NEHRU COLLEGE OF ENGINEERING AND RESEARCH CENTRE
(NAAC Accredited)
(Approved by AICTE, Affiliated to APJ Abdul Kalam Technological University, Kerala)

DEPARTMENT OF MECHATRONICS ENGINEERING

COURSE MATERIAL

EST 200 DESIGN ENGINEERING

VISION OF THE INSTITUTION

To mould true citizens who are millennium leaders and catalysts of change through excellence in education.

MISSION OF THE INSTITUTION

NCERC is committed to transform itself into a center of excellence in Learning and Research in Engineering and Frontier Technology and to impart quality education to mould technically competent citizens with moral integrity, social commitment and ethical values.

We intend to facilitate our students to assimilate the latest technological know-how and to imbibe discipline, culture and spiritually, and to mould them in to technological giants, dedicated research scientists and intellectual leaders of the country who can spread the beams of light and happiness among the poor and the underprivileged.

ABOUT DEPARTMENT

- Established in: 2013
- Course offered: B.Tech Mechatronics Engineering
- Approved by AICTE New Delhi and Accredited by NAAC
- Affiliated to A P J Abdul Kalam Technological University.

DEPARTMENT VISION

To develop professionally ethical and socially responsible Mechatronics engineers to serve the humanity through quality professional education.

DEPARTMENT MISSION

1) The department is committed to impart the right blend of knowledge and quality education to create professionally ethical and socially responsible graduates.

2) The department is committed to impart the awareness to meet the current challenges in technology.

3) Establish state-of-the-art laboratories to promote practical knowledge of mechatronics to meet the needs of the society

PROGRAMME EDUCATIONAL OBJECTIVES

I. Graduates shall have the ability to work in multidisciplinary environment with good professional and commitment.

II. Graduates shall have the ability to solve the complex engineering problems by applying electrical, mechanical, electronics and computer knowledge and engage in lifelong learning in their profession.

III. Graduates shall have the ability to lead and contribute in a team with entrepreneur skills, professional, social and ethical responsibilities.

IV. Graduates shall have ability to acquire scientific and engineering fundamentals necessary for higher studies and research.

PROGRAM OUTCOME (PO'S)

Engineering Graduates will be able to:

PO 1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 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.

PO 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.

PO 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.

PO 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.

PO 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.

PO 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.

PO 8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 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.

PO 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.

PO 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 OUTCOME(PSO'S)

PSO 1: Design and develop Mechatronics systems to solve the complex engineering problem by integrating electronics, mechanical and control systems.

PSO 2: Apply the engineering knowledge to conduct investigations of complex engineering problem related to instrumentation, control, automation, robotics and provide solutions.

COURSE OUTCOMES

CO 1	Explain the different concepts and principles involved in design engineering.
CO 2	Apply design thinking while learning and practicing engineering.
CO 3	Develop innovative, reliable, sustainable and economically viable designs incorporating knowledge in engineering.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	2	1					1			1		
CO 2		2				1		1				2
CO 3			2			1	1		2	2		1

Note: H-Highly correlated=3, M-Medium correlated=2, L-Less correlated=1

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`

Syllabus

Sustainability- need and concept, technology and sustainable development-Natural resources and their pollution, Carbon credits, Zero waste concept. Life Cycle Analysis, Environmental Impact Assessment studies, Sustainable habitat, Green buildings, green materials, Energy, Conventional and renewable sources, Sustainable urbanization, Industrial Ecology.

Module 1

Sustainability: Introduction, concept, evolution of the concept; Social, environmental and economic sustainability concepts; Sustainable development, Nexus between Technology and Sustainable development; Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs), Clean Development Mechanism (CDM).

Module 2

Environmental Pollution: Air Pollution and its effects, Water pollution and its sources, Zero waste concept and 3 R concepts in solid waste management; Greenhouse effect, Global warming, Climate change, Ozone layer depletion, Carbon credits, carbon trading and carbon foot print, legal provisions for environmental protection.

Module 3

Environmental management standards: ISO 14001:2015 frame work and benefits, Scope and goal of Life Cycle Analysis (LCA), Circular economy, Bio-mimicking, Environment Impact Assessment (EIA), Industrial ecology and industrial symbiosis.

Module 4

Resources and its utilisation: Basic concepts of Conventional and non-conventional energy, General idea about solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans and Geothermal energy.

Module 5

Sustainability practices: Basic concept of sustainable habitat, Methods for increasing energy efficiency in buildings, Green Engineering, Sustainable Urbanisation, Sustainable cities, Sustainable transport.

Reference Books

1. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
2. Bradley. A.S; Adebayo,A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
3. Environment Impact Assessment Guidelines, Notification of Government of India, 2006
4. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998
5. ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System
6. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.
7. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Language Book Society (ELBS).
8. Purohit, S. S., Green Technology - An approach for sustainable environment, Agrobios Publication

QUESTION BANK

Q:NO:	QUESTIONS	CO	KL
MODULE 1			
1.	What does it mean to design something?	CO1	K2
2.	How Is engineering design different from other kinds of design?	CO1	K2
3.	Where and when do engineers design?	CO1	K2
4.	What is the basic vocabulary in engineering design?	CO1	K2
5.	How to learn and do engineering design.	CO1	K2
6.	How to do engineering design?	CO1	K2
7.	Illustrate the process with an example.	CO1	K4
8.	How to identify the customer requirements of design?	CO1	K3
9.	How to finalize the design objectives?	CO1	K3
10.	How to identify the design constraints?	CO1	K3
11.	How to express the functions a design in engineering terms?	CO1	K3
12.	How to generate or create feasible design alternatives?	CO1	K3
13.	How to identify the "best possible design”?	CO1	K2
MODULE 2			
1	How does the design thinking approach help engineers in creating innovative and efficient designs?	CO2	K2
2	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)?	CO2	K2
3	Describe how to create a number of possible designs and then how to refine and narrow down to the 'best design'.	CO2	K3
4	How to perform design thinking as a team managing the conflicts?	CO2	K2
5	Design thinking approach for 1 HUMANITIES designing any simple products within a limited time and budget	CO2	K3
6	How does the design thinking approach help engineers in creating innovative and efficient designs?	CO2	K2
7	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)?	CO2	K2
8	Describe how to create a number of possible designs and then how to refine and narrow down to the 'best design'.	CO2	K3
9	How to perform design thinking as a team managing the conflicts?	CO2	K2
MODULE 3			
1	How do engineering sketches and drawings convey designs?	C03	K2
2	How can a design be communicated through oral presentation or technical reports efficiently?	C03	K2
3	How do mathematics and physics become a part of the design process?	C03	K2

