MUTHAYAMMAL ENGINEERING COLLEGE

(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC & Affiliated to Anna University)
Rasipuram - 637 408, Namakkal Dist., Tamil Nadu

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IQAC

LECTURE HANDOUTS

MECH | **I/II** | **L 01**

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **I**

Date of Lecture :

Topic of Lecture: Introduction to new product development

Introduction : (Maximum 5 sentences)

- New product development (NPD) is **the process of bringing a new product to the marketplace**. In business they may need to engage in this process due to changes in consumer preferences, increasing competition and advances in technology or to capitalise on a new opportunity..
- New product development is the process of converting an idea into a workable software product.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- By manufacturing new products, **a firm can meet seasonal requirements of customers in the market**.
- Customers are satisfied due to matching products in each of the seasons, and company can get reasonable business.
- Creativity and innovation is an efficient way to attain more market share or sales.

Detailed content of the Lecture:

- New Product Introduction (NPI) is the **process that takes an idea from an initial working prototype to a thoroughly refined and reproducible final product**. Since NPI requires a substantial investment of time and resources, careful planning goes into each step to ensure that the result will be worth the effort..
- The New Product Development (NPD) process is about grabbing the market opportunity that revolves around customer needs, checking the idea's feasibility, and delivering working software.

Seven Stages of New Product Development Process

Stage 1: Idea Generation

The goal should be to generate many worthy ideas that can form the foundation for the New Product Development strategy. The major focus for stage 1 should be to arrange brainstorming sessions where solving customer problems is given precedence.This phase is not about generating foolproof ideas that

are ready for implementation. Instead, raw and unproven ideas that can be shortlisted later should be discussed.

Emphasize on Customer Problems

The problem that is well described is a problem half-solved. Here's how to identify the issues that the target audience is facing:

a. Personal Problems

It is a good idea to look at problems that the business is itself facing to come up with the idea. All a business needs to do is focus on that specific problem and build a solution that can be tagged a "one for all" solution to the common problem.

b. Qualify Each of the Listed Problems

This step helps check the feasibility of the shortlisted problems and their solutions based on the 4U approach by Michael Skok, the founder of Startup Secrets. The 4U stands for:

Taking a deeper look at each of these aspects in detail will provide greater clarity.

- **Unworkable**: Figure out whether the brainstormed product concepts will address some real problems. Will the product be able to fill the existing customer experience gaps and will the product achieve product-market fit?
- **Unavoidable**: Is the problem the product will address unavoidable to the extent that it becomes mandatory to comply? It is necessary to find out whether solving that problem is a choice or a compulsion.
- **Urgent**: Is the problem urgent and is a solution highly demanded by the target market? If the answer is affirmative, this could be a chance to cover the white space in the market with the original product.
- **Underserved**: Are there no available products that address the existing user problems? Look for the whitespace in the market and hold on to the idea that looks promising.

c. Coming Up With Possible Solutions

If a problem has been identified, it's time to look for possible solutions. For every user problem, there ought to be potential New Product Development opportunities.

d. Narrowing Down Problems + Solutions

In case the stakeholders are not convinced regarding the shortlisted idea, try the Replicate, Re-Purpose, and Upgrade approach.

- **Replicate**: This focuses on creating a similar product as that of a competitor but launching it in new market conditions. When done with launching the minimum viable product (MVP), the strategy should be to expand the business by introducing out-of-the-box and unique features later on.
- **Re-Purpose**: This focuses on rewiring an existing business model. For instance, LinkedIn introduced LinkedIn Learning, an e-learning platform for professionals. This product was similar to an e-learning platform for students, however, they built new opportunities for expanding the target audience and market share.
- **Upgrading**: This concept of New Product Development revolves around introducing a new business model that is better than existing solutions. Better could mean improved performance, better speed, addressing the challenges that a competitor is facing, or introducing added functionalities.

Stage 2: Idea Screening

This New Product Development stage revolves around choosing the one idea that has the highest potential for success. Put all the ideas available on the table for internal review. That is, turn to people

with industry knowledge and experience in the field for idea screening

In a SWOT analysis, the Agile Development team, the product owner, the scrum master, and the product manager conduct a detailed analysis of the idea to identify an idea where strengths and opportunities overpower threats and weaknesses.

