JAWAHARLAL COLLEGE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, Affiliated to APJ Abdul Kalam Technological University, Kerala)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

(NBA Accredited)

COURSE MATERIAL

EST200 DESIGN AND ENGINEERING

VISION OF THE INSTITUTION

Emerge as a centre of excellence for professional education to produce high quality engineers and entrepreneurs for the development of the region and the Nation.

MISSION OF THE INSTITUTION

- To become an ultimate destination for acquiring latest and advanced knowledge in the multidisciplinary domains.
- To provide high quality education in engineering and technology through innovative teaching-learning practices, research and consultancy, embedded with professional ethics.
- To promote intellectual curiosity and thirst for acquiring knowledge through outcome based education.
- To have partnership with industry and reputated institutions to enhance the employability skills of the

students and pedagogical pursuits.

- To leverage technologies to solve the real life societal problems through community services.

ABOUT THE DEPARTMENT

- Established in: 2008
- Courses offered: B.Tech in Computer Science and Engineering
- Affiliated to the A P J Abdul Kalam Technological University.

DEPARTMENT VISION

To produce competent professionals with research and innovative skills, by providing them with the most conducive environment for quality academic and research oriented undergraduate education along with moral values committed to build a vibrant nation.

DEPARTMENT MISSION

- Provide a learning environment to develop creativity and problem solving skills in a professional manner.
- Expose to latest technologies and tools used in the field of computer science.
- Provide a platform to explore the industries to understand the work culture and expectation of an organization.
- Enhance Industry Institute Interaction program to develop the entrepreneurship skills.
- Develop research interest among students which will impart a better life for the society and the nation.

PROGRAMME EDUCATIONAL OBJECTIVES

Graduates will be able to

- Provide high-quality knowledge in computer science and engineering required for a computer professional to identify and solve problems in various application domains.
- Persist with the ability in innovative ideas in computer support systems and transmit the knowledge and skills for research and advanced learning.
- Manifest the motivational capabilities, and turn on a social and economic commitment to community services.

PROGRAM OUTCOMES (POS)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSO)

The students will be able to

- Use fundamental knowledge of mathematics to solve problems using suitable analysis methods, data structure and algorithms.
- Interpret the basic concepts and methods of computer systems and technical specifications to provide accurate solutions.
- Apply theoretical and practical proficiency with a wide area of programming knowledge, design new ideas and innovations towards research.

COURSE OUTCOMES:

S.NO	DESCRIPTION
C215.1	Explain the background of the present constitution of India and features.
C215.2	Utilize the fundamental rights and duties.
C215.3	Understand the working of the union executive, parliament and judiciary
C215.4	Understand the working of the state executive, legislature and judiciary.
C215.5	Utilize the special provisions and statutory institutions
C215.6	Show national and patriotic spirit as responsible citizens of the country

CO-PO AND CO-PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C215.1						2	2	2		2					
C215.2						3	3	3		3					
C215.3						3	2	3		3					
C215.4						3	2	3		3					
C215.5						3	2	3		3					
C215.6						3	3	3	2	3					
						3	3	3		3					

COURSE OUTCOMES VS POS MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1**):**

**** For Entire Course, PO /PSO Mapping; 1 (Low); 2(Medium); 3(High) Contribution to PO/PSO***

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Reference Materials

Assessment Pattern

Continuous Internal Evaluation (CIE) Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination (ESE) Pattern: There will be two parts; Part A and Part B.

Part A	: 30 marks
part B	: 70 marks

Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions.

Part B contains 2 case study questions from each module of which student should answer any one. Each question carry 14 marks and can have maximum 2 sub questions.

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	5	5	10
Understand	10	10	20
Apply	35	35	70
Analyse	-	-	-
Evaluate	-	-	-
Create	-	-	-

SYLLABUS`

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
			2	0	0	2
EST 200	DESIGN AND ENGINEERING					

Preamble:

The purpose of this course is to

i) introduce the undergraduate engineering studentsthe fundamental principles of design engineering,

ii) make them understand the steps involved in the design process and

iii) familiarize them with the basic tools used and approaches in design.

Students are expected to apply design thinking in learning as well as while practicing engineering, which is very important and relevant for today. Case studies from various practical situations will help the students realize that design is not only concerned about the function but also many other factors like customer requirements, economics, reliability, etc. along with a variety of life cycle issues.

The course will help students to consider aesthetics, ergonomics and sustainability factors in designs and also to practice professional ethics while designing.

Prerequisite:

Nil. The course will be generic to all engineering disciplines and will not require specialized preparation or prerequisites in any of the individual engineering disciplines.

Syllabus

Module 1

Design Process:- Introduction to Design and Engineering Design, Defining a Design Process-:Detailing Customer Requirements, Setting Design Objectives, Identifying Constraints, Establishing Functions, Generating Design Alternatives and Choosing a Design.

Module 2

Design Thinking Approach:-Introduction to Design Thinking, Iterative Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test. Design Thinking as Divergent-Convergent Questioning. Design Thinking in a Team Environment.

Module 3

Design Communication (Languages of Engineering Design):-Communicating Designs Graphically, Communicating Designs Orally and in Writing. Mathematical Modeling In Design, Prototyping and Proofing the Design.

Module 4

Design Engineering Concepts:-Project-based Learning and Problem-based Learning in Design.Modular Design and Life Cycle Design Approaches. Application of Bio-mimicry,Aesthetics and Ergonomics in Design. Value Engineering, Concurrent Engineering, and Reverse Engineering in Design.

Module 5

Expediency, Economics and Environment in Design Engineering:-Design for Production, Use, and Sustainability. Engineering Economics in Design. Design Rights. Ethics in Design

Text Books

1) YousefHaik, SangarappillaiSivaloganathan, Tamer M. Shahin, Engineering Design Process, Cengage Learning 2003, Third Edition, ISBN-10: 9781305253285,

2) Voland, G., Engineering by Design, Pearson India 2014, Second Edition, ISBN 9332535051

Reference Books

1.Philip Kosky, Robert Balmer, William Keat, George Wise, Exploring Engineering, Fourth Edition: An Introduction to Engineering and Design, Academic Press 2015, 4th Edition, ISBN: 9780128012420.

2. Clive L. Dym, Engineering Design: A Project-Based Introduction, John Wiley & Sons, New York 2009, Fourth Edition, ISBN: 978-1-118-32458-5

3. Nigel Cross, Design Thinking: Understanding How Designers Think and Work, Berg Publishers 2011, First Edition, ISBN: 978-1847886361

4. Pahl, G., Beitz, W., Feldhusen, J., Grote, K.-H., Engineering Design: A Systematic Approach, Springer 2007, Third Edition, ISBN 978-1-84628-319-2

QUESTION BANK

Q.NO.	QUESTIONS
1.	What does it mean to design something?
2.	How Is engineering design different from other kinds of design?
3.	Where and when do engineers design?
4.	What is the basic vocabulary in engineering design?
5.	How to learn and do engineering design.
6.	How to do engineering design?
7.	Illustrate the process with an example.
8.	How to identify the customer requirements of design?
9.	How to finalize the design objectives?
10.	How to identify the design constraints?
11.	How to express the functions a design in engineering terms?
12.	How to generate or create feasible design alternatives?
13.	How to identify the "best possible design”?
14.	Design simple products going through the different stages of design process.
	MODULE 2
15.	How does the design thinking approach help engineers in creating innovative and efficient designs?
16.	How can the engineers arrive at better designs utilizing the iterative design thinking process (in which knowledge acquired in the later stages can be applied back to the earlier stages)?
17.	Describe how to create a number of possible designs and then how to refine and narrow down to the 'best design'.
18.	How to perform design thinking as a team managing the conflicts?
19.	Design thinking approach for 1 HUMANITIES designing any simple products within a limited time and budget
	MODULE 3
20.	How do engineering sketches and drawings convey designs?
21.	How can a design be communicated through oral presentation or technical reports efficiently?
22.	How do mathematics and physics become a part of the design process?
23.	How to predict whether the design will function well or not?
24.	Design communication through detailed 2D or 3D drawings of simple products with design detailing, material selection, scale drawings, dimensions, tolerances, etc.

