

UNIT – 1
Introduction to Design
Unit-01/Lecture-01
<p>What is Design?</p> <p>Design is the strategic (Lateral thinking, Think like a beginner) approach for someone to achieve a unique expectation. It defines the specifications(Fast, accurate, high-performing,Light, Small, portable, Easy to use, Safe,Stylish), plans, parameters, costs, activities, processes and how and what to do within legal (patent agreement,Safety,,Designed protection against reasonable abuse) Codes and regulations, political, social, Aesthetics (Colour, shape, form, texture, finish,) environmental, safety(What safety requirements are permission by government Professional society's codes and standards,Need for warning labels Likely degrees of abuse or misunderstanding of operating procedures.) And economic constraints (Economic Environmental Ethical and Legal Health and Safety Manufacturability Political and Social, language, Sustainability) in achieving that objective.</p> <p style="text-align: center;">Or</p> <p>Design is the ability that sparks the ideas into real world. This makes things better for people. design is to create something that has never been Design could be viewed as an activities that translate idea into reality for something useful whether it is a car, building etc.Design is where customer requirement , business needs, technical considerations all come together in formulation of product or system</p> <p style="text-align: center;">Or</p> <p>Design is the creation of a plan for the construction of an object or a system ,Designing often necessitates considering the aesthetics, functional, economic and socio-political dimensions of both the design object and design process. It may involve considerable research, thought, modelling, interactive adjustment, and re-design. Meanwhile, diverse kinds of objects may be designed, including clothing, graphical user interface, skyscrapers, corporate, business processes and even methods of designing. The person designing is called a designer.</p> <p style="text-align: center;">Or</p> <p>Design is achieving goals within constraints that turn concept into something that desirable ,visible, commercially successful, and add value to people's lives</p> <p>Basic requirement of design :</p> <ol style="list-style-type: none"> 1 Who are the users 2 What are the needs 3 Where do alternatives come from 4 How do you choose alternatives

Difference between Design & Discovery :

Design should not be confused with discovery. Discovery is getting the first sight of, or the first knowledge of something, as when Columbus discovered America or Jack Kilby made the first microprocessor. We can discover what has already existed but has not been known before, but a design is the product of planning and work.



Misconception about Design : misconception about design is **fashion or style**, while the design is best employed at the end of product development process

Engineering Design : Engineering design is the decision making process in which the basic science, mathematics, and engineering science to convert resources optimally to meet a started objective

Or

Engineering design is the systematic, intelligent generation and evaluation of specifications for **artefact (manufactured product)** whose form and function achieve stated objectives and satisfy specified constraints(Restriction, limitation).

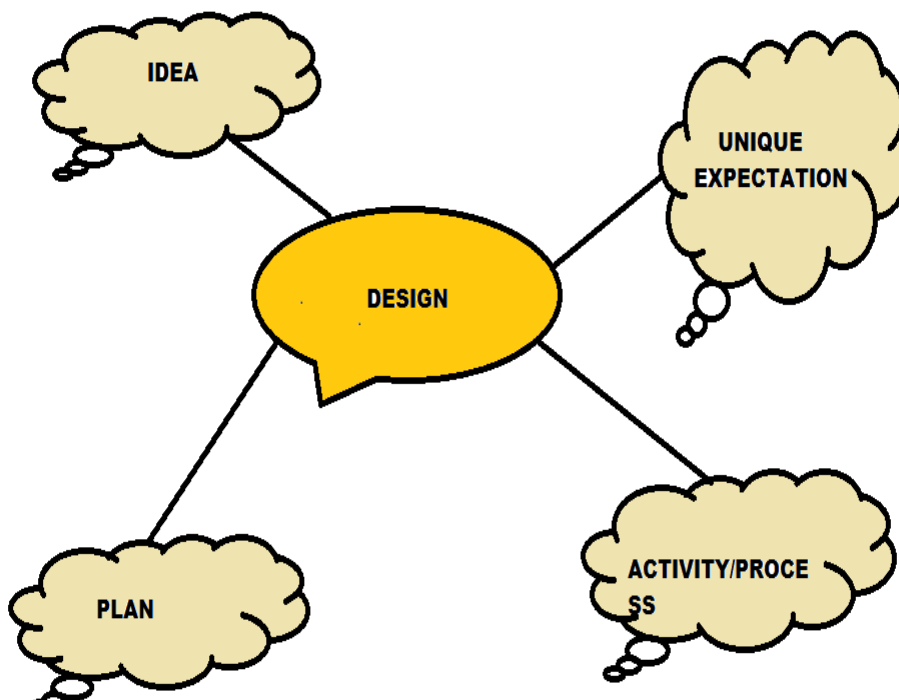
Or

Engineering design is the organized, thoughtful development and testing of characteristics of new objects that have a particular configuration or perform some desired function that meets our aims without violating any specified limitations

APPROCHES TO DESIGN :

Some popular approaches include:

- 1) **Keep it Simple Stupid:** which **strives (struggle)** to eliminate unnecessary complications.
- 2) **There is more than one way to do it:** a **philosophy (thinking)** to allow multiple methods of doing the same thing.
- 3) **Use-centred design:** This focuses on the goals and tasks associated with the use of the **artefact (manufactured product)**, rather than focusing on the end user.
- 4) **User-centered design:** This focuses on the needs, wants, and limitations of the end user of the designed artefact.
- 5) **Critical design:** uses designed **artefacts (manufactured product)** as an alive analysis or explanation on existing values, morals, and practices in a culture.



Creativity

- Requires creation of something that has not exist before or has not existed in the designer's mind before

Complexity (complication)

- Requires decisions on many variables and parameters

Choice

- Requires making choices between many possible solutions at all levels, from basic concepts to the smallest detail of shape

Compromise

- Requires balancing multiple and sometimes **contradictory(differ, clashing)** requirements

Keywords :

- 1) **Constraints :** Restriction
- 2) **Aesthetics:** Concerned with beauty
- 3) **Accessible:** Approachable, reachable, easy to understand
- 4) **Artefacts:** manufactured products

IMPORTANCE OF DESIGN

What are the importances of design?

1) DESIGN IN ENGINEERING: "The application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

2) DESIGN IN PRODUCTION: A designer does not usually produce the goods/services which immediately satisfy consumers' needs. Rather he produces the **prototype (sample, model)** which is used as a sample for reproducing the particular goods or services as many times as required. If customer is satisfied then mass production of goods may be taken up by a production department. In the course of production an error made by the production in manufacturing an item may be lead to its rejection, but an error in design, which will be repeated in all products, may lead to economic failure. The designer's responsibilities are serious.

Or

The relationship between design and production is one of planning and carry out. In theory, the plan should **anticipate (expect)** and **compensate (balance, give back)** for potential problems in the **execution (implementation, finishing)** process. Design involves problem-solving and creativity. In **contrast (compare)**, production involves a routine or pre-planned process. In some cases, it may be unnecessary and/or impractical to expect a designer with a broad multidisciplinary knowledge required for such designs to also have a detailed specialized knowledge of how to produce the product. Design and production are knotted in many creative professional careers, meaning problem-solving is part of execution and the reverse. As the cost of rearrangement increases, the need for separating design from production increases as well.

This is not to say that production never involves problem-solving or creativity, nor that design always involves creativity. Designs are rarely perfect and are sometimes repetitive. The imperfection of a design may task a production position (e.g. production, construction worker) with utilizing creativity or problem-solving skills to **compensate (pay cost)** for what was **overlooked (ignored)** in the design process. Likewise, a design may be a simple **repetition (copy)** of a known pre-existing solution, requiring **minimal (negligible, small, least)**, if any, creativity or problem-solving skills from the designer.

3) DESIGN FOR USER: Good design always begin with the needs of user so finding out what

the customer want is the first stage of what designer's do .the designer then builds on the result with a mixture of creativity and commercially **insight(within reach)**. Design should be easily grip by user otherwise dotcom business failed. There are more scientific ways of making sure that design hit the mark. Different designers use different methods combining market research, user testing, and prototyping and trend analysis. Any product launch is ultimately a **gamble(risk)**, but these methods help to decrease the risk of failure, a facts that comes to surprise the clients

4) DESIGN FOR PUBLIC SERVICES : Design can help public services in a no. of countless ways ,from making sure products and services that meet the needs of users to increasing innovation within organisation and bringing new view to issues such as **Procurement(buy something goods)**

5) Design FOR Business: Designer have to ask themselves a question such as

- a) Is the product they are creating really wanted?
- b) How it is different from everything else on the market?
- c) Do it fulfil a need?
- d) Will it cost too much to manufacture?
- e) Is it safe?

Recent industries development have had to consider the facts that Issue of “ **what we have to produce**” is gaining more importance as compare to “ **how to produce it**” **Emphasis(stress, importance)** on the customer makes design a alarming weapon for any buisness.putting an stress on design brings creativity into an organisation and increase chance of producing market leading as the **sophistication (cleverness, quality of refinement, wisdom ,displaying good taste)** of the consumers and global completion increases ,it becomes more and more valuable

6) DESIGN IN INDUSTRIES: Industrial design is a process deals with uniting factors as technology, marketing, sales, recycling, and disposal to create the balance between the commercial, **Immaterial** and **aesthetic** value of product .the word industrial design relates to an industrial production technology. Industrial design is a creative process which integrates the physical qualities of a product with **aesthetic (Concerned with beauty)** considerations. Design is both the result as end product and the process which creates the result

Keywords

- 1) **Immaterial : unimportant under the circumstances, rather than physical**
- 2) **Emphasis : Specially important value**
- 3) **Sophistication : quality of refinement, wisdom ,displaying good taste,**

Unit-01/Lecture-03
TYPES OF DESIGN

What are the different types of Engineering design?

Engineering design can be undertaken for many different reasons, and it may take different forms.

1) Original design, also called innovative design: This form of design is at the top of the ladder. It employs an original, innovative concept to achieve a need. Sometimes, but rarely, the need itself may be original. A truly original design involves invention. Successful original designs occur rarely, but when they do occur they usually interrupt existing markets because they have in them the seeds of new technology Of far-reaching consequences.

Example: The design of the microprocessor was one such original design.

2) Adaptive design: This form of design occurs when the design team adapts a known solution to satisfy a different need to produce a **novel (new, original)** application.

