of specifications, which spell out in precise, measurable detail *what* the product has to do.
- Product specifications do not tell the team *how* to address the customer needs.
- Establishing specification is a two stage process.
- Target specifications and final specifications

Product Specifications

- A *specification* (singular) consists of a *metric* and a *value.*
- For example, “average time to assemble” is a metric, while “less than 75 seconds” is the value of this metric.
- Note that the value may take on several forms, including a particular number, a range, or an inequality.
- Values are always labeled with the appropriate units

(e.g., seconds, kilograms, joules).

Together, the metric and value form a specification.

Procedure for establishing target specifications

1. Identify a list of metrics and measurement units that sufficiently address the needs
2. Collect the competitive benchmarking information
3. Set ideal and marginally acceptable target values for each metric (using at least, at most, between, exactly, etc.)
4. Reflect on the results and the process

Step 1:List of Metrics

- Metric list should reflect the degree to which the product satisfies that need.
- For example, consider the need that the suspension be “easy to install.”
- The team may conclude that this need is largely captured by measuring the time required for assembly of the fork to the frame.

Features of a metric

- ***Metrics should be complete.***
- ***Metrics should be practical.***
- ***Some needs cannot easily be translated into quantifiable metrics.***
- ***The metrics should include the popular criteria for comparison in the marketplace.***

Product Specifications Example: Mountain Bike Suspension Fork

Start with the Customer Needs

#	NEED		Imp
1	The suspension	reduces vibration to the hands.	3
2	The suspension	allows easy traversal of slow, difficult terrain.	2
3	The suspension	enables high speed descents on bumpy trails.	5
4	The suspension	allows sensitivity adjustment.	3
5	The suspension	preserves the steering characteristics of the bike.	4
6	The suspension	remains rigid during hard cornering.	4
7	The suspension	is lightweight.	4
8	The suspension	provides stiff mounting points for the brakes.	2
9	The suspension	fits a wide variety of bikes, wheels, and tires.	5
10	The suspension	is easy to install.	1
11	The suspension	works with fenders.	1
12	The suspension	instills pride.	5
13	The suspension	is affordable for an amateur enthusiast.	5
14	The suspension	is not contaminated by water.	5
15	The suspension	is not contaminated by grunge.	5
16	The suspension	can be easily accessed for maintenance.	3
17	The suspension	allows easy replacement of worn parts.	1
18	The suspension	can be maintained with readily available tools.	3
19	The suspension	lasts a long time.	5
20	The suspension	is safe in a crash.	5

Establish Metrics and Units

Metric #	Need #s	Metric	Imp	Units
1	1,3	Attenuation from dropout to handlebar at 10hz	3	dB
2	2,6	Spring pre-load	3	N
3	1,3	Maximum value from the Monster	5	g
4	1,3	Minimum descent time on test track	5	s
5	4	Damping coefficient adjustment range	3	N-s/m
6	5	Maximum travel (26in wheel)	3	mm
7	5	Rake offset	3	mm
8	6	Lateral stiffness at the tip	3	kN/m
9	7	Total mass	4	kg
10	8	Lateral stiffness at brake pivots	2	kN/m
11	9	Headset sizes	5	in
12	9	Steertube length	5	mm
13	9	Wheel sizes	5	list
14	9	Maximum tire width	5	in
15	10	Time to assemble to frame	1	s
16	11	Fender compatibility	1	list
17	12	Instills pride	5	subj
18	13	Unit manufacturing cost	5	US$
19	14	Time in spray chamber w/o water entry	5	s
20	15	Cycles in mud chamber w/o contamination	5	k-cycles
21	16,17	Time to disassemble/assemble for maintenance	3	s
22	17,18	Special tools required for maintenance	3	list
23	19	UV test duration to degrade rubber parts	5	hours
24	19	Monster cycles to failure	5	cycles
25	20	Japan Industrial Standards test	5	binary
26	20	Bending strength (frontal loading)	5	MN

Link Metrics to Needs

Need		1 Attenuation from dropout to handlebar at 10hz	2 Spring pre-load	3 Maximum value from the Monster	4 Minimum descent time on test track	5 Damping coefficient adjustment range	6 Maximum travel (26in wheel)	7 Rake offset	8 Lateral stiffness at the tip	9 Total mass	10 Lateral stiffness at brake pivots	11 Headset sizes	12 Steertube length	13 Wheel sizes	14 Maximum tire width	15 Time to assemble to frame	16 Fender compatibility	17 Instills pride	18 Unit manufacturing cost	19 Time in spray chamber w/o water entry	20 Cycles in mud chamber w/o contamination	21 Time to disassemble/assemble for maintenance	22 Special tools required for maintenance	23 UV test duration to degrade rubber parts	24 Monster cycles to failure	25 Japan Industrial Standards test	26 Bending strength (frontal loading)
1	reduces vibration to the hands.	•		•	•																						
2	allows easy traversal of slow, difficult terrain.		•																								
3	enables high speed descents on bumpy trails.	•		•	•																						
4	allows sensitivity adjustment.					•																					
5	preserves the steering characteristics of the bike.						•	•																			
6	remains rigid during hard cornering.		•						•																		
7	is lightweight.									•																	
8	provides stiff mounting points for the brakes.										•																
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11	works with fenders.																•										
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18	can be maintained with readily available tools.																						•				
19	lasts a long time.																							•	•		
20	is safe in a crash.																									•	•

Benchmark on Metrics

Metric #	Need #s	Metric	Imp	Units	ST Tritrack	Maniray 2	Rox Tahx Quadra	Rox Tahx Ti 21	Tonka Pro	Gunhill Head Shox
1	1,3	Attenuation from dropout to handlebar at 10hz	3	dB	8	15	10	15	9	13
2	2,6	Spring pre-load	3	N	550	760	500	710	480	680
3	1,3	Maximum value from the Monster	5	g	3.6	3.2	3.7	3.3	3.7	3.4
4	1,3	Minimum descent time on test track	5	s	13	11.3	12.6	11.2	13.2	11
5	4	Damping coefficient adjustment range	3	N-s/m	0	0	0	200	0	0
6	5	Maximum travel (26in wheel)	3	mm	28	48	43	46	33	38
7	5	Rake offset	3	mm	41.5	39	38	38	43.2	39
8	6	Lateral stiffness at the tip	3	kN/m	59	110	85	85	65	130
9	7	Total mass	4	kg	1.409	1.385	1.409	1.364	1.222	1.1
10	8	Lateral stiffness at brake pivots	2	kN/m	295	550	425	425	325	650
11	9	Headset sizes	5	in	1.000 1.125	1.000 1.125 1.250	1.000 1.125	1.000 1.125 1.250	1.000 1.125	NA
12	9	Steertube length	5	mm	150 180 210 230 255	140 165 190 215	150 170 190 210	150 170 190 210 230	150 190 210 220	NA
13	9	Wheel sizes	5	list	26in	26in	26in	26in 700C	26in	26in
14	9	Maximum tire width	5	in	1.5	1.75	1.5	1.75	1.5	1.5
15	10	Time to assemble to frame	1	s	35	35	45	45	35	85
16	11	Fender compatibility	1	list	Zefal	none	none	none	none	all
17	12	Instills pride	5	subj	1	4	3	5	3	5
18	13	Unit manufacturing cost	5	US$	65	105	85	115	80	100
19	14	Time in spray chamber w/o water entry	5	s	1300	2900	>3600	>3600	2300	>3600
20	15	Cycles in mud chamber w/o contamination	5	k-cycles	15	19	15	25	18	35
21	16,17	Time to disassemble/assemble for maintenance	3	s	160	245	215	245	200	425
22	17,18	Special tools required for maintenance	3	list	hex	hex	hex	hex	long hex	hex, pin wrnch
23	19	UV test duration to degrade rubber parts	5	hours	400+	250	400+	400+	400+	250
24	19	Monster cycles to failure	5	cycles	500k+	500k+	500k+	480k	500k+	330k
25	20	Japan Industrial Standards test	5	binary	pass	pass	pass	pass	pass	pass
26	20	Bending strength (frontal loading)	5	MN	55	89	75	75	62	102

Assign Marginal and Ideal Values

	Metric	Units	Marginal Value	Ideal Value
1	Attenuation from dropout to handlebar at 10hz	dB	>10	>15
2	Spring pre-load	N	480 - 800	650 - 700
3	Maximum value from the Monster	g	<3.5	<3.2
4	Minimum descent time on test track	s	<13.0	<11.0
5	Damping coefficient adjustment range	N-s/m	0	>200
6	Maximum travel (26in wheel)	mm	33 - 50	45
7	Rake offset	mm	37 - 45	38
8	Lateral stiffness at the tip	kN/m	>65	>130
9	Total mass	kg	<1.4	<1.1
10	Lateral stiffness at brake pivots	kN/m	>325	>650
11	Headset sizes	in	1.000 1.125	1.000 1.125 1.250
12	Steertube length	mm	150 170 190 210	150 170 190 210 230
13	Wheel sizes	list	26in	26in 700c
14	Maximum tire width	in	>1.5	>1.75
15	Time to assemble to frame	s	<60	<35
16	Fender compatibility	list	none	all
17	Instills pride	subj	>3	>5
18	Unit manufacturing cost	US$	<85	<65
19	Time in spray chamber w/o water entry	s	>2300	>3600
20	Cycles in mud chamber w/o contamination	k-cycles	>15	>35
21	Time to disassemble/assemble for maintenance	s	<300	<160
22	Special tools required for maintenance	list	hex	hex
23	UV test duration to degrade rubber parts	hours	>250	>450
24	Monster cycles to failure	cycles	>300k	>500k
25	Japan Industrial Standards test	binary	pass	pass
26	Bending strength (frontal loading)	MN	>70	>100

Process for setting the final specifications

1. Develop technical models to assess technical feasibility. The input is design variable and the output is a measurement using a metric.
2. Develop a cost model of the product.
3. Refine the specifications, making tradeoffs, where necessary to form a competitive map.
4. “Flow down” the final overall specs to specs for each subsystem (component and part).
5. Reflect on the results to see
   - ❖ Whether the product is a winner, and/or
   - ❖ How much uncertainty there is in the technical and cost model, or
   - ❖ Whether there is a need to develop a better technical model.

Set Final Specifications

	METRIC	Units	Value
1	Attenuation from dropout to handlebar at 10hz	dB	>12
2	Spring pre-load	N	650
3	Maximum value from the Monster	g	<3.4
4	Minimum descent time on test track	s	<11.5
5	Damping coefficient adjustment range	N-s/m	>100
6	Maximum travel (26in wheel)	mm	43
7	Rake offset	mm	38
8	Lateral stiffness at the tip	kN/m	>75
9	Total mass	kg	<1.4
10	Lateral stiffness at brake pivots	kN/m	>425
11	Headset sizes	in	1.000 1.125
12	Steertube length	mm	150 170 190 210 230
13	Wheel sizes	list	26in
14	Maximum tire width	in	>1.75
15	Time to assemble to frame	s	<45
16	Fender compatibility	list	Zefal
17	Instills pride	subj	>4
18	Unit manufacturing cost	US$	<80
19	Time in spray chamber w/o water entry	s	>3600
20	Cycles in mud chamber w/o contamination	k-cycles	>25
21	Time to disassemble/assemble for maintenance	s	<200
22	Special tools required for maintenance	list	hex
23	UV test duration to degrade rubber parts	hours	>450
24	Monster cycles to failure	cycles	>500k
25	Japan Industrial Standards test	binary	pass
26	Bending strength (frontal loading)	MN	>100

PRODUCT LIFE CYCLE

- Describes the advancement of products through identifiable stages of their existence.
- Product passes through the series of stages-their life cycle from the time they introduce in the market untill they are withdrawn
- The Product Life Cycle Concept is Based on Four Premises
  - Products have a limited life
  - Product sales pass through distinct stages each with different challenges and opportunities
  - Profits rise and fall at different stages
  - Products require different strategies in each life cycle stage

PRODUCT LIFE CYCLE

- The product will typically passes through four major stages in its life

PRODUCT LIFE CYCLE:INTRODUCTION

- Here the product is introduced in the market.
- The objective of this stage to create awarness and trial of the product launched
- Features of this stage are
  - Costs are high
  - Few competitiors
  - Sales and Profits are low
  - Relatively high prize
  - More money spend for promotion
  - Covers less market

PRODUCT LIFE CYCLE:GROWTH

- Product gets into more customers
- Objective is to maximize market share
- Features of this stage are
  - Sales rise rapidly
  - Profit at peak level
  - Price decreases
  - Increasing competitions
  - Unit cost decline
  - Mass market approach
  - Better revenue generation

PRODUCT LIFE CYCLE:MATURITY

- Here the sales continue to rise but more slowly
- The objective is to maximize profits defending market share.
- Features are
  - Profit gets stable
  - Competition at its peak
  - Price reduces further
  - Mass market
  - Product is established and promotion expenditures are less
  - Little growth potential for the product
  - Converting customers product to your own is a major challenge in maturity stage

PRODUCT LIFE CYCLE:DECLINE

- Here the sales decline permanently
- Objective is to reduce expenditure and sell the brand
- In this stage the expenditure begin to equal the profits or worse
- Features are
  - Market is saturated
  - Sales and profit decline
  - Company become cost conscious
  - Resources are blocked
  - Three options left
    - Repositioning or Rebranding
    - Amintain the product and reduces its cost
    - Take the product off the market

SUMMARY OF PRODUCT LIFE CYCLE FEATURES

Stages	**Introduction**	**Growth**	**Maturity**	**Decline**
Objectives	Create Product Awareness and Trial	Maximize Market Share	Maximize Profit when defending market share	Reduce expenditure and dilute the brand
Sales	Low Sales	Rapidly Increasing Sales	Peak Sales	Sales decline
Costs	High Cost Per Customer	Average cost per customer	Low cost per customer	High Cost
Profits	Negative	More Profit	High Profit	No profit
Customer	Innovators	Early Adopters	Early Majority +Late Majority	
Competitor	Few	More in Number	Stable Number, Beginning to decline	New comers

SUMMARY OF PRODUCT LIFE CYCLE STRATEGIES

Stages	**Introduction**	**Growth**	**Maturity**	**Decline**
Product	Basic product	Offer Product Extensions, Warranty	Diversify Brand and Models	Phase out weak items
Prize	Use cost plus	Price to penetrate market	Price to match or beat competitors	Cut price
Distribution	Build Selective Distribution	Build Intensive Distribution	Build More intensive Distribution	Go Selective :Phase out unprofitable outlets
Advertising	Build product awareness among early adopters and desires	Build awareness and interest in the mass market	Brand Differences and benefits	Reduce to retain hard core loyal
Sales promotion	Use heavy sales promotion	Reduce to take advantage of heavy consumer demand	Increase to encourage brand switching	Reduce to minimum level

New-Product Failures

- Why do new products fail?
  - Overestimation of market size.
  - Product design problems.
  - Incorrectly positioned, priced, or advertised.
  - Pushed by high level executives despite poor marketing research findings.
  - Excessive development costs.
  - Competitive reaction.

Product Development Process

- 0. Planning
- 1. Concept development
- 2. System level design
- 3. Detail design
- 4. Testing and refining
- 5. Production ramp-up
- 6.Marketing strategy development
- 7.Business analysis
- 8.Test marketing
- 9.Commercialization

Product Development Process

- **0. *Planning***
- The planning activity is often referred to as "phase zero" because it precedes the project approval and launch of the actual product development process.
- This phase begins with opportunity identification and assessment of technology developments
- The output of the planning phase is the project mission statement, which specifies the target market for the product, business goals, key assumptions and constraints.

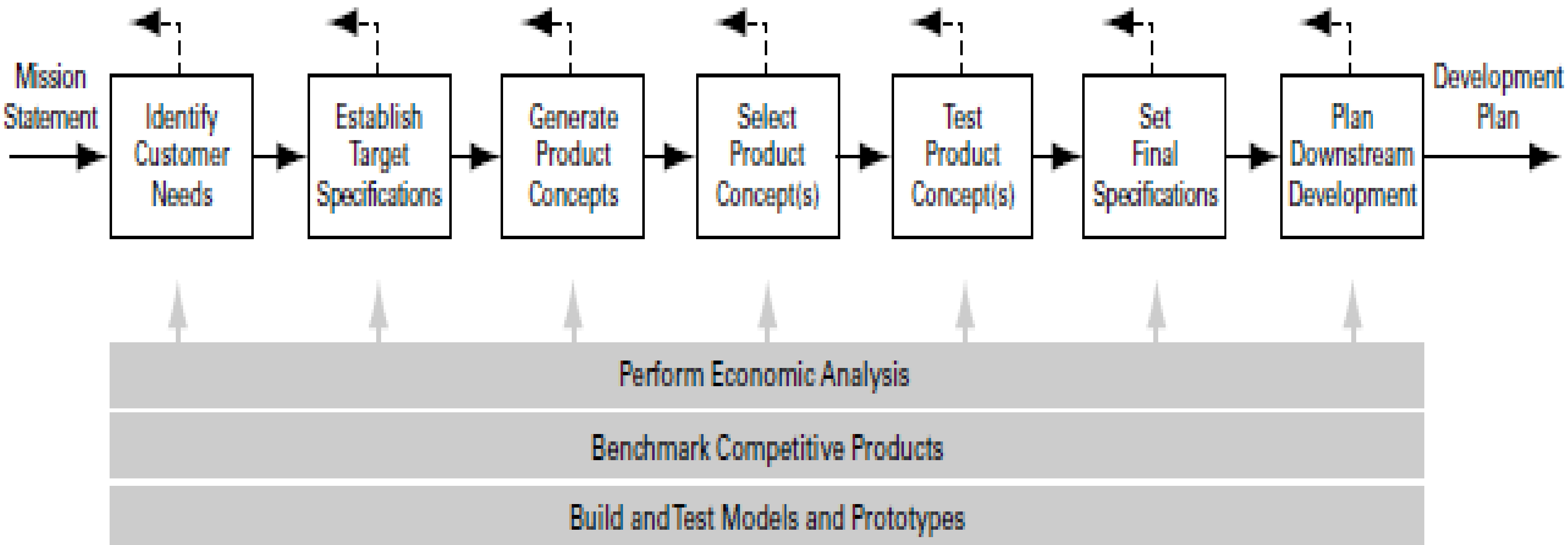
Concept Development

- The needs of the target market are identified, alternative product concepts are generated and evaluated, and a single concept is selected for further development.
- A concept is a description of the form, function and features of a product and is usually accompanied by a set of specifications, an analysis of competitive products, and an economic justification of the project.

Concept Development Steps

- Identify customer needs
- Establish target specification
- Analyze competing products
- Generate design concepts
- Select best design concept
- Refine specifications
- Economic analysis
- Project Planning

Concept Development Steps



System-level design:

- The system-level design phase includes the definition of the product architecture, decomposition of the product into subsystems and components, and preliminary design of key components.
- Initial plans for the production system and final assembly are usually defined during this phase as well.
- The output of this phase usually includes a geometric layout of the product, a functional specification of each of the product’s subsystems, and a preliminary process flow diagram for the final assembly process.

Detail design:

- The output of this phase is the control documentation for the product—the drawings or computer files describing the geometry of each part and its production tooling, the specifications of the purchased parts, and the process plans for the fabrication and assembly of the product.
- In the detail design phase, are: materials selection, production cost, and robust performance are finalized

Testing and refinement:

- The testing and refinement phase involves the construction and evaluation of multiple preproduction versions of the product.
- Early(alpha) prototypes are usually built parts with the same geometry and material properties but not necessarily fabricated with the actual processes to be used in production.
- Alpha prototypes are tested to determine whether the product will work as designed
- Later (beta) prototypes are usually built with parts supplied by the intended production processes but may not be assembled using the intended final assembly process.
- Beta prototypes are extensively evaluated internally and are also typically tested by customers in their own use environment.

Production ramp-up:

- In the production ramp-up phase, the product is made using the intended production system.
- Products produced during production ramp-up are sometimes supplied to preferred customers and are carefully evaluated to identify any remaining flaws.
- A post launch project review may occur shortly after the launch.
- This review includes an assessment of the project from both commercial and technical perspectives and is intended to identify ways to improve the development process for future projects.

Marketing strategy development:

- Part One:
  - Describes the target market, planned value proposition, sales, market share, and profit goals.
- Part Two:
  - Outlines the product’s planned price, distribution, and marketing budget.
- Part Three:
  - Describes the planned long-run sales and profit goals, marketing mix strategy.

Business analysis:

– Involves a review of the sales, costs, and profit projections to assess fit with company objectives.
– If results are positive, project moves to the product development phase.

Test marketing:

- Product and marketing program are introduced in a more realistic market setting.
- Not needed for all products.
- Can be expensive and time consuming, but better than making a major marketing mistake.

Commercialization:

- Must decide on **timing** (i.e., when to introduce the product).
- Must decide on **where** to introduce the product (e.g., single location, state, region, nationally, internationally).
- Must develop a **market rollout** plan.

Morphology of Design

- Morphology of design is a study of the chronological structure of the design project.
- It is defined by phases and their constituent steps.
- Consist of Seven Phases
- Of the seven phases, the first three phases belong to design, and the remaining four phases belong to production ,distribution consumption and retirement.

Morphology of Design

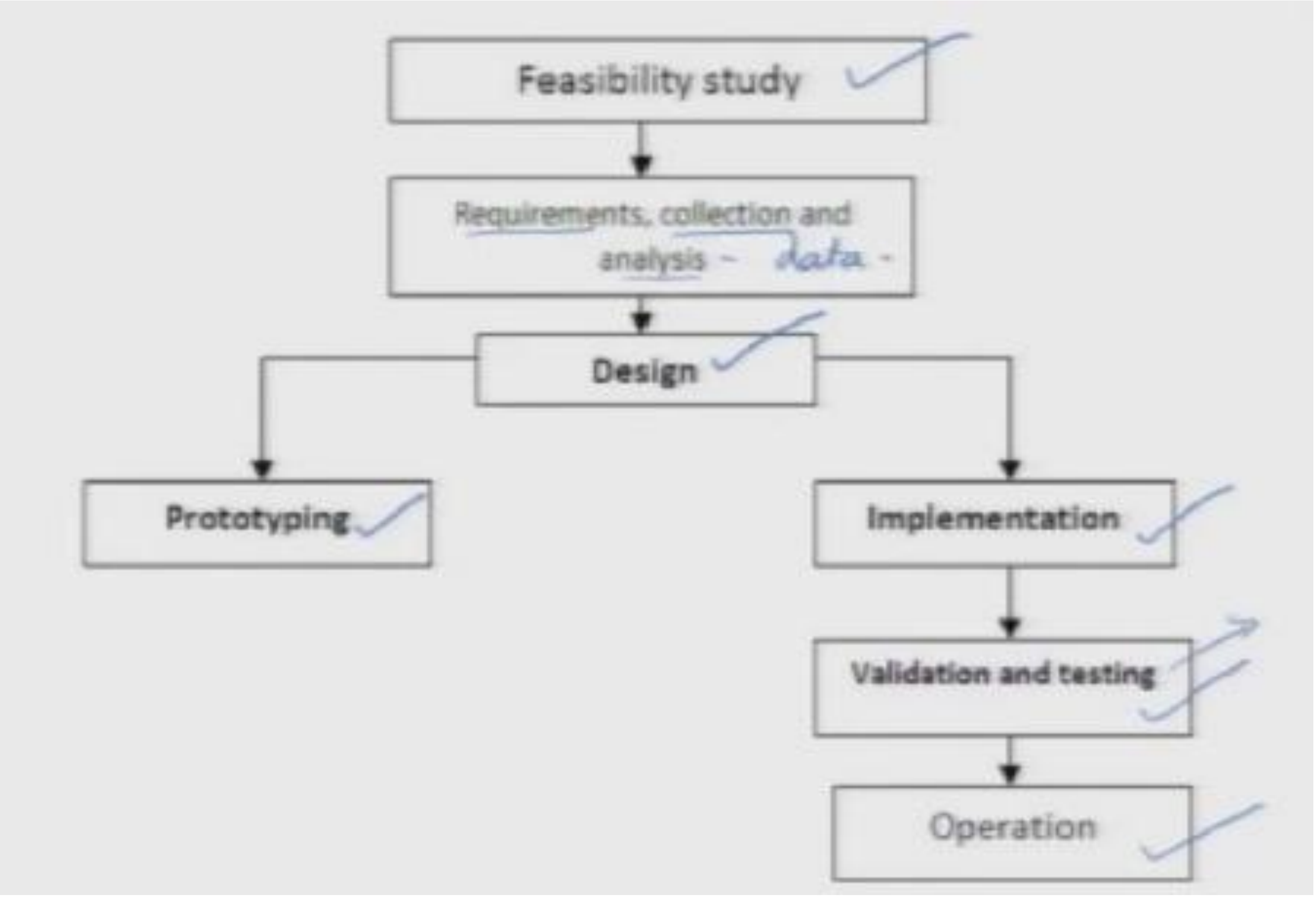
- Design process begins with the realization of unfulfilled needs of the society and ends with satisfying them.
- Engineering product design is concerned only with what is feasible.
- Necessary requirements are physical reliability and utility.

Morphology of Design

Phase 1:Feasibility Study

- Verify current existence of needs
- Explore design problems with constraints.
- Effort to seek number of feasible solutions
- Sorting of potential useful solutions from feasible set.
- In feasibility study ,the requirements, collection and analysis have to be done.
- Then what we do is we try to develop a design.
- If it is a product then we try to develop a prototype or if it is a solution software, we try to do implementation, validation and test our results and then we put into operation.

Phase 1:Feasibility Study



Phase 2:Preliminary Design

- Preliminary design phase starts with a set of useful solutions which were developed in the feasibility study.
- The purpose of the preliminary study is to find the best design alternatives.
- The purpose of this preliminary study is to establish which of the preferred alternative is the best design solutions.
- Surveying solution is tentatively accepted for closer examination
- Methods like FEA,CFD are used

Phase 2:Preliminary Design

- It involves
  - Formulation of mathematical models
  - Sensitivity Analysis
  - Formal optimisation
  - Simplification

Phase 3:Detailed Design

- After preliminary design, other studies examine the extent to which forces from surrounding or internal forces which affect the stability of the system
- The goal here is to furnish the engineering description of the examined design.
- The great flexibility is to show up to them at this point in designing.
- The preliminary design is developed as a master layout with this as a basis the detailed design or the specification of the component is carried out
- After the detailed design is done, now people look forward to local vendors, people look for international vendors, they try to pass on the design and then they ask them can you give the costing for it.