25.	How engineering students can learn design engineering through projects?
26.	How students can take up problems to learn design engineering?
27.	What is modular approach in design engineering? How it helps?
28.	How the life cycle design approach influences design decisions?
29.	How do aesthetics and ergonomics change engineering designs?
30.	How do the intelligence in nature inspire engineering designs?
31.	What are the common examples of bio-mimicry in engineering?
32.	How do concepts like value engineering, concurrent engineering and reverse engineering influence engineering designs?
33.	Develop new designs for simple 1 HUMANITIES products using bio-mimicry and train students to bring out new nature inspired designs.
34.	How designs are finalized based on the aspects of production methods, life span, reliability and environment?
35.	How to estimate the cost of a particular design and how will economics influence the engineering designs?
36.	What are design rights and how can an engineer put it into practice?
37.	How do ethics play a decisive role in engineering design?
38.	Conduct exercises using simple products to show how designs change with constraints of production methods, life span requirement, reliability issues and environmental factors.

Module 1
Notes

Introduction

Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to optimally convert resources to meet a stated objective. Among the fundamental elements of the design process is the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation.

Thus, although engineers are not the only people who design things, it is true that the professional practice of engineering is largely concerned with design; it is often said that design is the essence of engineering. To design is to pull together something new or to arrange existing things in a new way to satisfy a recognized need of society.

“Design establishes and defines solutions to and pertinent structures for problems not solved before, or new solutions to problems which have previously been solved in a different way.” The ability to design is both a science and an art. The science can be learned through techniques and methods to be covered in this text, but the art is best learned by doing design. It is for this reason that your design experience must involve some realistic project experience.

Science, Technology, Engineering & Art

In a nutshell, a Scientist studies nature, a Technologist manipulatesnature, and an Engineer exploits technology for human purposes. While Scientists may, at times, may conduct scientific studies for the sake of discovery, Engineers and Technologists always try to have in mind the ultimate benefit of humankind and results of their work are invariably beneficial for human purposes.

Engineering is the art of optimally using technology and is primarily concerned with how to direct to useful and economical ends the natural phenomena which scientists discover and formulate into acceptable. Engineering therefore requires the creative imagination to innovatively apply technology in order to obtain useful applications of natural phenomena.

It seeks newer, cheaper, better technologies of using natural sources of energy and materials.

Science Is very concerned with what is (exists) in the natural world. Whereas technology deals with how humans modify, change, alter, or

Engineering is creation based on the scientific knowledge put together, and Technology is the set of engineered creations put together.

- ❖ Science comes from observation of the world, Engineering comes from acquiring and applying knowledge, and Technology comes from repeated application and approval of the engineered tools.
- ❖ Science is about creating meaning of natural phenomenon, Engineering is about creating new devices, tools and processes, and Technology is about creating a collection of engineered and tested tools for the mankind.

*Eg-1: **Science** is based on observation: The friction between a sphere and a flat surface is minimum, allowing the sphere to roll with the slightest deviation from the horizontal position of the surface. Given the weight of the sphere and the tilt angle, all parameters of the sphere motion can be calculated, including the rolling friction.*

Technology: A wheel hub with ball bearings ensures long life and effortless wheel motion(e.g. cart wheel, etc.), by exploiting the minimum rolling friction principle.

Engineering: Modern vehicles wheel hubs are fitted with specially designed ball bearingswhich usually last well beyond the average life span of the vehicle.

Note: The intriguing behaviour of a ball on a tilted flat surface triggers the curiosity of the scientist who derives the physical and mathematical laws controlling that behaviour. The technologist finds (invents) the application(s) exploiting the laws governing the scientific phenomenon (whether he knows them or not). The engineer finds the most appropriate design for each specific technological application of the scientific principle

underpinning the natural world. And, **Engineering** attributes of design which let us develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

- ❖ Science is knowledge of the natural world put together,

Science: Burning wood produces heat, water, and carbon dioxide. Heat denatures proteins in food.

Technology: Fire can be used to cook food.

Engineering: Building a fireplace and chimney makes it easier to cook with fire without filling the room with smoke.

Hence it can be concluded that in every designs you can find the elements of science, engineering, technology and art.

Characteristics of Design or Aspects of Design

Having a defined engineering design and some vocabulary, we now define a process of design, that is, how we actually do a design. This may seem a bit abstract, because we will break down a complex process into smaller, more detailed design tasks. However, as we define those design tasks, we will identify specific design tools and methods that we use to implement a design process. Keep in mind that we are not presenting a recipe for doing design. Instead, we are outlining a framework within which we can articulate and think about what we are doing as we design something. Further, it is important to keep in mind that our overall focus will be on what we will identify as conceptual design, the early stage where different design ideas or concepts aredeveloped and analyzed.

It‟s not a big surprise that a whole bunch of questions immediately come to mind. Typically, design projects start with a statement that talks about a client‟s intentions or goals, the design‟s form or shape, its purpose or function, and perhaps some things about legal requirements. That statement then leads to the designer‟s first task: to clarify what the client wants in order to translate those wishes into meaningful objectives (goals), constraints (limits), and functions (what the design has to do). This clarification task proceeds as the designer asks the client to be moreprecise about what she really wants. Asking questions is an integral part of the design process. Aristotle noted long ago that knowledge resides in the questions that can be asked and the answers that can be provided.By looking at the kinds of questions that we can ask, we can articulate the design process as a Series of design tasks.

Thus the basic characteristics of any designs can be explained as follows:

Objective: a feature or behavior that the design should have or exhibit. Objectives are normally expressed as adjectives that capture what the design should be, as opposed to what the design should do. For example, saying that a ladder should be portable or lightweight expresses an attribute that the client wants the ladder to have. These features and behaviors, expressed in the natural languages of the client and of potential users, make the object “look good” in the eyes of the client or user.

Constraint: a limit or restriction on the design‟s behaviors or attributes. Constraints are clearly defined limits whose satisfaction can be framed into a binary choice (e.g., a ladder material is a conductor or it is not). Any designs that violate these limits are unacceptable. For example, when we say a ladder must meet OSHA standards, we are stating a constraint.

Function: a specific thing a designed device or system is expected to do. Functions are typically expressed as “doing” terms in a verb—noun pairing. Often they refer to engineering functions, such as the second function in Table 3.1: “Must not conduct electricity.” Note that this function is also a constraint.

Means: a way or method to make a function happen. Means or implementations are often expressed in very specific terms that, by their nature, are solution-specific. Means often come up because clients or others think of examples of things they‟ve seen that they think are relevant. Because they are so strongly function-dependent, they should be pruned from our attribute list for the time being, but we will revisit them after we have looked at functions.