Stage 3: Concept Development & Testing

Before starting with the New Product Development process, building a detailed version of the idea and the user stories should be given priority.

This value proposition evaluation is the first step towards concept development and testing. At the very least, it ensures that problems in the approach are discovered sooner and the team can course-correct earlier. That helps to ensure that technical debts will not accumulate.

The easy-to-follow concept development steps include:

1. **Quantifying Gain/Pain Ratio**

A business needs to create an insightful picture of the product from the user's perspective. This can be achieved by calculating the gain/pain ratio, where:

Gain = Benefits of the product for the customer. What is in it for them? **Pain** = The efforts made by the customer to understand and use the product.

2. Conducting a Competitor Analysis

Knowing about existing market players is a critical strategic step to consider. Understanding the competition makes it easier to infer:

- Where the competitor lacks
- Where is the scope for improvement
- Existing white space in the market

3. Enlisting the Major Product Features

The user stories involved in the New Product Development software project will make or break a business. When creating a list of such features, it is imperative to know — **how is it an innovative feature, and how is it going to solve a problem?**

4. Create a Value Proposition Chart

Even after being convinced of the wisdom & the utility of an idea, being able to state it clearly to the end-user, in their context, is quite a different story altogether. The end-user needs to be given a clear picture of what the new product is capable of doing.

This clean & presentable fashion can be best represented in the form of a value proposition chart. The format of which should include:

5. Concept Testing

Once the value proposition is ready, it is time to present it to the set of selected customers. How they perceive the idea is the test of the efforts so far. If the idea doesn't look promising, it is wise to repeat the idea screening steps to develop a new product.

Stage 4: Market Strategy/Business Analysis

Marketing strategy is all about drafting a way to reach out to the targeted audience. Perhaps the best and most straightforward method is to follow McCarthy's 4Ps of marketing for a New Product Development project.

1. Cost-Based Pricing Model

Here, the initial production cost is added to the markup percentage to come up with the new product's final price.

2. Market-Focused Pricing

This pricing is inferred after a thorough analysis of the pricing model of similar products in the target market.

The factors to consider when selecting a competitive price:

- **Price Above Market**: A higher price is suitable when proceeding with New Product Development initiatives that solve an urgent problem of the customers.
- **Copy Market**: Selling the new product at the same price as the competitors can initially be a safer move. However, marketing efforts would have to be ramped up to score better than the competitor.
- **Price Below Market**: A lower price bracket than the competitor is recommended to attract customers that can be converted into loyal ones over time, even if the new product solves things differently.

Stage 5: Product Development

When the New Product Development idea is in place, the market strategy is documented, and the business analysis is completed, it is time to move on with the product life-cycle development process.

1. Prototype

This focuses on creating the UI/UX for the product, which is then shared with the stakeholders. This helps in visualizing how the product will look and whether it complies with ergonomics best practices.

2. Minimum Viable Product (MVP)

This focuses on working on the user stories in Agile for the New Product that will set it apart from others. Once the design, development, and testing are done, the MVP is launched in the market with minimal features. The future iterations depend on the initial response.

Stage 6: Deployment

Once the MVP is ready, efforts shift from development to deploying the product in the live environment. This process involves embracing the DevOps culture and implementing the CI/CD pipeline.

The different stages of implementation include:

a. Commit

This stage involves:

- The newly developed features are integrated with the code for the existing features
- Quality assurance team ensures that the integrated code works fine
- CI/CD tools such as Jenkins run automated unit tests and sanity tests to check code's efficacy

b. Build

This stage involves:

- Developers push the software artifacts into the registry using Docker tools such as Gradle, Packer, AZK, etc.

c. Alpha Deployment

This stage involves:

- Developers test the performance of the new builds and the interactions between those builds.

d. Beta Deployment

This stage involves:

- Manual testing of the new product to validate its overall performance and efficiency of output considering all input scenarios.

e. Production Deployment

This stage involves:

- The product is pushed into the live environment, i.e., the product is available and ready to use by the end-users.

Stage 7: Market Entry/Commercialization

Commercialization is an umbrella term that entails varied strategies to ensure the success of the new product. Here is what commercialization includes:

1. Marketing the Concept Over Product

The idea here is simple: talk about the concept and the product's intent instead of endlessly boasting about the product features. In short, answer how the product will make the customer's life easier.