Phase 4:Planning for Production

- Fixed engineering specification, engineering design constraints are set in earlier phases now we think about manufacturing processes.
- As mentioned in the three phases are in the field of engineering design, but the fourth phase and further are related towards management.
- Every part requires a detail process plan.
- There is a process sheet which will be developed for each individual product, and then there will be more information about what is to be what all changes have to happen to the part such that it becomes a product ok.
- So, then the operation analysis is also performed.

Phase 5:Planning for Distribution

- Transportation cost can affect the outer design of the product.
- To facilitate handling special strapping and palletizing may be needed.(Eg:Cot)
- Major activities are
  - Planning the packaging system
  - Planning the warehouse facility
  - Planning the promotional activity
  - Designing the product for conditions arising in distribution

Phase 6:Planning for consumption

- The consumption in is the third process in the production-consumption cycle.
- It influences on the designs design.
- So, design for consumption includes the following factors.
  - Design for operation,
  - design for reliability,
  - design for convenience in use.
  - Design for safety
  - Design for aesthetic features
  - Design for maintenance
  - Design for adequate duration of services

Phase 7:Planning for retirement

- Last phase in the sequence of design of morphology.
- For large and semi permanent installation the removal may pose difficult engineering problems.
- Often goods are retired more frequently because of technical obsolescence than for physical deterioration.
- It may consider following aspects
  - Designing to reduce the rate of obsolescence
  - Designing the physical life to match anticipated service life.

MP482
PRODUCT DEVELOPMENT AND DESIGN

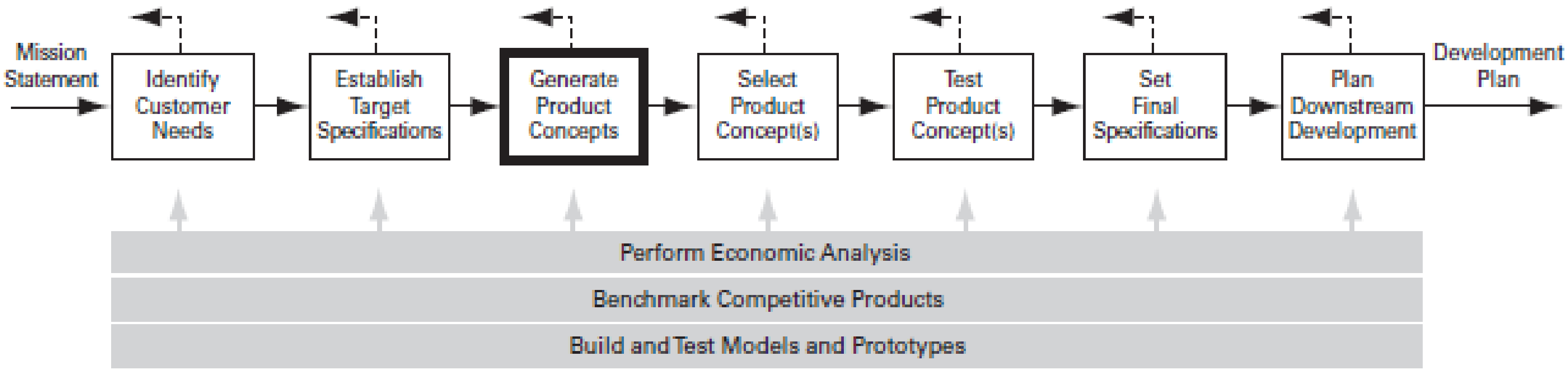
MODULE II

- Conceptual Design: Generation, selection & embodiment of concept. Product architecture. Industrial design: process, need.
- Robust Design: Taguchi Designs & DOE. Design Optimization

CONCEPT(PRODUCT CONCEPT)

- A product concept is an approximate description of the technology, working principles, and form of the product.
- It is a concise description of how the product will satisfy the customer needs.
- A concept is usually expressed as a sketch or as a rough three-dimensional model and is often accompanied by a brief textual description.
- Concept generation is relatively inexpensive and can be done relatively quickly in comparison to the rest of the development process

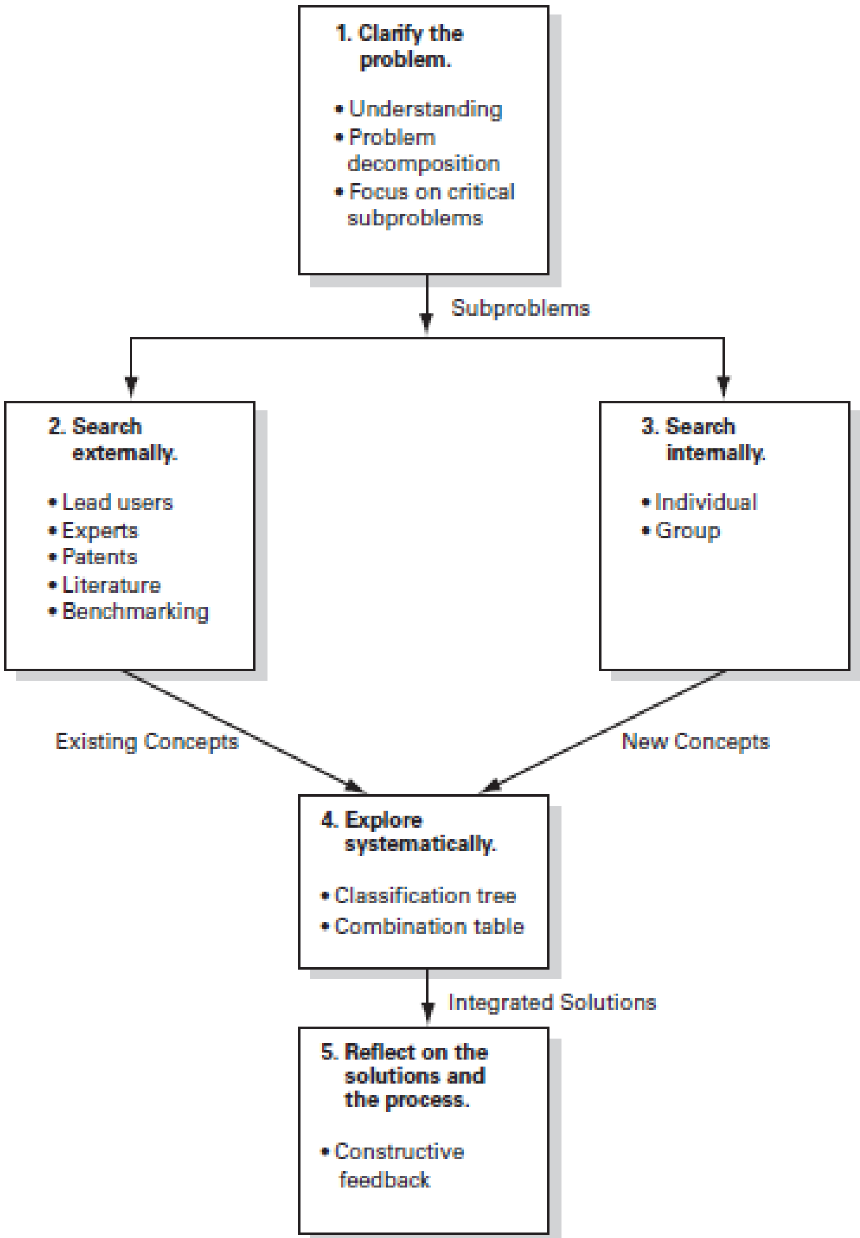
CONCEPT GENERATION



The concept generation process begins with a set of customer needs and target specifications and results in a set of product concepts from which the team will make a final selection.

Concept generation is almost always iterative

Five step concept generation method



- The method breaks a complex problem into simpler sub problems.
- Solution concepts are then identified for the sub problems by external and internal search procedures.
- Classification trees and concept combination tables are then used to systematically explore the space of solution concepts and to integrate the sub problem solutions into a total solution.
- Finally, the team takes a step back to reflect on the validity and applicability of the results, as well as on the process used.

Step 1: Clarify the problem

- Clarifying the problem consists of developing a general understanding and then breaking the problem down into sub problems if necessary.
- The mission statement for the project, the customer needs list, and the preliminary product specification are the ideal inputs to the concept generation process.
- Decompose a Complex Problem into Simpler Sub problems
- Eg: Document copier
- Decomposition may not be very useful for products with extremely simple functions. Eg:Paper clip

Step 1: Clarify the problem

- Dividing a problem into simpler sub problems is called *problem decomposition*.
- There are many schemes by which a problem can be decomposed.
  - Decomposition by functionality
  - Decomposition by sequence of user actions
  - Decomposition by customer needs.

Step 1: Clarify the problem: Functional Decomposition

- The first step in decomposing a problem functionally is to represent it as a single black box operating on material, energy, and signal flows,
- The next step in functional decomposition is to divide the single black box into sub functions to create a more specific description of what the elements of the product might do in order to implement the overall function of the product.
- Each sub function can generally be further divided into even simpler sub functions.
- The division process is repeated until the team members agree that each sub function is simple enough to workwith.
- A good rule of thumb is to create between 3 and 10 subn functions in the diagram

Step 1: Clarify the problem

- In some applications the material, energy, and signal flows are difficult to identify.
- In these cases, a simple list of the sub functions of the product, without connections between them, is often sufficient.
- Functional decomposition is most applicable to technical products, but it can also be applied to simple and apparently nontechnical products.

Step 1: Clarify the problem: Other Decomposition Approaches

- Decomposition by sequence of user actions
  - This approach is often useful for products with very simple technical functions involving a lot of user interaction.
- Decomposition by customer needs
  - This approach is often useful for products in which form, and not working principles or technology, is the primary problem.

Step 2:Search Externally

- External search is aimed at finding existing solutions to both the overall problem and the sub problems identified during the problem clarification step.
- external search occurs continually throughout the development process
- The external search for solutions is essentially an information-gathering process.
- Available time and resources can be optimized by using an expand-and-focus strategy:
- First *expand* the scope of the search by broadly gathering information that might be related to the problem and then *focus* the scope of the search by exploring the promising directions in more detail.

Step 2:Search Externally

- Five good ways to gather information from external sources:
  - Lead user interviews
    - *Lead users* are those users of a product who experience the needs months or years before the majority of the market benefit substantially from a product innovation
  - Expert consultation,
    - Experts may include professionals at firms manufacturing related products, professional consultants, university faculty, and technical representatives of suppliers.
  - Patent searches
    - Patents are a rich and readily available source of technical information containing detailed drawings and explanations of how many products work.
  - Literature searches
    - Published literature includes journals; conference proceedings; trade magazines; government reports; market, consumer, and product information; and new product announcements.
  - Competitive benchmarking.
    - *Benchmark Related Products* is the study of existing products with functionality similar to that of the product under development or to the sub problems on which the team is focused.

Step 3: Internal Search

- Internal search is the use of personal and team knowledge and creativity to generate solution concepts.
- Often called brainstorming, this type of search is internal in that all of the ideas to emerge from this step are created from knowledge already in the possession of the team.
- This activity may be the most open-ended and creative of any task in product development

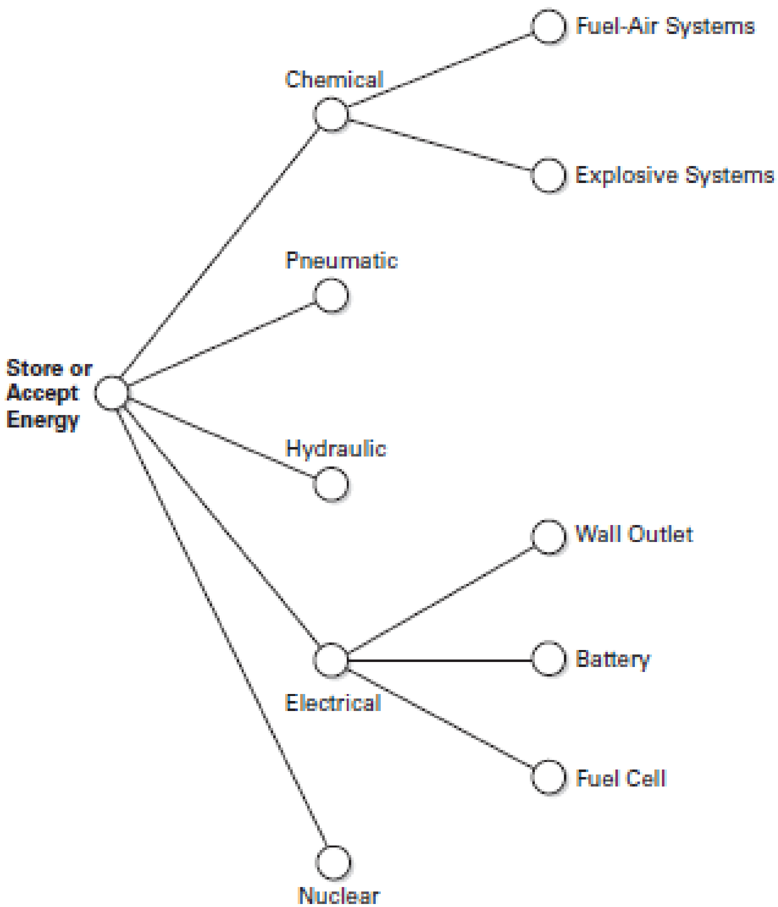
Step 4: Explore systematically

- As a result of the external and internal search activities, the team will have collected tens or hundreds of concept *fragments*—solutions to the sub problems.
- Systematic exploration is aimed at navigating the space of possibilities by organizing and synthesizing these solution fragments.
- There are two specific tools for managing this complexity and organizing the thinking of the team:
  - The *concept classification tree* and the *concept combination table*.
- The classification tree helps the team divide the possible solutions into independent categories.
- The combination table guides the team in selectively considering combinations of fragments.

Step 4: Explore systematically-Classification tree method

- Benefits of classification tree
  - The concept classification tree is used to divide the entire space of possible solutions into several distinct classes that will facilitate comparison and pruning.
  - Identification of independent approaches to the problem:
  - Exposure of inappropriate emphasis on certain branches

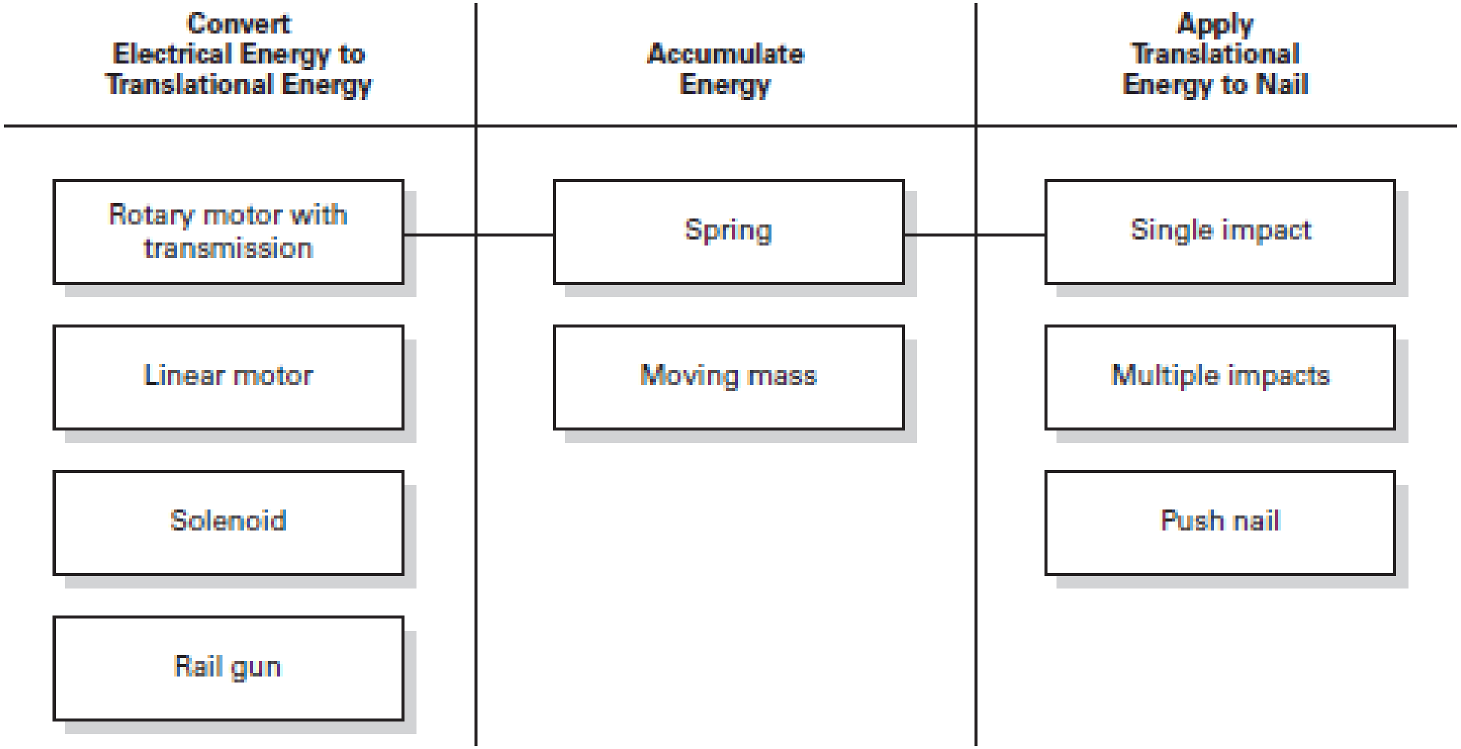
Step 4: Explore systematically- Classification tree method



Step 4: Explore systematically- Combination Table

- The concept combination table provides a way to consider combinations of solution fragments systematically.
- Potential solutions to the overall problem are formed by combining one fragment from each column.
- Two guidelines make the concept combination process easier.
  – First, if a fragment can be eliminated as being infeasible before combining it with other fragments, then the number of combinations the team needs to consider is dramatically reduced.
  – Second, the concept combination table should be concentrated on the sub problems that are coupled.

Step 4: Explore systematically-Combination Table



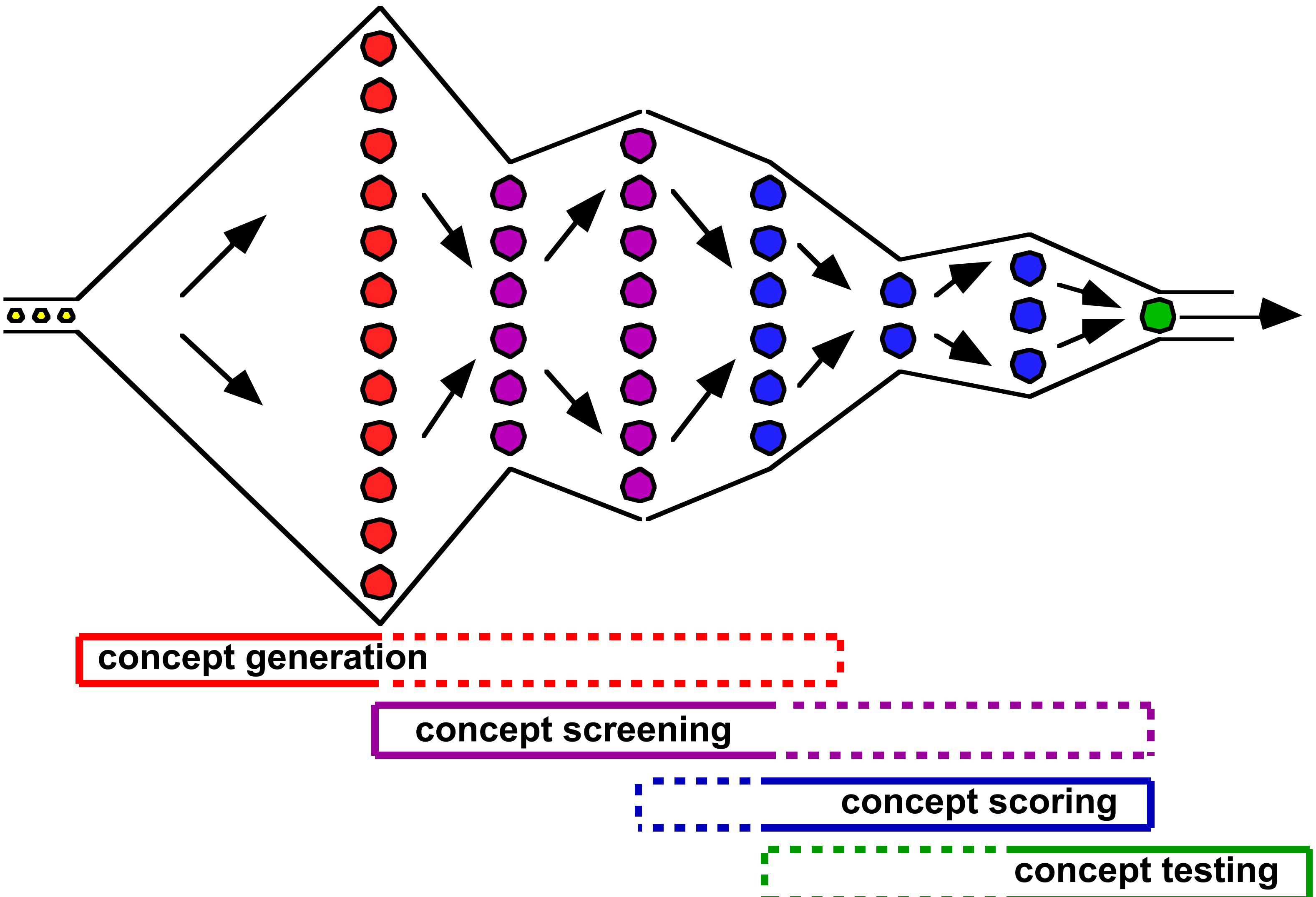
Step 5: Reflect on the Solutions and the Process

- Reflection should in fact be performed throughout the whole process.
- Is the team developing confidence that the solution space has been fully explored?
- Are there alternative function diagrams?
- Are there alternative ways to decompose the problem?
- Have external sources been thoroughly pursued?
- Have ideas from everyone been accepted and integrated in the process

Concept Selection

- *Concept selection* is the process of evaluating concepts with respect to customer needs and other criteria, comparing the relative strengths and weaknesses of the concepts, and selecting one or more concepts for further investigation, testing, or development

Concept Development Funnel



Concept Selection

- Concept selection is a convergent process, it is frequently iterative and may not produce a dominant concept immediately.
- A large set of concepts is initially down to a smaller set, but these concepts may subsequently be combined and improved to temporarily enlarge the set of concepts under consideration.
- Through several iterations a dominant concept is finally chosen

Concept Selection Approaches

- External decision
  - By use of an external group of customers, clients, etc.
- Product champion & intuition
  - By an influential member of the development team
- Multi-voting
  - Asking each member to pick a number of concepts and pick the one with most votes.
- Pros and cons
  - The team list the strengths and weakness of each concept.
- Prototype and test
  - Build and test prototype for each concept and select based on the test data.
- Decision metrics
  - The team rates each concept against selection criteria with varying importance/weights.

Two stages of concept selection

- Concept screening (the Pugh concept selection method)
  - To quickly narrow the number of concepts and to improve the concepts
  - Screening is a quick, approximate evaluation aimed at producing a few viable alternatives.

- Concept scoring
  - Scoring is a more careful analysis of these relatively few concepts in order to choose the single concept most likely to lead to product success.
  - Weighs the relative importance of the selection criteria
  - Focus on more refined comparisons with respect to each criteria

Two Stage Concept Selection Method

- Both stages, concept screening and concept scoring, follow a six-step process that leads the team through the concept selection activity.
- The steps are:
  - Prepare the selection matrix.
  - Rate the concepts.
  - Rank the concepts.
  - Combine and improve the concepts.
  - Select one or more concepts.
  - Reflect on the results and the process.

Concept Screening

- Concept screening is based on a method developed by the late Stuart Pugh in the 1980s and is often called Pugh concept selection (Pugh, 1990).
- The purposes of this stage are to narrow the number of concepts quickly and to improve the concepts

Concept Screening Process

1. Prepare the Selection Matrix
   - Criteria on LHS and concepts on top of the matrix
   - Reference Concept
   - Weightings
2. Rate Concepts
   - Scale (– 0 +) or (1–5)
   - Compare to Reference Concept or Values
3. Rank Concepts
   - Sum Weighted Scores
4. Combine and Improve
   - Remove Bad Features
   - Combine Good Qualities
5. Select the Best Concept
   - May Be More than One
   - Beware of Average Concepts
6. Reflect on the Process
   - Continuous Improvement

Concept Screening Process: Step 1 Prepare the Selection Matrix

- The inputs (concepts and criteria) are entered on the matrix.
- The concepts are best portrayed by both a written description and a graphical representation
- The concepts are entered along the top of the matrix, using graphical or textual labels of some kind.
- The selection criteria are listed along the left-hand side of the screening matrix
- These criteria are chosen based on the customer needs
- The criteria includes from 5 to 10 dimensions.
- The selection criteria should be chosen to differentiate among the concepts.
- Each criterion is given equal weight in the concept screening method.
- After careful consideration, the team chooses a concept to become the benchmark, or *reference concept*, against which all other concepts are rated.
- The reference is generally either an industry standard or a straight forward concept with which the team members are very familiar

Step 2: Rate the Concepts

- A relative score of “better than” (+), “same as” (0), or “worse than” (–) is placed in each cell of the matrix to represent how each concept rates in comparison to the reference concept relative to the particular criterion.