Form: It represents the shape of the design or otherwise how a design look like. Aesthetic and ergonomics of a design is depends upon the form of that design.

Objective Tree

Objectives trees are hierarchical lists of the client‟s objectives or goals for the design that branch out into tree-like structures. We build objectives trees in order to clarify and better understand a client‟s projectstatement. The objectives that designs must attain are clustered by sub- objectives and then ordered by degrees of further detail.**Objective Tree for Step Ladder Design**

The graphical tree display is very useful for portraying design issues, and for highlighting things we need to measure, since these objectives will provide our basis for choosing between alternatives. The tree formatalso corresponds to the mechanics of the process that many designers follow: One of the most useful ways of "getting your mind around" a large list of objectives is to put them all together, and then move them around until the tree makes sense. Note, too, that process just outlined—

from lists to refined lists to indented outlines to trees— has a lot in common with outlining, a fundamental skill of writing. A topical outline provides an indented list of topics to be covered, together with thedetails of the subtopics corresponding to each topic. Since each topic represents a goal for the material to be covered, the identification of an objectives tree with a topical (or an indented) outline seems logical.

In addition to their use in depicting design objectives, objectives trees are valuable in several other ways. First, and perhaps foremost, note that as we work down an objectives tree (or further in on the levels of indentation of an outline), we are not only getting more detail. We are also answering a generic how question for many aspects of the design.

"How are you going to do that?" Conversely, as we move up the tree, or further out toward fewer indentations, we are answering a generic why question about a specific objective: "Why do you want that?" This may be important if, when selecting a design, we find that one alternative is better with respect to one objective, but weaker with respect to another.

But if we"re working downward as we construct and organize a tree, where do we stop? When do we end our list or tree of objectives? One simple answer is: We stop when we run out of objectives and implementations begin to appear. That is, within any given cluster, we could continue to parse or decompose our objectives until we are unable to express succeeding levels as further objectives. The argument for this approach is that it points the objectives tree toward a solution-independent statement of the design problem. We know what characteristics the design has to exhibit, without having to make any judgment about how it might get to be that way. In other words, we determine the features or behaviors of the designed object without specifying the way the objective is realized in concrete form. We canalso limit the depth of an objectives tree by watching for verbs or"doing" words because they normally suggest functions. Functions donot generally appear on objectives trees or lists.

Obviously, it is important to take notes when we are generating our lists of objectives, because we are generating a lot of information, to ensure that all suggestions and ideas are captured, even those that seem silly or irrelevant at the moment. Then it becomes important to organize the information we‟re getting so we can use it effectively: It‟s always easier to prune and throw away things than to recapture spontaneous ideas and inspirations. Also, get the substance of the objectives down first: Once a rough outline of an objectives tree has emerged, it can be formalized and made to look presentable and pretty with any number of standard software packages for constructing organization charts, or similar graphical displays.

Finally, do we build an objectives tree as soon as we start a design job, or after doing some homework and learning more about the design task we‟re undertaking? There‟s no hard and fast answer to these questions, in part because building an objectives list or tree is not a mathematical problem with an attendant set of initial conditions that must be met.

Also, building a tree is not a one-time, let‟s-get-it-done kind of activity. It‟s an iterative process, but one that a design team should start with at least some degree of understanding of the design domain. Thus, some of the questioning of clients, users, and experts should have begun, and some of the tree building can go on episodically while more information is being gathered.

Initiating Creative Designs

Our time appreciates rationality and logic. We think that these qualities are the only functions in science, and together with carefully gathered knowledge those are the most powerful tools in our technical, economic and social progress. But in the case of design work we realize that these tools are quite dull and we have got into a tight place with them. All remarkable creative inventions are rational and logical, when we look at them afterwards, but in order to find something new in front of us more powerful tools are needed. The tools are sensations and intuition. Because of their subconscious nature, we often do not take them seriously in our scientific work. All practical designers, however, are acquainted with those subconscious functions of the mind and they use them in those phases of work, when we have to go ahead of present knowledge. The rationality and logic of the new results are checked afterwards and, in a favorable case, a new piece of science is attained.

A despising attitude towards pictures remained a prominent attitude. Science was still based on logical thinking described by words, and by admiring it, the preceding ideas and images were ignored. During the present century and even earlier the technique in the form of concrete machines has revolutionized our everyday life, and still we consider that machine inventions are based barely on scientific mechanics and economical needs. According to this point of view we teach our future engineers and even engineering design we have described using strictly logical systematics. This way of teaching is producing successful engineering designers less frequently because the engineering design is essentially reading and producing pictures and images. The stressing of systematics and the lack of training in pictorial thinking have led to the fact that concrete design work especially drafting, is carried out by designers having a lower technical education. The enormous development of electronics and physics has further increased the appreciation of sharp logic. Because modern products based on this technology have brought the technical services nearer the man, these sciences have got admiration and value without criticism. At the same time there is a tendency to underestimate drafting and to think thatengineering design has already reached its maturity and that its value is now in decline. The mechanical machines have been considered to represent the polluting chimney industry and they are attributed with all the disadvantages due to industry, whereas electronics and automation represent the new un-polluting communication society. It has not been realized that this is a false image without any basis.

Creative thinkers are distinguished by their ability to synthesize new combinations of ideas and concepts into meaningful and useful forms. A creative engineer is one who produces a lot of ideas. These can be completely original ideas inspired by a discovery. More often, creative ideas result from putting existing ideas together in novel ways. A creative person is adept at breaking an idea down to take a fresh look at its parts, or in making connections between the current problem and seemingly unrelated observations or facts.

We would all like to be called “creative,” yet most of us, in our ignorance of the subject, feel that creativity is reserved for only the gifted few. There is the popular myth that creative ideas arrive with flash-like spontaneity—the flash of lightning and clap of thunder routine. In keeping with the view of association, students of the creative process assure us that most ideas occur by a slow, deliberate process that can be cultivated and enhanced with study and practice.

A characteristic of the creative process is that initially the idea is only imperfectly understood. Usually the creative person senses the total structure of the idea but initially perceives only a limited number of its details. There ensues a slow process of clarification and exploration as the entire idea takes shape. The creative process can be viewed as moving from an amorphous idea to a well-structured idea, from thechaotic to the organized, from the implicit to the explicit. Engineers, by nature and training, usually value order and explicit detail and abhor chaos and vague generality. Thus, we need to train ourselves to be sensitive and sympathetic to these aspects of the creative process. We need also to recognize that the flow of creative ideas cannot be turned on upon command. Therefore, we need to recognize the conditions and situations that are most conducive to creative thought. We must also recognize that creative ideas are elusive, and we need to be alert to capture and record our creative thoughts.

Improving Creativity

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 withsmall 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 naiveté. 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 filament 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 f rom 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 andfollowed through.
- **Suspend your judgment:** We have seen that creative ideas develop slowly, but nothing inhibits the creative process more thancritical 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.

Brainstorming

Brainstorming is the most common method used by design teams for generating ideas. This method was developed by Alex Osborn 18 to stimulate creative magazine advertisements, but it has been widely adopted in other areas such as design. The word brainstorming has come into general usage in the language to denote any kind of idea generation.

Brainstorming is a carefully orchestrated process. It makes use of the broad experience and knowledge of groups of individuals. The brainstorming process is structured to overcome many of the mental blocks that curb individual creativity in team members who are left to generate ideas on their own. Active participation of different individuals in the idea generation process overcomes most perceptual, intellectual, and cultural mental blocks. It is likely that one person‟s mental block will be different from another‟s, so that by acting together, the team‟s combined idea generation process flows well.