2. Having a Brand Voice

A unique mindset and a unique voice always gain an all-ears audience. This is where the marketing team plays a significant role. They need to establish an effective communication style that represents the brand in the best manner.

3. Conducting Intriguing Webinars

Webinars are one way to attract quality leads. Conduct webinars that talk about how the new product will benefit the audience and describe the features that are being introduced.

Webinars can also help promote findability and discoverability:

- **Findability**: It is easy to find and use features that the customer is aware of.
- **Discoverability**: It is easy to find and use features that the customer has no knowledge about.

Benefits of the New Product Development Process

- Helps check the technical feasibility of the idea
- Ensures faster time to market
- Effectively addresses the customer needs
- Multiplies the chances of success
- Reduces technical debt

- Better management of the feature creep
- Negates the opportunity cost

Video Content / Details of website for further learning (if any):
https://www.netsolutions.com/insights/everything-about-new-product-development/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design – Kevin Otto – 3-9; 112-145

Course Faculty

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LECTURE HANDOUTS

L 02

MECH

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **I - Introduction**

Date of Lecture :

Topic of Lecture: Evolution of design

Introduction : (Maximum 5 sentences)

- Evolutionary Design is the practice of growing a system in a natural way, by adding the minimum amount of code to satisfy the business needs in an iterative and incremental approach.
- Most products develop in an evolutionary way. They slowly change into new forms over time, as designers produce variations on existing designs. However, some products develop in a revolutionary way. An innovation results in a wholly new and original product that can have a big effect on society.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- With the determining factors of a product's success, it will improve performance, efficiency and will reduce the cost and risk to the business at hand.

Detailed content of the Lecture:
A History of Product Design

In the 15th Century, as the Middle Ages were transitioning into the Renaissance, people in European population centers wanted to have the same items in their homes and workplaces. News of these useful or desirable items soon spread along trade routes to the far corners of the civilized world.

Emerging Design Centers: Large workshops began to emerge in places such as Florence, Venice, Nuremberg, and Bruges where groups of collocated artisans replicated designs in larger volumes. Apprentices took 7 to 14 years to learn and become a Master. Demand growth quickly outpaced this approach as a solution.

Pattern Books: The use of drawings to act as instructions on how to construct something was first developed by architects and shipwrights during the Italian Renaissance. By the early 16th Century competitive pressures led to the emergence of “pattern books” in Italy and Germany, which were collections of engravings illustrating decorative forms and motifs for application to a wide range of products. And, importantly, the design took place well in advance of manufacturing.

Emerging Industrial Centers: In the 17th Century, growth in monarchies led to large government-operated centers epitomized by the Gobelins Manufactory, opened by Louis XIV in Paris in 1667. Hundreds of craftsmen, artists, decorators, and engravers turned out everything from tapestries and

furniture to metalwork and coaches. This model was replicated in many cities, including the famous Meissen porcelain factory near Dresden in 1709. As long as reproduction remained craft-based, however, quality declined as scale increased.

The Industrial Age: The emergence of industrial design as a discipline mirrored the growth of industrialization and mechanization in Great Britain in the mid-18th Century. The term "industrial design" was first used in 1839 to describe how the school of St. Peter instructed draftsmen how to prepare patterns for silk manufacture.

Industrial Design: The first attributed use of the term "industrial design" in 1919 is credited to Joseph Claude Sinel, a self-proclaimed "industrial designer." However, many argue that the discipline began at least a decade before. Christopher Dresser is generally considered the first independent industrial designer. Then there is the *Practical Draughtsman's Book of Industrial Design*, printed in 1853. Together, these data points anchor the beginning of design as a profession between 1850 and 1900.

Common Design Skill Sets: The Rhode Island School of Design was founded in 1877. But, it was not until the Carnegie Institute of Technology opened its design program in 1934 that historians began to recognize design as a profession. For the next 50 years, until the appearance of consumer electronics devices, the profession remained in the hands of individuals whose talents were sought as employees or consultants.