4	How to predict whether the design will function well or not?	C03	K2
5	Design communication through detailed 2D or 3D drawings of simple products with design detailing, material selection, scale drawings, dimensions, tolerances, etc.	C03	K3
MODULE 4			
1	How engineering students can learn design engineering through projects?	CO4	K3
2	How students can take up problems to learn design engineering?	CO4	K2
3	What is modular approach in design engineering? How it helps?	CO4	K3
4	How the life cycle design approach influences design decisions?	CO4	K2
5	How do aesthetics and ergonomics change engineering designs?	CO4	K2
6	How do the intelligence in nature inspire engineering designs?	CO4	K2
7	What are the common examples of bio-mimicry in engineering?	CO4	K3
8	How do concepts like value engineering, concurrent engineering and reverse engineering influence engineering designs?	CO4	K2
9	Develop new designs for simple 1 HUMANITIES products using bio-mimicry and train students to bring out new nature inspired designs.	CO4	K4
MODULE 5			
1	How designs are finalized based on the aspects of production methods, life span, reliability and environment?	CO5	K2
2	How to estimate the cost of a particular design and how will economics influence the engineering designs?	CO5	K2
3	What are design rights and how can an engineer put it into practice?	CO5	K3
4	How do ethics play a decisive role in engineering design?	CO5	K2
5	Conduct exercises using simple products to show how designs change with constraints of production methods, life span requirement, reliability issues and environmental factors.	CO5	K4
6	How designs are finalized based on the aspects of production methods, life span, reliability and environment?	CO5	K2
7	How to estimate the cost of a particular design and how will economics influence the engineering designs?	CO5	K2

MODULE 1

ENGINEERING

Engineering is the application of scientific, economic, social and practical knowledge in order to invent, build, design, develop and maintain various devices, systems, machines, structures and processes.

DESIGN

A plan or drawing produced to show the look and function or workings of an object before it is made.

ENGINEERING DESIGN

- Engineering design is the process of devising a system, component, or process to meet desired needs.
- It is an iterative design making process in which the basic sciences, mathematics and engineering sciences are applied to optimally convert resources to meet a stated objective.

DESIGN LEVELS

ADAPTIVE DESIGN

- Mostly designer's work will be concerned with the adaptation of existing designs.
- There are branches of manufacturing in which development has practically ceased, so that there is hardly anything left for the designer to do except make minor modifications, usually in the dimensions of the product.
- Design activity of this kind demands no special knowledge or skill, and the problems presented are easily solved by a designer with ordinary technical training.
- Example: Elevator, Washing Machine etc.

DEVELOPMENT DESIGN

- Considerably more scientific training and design ability are needed for development design.
- The designer starts from an existing design, but the final outcome may differ markedly from the initial product.
- Example: Development could be from a manual gearbox in a car to an automatic one, from the traditional tube-based television to the modern plasma and LCD versions, Wired telephone to mobile phone etc.

NEW DESIGN

- Only a small number of designs are new designs. This is possibly the most difficult level in that generating a new concept involves mastering all the previous skills in addition to creativity and imagination, insight, and foresight.
- Example: Design of the first automobile, airplane, camera etc.

CAUSE FOR FAILURES IN MOST ENGINEERING DESIGNS

- Incorrect or overextended assumptions
- Poor understanding of the problem to be solved
- Incorrect design specifications
- Faulty manufacturing and assembly
- Error in design calculations
- Incomplete experimentation
- Error in drawings
- Inadequate data collection

PHASES OF DESIGN PROCESS

Figure 1.1: Phases of Design Process

The phases involved in design process includes six phases as shown in Figure 1.1.

1. **Identifying Customer needs:** First identify what the customer is expecting the system. This can be done in the following ways.

Client request:

- A client may submit a request for developing a product or artifact.
- The customer need should be expressed clearly.
- The client may know only the type of product that they need.
- Example: I need a Table

Modification of an existing design

- Client may ask modifications in the existing product.
- They may ask for customization in certain products.
- They may ask to change shape, functionalities, material used etc.
- Example: Different coffee brands uses different flavours,

Generation of new product

- Profit oriented companies always do research to generate entirely new concepts and products so that they can rule the market.
- Example: Design variants of televisions with new features and build materials.

2. Setting design objectives – Identify the design objectives. Perform feasibility analysis, market study abd document the finalized design objectives.

Conduct feasibility analysis

- **Technical feasibility**: Ensuring whether the requirements can be implemented using the existing technology or not.
- **Economic feasibility**: Ensuring whether the requirements can be implemented within the allotted budget or not.
- **Schedule feasibility**: Ensuring whether the requirements can be implemented within the allotted time or not.
- **Social feasibility**: Ensuring whether the developing product may affect the society in a harmful manner or not.

Perform market analysis

- Analyze the market and identify the competing products and its exciting features.
- Identify the supplementary features that may be expected from this product.

Document the finalized design objectives

- Document all the finalized requirements / design objectives.
- This document act as an agreement between the customer and the manufacturer.
- Example: System Requirement Specification (SRS) document.

3. Identifying design constraints – Identify the various constraints that exist which may affect the design process.

Functional constraints

- These constraints impose a limit on the proposed working principle of the product
- Example: Energy requirement, Materials used, Overall geometry and aesthetics etc.

Manufacturing constraints

- The direct production limitations are due to equipment/raw materials deficiency, methods involved in manufacturing, labour shortage etc.

Safety constraints

- These constraints impose a direct threat to the product or to the user.
- Example: Operational safety constraints, Environmental constraints, Safety issues due to inevitable human errors etc.

Time and economic constraints

- Customer always expect quick delivery of the product with minimum cost.
- Demand of the product also leads to time and economic constraints. Example: Vaccine for COVID.

Legal Ethical and Quality constraints

- The end product should be approved by various organizations or Quality Control (QC) and Quality Assurance (QA) agencies to ensure its quality and safety
- Example: ISO, ISI, Food Safety and Standards Authority of India (fssai)

Ergonomics and Aesthetic constraints

- Product should be user friendly, attractive, visually pleasing and easy to use.

4. **Establishing functions** – Identify all the functionalities to be performed by the system.

- Identifying all the functions to be performed by the proposed product.
- Identifying the functions to be carried out to implement this product.
- Performing risk analysis in the implementation phases.
- Functions can be:
  1) **Engineering functions**: Cost estimation, Production design, Concept design, Simulation or 3D models etc.
  2) **Manufacturing functions**: Assembly, determination of tools and machineries for production, purchasing raw materials, Allotting labour etc.
  3) **Quality control functions:** Auditing, Check for regularity and safety, Design auditing, energy auditing etc.
  4) **Commercial functions**: Service-related aspects, Marketing, Sales, Warehousing, Packing and shipping etc.

5. **Generating design alternatives**

- For a design problem, there will be multiple solutions.
- For example: We can design a mobile phone in different modes: Touch screen phone, Keypad phone etc.
- Every design solution has its own pros and cons.

6. **Choosing the best feasible design**

- From the various design alternatives, the designer has to choose the best feasible design by considering the various trade-off aspects.

CASE STUDY 1 – CARRY BAG

CASE STUDY 2 – WRIST WATCH

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

<u>Solution</u>

1. Identifying and detailing customer requirements.

- ✓ It should show the accurate time.
- ✓ It can be tied on the wrist.