A well-done brainstorming session is an enthusiastic session of rapid, free- flowing ideas. To achieve a good brainstorming session, it is important to carefully define the problem at the start. Time spent here can help us to avoid wasting time generating solutions to the wrong problem. It is also necessary to allow a short period for individuals to think throughthe problem quietly and on their own before starting the group process.

Participants in brainstorming sessions react to ideas they hear from others by recalling their own thoughts about the same concepts. This action of redirecting a stream of thought uncovers new possibilities in the affected team member. Some new ideas may come to mind byadding detail to a recently voiced idea or taking it in different, butrelated, directions. This building upon others‟ ideas is known as piggy- backing or scaffolding, and it is an indicator of a well- functioningbrainstorming session. It has been found that the first 10 or so ideas will not be the most fresh and creative, so it is critical to get atleast 30 to 40 ideas from your session. An important attribute of this method is that brainstorming creates a large number of ideas, some of which will be creative.

The evaluation of your ideas should be done at a meeting on a day soon after the brainstorming session. This removes any fear that criticism or evaluation is coming soon and keeps the brainstorming meeting looser. Also, making the evaluation on the day after the idea generation session allows incubation time for more ideas to generate and time for reflection on what was proposed. The evaluation meeting should begin by adding to the original list any new ideas realized by the team members after the incubation period. Then the team evaluates each of the ideas. Hopefully,

Need Identification and Problem Statement

During the course of human development, different kinds of needs existed. For instance, there has always been and always will be a need for improving and making new designs. Lincoln Steffens wrote. “The world is yours, nothing is done and nothing is known. The greatest poem isn‟t written, the best railroad isn‟t built yet, the perfect state hasn‟t been thought of. Everything remains to be done right, everything.” The engineer is a person who applies scientific knowledge to satisfy humankind‟s needs. It should be emphasized that the ability to design is a characteristic of an engineer.

One serious difficulty that engineers must overcome deals with the form in which problems are often presented to them. Even if some goals are given to the engineer, they often are not specifically stated. Problems may be presented vaguely: “The shaft is breaking.” “The controls aren‟t producing the desired effect.” “It costs too much to operate this engine.” Thus, the first task of the engineer involves determining the real problems. Then, the engineer must determine the extent and confines of the goals. It is necessary to formulate a clear, exact statement of the problem in engineering words and symbols. It is also necessary to isolate the problem form the general situation and to delineate its form. This definition should clearly identify every aspect of the problem on which attention should be concentrated. The nonessential should be stripped away, and the individual characteristics of the problem should be differentiated. It should be determined whether or not the immediate problem is part of the larger problem. If it is, its relationship to the total part should be determined.

Consider the following examples.

- A designer is presented with a situation involving the waste of irrigation water in public parks. The park keepers forget to turn off the water. A general formulation of the problem would be “What can we do to minimize the possibility of workers forgetting to turn off the water before the end of their shit? Ah engineer could ask the following questions. “Why do workers continue to forget toturn off the water?” “What is the sequence of events that workers use during their daily activities?” “What will happen if a keeper does not show up for his/her shift?” “Do we need to manually turn on and off the water?” A more precise form of the problem statement would be “How do we prevent irrigation water waste in public parks?”
- A company has proposed to use the density gradient to isolate red blood cells from whole blood and thus to treat white blood cells with a light-activated drug. The designer should ask questions suchas the following. “Is it necessary to use the density gradient if other methods of separation would be capable of isolating the red blood cells from the whole blood?” “If the white cells are being treated, why don‟t we isolate the white cells from the whole blood rather than isolate red blood cells?” “Why don‟t we impede the light into the blood and reduce the need for separation?”
- An engineer is presented with a problem caused by the formation of ice on roofs. The ice forms during certain types of weather, falls away from the roofs, and causes damage to vehicles and people below. A general formulation of this problem might be “How do we prevent ice from forming on roofs?” However, further questionsmay be asked. “What would happen if ice did form?” “What will cause the ice to fall?”

"What harm would such formation do?" These questions determine that the first definition was much too narrow. A much broader definition was "How do we prevent ice that forms on roofs from doing harm or damage to people and equipment below?"

Designers need to abstract the need statement from its current state to a statement that they can base their design on. Vague statements from the customer usually result in a bad design.

Before an engineer can define the problem properly, he or she must recognize all of the problems that exist. Most of the failures in machines do not occur because we make mistakes in analysing the problem, but because we fail to recognize that there is a problem.

So, it is evident that the needs should be identified clearly, otherwise a vague statement of need will lead to a vague understanding of the product to be designed. A vague understanding cannot give a solution that addresses the specific problem. Asking the right question requires engineering knowledge, practice, and common sense.

Market Survey

Establishing who your customers are is one of the most important initial steps that a designer needs to take. One of the vital concepts to grasp is that customers are not only the end users. Customers of a product are everyone who will deal with the product at some stage during its lifetime. This includes the person who will manufacture the product, the person who will sell the product, the person who will service the product, the person who will maintain the product during its lifetime in operation, etc.

Consider an example: Discuss with your colleagues who the possible customers of a golf cart are. Here are a few ideas to start you off.

- The golf player
- The golf country club (Institution)
- The transportation company that will transport-the cart
- The golf club (Equipment) manufacturers for storage of their clubs in the cart

Once all possible customers have been identified, their needs should be considered, and more often than not, their needs can conflict with each other. It is the responsibility of the designer to recognize all of these needs in a prioritized manner and later arrive at a feasible solution that isan optimal combination of all these „desires‟. One good way to identify the needs in a prioritized manner is to conduct a market survey. There are a number ways in which this can be carried out.

1. Focus group meetings
2. Telephone interviews
3. One-on-one interviews
4. Questionnaires

Each method cited has its advantages and disadvantages. In a focus group meeting, a group of 6 to 12 potential „customers‟ meet and discuss their needs and other aspects of the product. If the product alreadyexists, the discussion usually focuses on a „satisfaction‟ based feedback in terms of what they liked, what they disliked, and what they would liketo see improved. However, for a new product, the discussion usually focuses on their wishes and desires in a particular market segment, what they would like to see introduced to improve their lives, or what current problems exist in the similar products on the market. It is important to ensure that any potential solutions are filtered out at this stage andconverted into a neutral need. However, this method is an expensive process, and the sample size is relatively small. It is however a good starting point and is frequently used as a precursor to sending out a larger survey in the form of questionnaires. Telephone and one-on-one interviews can eliminate some of the ambiguities that arise for questionnaires. However, they are very expensive to run and also have a potential disadvantage of the interviewer „leading‟ the interview and causing bias. For example, a question can be asked: “Would you really walk a long distance in the cold, rainy weather, in the middle of rush hour to get to your office early in the morning, or would you prefer taking the cheap, fast, and comfortable public transport?” An unbiased question could be “What is your preferred mode of transport to your office in the morning?”