The Design Industry: By the 1980s, business demand for design skills had grown to the point where profitable design consultancies could be formed. Firms like Alessi (1921), Teague (1926), Design Concepts (1967), Frogg Design (1969), and others pre-date this period, but then growth exploded. Driven by broadening consumer electronics markets, the advent of global competition, shortening product life cycles, and the rapid evolution of CAD into 3D design and surface modeling, design grew from a profession into an industry. RKS (1980), Continuum (1983), Seymour Powell (1984), KartenDesign (1984), IDEO (1991), and dozens of other companies were in business by the mid-1990s.

Design Specialization: During the past 30 years, User Interface Design has already separated from generalized Industrial Design as a specialty. Sustainable Design is close behind and Additive Design is on the doorstep as 3D printing matures into Additive Manufacturing. Meanwhile, Design for the IIoT and IoT and Design for Big Data Analytics will both soon distinguish themselves as well. If you are a designer, or an engineer who does a lot of designing, this would be a good time to read the tea leaves and pick your spots accordingly. Trade schools and academic institutions now offer specialty degrees, and history tells us that is a meaningful development.

The Current waves of Product Design

The modernist design ideology values creative artistic expression and this led to celebrity designers taking a leap in their careers with extravagant designs. Art and design started merging, showing us that art itself is the work of a designer. Products brought the character into our abodes giving us values depending on the items we owned. This ideal flourished in the materialistic present with people all wanting the new and trendy. However, this created a horrific consumer culture due to the impermanence of products and the urge to replace them with newer designs.

Hence sustainability came into the picture to reduce this materialistic ideology and user-centric design was once again given prime importance.

Product Design of the Future

With the advancement in technology, the future of Product design could very well be far from reality. Designers have advanced technology which can help them propel their ideas to new levels. One such example is the 3D printer which was introduced decades ago but has in recent times become widely accessible to the common man.

New prototypes of this wonderful innovation can generate 3d models of designs that are visualized by the designer in the bare minimum time. This allows designers to test out their products with maximum ease and in the shortest time possible. However, with such advancements to aid them this field has become a challenging and competitive field that also has an equal probability of success and failure.
Video Content / Details of website for further learning (if any): **https://www.re-thinkingthefuture.com/product-design/a4915-past-present-and-future-product-design/** **https://www.machinedesign.com/automation-iiot/article/21837666/a-history-of-product-design**
Important Books/Journals for further learning including the page nos: 1. A text book of Product Design - Kevin Otto – 3-9; 112-145

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LECTURE HANDOUTS

L 02

MECH

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **I - Introduction**

Date of Lecture :

Topic of Lecture: Types of design

Introduction : (Maximum 5 sentences)

- The definition of product design describes the process of imagining, creating, and iterating products that solve users' problems or address specific needs in a given market.
- The key to successful product design is understanding the end-user customer, the person for whom the product is being created.
- Product design is the process of identifying a market opportunity, clearly defining the problem, developing a proper solution for that problem and validating the solution with real users.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Good design makes a business grow by enhancing profitability and turnover because it transforms the needs of customers into the desired shape and value of the product demanded.
- Product design is a major crowd pull especially in technology markets .
- A major role played by product design is on the differentiation of the product from the competition.

Detailed content of the Lecture:

Product design

- Product design is important to an organization or a brand as it differentiates the brands from others.
- Product design is the way you arrange the features and benefits of the product to be presented to the customer. The design can be a benefit in itself.
- When compared with a competition, if you have the better product design, your product will be chosen above competition in the market.

The types of product design

The three main types of product design are system, process and interface design. They each have the goal of tackling different problems in the user experience but are equally important when it comes to the final design.

Here are the three types of product design, explained.

System design

The layout of a shop is a simple and popular example of a system design. The product designer of shelves is practically an information architect in a real-life marketplace with hundreds of items.

They will organize the items into logical categories (e.g. confectionery, snacks, cooking supplies, dairy, etc.), then assemble the different categories in a logical order (e.g. multiple types of food on one side, cleaning products on the other side of the store), and ensure that the things that customers should notice are highlighted (sale, new product on promotion, etc.).