2. Setting design objectives

- ✓ Ensure whether we can design a wrist watch using existing technology, allotted budget and time schedule.

3. Identifying design constraint

- ✓ It should have a strap / chain to tie on the wrist.
- ✓ Should follow the quality guidelines like ISI / ISO standards.

4. Establishing functions

- ✓ It should display time accurately.
- ✓ It should be cell/battery/ solar powered.
- ✓ It should have a strap / chain to tie on the wrist.
- ✓ It should be simple and light weight.

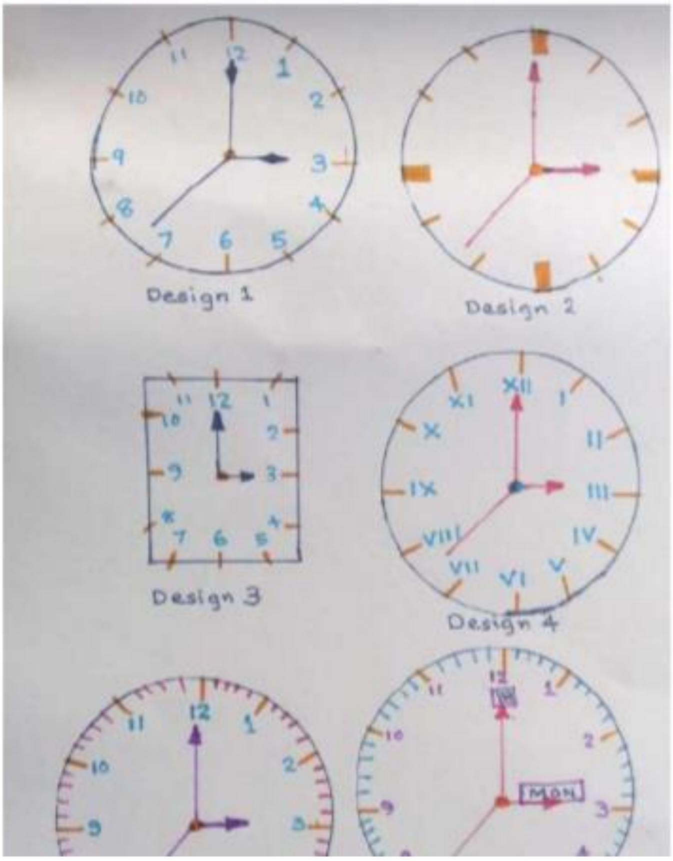
5. Generating design alternatives

Possible alternatives in mode: Analog watches, Digital watches, Smart watches

Possible alternatives in strap: Leather strap with different colors, Chain strap with different colors

Possible shapes of dial: Round, Rectangle, Oval, Square etc.

Number pattern in dial: Numbers like 1,2...12 or Roman numbers like I, II .... XII.



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6. Choosing the best design

In the above designs of analog watches, Design 6 can be considered as best as it uses number system 1,2...12 which is understood for common people. It has detailed minutes and seconds mapping of time. It shows the current date and day. It has all the three needles like second, minute and hour.

MODULE 2

DESIGN THINKING

- Design thinking is simply "a process for creative problem solving"
- Design thinking is a non-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.
- It is most useful to solve problems that are ill-defined (unclear) or unknown.

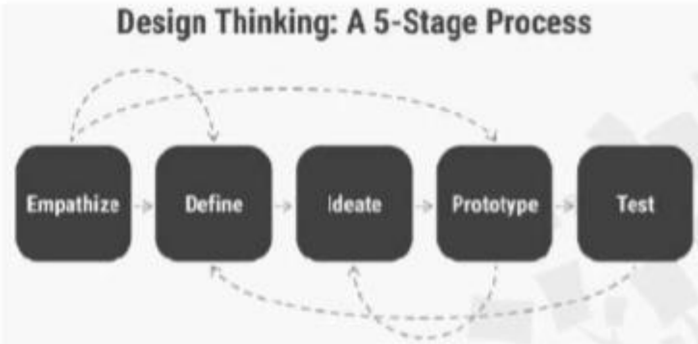


Figure 2.1: 5-stage process involved in design thinking

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.

2. 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 statements.
- The problem definition should be clear and unambiguous.
- 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 identify 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.

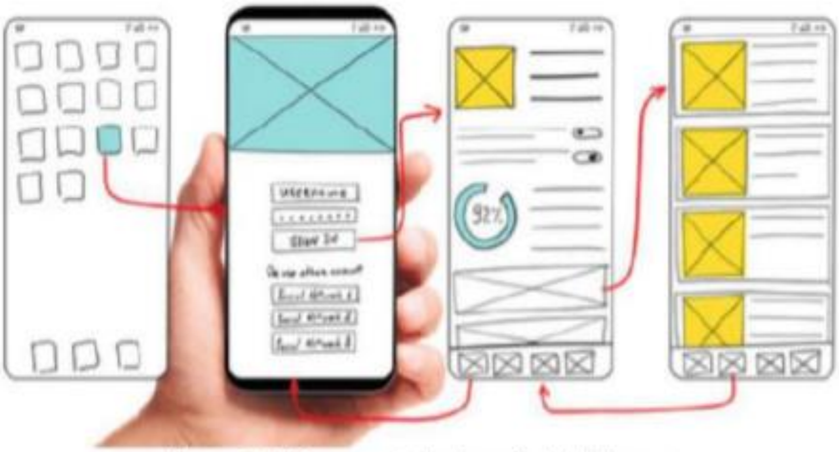


Figure 2.2: Paper prototyping of a Mobile app

Figure 2.3: 3D models

5. Test

- Evaluators rigorously test the prototypes.
- 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.

<u>**Solution:**</u>

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 keeping 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 shoulder strap should be of soft material.
[8] It should be waterproof so that it can be used in rainy 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 2.1 shows the differences between divergent & convergent thinking.

Table 2.1: Difference between 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 that focuses on figuring out the most effective answer to a problem.	In contrast, divergent thinking refers to opening the mind in various directions and trying out multiple solutions for a problem.
Its characteristics include •Speed •Accuracy •Logic	Its characteristics include •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

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 weapon
- ✓ 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 weapon
- ✓ Tool of torture
- ✓ Prop something open

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.
- ➢ 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.
- ➢ Respect, collaboration, and open-mindedness are prevalent.
- ➢ Team members communicate readily; 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. Prepare 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.
- **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 being. 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. When 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 open – if people have issues, they 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 easily.

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 waste 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 keep 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 out medicines for each room.
- No doors 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
- Easier to keep medicines as boundaries and lids are there for each rack.

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 sort out 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 sort out 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 patient 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 wastes.
- Have open table to keep patient charts / records.
- Have locks for wheels.