The questionnaire format is one of the most popular survey methods, as it involves taking the opinion of a large number of people (sample) at a relatively low cost. It is important to construct a questionnaire carefully in order to provide meaningful, useful, and unbiased feedback. Here are some points to follow when creating a questionnaire:

- ✓ Develop a standard set of questions. The main goal of a questionnaire is to ascertain potential needs, problems, likes, and dislikes. It is useful at this stage to also identify which (if any) market segment would be most interested in the product as well as to gain an estimate of how much they would be willing to spend.
- ✓ Ensure that the questionnaire is easy to read and complete. Use simple language and simple formatting. Try to keep the writing to a minimum, and offer multiple choice questions or yes/no answers where possible. Leave an opportunity for writing for those who wish to do so.
- ✓ Identify the demographic you want to target. Mailing lists can be purchased from market research companies. KY Wee.com
- ✓ Test the questionnaire initially on a pilot sample (friends, family, or small group of people) before sending it out to the entire sample. This is an opportunity to iron outany ambiguous questionsand to observe whether or not you are obtaining the desired information.
- ✓ Introduce only one issue per question.
- ✓ Similar to interviews, you do not want to give your questions a bias. Ensure all questions are unbiased.
- ✓ Avoid negative questions, which cause confusion. For example, a question such as “Do you not like to travel in the morning” may result in the answer “No, I do not like to travel in the morning”. Reading this carefully reveals a double-negative answer which means “I do like to travel in the morning.”

✓

- ✓ Ask a few conflicting questions and compare the answers to ensure that the person who has completed the questionnaire actually read the questions. For example ask “Do you ALWAYS switch off the electricity from the mains?” Later on ask “Do you forget to switch off the electricity from the mains?” If the person completing the questionnaire replied the same yes or no to both questions, then this particular feedback is not reliable.

Preliminary Research on Customer Needs

In a large company, the research on customer needs for a particular product or for the development of a new product is done using a number of formal methods and by different business units. The initial work may be done by a marketing department specialist or a team made up of marketing and design professionals. The natural focus of marketing specialists is the buyer of the product and similar products. Designers focus on needs that are unmet in the marketplace, products that are similar to the proposed product, historical ways of meeting the need and technological approaches to engineering similar products of the type under consideration. Clearly, information gathering is critical for this stage of design.

Design teams will also need to gather information directly from potential customers. One way to begin to understand needs of the targeted customers is for the development team to use their own experience and research to date. The team can begin to identify the needs that current products in their area of interest do not meet and those that an ideal new product should meet. In fact, there‟s no better group of people to start articulating unmet needs than members of a product development team who also happen to be end users of what they are designing.

Design attributes and customer requirements

Not all customer requirements are equal. This essentially means that customer requirements have different values for different people. The design team must identify those requirements that are most important to the success of the product in its target market and must ensure that those requirements and the needs they meet for the customers are satisfied by the product. This is a difficult distinction for some design team members to make because the pure engineering viewpoint is to deliver the best possible performance in all product aspects. A Kano diagram is a good tool to visually partition customer requirements into categories that will allow for their prioritization.

Kano recognized that there are four levels of customer requirements: **(1) expecters, (2) spokens, (3) unspokens, and (4) exciters.**

Expecters: These are the basic attributes that one would expect to see in the product, i.e., standard features. Expecters are frequently easy to measure and are used often in benchmarking.

Spokens: These are the specific features that customers say they want in the product.

Because the customer defines the product in terms of these attributes, the designer must bewilling to provide them to satisfy the customer.

Unspokens: These are product attributes the customer does not generally talk about, but they remain important to him or her. They cannot be ignored. They may be attributes the customer simply forgot to mention or was unwilling to talk about or simply does not realize he or she wants. It takes great skill on the part of the design team to identify the unspoken requirements.

Exciters: Often called delighters, these are product features that make the product unique and distinguish it from the competition. Note that the absence of an exciter will not make customers unhappy, since they do not know what is missing.

MODULE 2

DESIGN THINKING

Design thinking is simply “a process for creative problem solving”
Design thinking is a nan-linear, iterative process that teams use to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test.

ITERATIVE DESIGN THINKING PROCESS STAGES

Consist of five phases— Empathize, Define, Ideate, Prototype and Test.
c It is mast useful to solve problems that are ill-defined (unclea r) or unknown.

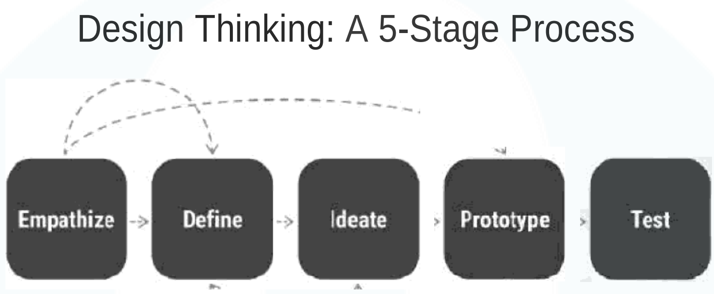

Figure 2.1: 5-stage process involved in design thinking

1. Empathize

Designer should gain an empathetic understanding of the problem that they are trying to solve, typically through user research.
Empathy is crucial to a human-centered design process such as design thinking because it allows you to set aside your own assumptions about the world and gain real insight into users and their needs.
Place yourself as an end user and identify the user expectations and needs.

Z. Define

It’s time to accumulate the information gathered during the Empathize stage.
You then analyze your observations and synthesize them to define the core problems you and your team have identified. These definitions are called problem sta cements.
The problem definition should be clear and unam biguo us.
Define the objectives or user requirements

3. Ideate

The solid background of knowledge from the first two phases means you can start to “think outside the box”, look for alternative ways to view the problem and identify innovative solutions to the problem statement you’ve created.
Brainstorming is particularly useful here.

4. Prototype

This is an experimental phase. The aim is to ide ntify the best possible solution for each problem found.

Designer team should produce some inexpensive, scaled-down versions of the product(or specific features found within the product] to investigate and validate the ideas they generated.

This could involve simply paper prototyping, simulations, 3D models, animations etc.

Figure 2.2: Paper prototyping of a Mobile app

Figure 2.3: 3D models

5. Test

Evaluators rigorously test the prototypes.

c Although this is the final phase, design thinking is iterative: Teams often use the results to redefine one or more further problems.

So, they can return to previous stages to make further iterations, alterations and refinements — to identify the best alternative solution.

DESIGN THINKING ITERATIVE APPROACH CASE STUDY — BAG FOR COLLEGE STUDENTS

Illustrate the design thinking approach for designing a bag for college students within a limited budget. Describe each stage of the process and the iterative procedure involved. Use hand sketches to support your arguments.

Solution:

Objective: To design a bag for college students in limited budget.

1. Empathize

[1] It should have a facility to carry books, tiffin and other small articles.
[2] It should be closed.

2. Define

[1] It should have separate racks for keeping books and tiffin
[2] It should have zips to lock.
[3] It should be light weight with sleek design.

3. Ideate

[1] It should have separate racks for kee ping books and tiffin
[2] It should have zips to lock.
[3] It should be light weight with sleek design.
[4] It should have a compartment to keep the laptop.
[5] It should have a compartment on the outer side to keep water bottles.
[6] It should have a small pouch on the outside to keep necessary things like pen, keys, chargers etc.
[7] The s houlder strap should be of soft material.
[8] It should be waterproof so that it can be used in rai»v season too.
[9] It should have an inner secret pouch to keep money or any other important thing.

4. Prototype

The 2D prototype is shown on the right.

5. Test

Ensure that all the expected functionalities are incorporated in the product. The above prototype has separate racks for keeping books and laptop. It has a water bottle holder. The shoulder strap is made of soft sponge material. The material used is waterproof polyester. It is light weight and has sleek design.

