

Production & Industrial Engineering

Industrial Engineering



Comprehensive Theory
with Solved Examples and Practice Questions





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Product Design and Development

INTRODUCTION

A product is an article obtained by the transformation of raw material and is marketed/sold by the manufacturer, i.e. a product is a salable item. It may be

- (i) Consumer product, e.g. cigarettes, televisions or
- (ii) Industrial product, e.g. a lathe, an overhead bridge crane, etc.

Every organisation has to design, develop and introduce new products as a survival and growth strategy. Organisations objective of achieving growth of business is only through introduction of new products. Organisation's are required to design the new products for the following reasons:

- To be in business for a long time believing the fact that business is a long lasting institution.
- To satisfy unfulfilled needs of the customers.
- The company's existing product line becomes saturated and the sales is on the decline.
- To enter into new prospective businesses through diversification (related or unrelated).
- Too much competition in the existing product line.
- The profit margin is on the decline.

1.1 Product Life Cycle

The product once introduced into the market will undergo definite phases. The various phases of life-cycle of a product are represented in the figure given below.

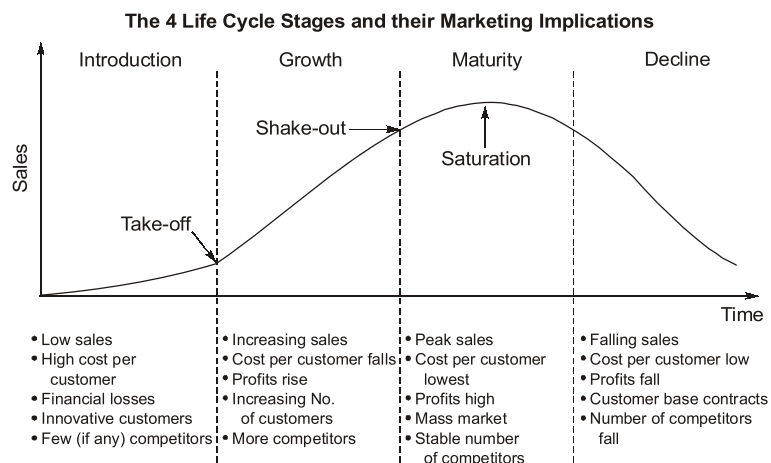


Fig. Product-Life Cycle

1.1.1 Introduction Stage

When a product is launched on the market, its sales will begin to grow slowly and profit, if any, will be rather small. This can be attributed to the lead time which is required for marketing efforts to take effect. At this stage, the product is new and untested, which implicates that potential customers may be unwilling or reluctant to purchase it. A second reason for rather low profitability at the introduction stage is that the company is unlikely to be making full use of its production capacity. As a result, it will be unable to benefit from the economies of scale that are associated with higher levels of production. The low profitability does also come from the need to recover development and launch costs. The main priority of the firm at the introduction stage is to generate widespread awareness of the product in its target segment and to stimulate trial. This is especially the case for new-to-the-world products, which are truly innovative by nature. In this case, primary demand will first have to be established. The company should focus its marketing activities on those buyers who are readiest to buy: innovators, which are usually to be found within the higher-income groups. This behavior was evident for instance when the manufacturers of the first smart phones targeted B2B customers when the products were first introduced to the market.

There are various marketing strategies that can be used for introducing a new product to the market. Two pricing strategies are available. The choice between the two strategies depends on the nature of the product and the level of competition:

- **Price skimming** involves charging a high initial price, before reducing the price gradually to “skim” each potential target group in the market as the market grows.
- **Price penetration** involves setting a low price to enter the market quickly and capturing market share, before adjusting the price to increase profits once the market has grown.

Actually, a significant share of new products fails to progress beyond the introduction stage of the PLC. This is often caused by a lack of understanding of the characteristics of the product life cycle stages and their implication on the required marketing strategies. At the introduction stage, this failure is worst: Customers who are dissatisfied with their first purchase of a product or a brand will be unlikely to make repeat purchases and recommendations, which are in turn essential for sales increases. Therefore, it is absolutely crucial to ensure that the products provide valuable benefits to the customer and superior customer value if survival and growth are to follow. The most important point is to get it right the first time.