Choosing the best design

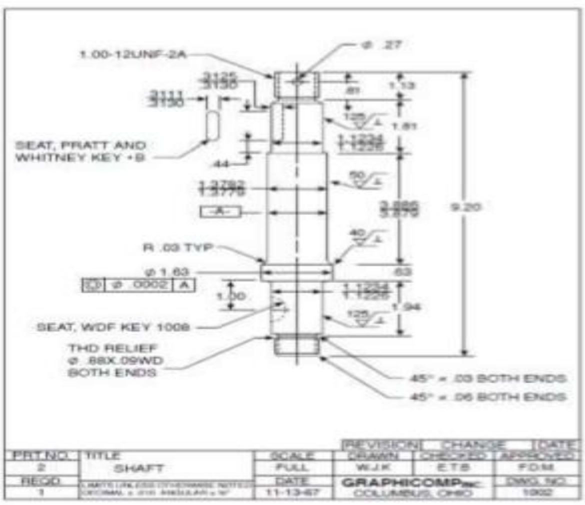
Model 7 can be chosen as the best design as it incorporates all the expected functionalities as well as exciting functionalities of a drug trolley.

MODULE 3

Background

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.

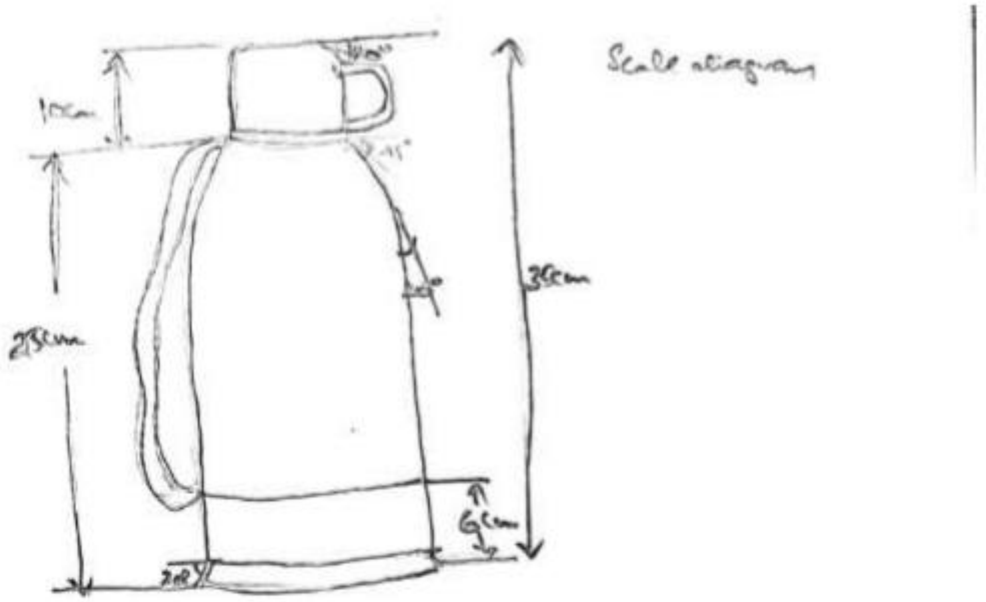


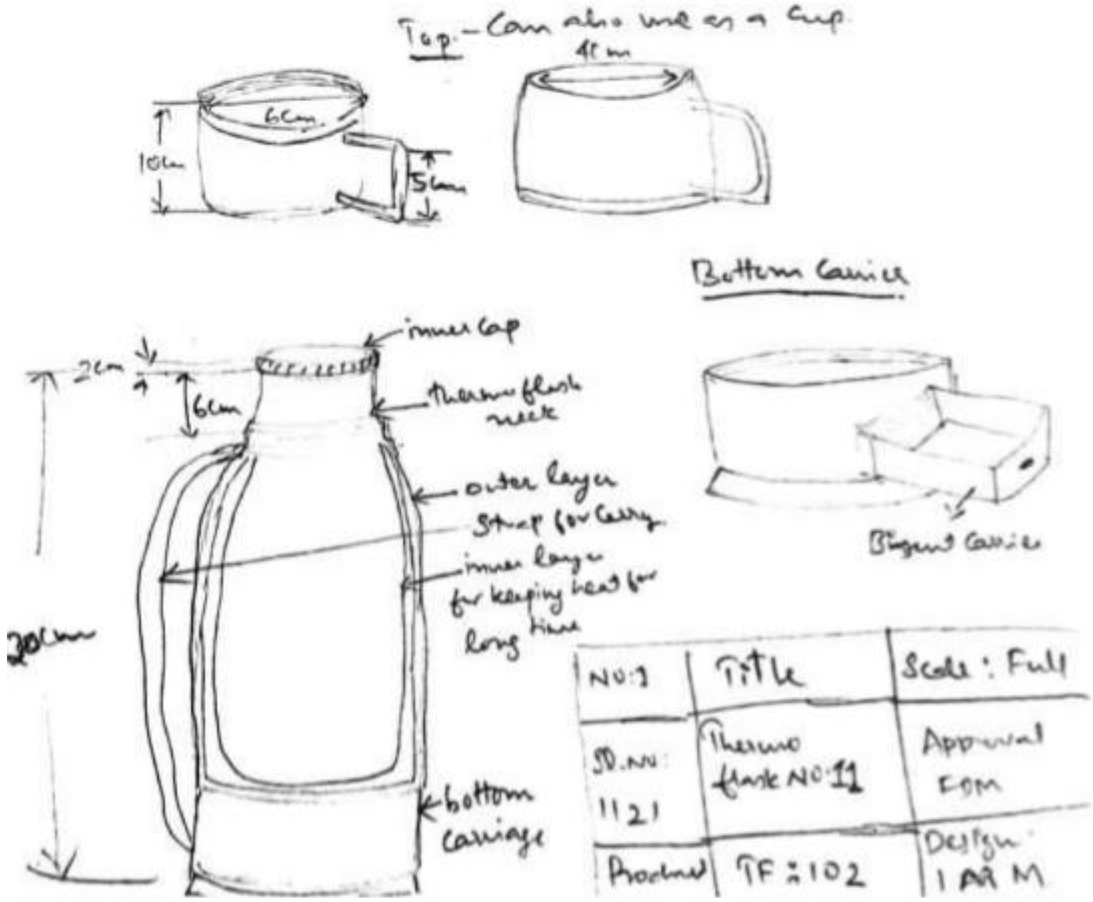
MATHEMATICAL MODELING IN DESIGN

- MATHEMATICAL MODELS are central to design because we have to be able to predict the behavior of the devices or systems that we are designing.
- It is important for us to ask: How do we create mathematical models? How do we validate such models? How do we use them? And, are there any limits on their use?
- We will focus on representing the behaviour and function of real devices in mathematical terms.
- Basic Principles of Mathematical Modeling
    - Why do we need a model?
    - For what will we use the model?
    - What do we want to find with this model?
    - What data are we given?
    - What can we assume?
    - How should we develop this model, that is, what are the appropriate physical principles we need to apply?
    - What will our model predict?
    - Can we verify the model's predictions (i.e., are our calculations correct?)
    - Are the predictions valid (i.e., do our predictions conform to what we observe?)
    - Can we improve the model?

Q1) 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.