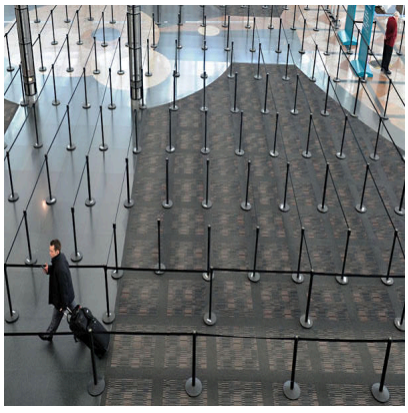
The designer considers not just the customer's intuition and convenience of use, but also the market's commercial goals. Customers will go counter-clockwise and notice the heart-shaped chocolate boxes and flowers on the right side of the door, for example, during Valentine's Day.

Process design

In websites, such as e-commerce, process design is critical since it facilitates exploring, selecting, saving, adding to cart, and finally paying for things. But, let's return to a more concrete example: an airport.

Airports have a lot of waiting, zig-zag queues, and chambers that can only be entered and exited by one door, among other things. The reason for this is that there are a number of processes that are critical for safety and efficiency, including check-in, security checks, passport control, customs, and other procedures.

The zig-zag lines and doors that don't open from the inside once you've checked your luggage aren't part of the design. They're there to help passengers fit more people in a line and to keep passengers from adding or purchasing dangerous things after security has inspected everything they own. Airport layouts are complicated and unintuitive for a reason, and that reason is safety.


Qminder

Interface design

Interface design is focused on the aesthetic experience of the product. It has a human-first approach: before looks and innovation, the interface is a touchpoint between the user and the product and its usability and it serves to solve their real problems. The idea is to guide the user through the product and make them feel like they can use it instinctively.

Let's say that we are talking about an ATM. Its interface must be clear and guide the person

withdrawing money from the machine to do that effortlessly.

By implementing colors, fonts, icons, shapes and different sizes on all elements, they can guide the person into easily understanding how to use the ATM.

Video Content / Details of website for further learning (if any):
https://www.manypixels.co/blog/post/different-types-of-product-design

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design - Kevin Otto – 3-9; 112-145

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LECTURE HANDOUTS

L 01

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **I**

Date of Lecture :

Topic of Lecture: Design process

Introduction: (Maximum 5 sentences)

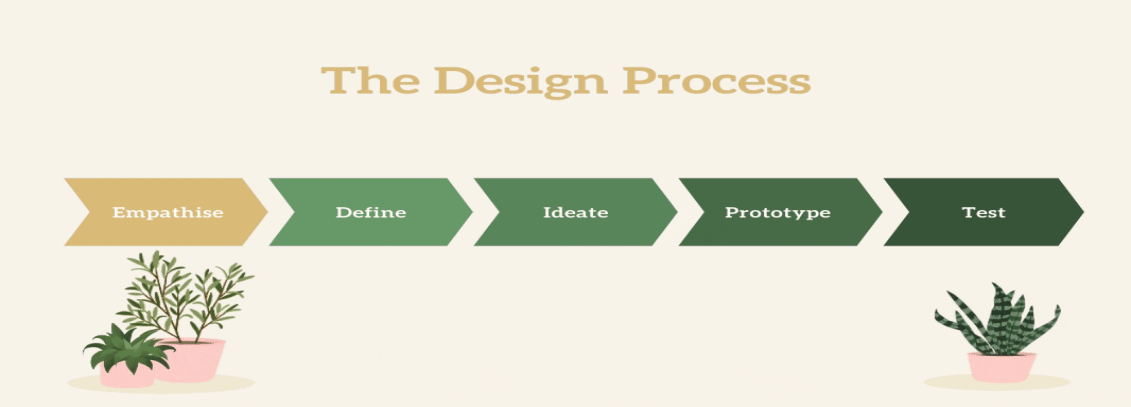
- The Product Design process is a critical framework that designers use to solve problems.
- Design process is a way of figuring out what you need to do, then doing it.
- Design thinking minimizes the uncertainty and risk of innovation by engaging customers or users through a series of prototypes to learn, test, and refine concepts. Design thinkers rely on customer insights gained from real-world experiments, not just historical data or market research

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- **Research phase** inform every subsequent part of the design process, that you can easily kill ideas.
- design process looks like with your client, it allows you to establish realistic project deliverables and deadlines together. Your client will know exactly what to expect from you and when to expect it, eliminating needless miscommunication later.