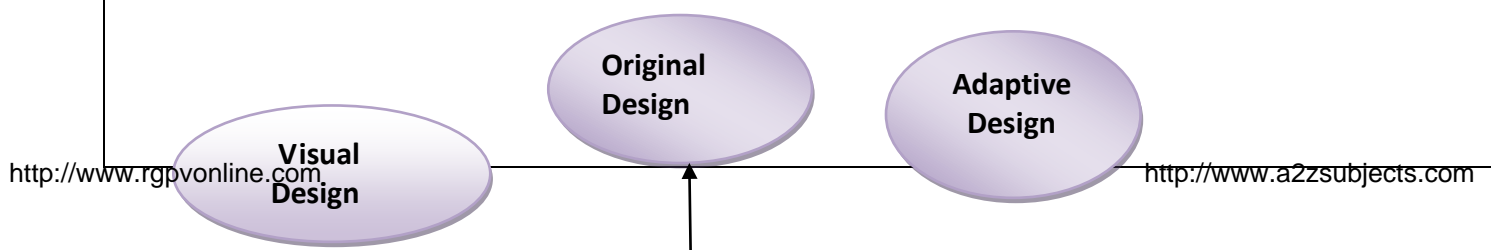
For example: Adapting the ink-jet printing concept to spray binder to hold particles in place in a Rapid prototyping machine. Adaptive designs involve synthesis and are relatively Common in design.

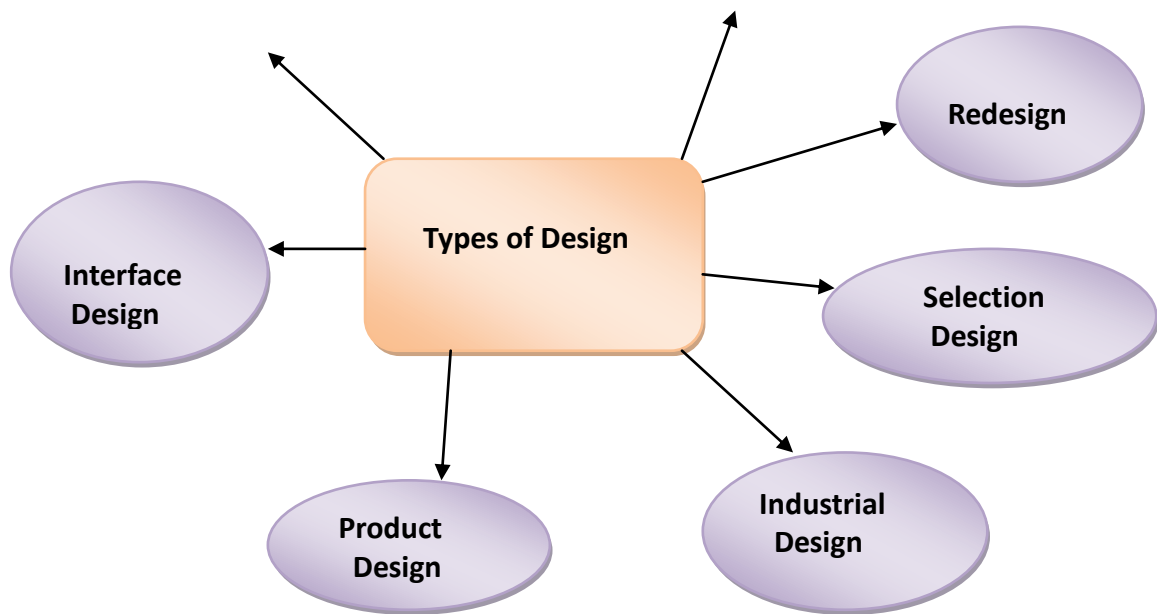
3) Redesign: Much more frequently, engineering design is employed to improve an existing design. The task may be to redesign a component in a product that is failing in service, or to redesign a component so as to reduce its cost of manufacture. Often redesign is accomplished without any change in the working principle or concept of the original design.

For example: the shape may be changed to reduce stress concentration, or a new material substituted to reduce weight or cost. When redesign is achieved by changing some of the design parameters, it is often called **variant design**.

4) Selection design: Most designs employ standard components such as bearings, small motors, or pumps that are supplied by vendors concentrate in their manufacture and sale. Therefore, in this case the design task consists of selecting the components with the needed performance, quality, and cost from the catalogs of potential vendors.

5) Industrial design: This form of design deals with improving the request of a product to the human senses, especially its visual appeal. While this type of design is more creative than engineering, it is a vital phase of many kinds of design. Also include by industrial design is a consideration of how the human user can best interface with the product.





6) PRODUCT DESIGN :

Product design deals with the conversion of ideas into reality and in other forms of human activities, aims at fulfilling human needs. A designer does not usually produce the goods/services which immediately satisfy consumers needs. Rather he produces the **prototype (sample, model)** which is used as a sample for reproducing the particular goods or services as many times as required. If customer is satisfied then mass production of goods may be taken up by a production department. In the course of production an error made by the production in manufacturing an item may lead to its rejection, but an error in design, which will be repeated in all products, may lead to economic disaster. The designer's responsibilities are serious.

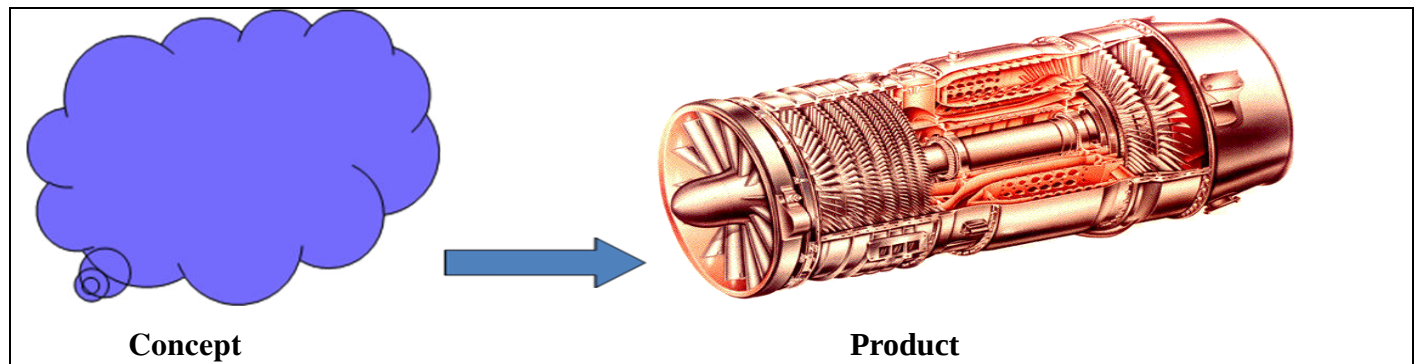
Essential factors of Product Design:

i) **Need:** A design must be in response to individual or social needs, which can be satisfied by technological status of times when the design is to be prepared.

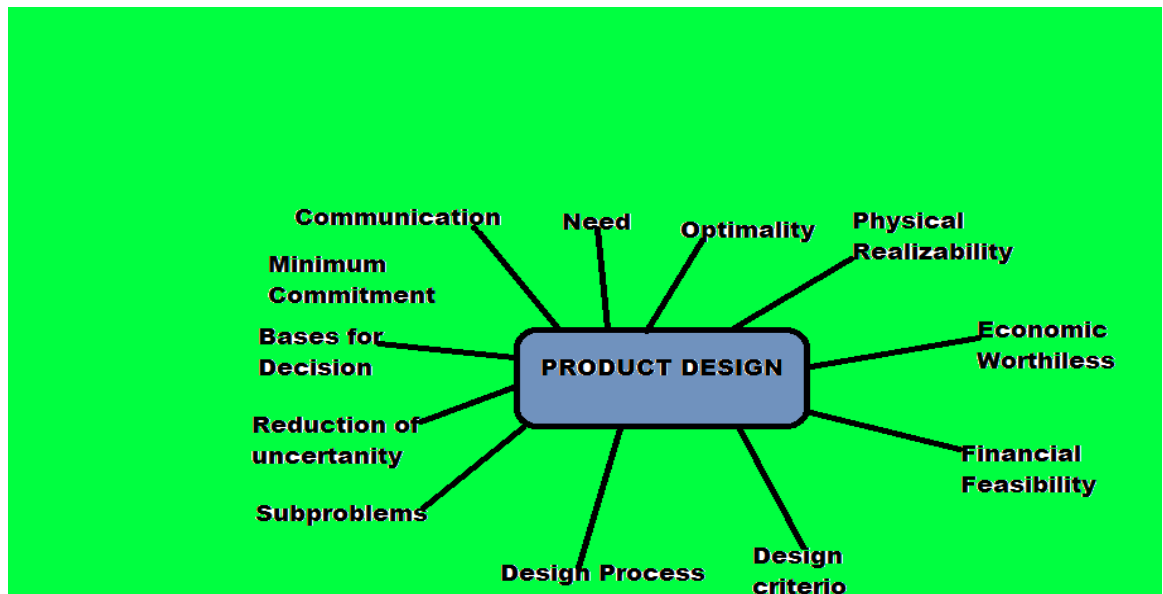
Specifications of Customer Needs

- Affordable as a birthday present
- Fully assembled
- It is safe
- Looks good
- Last a long time

ii) **Physical Reliability:** A good design should be convertible into material goods i.e. it may be physical reliable. Process of making many decisions that converts a theoretical concept into a hardware reality.



iii) Economic Worthiness : The goods or services described by a design must have a utility to the consumer which equal or exceeds the sum of total costs of making it available for him



iv) Financial Feasibility: The operation of designing, producing and distributing the goods must be financially supportable i.e. a design product should be capable for being funded by suitable agencies or people. The method for review of financial feasibility could be “net present value “which state that the present value of cash flows in the project when added up by during the useful life of the product should be greater than initial investment for the project.

v) optimality : The choice of design concept must be most favourable against the under constraints for mechanical strength , minimum cost , minimum weight, are usually taken up as criterion for optimisation

vi) Design criterion: Which represent the designer’s compromise among possibly **conflict (argument, clash)** value judgement which include those of the consumer, producer and distributor and his own.

vii) Design Process: The iterative nature of design is owing to feedback from existing design and improvement with further information in the form of technological, financial, and creativity input.

viii) Sub problems: During the process of solution of design problem ,a sub layer of sub problems appears, the solution of original problem is dependent on the solution of sub problems

viii) Reduction of certainty: Design is derived after processing of information that results in a transition

from uncertainty, about the success or failure of a design towards certainty.

viii) Economic worth of evidence: Information gathering and processing have a cost that must be balanced by the worth of **evidence (proof, verification)**, which offers the success or failure of design.

Authentic(genuine, real) information should be gathered to make the design project a success today information is regarded as a resource which is valuable as a money, manpower & material

ix) Bases for decision : A design project is terminated when it is clear that its failure calls for its discarded

x) Minimum commitment: In the solution of a design problem at any stage of a process commitment which will fix further decision must be made beyond what is necessary to carry out the immediate solution.

xi) Communication: A design is explanation of an object and instruction for its production. It will exist to the extent it is expressed in the available modes of communication. The best way to communicate a design is through drawings, which is a universal language of designers.