Solution:




Top - Can also use as a cup
4cm
6cm
10cm
5cm
Bottom Carrier
inner cap
2cm
6cm
thermo flask neck
outer layer
strap for carry
inner layer for keeping heat for long time
20cm
bottom carriage
NO:1
Title
Scale: Full
Thermo flask NO:11
Approval
TF:102

Material selection

Top cap:

- This section can also be used a cup for drinking coffee
- Since it has to withstand hot coffee, we must use a high-quality plastic material which can support minimum 200 ^{0}C on inside
- The plastic is coated with a low weight steel material
- The colour of the material can be of three choices – Black, red & steel colour

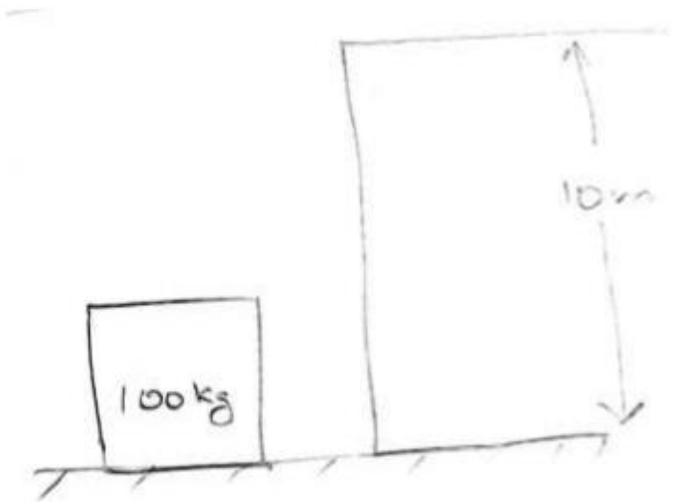
Body:

- Body is the main part of the flask
- Which will keep the hot coffee for long time.
- It contains an inner part and outer part
- Outer part is commonly used flask material which is a weight less steel material
- Inner part is glass which is coated with material which will not conduct temperature
- The inner section temperature should not affect the outer part

Bottom cap

- The bottom carrier can be used as a biscuit carrier
- The material use for this carrier can be the same material as flask is made

Q2) 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.



- In the question the task is to move the 100kg of weight to 10-meter height
- We can pull the wight using pullies to the requires height
- The given data
  - Weight of the item – 100kg
  - Height/displacement to be move – 10 meters

Let us discuss some basic physics principle for the particular job. To lift the weight we need to know how much power used for this job

To calculate the power let us use the basic equation of power expression

$$P = \frac{W}{T}$$

Where

W = work done

T = Time

The expression for word done is

$$W = F * S$$

Where

F = Force

S = displacement

To find the force we need the force expression

$$F = m * a$$

Where m is the mass and a is the acceleration

Let us assume a = 9.8 m/s and the value of m is given which is 100 kg

So

$$F = 100 * 9.8 = 980N$$

From the value of the force we can calculate the work

$$W = 980 * 10 = 9800J$$

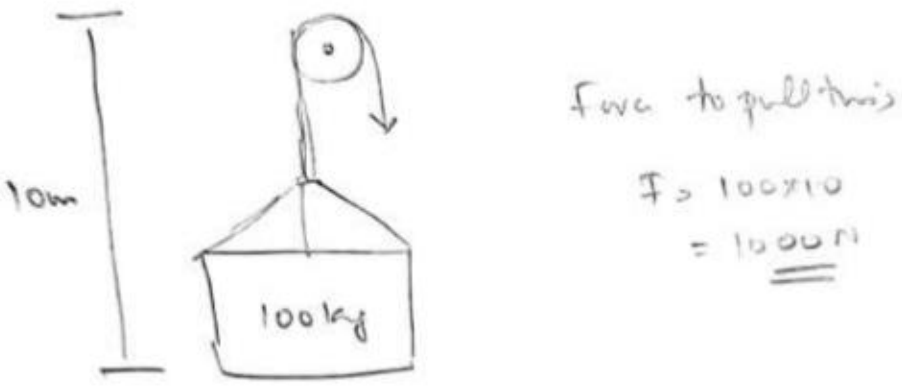
Now power

Let us assume T=60 seconds

$$P = \frac{9800}{60} = 163.3\, w$$

The pully system can be used to lift the weight

The pully system can be used to lift the weight



From the given diagram we can see that using physics principle the and technique can reduce the power to pull the weight. So we can conclude that the physics and mathematical principle can aid the engineering design.

MODULE 4

Background

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 solutions

Project-based learning

- 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.
- Involves
    - Knowledge
    - Critical thinking
    - Collaboration
    - communication

Similarities
Both PBLs: • Focus on an open-ended question or task • Provide authentic applications of content and skills • Build 21st century success skills • Emphasize student independence and inquiry • Are longer and more multifaceted than traditional lessons or assignments

Differences	
Project Based Learning	**Problem Based Learning**
Often multi-subject	More often single-subject, but can be multi-subject
May be lengthy (weeks or months)	Tend to be shorter, but can be lengthy
Follows general, variously-named steps	Classically follows specific, traditionally prescribed steps
Includes the creation of a product or performance	The "product" may be tangible OR a proposed solution, expressed in writing or in a presentation
May use scenarios but often involves real-world, fully authentic tasks and settings	Often uses case studies or fictitious scenarios as "ill-structured problems"

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).

Life Cycle Design

- As a design approach, Life Cycle Design is characterized by three main aspects:
    - the perspective broadened to include the entire life cycle;
    - the assumption that the most effective interventions are those made in the first phases of design;
    - the simultaneity of the operations of analysis and synthesis on the various aspects of the design problem.
- Main phases of a product's life cycle
    - Recognition and design development
    - Pre-production
    - Production
    - Distribution

- Use
- Retirement,

Ergonomics in design

- Ergonomics is basically the science of analysing work and then designing items (tools, equipment, products) and methods to most appropriately fit the capabilities of the user.
- Ergonomics design approach focuses on human comfort and decreased fatigue through product design.
- Means, during the design phase of a product, all the aspects of the product that can cause discomfort while using that product are identified. Then, analyses the causes of the discomfort and appropriate solutions will be incorporated in the product design
- To develop an ergonomic design (for a product or system), the designer will have to consider and analyse anthropometric data (dimensions of human body), posture of working while using the product, kind of movements and kind of workspace.
- ultimately, ergonomic design involves every aspect of user-product interaction, for the comfortable utilization of a product.

AESTHETICS IN DESIGN

- Aesthetics is the feel that a human being perceives.
- When a person perceives a sense of pleasure through any of the senses while using a product, then we can say that the product is aesthetically appealing.
- Example: a beautiful person, a good food, nice perfume
- Products are intentionally designed to generate a defined perception in potential customers
- Aesthetics of a product (that is how a customer feels about a product) is a very important
- This feel (or perception) enables the customer to distinguish and choose a product from similar products.
- Few examples for demarcation of percept ions are; hot and cold, smooth and rough, soft and hard, heavy and light, dark and bright, sweet and sour, loud and quiet, sharp and dull, spacious and congested, etc.. customers generally combine few of these feels (or attributes) and arrive at conclusion of a product as reliable, enjoyable and precise.