DESIGN THINKING AS DIVERGENT — CONVERGENT QUESTIONING

- Design thinking is an iterative approach and we follows two generic patterns of design thinking: Divergent thinking and Convergent thinking.
- Divergent thinking is the process of thinking that explores multiple possible solutions in order to generate creative ideas. i.e. Think for all possible ways to reach a solution.
- Convergent Thinking is the process of figuring out a concrete solution to any problem. i.e. Thinks for a final solution.
- Table Z.1 shows the differences between divergent & convergent thinking.

Table 2.1: Difference betwee n Divergent — Convergent thinking process

Convergent Thinking	Divergent Thinking
Convergent Thinking is the process of figuring out a concrete solution to any problem.	**Divergent thinking** is the process of thinking that explores multiple possible solutions in order to generate creative ideas.
It's a straight:forward process thatfocuses on figuring out the most efféctiv• newer *to* a problem:	In contrast, diyergent thinking refers to openingthe mind in various directions and trying out multiple solutions for a proolem.
Its characteristics include • ursp *Lqgic	•Spontaneous •Free-flowing •Non-linear
Convergent thinking helps to find out the best possible answer to any problem, which are accurate most of the time, and no room for ambiguity is left.	Although Divergent thinking keeps the options open, a completely accurate answer isn't identified.

CONVERGENT — DIVEREGENT THINKING — CASE STUDY OF BULB

Convergent thinking:
a few similar ideas

Divergent thinking:
many different ideas

Figure 2.4: Convergent — Divergent thinking of electric bulb

DIVERGENT THINKING — CASE STUDY OF PEN

List out some uses of pen other than writing

as a straw
as a toy "telescope" for kids
To rewind cassette tape
as an improvised stabbing weapo n
As a paper punch
Use as a ruler
To make a smart phone stylus
' To make a whistle

DIVERGENT THINKING — CASE STUDY OF FORK

List out some uses of fork other than eating aid.

Scramble things
Mix things
Stir stuff
Poke things or people
Give it to a small farmer as a pitch fork
Scratcher
Get something out of a fire
Murder wea pan
Tool of to rture
Pro p something o pen

DESIGN THINKING AS A TEAM

In order to get best and creative solutions, design thinking process is generally performed as a team activity.
Every member may raise their own ideas and solutions.
c The team will analyze the pros and cons of each solution or design and then finalize the best suitable solution.
But during design thinking as a team activity, conflicts between team members may arise. So It is very important to resolve these conflicts.

CHARACTERISTICS OF AN EFFECTIVE TEAM

Team goals are as important as individual goals.
The team understands the goals and is committed to achieving them.
Trust replaces fear, and people feel comfortable taking risks.
c Respect, collaboration, and open-mindedness are prevalent.
6 Team me mbers communicate readi!v: diversity of opinions is encouraged.
Decisions are made by consensus and have the acceptance and support of the members of the team.

STEPS IN RESOLVING CONFLICTS

1. Pre pare the resolution
2. Understand the situation
3. Reach agreement

Step 1: Prepare for resolution

Acknowledge the conflict — The conflict has to be acknowledged before it can be managed and resolved. The tendency is for people to ignore the first signs of conflict, perhaps as it seems trivial, or is difficult to differentiate from the normal, healthy debate that teams can thrive on. If you are concerned about the conflict in your team, discuss it with other members. Once the team recognizes the issue, it can start the process of resolution.

Discuss the impact — As a team, discuss the impact the conflict is having on team dynamics and performance.

c Agree to a cooperative process — Everyone involved must agree to cooperate in to resolve the conflict. This means putting the team first, and may involve setting aside your opinion or ideas for the time be ing. If someone wants to win more than he or she wants to resolve the conflict, you may find yourself at a stalemate.

Agree to communicate — The most important thing throughout the resolution process is for everyone to keep communications open.

Step 2: Understand the situation

Clarify positions — Whatever the conflict or disagreement, it's important to clarify people's positions. Whether there are obvious factions within the team who support a particular option, approach or idea, or each team member holds their own unique view, each position needs to be clearly identified and articulated by those involved.

List facts, assumptions and beliefs underlying each position — What does each group or person believe? What do they value? What information are they using as a basis for these beliefs? What decision-making criteria and processes have they employed?

Analyze in smaller groups — Break the team into smaller groups, separating people who are in alliance. In these smaller groups, analyze and dissect each position, and the associated facts, assumptions and beliefs.

Convene back as a team — After the group dialogue, each side is likely to be much closer to reaching agreement. The process of uncovering facts and assumptions allows people to step away from their emotional attachments and see the issue more objectively. Whe n you separate alliances, the fire of conflict can burn out quickly, and it is much easier to see the issue and facts laid bare.

Step 3: Reach agreement

Now that all parties understand the others' positions, the team must decide what decision or course of action to take. With the facts and assumptions considered, it's easier to see the best of action and reach agreement.

PREVENTING CONFLICTS

Dealing with conflict immediately — avoid the temptation to ignore it.
Being a pe n — if people have issues, thev need to be expressed immediately.
Practicing clear communication —articulate thoughts and ideas clearly.
Practicing active listening — paraphrasing, clarifying, questioning.
Practicing identifying assumptions —asking yourself "why" on a regular basis.
Not letting conflict get personal — stick to facts and issues, not personalities.
Focusing on actionable solutions — don't belabor what can't be changed.
Encouraging different points of view — insist on honest dialogue and expressing feelings.
Not looking for blame — encourage ownership of the problem and solution.
Demonstrating respect — if the situation escalates, take a break and wait for emotions to subside.

DESIGN THINKING APPROACH CASE STUDY 1— DRUG TROLLEY IN HOSPITALS

Construct a number of possible designs and then refine them to narrow down to the best design for a drug trolley used in hospitals. Show how divergent —convergent thinking helps in the process. Provide your rationale for each step using hand sketches only.

Solution:

Objective: To design a drug trolley that can be used in hospitals.

Intended users: Hospital staff like nurses.

Scope / Domain: Hospitals

Expected functionalities:

[1] It should have wheels as we need to move it from one room to another.
[2] It should have racks to keep the medicines.
[3] It should be light weight with sleek design so that we can move it easi!v

Exciting functionalities:

[1] The wheel should have a lock such that it can be prevented from moving when not in use.
[2] It should have racks with closing doors or lids.
[3] It should have separate rack for keeping drugs for each room patients.
[4] It should have a facility to dispose medicinal wa ste like used cotton, syringe etc.
[5] It should have an open table on the top to keep case diary/charts of patients.

Possible Designs using Divergent thinking process

Model 1:

Pros:

- Simple and Light weight
- Easier to kee p medicines and boundaries are provided in all 3 sides which prevents from medicines falling down while moving.

Cons:

- Difficult to sort out medicines for each room.
- No doors for racks and no open table.
- Wheels have no locks

Model 2:

Pros:

- Simple and Light weight
- Easier to keep medicines

Cons:

- Difficult to sort aut medicines for each room.
- No doars for racks and no open table.
- Wheels have no locks
- As there are no boundaries, there is a high chance of falling down the medicines while moving.

Model 3:

Pros:

- Simple and Light weight
- E c ker to keep medicines as boundaries and lids are there for each t

Cons:

- Difficult to sort out medicines for each room.
- Wheels have no locks

Model 4:

Pros:

- Simple and Light weight
- Easier to keep medicines as drawers are used.
- An open table is there on the top to keep case diary/charts of patients.
- Wheels have locks

Cons:

- Difficult to so rt o ut medicines for each room.
- No option for disposing clinical wastes.