Detailed content of the Lecture:

The Design Process
is an approach for breaking down a large project into manageable chunks. Architects, engineers, scientists, and other thinkers use the design process to solve a variety of problems. Use this process to define the steps needed to tackle each project, and remember to hold to all of your ideas and sketches throughout the process.



1. **Empathise with your users**

It's crucial to assess whether there is a strong demand or need for your product before beginning the design and development process. We often validate this product-market fit by conducting what we call user research.

User research

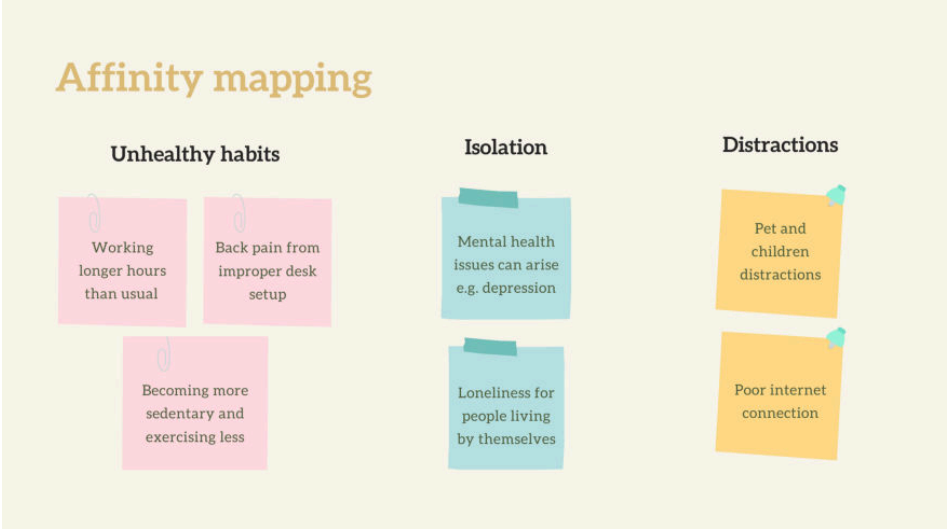
Some methods for user research include:

- **User interviews.** A very common qualitative research technique that can be conducted in-person or remotely. Whilst organizing and analyzing findings from interviews can be time consuming, the benefit of this method is that you can uncover insights from direct conversation with users than from surveys alone.
- **Online surveys.** Surveys and questionnaires enable you to obtain a large volume of quantitative data in a short amount of time. Whilst they can be relatively quick and inexpensive to run, the downside to this is that you may lack deeper insights that you would normally get from in-person interactions.
- **Contextual inquiry.** A method in which you observe people go about their day-to-day tasks in their natural environment. This allows you to truly empathise with your users as it forces you to put yourself in their shoes.
- **Market research:** Understanding how your competitors approach similar problems is a crucial component of the product design process as it allows you to learn from their design patterns and mistakes.

User analysis

Once we've collected the data from user research, we often synthesise our findings by grouping them into common themes — an exercise which we call Affinity mapping. Affinity mapping allows us to form insights from raw data which we can then use to inform our decision making.

For the purposes of the workshop, I wanted to focus on a relevant topic that was having a profound impact on people today. Knowing that the recent global pandemic had forced many people to work from home, I was curious to explore what impact this was having on people working remotely today.