Example: In the present day **CAD (Computer aided design)** and **DRAFTING** has resulted in very effective communication between designer and sponsor. Communicate the designer's final solution through media such as **PowerPoint, poster session, technical report, Market the Product, Distribute.**

7) Interface Design: The goal of interface design is to translate the theoretical functionality conveyed by the product designer and clear how the user actually experience and manager to understand that functionality in the product, on a step by step basis.

The interface design is most responsible for making the product as naturally usable as possible so that the highest % of user derive the value promised by it. A good interface designer understand the constraints and opportunity offered by their medium and plays the very concerned role of envision, **study how the people of all targeted background will learn how to use the product.**

8) Visual Design: The goal of visual design is to ensure that the product conveys a sense of quality and obtain the proper emotional response from its users. Visual design is the most aesthetic and subjective design type, but it's also the most immediately recognizable one. While visual designers take their signal from product and interface designers, they are responsible for technique and delivering a philosophy for the product. They spend most of their time making interface elements both attractive and properly toned so as to support the purpose and value of the product for users, and a good visual designer knows how to make a product satisfying without making resources that are overly striking. A visual designer spends the most time on detail, since they sit closest to the user's actual experience. And they deliver high-resolution images, animations or other user-ready elements that can be incorporated directly into the product.

Unit 01/Lecture 04

Engineering Design Process

Explain Engineering Design Process

The engineering design process is a series of steps that engineers follow when they are trying to solve a problem and design a solution for something; it is a logical approach to problem solving. There is no single universally accepted design process. It seems as though most engineers have their own twist for how the process works. The process generally starts with a problem and ends with a solution, but the middle steps can vary.

Or

A design process is a systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to solve or satisfy human needs or wants and to narrow down the possible solutions to one final choice.

or

Design process is a collection of procedures and habits that help teams design better products

Designing is the process of making many decisions that converts an abstract concept into a hardware reality

- The design process is a purposeful method of planning practical solutions to problems.
- The design process is never final; there are always multiple solutions to a problem.
- The design process is influenced by requirements called criteria and constraints.

USING THE ENGINEERING DESIGN PROCESS:

As discussed above, there is no single engineering design process. Throughout this course we will use an 11-step design process as they conceptualize, design, and create

Step 1 – UNDERSTAND – Define the Problem

Step 2 – EXPLORE – Do Background Research

Step 3 – DEFINE – Determine Solution Specifications

Step 4 – IDEATE – Generate Concept Solutions

Step 5 – PROTOTYPE – Learn How Your Concepts Work

Step 6 – CHOOSE – Determine a Final Concept

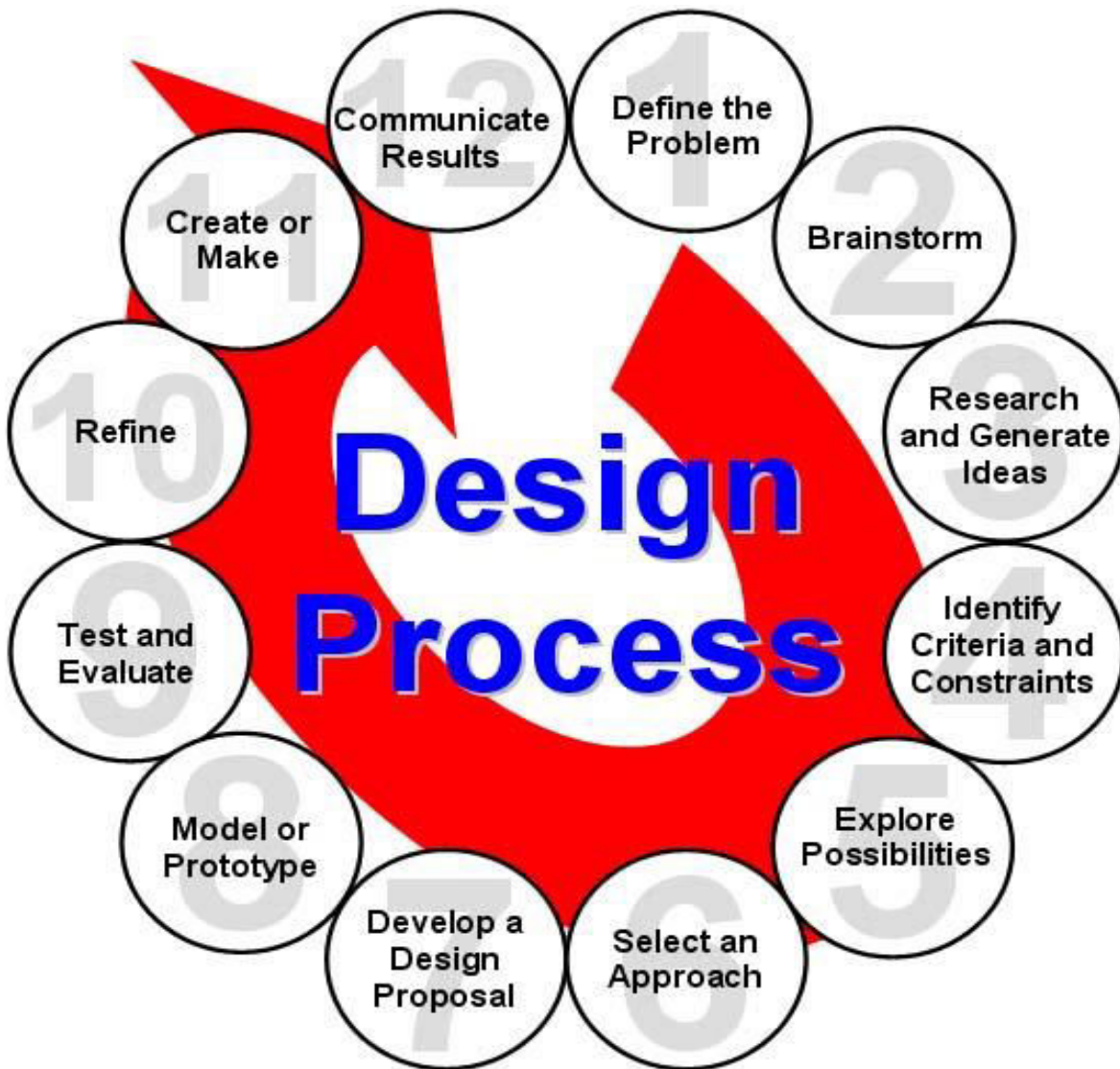
Step 7 – REFINE – Do Detailed Design

Step 8 – PRESENT – Get Feedback & Approval

Step 9 – IMPLEMENT – Implement the Detailed Solution

Step 10 – TEST – Does the Solution Work?

Step 11 – ITERATE



STEP 1: UNDERSTAND

In this step engineers will define the problem they are trying to solve. This is the single most important step in the design process. Without fully understanding the problem how can an engineer solve it successfully? This step is frequently done incorrectly or incompletely and results in a failure of the design. It is important to define the true problem one is solving. Defining the problem is like conducting detective work. You must examine the evidence and form some conclusions.

Identifies requirements design must satisfy for success

1. **Marketing requirements**
 - Customer needs
2. **Engineering requirements**
 - Applies to technical aspects
 - Performance requirements

Receive a problem to solve from customer, gather information.

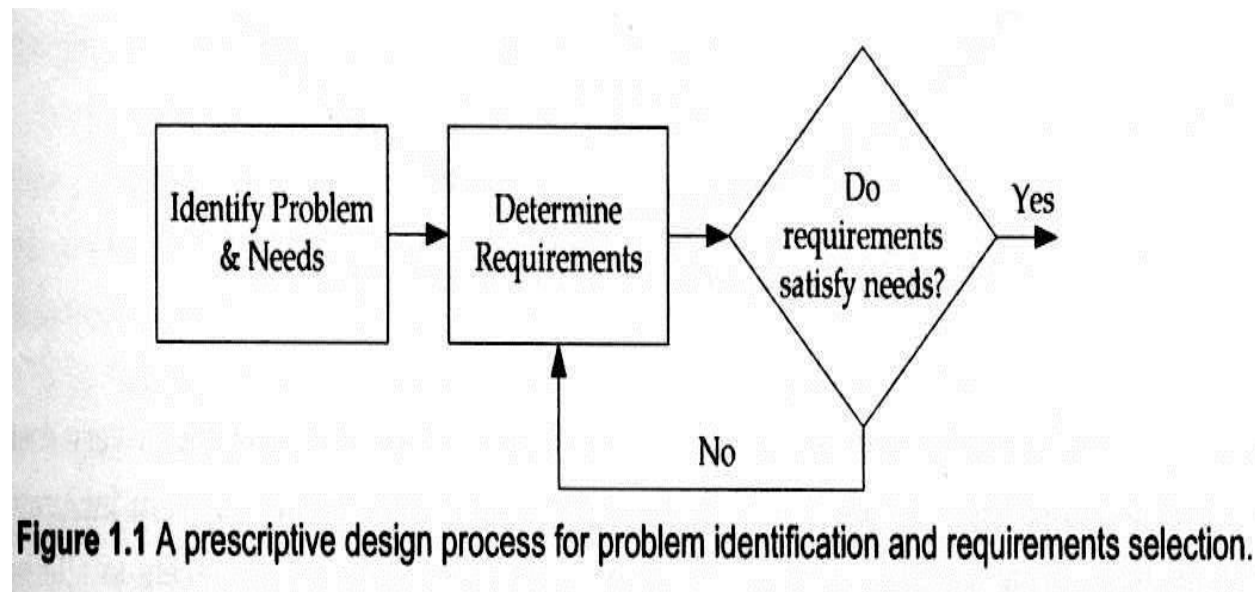


Figure 1.1 A prescriptive design process for problem identification and requirements selection.

Example:

- 1) Design a vehicle that can communicate with other vehicles to prevent accidents.
- 2) Design an athletic shoe that decreases the amount of sprained ankles when worn on hardwood gym floors ,milege,safety devices for kit

STEP 2: EXPLORE

In this step engineers will do background research on the problem their solving. They will investigate the ways others have attempt similar problems. Engineers will also gather details on the environment they're dealing with, the situations their solution will be used in, and the ways it will be used. Research may require going to the library, using computer databases, writing letters, performing experiments, and asking questions

Conduct interviews with those affected by the problem.

- What information has been published about the problem?
- Is there a solution to the problem that already may be available?
- Research solutions that may already exist; identify shortcomings and reasons why they aren't appropriate to a given situation.
- If the answer to the above is yes, who is producing it?
- What are the advantages of their solution?
- What are the disadvantages to their solution?
- Compile ideas and report findings to the team.
- What is the cost?
- Is cost significant issue?
- What is the ratio of time compared to overall cost?
- Are there legal issues to consider?
- Are there environmental concerns which must be considered?

