UNIT – 4

Product Design Cycle

Unit-04/Lecture-01

Identification of customer needs and market research essentials:

Information gathered from customers and research on products from market literature and experimentation contributes to creating a ranked listing of customer needs and wants. These are the needs that form the end user's opinion about the quality of a product. As odd as it may seem, customers may not express all their requirements of a product when they are interviewed. To understand how that can happen and how the omissions can be mitigated, it is necessary to reflect on how customers perceive "needs."

From a global viewpoint, we should recognize that there is a hierarchy of human needs that motivate individuals in general.

Physiological needs*: such* as thirst, hunger, sleep, shelter, and exercise. These constitute the basic needs of the body, and until they are satisfied, they remain the prime influence on the individual's behavior.

Safety and security needs*:* which include protection against danger, deprivation, and threat. When the bodily needs are satisfied, the safety and security needs become dominant.

Social needs*: for* love and esteem by others. These needs include belonging to groups, group identity, and social acceptance. *Psychological needs* for self-esteem and self-respect and for accomplishment and recognition.

Self-fulfillment needs for the realization of one's full potential through self development, creativity, and self-expression.

Different view of customer requirement:

From a design team point of view, the customer requirements fit into a broader picture of the PDP requirements, which include product performance, time to market, cost, and quality.

Performance deals with what the design should do when it is completed and in operation. Design teams do not blindly adopt the customer requirements set determined thus far. However, that set is the foundation used by the design team. Other factors may include requirements by internal customers (e.g., manufacturing) or large retail distributors.

The ***time*** dimension includes all time aspects of the design. Currently, much effort is being given to reducing the PDP cycle time, also known as the time to market, for new products. For many consumer products, the first to market with a great product captures the market

Cost pertains to all monetary aspects of the design. It is a paramount consideration of the design team. When all other customer requirements are roughly equal, cost determines most customers' buying decisions. From the design team's point of view, cost is a result of many design decisions and must often be used to make trade-offs among features and deadlines.

Quality is a complex characteristic with many aspects and definitions. A good definition of quality for the design team is the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs.

Garvin identified the *eight basic dimensions of quality* for a manufactured product. These have become a standard list that design teams use as a guide for completeness of customer requirement data gathered in the PDP.

Performance: The primary operating characteristics of a product. This dimension of quality can be expressed in measurable quantities, and therefore can be ranked objectively.

Features: Those characteristics that supplement a product's basic functions. Features are frequently used to customize or personalize a product to the customer's taste.

Reliability: The probability of a product failing or malfunctioning within a specified time period.

Durability: A measure of the amount of use one gets from a product before it breaks down and replacement is preferable to continued repair. Durability is a measure of product life. Durability and reliability are closely related.

Serviceability: Ease and time to repair after breakdown. Other issues are courtesy and competence of repair personnel and cost and ease of repair.

Conformance: The degree to which a product's design and operating characteristics meet both customer expectations and established standards. These standards include industry standards and safety and environmental standards. The dimensions of performance, features, and conformance are interrelated. When competing products have essentially the same performance and many of the same features, customers will tend to expect that all producers of the product will have the same quality dimensions. In other words, customer expectations set the baseline for the product's conformance.

Aesthetics: How a product looks, feels, sounds, tastes, and smells. The customer response in this dimension is a matter of personal judgment and individual preference. This area of design is chiefly the domain of the *industrial designer,* who is more an artist than an engineer. An important technical issue that affects aesthetics is *ergonomics,* how well the design fits the human user.

Perceived quality: This dimension generally is associated with reputation. Advertising helps to develop this dimension of quality, but it is basically the quality of similar products previously produced by the manufacturer that influences reputation.

UNIT 4/LECTURE 2

Concept generation

Concept generation :

The best engineers will use creative thinking methods and design processes that assist in the synthesis of new concepts not previously imagined. Creative thinking is highly valued across many fields of endeavor, especially those that deal with problem solving. Creative cognition is the use of regular cognitive operations to solve problems in novel ways. One way to increase the likelihood of positive outcomes is to apply methods found to be useful for others.

Following are some positive steps you can take to enhance your creative thinking.

Develop a creative attitude: To be creative it is essential to develop confidence that you can provide a creative solution to a problem. Although you may not visualize the complete path through to the final solution at the time you first tackle a problem, you must have self-confidence; you must believe that a solution will develop before you are finished. Of course, confidence comes with success, so start small and build your confidence up with small successes.