Affinity mapping exercise used to group common issues

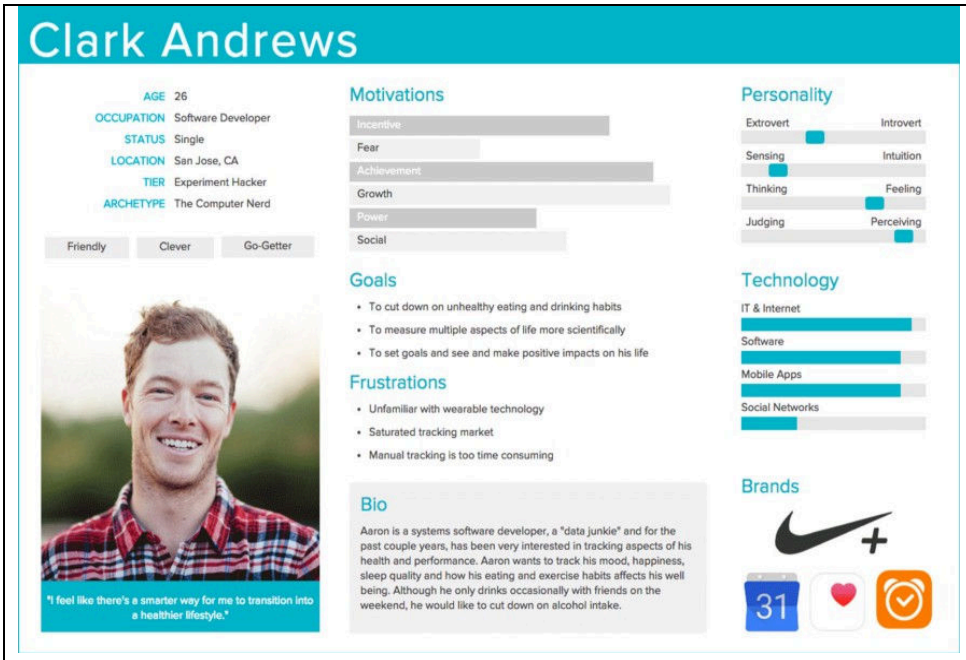
Common themes identified from the research were:

- **Unhealthy habits.** Due to the blending of work and home environments, there was a tendency for people to work longer hours than usual. Sitting down for too long and not moving around as much meant that remote workers were experiencing physical health issues such as back pain as their lifestyle became more sedentary.

- **Isolation.** The lack of coffee chats, social gatherings and hallway chats usually found in office environments meant that many people living alone were experiencing isolation from loss of in-person connections. Prolonged quarantine and lock-downs have contributed to a rise in mental health issues such as anxiety and depression.

- **Distractions.** External environmental factors such as children and pets, as well as technological disruptions from poor internet and electricity blackouts, have led to a loss in focus times and productivity. This meant that remote workers would often work overtime to compensate for the loss in productivity, leading to a vicious cycle of unhealthy habits.

When it comes to user research, we also need to understand who we're building for, so creating user personas is important part of this process. The purpose of persona mapping helps to formulate reliable and realistic representations of the key audience segments when it comes to empathising with our users.



Example of a user persona *(Image credit: Adobe)*

2. Define the problem

Now that we have a better understanding of the problems, we can start to focus on the core user issues and turn them into opportunities by using what we call the problem statement definition. This step is important as it allows you to understand the goal of your design project and provide a clear objective to work towards.

We often start with the phrase ‘How Might We' to create our problem statement. For example:

How might we encourage people working from home to adopt better health and wellness habits?

3. Ideate

Once you’ve defined your problem statement, we move into the ideation phase. Ideation is a time when team members brainstorm on a range of creative ideas and solutions that address the problem statement. This is an extremely valuable step as it allows you to build trust by getting stakeholders together in a room to align on the future vision.

Competitor research

Often we refer to competitors in the market as a way to learn and take inspiration from. When conducting competitive analysis, we often look for design patterns — in their product offering, the user experience and the visual design. I’ve listed two examples of products that are tackling a similar problem in the health and wellness space below.

Headspace is an example of a mental health and meditation app that allows users to sign up and engage

in meditation courses.

Zen mode is also an app that locks you out of your phone so that you're forced to take a break away from the screen.

In both examples, you can see that the user journey is very similar. A user would:

1. Sign up or log into the app
2. Define their goals
3. Receive a task to complete
4. Perform the task and;
5. Track their progress over time

User Journey mapping

User Journey mapping is a process that a user must go through in order to accomplish a goal. A user journey is presented as a series of steps and actions in a timeline skeleton. Such a layout makes it easier for all team members to understand and follow the user's narrative.

Sketching the solution

Sketching is a valuable activity as it allows stakeholders (PMs, engineers and customers) to get into a room and align on the vision. This drawing exercise encourages non-designers to put forth their ideas and is a great way to foster collaboration as some of the most creative ideas can come from people who don't have a design background.

When we're sketching, we often refer back to our problem statement and user journey map to help us frame the problem space and define the scope of the work.

Design principles

As mentioned at the start of this article, we often need a north star or vision to work towards. Having design principles to guide your solution is useful as it helps to establish what we want our product to become and what we don't want our product to become.