Bio-mimicry in design

- "**Biomimicry** borrows nature's blueprints, recipes, processes, and ecosystem strategies and then comes up with **design** principles to solve our own problems

Value of engineering (VE)

- Technique for improving the value of the product, project and process
- The term value defined as the ratio of function to cost
- $\text{Value} = \frac{function}{cost}$

Reverse engineering

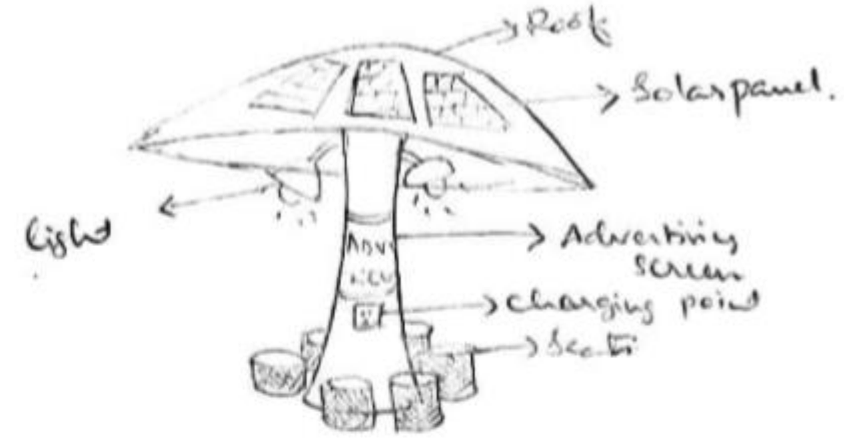
- Reverse Engineering is an approach in which an existing product is analyzed and another product is developed in light of the analysis.
- The product that is analyzed can be own product of the producer or a product from a competitor.
- In reverse engineering, a product is dissected or dis-assembled to find out in detail how a part works an why is it used. This information obtained by this process can then be applied to solve own design problem or develop a new product.
- Reverse Engineering is essentially a functional decomposition process in the reverse direction.
- an existing product is analyzed into subsystems, which are further analyzed into deep to ultimately establish the product concept
- This analysis will help the designer to identify weak side of the design

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

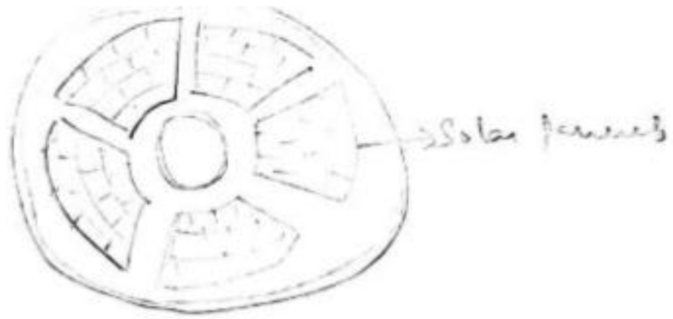
Solution

- Nature inspired bus waiting shed can be of many options. Some of the options are a banar leaf, or any large leaf, a big mushroom
- Let us discuss the design of the bus station from one of the item, mushroom

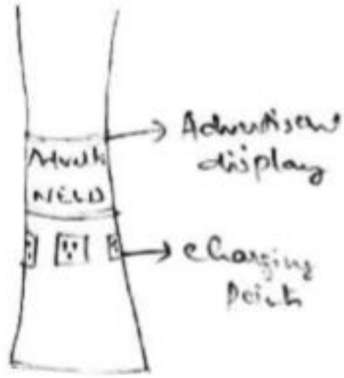
- We are using the above shape because it covers a large area and there is space underneat without affecting the rain
- It has a large surface area for placing the solar panel when has sun exposure
- Also its body or middle section can hold the circuit and the battery for the solar panel



Side view



Top view



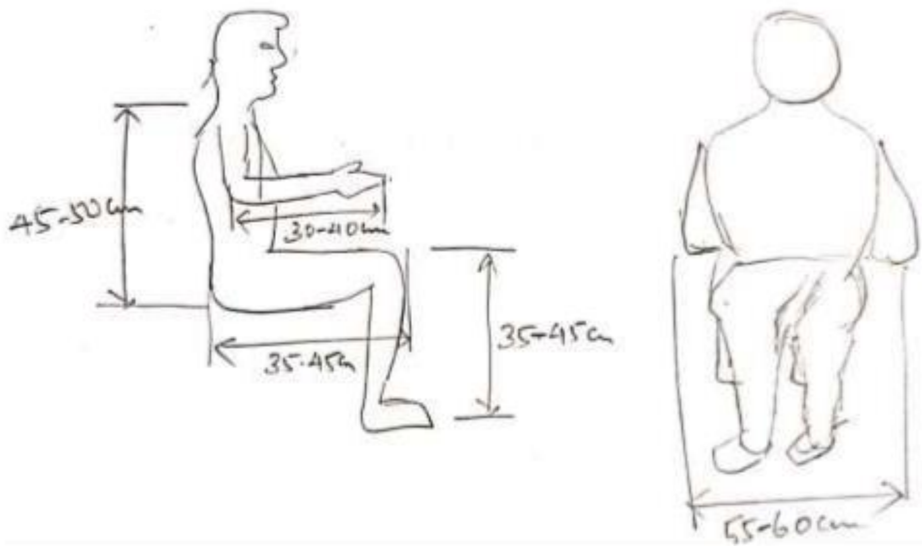
- The solar panels can be placed over the top of the design
- The circuits and the batteries can be place at the middle and root parts of the structure
- We can add a LED screen in the surface of the body for the advertisement and the news
- The power supply for the LED screen can be taken from the batteries of the solar panel
- We can add charging points around the body for mobile charging. Which's power can also be drawn from the same battery
- The light for the bus station can also be powered with the same battery
- We can place some permanent seats around the inner body of the structure. Can also have space under the seat for extra batteries

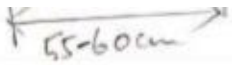
Q2) Show the design of a simple sofa and then depict how the design changes when considering 1) aesthetics and 2) ergonomics into consideration. Give hand sketches and explanations to justify the changes in designs.