Unlock your imagination: You must rekindle the vivid imagination you had as a child. One way to do so is to begin to question again. Ask "why" and "what if," even at the risk of displaying a bit of naïveté. Scholars of the creative process have developed thought games that are designed to provide practice in unlocking your imagination and sharpening creative ability.

Be persistent: We already have dispelled the myth that creativity occurs with a lightning strike. On the contrary, it often requires hard work. Most problems will not succumb to the first attack. They must be pursued with persistence. After all, Edison tested over 6000 materials before he discovered the species of bamboo that acted as a successful fi lament for the incandescent light bulb. It was also Edison who made the famous comment, "Invention is 95 percent perspiration and 5 percent Inspiration."

Develop an open mind: Having an open mind means being receptive to ideas from any and all sources. The solutions to problems are not the property of a particular discipline, nor is there any rule that solutions can come only from persons with college degrees. Ideally, problem solutions should not be concerned with company politics. Because of the NIH factor (not invented here), many creative ideas are not picked up and followed through.

Suspend your judgment: We have seen that creative ideas develop slowly, but nothing inhibits the creative process more than critical judgment of an emerging idea. Engineers, by nature, tend toward critical attitudes, so special forbearance is required to avoid judgment at an early stage of conceptual design.

Set problem boundaries: We place great emphasis on proper problem definition as a step toward problem solution. Establishing the boundaries of the problem is an essential part of problem definition. Experience shows that setting problem boundaries appropriately, not too tight or not too open, is critical to achieving a creative solution.

Barriers to create thinking:

Before we look at formal methods of enhancing creativity, it is important for you to understand how *mental blocks* interfere with creative thinking. A mental block is a mental wall that prevents the problem solver from correctly perceiving a problem or conceiving its solution. A mental block is an event that inhibits the successful use of normal cognitive processes to come to a solution. **There are many different types of mental blocks.**

i) **Perceptual Blocks**

Perceptual blocks have to do with not properly defining the problem and not recognizing the information needed to solve it.

Stereotyping: Thinking conventionally or in a formulaic way about an event, person, or way of doing something. Not thinking "out of the box." The brain classifies and stores information in labeled groups. When new information is taken in, it is compared with established categories and assigned to the appropriate group. This leads to stereotyping of ideas since it imposes preconceptions on mental images. As a result, it is difficult to combine apparently unrelated images into an entirely new creative solution for the design.

Information overload: You become so overloaded with minute details that you are unable to sort out the critical aspects of the problem. This scenario is termed "not being able to see the forest for the trees." Cognitively this is a situation of engaging all the available short-term memory so that there is no time for related searches in long-term memory.

Limiting the problem unnecessarily: Broad statements of the problem help keep the mind open to a wider range of ideas.

Fixation: People's thinking can be influenced so greatly by their previous experience or some other bias that they are not able to sufficiently recognize alternative ideas. Since divergent thinking is critical to generating broad sets of ideas, fixation must be recognized and dealt with. A kind of fixat ion called memory blocking is discussed in the section on intellectual blocks.

Priming or provision of cues: If the thinking process is started by giving examples or solution cues, it is possible for thinking to stay within the realm of solutions suggested by those initial starting points. This is known as the conformity effect. Some capstone design instructors have noted this commenting that once students find a relevant patent for solving a design problem, many

of their new concepts follow the same solution principle.

ii) Emotional Blocks

These are obstacles that are concerned with the psychological safety of the individual. They reduce the freedom with which you can explore and manipulate ideas. They also interfere with your ability to conceptualize readily.

Fear of risk taking: This is the fear of proposing an idea that is ultimately found to be faulty. This is inbred in us by the educational process. Truly creative people must be comfortable with taking risks.

Unease with chaos: People in general, and many engineers in particular, are uncomfortable with highly unstructured situations.

Unable or unwilling to incubate new ideas : In our busy lives, we often don't take the time to let ideas lie dormant so they can incubate properly. It is important to allow enough time for ideas to incubate before evaluation of the ideas takes place. Studies of creative problem-solving strategies suggest that creative solutions usually emerge as a result of a series of small ideas rather than from a "home run" idea. *Motivation:* People differ considerably in their motivation to seek creative solutions to challenging problems. Highly creative individuals do this more for personal satisfaction than personal reward. However, studies show that people are more creative when told to generate many ideas, so it shows that the motivation is not all self-generated.

iii) Cultural Blocks

People acquire a set of thought patterns from living in a culture. Most of us have experienced an educational system that has valued knowledge and suppressed our childhood proclivity to ask "why" and "how." Certain industries are tradition bound and are reluctant to change, even in the face of decreasing profitability. Often it takes new top management, coming in from a different industry, to get them back on the road to profitability. Countries even differ in their attitudes toward creative problem solutions. This can be traced to differences in political and educational systems, and business culture.