Examples:

- ✓ Read books and magazines
- ✓ View films or videos
- ✓ Search the Internet
- ✓ Ask questions of the “experts”
- ✓ Create and analyze a survey
- ✓ Libraries
- ✓ Professional Society
- ✓ Journal, publications and newsletter
- ✓ Newspapers and magazines
- ✓ Market assessment surveys
- ✓ Government publications
- ✓ Patent searches and listings
- ✓ Technical salespersons and their references catalogs
- ✓ Professional experts including researchers, professors and other scientists
- ✓ The competition's product (how they designed it? Disassemble their product and study it)

STEP 3: DEFINE

In this step engineers will specify WHAT the solution will accomplish, without describing HOW it will do it. They do this through the use of specifications.

What are specifications?

A specification is defined as a clear set of requirements to be satisfied by a material, product, or service. In this case, specifications are requirements for the solution of the problem defined in Step 1 of the design process.

Specifications typically come from two places:

1. Design Constraints**2. Functional Requirements****What are constraints?**

A constraint can be defined as a condition that a solution to a problem must satisfy. Constraints, in short, are restrictions.

What are functional requirements?

Functional requirements describe how well the finished solution must perform.

Again, specifications outline **WHAT** the solution will do and how **WELL** it will do it, not **HOW** it will do it.

- Identify what the solution should do and the degree to which the solution will be chase.
- Identify constraints (i.e., budget and time are typical considerations).
- Draft the Design Brief

STEP 4: IDEATE:

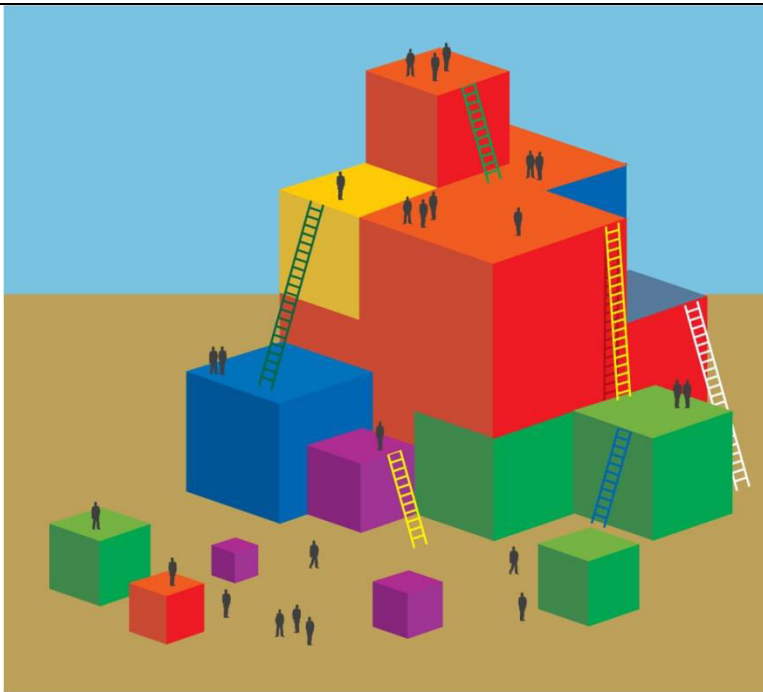
Develop multiple ideas that will solve the problem and meet the requirements. The alternatives may all be quite different

Criteria:

- ✓ How will the solution actually work?
- ✓ What materials should I use?
- ✓ What should the product look like so that people will buy it?

Constraints:

- ✓ Will it be completed by the deadline?
- ✓ What size should it be?



Ideate means to plan, imagine, or envision of an idea. Now that the engineer knows **WHAT** the solution will do; he or she must determine **HOW** it will do it. Everyone does the same thing when faced with a problem or a decision to make: they think of alternative courses of action, even if they do this unthinking. Formally documenting this sensitive action may help when solving complex engineering problems.

This is a step that requires some creativity. Some of the questions most commonly asked of engineers are, **“How did you come up with that?”** and **“Where do you get your ideas?”** Ideas come from everywhere! Inspiration can come from anywhere!

The keywords here are: **“imagination”** and **“think.”** This is where the designer needs to brainstorm multiple ways to fulfill the specifications. It is important to remember to look for inspiration everywhere. **A common mantra is, “steal from the best, then invent the rest.”** Good designers will look in the world around them and try to find solutions to adapt to their problem and build off. Innovation is also important early in the design process (**don’t wait to innovate, always put innovation first**); there is a good balance to be found between **“thinking outside the box”** and **“using pre-made designs.”**

Often combining two ideas or compromising between two different suggestions may yield a good concept. Again, improvements and innovations early in the process will yield better results later in the process.

Brainstorming – Group Creativity Technique, Brainstorming involves bringing a group of people together to generate many different ideas, All ideas are considered – none are criticize!

- A group problem-solving process in which each person in the group presents ideas in an open forum.
- Generate and record ideas.
- Keep the mind alert through rapidly paced sessions.
- Develop preliminary ideas.

This stage in the engineering design process requires great creativity and the generation of a number of options for the problem's solution. To accomplish this, one must use an engineering tool known as **BRAINSTORMING**. Brainstorming is an exercise in which groups of individuals work together to generate large numbers of ideas.



Some important rules for brainstorming:

1. When brainstorming, teams focus on the quantity of ideas generated, not the quality. The premise is that from lots of ideas will come a few great ones!
2. Reserve judgment. There are no bad ideas during the brainstorming session, because even the most outlandish concept could inspire someone else to come up with something great. Crazy ideas may also be improved and developed during the collaborative process and become feasible ideas.
3. Record everything. Student designers should document all the ideas generated during brainstorming in

their engineering notebooks.

STEP 5: PROTOTYPE:

Model building is used to gather additional information and test design ideas. In this stage of the process engineers take some of their concepts from the previous step and make **mock-up** versions of them. The goal of this stage is to learn how each concept solution will function in “**real life**” and how it interacts with the real environment. This is also where a designer will start to determine which design concept will work the best. These prototypes are designed to be crude, but functional enough to be educational to the designer. The keyword here is “**LEARN.**” Designers don’t need to prototype everything, just the things they want to work!



Examples:

Realistic drawings or renderings help you visualize what the solution will look like in real life.

Scale models or mock-ups are small, accurate representations of the final product.

3D CAD (computer aided designs) can show objects in action.

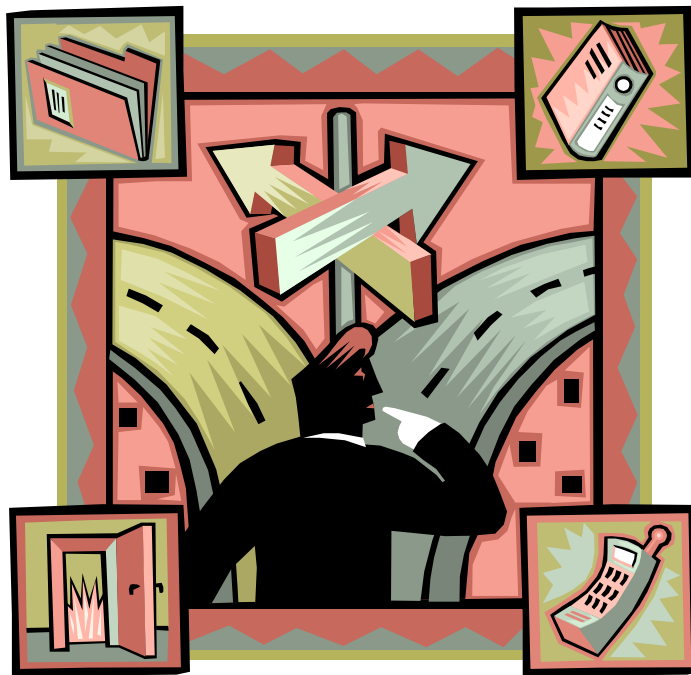
A **prototype** is a working model; it looks and functions just like the finished product

STEP 6: CHOOSE:

Decide on an idea that best meets the criteria, fits within the constraints, and has the least amount of negative characteristics; List the strengths and weaknesses of each alternative.

Optimization – Making improvements to the design idea for better performance or increased safety

Trade-off – Giving up one desirable quality for another (i.e., giving up on using a certain material so that the object is more affordable)



At this point in the process the designer or design group has several different potential solutions for the problem. This step is where the designers will use the lessons learned from their prototyping to determine which concept is best and go forward with it. This is not always an easy decision. Sometimes the “**right**” solution just exposes itself. Other times it is difficult to even define “**best**.” Teams can compare how each concept fulfills the specifications from step three in the process and see if one is significantly better than the others. Designers should look for the simple and **elegant (graceful, neat)** solution.

When choosing concepts as a design group, it is appealing to rely on a vote. However, a vote is nothing but

an unjustified opinion, and an unjustified opinion isn't worth much in an engineering discussion. When it comes to design decisions it is better to talk through things and make a logical decision by building agreement. As discussed previously, it is important to be as quantitative as possible; one shouldn't just say something is **“better”**.

In some cases the decision-making is not made by the whole design group, but by a smaller leadership group or even by a single leader. In this situation the leadership is responsible for impartially comparing each of the alternatives and then choosing the course of action. This method does not always work well, especially if the rest of the design group does not recognize the authority of the leadership and questions the final decision.

- **Review brainstormed information and answer any lingering questions.**
- **Narrow ideas down through a voting process, or by use of a decision matrix.**
- **Decide on final idea, usually through group agreement**

STEP 7: REFINE:

After studying all test data and evaluating design solutions, you may need to make changes.

Now is the time to improve a design – before production begins.

During the improve design phase, you may consider new ideas.



This is the stage of the design process where engineers take their chosen concept and make it into

something more “**real.**” This stage is all about the details. At the end of this stage design teams should have everything necessary so that the full design can be constructed or implemented. Some of the pieces that may be generated during this step are **CAD Models, Assembly Drawings, Manufacturing Plans, Bill of Materials, Maintenance Guides, User Manuals, Design Presentations, Proposals** and more.

- Explore the idea in greater detail with understand sketches.
- Make critical decisions such as material types and manufacturing methods.
- Generate through computer models detailed sketches to further refine the idea.
- Produce working drawings so the idea can be built.
- Make design changes; modify or rebuild the prototype.
- Make refinements until accuracy and repeatability of the prototype’s performance results are consistent.
- Update documentation to reflect changes.

STEP 8: PRESENT

The detailed design must often go through some sort of design review or approval process before it can be implemented. A design review can come in many forms. Some reviews occur as a simple conversation between two of the designers. Some reviews are done as a meeting of the Design Group where they recap and check the work that has been completed and try to find any errors.

Common questions from a Design Review:

- Why was it done this way?
- Did you think of doing it a different way?
- Why did you rule out other alternatives?
- Does it fulfil our requirements and specs?
- How can we make it function better?
- How can we make it weight less?
- How can we make it faster?
- How can we make it more **robust (Tough, strong)**?
- How can we make it smaller?
- How can we make it simpler?
- How can we make it more efficient?
- How can we make this cheaper?
- How can we make this easier to construct?