Model 5:

Pros:

- Simple and Light weight
- Easier to keep medicines as drawers are used.
- An open table is there on the top to keep case diary/charts of patients.
- Have both open and closed racks to keep drugs accordingly.

Cons:

- Difficult to so rt o ut medicines for each room.
- No option for disposing clinical wastes.
- No lock for wheels

Model 6:

Pros:

- Simple and Light weight
- Easier to keep medicines and sort out medicines for each patie nt as different partitions are provided for each room.
- Have both open and closed racks to keep drugs accordingly.

Cons:

- No open table is there on the top to keep case diary/charts of patients
- No option for disposing clinical wastes.
- No lock for wheels

Model 7:

Pros:

- Simple and Light weight
- Easier to keep medicines and sort out medicines for each patient as different partitions are provided for each room.
- Have both open and closed racks to keep drugs accordingly.
- Have facility to dispose clinical wa stes.
- Have ope n table to keep patient charts / records.
- Have locks for wheels.

Choosing the best design

Model 7 can be chosen as the best design as it incorporates all the expected functionalities as well as exciting functionalities of a drug trolley.

Model Question paper

Reg No.:_____________Name:_______________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD/FOURTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code: EST 200

Course Name: **DESIGN AND ENGINEERING**

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each question carries 3 marks

Use only hand sketches

(1) Write about the basic design process.

(2) Describe how to finalize the design objectives.

(3) State the role of divergent-convergent questioning in design thinking.

(4) Discuss how to perform design thinking in a team managing the conflicts.

(5) Show how engineering sketches and drawings convey designs.

(6) Explain the role of mathematics and physics in design engineering process.

(7) Distinguish between project-based learning and problem-based learning in design engineering.

(8) Describe how concepts like value engineering, concurrent engineering and reverse engineering influence engineering designs?

(9) Show how designs are varied based on the aspects of production methods, life span, reliability and environment?

(10) Explain how economics influence the engineering designs?

(10x 3 marks =30 marks)

Part B

Answer any ONE question from each module. Each question carry 14 marks

Module 1

(11) Show the designing of a wrist watch going through the various stages of the design process. Use hand sketches to illustrate the processes.

(12) Find the customer requirements for designing a new car showroom. Show how the design objectives were finalized considering the design constraints?

Module 2

(13) Illustrate the design thinking approach for designing a bag for college students within a limited budget. Describe each stage of the process and the iterative procedure involved. Use hand sketches to support your arguments.

(14) Construct a number of possible designs and then refine them to narrow down to the best design for a drug trolley used in hospitals. Show how the divergent-convergent thinking helps in the process. Provide your rationale for each step by using hand sketches only.

Module 3

(15) Graphically communicate the design of a thermo flask used to keep hot coffee. Draw the detailed 2D drawings of the same with design detailing, material selection, scale drawings, dimensions, tolerances, etc. Use only hand sketches.

or

(16) Describe the role of mathematical modelling in design engineering. Show how mathematics and physics play a role in designing a lifting mechanism to raise 100 kg of weight to a floor at a height of 10 meters in a construction site.

Module 4

(17) Show the development of a nature inspired design for a solar powered bus waiting shed beside a highway. Relate between natural and man-made designs. Use hand sketches to support your arguments.

or

(18) Show the design of a simple sofa and then depict how the design changes when considering 1) aesthetics and 2) ergonomics into consideration. Give hand sketches and explanations to justify the changes in designs.

Module 5

(19) Examine the changes in the design of a foot wear with constraints of 1) production methods, 2) life span requirement, 3) reliability issues and 4) environmental factors. Use hand sketches and give proper rationalization for the changes in design.

(20) Describe the how to estimate the cost of a particular design of i) a website, ii) the layout of a plant, iii) the elevation electronic system or device and v) a car. Show how economics will influence the engineering your arguments.

using ANY of the following:
of a building, iv) anelectrical or

designs. Use hand sketches to support

(5x14 marks =70 marks)

MODULE III

ENGINEERING SKETCHES

Drawing is very important in design because a lot of information is created and transmitted in the drawing process. • Design drawings include sketches, freehand drawings, and • computer-aided design and drafting (CADD) models that extend from simple wire-frame drawings through elaborate solid models

In brief, graphic images are used to communicate with other designers, the client, and the manufacturing organization. Sketches and drawings: • serve as a launching pad for a brand-new design; • support the analysis of a design as it evolves; • simulate the behavior or performance of a design; • record the shape or geometry of a design; • communicate design ideas among designers; • ensure that a design is complete (as a drawing and its associated marginalia may remind us of still-undone parts of that design); • communicate the final design to the manufacturing specialists

SKETCHING

Sketching is a powerful tool in design because it enables us to convey our design ideas to others quickly and concisely. • Types

A. **Orthographic sketches** • lay out the front, right and top views of a part

B. **Axonometric sketches** • start with an axis, typically a vertical line with two lines 30 drgree from the horizontal.

C. **Oblique sketches** • The front view is blocked in roughly first, depth lines are then added, and details such as rounded edges are added last.

D. **Perspective sketches.**

LAYOUT DRAWINGS

working drawings that show the major parts or components of a device and their relationship • They are usually drawn to scale, do not show tolerances, and are subject to change as the design process evolves.

DETAIL DRAWINGS

show the individual parts or components of a device and their relationship • These drawings must show tolerances, and they must also specify materials and any special processing requirements. • Detail drawings are drawn in conformance with existing standards, and are changed only when a formal change order provides authorization.

COMMUNICATING DESIGNS ORALLY AND IN WRITING

REPORTING is an essential part of a design project • We communicate final design results in several ways, including oral presentations, final reports (that may include design drawings and/or fabrication specifications), and prototypes and models. • The primary purpose of such communication is to inform our client about the design, including explanations of how and why this design was chosen over competing design alternatives. • It is most important that we convey the results of the design process. • we should ensure that final reports and presentations are not narratives or chronologies of our work • Rather, the presentations and reports should be lucid descriptions of design outcomes, as well as the processes with which those outcomes were achieved.

GUIDELINES FOR TECHNICAL COMMUNICATION

1.Know your purpose.

2. Know your audience.

3. Choose and organize the content around your purpose and your audience.

4. Write precisely and clearly.

5. Design your pages well.

6. Think visually.

7. Write ethically

MODULE IV

PROBLEM-BASED LEARNING

It empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem,' • It is a teaching pedagogy that is student- centered • Students learn about a topic through the solving of problems and generally work in groups to solve the problem where, often, there is no one correct answer.