Example:Concept Screening

	Concepts						
Selection Criteria	**A Master Cylinder**	**B Rubber Brake**	**C Ratchet**	**D (Reference) Plunge Stop**	**E Swash Ring**	**F Lever Set**	**G Dial Screw**
Ease of handling	0	0	–	0	0	–	–
Ease of use	0	–	–	0	0	+	0
Readability of settings	0	0	+	0	+	0	+
Dose metering accuracy	0	0	0	0	–	0	0
Durability	0	0	0	0	0	+	0
Ease of manufacture	+	–	–	0	0	–	0
Portability	+	+	0	0	+	0	0
Sum +'s	2	1	1	0	2	2	1
Sum 0's	5	4	3	7	4	3	5
Sum –'s	0	2	3	0	1	2	1
Net Score	2	–1	–2	0	1	0	0
Rank	1	6	7	3	2	3	3
Continue?	Yes	No	No	Combine	Yes	Combine	Revise

Step 3: Rank the Concepts

- After rating all the concepts, the team sums the number of "better than," "same as," and "worse than" scores and enters the sum for each category in the lower rows of the matrix.
- Net score can be calculated by subtracting the number of "worse than" ratings from the "better than" ratings
- Once the summation is completed, the team rank-orders the concepts.
- In general those concepts with more pluses and fewer minuses are ranked higher

Step 4: Combine and Improve the Concepts

- Consider if there are ways to combine and improve certain concepts. Two issues to consider are:
  - Is there a generally good concept that is degraded by one bad feature? Can a minor modification improve the overall concept and yet preserve a distinction from the other concepts?
  - Are there two concepts that can be combined to preserve the “better than” qualities while annulling the “worse than” qualities?
- Combined and improved concepts are then added to the matrix, rated by the team, and ranked along with the original concepts.
- In our example, concepts D and F could be combined to remove several of the “worse than” ratings to yield a new concept, DF, to be considered in the next round.
- Concept G was also considered for revision.

Step 5:Select One or More Concepts

- Once the team members are satisfied with their understanding of each concept and its relative quality, they decide which concepts are to be selected for further refinement and analysis.
- Based upon previous steps, the team will likely develop a clear sense of which are the most promising concepts.
- The number of concepts selected for further review will be limited by team resources (personnel, money, and time).

Step 6:Reflect on the Results and the Process

- All of the team members should be comfortable with the outcome.
- An explicit consideration of whether the results make sense to everyone reduces the likelihood of making a mistake and increases the likelihood that the entire team will be solidly committed to the subsequent development activities.

Concept Scoring

- Concept scoring is used when increased resolution will better differentiate among competing concepts.
- In this stage, the team weighs the relative importance of the selection criteria and focuses on more refined comparisons with respect to each criterion.
- The concept scores are determined by the weighted sum of the ratings

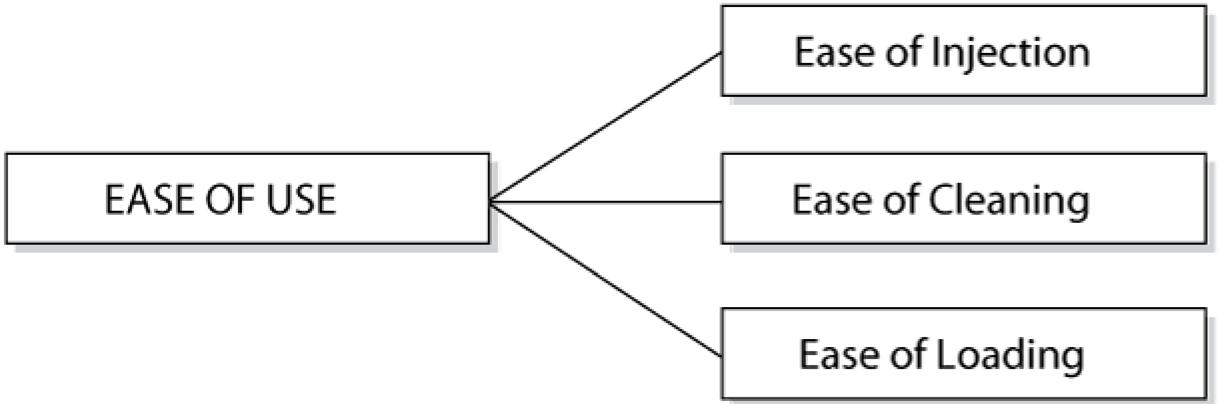
Concept scoring steps

1. Prepare a selection matrix, based on the selection criteria
2. Rate the concepts
3. Rank the concepts
4. Combine and improve concepts
5. Select one or more concepts
6. Reflect on the results and the process

Step 1: Prepare the Selection Matrix

- As in the screening stage, the team prepares a matrix and identifies a reference concept
- The concepts that have been identified for analysis are entered on the top of the matrix.
- The concepts have typically been refined to some extent since concept screening and may be expressed in more detail.
- In conjunction with more detailed concepts, the team may wish to add more detail to the selection criteria.
- The use of hierarchical relations is a useful way to illuminate the criteria.

Step 1: Prepare the Selection Matrix



From *Product Design and Development* by Karl Ulrich and Steven Eppinger (McGraw-Hill/Irwin)

Step 1: Prepare the Selection Matrix

- After the criteria are entered, the team adds importance weights to the matrix.
- Several different schemes can be used to weight the criteria, such as assigning an importance value from 1 to 5, or allocating 100 percentage points among them.

Step 1: Prepare the Selection Matrix

		Concept							
		A (Reference) Master Cylinder		DF Lever Stop		E Swash Ring		G+ Dial Screw+	
Selection Criteria	**Weight**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Ease of handling	5%	**3**	0.15	3	0.15	4	0.2	4	0.2
Ease of use	15%	**3**	0.45	4	0.6	4	0.6	3	0.45
Readability of settings	10%	2	0.2	**3**	0.3	5	0.5	5	0.5
Dose metering accuracy	25%	**3**	0.75	3	0.75	2	0.5	3	0.75
Durability	15%	2	0.3	5	0.75	4	0.6	**3**	0.45
Ease of manufacture	20%	**3**	0.6	3	0.6	2	0.4	2	0.4
Portability	10%	**3**	0.3	3	0.3	3	0.3	3	0.3
	Total Score	2.75		3.45		3.10		3.05	
	Rank	4		1		2		3	
	Continue?	No		Develop		No		No	

Step 2:Rate the concept

- As in the screening stage, it is generally easiest for the team to focus its discussion by rating all of the concepts with respect to one criterion at a time.
- Because of the need for additional resolution to distinguish among competing concepts, a finer scale is now used.
- Recommend a scale from 1 to 5:
- Another scale, such as 1 to 9, may certainly be used, but finer scales generally require more time and effort.
- To avoid scale compression, it is possible to use different reference points for the various selection criteria.
- Reference points may come from several of the concepts under consideration, from comparative benchmarking analysis, from the target values of the product specifications, or other means.

Step 2:Rank the concept

Relative Performance	Rating
Much worse than reference	1
Worse than reference	2
Same as reference	3
Better than reference	4
Much better than reference	5

Step 3: Rank the Concepts

- Once the ratings are entered for each concept, weighted scores are calculated by multiplying the row scores by the criteria weights.
- The total score for each concept is the sum of the weighted scores:

$$S_j = \sum_{i=1}^{n} r_{ij} w_i$$

r_{ij} = raw rating of concept j for the ith criterion
w_i = weighting for ith criterion
n = number of criteria
S_j = total score for concept j

- Finally, each concept is given a rank corresponding to its total score

Step 4: Combine and Improve the Concepts

- As in the screening stage, the team looks for changes or combinations that improve concepts.
- Although the formal concept generation process is typically completed before concept selection begins, some of the most creative refinements and improvements occur during the concept selection process as the team realizes the inherent strengths and weaknesses of certain features of the product concepts.

Step 5: Select One or More Concepts

- Based on the selection matrix, the team may decide to select the top two or more concepts.
- These concepts may be further developed, prototyped, and tested to elicit customer feedback

Step 6: Reflect on the Results and the Process

- As a final step the team reflects on the selected concept(s) and on the concept selection process.
- Two questions are useful in improving the process for subsequent concept selection activities:
  - In what way (if at all) did the concept selection method facilitate team decision making?
  - How can the method be modified to improve team performance?

Concept Testing

- Further narrow the set of concepts under consideration,
  - based data gathered from potential customers in the target markets, rather than the judgments made by the development team
- Specific Objectives
  - Select one from multiple concepts,
  - Gather information on how to improve a concept, and
  - Estimate the sales potential of the product

Concept testing process

1. Define the purpose of the concept testing
2. Choose a survey population and sample size
3. Choose a survey format
4. Communicate the concept
5. Measure customer response
6. Interpret the results
7. Reflect on the results and the process

Define the purpose (step 1)

- Which of the alternative concepts should be pursued
- How can the concept be improved to better meet customer needs
- Approximately how much units are likely to be sold
- Should the development be continued

Choose a survey population and sample size (step 2)

1. The team should choose a survey population that mirrors the target market in as many ways as possible.
2. Sample size varies from a few to thousands
3. Factors affecting the sample size
    1. The stage of product development
    2. Cost to conduct survey
    3. Nature and intent of the survey
    4. Budget (amount) of the development project
    5. How possible to collect the intended information.
4. Possible to structure multiple surveys with different objectives at different stages.

Choose a survey format (step 3)

- Formats
  - Face to face interaction
  - Telephone
  - Postal mail
  - Electronic mail
  - Internet (a test site on the internet)
- Each has its pros and cons
- Each has its bias.

Communicate the concept (step 4)

- The choice of survey format is closely linked to the way in which the concept will be communicated.
- Communication means
  - Verbal description
  - Sketch
  - Photos and renderings
  - Storyboard (a series of images shown a temporal sequence of actions involving the products)
  - Video (allowing more dynamic than the story board)
  - Simulation
  - Interactive multimedia (video and simulation)
  - Physical appearance model (looks-like)
  - Working prototypes (works-like)

Communicating the Concept

- Verbal description
  - A verbal description is generally a short paragraph or a collection of bullet points summarizing the product concept.
  - This description may be read by the respondent or may be read aloud by the person administering the survey.
- ***Sketch:***
  - Sketches are usually line drawings showing the product in perspective, perhaps with annotations of key features

Communicating the Concept

- ***Photos and renderings:***
  - Photographs can be used to communicate the concept when appearance models exist for the product concept.
  - Renderings are nearly photo-realistic illustrations of the concept.
- ***Storyboard:***
  - A storyboard is a series of images that communicates a temporal sequence of actions involving the product.
- ***Video:***
  - Video images allow even more dynamism than the storyboard.
  - With video, the form of the product itself can be clearly communicated, as can the way in whichthe product is used.

Communicating the Concept

- ***Simulation:***
  - Simulation is generally implemented as software that mimics the function or interactive features of the product. Simulation would probably not be the ideal way to communicate the key features of a scooter, but in some other cases simulation can be effective.
- ***Interactive multimedia:***
  - Interactive multimedia combines the visual richness of video with the interactivity of simulation. Using multimedia, you can display video and still images of the product.
- ***Physical appearance models:***
  - Physical appearance models, also known a "looks-like" models, vividly display the form and appearance of a product. They are often made of wood or polymer foams and are painted to look like real products.

Communicate the concept (step 4)

	Telephone	Electronic Mail	Postal Mail	Internet	Face-to-Face
Verbal description	•	•	•	•	•
Sketch		•	•	•	•
Photo or rendering		•	•	•	•
Storyboard		•	•	•	•
Video				•	•
Simulation				•	•
Interactive multimedia				•	•
Physical appearance model					•
Working prototype					•

Communicating the Concept

- ***Working prototypes:***
- When available, working prototypes, or works-like models, can be useful in concept testing.
- However, the use of working prototypes is also risky.
- The primary risk is that the respondents will equate the prototype with the finished product.
- In some cases, prototypes perform better than the ultimate product

Communicating the Concept

Sketch

Rendering

Story Board

3D Model

Measure customer response (step 5)

- Measurement
  - Mere their preferences among alternative concepts
  - Understand why and how they respond to the product concepts
  - Attempt to measure purchase intent (the likelihood of buying)
  - But avoid aggressively promoting the product concepts
- Definitely would buy.
- Probably would buy.
- Might or might not buy.
- Probably would not buy.
- Definitely would not buy.

Interpret the results (Step 6)

- $Q = N \times A \times P$
  - Where $P = Cd \times Fd + Cp \times Fp$
    - Q = the quantity of the expected sales
    - N = the number of potential customers expected to buy
    - A = the fraction of these potential customers aware of the product and the product is available
    - P = the probability that the product is purchased if the customer is aware of it and it is available.
    - Fd = the the fraction of survey respondents indicating that they would definitely purchase
    - *F*p= is the fraction of survey respondents indicating that they would *probably purchase*
    - Cd(Calibration constants) = the percentage that those in Fd will actually buy (.1-.5)
    - Cp = the percentage that those in Fp will actually buy (0-.25)
- Be aware that sales also depends on
  - Words of mouth
  - Fidelity of the concept description
  - Pricing
  - Level of promotion

Step 7:Reflect on the results and the process

- The primary benefit of the concept test is in getting feedback from real potential customers.
- The team benefits from thinking about the impact of the three key variables in the forecasting model: (1) the overall size of the market, (2) the availability and awareness of the product, and (3) the fraction of customers who are likely to purchase.

Definition
– Product Architecture

- A product can be thought of in both functional and physical terms.
- The functional elements of a product are the individual operations and transformations that contribute to the overall performance of the product.
- Eg:For a printer, some of the functional elements are “store paper” and “communicate with host computer.
- The *physical elements* of a product are the parts, components, and subassemblies that ultimately implement the product’s functions.

Definition
– Product Architecture

- The physical elements of a product are typically organized into several major physical building blocks, which we call chunks.
- Each chunk is then made up of a collection of components that implement the functions of the product.
- The architecture of a product is the scheme by which the functional elements of the product are arranged into physical chunks and by which the chunks interact.

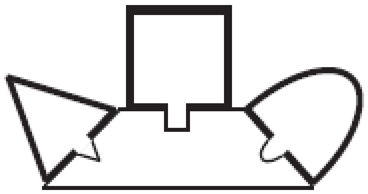
Modular vs. integrated architecture

- Modular
  - Chunks implement one or a few functional elements in their entirety (each functional element is implemented by exactly one physical chunks)
  - The interactions between chunks are well defined and are generally fundamental to the primary functions of the products.
- Integrated
  - Functional elements of the product are implemented using more than one chunk
  - A single chunk implements many functions.
  - The interaction between chunks are ill defined and may be incidental to the primary functions of the products.

Types of Modularity

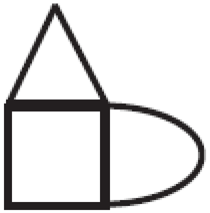
- Modular architectures comprise three types: slot, bus, and sectional
- Each type embodies a one-to-one mapping from functional elements to chunks and well defined interfaces.
- The differences between these types lie in the way the interactions between chunks are organized

Types of Modularity



Slot-Modular
Architecture

Bus-Modular
Architecture



Sectional-Modular
Architecture

Types of Modularity

- Slot-modular architecture:
  - Each of the interfaces between chunks in a slot-modular architecture is of a different type from the others, so that the various chunks in the product cannot be interchanged.
- ***Bus-modular architecture:***
  - In a bus-modular architecture, there is a common *bus* to which the other chunks connect via the same type of interface.
- ***Sectional-modular architecture:***
  - In a sectional-modular architecture, all interfaces are of the same type, but there is no single element to which all the other chunks attach.

Factors affecting architecture modularity

- Product changes
- Product variety
- Component standardization
- Product performance
- Manufacturability
- Product development management

Factors affecting architecture modularity (product changes)

For modular architecture

- Allows to minimize the physical changes required to achieve a functional change

Reasons for product changes

- Upgrades(technological changes)
- add-ons(add components to basic unit)
- adaptation (adapt to different operation environments(220v and 110v power))
- wear (e.g., razors, tires, bearings)
- consumption (for example, toner cartridges, battery in cameras)
- flexibility in use (for users to reconfigure to exhibit different capabilities (many cameras can be used with different lens and flash options))
- re-use in creating subsequent products

Factors affecting architecture modularity (product variety)

- The range of products (models) concurrently available in the market
- Modular can vary without adding tremendous complexity to the manufacturing system.
- Eg:Watches

Factors affecting architecture modularity

- Component standardization
  - Use the same components in multiple products
  - Increase production volumes

Factors affecting architecture modularity

- Product performance (for integrated design)
  - Allow optimizing the performance for an individual integrated architecture.
  - Allow function sharing
    - Implementing multiple functions using a single physical element.
  - Allow for redundancy to be eliminated through function sharing and geometric nesting
    - Thus could lower the manufacturing cost

Factors affecting architecture modularity

- Manufacturability
  - DFM can be performed on the chunk-level but not across several chunks.
    - For example, minimize the total number of part counters.
  - Thus, it is more applicable to an integrated design.
- One important design-for-manufacturing (DFM) strategy involves the minimization of the number of parts in a product through *component integration*.

Factors affecting architecture modularity

- Product development management
  - Better for modular architecture
    - Each modular chunk is assigned to an individual or a small group
    - Known and relatively limited functional interactions with other chunks.
  - Not as easy for integrated architecture
    - Detailed designs will require close coordination among different groups.

Architecture Design Process

- Create a schematic of the product
- Cluster the elements of the schematic
- Create a rough geometric layout
- Identify the fundamental and incidental interactions.

Step 1:Creating a product schematic

- A *schematic* is a diagram representing the team's understanding of the constituent elements of the product.
- Create a schematic diagram representing the (physical or functional) elements of the product, using blocks, arrows, and other notations.
  - Flow of forces or energy
  - Flow of material
  - Flow of signal or data
- A good rule of thumb is to aim for fewer than 30 elements in the schematic, for the purpose of establishing the product architecture.
- If the product is a complex system, involving hundreds of functional elements, then it is useful to omit some of the minor ones and to group some others into higher-level functions to be decomposed later

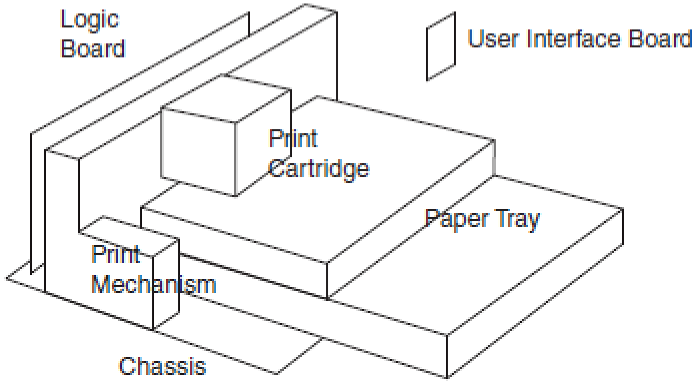
Step 2:Cluster the elements of the schematic

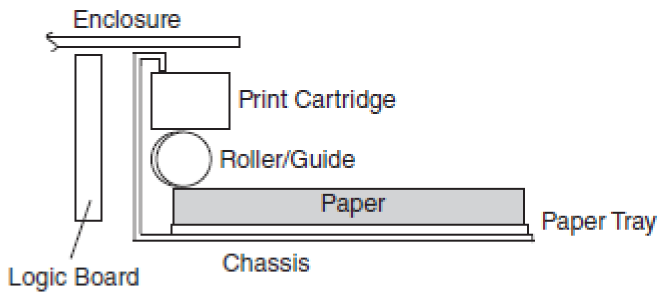
- The challenge of step 2 is to assign each of the elements of the schematic to a chunk
- At one extreme, each element could be assigned to its own chunk, yielding 15 chunks.
- At the other extreme, the team could decide that the product would have only one major chunk and then attempt to physically integrate all of the elements of the product
- Factors for considering clustering
  - Geometric integration and precision
  - Function sharing
  - Capability of vendors
  - Similarity of design or production technology
  - Localization of design (or part) change
  - Accommodating variety
  - Enabling standardization
  - Portability of the interfaces

Step 3:Creating a rough geometric layout

- A geometric system layout in
  - 2D or 3D drawings,
  - 2D or 3D graphics, or
  - Physical models.
- Creating a geometric layout forces the team to consider whether the geometric interfaces among the chunks are feasible and to work out the basic dimensional relationships among the chunks

Step 3:Creating a rough geometric layout

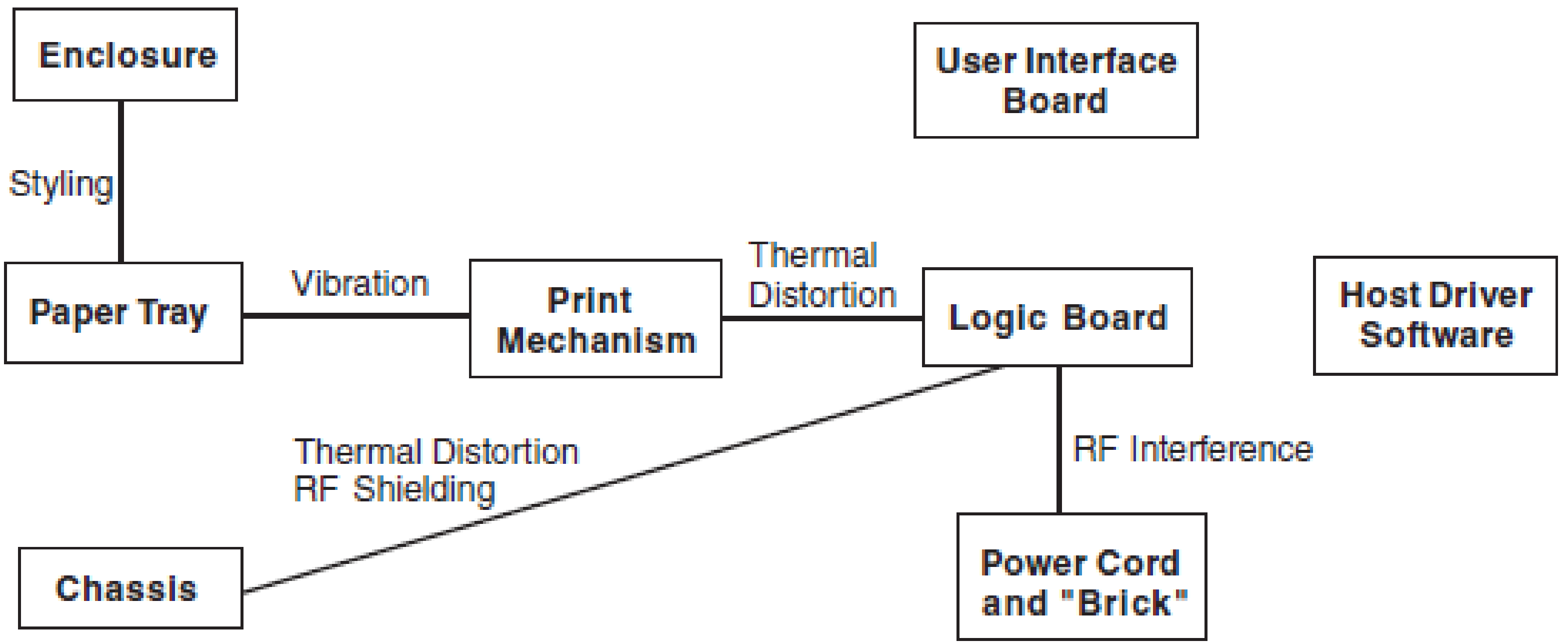




Step 4:Identify the fundamental and incidental interactions

- Fundamental interactions
  - Those which connect the building blocks, such as energy flows, material flows, and data flows.
  - First, *fundamental interactions* are those corresponding to the lines on the schematic that connect the chunks to one another.
  - For example, a sheet of paper flows from the paper tray to the print mechanism.
- Incidental interactions
  - Those that arise because of geometric arrangements of the building blocks, such as thermal expansion or heat dissipation.
  - For example, vibrations induced by the actuators in the paper tray could interfere with the precise location of the print cartridge in the x-axis.

Step 4:Identify the fundamental and incidental interactions



Industrial Design

- The Industrial Designers Society of America (IDSA) defines industrial design as “the professional service of creating and developing concepts and specifications that optimize the function, value, and appearance of products and systems for the mutual benefit of both user and manufacturer.

Need of ID

- Dreyfuss (1967) lists five critical goals that industrial designers can help a team to achieve when developing new products:
  - ***Utility:*** The product's human interfaces should be safe, easy to use, and intuitive.
  - ***Appearance:*** Form, line, proportion, and color are used to integrate the product into a pleasing whole.
  - ***Ease of maintenance:***
  - ***Low costs:***.
  - ***Communication***

Need of ID

- The range of expenditures on ID is tremendous
- A convenient means for assessing the importance of ID to a particular product is to characterize importance along two dimensions: ergonomics and aesthetics.
  - (Note that we use the term *ergonomics* to encompass all aspects of a product that relate to its human interfaces)

Need of ID : Ergonomics Need

- **How important is ease of use?**
  - Ease of use may be extremely important both for frequently used products, such as an office photocopier, and for infrequently used products, such as a fire extinguisher.
  - Ease of use is more challenging if the product has multiple features and/or modes of operation that may confuse or frustrate the user.
- **How important is ease of maintenance?**
  - If the product needs to be serviced or repaired frequently, then ease of maintenance is crucial.
  - For example, a user should be able to clear a paper jam in a printer or photocopier easily.
- **How many user interactions are required for the product's functions?**
  - In general, the more interactions users have with the product, the more the product will depend on ID.

Need of ID:Ergonomics Need

- ***How novel are the user interaction needs?***

  A user interface requiring incremental improvements to an existing design will be relatively straightforward to design, such as the buttons on a new desktop computer mouse.

- ***What are the safety issues?***

  All products have safety considerations. For some products, these can present significant challenges to the design team.

  For example, the safety concerns in the design of a child's toy are much more prominent than those for a new computer mouse.

Need of ID: Aesthetics Need

- ***Is visual product differentiation required?***
  - Products with stable markets and technology are highly dependent upon ID to create aesthetic appeal and, hence, visual differentiation.
  - In contrast, a product such as a computer's internal disk drive, which is differentiated by its technological performance, is less dependent on ID.
- ***How important are pride of ownership, image, and fashion?***
  - A customer's perception of a product is in part based upon its aesthetic appeal.
  - An attractive product may be associated with high fashion and image and will likely create a strong sense of pride among its owners.
  - When such characteristics are important, ID will play a critical role in determining the product's ultimate success.
- ***Will an aesthetic product motivate the team?***
  - A product that is aesthetically appealing can generate a sense of team pride among the design and manufacturing staff.