Solution:

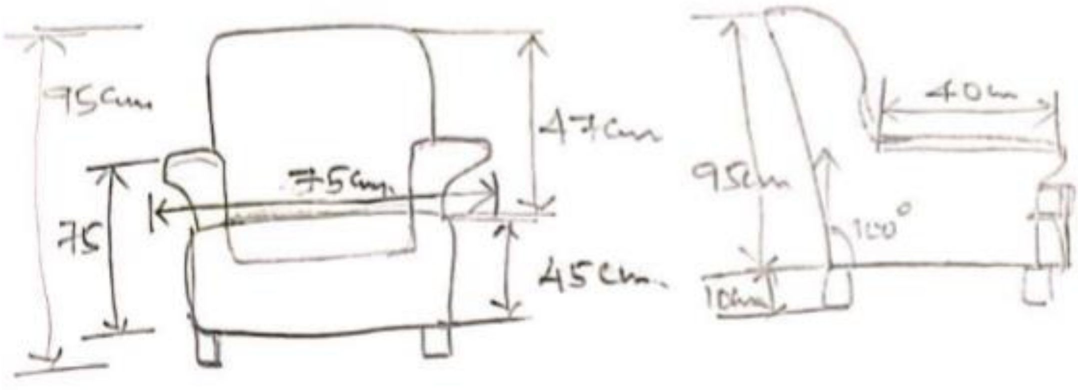
Ergonomic design

- In the ergonomic design we have to focus on the human comfort and decrease fatigue through product
- A sofa is a device used for comfort sitting or lying if needed
- The measurement of an average human being is as shown in figure





- A sofa can be used by any age range of people so that the height of sitting section of the sofa can be 45 cm
- The height of the back side must be 47 cm
- The total width of the sofa chair must be 75 cm
- The hand rest area must be of height 75 cm
- The total height of the sofa is nearly around 95cm
- For comfort sitting the sofa's backside angle is slightly gave n angle of 100 degree



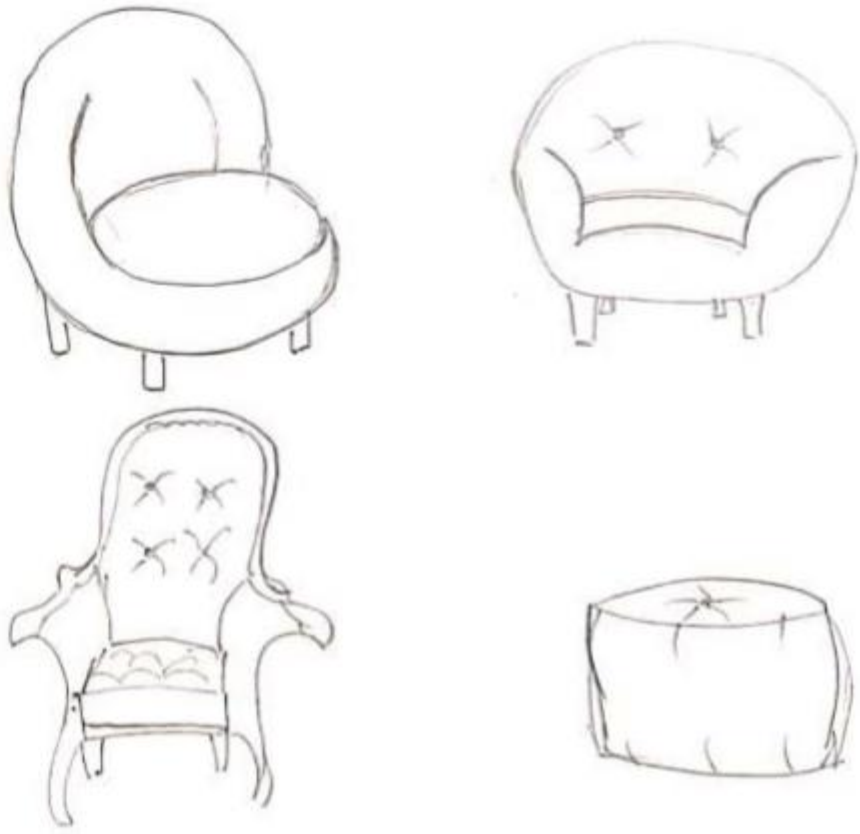
Material used

- For better comfort we can use cushion and sponge materials for inside of sofa
- The frame material can be used of good quality wood
- The sofa covering material can be made of good quality washable synthetic leather for long lasting and to avoid getting dirty

To develop an ergonomic design (for a product or system), the designer will have to consider and analyse anthropometric data (dimensions of human body), posture of working while using the product, kind of movements and kind of workspace. Ultimately, ergonomic design involves every aspect of user-product interaction, for the comfortable utilization of a product

Aesthetic design

- In aesthetic design we are focussing on the beauty and look of the sofa
- We also consider some other aspects like quality and strength of the material used
- By considering the basic sofa design concepts and measurements we can alter the design of the sofa
- The design of the sofa must be attractive than ergonomic
- Some of the aesthetic designs are given below



Products are intentionally designed to generate a defined perception in potential customers. Aesthetics of a product (that is how a customer feels about a product) is a very important aspect for its business merit and acceptability. This feel (or perception) enables the customer to distinguish and choose a product from similar products.

MODULE 5

Background

- **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.
- **Design for Assembly (DFA):** 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.

- **DESIGN FOR USE**
    - **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.
    - **Maintainability**
    - Maintainability can be defined as "the probability that a failed component or system will be restored or repaired to a specific condition within a period of time when maintenance is performed within prescribed procedures."

- Designing for maintainability requires that the designer take an active role in setting goals for maintenance, such as times to repair, and in determining the specifications for maintenance and repair activities in order to realize these goals.
- This can take a number of forms, including:
    - selecting parts that are easily accessed and repaired;
    - providing redundancy so that systems can be operated while maintenance continues;
    - specifying preventive or predictive maintenance procedures; and
    - indicating the number and type of spare parts that should be held in inventories in order to reduce downtime when systems fail.

- **DESIGN FOR SUSTAINABILITY**
    - **Environmental Life-Cycle Assessments**
    - Life-cycle assessment is a tool that was developed to help product designers understand, analyse, and document the full range of environmental effects of design, manufacturing, transport, sale, use, and disposal of products.
    - LCA has three essential steps:
        - Inventory analysis lists all inputs (raw materials and energy) and outputs (products, wastes, and energy), as well as any intermediate outputs.
        - Impact analysis lists all of the effects on the environment of each item identified in the inventory analysis, and quantifying or qualitatively describing the consequences (e.g., adverse health effects, impacts on ecosystems, or resource depletion).
        - Improvement analysis lists, measures, and evaluates the needs and opportunities to address adverse effects found in the first two steps.

ENGINEERING ECONOMICS IN DESIGN

Labor, Materials, and Overhead Costs

- Costs are often broken up into the categories of labor, material, 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
- a simple starting point for estimating costs is to keep good records or the activities needed to build our design's prototype.
- **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.

- 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**.
- Estimating the costs of producing a design requires careful consultation with clients or their suppliers.
- In practice, each engineering discipline has its own approaches to cost estimating that are captured by general guidelines

(Q1) 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.