Cost-Benefit Analysis

When reviewing a design it is sometimes important to perform a cost-benefit analysis. When performing this kind of analysis, a designer will look at an aspect of the design to see two things: what it costs, and how much benefit it provides. "Cost" does not always refer to money. A feature's cost refers to the resources that must be diverted to it; these could be time, personnel, money,

STEP 9: IMPLEMENT

Once the design has been completed and approved, it needs to be implemented. Depending on the nature of the problem being solved, the solutions to the problem could vary wildly. Depending on the type of solution, the implementation could also vary. The implementation could consist of using a new process that was designed, or it could consist of following a manufacturing plan and producing some physical object. For instance, in the example of the elevator riddle discussed previously, there are a number of solutions proposed and these solutions all took different forms.

If an engineer is trying to solve how to tie shoes faster, they are designing a process for tying shoes. Their implementation would be to tell people about their new shoe-tying procedure. If an engineer is trying to design a better shoe, their implementation would be the manufacture and sale of the new shoes. Implementations can take many forms.

STEP 10: TEST:

Models of design solutions must be tested and important questions must be answered during the evaluation. In this stage engineers will test their implemented solution to see how well it works. The implementation must be **reviewed to see what worked, what didn't, and what should be improved**. The testing procedures and results should be well documented. The main thing that should be determined during this stage in the process is whether or not the final implementation performs as expected and fulfills the specifications.

So what happens if the design is not found to be acceptable? The design group must find a way to make it acceptable! The design group needs to come up with a plan of improvement to get the solution up to

execute (complete, finish). Their plan may include starting over and going back to the drawing board to create a new plan entirely.

- Design experiments and test the prototype in controlled and working environments.
- Gather performance data; analyze and check results against established criteria.
- Conduct a formal evaluation to flesh out areas of concerns, identify shortcomings, and establish any need for redesign work
- Is it safe for people and the environment?
- Is it comfortable?
- Is it affordable?
- Is it aesthetically pleasing (does it look good)?
- Will it last as long as it needs to?
- Does it meet the criteria and constraints?
- Does it work?



STEP 11: ITERATE

There were several mentions steps during the design process of repeating certain steps multiple times until an acceptable result is achieved. This act of repetition is known as “iteration.” This iteration results in a better end result and is one of the most important parts of design; this is why it is said that design is an iterative process! One important thing designers should note is that iteration does not just take place at the end of the process, it will happen during EVERY stage in the process..

The greater the number of iterations a design goes through, the better the final result will be, so why would a designer ever stop iterating? At first each repeat will result in large improvements to the design, but the

longer the process goes on, the fewer problems there will be to fix and the smaller the improvements. This is known as the law of diminishing returns. Improvements to the design will get smaller with each successive improvement. Eventually a designer may decide that the next improvement is too small to be worth the effort, and the design is good enough. Some designers take longer to call a design "finished" than others because they strive for perfection. Unfortunately, in the real world it is not always possible to achieve perfection. In the real world, if an engineering contractor misses a deadline, they may not get another chance, and they may have trouble finding other contracting jobs!

Unit-01/Lecture 05

Simplified Iteration model

What is simplified iteration model?

ITERATION: There were several mentions steps during the design process and repeating certain steps multiple times until an acceptable result is achieved. This act of repetition is known as "iteration." This iteration results in a better end result and is one of the most important parts of design; this is why it is said that design is an iterative process. One important thing designers should note is that iteration does not just take place at the end of the process, it will happen during every stage in the process.

The design process is NOT a linear thing; it is common to jump from step to step. Sometimes a design team may jump back and forth between steps one and two several times before ever moving onto step three. Design teams should NOT be afraid of going backward in the process. At any step in the process, a design team may find themselves skipping backwards to any other step. The ultimate goal is to create the best design possible by improving it over and over again. Repeat parts of the process to improve the final result.

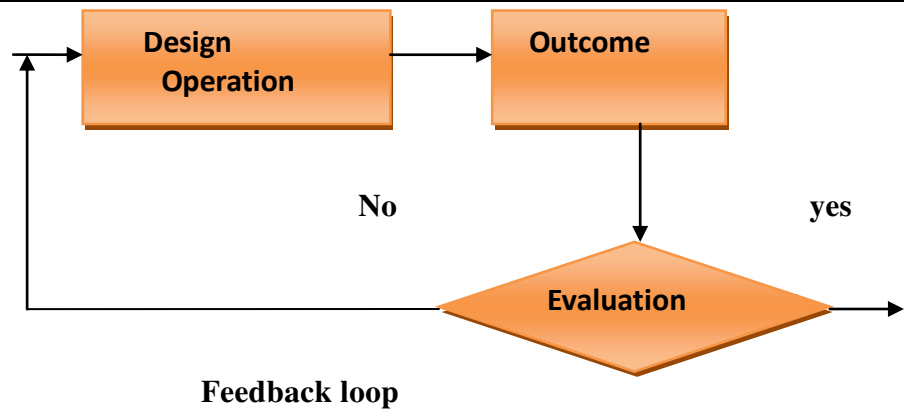
The greater the number of iterations a design goes through, the better the final result will be, so why would a designer ever stop iterating? At first each repeat will result in large improvements to the design, but the longer the process goes on, the fewer problems there will be to fix and the smaller the improvements. This is known as the law of *diminishing returns*. Improvements to the design will get smaller with each successive improvement. Eventually a designer may decide that the next improvement is too small to be worth the effort, and the design is good enough.

Some designers take longer to call a design "finished" than others because they **strive** (**Struggle**) for perfection. Unfortunately, in the real world it is not always possible to achieve perfection.

General
Information



Specific



When to use iterative model:

- When the project is big.
- Major requirements must be defined; however, some details can **evolve (Change)** with time.
- Requirements of the complete system are clearly defined and understood.

Need of Iteration:

Determining the need to iterate is important to improve the design process on cost, time, and quality, but currently there is no categorization of iterations **conducive (helpful, favorable, beneficial)** to this goal. After exploring the possible causes and attempts to address them, we propose to classify iterations as rework, design, or behavioral. This framework suggests that design teams should try to eliminate rework iterations, perform design iterations without skipping **abstraction (Idea, concept, thought)** levels, and do behavioral iterations in parallel.

Or

Iteration model: The basic idea behind this method is to develop a system through **repeated cycles (iterative)** and in smaller portions at a time (incremental), to take advantage of what was learned during development of earlier parts or versions of the system. **Learning comes from both the development and use of the system**, where possible key steps in the process start with a simple implementation of a subset and iteratively enhance the evolving versions until the full system is implemented. At each iteration design modifications are made and new functional capabilities are added.

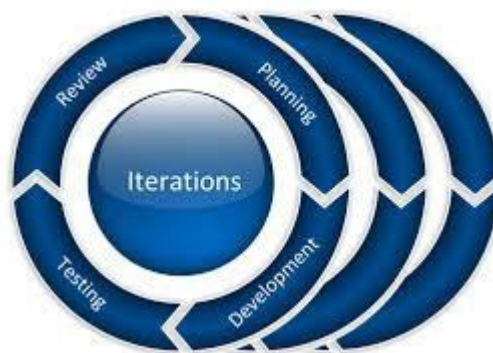
The procedure itself consists of the initialization step, the iteration step, and the Project Control List. The initialization step creates a base version of the system. The goal for this initial implementation is to create a product to which the user can react. It should offer a sampling of the key aspects of the problem and provide a solution that is simple enough to understand and implement easily. To

guide the iteration process, a project control list is created that contains a record of all tasks that need to be performed. It includes such items as new features to be implemented and areas of redesign of the existing solution. The control list is constantly being revised as a result of the analysis phase

The iteration involves the redesign and implementation of iteration is to be simple, straightforward, and modular, supporting redesign at that stage or as a task added to the project control list. The level of design detail is not dictated by the iterative approach. In a light-weight iterative project the code may represent the major source of documentation of the system; however, in a critical iterative project a formal Document may be used. The analysis of iteration is based upon user feedback, and the program analysis facilities available. It involves analysis of the structure, modularity, usability, reliability, efficiency, & achievement of goals. The project control list is modified in light of the analysis results.

Incremental development slices the system functionality into increments (portions). In each increment, a slice of functionality is delivered through cross-discipline work, from the requirements to the deployment. The Unified Process groups increments/iterations into phases: inception, elaboration, construction, and transition.

Each of the phases may be divided into 1 or more iterations, which are usually time-boxed rather than feature-boxed. Architects and analysts work one iteration ahead of developers and testers to keep their work-product backlog full.



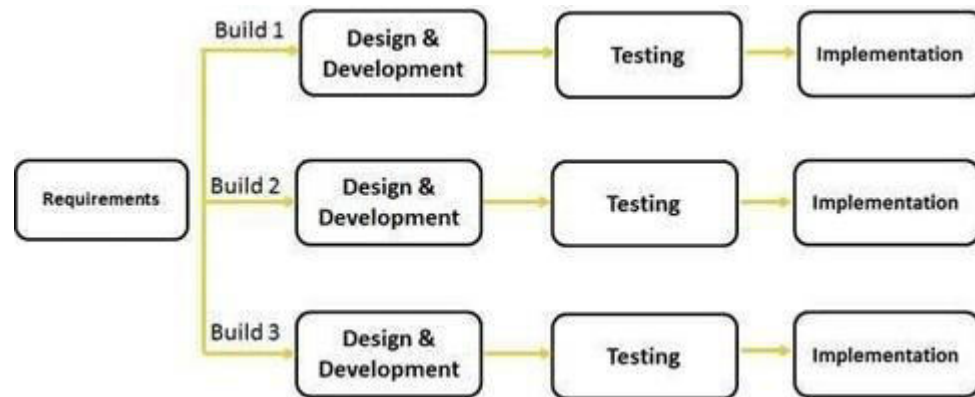
Simplified Iteration model:

An iterative life cycle model does not attempt to start with a full specification of requirements. Instead, development begins by specifying and implementing just part of the software, which is then reviewed in order to identify further requirements. This process is then repeated, producing a new version of the software at the end of each iteration of the model.

Iterative Model design

Iterative process starts with a simple implementation of a subset of the software requirements and iteratively enhances the evolving versions until the full system is implemented. At each iteration, design

modifications are made and new functional capabilities are added. The basic idea behind this method is to develop a system through repeated cycles (iterative) and in smaller portions at a time (incremental).



Iterative and Incremental development is a combination of both iterative design or iterative method and incremental build model for development. "During design, more than one iteration of the development cycle may be in progress at the same time." and "This process may be described as an "evolutionary acquisition" or "incremental build" approach."