Industrial Design Process

- Investigation of customer needs.
- Conceptualization.
- Preliminary refinement.
- Further refinement and final concept selection.
- Control drawings or models.
- Coordination with engineering, manufacturing, and external vendors

Investigation of customer needs.

- The product development team begins by documenting customer needs
- Because industrial designers are skilled at recognizing issues involving user interactions, ID involvement is crucial in the needs process.
- While involvement of marketing, engineering, and ID certainly leads to a common, comprehensive understanding of customer needs for the whole team, it particularly allows the industrial designer to gain an intimate understanding of the interactions between the user and the product.

Conceptualization.

- Once the customer needs and constraints are understood, the industrial designers help the team conceptualize the product.
- During the concept generation stage engineers naturally focus their attention upon finding solutions to the technical sub functions of the product.
- At this time, the industrial designers concentrate upon creating the product’s form and user interfaces.
- Industrial designers make simple sketches, known as thumbnail sketches, of each concept.
- These sketches are a fast and inexpensive medium for expressing ideas and evaluating possibilities.

Preliminary refinement.

- In the preliminary refinement phase, industrial designers build models of the most promising concepts.
- Soft models are typically made in full scale using foam or foam-core board.
- They are the second-fastest method—only slightly slower than sketches—used to evaluate concepts.

Further refinement and final concept selection.

- At this stage, industrial designers often switch from soft models and sketches to hard models and information-intensive drawings known as *renderings*.
- Renderings show the details of the design and often depict the product in use.
- Drawn in two or three dimensions, they convey a great deal of information about the product.
- Renderings are often used for color studies and for testing customers' reception to the proposed product's features and functionality.

Control Drawings or Models

- Industrial designers complete their development process by making *control drawings* or *control models* of the final concept.
- Control drawings or models document functionality, features, sizes, colors, surface finishes, and key dimensions.
- Although they are not detailed part drawings (known as engineering drawings), they can be used to fabricate final design models and other prototypes.
- Typically, these drawings or models are given to the engineering team for detailed design of the parts. and assembly services.

Coordination with Engineering, Manufacturing, and External Vendors

- The industrial designers must continue to work closely with engineering and manufacturing personnel throughout the subsequent product development process.
- Some industrial design consulting firms offer quite comprehensive product development services, including detailed engineering design and the selection and management of outside vendors of materials, tooling, components and assembly services.

MP482
PRODUCT DEVELOPMENT AND DESIGN

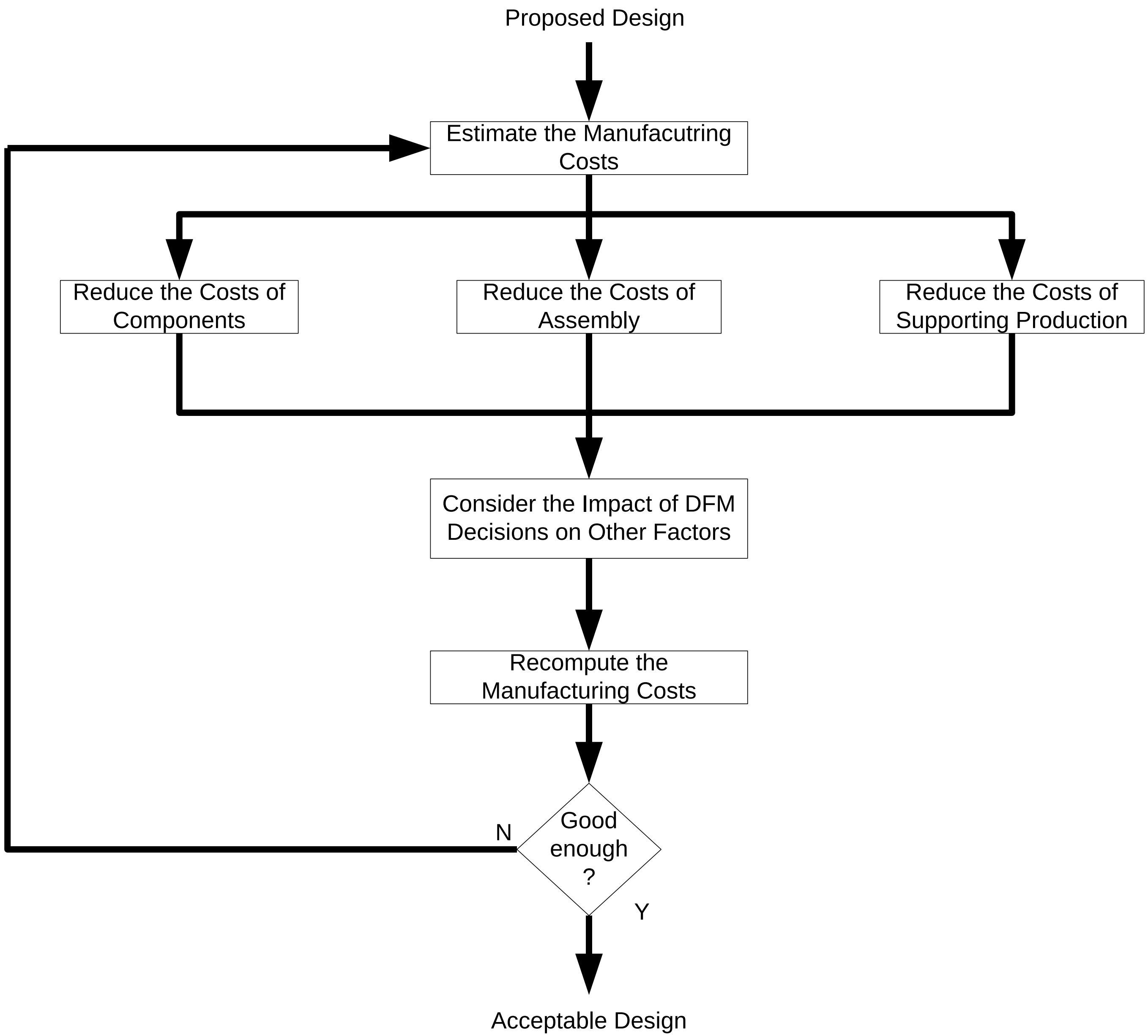
MODULE III

- Design for Manufacturing and Assembly: Methods of designing for Manufacturing and Assembly
- Designs for Maintainability.
- Designs for Environment.
- Product costing.
- Ethics in product design, legal factors and social issues.

Design for Manufacturing and Assembly

- Design for manufacturing (DFM) is design based on minimizing the cost of production and/or time to market for a product, while maintaining an appropriate level of quality.
- The strategy in DFM involves minimizing the number of parts in a product and selecting the appropriate manufacturing process.
- DFM and DFA starts with the formation of the design team which tends to be multi-disciplinary, including engineers, manufacturing managers, cost accountants, and marketing and sales professionals.

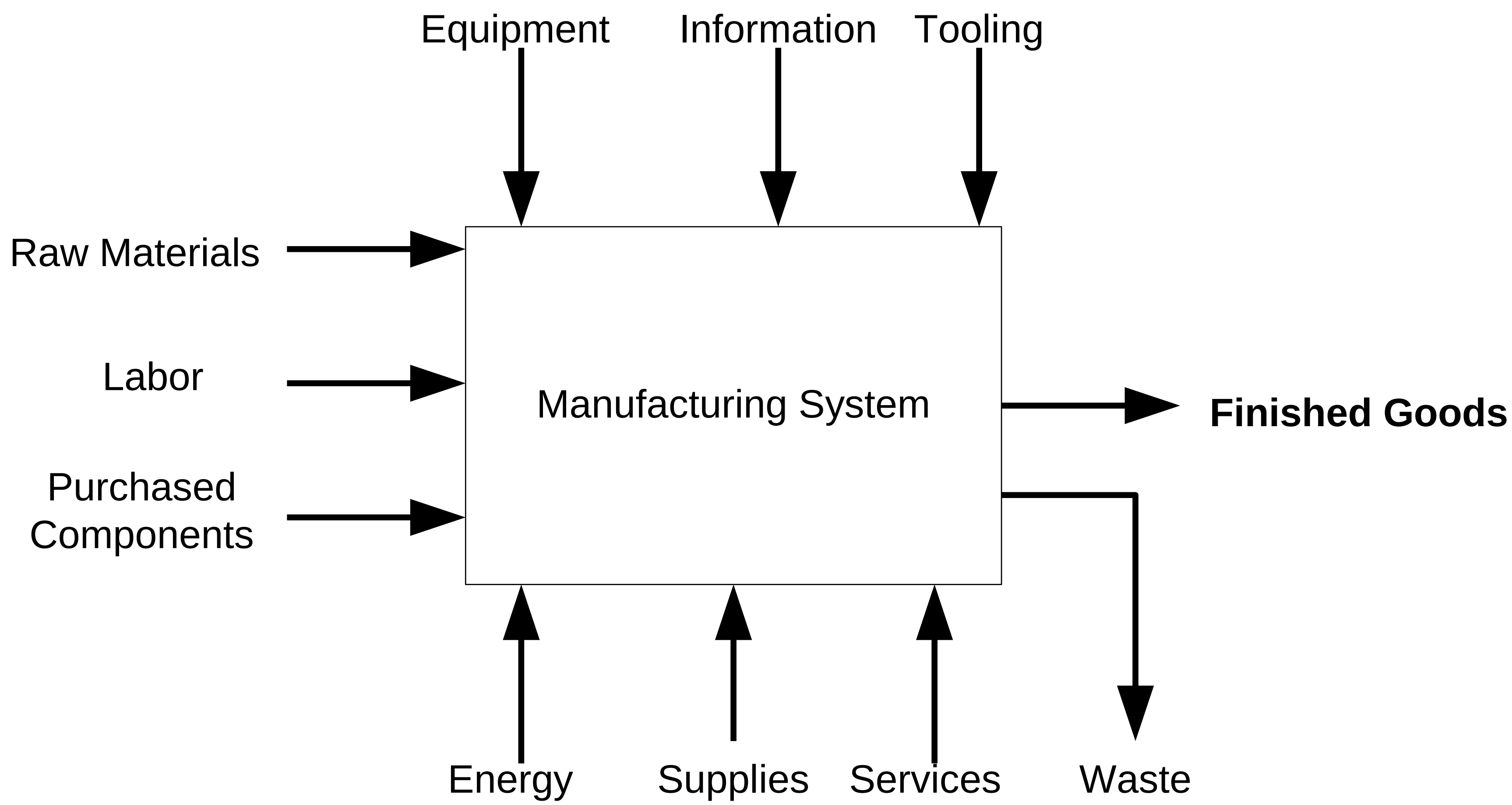
DFM Method


Proposed Design
Estimate the Manufacutring Costs
Reduce the Costs of Components
Reduce the Costs of Assembly
Reduce the Costs of Supporting Production
Consider the Impact of DFM Decisions on Other Factors
Recompute the Manufacturing Costs
Good enough ?
N
Y
Acceptable Design

DFM Method

- Estimate the manufacturing costs.
- Reduce the costs of components.
- Reduce the costs of assembly.
- Reduce the costs of supporting production.
- Consider the impact of DFM decisions on other factors.

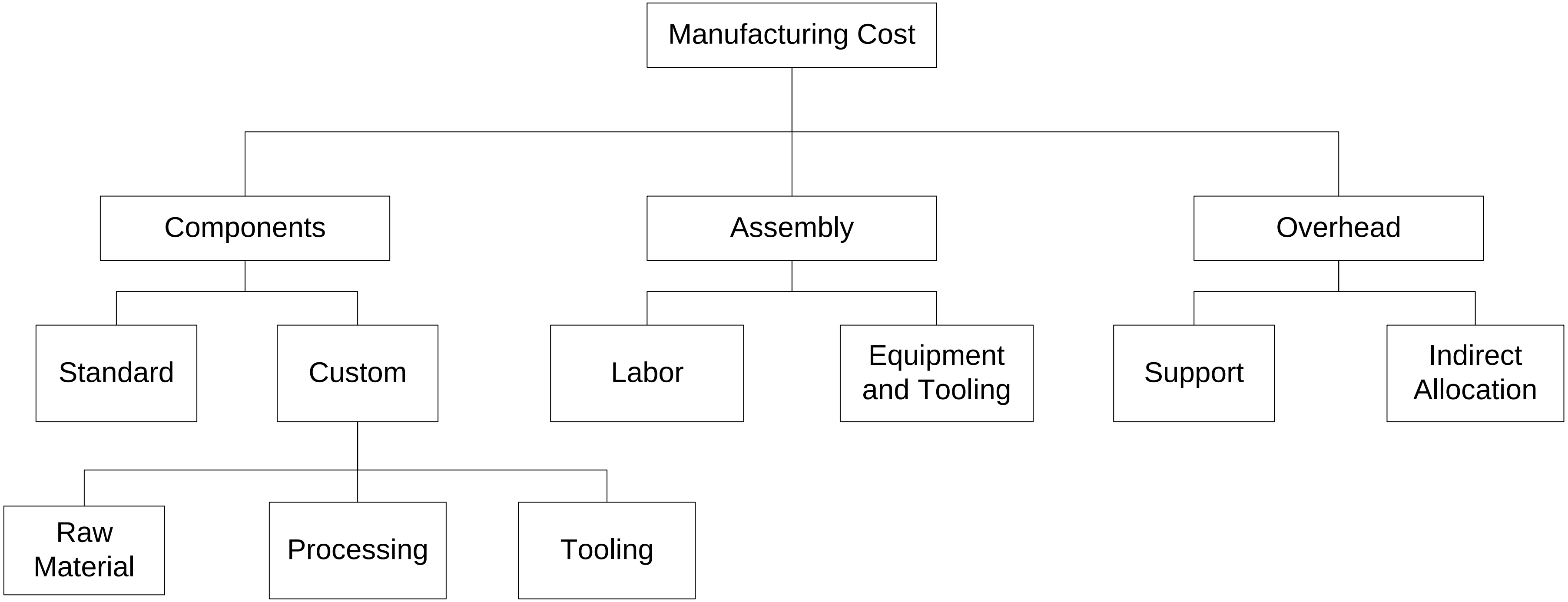
Estimate the Manufacturing Costs



Manufacturing Costs Defined

- Sum of all the expenditures for the inputs of the system (i.e. purchased components, energy, raw materials, etc.) and for disposal of the wastes produced by the system
- *Unit manufacturing cost*, which is computed by dividing the total manufacturing costs for some period (usually a quarter or a year) by the number of units of the product manufactured during that period.

Elements of the Manufacturing Cost of a Product

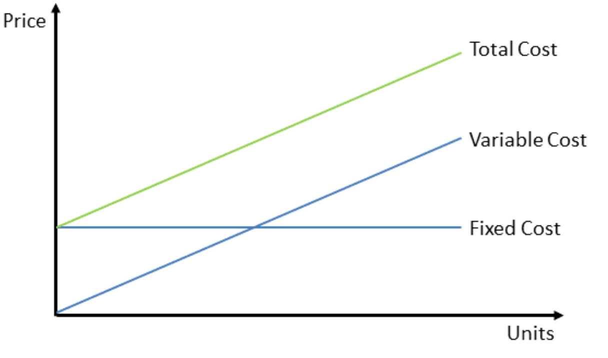


Manufacturing Cost of a Product

- Component Costs (parts of the product)
  - Parts purchased from supplier
  - Custom parts made in the manufacturer’s own plant or by suppliers according to the manufacturer’s design specifications
- Assembly Costs (labor, equipment, & tooling)
- Overhead Costs (all other costs)
  - Support Costs (material handling, quality assurance, purchasing, shipping, receiving, facilities, etc.)
  - Indirect Allocations (not directly linked to a particular product but must be paid for to be in business)

Fixed Costs vs. Variable Costs

- Fixed Costs – incurred in a predetermined amount, regardless of number of units produced (i.e. setting up the factory work area or cost of an injection mold)
- Variable Costs – incurred in direct proportion to the number of units produced (i.e. cost of raw materials)



Reduce the Cost of Components

- Understand the Process Constraints and Cost Drivers
- Redesign Components to Eliminate Processing Steps
- Choose the Appropriate Economic Scale for the Part Process
- Standardize Components and Processes
  - Internal Standardization and External Standardization
- Adhere to “Black Box” Component Procurement

Understand the Process Constraints and Cost Drivers

Redesign costly parts with the same performance while avoiding high manufacturing costs.

Work closely with design engineers—raise awareness of difficult operations and high costs.

Redesign Components to Eliminate Processing Steps

- Reduce the number of steps of the production process
  - Will usually result in reduce costs
- Eliminate unnecessary steps.
- Use substitution steps, where applicable.
- Analysis Tool – Process Flow Chart and Value Stream Mapping

Choose the Appropriate Economic Scale for the Part Process

Economies of Scale – As production volume increases, manufacturing costs usually decrease.

- Fixed costs divided among more units.
- Variable costs are lower since the firm can use more efficient processes and equipment.

Standardize Components and Processes

- Economies of Scale – The unit cost of a component decreases as the production volume increases.
- Standard Components—common to more than one product
- Analysis tools – group technology and mass customization

Adhere to “Black Box” Component Procurement

- Black box—only give a description of what the component has to do, not how to achieve it
- Successful black box design requires clear definitions of the functions, interfaces, and interactions of each component.

Reduce the Costs of Assembly

- Design for Assembly (DFA) index
- Integrated Parts
- Maximize Ease of Assembly
- Consider Customer Assembly

DFA Systems

- *Design for assembly* (DFA) is a fairly well-established subset of DFM that involves minimizing the cost of assembly.

Design for Assembly Index

$$\text{DFA index} = \frac{\text{(Theoretical minimum number of parts) x (3 seconds)}}{\text{Estimated total assembly time}}$$

The “3 seconds” in the numerator reflects the theoretical minimum time required to handle and insert a part that is perfectly suited for assembly.

Integrated Parts

Advantages

- Do not have to be assembled
- Often less expensive to fabricate rather than the sum of each individual part
- Allows critical geometric features to be controlled by the part fabrication process versus a similar assembly process

Maximize Ease of Assembly

- Part is inserted from the top of the assembly
- Part is self-aligning
- Part does not need to be oriented
- Part requires only one hand for assembly
- Part requires no tools
- Part is assembled in a single, linear motion
- Part is secured immediately upon insertion

Consider Customer Assembly

- Customers will tolerate some assembly
- Design product so that customers can easily and assemble correctly
- Customers will likely ignore directions

Reduce the Costs of Supporting Production

- Minimize Systemic Complexity (inputs, outputs, and transforming processes)
- Error Proofing (Poka Yoke)
  - Anticipate possible failure modes
  - Take appropriate corrective actions in the early stages
  - Use color coding to easily identify similar looking, but different parts

Consider the Impact of DFM Decisions on Other Factors

- Development Time
- Development Cost
- Product Quality
- External Factors
  - Component reuse
  - Life cycle costs

Guideline for DFM

- Reduce the number of parts in design
- Develop the product with modular design
- Design for error proofing
- Design for intended orientation and handling
- Provide simple patterns and fastening
- Use common standard parts
- Design parts for multiple use
- Consider company's production system, capabilities,limitations and regulations
- Design for verifiability
- Provide tolerance judiciously
- Incorporate robustness
- Develop the product with modular design

Guidelines for DFA

- Minimise number of parts
- Choose mode of assembly
- Encourage modular assembly
- Stack assemblies
- Eliminate adjustments
- Eliminate non value added process
- Use self fastening
- Maximize compliance
- Minimize handling
- Facilitate parts handling
- Use standard parts

Design For Environment

- Design for Environment (DFE) is a method to minimize or eliminate environmental impacts of a product over its life cycle.

- Effective DFE practice maintains or improves product quality and cost while reducing environmental impacts.

Herman Miller
Setu Multipurpose Chair

- Environmentally friendly and non-toxic materials
  - 41% aluminum, 41% polypropylene, 18% steel, by weight
- Use of recycled materials
  - 44% by weight - 23% post-consumer, 21% post-industrial
- Less material content
  - 20 lbs lighter than most task chairs
- Easy to disassemble
  - 86% easily separable materials
- Recyclable
  - 92% by weight
- Production line uses 100% green power
- No air or water emissions released in production
- Returnable and recyclable packaging

Source: Herman Miller, Inc.

HermanMiller

Environmental Impacts

Global Warming

Resource depletion

Solid waste

Water pollution

Air pollution

Land degradation

www.buildbabybuild.com
www.flickr.com Ben Rad
www.wonkroom.thinkprogress.org

www.co.rockingham.nc.us
commons.wikimedia.org
www.adb.org

Environmental Impacts

Global warming:

- the temperature of the earth is gradually increasing as a result of the accumulation of greenhouse gases, particulates, and water vapor in the upper atmosphere.
- This effect appears to be accelerating as a result of emissions of carbon dioxide (CO_2), methane (CH_4), chlorofluorocarbons (CFCs), black carbon particles, and nitrogen oxides (NO_x) from industrial processes and products.

Resource depletion:

- Many of the raw materials used for production, such as iron ore, gas, oil, and coal, are nonrenewable and supplies are limited.

Solid waste:

- Products may generate solid waste throughout their life cycle. Some of this waste is recycled, but most is disposed in incinerators or landfills. Incinerators
- generate air pollution and toxic ash (which goes into landfills).
- Landfills may also create concentrations of toxic substances, generate methane gas (CH_4), and release groundwater pollutants.

Environmental Impacts

Water pollution:

- The most common sources of water pollution are discharges from industrial processes, which may include heavy metals, fertilizers, solvents, oils, synthetic substances, acids, and suspended solids.

Air pollution:

- Sources of air pollution include emissions from factories, power generating plants, incinerators, residential and commercial buildings, and motor vehicles. Typical pollutants include CO2, NOx, sulfur dioxide (SO2), ozone (O3), and volatile organic compounds (VOCs).

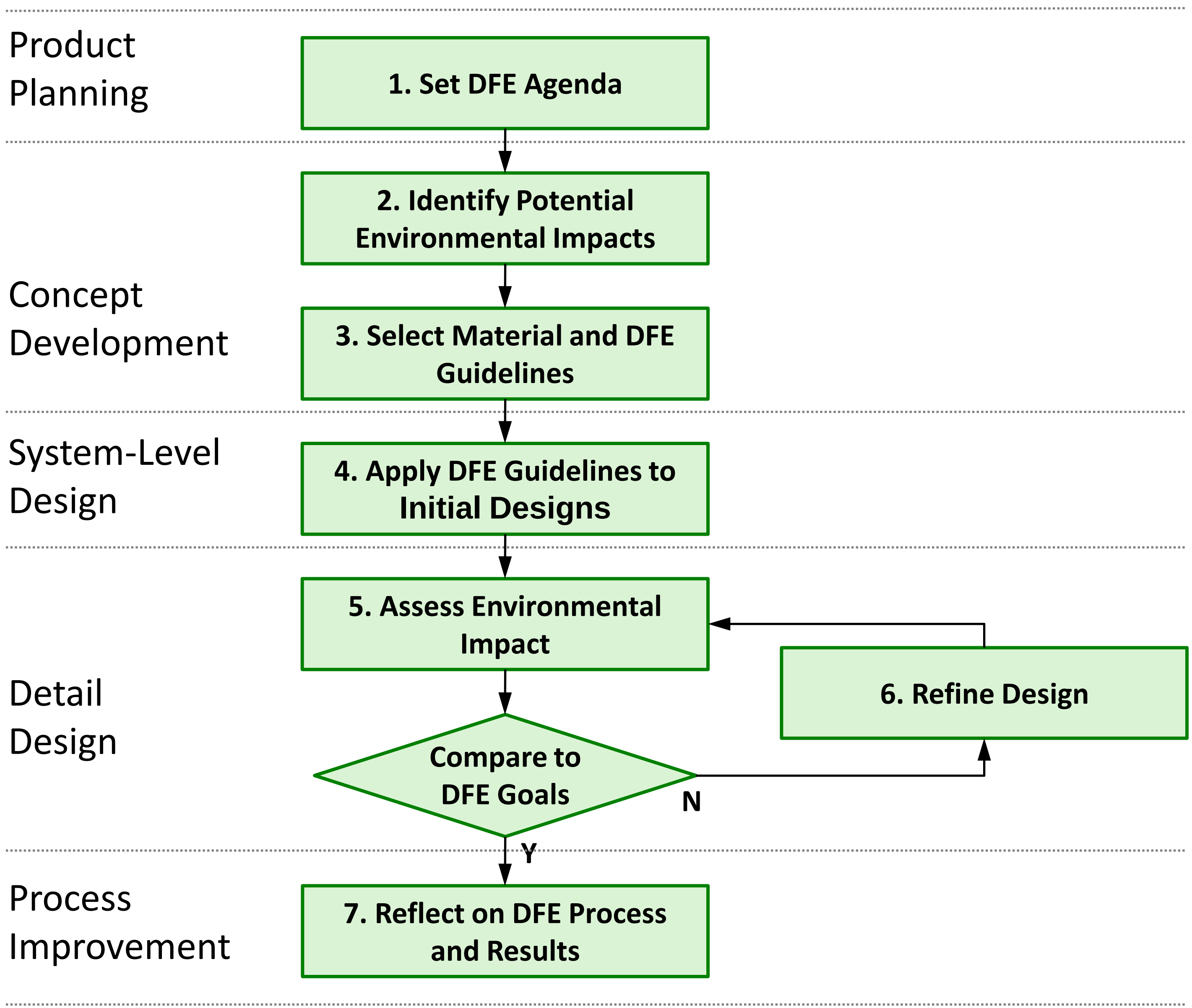
Land degradation:

- Land degradation concerns the adverse effects that raw material extraction and production, such as mining, farming, and forestry, have on the environment.

Ozone depletion:

- The ozone layer protects the earth against the harmful effects of the sun's radiation. It is degraded by reactions with nitric acid (created by the burning of fossil fuels) and chorine compounds (such as CFCs).