1.1.2 Growth Stage

If the product meets existing market needs or stimulates previously untapped needs, it will enter the growth stage. In this stage, sales will usually lift off. This point is called the *take-off point*. Profits are generated as sales revenues increase faster than costs. But competitors will also have had time to assess the product, predict its impact on the market and potentially respond with a similar or improved version of the offering. As a result, the total size of the market tends to grow, and the new competitors can increase their sales by attracting new customers rather than undercutting each other on price. An increase in the number of distribution outlets tends to go in hand with this.

1.1.3 Maturity Stage

When a the sales growth of the product slows down, the maturity stage is reached. During this stage, there is a tendency for companies to capture customers from their competitors by undercutting each other on prices and increasing promotional efforts. As competitive rivalry intensifies, the weaker competitors are forced out of the market. This point is known as the *shake-out point*. Thus, only the strongest players remain to dominate the more stable market. The maturity stage does usually last longer than the previous stages, but also poses the strongest challenges to the marketing: the firm will try to prevent the sales to decline, while maintaining profitability. The problem at this stage is heavy price competition and resulting increased marketing expenditure from all competitors in order to retain brand loyalty.

Certainly, there are some famous brands and products that are still in the maturity stage after thirty years and more. For instance, consider Mars' bars or Coca-Cola. Although these products have changes only very little

since their launch, they are still highly successful or even more successful than ever. Other products survive by evolving to meet changing consumer needs

During the maturity stage, the firm can choose from a number of alternative strategies to ensure the future success of the product. These strategies range from innovating the market (market development) over modifying the product (product development) to altering the marketing mix (marketing innovation).

1.1.4 Decline Stage

If the characteristics of the product life cycle stages and their marketing implications are understood properly, the product may have made it to the final stage in the PLC: the decline stage. Usually, the firm will have tried to keep the product as long as possible in the maturity stage. However, once the sales of a product start to fall or profitability can no further be maintained, the decline stage is reached. This does often happen as a result of the market entry of substitute products which satisfy customer needs better than the previous product.

There are several alternative strategies available for handling the decline stage appropriately.

- **Milking or Harvesting** : When this strategy is used, the product receives only little or no marketing support. The firm aims to maximize the life of the product while generating the cash and the time required to establish new products. In addition, the slow decline of the product provides the firm with sufficient time to adjust to the declining cash flow and to find alternative means of generating income.
- **Phased Withdrawal** : Unlike under the milking approach, where the product could in theory continue indefinitely, phased withdrawal involves setting a hard cut-off date for the product. Before the cut-off date, there may be interim stages at which the product is either pulled form certain channels of distribution or certain geographic areas. Phased withdrawal provides the advantage of enabling the firm to plan the introduction of replacement products. However, it can be a source of dissatisfaction to customers, who may not like the sudden disappearance of their favoured product. A typical example of the phased withdrawal strategy can be found in the automotive industry: car manufacturers normally set hard cut-off dates to existing products, so that both dealers and the public are notified of product withdrawals and new product launches.
- **Contracting out or Selling** : Loyal users of a product can be retained when the brand or the rights to produce and sell the product are handed on to a niche operator or by subcontracting. Many smaller firms use this strategy since they are flexible enough to offer the product's market a satisfactory return. Each party involved in this strategy benefits from the deal: the originating firm can dispose profitably of a product it no longer wants, consumers can keep buying products they desire, and the subcontractor or buyer can gain the benefits of a brand they could never have established on their own.

Management have to consider few things before dropping the product :

- (a) Effects on customers who expect service and replacement parts.
- (b) Effects on employees if you fire the workers who are involved in making the product.
- (c) Effect on other related products in the product line.