In incremental model the whole requirement is divided into various builds. During each iteration, the development module goes through the requirements, design, implementation and testing phases. Each subsequent release of the module adds function to the previous release. The process continues till the complete system is ready as per the requirement. The key to successful use of an iterative development lifecycle is rigorous validation of requirements, and verification & testing of each version of the software against those requirements within each cycle of the model. As the design evolves through successive cycles, tests have to be repeated and extended to verify each version of the design.

Advantages of Iterative model:

- In iterative model we can only create a high-level design of the application before we actually begin to build the product and define the design solution for the entire product. Later on we can design and built a skeleton version of that, and then evolved the design based on what had been built.
- In iterative model we are building and improving the product step by step. Hence we can track the defects at early stages. This avoids the downward flow of the defects.
- In iterative model we can get the reliable user feedback. When presenting sketches and blueprints of the product to users for their feedback, we are effectively asking them to imagine how the product will work.
- In iterative model less time is spent on documenting and more time is given for designing.

Disadvantages of Iterative model:

- Each phase of an iteration is **rigid (severe, strict)** with no overlaps
- Costly system design issues may arise because not all requirements are gathered up front for the

entire lifecycle

Unit 01/ lecture-6

Various ways to think about design like visualization, photography

What is visualization?

The word is problematic, and there have been very few definitions that try to define this field we are working in. More importantly: what is not visualization? It is easy to argue that anything visual is visualization in some way – but does that mean anything? Here is a definition of visualization and a few examples to illustrate the different criteria

The following are three minimal criteria that any visualization has to fulfil to be considered **pragmatic (practical, realistic, sensible)** visualization. A good visualization certainly has to do more, but these criteria are useful to draw the line between a lot of things that are often called visualization and what we consider visualization in this field.

- **Based on (non-visual) data:** visualization's purpose is the communication of data. That means that the data must come from something that is abstract or at least not immediately visible (like the inside of the human body). These rules out **photography and image processing**. Visualization transforms from the invisible to the visible.
- **Produce an image:** It may seem obvious that visualization has to produce an image, but that is not always so clear. Also, the visual must be the primary means of communication; other modalities can only provide additional information. If the image is only a small part of the process, it is not visualization.

The result must be **readable** and **recognizable (identifiable)**. The most important criteria are that the visualization must provide a way to learn something about the data. Any transformation of non-trivial data into an image will leave out information, but there must be at least some relevant aspects of the data that can be read. The visualization must also be recognizable as one and not pretend to be something else. Classifications of visualization are often based on technical criteria, and leave out artistic ways of visualizing information. Understanding the differences between information visualization and other forms of visual communication provides important insights into the way the field works, though, and also shows the path to new approaches. We propose a classification of several types of information visualization based on aesthetic criteria. The notions of artistic and pragmatic visualization are introduced, and their properties discussed. Finally, the idea of visualization criticism is proposed, and its rules are laid out. Visualization criticism bridges the gap between design, art, and technical/pragmatic information visualization. It guides the view away from implementation details and single mouse clicks to the meaning of visualization. A

good part of the confusion about visualization comes from the fact that there is no clear or generally accepted definition of visualization. Such a definition would clearly vary between fields, but at least within one field (like computer science, design, illustration, etc.), it needs to be consistent. Also, by understanding the differences between definitions in different fields, we can identify elements that help in building the bridge between them. These are not just the similarities though, but also the differences that require investigation.

Examples for visualization are: architectural visualization, **terrain(land,ground,territory)** visualization, 3D medical/volume visualization, 2D or 3D flow visualization, flow topology visualization, presentation graphics, abstract data visualization, information dashboards, music visualization, photomontage or collage, traffic signs, traffic signals, sign language, icons, visualizing oneself in a different job/situation, visualization of concepts, drawing fractals, etc.

These are clearly very different types of visual communication, and many of them are not generally considered visualization; others are, but only by specific groups. Why is that? And how can we differentiate between them in a way that is not **ad hoc (unplanned, informal)**? We consider the following criteria to be a minimal set of requirements for any visualization. The remainder of this discussion will concentrate on information visualization, but these criteria apply equally to scientific visualization. It is based on (non-visual) data. The data to be visualized must come from outside the program, and the program must be able (at least in principle) to work on different data sets. Also, visualization is not image processing or photography; if the source data is an image and is used as an image in the result, it is not being visualized. It produces an image. Clearly, each visualization has the goal of producing one or more images from the data, and the visual must be the primary means of communicating the data. Other media can be part of visualization, but the visualization must be able to stand on its own.

The result is readable and recognizable. There are many ways to transform data into images, most of which do not allow the viewer to understand the underlying data. Visualization must produce images that are readable by a viewer, even if that requires training and practice. Visualization images must also be recognizable as such, and not appear to be something else. The use of additional elements (or even “eye candy”) is certainly possible, but must not take **precedence (priority, preference)** over the communication goals of the visualization. Visualizations also have other properties like interaction, visual efficiency, etc. And while these are certainly important, the above criteria appear to be sufficient to precisely define information visualization the way it is generally used in its technical sense.

Pragmatic Visualization

Pragmatic visualization is what we term the technical application of visualization techniques to analyze data. The goal of pragmatic visualization is to **explore (investigate, discover, look at, survey)**, analyze, or present information in a way that allows the user to thoroughly understand the data. Card et al. describe this process as knowledge crystallization, and the recent initiatives in visual analytics have **used the slogan “Detecting the Expected, Discovering the Unexpected”**. Visual efficiency is of course a key criterion for work in visualization. The goal is to produce images that convey the data as quickly and effortlessly as possible. User studies are conducted to measure the speed and accuracy of users, and to compare different methods and tasks

Artistic (creative, imaginative) Visualization:

The goal of artistic visualization is usually to communicate a **concern (worry, fear, unease)**, rather than to show data. The data is used as the basis, the raw material. It also provides a proof that the concern in question is, in fact, real. This is perhaps why artists call this visualization: the underlying problem may not be visible, but is made visible through the piece. Visual efficiency does not play a role in artistic visualization, quite the contrary. The goal is not to **enable (allow)** the user to read the data, but to understand the basic concern. In many ways, this step is the opposite of pragmatic visualization: rather than making the data easily readable, it is transformed into something that is visible and interesting, but that must still be readily understood. In other words, artistic visualization has a sublime quality that pragmatic visualization does not have. Data collection is often an integral part of a visualization art piece. The fact that the data exists at all can be used to create awareness, and data flowing in real time can make the piece “live”.

DESIGN VERSUS SCIENTIFIC METHOD

The Scientific Method – What is it?

The Scientific Method is a process used to validate observations while minimizing observer **bias** (**partiality**). Its goal is for research to be conducted in a fair, **unbiased (impartial)** and repeatable manner.

The Scientific Method – What it's Not.

The Scientific Method is a process for explaining the world we see. It is:

- **Not** a formula
- **Not** Magic

There are many scientific disciplines that address topics from medicine and astrophysics to agriculture and zoology. In each discipline, modern scientists use a process called the "Scientific Method" to advance their knowledge and understanding. This method describes the scientists use to conduct research, describe and explain nature, ultimately trying to prove or disprove theories. Scientists all over the world conduct research using the Scientific Method

The scientific research efforts, analyses, and **subsequent** (**following, successive, later**) information distributed by Cooperative department are driven by careful review and combination of significant scientific research

DEFINITIONS:

It is important to understand three important terms before describing the Scientific Method.

a) Hypothesis – This is a statement made by a researcher that is a working assumption to be tested and proven. It is something "considered true for the purpose of investigation"

Example: "The earth is round."

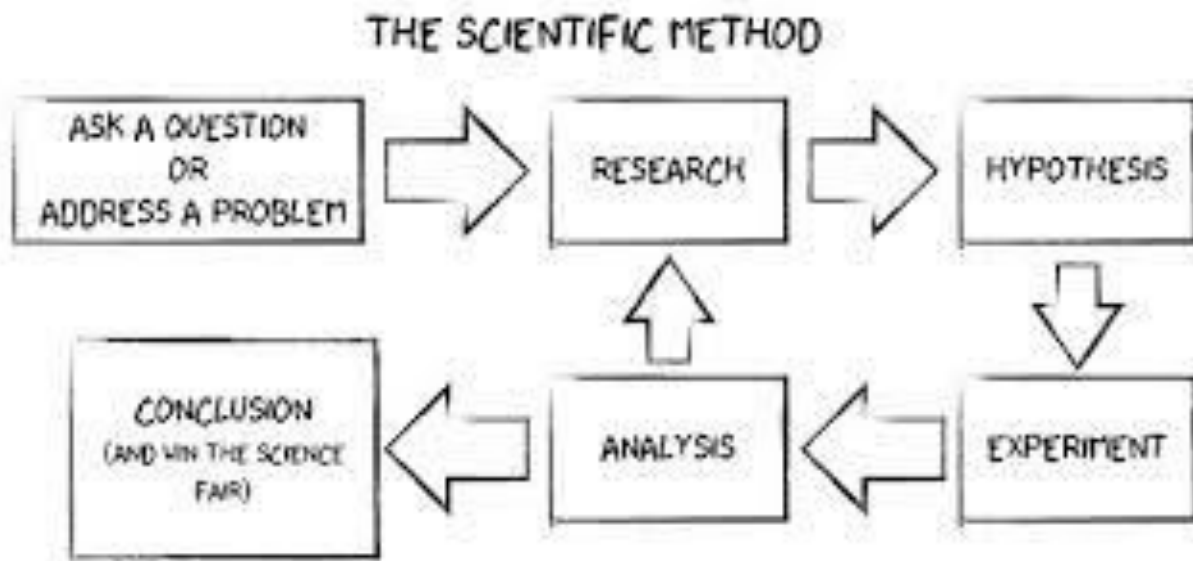
b) Theory – general principles drawn from facts that explain observations and can be used to predict new events.

Example: Newton's theory of gravitation or Einstein's theory of relativity.

c) Falsifiable/ Null Hypothesis – To prove to be false, The hypothesis that is generated must be able to be tested, and either accepted or rejected. Scientists make hypotheses that they want to *disprove* in order that they may prove the working assumption describing the observed phenomena. This is done by declaring the statement or hypothesis as falsifiable. So, we would state the above hypothesis as "the earth is not round," or "the earth is square" making it a working statement to be disproved.