DFE Process



Product
Planning
1. Set DFE Agenda
2. Identify Potential Environmental Impacts
Concept
Development
3. Select Material and DFE Guidelines
System-Level
Design
4. Apply DFE Guidelines to Initial Designs
5. Assess Environmental Impact
6. Refine Design
Detail
Design
Compare to DFE Goals
N
Y
Process
Improvement
7. Reflect on DFE Process and Results

Step 1: Set the DFE Agenda: Drivers, Goals, and Team

- Consists of three activities:
  - Identifying the internal and external drivers of DFE,
  - setting the environmental goals for the product,
  - setting up the DFE team.

Step 1: Set the DFE Agenda: Drivers, Goals, and Team

- Identify the Internal and External Drivers of DFE
- Internal drivers are the DFE objectives within the organization.
- ***Product quality:***
  - A focus on environmental performance may raise the quality of the product in terms of functionality, reliability in operation, durability, and repairability.
- ***Public image:***
  - Communicating a high level of environmental quality of a product can improve a company's image.
- ***Cost reduction:***
  - Using less material and less energy in production can result in considerable cost savings. Generating less waste and eliminating hazardous waste results in lower waste disposal costs.
- ***Innovation:***
  - Sustainable thinking can lead to radical changes in product design and may foster innovation across the whole company.

Step 1: Set the DFE Agenda: Drivers, Goals, and Team

- ***Operational safety:***
  - By eliminating toxic materials, many DFE changes can help improve the occupational health and safety of employees.
- ***Employee motivation:***
  - Employees can be motivated to contribute in new and creative ways if they are able to help reduce the environmental impacts of the company's products and operations.
- ***Ethical responsibility:*** I
  - Interest in sustainable development among managers and product developers may be motivated in part by a moral sense of responsibility for conserving the environment and nature.
- ***Consumer behavior:***
  - Wider availability of products with positive environmental benefits may accelerate the transition to cleaner lifestyles and demand for greener products.

Step 1: Set the DFE Agenda: Drivers, Goals, and Team

- External drivers are the DFE objectives within the organization
- ***Environmental legislation:***
  - Product-oriented environmental policy is developing rapidly.
- ***Market demand:***
  - Today, companies operate in a business environment of increasingly well-informed industrial customers and end users who may demand sustainable products.
  - Negative publicity, blogs, and boycotts of products, manufacturers, or retailers can have considerable impact on sales.
  - Of course, the opposite positive effect is becoming more powerful as well

Step 1: Set the DFE Agenda: Drivers, Goals, and Team

- ***Competition:***
  - Sustainability activities undertaken by competitors can lead to pressure for more emphasis on DFE.
- ***Trade organizations:***
  - Trade or industrial organizations in some branches of industry— such as packaging and automobile manufacturing—encourage companies to take environmental action by sharing technology and establishing codes of conduct.
- ***Suppliers:***
  - Suppliers influence company behavior by introducing more sustainable materials and processes. Companies may choose to audit and confirm environmental declarations of their suppliers.
- ***Social pressures:***
  - Through their social and community contacts, managers and employees may be asked about the responsibility that their business takes for the environment.

Step 1: Set the DFE Agenda: Drivers, Goals, and Team

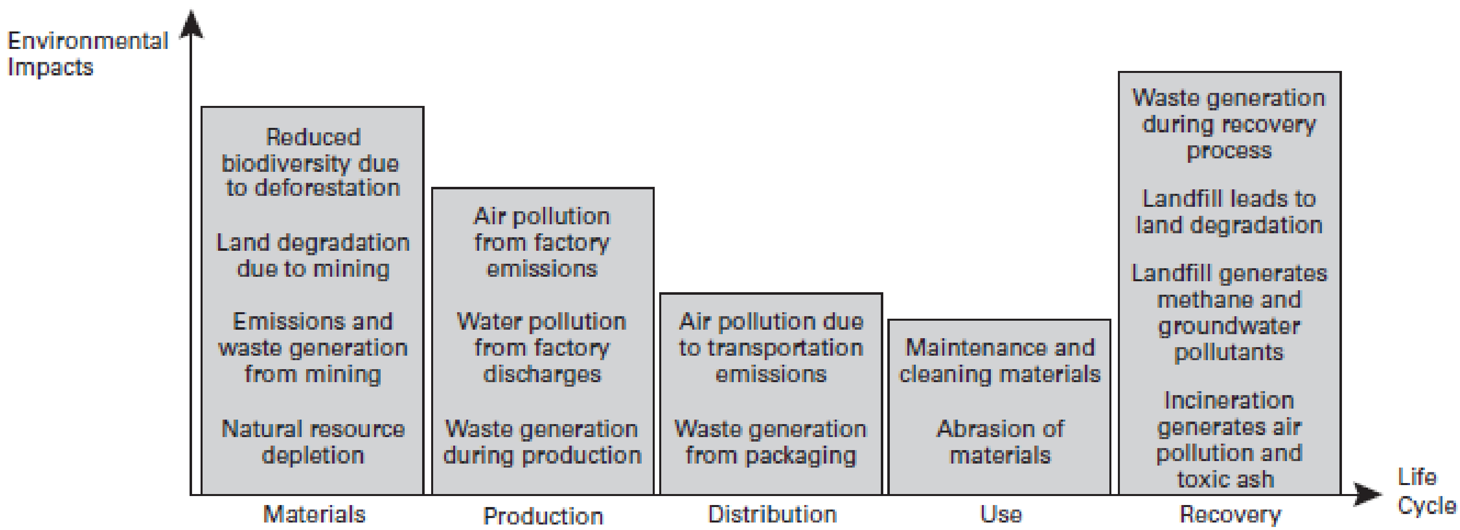
- Set the DFE Goals
  - An important activity in the product planning phase is to set the environmental goals for each product development project.
  - These goals define how the organization complies with environmental regulations and how the organization reduces the environmental
  - Eg of DFE goals: Use renewable materials,Avoid toxic materials,Facilitate material recycling

Step 1: Set the DFE Agenda: Drivers, Goals, and Team

- SET DFE TEAM
  - DFE requires participation by many functional experts on the product development project.
  - The typical composition of a DFE team (often a subteam within the overall project team) consists of a DFE leader, an environmental chemistry and materials expert, a manufacturing engineer, and a representative from the purchasing and supply chain organization.
  - Of course, the DFE team composition depends on the organization and needs of the specific project, and may also include marketing professionals, outside consultants, suppliers, or other experts.

Step 2:Identify Potential Environmental Impacts

- The team lists for each life cycle stage the anticipated key environmental impacts.
- The height of each bar in the chart represents the team's judgment about the overall magnitude of the potential environmental impacts and therefore where to focus their DFE efforts.



Step 3: Select DFE Guidelines

- Guidelines help product design teams to make early DFE decisions without the type of detailed environmental impact analysis that is only possible after the design is more fully specified.
- Relevant guidelines may be selected based in part on the qualitative assessment of life cycle impacts (from step 2).
- Selecting relevant guidelines during the concept development phase allows the product development team to apply them throughout the product development project.

DFE and Material Guidelines

Example DFE Guidelines

- Do not combine materials incompatible in recycling
- Label all component materials for recycling
- Enable easy disassembly into separate material recycling streams
- Use no surface treatments
- Eliminate packaging
- Reduce weight and size for shipping

Example Material Guidelines

- Use recycled and recyclable industrial materials
- Use natural materials which can be returned to biological decay cycles
- Use processes which do not release toxic materials
- Capture and reuse all hazardous materials

Step 4: Apply the DFE Guidelines to the Initial Product Design

- As the product architecture is developed during the system-level design phase , some initial material choices are made along with some of the module design decisions.
- In the detail-design phase, the exact materials specifications, detailed geometry, and manufacturing processes are determined.
- By specifying low-impact materials and reducing energy consumption, product development teams create more environmentally friendly products.
- Furthermore, the DFE guidelines may inspire product development teams to come up with improvement in the functionality and durability of the product, which may lead to significant lower environmental impacts

Step 5: Assess the Environmental Impacts

- The next step is to assess, to the extent possible, the environmental impacts of the product over its entire life cycle.
- To do so with precision requires a detailed understanding of how the product is to be produced, distributed, used over its lifetime, and recycled or disposed at the end of its useful life.
- This assessment is generally done on the basis of the detailed bill of materials (BOM), including sources of energy, component material specifications, suppliers, transportation modes, waste streams, recycling methods, and disposal means.
- Several quantitative life cycle assessment (LCA) tools are available to conduct such an environmental assessment.

Step 6: Refine the Product Design to Reduce or Eliminate the Environmental Impacts

- The objective of this step and subsequent DFE iterations is to reduce or eliminate any significant environmental impacts through redesign.
- The process repeats until the environmental impacts have been reduced to an acceptable level and the environmental performance fits the DFE goals.
- Redesign for ongoing improvement of DFE may also continue after production begins.

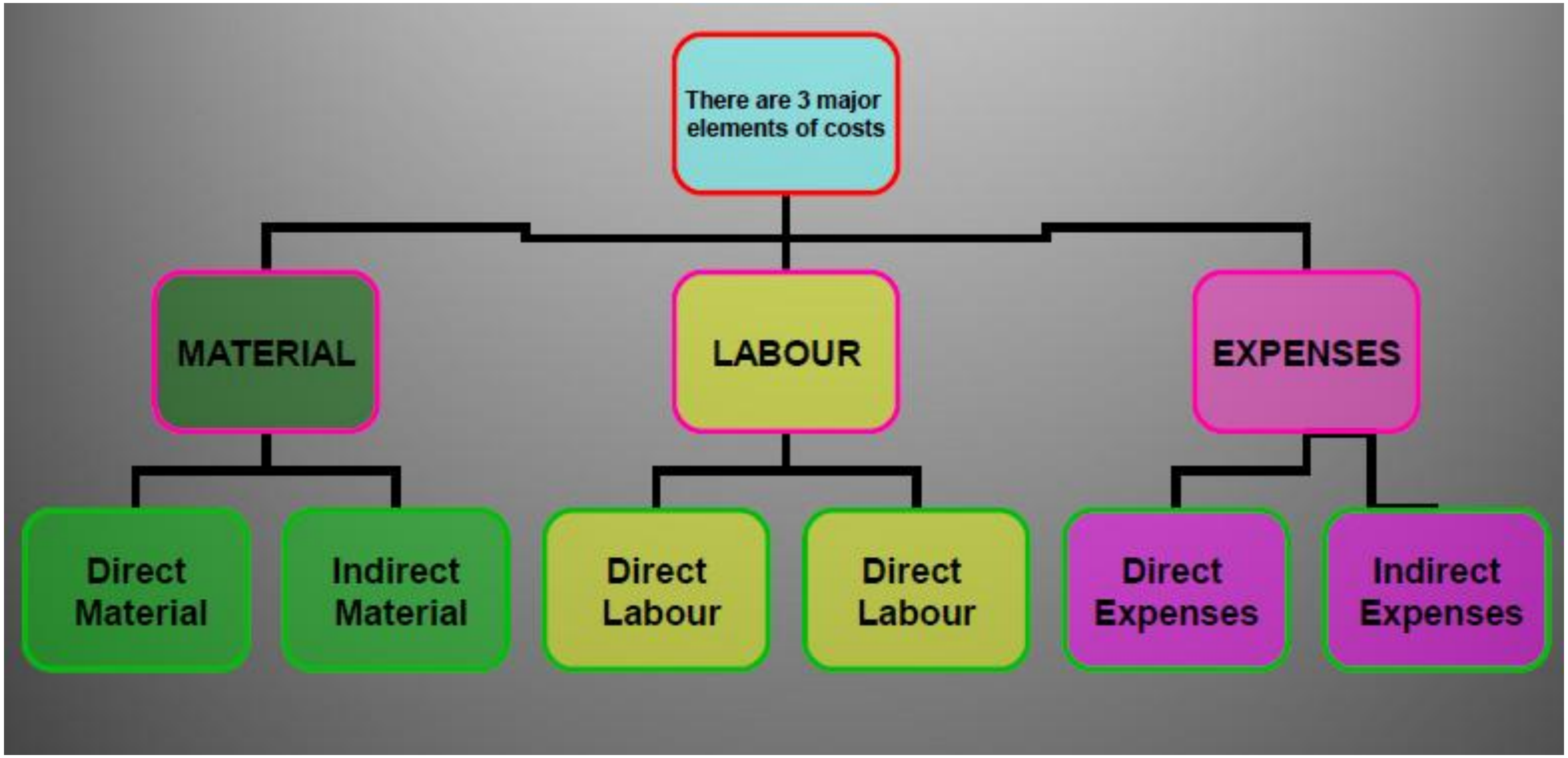
Step 7: Reflect on the DFE Process and Results

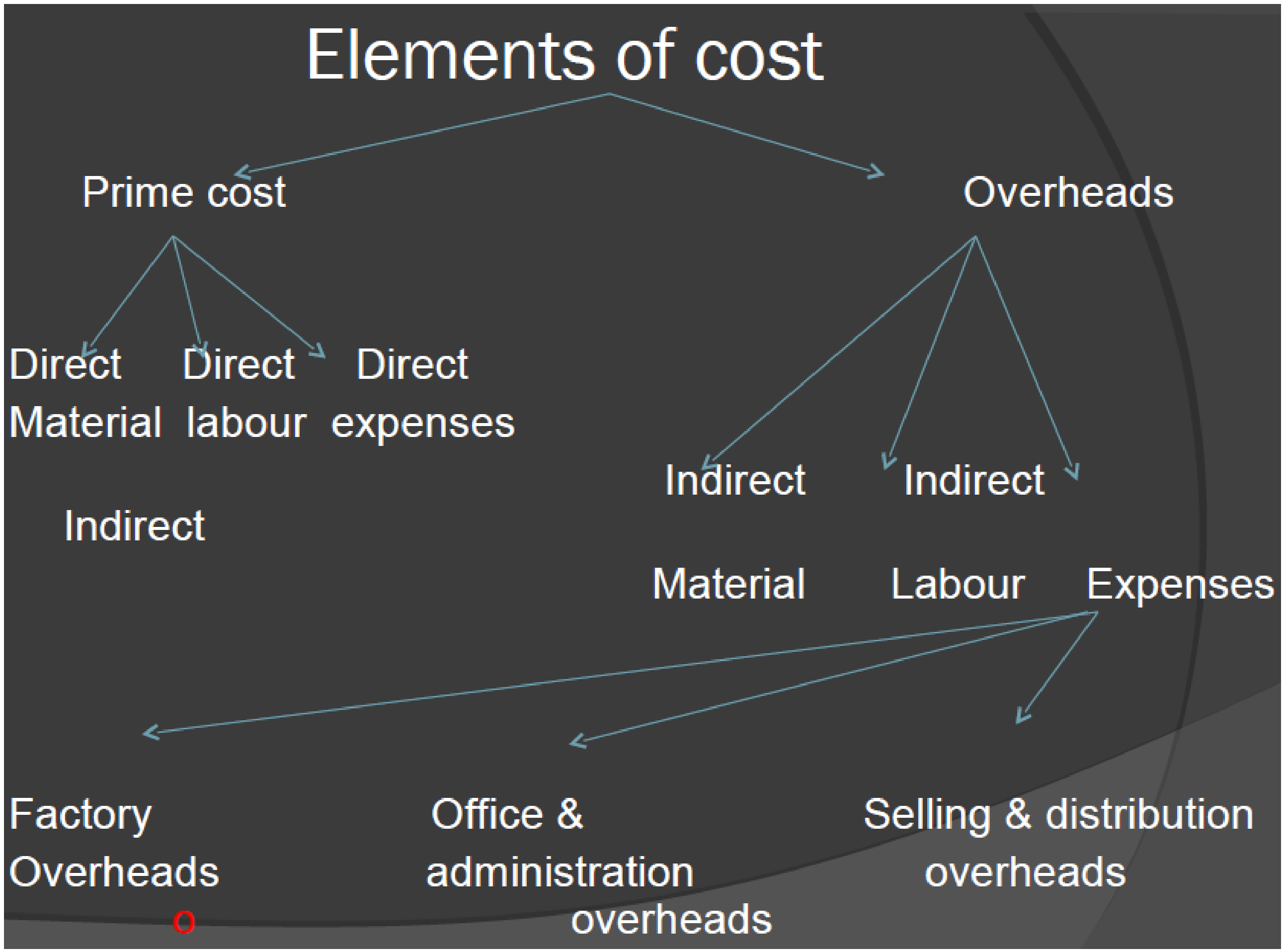
- As with every aspect of the product development process, the final activity is to ask:
- How well did we execute the DFE process?
- How can our DFE process be improved?
- What DFE improvements can be made on derivative and future products?

Product Costing/Cost of a Product

- **Product cost** refers to the costs incurred to create a **product**.
- Major components of Cost of product are
  - Material Cost
  - Labour Cost
  - Expense Cost
    - Factory Overhead cost
    - Administrative cost
    - Selling and Distribution Overhead

Elements of Cost




Elements of cost
Prime cost
Overheads
Direct Material
Direct labour
Direct expenses
Indirect
Indirect Material
Indirect Labour
Expenses
Factory Overheads
Office & administration overheads
Selling & distribution overheads

Material Cost

- Material indicates principal substances used in production. Examples are: cotton, jute, iron-ore, and silicon.
- The cost of material is further divided in to direct and indirect materials.
- Cost of commodities supplied
- It is of two types
  - Direct Material
  - Indirect material cost

Material Cost : Direct Material

- Direct materials refer to the cost of materials which become a major part of the finished product.
- Direct material is one which goes into a salable product or its use is directly essential for the completion of that product
- They are raw materials that become an integral part of the finished product and are conveniently and economically traceable to specific units of output.
- Some examples of direct materials are: raw cotton in textiles, crude oil to make diesel, steel to make automobile bodies.

Material Cost : Indirect Material

- These are materials which are used ancillary to manufacture and cannot be traced in to the finished product.
- Indirect material is one which is necessary in the production process but is not directly used in the product itself
- These form a part of manufacturing overhead.
- Examples are glue, thread, nails, consumable stores, printing and stationary material

Labour cost

- Labor is the physical or mental effort expended on the production of an item.
- It is the active factor of production
- It is the cost of remuneration ,wages,salaries,commisions of the employees of an enterprise
- It is classified as
  - Direct Labour cost
  - Indirect Labour cost

Labour Cost :Direct Labour cost

- Direct labour is defined as the labour associated with workers who are engaged in the production process.
- It the labour costs for specific work performed on a product that is conveniently and economically traceable to end products.
- It is the cost of labour that can be identified directly with the manufacture of the product
- Direct labour is expended directly upon the materials comprising the finished product.
- Examples are the labour of machine operators and assemblers
- Eg: wages of a welder fabricating a structure form a part oif the total direct labour cost

Labour Cost :Indirect Labour cost

- This includes wages paid for all labour which is not directly engaged in changing the shape or composition of raw materials.
- It cannot be traced directly to the product.
- Like indirect materials, indirect labour forms part of the manufacturing overheads.
- Examples of indirect labor cost are wages paid to foremen, supervisors, storekeepers, time-keepers, salaries of office executives and the commission payable to sales representatives.

Expenses

- It is a collective title which refers to all charges other than those incurred as direct result of employing workers or obtaining material
- Two types
  - Direct Expense
  - Indirect Expenses

Expenses: Direct Expense Cost

- Direct expenses include any expenditure other than direct material and direct labor directly incurred on a specific cost unit (product or job).
- Such special necessary expenses can be identified with cost units and are charged directly to the product as part of the prime cost.
- Some examples of direct expenses are:

  (a) Cost of special layout, designing or drawings;

  (b) Hire of tools or equipment for a particular production or product;

  (c) Maintenance costs of such equipments.

Expenses: Indirect Expense Cost

- Indirect expenses are those incurred for the business as a whole rather than for a particular order, job or product.
- Examples of such expenses are rent, lighting, insurance charges.

Overheads

- Overheads may be defined as the aggregate of indirect material, indirect labor and indirect expenses.
- Thus, all indirect costs are overheads.
- These cannot be associated directly with specific products.
- Hence, the amount of overhead has to be allocated and apportioned to products and services on some reasonable basis.
- Overheads may be subdivided in to following groups:

a)Factory overheads.

b) Administrative overheads.

c) Selling and distribution overheads

Factory Overhead

- Overheads are all expenses other than direct expenses
- Factory overhead also called manufacturing expenses or factory burden may be defined as the cost of indirect materials, indirect labor and indirect expenses.
- Examples of such items are lubricants, cotton waste, hand tools, works stationery.
- Factory overhead includes
  - Building expenses
    - Rent
    - insurance
    - Repairs
    - Heating and Lighting
  - Indirect Labour
    - Supervisors and foreman
    - Shop clerk
    - Shop Inspectors

Administrative Overhead

- It consist of expenses incurred in the direction, control and administration of an enterprises
- Administrative overhead includes costs of planning and controlling the general policies and operations of business enterprises.
- Examples are
  - Office rent
  - Salaries and wages of clerks
  - Rates and taxes
  - Bank charges

Selling and distribution overhead

- Selling and distribution overhead is also known as marketing or selling overhead.
- Distribution expenses usually begin when the factory costs end.
- Such expenses are generally incurred when the product is in saleable condition.
- It covers the cost of making sales and delivering/dispatchin products.
- These costs include advertising, salesmen salaries and commissions, packing, storage, transportation, and sales administrative costs.

Price of a Product

- Prime cost=Direct material +Direct labour + Direct expenses
- Factory Cost =Prime Cost +Factory Overhead
- Cost of Production=Factory Cost +Administrative Over Head
- Cost of Sales=Cost of Production + Selling and Distribution Overhead
- Price=Cost of Sales+Profit

Design for Maintainability

- Maintainability is the degree to which the design can be maintained or repaired easily, economically and efficiently.
- Many durable or long life products need maintenance throughout their useful life.
- Consideration of a products maintenance features early in the design process can reduce maintenance costs, downtime and improve safety
- It is embodied in the design of the product.
- A lack of maintainability will be evident as high product maintenance costs, long out-of service times, and possible injuries to maintenance engineers.

Design for Maintainability

- One of the first things to consider is who will be undertaking the maintenance of the product?
- This is where anthropometric design comes in.
- A human factors engineer takes into consideration the critical dimensions such as vertical and horizontal reach, abdominal depth, shoulder breadth, standing eye height etc. of the target audience.
- The engineer, when applying the access dimension, should also consider the addition of Personal Protective Equipment (PPE), such as gloves, clothing thickness, kneeling pads and allowance for tools.

Types of Maintenance

- There are various forms of maintenance, mainly corrective maintenance (when something goes wrong), preventative maintenance (these are scheduled maintenance activities carried out to prevent a failure)
- 1. Preventative maintenance, for example replacing engine spark plugs every 30,000 km, or changing the oil filter.
  - Preventative maintenance requires the replacement of parts that are still working but are expected to fail soon.
  - For example an old oil filter may cause serious engine damage by starving bearings of oil, or allowing abrasive metal sludge into clean areas.
- 2. Remedial maintenance (repair or corrective maintenance), for example fitting a new vehicle starter motor where the existing motor has burned out. Remedial maintenance is performed after the product has failed

Factors to be considered for maintainability

- 1. Standardization
  - Select from the smallest set of parts with as much compatibility as possible.
  - Use standard parts in design
- 2. Modularization
  - Create a set of standard sizes, shapes, modular units.
  - If we expect to different models with different features, using a standard structure allows the interchange of compatible parts to alter functionally without changing the majority of the product.
  - example is light bulbs. You can select the functional bulbs (brightness, intensity, color, etc.) and they will fit in the same socket.

Factors to be considered for maintainability

- 3. Functional packaging
  - Gather all the required elements to complete a maintenance task in one kit.
- 4. Interchangeability
  - Single source, lack of compatibility with other similar functioning parts, another spare part in inventory, and limitations on future design changes if you want to stay in that custom form factor.
  - Select parts that are useful for a range of products or applications.

Factors to be considered for maintainability

- 5. Accessibility
  - If an item requires replacement or adjustment as part of the expected maintenance, then it should permit access.
  - Consider tools, lighting, environment, and experience of a maintenance crew.
  - Providing access panels is one factor, safety another.
- 6. Malfunction annunciation
  - A key step in performing maintenance is to know what caused the problem or which parts are damaged and require replacement.
    - Minimizing the need for inspection tools and diagnostic tasks minimizes the time/cost of the corrective maintenance tasks.
    - Let the system inform the technician what requires attention.

Factors to be considered for maintainability

- 7. Fault isolation
  - A failure in one part of a system can cause failure of other elements in the system.
  - If possible, try to avoid such a situation.
- 8. Identification
  - Name the parts with unique identifiers.
  - This streamlines documentation, procedures, and maintenance tasks.
  - Be consistent and provide meaningful or memorable naming conventions to avoid confusion.

Measures of Maintainability

- Mean Time Between Failure (MTBF) is a basic measure of reliability for repairable systems and it is the mean time that a machine operates between failures.
- Mean Time To Failure (MTTF) is a basic measure of reliability for non-repairable systems. It is the mean time expected until the first failure of a piece of equipment.
- Mean Time To Repair (MTTR) is the average time required to fix a failed component or device and return it to production status

Lines of Maintenance /Lines of Repair

- Geographical points (where the repair happens) of repair are often referred to as ‘lines of maintenance’ as follows:
- 1st line maintenance occurs at the point of use.
  - It could be at home, wherever a vehicle breaks down,.
  - It is appropriate to make the replacement of small modular items that require a minimum kit of tools and can be replaced within minutes.
- 2nd line maintenance occurs at a nearby maintenance depot.
  - This could be railway workshops, a car dealer,.
  - It is appropriate where an extended toolkit or special skills and processes are required, where adjustments must be made, where special handling is required, where the time to repair may be lengthy, where reassembly is complex, or where protection against the weather is important.
- 3rd line maintenance is undertaken by the manufacturer where the repair process requires skills and equipment beyond those available at the local service centre.