Solution

<u>Design of a foot wear</u>

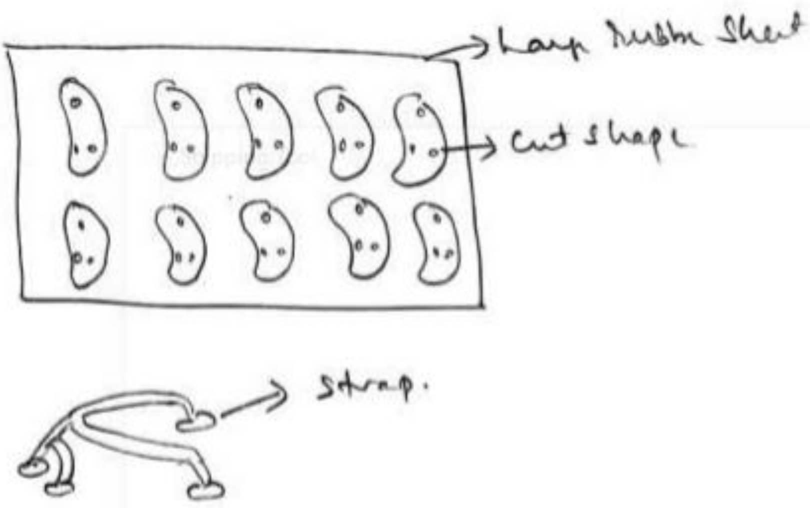
A design of foot wear is simple. We have to consider certain simple things while we are designing with the given constraints

Let us discuss each

<u>Constraints of production method</u>

Since we are designing a rubber foot wear we can have a good rubber material for foot wear with long lasting life

- Foot wear is produced in bulk so we need large amount of production materials
- So, to reduce the cost we can use large sheets of rubber material and cut the foot wear from that using machines
- The other works like stitching or combining parts of the foot wear are being done with workers so labours are required to do those jobs
- For stitching we can use good quality nylons



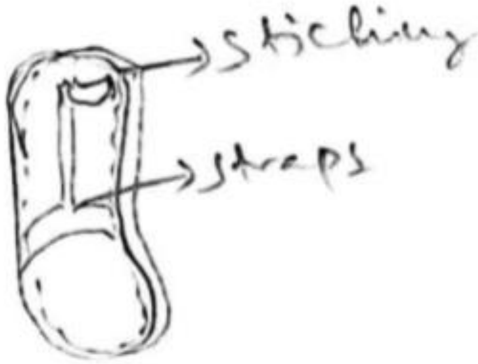
Constraints of life span requirements

- By considering life span requirement of a foot wear it is difficult to consider the return of the product and recycling. So me must make the product with a bio degradable material. The best option for that is good quality rubber

- Another problem may be manufacturing defects or manmade error, We can provide a service for the foot wear around 1-2 year for that
- On the life span another issue is using the foot wear at the time of rainy seasons. By using the rubber product for the manufacturing, we can solve that issue
- To get the old product back and recycle. we can give some discounts for the old product for new purchases. By giving that way we can make sure the return of the product after the use and done for the recycling purpose

Constraints of reliability

- One of the main reliability issues is long life of the foot wear on all seasons. This constrains can be resolved using the good footwear material rubber
- Another constrains is breaking the straps. This can be reduced by strong materials at the end and also by stitching the joints of the foot wear after the instalment of the strap
- Wear and tear at the corners of the foot wear can be also reduced by stitching around the corners of the foot wear with good nylon.
- Another constrain is wear the bottom side of the foot wear while at the long use. To inclreas the life of the foot wear we can use strong and bendable quality rubber material at the bottom of the foot wear as souls of the foot wear



Constraints of the environmental factors

- The product like foot wear the environmental factors are mainly use of the product at the time of rainy season. As we discussed before, making of the product with good quality factors can be extend the life time of the foot wear

- Due to govt. orders the product used for the making of foot wear must be bio degradable. We already mentioned that in the previous steps
- Since we are also considered the recycling steps and initiation for the products. It will help more in the environmental factors.
- We must also follow the govt. rules for the machine used in the manufacturing factory. Or we can import the product from other merchandises which will solve the other pollution problems and cost.

(Q2) Describe the how to estimate the cost of a particular design using ANY of the following: i) a website, ii) the layout of a plant, iii) the elevation of a building, iv) an electrical or electronic system or device and v) a car. Show how economics will influence the engineering designs. Use hand sketches to support your arguments.

Solutions

From the above question let us consider the cost estimation of a website creation and maintenance. I am estimating the cost of a shopping website design. Mainly for a product design there are three costs 1) labour cost , 2) material cost and 3) overhead cost. Let us discuss each

Labour cost

- The labour cost of the website creation is mainly for the website designers and programmers. For the creation of the established shopping website fully we need minimum 10 to 15 designers, programmers and supporting engineers
- The estimated time for the full functioning of the website may take around 5- 8 months
- We need to pay the salary for the workers at that time period. Let us take nearly 15000 per month one person. Then the total salary for a month will be **15*15000 = 225000**.
- That amount should provide for the estimated time period of 8 months. Which will cost **8*225000 = 18,00,000 rs**
- After the website creation we can provide support and annual maintenance of the website afterwards. This may cost 3-5 worker's salary and other benefits. The salary may cost **5*15000 = 75000 rs**. Tis cost will continue as long as the website is functioning.
- The other works like marketing and social media marketing can be done by 2 workers. The salary for them may cost **2*10000 =200000 rs**
- We can also reduce the cost by hiring a website creation outsourcing company for to do the jobs, which will reduce the employee salary and other expences

Material cost

- The main material cost for the website creation is computer expense. At the tine of the website creation above mentioned workers need 10 – 15 computer sets for the website design and developing. So for a single computer set will cost nearly **30000** per system. So the total cost will be **15*30000= 450000**.
- Also, must have servers/ cloud storage for the smooth functioning and controlling of the website which will cost **100000** per server
- If we chose the cloud storage then we must pay yearly rent for the cloud servers
- There must be an office for the functioning of the website we can have own building or rented building. The cost will be depending on the option
- The initial cost of this will be high for a starting company. We can also reduce this cost by outsourcing the work with another firm
- The other cost will be website domain cost which will be nearly **3000/year** which is a mandatory cost in each year
- Another mandatory cost is website hosting which nearly cost **2000/year**
- Some of the costs can be reduced by outsourcing the works to another firms.

Overhead costs

- Over head cost are the cost happening after the cost estimation. There will be always overflow of the cost estimation after the establishment and while the functioning of the website. We must consider those options also. Some of the overhead cost is mentioned below
    - Some cases we might need to develop an app for the website to use it in mobile phones. This may cost additional
    - Some cased to improve the traffic and working of the website we might need additional certificate for website like sst certificate.
    - Additional publicity cost will be there for reaching the website to more people. This can be done by social media advertising, additional discounts for the products. These steps can cost extra
    - If the website got hit then we might nee some additional office staffs
    - We can also use some delivery staffs for the fast delivery of the products. These will come under the labour cost afterwards
    - Due to some issues there may be a chance to extend the website completing time period. This can cause the additional cost of the employee salary.

These are the preliminary costs estimation for the shopping websites. In spite of the above points there is a possibility that additional unexpected cost can also be happen. So we need to be prepared for those additional cost estimation before starting the work