For example, in many countries it is a shameful disgrace for a business leader to take his company into bankruptcy, while in others it is a mark of creative entrepreneurship and normal risk-taking.

iv) Intellectual Blocks

Intellectual blocks arise from a poor choice of the problem-solving strategy or having inadequate background and knowledge.

Poor choice of problem-solving language or problem representation *:* It is important to make a conscious decision concerning the "language" for your creative problem solving. Problems can be solved in either a mathematical, verbal, or a visual mode. Often a problem that is not yielding

readily to solution using, for example, a verbal mode can be readily solved by switching to another mode such as the visual mode. Changing the representation of a problem from the original one to a new one (presumably more useful for finding a solution) is recognized as fostering creativity. 16

Memory block: Memory holds strategies and tactics for finding solutions as well as solutions themselves. Therefore, blocking in memory searches is doubly problematic to creative thinking. A common form of blocking is maintaining a particular search path through memory because of the false belief that it will lead to a solution. This belief may arise from a false hint, reliance on incorrect experience, or any other reason that interrupts or distracts the mind's regular problem-solving processes.

Insufficient knowledge base: Generally, ideas are generated from a person's education and experience. Thus, an electrical engineer is more likely to suggest an electronics-based idea, when a cheaper and simpler mechanical design would be better. This is one reason why persons with broad backgrounds tend to be more creative, and it is a strong reason for working in interdisciplinary design teams. However, the search for pertinent information can be carried too far such that you are exposed to all of the assumptions and biases of previous workers in the field. This could limit your creativity. Perhaps a better approach to gathering information is to do enough to get a good feel for the problem and then use this knowledge base to try to generate creative concepts. After that it is important to go back and exhaustively develop an information base to use in evaluating the creative ideas.

Incorrect information: It is obvious that using incorrect information can lead to poor results. One form of the creative process is the combining of previously unrelated elements or ideas (information); if part of the information is wrong then the result of creative combination will be fl awed. **For example,** if you are configuring five elements of information to achieve some result, and the ordering of the elements is critical to the quality of the result, you have 120 different orderings. If one of the elements is wrong, all 120 alternative orderings are wrong. If you only need to take two (2) of the five (5) elements, then there are 20 possible combinations. Of these 20, four will lead to wrong results because they will contain the incorrect element. The higher the number of elements that are combined, the more difficult it will be to sort out the correct combinations from those that are flawed.

Environmental Blocks

These are blocks that are imposed by the immediate physical or social environment.

Physical environment: This is a very personal factor in its effects on creativity. Some people can work creatively with all kinds of distractions; others require strict quiet and isolation. It is important for each person to determine their optimum conditions for creative work, and to try to achieve this

in the workplace. Also, many people have a time of day in which they are most creative. Try to arrange your work schedule to take advantage of this.

Criticism: Non supportive remarks about your ideas can be personally hurtful and harmful to your creativity. This is especially true if they come from a left-brained boss. It is common for students in a design class to be hesitant to expose their ideas, even to their team, for fear of criticism. This lack of confidence comes from the fact that you have no basis of comparison as to whether the idea is good. As you gain experience you should gain confidence, and be able to subject your ideas to friendly but critical evaluations. Therefore, it is very important for the team to maintain an atmosphere of support and trust, especially during the concept design phase.

These same questions can be used to help you approach the problem from different angles.

- Who? Who uses it, wants it, will benefit by it?
- What? What happens if X occurs? What resulted in success? What resulted in failure?
- When? Can it be speeded up or slowed down? Is sooner better than later?
- Where? Where will X occur? Where else is possible?
- Why? Why is this done? Why is that particular rule, action, solution, problem, failure involved?
- How? How could it be done, should it be done, prevented, improved, changed, made?

Five Whys

The Five Whys technique is used to get to the root of a problem. It is based on the premise that it is not enough to just ask why one time. For example:

- Why has the machine stopped? A fuse blew because of fan overload.
- Why was there an overload? There was inadequate lubrication for the bearings.
- Why wasn't there enough lubrication? The lube pump wasn't working.
- Why wasn't the pump working? The pump shaft was vibrating because it had worn due to abrasion.
- Why was there abrasion? There was no fi lter on the lube pump, allowing debris into the pump.