Ethics for Design

- *Ethics are the moral principles by which we judge right or wrong, good or bad.*
- They are the rules of conduct recognized by our society.
- "Ethics refers to well-founded standards of right and wrong that prescribe what humans ought to do, usually in terms of rights, obligations, benefits to society, fairness, or specific virtues."
- The term “ethics” is now widely used throughout the community including the government, business, education, legal, manufacturing and design sectors

Legal and Ethical Issues in Design

- Legal and ethical issues must be considered if a design is to be accepted by the market and/or the community.
- Assessing the impact of the design on the consumer:
  - The designer may consider safety, ease of use, built-in obsolescence and whether anyone will really benefit from the design.
- Protection of intellectual property:
  - The designer needs to be aware of patents which can be legally enforced, thus giving the patent holder exclusive rights to the invention.
- Privacy:
  - Certain inventions and uses of technology have the potential to invade privacy such as computer databases, security monitoring devices and sophisticated communication systems.
  - The *Privacy and Personal Information Protection Act* imposes obligation on agencies in their collection, storage, use and distribution of personal information.

Legal and Ethical Issues in Design

- Advertising of designs:
  - Some designs are forcefully advertised, especially to the young and impressionable.
  - Subliminal messages may also be considered unethical.

- The right to alter natural order:
  - Some people believe that designs should honour the concept of natural order.
  - Eg. Tomatoes are now genetically modified with flounder genes to improve their keeping qualities.
- Sustainable technology:
  - Designers may choose one design over another depending on whether the resources used in design and production are conserved while still meeting the production requirements.

Legal and Ethical Issues in Design

- Whether designs should be tested on animals and humans:
  - There has been a trend towards minimal testing on animals and many companies promote the fact their products are not tested on animals.
  - All animal (including human) testing is strictly controlled by government regulations.
- Environmental impact:
  - Designs have been modified and created because of concerns about the impact humans have on the environment through using both renewable and non-renewable resources.
- Minority groups:
  - Some groups in our society require special design attention such as the disabled, the elderly and isolated communities.
  - Often these designs are only required in small quantities and so it can be expensive or of low profitability.

Ethical Considerations

- As designers, it is important to be aware of the effect of our designs on other people and society in general
- Designers need to contemplate the morality of their research as well as the advances they are making.
- Design needs to be undertaken in a societal context
- Another ethical problem in the design industry is that of ownership of intellectual property and of inventions.
- Built in Obsolescence
  - **Planned obsolescence**, or **built-in obsolescence**, in industrial design is a policy of planning or designing a product with an artificially limited useful life, so it will become obsolete (that is, unfashionable or no longer functional) after a certain period of time.
  - The rationale behind the strategy is to generate long-term sales volume by reducing the time between repeat purchases (referred to as "shortening the replacement cycle")

Ethical Considerations

- Avoiding processes and technologies that affect the safety of the employees and public,
- Producing product safe for customers,
- Waste product utilization and recycling,
- Profiting from products bad for health (drugs, cigarettes, alcohol) and people (gambling)

Examples

- Car
  - Crash Test
  - Emission Level
  - Standards
- Mobile Phones
  - Pre-certification testing
  - Conformance testing (e.g. according to 3GPP standards)
  - Regulatory testing (RED, FCC, ISED Canada etc.)
  - Interoperability testing
  - Antenna testing (OTA) – recognized by Vodafone, T-Mobile, AT&T etc.
  - Battery life testing
  - Safety, SAR, health testing
  - Application testing

MP482
PRODUCT DEVELOPMENT AND DESIGN

MODULE IV

- Value Engineering / Value Analysis. : Definition. Methodology, Case studies.
- Economic analysis: Qualitative & Quantitative.

Value

- Value, as defined, is the ratio of function to cost.
- Value is the lowest price you must pay to provide a reliable function or service
- Value can therefore be manipulated by either improving the function or reducing the cost.
- It is the on.

$$\text{Value} = \frac{\text{Function (or Utility)}}{\text{Cost}}$$

Function

- Value engineering Defines function as that which makes a product work or sell
- It is the end result or action desired by customer.
- Customer wants a function to be achieved reliably ,efficiently and effectively by product or service.

Cost

- Amount incurred to manufacture the product so that it performs the intended function.

Types of Values

- Cost Value
  - It is the cost of manufacturing a product
- Use Value
  - Also called functional value
  - Considers the work done, functions performed or services rendered by the component or product
- Esteem Value
  - Involves the qualities and appearance of a product which attracts person and create a desire to possess the product.
- Exchange Value
  - Product is said to have exchange value if the same product can be exchanged for something else.

Types of Function

- Function specifies the purpose of the product or what the product does, what is its utility,etc.
- Types of Functions are
  - Primary Function
    - Basic function that product must exhibit
    - Cannot be changed
  - Secondary Function
    - Supporting Functions
    - Can be modified or eliminated
  - Tertiary Function
    - Additional benefits that a product gets
    - Can be modified or eliminated

Types of Function Example

- Eg: Painting a merchant navy ship
- Primary Function:
  - Save the ship against corrosion and deterioration
- Secondary Function:
  - To make it recognizable
- Tertiary Function :
  - To make brilliant appearance

Value Analysis

- Value Engineering (VE, or Value Analysis) is a management technique that seeks the best functional balance between cost , reliability and performance of a product, project, process or service.
- A process of systematic review that is applied to existing product designs in order to compare the function of the product required by a customer to meet their requirements at the lowest cost consistent with the specified performance and reliability needed.

Value Engineering and Value Analysis

Difference between VA and VE

Value Analysis (VA) is the application of creative techniques for increasing the *Value* and *Functions* to an **already *Existing Product* / *Services*** to minimize the *Cost* of that Product. This is like a Post-mortem analysis, done after the fact, so a Remedial Process.

Value Engineering (VE) is the application of creative techniques for increasing the *Value* and *Functions* for ***New Products*** at the design stage itself, to minimize the *Cost* of the Product. This is done before the fact at pre-manufacturing stages such as concept development and design, so a Preventive Process.

Value Engineering and Value Analysis

Value Analysis	Value Engineering
It indicates application on the product that is into manufacturing	It indicates application on the product at its design stage
In value analysis all factors come together including workers,subcontractors,engineers to make a team with total experience and knowledge	Value engineerin is always done by a specific product design(engineers) team
It may change the present stage of the product or operation	The changes are executed at the initial stages only
It is worked out mostly with the help of knowledge and experience	It requires specific technical knowledge

Objectives of Value Analysis

- To provide better value to a product/service.
- To improve the company's competitive position.
- To ensure that every element of Cost (Labour Materials Suppliers and service) contribute equally to the Function of the product.
- To Eliminate unnecessary Cost.
- To use efficient process
- Faster cost reduction technique

Application of Value Analysis

- Capital goods – plant, equipment, machinery, tools, etc.
- Raw and semi-processed material, including fuel.
- Materials handling and transportation costs.
- Purchased parts, components, sub-assemblies, etc.
- Maintenance, repairs, and operational items.
- Finishing items such as paints, oils, varnishes, etc.
- Packing materials and packaging.
- Printing and Stationery items.
- Miscellaneous items of regular consumptions.
- Power, water supply, air, steam & other utilities (services).

Application of Value Analysis

- Military Equipment
- Import substitutes
- Automobile Industries
- Material Handling equipment
- Machine Tool industry

Advantage of Value Analysis

- It leads to improvements in product design so that, most appropriate products are produced .
- High quality (value) is maintained.
- All-round efficiency is achieved by eliminating waste of various types.
- Cost savings provide a measure for judging managerial effectiveness.
- New ideas are generated and incorporated.
- Teams spirit and morale are improved.
- Areas requiring attention and improvement are pin pointed.
- Improves the company’s competitive position.
- Each element of Cost contribute equally to the Function of the product.
- Uses efficient process
- Faster cost reduction technique

Value Analysis Job Plan/Value Analysis Methodology

- Orientation Phase
- Information Phase
- Functional Phase
- Creative Phase
- Evaluation Phase
- Development Phase
- Presentation Phase
- Implementation and Follow-up Phase

Orientation Phase

- Identify issues
- Prioritize Issues
- Drafts scopes and objective
- Establish evaluation factors
- Determine Study Team
- Collect Data
- Prepare for value study

Information Phase

- Further familiarization of the project by the team; all team members participate in determine the true needs of the project.
- Areas of high cost or low worth are identified.
- In this first phase, the team attempts to understand why the project exists and who or what it is to produce.
- They obtain project data, present the original design or product concepts, and understand the project scope.
- Schedule, costs, budget, risk, and other non-monetary issues are studied until the team is comfortable with the concept of the project, what it is to produce, and who its end users are.
- This step also includes things like site visits and meetings with the project team, if required.
- Project documents like plans, drawings, specifications, and reports are obtained and the value engineering team becomes familiar with them.

Functional Phase

- Functional analysis outlines the basic function of a product using a verb and a noun such as ‘boil water’ as in the case of our kettle.
- The team attempts to determine the functions the project serves. Functions come in two forms:
- ***Primary functions*** are those that represent the reason for the project’s existence,
- ***Secondary functions*** are those that the project serves without being core to the project.
- The functions are described in verb/noun pairs, such as “supply water to all suites,” or “Maintain view of adjacent park.”

Creative Phase

- This step requires a certain amount of creative thinking by the team.
- A technique that is useful for this type of analysis is brainstorming.
- This stage is concerned with developing alternative.

Evaluation Phase

- In this phase of the workshop, the VA team judges the ideas developed during the creative phase.
- The VA team ranks the ideas.
- Ideas found to be irrelevant or not worthy of additional study are disregarded.
- Those ideas that represent the greatest potential for cost savings and improvements are selected for development.

Development Phase

- The team develops the selected ideas into alternatives (or proposals) with a sufficient level of documentation to allow decision makers to determine if the alternative should be implemented.

Presentation Phase

- The presentation phase is actually presenting the best alternative (or alternatives) to those who have the authority to implement the proposed solutions that are acceptable.

Implementation And Follow Up

- Develop an implementation plan
- Execute the plan
- Monitor the plan to completion Objective:

During the implementation and follow-up phase, management must assure that approved recommendations are converted into actions.

Case Study

- Focus Adjustment Knob for Slit Lamp in microscope

Phases

- Product selection plan
- Gather information of product
- Functional analysis
- Creativity Worksheet
- Evaluation sheet
- Cost analysis
- Result

Plan For Product Selection

- This Product is used to adjust the focus of lens for magnification purpose.
- The present specifications of this part and its material used are costlier than the average industry cost.
- Value of this product can be increased by maintaining its functions and reducing its cost or keeping the cost constant and increasing the functionality of the product.

Obtain Product Information

- i. Material – Aluminum Bronze Alloy
- ii. Diameter of base plate –30 mm
- iii. Thickness of plate--3 mm
- iv. Cost of the scrap is – 293 rupee/Kg
- v. Pieces Produced annually – 8000
- vi. Process used – C.N.C. indexing milling
- vii. Cycle time—2.5 min
- viii. Anodizing—2/min
- ix. Material cost—65 gm
- x. Total Present cost – 29.99 rupee /piece

3.Functional Analysis

FUNCTIONAL ANALYSIS

Name	Basic Function Verb	Basic Function Noun	Secondary Function Verb	Secondary Function Noun
Focus Adjustment Knob	Index	Lens	Fix	Gear tooth

4. Develop Alternate Design Or Methods

- During brainstorming these ideas were listed: i. Change design ii. Change material iii. Use plastic iv. Make it lighter v. Change the production process vi. Use nylon indexing unit

5. Evaluation Phase

- For judging the ideas, the following designs were considered:
- A. Function
- B. Cost
- C. Maintainability
- D. Quality
- E. Space

6.Cost Analysis

6. Cost Analysis

Item	Material cost (₹)	Machining cost (₹)	Anodizing cost (₹)	Total cost/Pc (₹)
Focus Adjustment Knob	19.04	7.30	3.65	29.99
Nylon index unit	11.60	6.80	-	18.40
Part Eliminated	-	-	-	-
Difference /part	9.44	12.72	6	11.59

7. Result

- The total savings after the implementation of value engineering are given below:
- Cost before analysis – 29.99 rupee
- Total Cost of nylon knob – 18.40 rupee
- Saving per product – 11.59 rupee
- Percentage saving per product – 38.64 %
- Annual Demand of the product – 8000
- Total Annual Saving – 92,720 rupee
- Value Improvement - 62.98 %

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MP482
PRODUCT DEVELOPMENT AND DESIGN

MODULE V

- Ergonomics in product design. Aesthetics in product design. Concepts of size and texture, colour .Psychological and Physiological considerations.
- Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design.

Aesthetic Consideration in Design

Aesthetics derived from greek word "aesthetikos" means sensory perception

A set of principles concerned with the nature and appreciation of beauty.

The branch of philosophy which deals with questions of beauty and artistic taste.

Importance of Aesthetics

- However there are number of products in the market, having same qualities of efficiency, durability and cost.
- Hence the customers is attracted towards the most appealing product.

- **The word Aesthetics is defined as a set of principles of beauty.**
- It deals with the appearance of the product.
- The growing realization of the need of aesthetic consideration in the product design given rise to a separate discipline known as industrial design.
- The industrial designer is to create new forms and shapes which are aesthetically pleasing.
- Ex- chromium plating of an automobile component improve the corrosion resistance along with appearance.

Guidelines in Aesthetic Design

- The appearance should contribute to the performance of the product e.g. the aerodynamic shape of a automobile will decrease air resistance results in improve fuel economy by decreasing fuel consumption.
- The appearance should reflect the function of the product e.g. the aerodynamic shape of car indicate the speed.

- The appearance should reflect the quality of the product.
- The appearance should not be at too much of extra cost unless it is the prime requirement.
- The appearance should be suitable to the environment in which the product is used.
- The appearance should be achieved by the effective and economical use of the material.

Aspects of Aesthetic Design

- The various aspects of the aesthetic design are

1. Shape (form) and Size
2. Colour
3. Variety
4. Continuity
5. Style
6. Contrast
7. Symmetry and balance
8. Material and surface finish
9. Texture
10. Harmony

1A). Shape (form)

- There are basic five shapes of the product namely step, taper, shear, streamline and sculpture.
- The external shape of any product can be given is based on the one or combination of basic shapes.

a) **Step form** – The step form is a stepped structure having vertical accent. It is similar to the shape of a multistory building.

b) **Taper form** – The taper form consists of a tapered blocks or tapered cylinders.

c) **Shear form** – The shear form has a square outlook(sharp).

d) **Streamline form** – The streamline form has a streamlined shape having a smooth flow as seen in automobile and aero-plane structure.

e) **Sculpture form** – The sculpture form consists of ellipsoids, paraboloids and hyperboloids.

1 B). Size

- Due to miniaturization of the advance technology developed in electronics and other field the designer can now use previously unacceptable housing got integrated items.
- So freeing them from many of design constraints, new design of telephone is an example of integrating the entire telephone in a single component provide good balance, proportions and ergonomic styling.
- This freedom of design now manifest in the choice.

2. Colour

- Colour is one of the major important factor to the aesthetic appeal of the product.
- Such as creating interest, eliminating eye fatigue, assisting memory, directing attention.
- The choice of colour should be compatible with the conventional ideas of the operator.
- **Morgon** has suggested the meaning of the colour as shown in the table.

COLOUR	MEANING
Red	Danger – Hazard - Hot
Orange	Possible Danger
Yellow	Caution
Green	Safety
Blue	Caution - cold
Gray	Dull

3. Variety -

- Variety is particularly important in marketing range of products like refrigerator, fans, stereo system, vehicles, etc.

4. Continuity –

- A product which has good continuity of element is aesthetically appealing.
- Continuity is thus associated with the order or tidiness of the product.
- **For example – a fillet radius at the change of cross section adds the continuity to the product and hence improve the appearance.**

5. Style –

- Style is visual quality of the product which set it apart from the rest of the functionally identical products.
- Good style, with skillful work increase the product attraction.
- The product designed with aesthetic not only look nice but should also create an impression that it work more efficiently.
- Bold style provides a feel of strength and ruggedness
- Flowy style provides a feel of softness and compactness
- Jaggued style suggests aggression
- The product should gives the impression of the satisfactory performance or purpose.

6. Contrast

- Contract is distinction between adjustment elements of the product which have clearly different characteristics and functions.
- The contrast improve the appearance of the product.
- The choice of the colours can be particularly important.

7. Symmetry and balance

- Symmetry suggest a state of order but asymmetry can create a greater sense of interest.
- Both have been used successfully in architecture.
- Symmetrical arrangement of identical component on a board contributes to an impression or order and tidiness.
- The computer system is an example of functional requirements to led the use of asymmetrical arrangement.
- This increase visual attraction.

8. Material and surface finish

- The material and surface finish of the product contribute significantly to the appearance.
- The production of smooth and harder surface is necessary for greater strength and bearing load is depend upon the property of material e.g. the material like stainless steel gives better appearance than the cast iron, plain carbon steel or low alloy steel.
- It was found that the bearing properties, wear qualities and fatigue life of any machine component have a directly related to surface texture.

- Hence to increase the life of any machine component subjected to various types of load the working and non working surfaces must be very good finish.
- The component or the product with better surface finish are always aesthetically pleasing.
- The surface coating processes like spray painting, electroplating, anodizing etc. greatly enhance the aesthetic appeals of the product.

9. Texture

- Refers to surface quality
  - Smooth
  - Metallic
  - Sandy
  - Leathery
  - Rubbery
  - Feathery
  - Spongy

10. Harmony

- Rhythm or Harmony
- It is the presentation of a design in accordance with the context or background,

Ergonomics in Design

- ***Ergonomics*** is defined as the relationship between man and machine and the application of anatomical, physiological and psychological principles to solve the problem arising from this relationship.
- The word ergonomics is coined from the two Greek words '**ergon**' which means '**work**' and '**nomos**' which means ' **natural laws**'.
- Ergonomics means the natural law of work.
- **Ergonomics is scientific study of man and machine(which he works)) and environment (in (which he works)**

Ergonomics in Design

- The main objective of the ergonomics is to make machine fit for the user rather than to make the user adapt himself to the machine.
- It aims to increase the comfort and productivity also decreases the physical and mental stresses of the users.

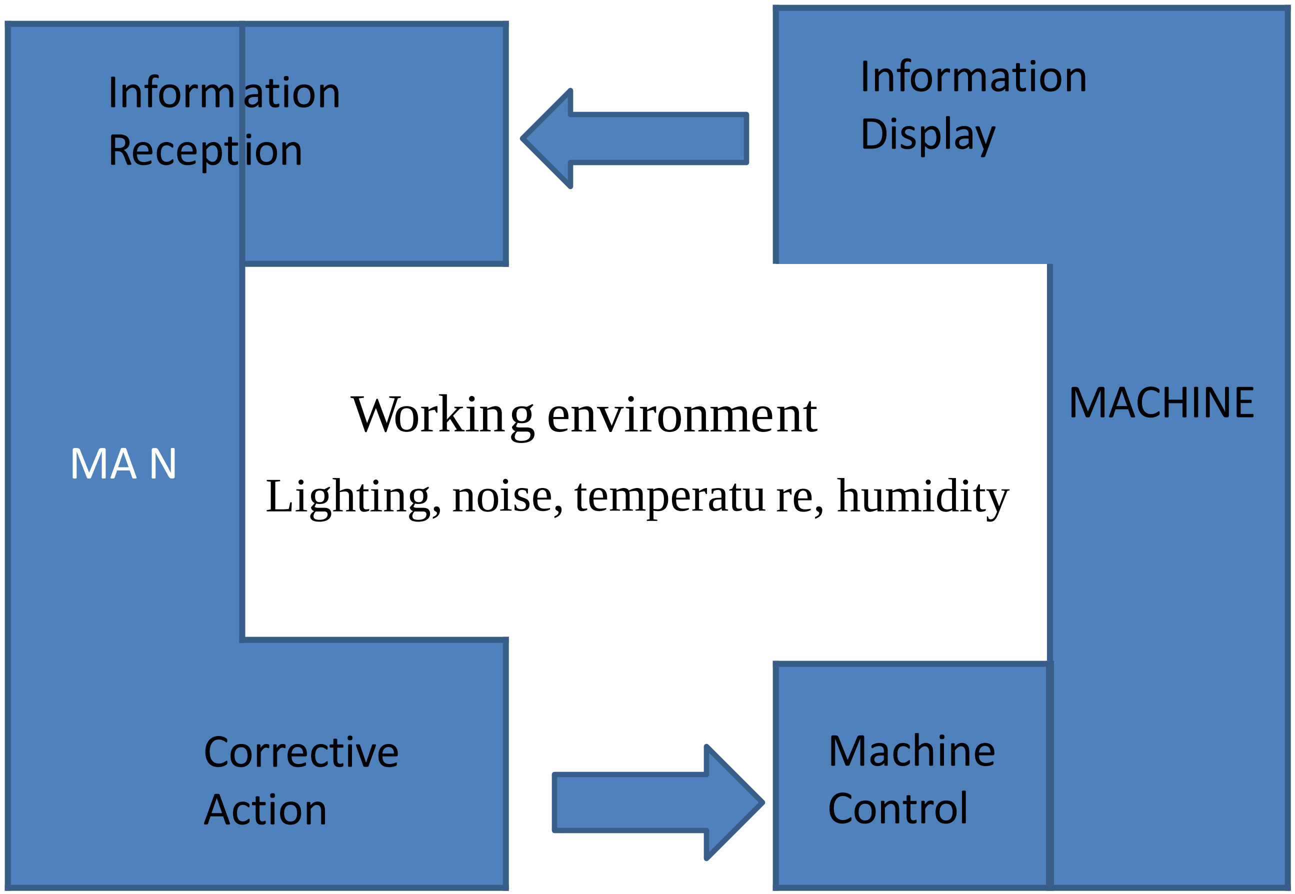
Factors considered in ergonomic design/Areas of Ergonomics

- The relation between man and machine.
- Anthropometry: The anthropometric data (dimensions of human body)
- Physiological Considerations
- Psychological Considerations

- Anatomy(One part is anthropometry) basically deals with the human beings
- Physiology is about the strength, speed, the body dimensions
- Psychology is about, that how the information is processed by the operators or worker during the operation and what kind of action he takes, while he is in work.

Man-Machine Relationship

- Any machine can not be continue working for a longer period of time without the aid of man.
- The work can be perform by a man machine system.
- Hence a man-machine system may be defined as a combination of activities between man and machine to get the desire output from the given input.


Inform ation
Reception
MA N
Corrective
Action
Information
Display
MACHINE
Machine
Control
Working environment
Lighting, noise, temperatu re, humidity

- From display instruments, the operator can get the information about the operation of machine.
- If he feels that the correction is necessary then he take the corrective action to operate the control or lever.
- This corrective action of man alter the performance of the machine.
- Which will be indicated on display panel.
- The contact of man machine system in a closed loop system arise at two places – information display instrument which gives information to the man and control which will operate by man to adjust the machine.

Design of Equipment for Control

- Which may include a graduated dial or a display or signal to indicate the response of the machine to the instructor.
- The type and size of the control devices selected depends upon the following number of factors, the principle ones are –
  1. The required speed of operation.
  2. The required accuracy of the control.
  3. The required operating force.
  4. The direction of movement for on/off or increase/decrease.
  5. The required range.

Types of Controls

1. **Hand wheel –**
2. **Small Crank –**
3. **Round knob –**
4. **Joysticks –**
5. **Push buttons –**

Ergonomic consideration in design of control

- The control should be easily accessible and logically positioned.
- The control operation should involve minimum motion and avoid awkward movements.
- The shape of the control component which come in contact with the hands should be in conformity with the anatomy of human hands.
- Proper colour produces beneficial psychological effect.
- The control should be painted in red colour with the gray background of machine tool to call for attention.

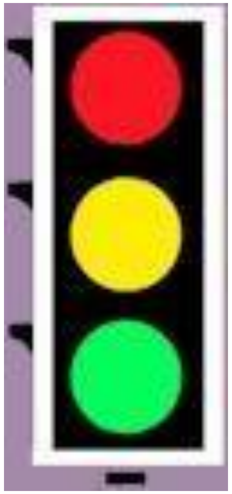
Design of Display Control

- The displays are the devices through which the man receives the information from the machine.
- The display in one which allows the proper combination of speed, accuracy and sensitivity of display.

Types of Displays

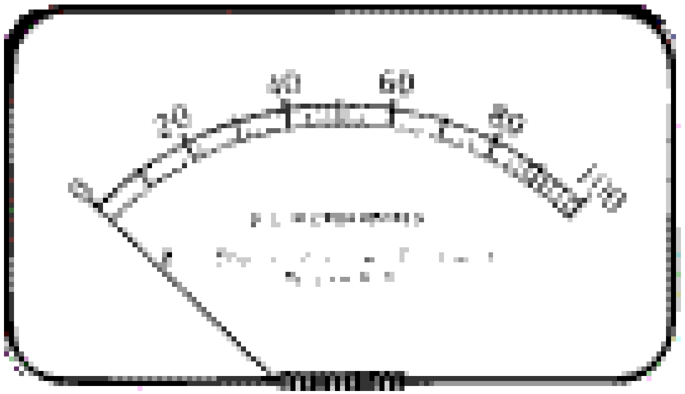
1. **Qualitative displays –**

- The display or signal is used to indicate only the condition or state without giving the value are known as qualitative display.
- E.g. on/off response to open or closed the valve, power on/off traffic signals.



2. Quantitative display –

- This type of display gives the quantitative measurement or numerical information are known as quantitative display.
- E.g. Fuel indicator in motorcycle, voltmeter, ammeter, speedometer, watches, etc.



Ergonomic consideration in design of display

1. The scale on the dial indicator should be divided in suitable linear progression.
2. The number of subdivisions should be minimum.
3. The vertical figures should be used for stationary dials and radically oriented figures should be used for rotating dials.
4. The pointer should have knife edge with a mirror to minimize parallax error.
5. Differentiation in display group should be made with the help of colour, shape and size.

6. The numbering should be increase in clockwise direction on a circular scale, upwards on vertical scale and rightward on a horizontal scale.

7. Important displays like warning, can be made more effective by the use of flashing lights.

8. The height of the letter or numbers should be

$$Height \geq \frac{\text{Reading distance}}{200}$$

Anthropometry

- It is the science that measures the range of body sizes in a population.
- It is very important for a designer to remember that people come in many sizes and shapes while designing a product.
- Anthropometric data vary considerably between human races.
- Age and occupation of the user is also relevant in anthropometric study.