Table. Characteristics of Phases of PLC

Particulars	Introduction	Growth	Maturity	Decline
1. Product Variety	High Variety	Increasing Standardisation	Dominant Design feature of product	High standard commodity
2. Volume	Low Volume	Increasing Volume Consolidation	High Volume	Decreasing Volume
3. Industry Structure	Small Competition	Beginning of Competition	Few large companies	Survivors
4. Form of Competition	Product Characteristics	Product Quality and availability	Price and dependability	Price

1.2 Product Policy of an Organization

Product policy is the top management (Strategic) decision. Every organization has its own product strategies or policies which form the basis of competing in the market and they become the Unique Selling Proposition (USP) of the company. The various product policies are :

1. **Lowest Price** : The company will be the price leader and the company is going to offer the product at the cheapest price than its competitors. Price becomes the criteria used to compete in the market. Though the profit per unit is less, the company is going to make the substantial profit by the large volume.
2. **Highest Quality** : Some organisations offer highest quality products irrespective of the cost. They are catering to the needs of special class of customers who value quality as the only criteria to purchase the product.
3. **Compromise between Cost and Quality** : Some organisations in order to capture the larger sections of the customers, offer products with the optimum blend of quality and cost. The products are reasonably of good quality in proportion to its price. These organisations try to give good value to the customers for his money.
4. **Safety** : Some organisations give maximum importance to safety. Safety is the criteria on which they compete in the market. For example, all home appliances, electrical gadgets, etc.

Thus, organisations have to choose the policies suitable for them. This policy is going to influence the design to the large extent.

1.3 Selection of Profitable Product

It is the product that makes or mar the fortune of the company. So utmost care should be taken in the identification of the product.

Before selecting a product, organisations have to carry out SWOT analysis in order to know their strength areas, weaknesses or limitations, opportunities before the organisation and the perceived threat. The organisations have to explore the opportunities (products) which fall under their strength areas so that they are able to cash on the opportunities. Product selection is a team effort.

Following are the methods to identify the profitable product :

1. **By chance** : It is impossible to ignore the effects of chance. A meeting in a train with a stranger, sight of a new device, an attendance at a social gathering can create the idea which may lead to a successful product.
2. **Desire to utilise idle resources** : Many organisations have idle resources like excess cash, unused plant and equipment, unutilised management talent, surplus distribution channels and the management may conceive an idea of putting these resources to productive use which gives rise to new product.
3. **Demand supply gap** : If the gap between demand and supply is big, then the products are selected to bridge this gap.
4. Need to support existing range.
5. Forward and/or backward integration.
6. By spreading the risk.
7. To supplement a declining income.
8. To keep pace with changing fashion and customer preferences and tastes.
9. To exploit special skills.
10. To attract prestige.
11. To exploit special assets.

No project should be undertaken until it is viewed objectively from all aspects and a detailed feasibility study is carried out. The personal preference and immediate excitement should not be given any room.

1.4 Product Development

Development is carried out after applied research which follows pure research. Development concerns the most economically feasible method for applying the principles identified through Research Development involves design/redesign and fabrication of new or modified product and then testing it to find its usefulness.

Product Research and Development are concerned with all aspects of the product design and applications including its

- (i) functional efficiency
- (ii) quality
- (iii) unexplored uses
- (iv) investigation of materials and possible substitutes
- (v) utilization of waste products
- (vi) standardization and customer satisfaction.

1.4.1 Objectives of Product Development

- **To fulfill the customer needs** : Product planning identifies customer needs, requirements, specifications, aspirations, liking & preferences and also guides the firm's resources & efforts towards the accomplishment of them.
- **To spotlight firms strengths and weaknesses** : Each firm has its own strengths and weaknesses. The future plan, the blueprint of action is founded in product planning on the set of given strengths & weaknesses. By pinpointing strengths and weaknesses the product can be devised so as to minimize the weakness and maximize the strength.
- **To fortify better resource utilization** : The minimum cost level of production is possible only when the company resources are geared to its production plan. As product planning is related with developments of better quality products, improvement of existing ones to changing consumer tastes & needs, the limited and costly resources are so employed as to the greatest ,better & cheaper production.
- **To guarantee firm's survival** : Products are the hope for firm's survival. The product that fulfils the ever changing need and taste of consumer enables the firm to survive successfully. Product renovation and innovation are the two key strategies which are considered to be quite important for those firms who want to survive for many years to come.
- **To increase firm's sale** : Every firm depends on sales as the only source of income to meet the outgoings & retain a decent margin to justify its hard work of putting resources & taking risks. Every firm wants to milk maximum sales by targeting right customer class at the right time.