Unit-04/Lecture-03

TECHNOLOGY AND MARKET ASSESSMENT(Review):

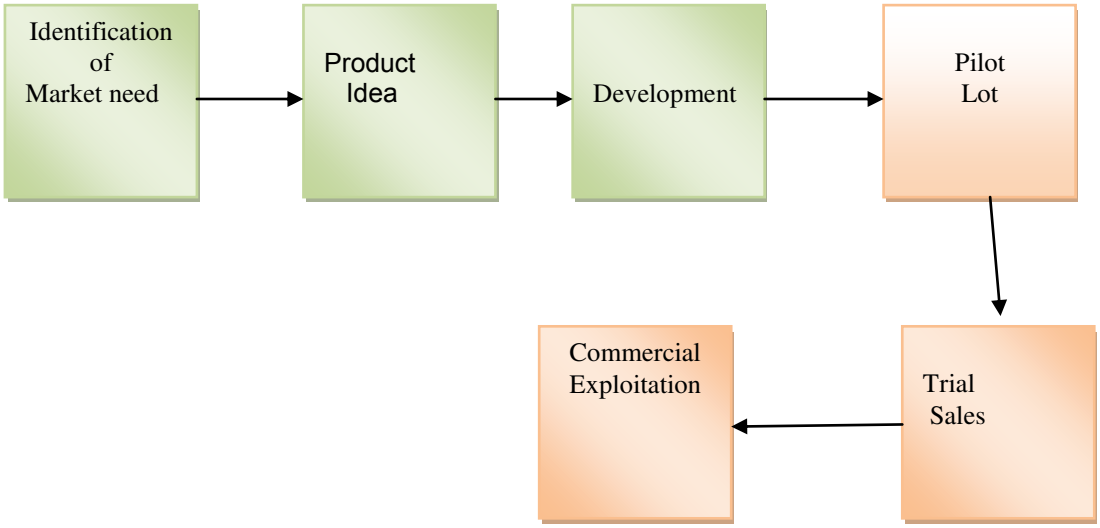
Many of the products that engineers are developing today are the result of new technology. Much of the technology explosion started with the invention of the digital computer and transistor in the 1940s and their subsequent development through the 1950s and 1960s. The transistor evolved into micro-integrated circuits, which allowed the computer to shrink in size and cost, becoming the desktop computer we know today. Combining the computer with communications systems and protocols like optical fiber communications gave us the Internet and cheap, dependable worldwide communications. At no other time in history have several breakthrough technologies combined to so substantially change the world we live in. Yet, if the pace of technology development continues to accelerate, the future will see even greater change Generally,

The advancement of technology occurs in three stages:

Invention: The creative act whereby an idea is conceived, articulated, and recorded.

Innovation: The process by which an invention or idea is brought into successful practice and is utilized by the economy.

Diffusion: The successive and widespread implementation and adoption of successful innovations.



Without question, innovation is the most critical and most difficult of the three stages. Developing an idea into a product that people will buy requires hard work and skill at identifying market needs. Diffusion of technology throughout society is necessary to preserve the pace of innovation. As technologically advanced products are put into service, the technological sophistication of consumers' increases. This ongoing education of the customer base paves the

way for the adoption of even more sophisticated products. A familiar example is the proliferation of bar codes and bar code scanners. Many studies have shown that the ability to introduce and manage technological innovation is a major factor in a country's leadership in world markets and also a major factor in **raising its standard of living**. Science-based innovation in the United States has seed such key industries as **jet aircraft, computers, plastics, and wireless communication.** Relative to other nations, however, the importance of the United States' role in innovation appears to be decreasing. If the trend continues, it will affect our well-being. The digital imaging example illustrates how a basic technological development created for one purpose can have greater potential in another product area. However, its initial market acceptance is limited by issues of performance and manufacturing cost. Then a new market develops where the need is so compelling that large development funding is forthcoming to overcome the technical barriers and the innovation becomes wildly successful in the mass consumer market. In the case of digital imaging, the innovation period from invention to widespread market acceptance was about thirty-five years.