Anthropometry

- Anthropometry is a combination of the two words, which involves anthro and pometry, in, these are the two Greek words, "anthro" means the man and "pometry" stands for the measurements.
- The literal meaning of this anthropometry is about measurement of the humans, which involves the measurement of the body dimensions of the human being, with respect to the different reference points.

Anthropometry

- These anthropometric data, which has been generated can be effectively used to determine the boundary areas of the workplace and the height and the shape of the seats and work tables.
- The designing and locating the handles and the lever, so that they can be easily operated by the operator, during the use.

Anthropometric Parameters

- Weight
- Stature
- Posture
  - Standing
  - Sitting
- Arm Span
- Head Length

Steps in Design of Mechanical System using anthropometric data

- What are the important /relevant body dimensions?
- Define the relevant population who is likely to use
- This helps to establish the dimensional range that needs to be considered in design
- Design for extremes
- Design for adjustable range
- Design for average

Physiological Consideration in Ergonomic Design

- The area of the study is mainly concerned with the determination of
  - Speed and accuracy with which body movements can be carried out.
    - The different body dimensions have the different accuracy speed and the capacity to apply force
  - Human stamina
    - Human being can deliver energy for carrying out the operation at particular rate.
    - If the excessive energy is required for carrying out the job, then he needs break.
  - Influence of working conditions on human performance

Physiological Consideration: Speed,Accuracy and Force

- Information regarding the speed, accuracy and the force of movement of each body member helps in designing of the machines and the jobs in such a way that
  - heavy work is done by the big muscles and
  - the light work is done by the small ones.

Physiological Consideration: Human Stamina

- Knowledge of human stamina helps in organization of the human work ie work and rest schedules.
- In general, an average energy expenditure for a human being is, at the rate of 4 kilo calorie per minute(280Watts). is maximum, that a man is capable to deliver for long period without need of rest.
- So, for the work that demands more energy, than the 4 kilo calorie per minute, worker will have to use his energy reserves and eventually he needs rest, so that, his muscles can recover

Physiological Consideration: Influence of the working conditions

- If the working conditions are not proper, they lead to the very poor performance by the operator and which in turn will reduce output from the worker
- A poor ventilation, illumination, high temperature, noise level in the industry are frequently encountered and these lead to, the loss of efficiency and increased rate of accidents

Physiological Consideration: Influence of the working conditions

- The working environment affect the man-machine relationship.
- The environment affect the efficiency and the health of the operator.
- The most important factors which affect the efficiency of human are
  - Lighting
  - Noise
  - Temperature
  - Relative Humidity
  - Ventilation, air quality and thermal comfort
  - Vibration

1. <u>Lighting</u> –

- Working in dim or overbright work environments can result in eyestrain, headaches, irritability and, inevitably, reduced productivity.
- Light sources, including the sun, can create unwanted reflections, glare and shadows in the workplace that can cause discomfort and distraction
- Low levels of lighting can cause depression, which for some people may be severe.

2. Noise –

- Excessive exposure to loud noise can irreversibly damage the ear, resulting in noise-induced hearing loss.
- ‘Nuisance’ noise can be annoying and distracting and result in reduced job performance and satisfaction.
- Noise may also be unsafe if it impairs communication in the work environment, such as by overpowering auditory alarms.

3. Temperature –

- For an operator to perform the task efficiently, he should neither feel hot or cold.
- When the heavy work is done, the temperature should be relatively lower and when the light work is done, the temperature should be relatively higher.

4. Humidity and Air Circulation –

- Humidity has little effect on the efficiency of the operator at ordinary temperatures.
- However, at high temperatures, it affects significantly the efficiency of the operator.

5.Vibration

- Whole body vibration can affect comfort and performance even at low levels and can cause damage to the spine, stomach pain and gastrointestinal complaints.
- Hand-arm vibration, such as from hand tools, can have negative effects on muscles and the skeleton, and can contribute to carpal tunnel syndrome, low-back pain and vibration white finger, for example.

Psychological Considerations in Design

- The psychology, in ergonomics is mainly concerned with the human behavior and his ability to work under the working conditions.
- That is, mainly related with the mentally strain and the fatigue.
- In ergonomics, psychology is mostly concerned with the processing of the information and the which, basically involves the sequence of the signal.
- Signal-Reception –channel- decision -action

Psychological Considerations in Design

- For efficient performance of the task, it is necessary that, the operator receives the information correctly, process the information properly, makes the correct interpretation and based on that it takes suitable decision and then corrective action, or the action which is required for success of the process.
- The efficient performance of the task therefore, to a great extent depends on, how the received has been interpreted, for taking suitable decision.

Man Machine System

- Combination of Man and machine, interacting with each other to get desired outputs from given inputs.
- Based on man involvement
  - Closed loop system
  - Open Loop system
- Based on mode of operation
  - Manual System
  - Mechanical System
  - Automatic system

Creativity

- Creativity is defined as the skill of being able to produce something – new – be it a product, an idea, a concept, a process or a solution to a specific problem – having some value.

- Creativity is characterized by the ability to perceive the world in new ways, to find hidden patterns, to make connections between seemingly unrelated phenomenon.

Creativity Techniques

- Brainstorming
- Mind Mapping
- Six thinking hats
- Morphological analysis

What is brainstorming?

- Brainstorming is a means of generating ideas.
- Brainstorming can be used to identify alternatives, obtain a complete list of items and to solve problems.
- Brainstorming is "a conference technique by which a group attempts to find a solution for a specific problem by amassing all the ideas spontaneously by its members
- To brainstorm is to use a set of specific rules and techniques which encourage and spark off new ideas which would never have happened under normal circumstances
- Brainstorming is a group activity based on the principle of suspending judgment that is idea generation and evaluation phases are separate.

Rules of Brain storming

- Criticism is not allowed-Judging ideas negatively should be avoided
  - Evaluation is done only later.
  - Participants are not expected to explain or defend ideas at this stage.
- Wild ideas are allowed and encouraged
  - Complete freedom to speak ones mind without being judged
- Generation of large number of ideas-quantity is the focus
  - Both flexibility(range of different classes of ideas) and fluency (greater number of ideas within each class)
- Participants are free to build on other ideas
  - They can take others idea and add on to it

Brainstorming steps

- Brainstorming group consists of 10-12 people including a leader,a person in charge of noting down the proceedings and regular or guest members.
- Person who poses the problem is also usually present.
- Arrangements or process of brainstorming are
  - Set the environment
  - Setting the scene
  - Rules for the session
  - Running the brainstorming session
  - Affinity analysis
  - Summary and further action

Brainstorming steps

- Set the environment
  - Location: preferable to be held away from normal place of work
  - Room: natural light, plenty of space
  - Materials: whiteboard and pens. Provide a pack of post-it notes and pen for each attendee
- Setting the scene
  - Explain the brainstorming technique.
  - Specify the rules.
  - Loosening up: use a free thinking exercise and/or a practice brainstorming session*.

Brainstorming steps

- Rules for the session
  - Criticism is not allowed-Judging ideas negatively should be avoided
    - Evaluation is done only later.
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Brainstorming steps

- Running the session
  - Questioner states the problem with necessary explanations and clarifications
  - Problem is redefined with inputs from the team
  - Questioner chooses the redefinitions that seem most relevant to him
  - Ideas are generated keeping these redefinitions in view.
    - Allocate 3-5 minutes to write on the post-it notes as many ideas as possible – one idea per note
    - Each person quickly writes their thoughts onto the post-it notes regardless of how impractical, outrageous, extreme, crazy they may be

Brainstorming steps

- Affinity Analysis
  - Each person in turn sticks their post-it notes on the whiteboard, putting their note near to an idea that is similar to theirs. This should result in clusters of post-it notes representing similar ideas.
  - Review the ideas by cluster. For each type of idea ask the group "How could we make this work?"

Brainstorming steps

- Summary and further action
  - Write up a summary of each type of idea/solution presented.
  - Determine an action plan for working through the ideas.
  - The action plan may be to test or further research the alternatives identified to select a shortlist of the most suitable solutions for further evaluation.

Six Thinking Hats

- ***Six Thinking Hats*** is a system designed by Edward de Bono which describes a tool for group discussion and individual thinking involving six colored hats.
- "Six Thinking Hats" and the associated idea parallel thinking provide a mean for groups to plan thinking processes in a detailed and cohesive way, and in doing so to think together more effectively

Six Thinking Hats

- Six distinct directions are identified and assigned a color. The six directions are:
- Managing **Blue** – what is the subject? what are we thinking about? what is the goal? Can look at the big picture.
- Information **White** – considering purely what information is available, what are the facts?
- Emotions **Red** – intuitive or instinctive gut reactions or statements of emotional feeling (but not any justification).
- Discernment **Black** – logic applied to identifying reasons to be cautious and conservative. Practical, realistic.
- Optimistic response **Yellow** – logic applied to identifying benefits, seeking harmony. Sees the brighter, sunny side of situations.
- Creativity **Green** – statements of provocation and investigation, seeing where a thought goes. Thinks creatively, outside the box.

Creativity vs Innovation

- Creativity is the process of developing new or interesting ideas
- Innovation is the process of transforming creative ideas into valuable or profitable solutions.

Creative Thinking vs Critical Thinking

Creative thinking is a way of looking at problems or situations from a fresh perspective to conceive of something new or original.

Critical thinking is the logical, sequential disciplined process of rationalizing, analyzing, evaluating, and interpreting information to make informed judgments and/or decisions.

Creative Thinking vs Critical Thinking

Critical Thinking	Creative Thinking
Analytical	Generative
Convergent	Divergent
Left brain	Right brain
Logical	Intuitive
Sequential	Imaginative
Objective	Subjective
Reasoning	Speculating
Reality Based	Fantasy Based
Vertical	Lateral
Probability	Possibility
Judgmental	Non-judgmental
Verbal	Visual
Hypothesis testing	Hypothesis forming
Closed-ended	Open-ended
Pattern Users	Pattern Seekers

MP482
PRODUCT DEVELOPMENT AND DESIGN

MODULE VI

- Concurrent Engineering
- Rapid prototyping: concepts, processes and advantages.
- Tools for product design – Drafting / Modelling software.
- Patents & IP Acts. Overview, Disclosure preparation

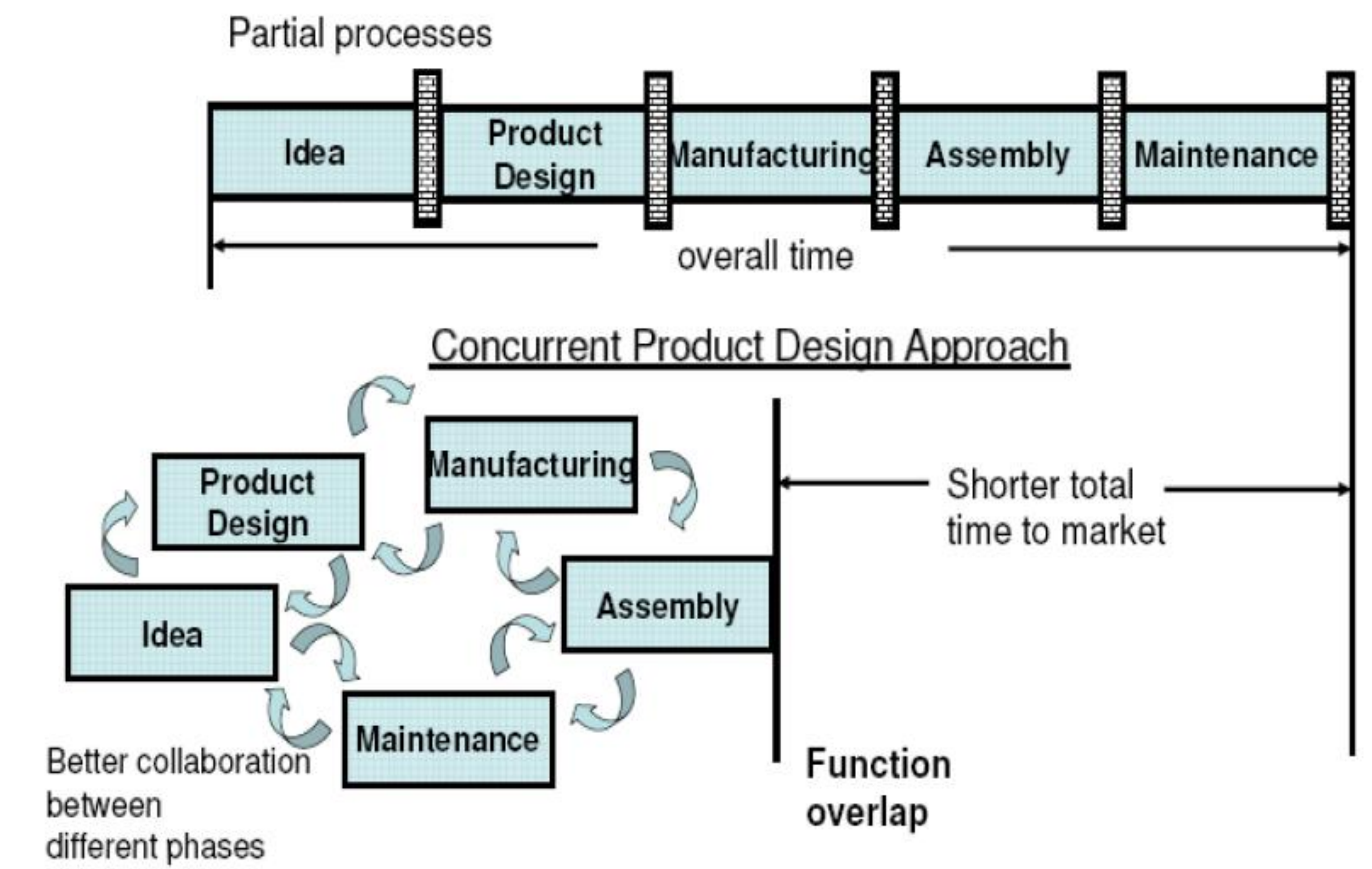
Concurrent Engineering

- Concurrent engineering is a business strategy which replaces the traditional product development process with one in which tasks are done in parallel and there is an early consideration for every aspect of a product's development process.
- This strategy focuses on the optimization and distribution of a firm's resources in the design and development process to ensure effective and efficient product development process.

Concurrent Engineering

- “The simultaneous performance of product design and process design.
- Typically, concurrent engineering involves the formation of cross-functional teams.
- This allows engineers and managers of different disciplines to work together simultaneously in developing product and process design.

Concurrent Engineering



Concurrent Engineering

- Concurrent engineering methodologies permit the separate tasks of the product development process to be carried out simultaneously rather than sequentially.
- Potential problems in fabrication, assembly, support and quality are identified and resolved early in the design process.

Concurrent Engineering

- Concurrent Engineering is a strategy where all the tasks involved in product development are done in parallel.
- Collaboration between all individuals, groups and departments within a company.
  - Customer research
  - Designers
  - Marketing
  - Accounting
  - Engineering

Need of Concurrent Engineering

- React to the changing market needs rapidly, effectively, and responsively.
- To reduce their time to market and adapt to the changing environments.
- Decisions must be made quickly and they must be done right the first time out.
- Concurrent engineering is a process that must be reviewed and adjusted for continuous improvements of engineering and business operations.

Advantages of Concurrent Engineering

- Decrease in time to market.
- Reduces Capital investment by 20% or more.
- Continuous improvement of product quality.
- Increases Product Life Cycle Profitability.
- Increased productivity
- Faster product development
- Less work in progress
- Reduces/eliminates repetition of tasks
- Reduces waste and reworking of design
- Company operates more efficiently
- Reduced Design and Development Times

Disadvantages of concurrent engineering

- Since the designer would no longer be king. There would be lot of ideas (for product) floating around from manufacturing, quality, service causing ego issues.
- There is always a tendency of the respective teams to protect their areas. For eg. Manufacturing engineers might not easily accept a change in design which increases performance but reduces manufacturability.
- The quality of ideas generated can go down.

Rapid Prototyping

- Rapid Prototyping technology employs various engineering e.g. computer control and software techniques including laser, optical scanning, photosensitive polymers, material extrusion and deposition, powder metallurgy etc. to directly produce a physical model layer by layer (Layer Manufacturing) in accordance with the geometrical data delivered from a 3D CAD model.

Differences between conventional machining and rapid prototyping

Rapid Prototyping	Non-Conventional machining processes
• Produce a model by adding material layer by layer. • Addition process. • Unlimited complexity. • No tooling is required. • Parts assembled in a one stage. • Error or flaws can be detected at an early stage.	• Produce a model by removing material bit by bit. • Subtraction process • Limited complexity. • Tooling is necessary. • Parts assembled different stages • Error cannot check earlier stage

Need of RPT/Advantages

- Prototyping can improve the quality of requirements and specifications provided to developers.
- Reduced time
- Reduced cost
- Complex designs which are difficult in conventional methods is possible
- Users are actively involved in the development.
- Quicker user feedback is available leading to better solutions.
- Errors can be detected much earlier.
- Missing functionality can be identified easily

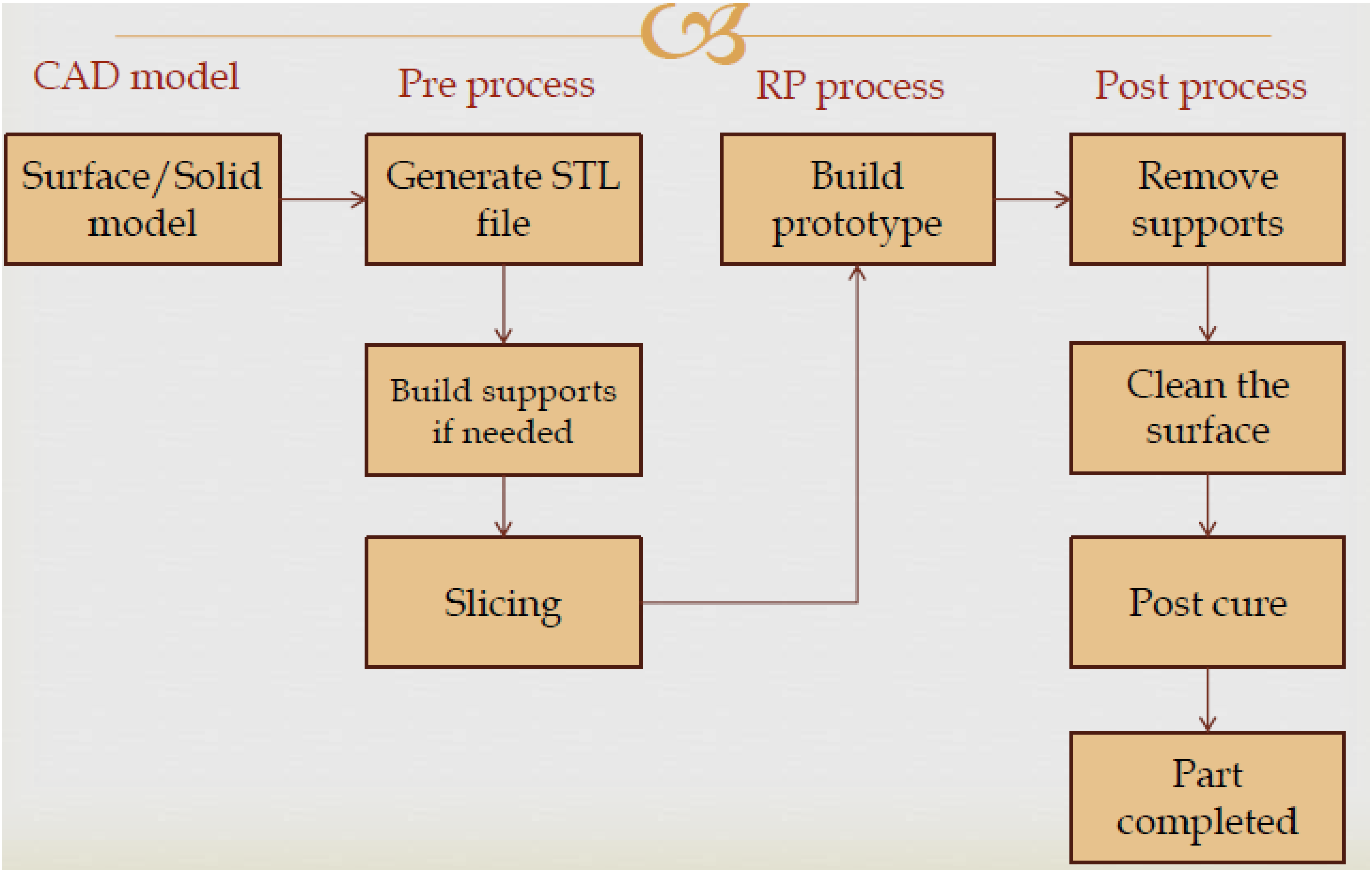
Disadvantages of RPT

- High precision RP machines are still expensive.
- RP systems are difficult to build parts with accuracy under +/- 0.02mm and wall thickness under 0.5mm.
- The physical properties of the RP parts are normally inferior to those samples that made in proper materials and by the traditional tooling.
- The RP parts are not comparable to (CNC) prototype parts in the surface finishing, strength, elasticity, reflective index and other material physical properties

Workflow of RP processes

- All RP techniques employ the basic five-steps processes:
  - Create a CAD model of the design.
  - Convert the CAD model to STL format.
  - Slice the STL file into thin cross-sectional layers.
  - Construct the model one layer atop another.
  - Clean and finish the model.

Workflow of RP processes



1. CAD Model Creation

- First, the object to be built is modeled using a Computer-Aided Design (CAD) software package.
- Solid modelers, such as Pro/ENGINEER, tend to represent 3-D objects more accurately than wire-frame modelers such as AutoCAD, and will therefore yield better results.

2. Conversion to STL Format

- To establish consistency, the STL format has been adopted as the standard of the rapid prototyping industry.
- The second step, therefore, is to convert the CAD file into STL format. This format represents a three-dimensional surface as an assembly of planar triangles
- STL files use planar elements, they cannot represent curved surfaces exactly.
- Increasing the number of triangles improves the approximation

3. Slice the STL File

- In the third step, a pre-processing program prepares the STL(Standard Triangulated Language) file to be built.
- The pre-processing software slices the STL model into a number of layers from 0.01 mm to 0.7 mm thick, depending on the build technique(G Code Generation using software like Maker ware,Slicr)
- The program may also generate an auxiliary structure to support the model during the build.
- Supports are useful for delicate features such as overhangs, internal cavities, and thin-walled sections.

4. Layer by Layer Construction

- The fourth step is the actual construction of the part.
- RP machines build one layer at a time from polymers, paper, or powdered metal.
- Most machines are fairly autonomous, needing little human intervention.

5. Clean and Finish

- The final step is post-processing. This involves removing the prototype from the machine and detaching any supports.
- Some photosensitive materials need to be fully cured before use
- Prototypes may also require minor cleaning and surface treatment.
- Sanding, sealing, and/or painting the model will improve its appearance and durability.

Types of RPT

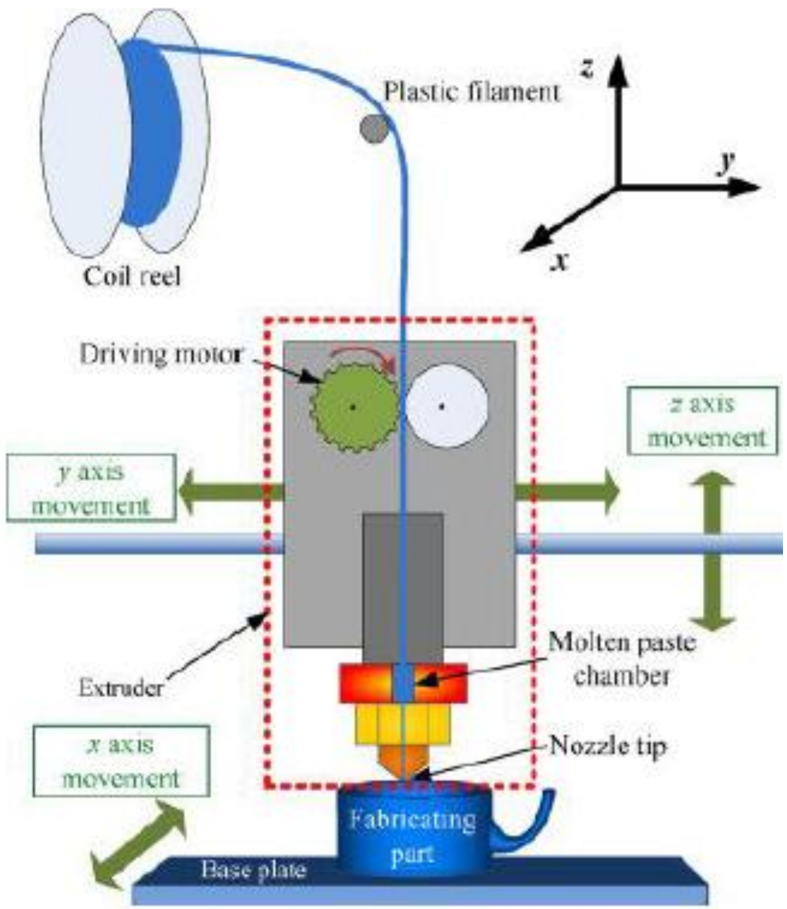
- Liquid Based
  - Liquid-based RP systems have the initial form of its material in liquid state.
  - Through a process commonly known as curing ,the liquid is converted into the solid state.
  - Eg:Stereolithography
- Solid Based
  - Except for powder, solid-based RP systems are meant to encompass all forms of material in the solid state.
  - Eg: Fused Deposition Modeling, Laminated Object Manufacturing
- Powder Based
  - However, it is intentionally created as a category outside the solid-based RP systems to mean powder in grain-like form.
  - Eg: Selective Laser Sintering, Laser Engineered Net Shaping

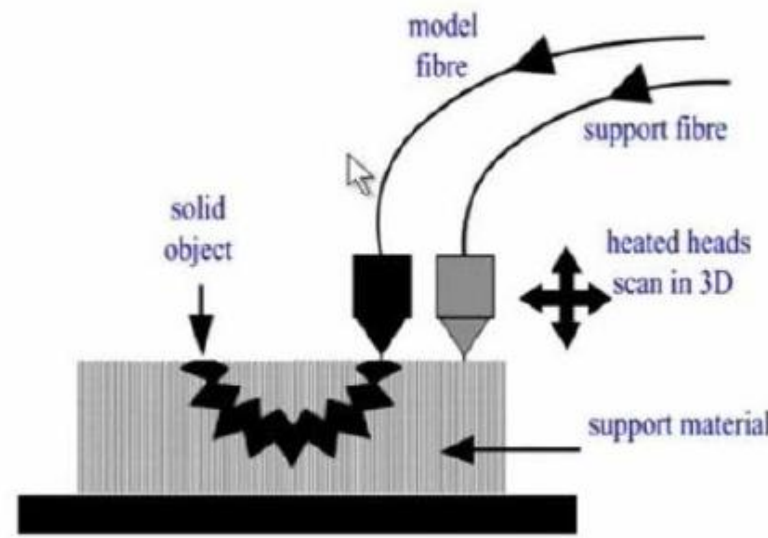
Fused Deposition Modelling

- Fused deposition modeling (FDM):- FDM works on an "additive" principle by laying down material in layers; a plastic filament or metal wire is unwound from a coil and supplies material to produce a part

Fused Deposition Modelling

- The FDM technique relies on melting and selectively depositing a thin filament of thermoplastic polymer (ABS - engineering and medical grade - plastic, Polycarbonate and investment casting wax) in a cross-hatching fashion to form each layer of the part.
- The material is in the form of a wire supplied in sealed spools which is mounted on the machine and the wire is threaded through the FDM head.
- The head is moved in the horizontal X and Y directions for producing each layer through zigzag movements.
- The supporting table moves in the vertical direction and is lowered after the completion of each layer.