1.4.2 Characteristics of Successful Product Development

- **Product Quality** : How good is the product resulting from the development effort? Does it satisfy customer needs? Is it robust and reliable? Product quality is ultimately reflected in market share and the price that customers are willing to pay.
- **Product Cost** : What is the manufacturing cost of the product? This cost includes spending on capital equipment and tooling as well as the incremental cost of producing each unit of the product. Product cost determines how much profit accrues to the firm for a particular sales volume and a particular sales price.
- **Development Time** : How quickly did the team complete the product development effort? Development time determines how responsive the firm can be to competitive forces and to technological developments, as well as how quickly the firm receives the economic returns from the team's efforts.
- **Development Cost**: How much did the firm have to spend to develop the product? Development cost is usually a significant fraction of the investment required to achieve the profits.

- **Development Capability** : Are the team and the firm better able to develop future products as a result of their experience with a product development project? Development capability is an asset the firm can use to develop products more effectively and economically in the future.

1.4.3 Who Designs and Develops the Product

Product development is an interdisciplinary activity requiring contributions from nearly all the functions of a firm; however, three functions are almost always central to a product development project:

- **Marketing** : The marketing function mediates the interactions between the firm and its customers. Marketing often facilitates the identification of product opportunities, the definition of market segments, and the identification of customer needs. Marketing also typically arranges for communication between the firm and its customers, sets target prices, and oversees the launch and promotion of the product.
- **Design** : The design function plays the lead role in defining the physical form of the product to best meet customer needs. In this context, the design function includes engineering design (mechanical, electrical, software, etc.) and industrial design (aesthetics, ergonomics, user interfaces).
- **Manufacturing** : The manufacturing function is primarily responsible for designing and operating the production system in order to produce the product. Broadly defined, the manufacturing function also often includes purchasing, distribution, and installation. This collection of activities is sometimes called the supply chain.

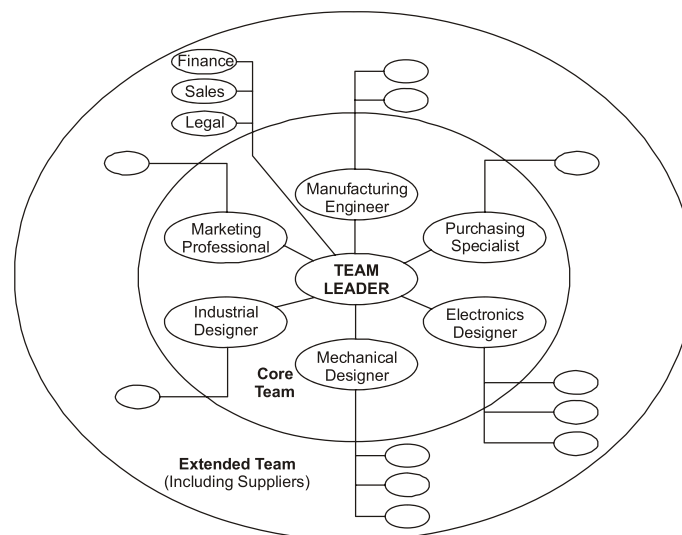


Fig. The composition of product development team for an electromechanical product of modest complexity

1.4.4 Types of Product Development Projects

Product development projects can be classified in following four categories :

- **New product platforms** : This type of project involves a major development effort to create a new family of products based on a new, common platform. The new product family would address familiar markets and product categories. The Xerox Lakes project, aimed at the development of a new, digital copier platform, is an example of this type of project.
- **Derivatives of existing product platforms** : These projects extend an existing product platform to better address familiar markets with one or more new products. To develop a new copier based on an existing light-lens (not digital) product platform would be an example of this type of project.
- **Incremental improvements to existing products** : These projects may only involve adding or modifying some features of existing products in order to keep the product line current and competitive. A slight change to remedy minor flaws in an existing copier product would be an example of this type of project.