MARKET ASSESSMENT: The marketing department in a company creates and manages the company's relationship with its customers. It is the company's window on the world with its customers. It translates customer needs into requirements for products and influences the creation of services that support the product and the customer. It is about understanding how people make buying decisions and using this information in the design, building, and selling of products. Marketing does not make sales; that is the responsibility of the Sales department. The marketing department can be expected to do a number of tasks. First is a Preliminary marketing assessment, a quick scoping of the potential sales, competition, and market share at the very early stages of the product development. Then they will do a detailed market study. **This involves face-to-face interviews with potential customers to determine their needs, wants, preferences, likes, and dislikes**. This will be done before detailed product development is carried out. Often this involves meeting with the end user in the location where the product is used, usually with the active participation of the design engineer. Another common method for doing this is the focus group. In this method a group of people with a prescribed knowledge about a product or service is gathered around a table and asked their feelings and attitudes about the product under study. If the group is well selected and the leader of the focus group is experienced, the sponsor can expect to receive a wealth of opinions and attitudes that can be used to determine important attributes of a potential product. The marketing department also plays a vital role in assisting with the introduction of the product into the marketplace. They perform such functions as undertaking customer tests or field trials (beta test) of the product, planning for test marketing (sales) in restricted regions, advising on product packaging and warning labels,

preparing user instruction manuals and documentation, arranging for user instruction, and advising on advertising. Marketing may also be responsible for providing for a product support system of spare parts, service representatives, and a warranty system.Marketing is concerned with the interaction between the corporation and the customer. Customers are the people or organizations that purchase products. However, we need to differentiate between the customer and the user of the product. The market is an economic construct to identify those persons or organizations that have an interest in purchasing or selling a particular product, and to create a ground for their transactions. We generally think of the stock market as the perfect market.

A quick review of the evolution of consumer products is a good way to better understand markets. At the beginning of the Industrial Revolution, markets were mainly local and consisted of supportive communities of consumers and workers in manufacturing companies. Because the manufacturing enterprise was locally based, there was
A close link between the manufacturers and the users of their product, so direct feedback from customers was easily achieved. **With the advent of railroads and telephone communication, markets expanded across the country** and very soon became national markets. This created considerable **economy of scale**, but it required new ways of making products available to the customer. Many companies created a national distribution system to sell their products through local stores. Others depended on retailers who offered products from many manufacturers, including direct competitors. **Franchising** evolved as an alternative way of creating local ownership while retaining a nationally recognized name and product. Strong ***brand names*** evolved as a way of building customer recognition and loyalty. As the capability to produce products continued to grow, the markets for those products expanded beyond the borders of one country. Companies then began to think of ways to market their products in other countries.

EXAMPLE: The Ford Motor Company was one of the first U.S. companies to expand into overseas markets. Ford took the approach of developing a wholly owned secondary in the other country that was essentially self contained. The subsidiary designed, developed, manufactured, and marketed products for the local national market. The consumer in that country barely recognized that the parent company was based in the United States. This was the beginning of ***multinational companies***. The chief advantage of this approach was the profits that the company was able to bring back to the United States. However, the jobs and physical assets remained overseas. Another approach to multinational business was developed by the Japanese automakers. These companies designed, developed, and manufactured the product in the home nation and marketed the product in many locations around the world. This became possible with a product like automobiles **when roll-on / roll-off ships made low-cost transportation a reality**. Such an approach to marketing gives the maximum benefit to the home nation, but with

time a reaction developed because of the lost jobs in the customer countries. Also, developing a product at a long distance from the market makes it more difficult to satisfy customer needs when there is a physical separation in cultural backgrounds between the development team and the customers. More recently, Japanese companies have established design centers and production facilities in their major overseas markets. It is very clear that we are now dealing with a *world market.* Improved manufacturing capabilities in countries such as China and India, coupled with low-cost transportation using container ships, and instant worldwide communication with the Internet, have enabled an increasing fraction of consumer products to be manufactured overseas**.** Although the customers for a product are called a "market" as though they were a homogeneous unit, this generally is not the case. In developing a product, it is important to have a clear understanding of which segments of the total market the product is intended to serve. There are many ways to segment a market. Typically there is frequent one-on-one interaction between the design team and the customer to make sure the user's needs are met. For small-batch engineered products, the degree of interaction with the customer depends on the nature of the product. For a product like railcars the design specification would be the result of extensive direct negotiation between the user's engineers and the vendor. For more standard products like a CNC lathe, the product would be considered an "off-the-shelf" item available for sale by regional distributors or direct from catalog sales.

A marketing plan should contain the follow information:

- Evaluation of market segments, with clear explanation of reasons for choosing the target market
- Identify competitive products
- Identify early product adopters
- Clear understanding of benefits of product to customers
- Estimation of the market size in terms of dollars and units sold, and market share
- Determine the breadth of the product line, and number of product variants
  Estimation of product life
- Determine the product volume/price relationships
- Complete financial plan including time to market, ten-year projection of costs and income