Problem-based learning typically follow prescribed steps:

1. Presentation of an "ill-structured" (open-ended, "messy") problem 2. Problem definition or formulation (the problem statement) 3. Generation of a "knowledge inventory" (a list of "what we know about the problem" and "what we need to know") 4. Generation of possible solutions 5. Formulation of learning issues for self-directed and coached learning 6. Sharing of findings and solution

Project-based learning is an instructional approach where we learn by investigating a complex question, problem or challenge. • It promotes active learning, engages students, and allows for higher order thinking • Students explore real-world problems and find answers through the completion of a project. • Students also have some control over the project they will be working on, how the project will finish, as well as the end product

DIFFERENCE BETWEEN PROBLEM BASED AND PROJECT BASED LEARNING

students who complete problem-based learning often share the outcomes and jointly set the learning goals and outcomes with the teacher. • On the other hand, project-based learning is an approach where the goals are set. It is also quite structured in the way that the teaching occurs. PROJECT BASED LEARNING • goals are set and quite structured • often multidisciplinary and longer • follows general steps • involves authentic tasks that solve realworld problems • often share the outcomes and jointly set the learning goals and outcomes • more likely to be a single subject and shorter • provides specific steps • uses scenarios and cases that are perhaps less related to real life PROBLEM BASED LEARNING

often share the outcomes and jointly set the learning goals and outcomes • more likely to be a single subject and shorter • provides specific steps • uses scenarios and cases that are perhaps less related to real life

MODULAR DESIGN

Module' means separate elements • Modular design is an approach in which a product is designed for assembling in module-wise fashion. • Modular products are the artifacts that are composed of many modules • These modules function together to get the overall function of the product. •

Modular products can be machines, assemblies and components that fulfill various overall functions through the combination of distinct building blocks or modules. • In a modular product (or modular system), the overall function performed by the product is the results achieved through a combination of discrete units (modules).

Dividing a product into discrete units based on some criteria is called as modularization of a product. • As we have seen, modular products or modular Systems are built up on separable or inseparable units called as modules. • The basic idea behind modular design is to organize a complex system as a set of distinct component that can be developed independently and then assembled together to perform a function

MODULE V

Concurrent engineering : a multidisciplinary design team works simultaneously and in parallel to design a product, a manufacturing approach, a distribution scheme, user support,maintenance, and ultimately disposal

Design for manufacturing (DFM) is design based on minimizing the costs of production and/or the time to market for a product, while maintaining an appropriate level of quality. DFM begins with the formation of the design team. In commercial settings, design teams committed to DFM tend to be multidisciplinary, and they include engineers, manufacturing managers, logistics specialists, cost accountants, and marketing and sales professionals. Each brings particular interests and experience to a design project, but all must move beyond their primary expertise to focus on the project itself

A basic methodology for DFM consists of six steps: Estimate the manufacturing costs for a given design alternative; • Reduce the costs of components; reduce the costs of assembly; Reduce the costs of supporting production; • Consider the effects of DFM on other objectives; and If the results are not acceptable, revise the design once again

Assembly refers to the way in which the various parts, components, and subsystems are joined, attached, or otherwise grouped together to form the final product. • Handles parts or components (i.e., retrieves and positions them appropriately relative to each other) • Inserts (or mates or combines) the parts into a finished subsystem or system.

Reliability • To an engineer, reliability is defined as "the probability that an item will perform its function under stated conditions of use and maintenance for a stated measure of a variate • we can properly measure the reliability of a component or system only under the assumption that it has been or will be used under some specified conditions. • the appropriate measure of use of the design, called the variate, may be something other than time

What is a design right? • If you have created a new design, it's worthwhile considering registering it to effectively prevent others from copying or exploiting your design. A registered design is an excellent and cost-effective tool to protect your rights against copying and counterfeiting. • A design registration means you can register the look of your product. It gives you an exclusive right to your design for a limited time • Designs can be registered to protect the look of your whole product, a part of your product, or even just a small detail. Your product might be something functional, like a mobile phone, a drill, or a toothbrush, or something more decorative like a vase or a piece of jewellery.

ECONOMICS IN DESIGN ENGINEERING

Cost estimation is a complex business that requires skill and experience. However, there are several ways that we can break out the cost structure of a device that we are designing. The simplest, conceptually, is to estimate labor, materials, and overhead costs. This simple statement ignores profits, and it masks the complexity of the full cost related details of all but the simplest of artifacts.

LABOR, MATERIALS, AND OVERHEAD COSTS

Labor costs include payments to the employees who build the designed device, as well as to support personnel who perform necessary but often invisible tasks such as taking and filling orders, packaging, and shipping the device. Labor costs also include a variety of indirect costs that are less evident because they are generally not paid directly to employees. These indirect costs are sometimes called fringe benefits and include health and life insurance, retirement benefits, employers' contributions to Social Security, and other mandated payroll taxes

Materials include those items and inputs directly used in building the device, along with intermediate materials and inventories that are consumed in the manufacturing process. A key tool for estimating the materials cost of an artifact is the bill of materials (BOM), the list of all of the parts in our design, including the quantities of each part required for complete assembly. The BOM is particularly useful since it is usually developed directly from the assembly drawings, and so it reflects our final design intentions. We might think of the BOM as being that part of a recipe that specifies all of the ingredients that we need, as well as the exact quantities needed to make a specified lot size. Materials costs can often be reduced significantly by using commercial off-the-shelf materials rather than making our own. This is because outside vendors have the machinery and expertise to make very large numbers of parts for a lot of customers.

The costs incurred by a manufacturer that cannot be directly assigned to a single product are termed overhead. If, for example, a company makes a product in a factory that also produces 20 other products, the cost of the building, the machines, the janitorial staff, the electricity, and so on, must somehow be shared or distributed among all of the 21 items. If the company ignored these overhead costs in setting its product's prices, it would soon find itself unable to pay for the building and the services necessary to maintain it. Other elements of overhead include the salaries of executives, who are presumably using some share of their time to supervise each of the company's activities, as well as the costs of needed business functions such as accounting, billing, and advertising. While there are accounting standards that define cost categories and their attributes, precise estimates of overhead costs vary greatly with the structure and practices of the company in question. One company may have only a small number of products and a very lean organization, with most of its costs directly attributed to the products made and sold, and only a small percentage allocated to overhead. In other organizations the overhead can be equal to or greater than the labor costs that are directly assignable to one or more products. Estimating the costs of producing a design requires careful consultation with clients or their suppliers.

DESIGN FOR PRODUCTION

In many cases, a designed artifact will be produced or manufactured in large quantities. In recent years, companies have come to learn that the design of a product can have an enormous impact on the methods and costs of producing it. The time it takes to get a product to the consumer, known as the time to market, defines a company's ability to shape a market. Design processes that anticipate manufacturing issues can be key elements in speeding products through to commercial production.

Design for Manufacturing (DFM)

Design for manufacturing (DFM) is design based on minimizing the costs of production and/or the time to market for a product, while maintaining an appropriate level of quality. The importance of maintaining an appropriate level of quality cannot be overstated because without an assurance of quality, DFM is reduced to simply producing the lowest cost product. DFM begins with the formation of the design team. In commercial settings, design teams committed to DFM tend to be multidisciplinary, and they include engineers, manufacturing managers, logistics specialists, cost accountants, and marketing and sales professionals.

A basic methodology for DFM consists of six steps:

1. estimate the manufacturing costs for a given design alternative;

2. reduce the costs of components;

3. reduce the costs of assembly;

4. reduce the costs of supporting production;

5. consider the effects of DFM on other objectives; and

6. if the results are not acceptable, revise the design once again.

There are some specific things that design teams can keep in mind when doing DFM.

1. First of all, consulting with experts on manufacturing can often reveal manufacturing techniques that will (or will not) work with your design. Whether they are faculty members at a university, experts at the client's firm, or even retired manufacturing engineers, tapping into their knowledge is tremendously helpful for the designer.

2. Second, production costs can usually be reduced by using commercially available inputs rather than custom parts. The use of off-the-shelf components will also make cost estimation simpler, since there are catalogs listing specifications and prices.
3. Finally, DFM must always be done with the client's objectives in mind—in some fields, ease of manufacturing or even reduced costs may not be uppermost in the client's mind, especially if lives are at stake.