2 Process

The Scientific Method is not a formula, but rather a process with a number of sequential steps designed to create an explainable outcome that increases our knowledge base. This process is as follows:



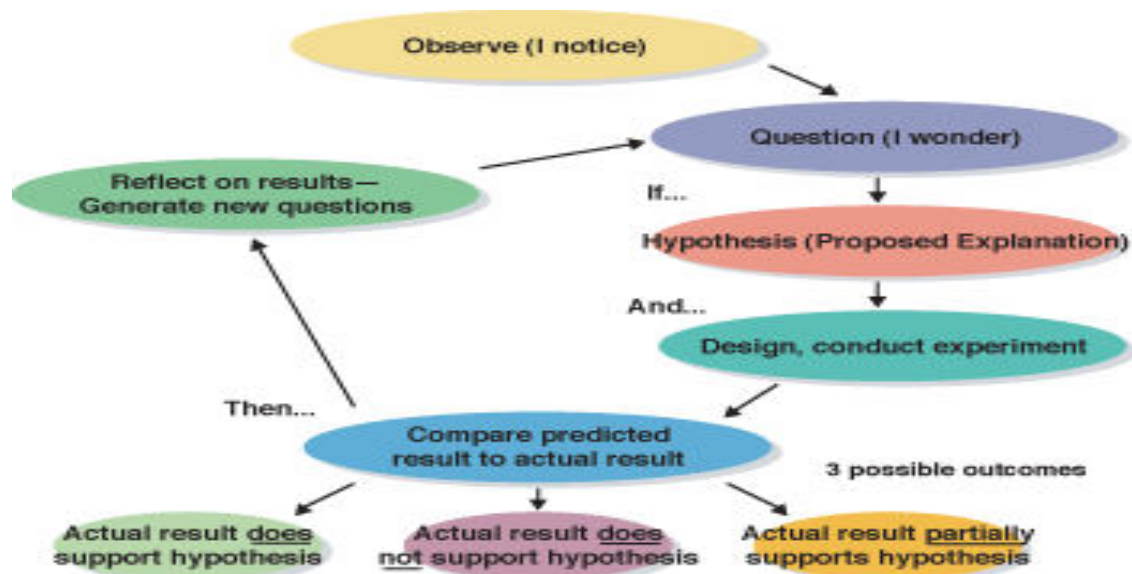
STEP 1. Make an OBSERVATION - gather and understand information about an event, phenomenon, process, or an exception to a previous observation, etc.

STEP 2. Define the PROBLEM – ask questions about the observation that is **relevant (significant, important)** and testable. Define the null hypothesis to provide fair results.

STEP 3: Form the HYPOTHESIS – create an explanation, for the observation that is testable and falsifiable.

STEP 4: Conduct the EXPERIMENT – set up and perform an experiment to test the hypothesis.

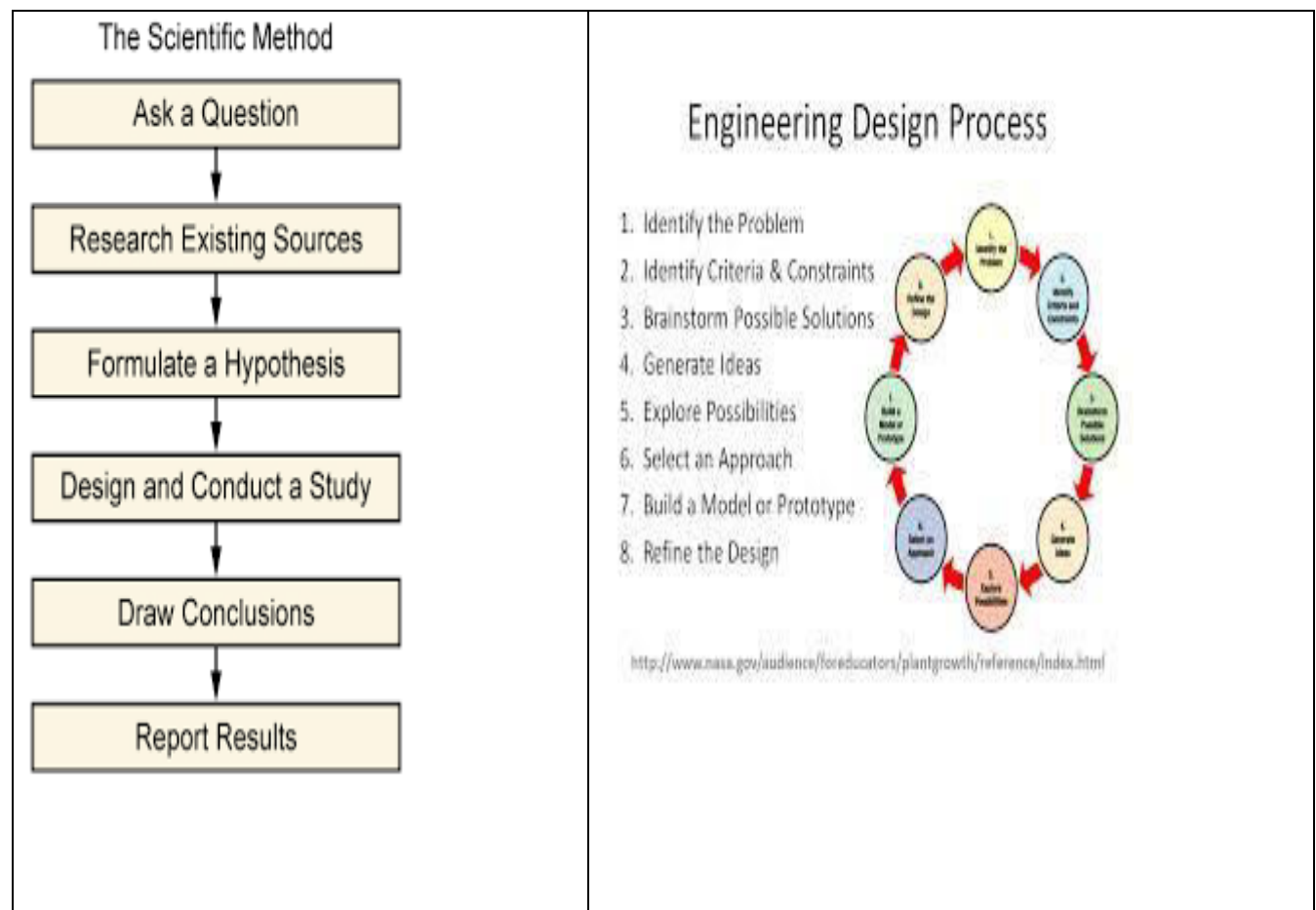
STEP 5: Derive a THEORY – create a statement based in the outcome of the experiment that explains the observation and predicts the likelihood of future observations.



What do we need to consider when using the Scientific Method?

The Scientific Method requires that we ask questions and perform experiments to prove or disprove questions in ways that will lead to **unbiased (impartial, balanced)** answers. Experiments must be well designed to provide accurate and **repeatable (precise)** results. If we test hypotheses correctly, then we can prove the cause of a phenomenon and determine the **likelihood (probability)** of the events to happen again. This provides predictive power. The Scientific Method enables us to test a hypothesis and distinguish between the correlation of two or more things happening in association with each other and the actual cause of the phenomenon we observe.

In summary, the Scientific Method produces answers to questions posed in the form of a working hypothesis that enables us to derive theories about what we observe in the world around us. Its power lies in its ability to be repeated, providing unbiased answers to questions to derive theories. This information is powerful and offers opportunity to predict future events and phenomena.



A Comparison of the Scientific Method and the Design Process:

Most projects will be experimental in nature using the scientific method and will fall into the experimental category. However, if the objective of your project is to invent a new device, procedure, then your project may fall into the design category.

Scientific Method	Design Process
Identify and write a testable question	Define a need or real world problem
Perform background research	Perform background research
Formulate a hypothesis and identify variables	Establish design criteria
Design an experiment, establish procedure	Prepare preliminary(beginning, introduction) , design
Test the hypothesis by conducting the experiment	Build and test a prototype
Analyze the results and draw a conclusion	Test and redesign as necessary
Present results	Present results
<p>1. IDENTIFY AND WRITE A TESTABLE QUESTION</p> <p>Decide what question you want to answer or what Problem you want to solve. A testable hypothesis is answered through observations or experiments that provide evidence. Be sure to have adequate technical and financial resources available to Conduct our research. State your objective clearly in writing.</p> <p>2. PERFORM BACKGROUND RESEARCH</p> <p>Before you begin your project, you must become as Knowledgeable as you can about your topic and about other research that has been done on that topic. You may use books, scientific literature, the Internet, or interviews with scientists or other knowledgeable people. This research not only helps you get ready to conduct your experiment</p>	<p>1. DEFINE A NEED</p> <p>Instead of stating a question, state a need. Can you describe in detail a problem that Your design will solve? Does your research Relate to a real world need?</p> <p>2. PERFORM BACKGROUND RESEARCH</p> <p>For a design project, the background research may include:</p> <ul style="list-style-type: none"> • A complete description of your target User • Information about the science behind your design area • Answers to research questions about user needs • Information about products that meet similar needs

3. FORMULATE A HYPOTHESIS AND IDENTIFY VARIABLES

Based on the background research, write a statement that predicts the outcome of the experiment. Many hypotheses are stated in an “If... then” statement where the “If” statement pertains to the independent variable, and the “then” statement pertains to the dependent variable. **For example:** ‘If plants are grown under various colors of light, then the plants grown under the blue and red lights will show the greatest increase in Biomass.’

4. DESIGN AN EXPERIMENT, ESTABLISH A PROCEDURE

Decide what data you need to meet your research objective and how you will collect it. Be sure to consider possible **hazards (danger)** in your experimental approach and decide how you can conduct your research safely. In addition, there are special rules concerning the use of human and non-human error in your research. Be sure to consult these

- Research about design criteria
- What existing solutions are out there already, and how well do they solve the problem?

You may use books, scientific literature, the Internet, or interviews with scientists or other Knowledgeable people. This research not only helps you get ready to conduct your experiment

3. ESTABLISH DESIGN CRITERIA

Engineering Projects: Decide what features Our design must have, for example: size, weight, cost, performance, power, etc. Perhaps include a table showing how each Design criterion will be addressed by the features of the product being designed.

4. PREPARE A PRELIMINARY DESIGN

Engineering projects should have a materials list, programming and mathematical projects Do not need a materials list. Projects should include a block diagram, flowchart or sketch of the design that shows all of the parts or Subsystems of the design. Describe how all Of the parts of the design will work together.

rules before finalizing your experimental design.

In order to obtain valid experimental results,

consider the following items when designing the experiment:

- Make sure the quantity and quality of data you Collect provides a reasonable assurance that your research objectives will be met.
- Identify all significant variables that could affect your results.
- To the best of your ability, control any significant variables not manipulated in your experiment.
- Include a control or comparison group in your experimental design.

Be sure to establish deadlines for completing the

Different phases of your research. These phases might include building equipment, collecting data, analyzing the results, writing the report and

Construction your display board.

5. CONDUCT THE EXPERIMENT

Follow your experimental design to collect data and make observations. Be sure to keep a log as you conduct the experiment to record your data, any problems you encounter, how you addressed them, and how these problems might have affected your data. This log will be used when you write your report.

Keep these points in mind when conducting your experiment:

- If you get results that seem wrong or inconsistent, do not just throw them out. Try to figure out what happened. Maybe the data is correct and your hypothesis is imperfect. Try to explain these “outliers” in your Data, Analysis, and Discussion section.