**Student's
Assignments****1**

- Q.1** The following is the preliminary stage of Production planning
(a) Capacity planning
(b) Material requirements planning
(c) Scheduling
(d) Product development and design
- Q.2** The following is the source(s) for developing new or improved product
(a) Research and Development department of the enterprise
(b) Consumer suggestions and Complaints
(c) Other competitive products in the market
(d) All of the above
- Q.3** Product cost can be reduced by considering the following aspect(s) at the design stage
(a) Minimum number of operations
(b) Unnecessary tight tolerance should not be provided
(c) Design should consist of standard parts
(d) All of the above
- Q.4** The ultimate objective of the product is
(a) To provide a new look
(b) Utilizing existing manpower
(c) To monopolize the market
(d) All of the above
- Q.5** Based on their field of application, manufactured goods can be classified as
(a) Primary, Secondary and Tertiary
(b) Consumer, Capital and Defense
(c) Essential, Market and Standard
(d) Primary, Luxury and Consumer
- Q.6** The following aspect of product is concerned with the ease and efficiency of the product performance
(a) Functional aspect (b) Operational aspect
(c) Durability aspect (d) Aesthetic aspect
- Q.7** The "simplicity to operate and easy to understand" of product is concerned with its following aspect
(a) Functional aspect (b) Operational aspect
(c) Durability aspect (d) Aesthetic aspect
- Q.8** ____ helps in establishing the interchangeability of products
(a) Standardization (b) Simplification
(c) Diversification (d) Specialization
- Q.9** In which of the following type the manufacturing cost may go up
(a) Standardization (b) Simplification
(c) Diversification (d) All of the above
- Q.10** Product ____ is the ultimate objective of variety reduction
(a) Simplification (b) Standardization
(c) Specialization (d) All of the above
- Q.11** The following eases the process of stock control
(a) Standardization (b) Simplification
(c) Both 'A' and 'B' (d) None of the above
- Q.12** The following is the Durability aspect(s) of a product
(a) Efficiency of the product
(b) Easy to understand
(c) Ease with which a product can be maintained
(d) All of the above
- Q.13** First step in process of developing new product must be
(a) idea generation
(b) idea screening
(c) concept development and testing
(d) business analysis
- Q.14** In product life cycle introductory stage, marketing objective is to
(a) maximize the market share
(b) create product awareness
(c) defend market share and profits
(d) reduce expenditure
- Q.15** The following is/are the source(s) for developing new or improved product.
(a) Research and Development department of enterprise.
(b) Consumer suggestions and complaints.
(c) Other competitive products in the market.
(d) All of the above

- (a) 1 - 2 - 3 - 5 - 4 - 6 (b) 1 - 3 - 2 - 4 - 5 - 6
(c) 1 - 3 - 2 - 5 - 4 - 6 (d) 1 - 2 - 3 - 4 - 5 - 6

- Q.27** What is concurrent design process.
(a) The process includes only engineers.
(b) The process includes only the business part of the design.
(c) The process includes all disciplines involved in designing a product.
(d) None of the above

A N S W E R S

1. (d) 2. (d) 3. (d) 4. (c) 5. (b)
6. (a) 7. (a) 8. (a) 9. (c) 10. (c)
11. (c) 12. (c) 13. (a) 14. (b) 15. (d)
16. (d) 17. (c) 18. (a) 19. (c) 20. (b)
21. (0.909) 22. (c) 23. (382800) 24. (d)
25. (b) 26. (c) 27. (c)

H I N T S

- 13. (a)**
Idea Generation-Idea Screening-Concept development and testing-Marketing Strategy-Business analysis-Product development-Test marketing.
- 14. (b)**
Introductory stage our aim to:
establish a clear brand identity
connect with the right partners to promote your products
set up consumer tests, or provide samples or trials to key target markets

- 15. (d)**
All of the above are sources for developing new or improved product.

- 21. (0.909) (0.90 to 0.92)**

$$\begin{aligned} \text{Deflator} &= \frac{\text{Current year price}}{\text{Base year price}} \\ &= \frac{10}{11} = 0.909 \end{aligned}$$

- 23. (382800)**

$$\begin{aligned} \text{Cost saving after Value engineering} &= 1950 - 1660 = 290 \\ \text{Annual saving} &= 1320 \times 290 = 382800 \end{aligned}$$

- 24. (d)**
I - Introduction
II - Growth
III - Maturity
IV - Decline

- 25. (b)**
Logical sequence is – problem identification → Preliminary Ideas → Design refinement → Analysis → Optimization → Documentation.

- 27. (c)**
The process includes all disciplines involved in designing a product.