Plastic filament
z
y
x
Coil reel
Driving motor
z axis movement
y axis movement
Extruder
Molten paste chamber
Nozzle tip
x axis movement
Fabricating part
Base plate


model fibre
support fibre
solid object
heated heads scan in 3D
support material

Fused Deposition Modelling

- Here, a spool of thermoplastic filament is fed into a heated extrusion head with a narrow nozzle.
- The x and y movements of the nozzle are controlled by a computer, so that the exact outline of each layer is obtained.
- The filament is unwound from a coil and gets melted and extruded as a continuous thread of polymer to produce a layer.
- Each layer is formed by depositing the molten thermoplastic material as per the outline of the layer.
- The subsequent layers are bonded to the earlier ones by heating.
- The method is also known as Fused Filament Fabrication (FFF). A wide range of durable thermoplastics like PLA, ABS, PVA, polycarbonate etc. are used as the material in this process.

Fused Deposition Modelling

- For certain shapes, a support structure may be needed and this is provided by a second nozzle squeezing out a similar thread of molten material.
- The material extruded by the second nozzle is usually given a different color.
- By using different colors, the actual object and the support material can be easily distinguished.
- At the end of the build process, the support structure is broken away and discarded to take out the object.

Fused Deposition Modelling(FDM)

Advantages

- No post curing.
- Variety of materials.
- Easy material changeover.
- Office environment friendly.
- Low end, economical machines.

Disadvantages

- Not good for small features, details and thin walls.
- Surface finish.
- Supports required on some materials / geometries.
- Support design / integration / removal is difficult.
- Weak Z-axis.
- Slow on large / dense parts

Intellectual Property

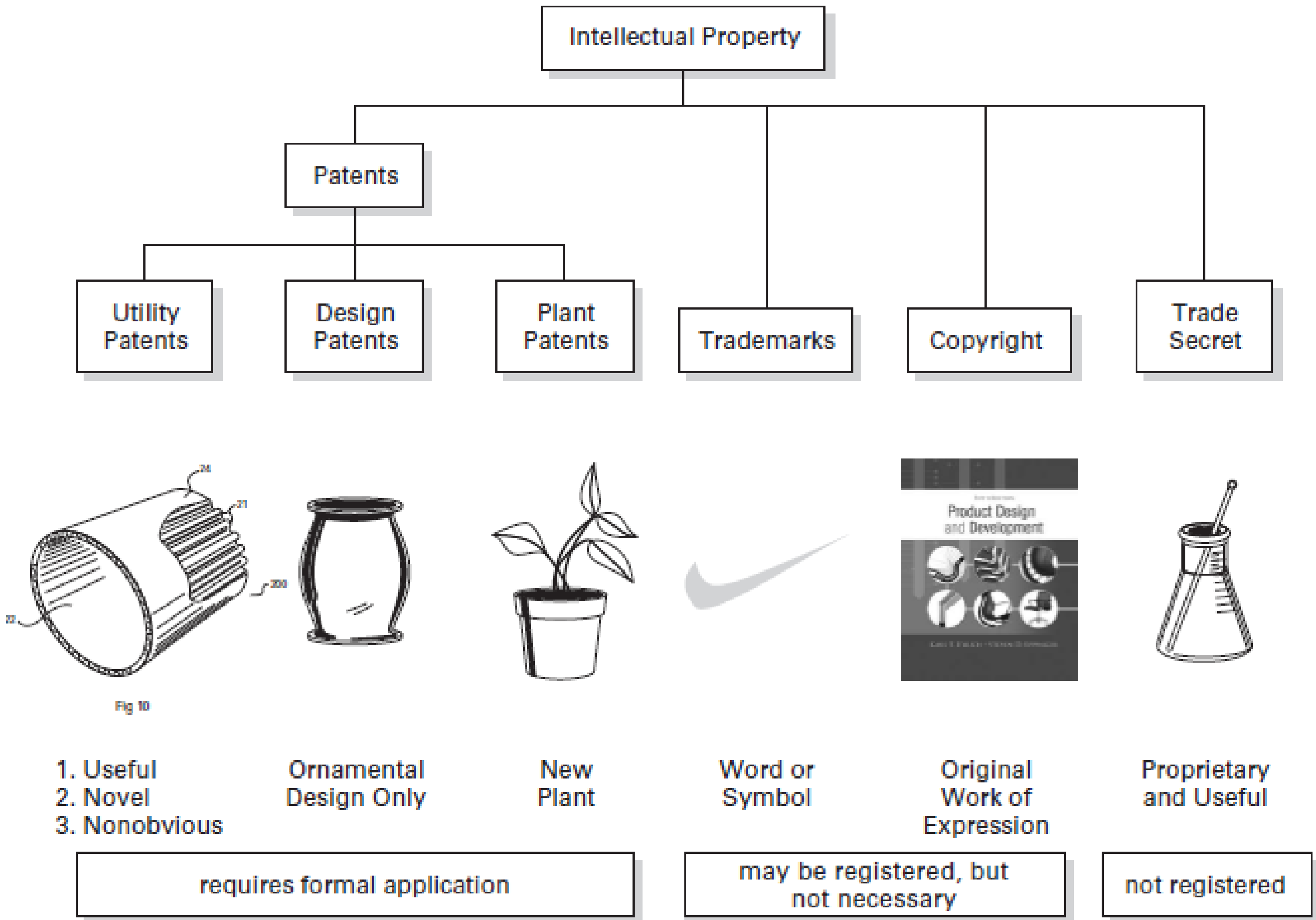
- Intellectual property is the product or creation of the mind.
- It is different from other properties in term that it is "intangible". Hence it needs some different way for its protection.
- IPR (Intellectual Property Right) is the body of law developed to protect the creative people who have disclosed their invention for the benefit of mankind.
- This protects their invention from being copied or imitated without their consent.

Intellectual Property

- *Intellectual property* refers to the legally protectable ideas, concepts, names, designs, and processes associated with a new product.
- Intellectual property can be one of the most valuable assets of firms.
- Unlike physical property, intellectual property cannot be secured with lock and key to prevent its unwanted transfer.
- Therefore, legal mechanisms have been developed to protect the rights of intellectual property owners.

Types of intellectual property

- Patent
- Trademark
- Trade secret
- Copyright


Intellectual Property
Patents
Utility Patents
Design Patents
Plant Patents
Trademarks
Copyright
Trade Secret
Fig 10
Product Design and Development
1. Useful
2. Novel
3. Nonobvious
Ornamental Design Only
New Plant
Word or Symbol
Original Work of Expression
Proprietary and Useful
requires formal application
may be registered, but not necessary
not registered

Types of intellectual property

- **Patent:**
  - A patent is a grant from the government which confers on the guarantee for a limited period of time the exclusive privilege of making, selling and using the invention for which a patent has been granted.
- **Trademark:**
  - Exclusive right given by government to the trademark owner to use a specific name or symbol in association with a class of product or process.
  - Normally trademarks are typically brands or product names

Types of intellectual property

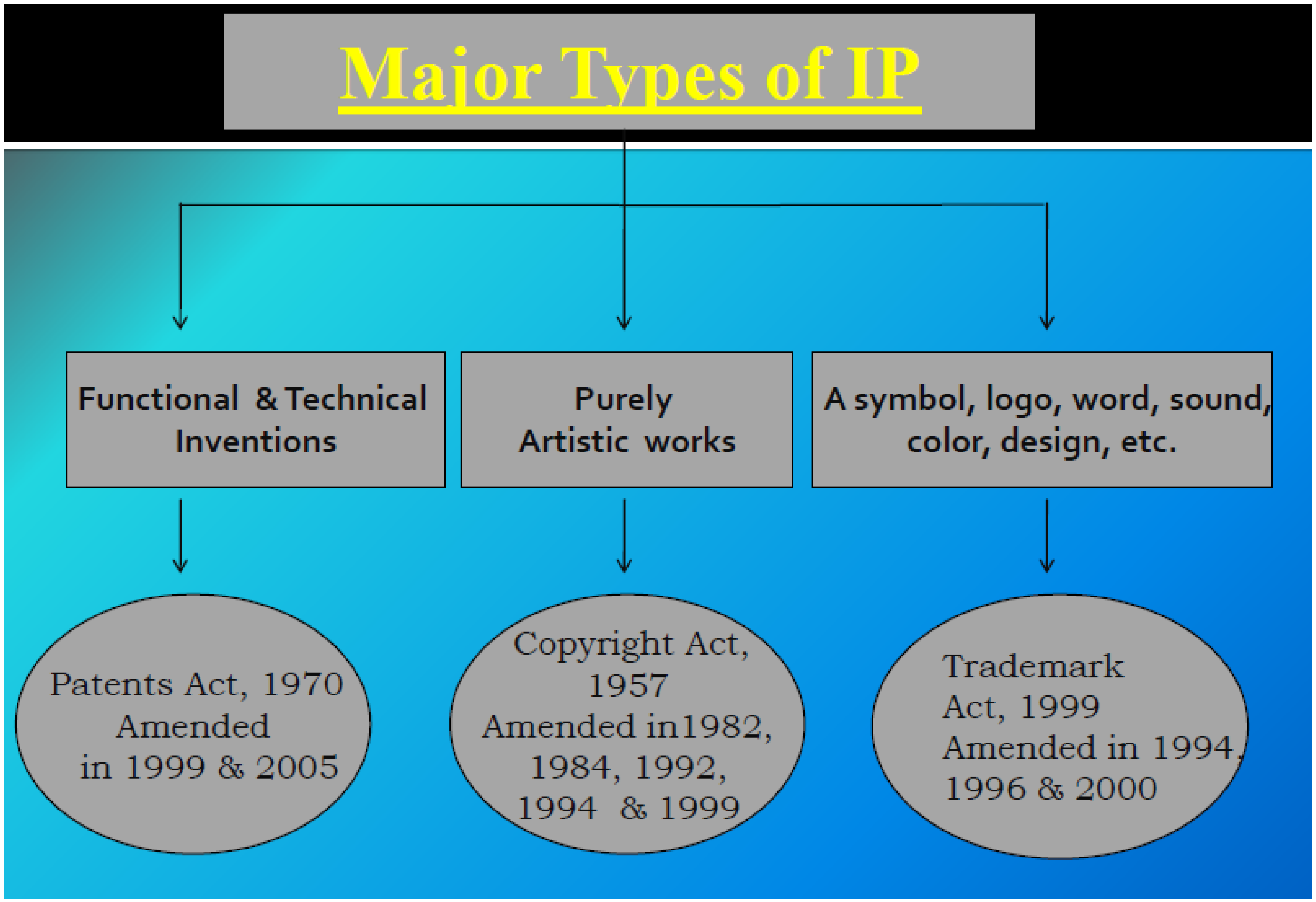
- **Trade Secret:**
  - A trade secret is a information used in a trade or business that offers its owner a competitive advantage and that can be kept as secret.
  - A symbol, logo, word, sound, color, design, or other device that is used to identify a business or a product in commerce.
- Different Symbols are :
  - ™ Intent to use application filed for product
  - SM Intent to use application filed for services
- **Copyright:**
  - Exclusive right granted by the government to copy and distribute an original work of expression, whether literature, graphics, music, art, entertainment, or software.
  - Registration of a copyright is possible but not necessary.
  - Can Lasts up to 95years

Types of Patent

- Two basic types
  - Design patents
  - Utility patents
- Design type:
  - Design patent provides legal right to exclude someone from producing and selling of a product.
- Utility type:
  - Patenting of an invention that relates to a new process machine, article of manufacture, composition of matter, or a new and useful improvements.

THE INDIAN PATENT ACT

- In India the grant of patents is governed by the patent Act 1970 and Rules 1972.
- The patents granted under the act are operative in the whole of India.
- **HISTORY**
  - The Patent Law of 1856
  - The Patent and Designs Act, 1911.
  - The Patents Act, 1970 and Rules 1972
  - The Patent amendment act 2005


Major Types of IP
Functional & Technical Inventions
Purely Artistic works
A symbol, logo, word, sound, color, design, etc.
Patents Act, 1970 Amended in 1999 & 2005
Copyright Act, 1957 Amended in1982, 1984, 1992, 1994 & 1999
Trademark Act, 1999 Amended in 1994, 1996 & 2000

What can be patented?

- The invention must fall into one of the five “statutory classes’: Processes, Machines , Manufactures, Compositions of matter, and New uses of any of the above
- The invention must be “useful”
- The invention must be “novel”
- The invention must be “non-obvious’

What can be patented?

Useful:

- The patented invention must be useful to someone in some context.

Novel:

- Novel inventions are those that are not known publicly
- Invention must not be published in India or elsewhere
- Invention must not be in prior public knowledge or prior public use with in India

- **Nonobvious:**
  - Patent law defines obvious inventions as those that would be clearly evident to those with “ordinary skill in the art” who faced the same problem as the inventor.
  - Ex: cloth hanger

Rights of a patentee

Right to exploit the patent.

- The patentee has a right to prevent 3rd parties, from exploiting the patented invention.

Right to grant license.

- The patentee has a power to assign rights or grant license.

Right to surrender.

- The patentee is given the right to surrender the patent by giving notice in prescribed manner to the controller.

Right to sue for infringement.

- A patentee is given the right to institute proceeding for infringement of the patent in a district court .

Drafting or Modeling Software

- CATIA
- ProE
- Autocad
- Solidworks
- Creo

Features of Modeling Software

- 2D Drawings(To manufacturing section)
- Part by Part Modeling
- Assembly of Parts
- Animation
- Analysis(Load/Stress ,Thermal ,etc.)

Patent Disclosure Preparation

- The disclosure will be in the form of a patent application, which can serve as a provisional patent application and with relatively little additional work could be a regular patent application.
- We can approach patent attorney for filing the disclosure, however it is recommend that inventor draft the disclosure and revise by attorney.

Steps Involved in Patent Disclosure

- Step1: Formulate a strategy and plan
- Step2: Study prior inventions
- Step3: Outline claims
- Step4: Write the specification (description) of the invention
- Step5: Refine claims
- Step6: Pursue application
- Step7: Reflect on the results and the process

Step1: Formulate a strategy and plan

- While formulating a patent, the team should decide on three important factors
  - **Timing** of the filing of a patent application
  - **Type** of application to be filed
  - **Scope** of the application
- **Timing of the filing of a patent application:**
  - Legally, patent application must be filed within one year of the first disclosure of an invention.
  - Although it is recommend that filing precede disclosure, the inventor usually benefits by delaying the application until just before such disclosure.

Step1: Formulate a strategy and plan

- **Type of application:**
  - First, the team must decide whether to file a *regular patent application* or a *provisional patent application*.
  - Secondly team should decide whether to file domestic and/or foreign patent.
- A provisional patent application needs only to fully describe the invention, it does not need to contain claims or comply with the formal structure.
- The principal advantage of a provisional patent application is that it requires less cost and effort to prepare and file than a regular patent application
- Disadvantages are
  - Delays the eventual issuance by one year,
  - Cannot add details in later(regular patent application) .

Step1: Formulate a strategy and plan

- **Scope of Application**
- The team should evaluate the overall product design and decide which embody inventions that are likely to be patentable.
- Complex products often embody several inventions, As a results team may need to file multiple applications.
- While defining the scope of the patent, the team should also consider who the inventors are.

Step 2: Study prior inventions

- What is Prior art?
  - Firstly by studying prior patent literature, design teams can learn whether an invention may infringe on existing unexpired patents.
  - Secondly by studying the prior art, the inventors gets a sense how similar their invention to the prior invention and how likely they are to be granted a patent.
  - Third the team will develop background knowledge enabling the members to craft a novel claims.
- Some of the sources information on prior inventions include:
  - Existing and historical product literature.
  - Patent searches
  - Technical and trade publications

Step3: Outline claims

- Issuance of a patent gives the owner a legal right to exclude others from infringing on the invention specifically described in the patent’s claims.
- Claims describe certain characteristics of the invention.
- They are written in formal legal language and must adhere to some rules of composition.
- At this point , team benefits from thinking carefully about what it believes is unique about the invention.

Step 4: Write the Description of the Invention

- It is the body of the patent application as it describes the invention.
- Description must present the invention in enough detail that someone with “ordinary skill in the art” could implement the invention.
- The description should be a marketing document in promoting the value of the invention and the weakness in existing solution.

Step 4: Write the Description of the Invention

A typical description includes the following elements:

- Title
- List of inventors
- Field of the invention
- Background of the invention
- Summary of the invention
- Brief description of the drawings
- Detailed description of the invention

Further discussion of detailed description includes

- Figures
- Writing the detailed description
- Defensive disclosure

Step 4: Write the Description of the Invention

- ***Title:***
  - Provide a short descriptive label for the invention, for example, "Recyclable Corrugated Beverage Container and Holder."
- ***List of inventors:***
  - All inventors must be listed.
  - A person should be listed as an inventor if he or she originated any of the inventions claimed in the application.
  - There are no legal limits to the number of inventors and no requirements about the order in which inventors are listed.
  - A failure to list an inventor could result in a patent eventually being declared not valid.
- ***Field of the invention:***
  - Explain what type of device, product, machine, or method this invention relates to. For example, the Coffin patent reads, "This invention relates to insulating containers, and especially to those which are recyclable and made of cellulosic materials."

Step 4: Write the Description of the Invention

- ***Background of the invention:***
  - State the problem that the invention solves.
  - Explain the context for the problem, what is wrong with existing solutions, why a new solution is needed, and what advantages are offered by the invention.
- ***Summary of the invention:***
  - This section should present the substance of the invention in summarized form.
  - The summary may point out the advantages of the invention and how it solves the problems described in the background.
- ***Brief description of the drawings:***
  - List the figures in the description along with a brief description of each drawing.
- ***Detailed description of the invention:***
  - This section of the description is usually the most comprehensive and contains detailed descriptions of embodiments of the invention along with an explanation of how these embodiments work.

Step5: Refine claims

- The claims are a set of numbered phrases that precisely define the elements of the invention.
- These claims are basis for all offensive rights.
- **Writing the claims:**
- Although claims must be expressed verbally, they adhere to a strict mathematical logic.
- X=A+B+C…….., where A=u+v+w…, B=….,
- Multiple claims are arranged in hierarchically into independent claims and dependent claims.
- Independent claims stand alone and forms root nodes of hierarchy claims.
- Dependent claims always add restriction to an independent claim.

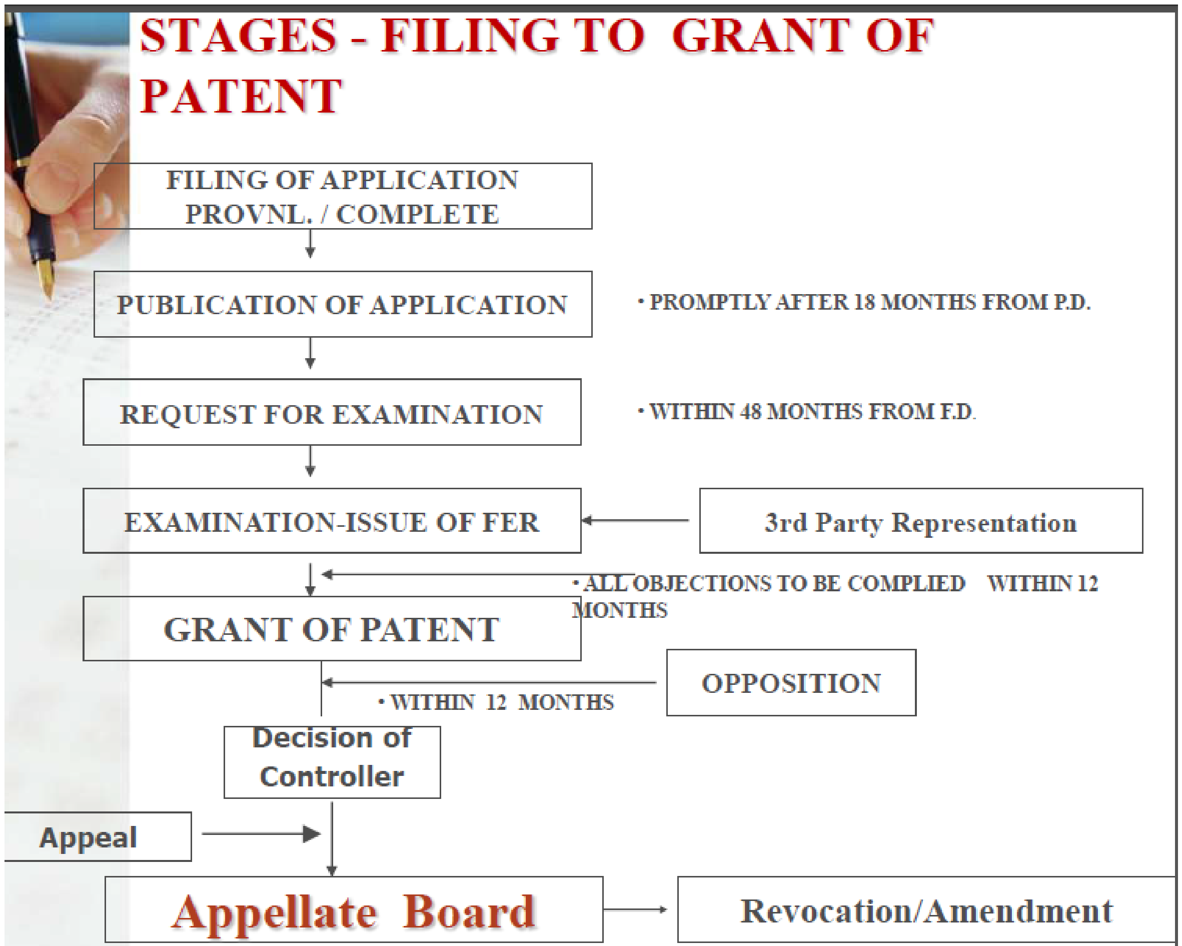
Step6: Pursue application

- Once an invention disclosure is prepared, the team can proceed in four different ways
  - The team can file a provisional patent application
  - The team may file a regular patent application
  - The team may file a Patent Cooperation Treaty(PCT)
  - The team can defer application indefinitely

Step7: Reflect on the results and the process

- What are the essential and distinctive features of the product concept?
- Are these features reflected in the description of the invention and in claims?
- Timing of the future required actions
- What did the team learn about the prior art that may inform future product development
- Did the team begin the process too early or too late? What is the ideal timing for next effort?

STAGES FROM FILING TO GRANT OF A PATENT



Obtaining A Patent

- File an application for patent
  - With one of the patent offices based on territorial jurisdiction of the place of office or residence of the applicant /agent
  - Pay the required fee
- Information concerning application form and details of fee available at www.ipindia.nic.in
- Guidelines for applicants also available on this website

Formality Check

- An Examiner checks the formal requirements before accepting the application and the fee – this is done immediately
- Issue of application number and the cash receipt – this is done the same day
- In case of receipt of application by post, cash receipt, application number is sent by post within 2- 3 days

Publication

- Application is kept secret for a period of 18 months from the date of filing
- In 19th month, the application is published in the official journal – this journal is made available on the website weekly
- Applicant has an option to get his application published before 18 months also
- In that case, application is published within one month of the request

Request for Examination

- Application is examined on request
- Request for examination can be made either by the applicant or by a third party
- A period of 48 months, from the date of filing, is available for making request for examination

Examination

- Application is sent to an Examiner within 1 month from the date of request for examination
- Examiner undertakes examination w.r.t
  - whether the claimed invention is not prohibited for grant of patent
  - whether the invention meets the criteria of patentability

Issue of FER

- A period of 1 to 3 months is available to Examiner to submit the report to the Controller
- 1 month’s time available to Controller to verify the Examiner’s report
- First Examination Report (FER) containing list of the objections is issued within 6 months from the date of filing of request

Response from the Applicant

- 12 months' time, from the date of issue of FER, is available to the applicant to meet the objections
- If objections are met, grant of patent is approved by the Controller – within a period of 1 month

Pre-grant Opposition

- After publication, an opposition can be filed within a period of 6 months
- Opportunity of hearing the opponent is also available

Examination of Pre-grant Opposition

- Opposition (documents) is sent to the applicant
- A period of 3 months is allowed for receipt of response

Consideration of Pre-grant Opposition

- After examining the opposition and the submissions made during the hearing, Controller may
  - Either reject the opposition and grant the patent
  - Or accept the opposition and modify/reject the patent application
- This is to be done within a period of 1 month from the date of completion of opposition proceedings

Grant of a Patent

- A certificate of patent is issued within 7 days
- Grant of patent is published in the official journal