5. BUILD AND TEST A PROTOTYPE

(Programs, algorithms, and mathematical models may be considered prototypes) When others are conducting their experiment, investigators doing an engineering, computer programming, or mathematics project should be constructing and testing a prototype of their best design.

For example: you may involve targeted users in your testing to get feedback on your design; or some projects may analyze data Sets.

- Don't get discouraged when you encounter problems. Scientists regularly have to repeat experiments to get good, reproducible results. Sometimes you can learn more from a failure than you can from a success.

6. ANALYZE THE RESULTS AND DRAW CONCLUSIONS

Make sufficient calculations, comparisons and/or graphs to ensure the reliability and repeatability of Your experiment. In what way does this analysis prove or disprove your hypothesis. What conclusion can you draw from this analysis?

7. REPORT THE RESULTS

Your report should provide all the information necessary for someone who is unfamiliar with your Project to understand what you were trying to carry out, how you did it, and whether you succeeded. It should be detailed enough to allow Someone else to duplicate your experiment exactly. Be sure to include charts and graphs to summarize your data. The report should not only talk about your successful experimental attempts, but also the problems you encountered and how you solved Them. Be sure to explain what new knowledge has been gained and how

6. REDESIGN AND RETEST

Evidence that changes in design were made to better meet the performance criteria Established at the beginning of the project. Test results may be included in tables, if Applicable. Data analysis/validation may Also be a part of this step.

7. REPORT THE RESULTS

Your report should provide all the information necessary for someone who is unfamiliar with your project to understand what you were trying to accomplish, how you did it, and whether you succeeded. The report should not only talk about your successful design attempts, but also the problems you encountered and how you solved them. Be sure to explain what new knowledge has been gained and how it leads to further questions.

it leads to further questions.	
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Unit-01/Lecture 10

PROBLEM SOLVING METHODOLOGY

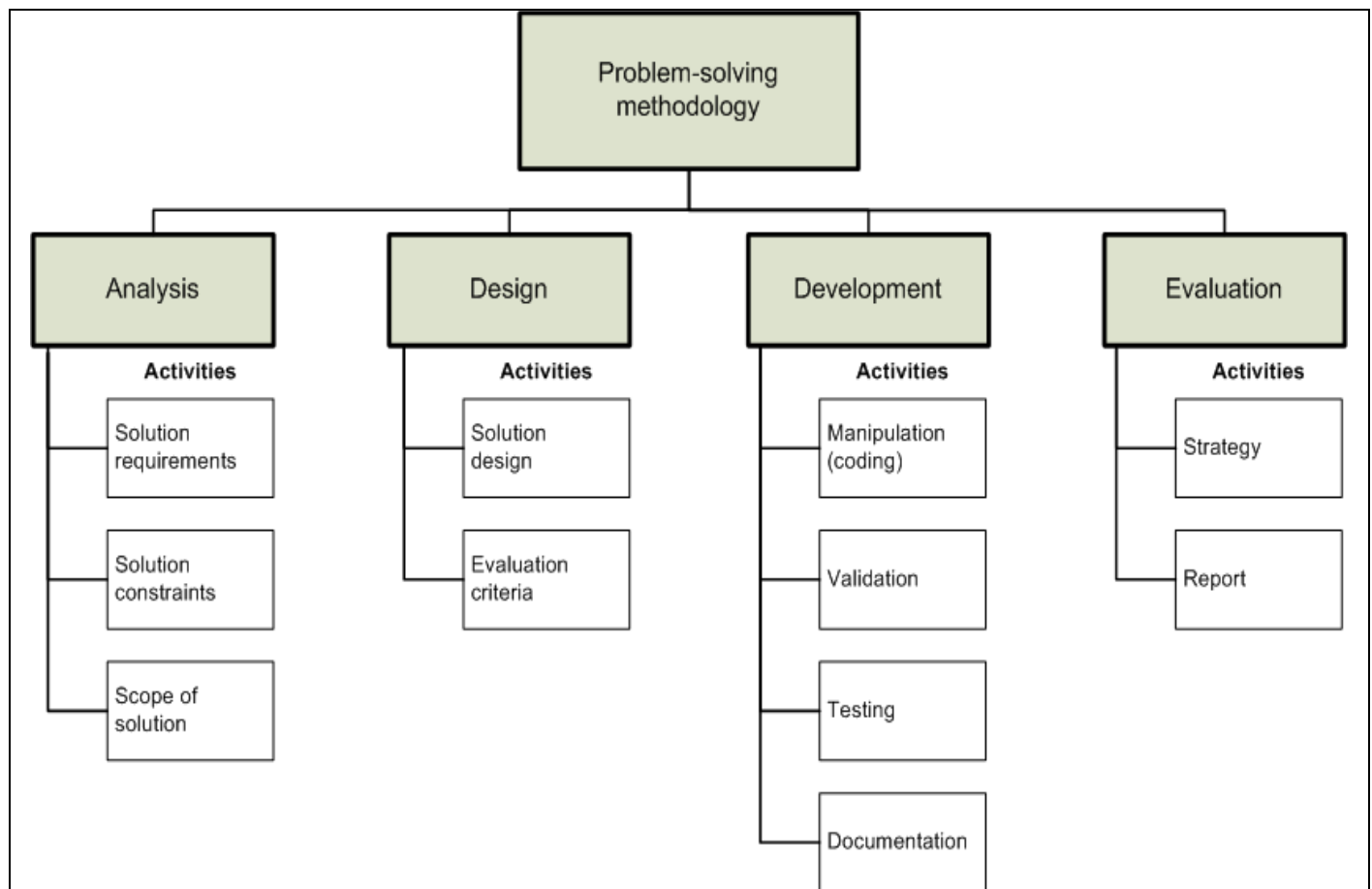
Problem solving methodology:

Introduction:

Designing can be approached as a problem to be solved. A problem-solving methodology that is useful in design consists of the following steps.

- Definition of the problem
- Gathering of information
- Generation of alternative solutions
- Evaluation of alternatives and decision making
- Communication of the results

EXAMPLE: it is a mental process in psychology and a computerized process in science. It consists of using generic methods, in an orderly manner, for finding solutions to problems. Some of the problem-solving techniques developed and used in artificial intelligence, computer science, engineering, mathematics, medicine, etc. are related to mental problem-solving techniques studied in psychology



Design is a methodology for systematically creating solutions to information problems. As applied in this study design the methodology comprises four stages: **analysis, design, development** and **evaluation**.

1) Analysis involves:

a) Determining the solution requirements.

- i) What information does the solution have to provide?
- ii) What data is needed to produce the information?
- iii) What functions does the solution have to provide?
- iv) These requirements can be classified as being functional, namely what the solution is required to do, and non-functional
- v) Which describes the quality the solution should possess, such as user-friendliness, reliability, portability, robustness, maintainability?
- vi) Tools to assist in determining the solution requirements include context diagrams, data flow diagrams and use cases.

b) Identifying the constraints on the solution.

- i) What conditions need to be considered when designing a solution?
- ii) Typical constraints include cost, speed of processing, requirements of users, legal

requirements, security, and compatibility, level of expertise, capacity, and availability of equipment.

c) Determining the scope of the solution.

- i) What can the solution do?
- ii) What can't the solution do?
- iii) What are the benefits of the solution to the user?
- iv) The scope states the boundaries or parameters of the solution. Benefits can be stated in terms of their efficiency and effectiveness.

Analysis typically answers the 'what questions' - what will solve a problem, given particular circumstances? What benefits will the solution bring to the user?

2) Design involves:

a) Planning how the solution will function:

- i) The solution design typically involves identifying what specific data is required and how the data will be named, structured, validated and manipulated.
- ii) Typical design tools for this purpose include data dictionaries and data structure diagrams, flowcharts, pseudo code, object descriptions.
- iii) Solution design also involves, where suitable, showing how the various components of a solution relate to one another, for example web pages, style sheets, scripts; queries, forms, reports; modules, procedures, functions.
- iv) Typical design tools used to show relationships include storyboards, site maps, entity-relationship diagrams, data flow diagrams, structure charts, ladder charts, context diagrams, use cases.
- v) This typically involves identifying the position of text, images and graphics, font sizes, colours and text enhancements. Design tools used for this purpose include layout diagrams, annotated diagrams/mocks up.

b) Determining the evaluation criteria.

- i) What measures will be used to judge whether or not the solution requirements have been met? These criteria should relate to the solution requirements identified in the analysis

stage.

3) Development involves:

- a) **Manipulating:** data to 'build' or create the solution following initial designs. Where suitable, internal documentation is also written, which documents the functioning of the solution.
- b) **Validation:** to check for the reasonableness of data being input. Validation can be both manual and electronic. Proof reading is a manual technique and it occurs when data is entered directly into the solution and remains fixed. When the validation process has been built into the solution (electronic technique), then its effectiveness is determined through the testing activity.
- c) **Testing:** whether the solution does what it was intended to do. This activity typically involves:
 - establishing what tests will be conducted
 - determining what test data, if any, will be used
 - determining expected results
 - conducting the test
 - recording the actual results
 - Correcting any identified errors.

d) Writing documentation to support the use of the solution.

4) Evaluation involves:

- i) **Determining a strategy:** for finding out the amount to which the solution meets the required needs. Typically this would include specifying a timeline, outlining what data will be collected and by what methods and techniques, and how the data relates to the criteria, which were developed in the designing stage.
- ii) **Reporting:** on the amount to which the solution meets the requirements of the user. It usually takes place after the solution has been used by the user/client and is based on the criteria developed in the designing stage.

The following techniques are usually called problem-solving strategies

- a) **Abstraction:** solving the problem in a model of the system before applying it to the real system
- b) **Analogy:** using a solution that solves an analogous problem

- c) **Brainstorming:** (especially among groups of people) suggesting a large number of solutions or ideas and combining and developing them until an optimum solution is found
- d) **Divide and conquer:** breaking down a large, complex problem into smaller, solvable problems
- e) **Hypothesis testing:** assuming a possible explanation to the problem and trying to prove (or, in some contexts, disprove) the assumption
- f) **Lateral thinking:** approaching solutions indirectly and creatively
- g) **Means-ends analysis:** choosing an action at each step to move closer to the goal
- h) **Method of focal objects:** manufacture apparently non-matching characteristics of different objects into something new
- i) **Morphological analysis:** calculate the output and interactions of an entire system
- j) **Proof:** try to prove that the problem cannot be solved. The point where the proof fails will be the starting point for solving it
- k) **Reduction:** transforming the problem into another problem for which solutions exist
- l) **Research:** employing existing ideas or adapting existing solutions to similar problems
- m) **Root cause analysis:** identifying the cause of a problem
- n) **Trial-and-error:** testing possible solutions until the right one is found