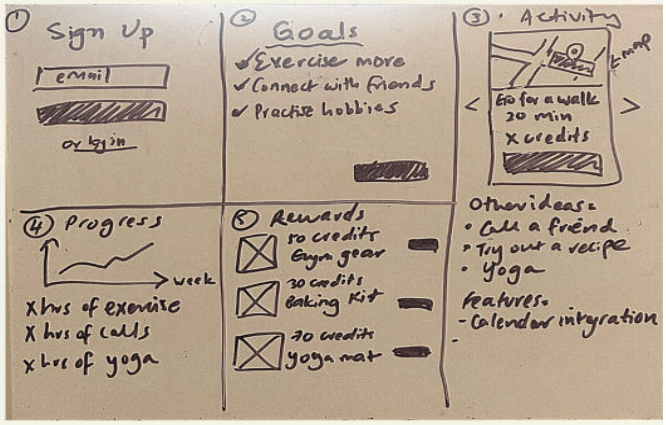
Some guiding principles for a mental health and wellness product could be:

- Simple but **not overwhelming**
- Human and empathetic, **not robotic**
- Motivating and engaging, **not a chore**
- Flexible and personalised, **not forced**
- Encourages LESS screen time, **not more**

Here is an example of an idea that I sketched out:

Example

An app that nudges you to take a break by providing you with personalised health and wellness activities.



Example sketch for a health and wellness app

Similar to Zen mode, I came up with an idea for an app that encourages you to take a break by providing you with personalised activities.

As a user, I would:

1. Sign up or log in
2. Define my goals (e.g. exercise more, connect with friends, explore new hobbies)
3. Receive activity ideas (e.g. go for a walk at a park nearby, call a friend, try out a painting class)
4. Receive credits upon task completion
5. Track my progress towards my goals
6. Exchange my credits for rewards

Once you've sketched out your solution, don't be afraid to share your ideas. Part of the design process is being able to share your work and receive feedback from others.

4. Prototype the solution

Once you're happy with your solution, you can use design and prototyping tools such as Figma, Sketch and Invision or Adobe XD to create a clickable prototype.

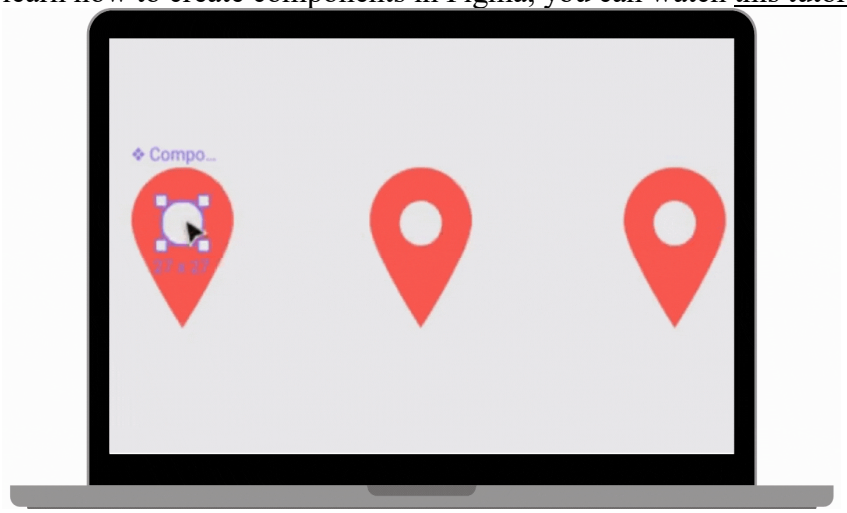
Examples of prototyping tools

Personally I would recommend Figma as it is an all-in-one tool that has both design and prototyping functionalities. I would also recommend looking at the Figma Community which is a great repository for you to remix, reuse and repurpose existing templates that other users publish freely online— similar to Github but specifically for design.

For the purposes of the workshop I used an existing Figma template that already had a design system created. Figma has really great tutorials that you can watch to learn how to piece together screens using pre-made components.

Creating components

Components are very useful when it comes to speeding up your design workflow. The **master component** is created when you first turn a UI element into a component. It defines the properties of that component. The **instance** is a copy of the master component that you can reuse across designs. To learn how to create components in Figma, you can watch this tutorial.


Editing a master component applies the changes to the instances

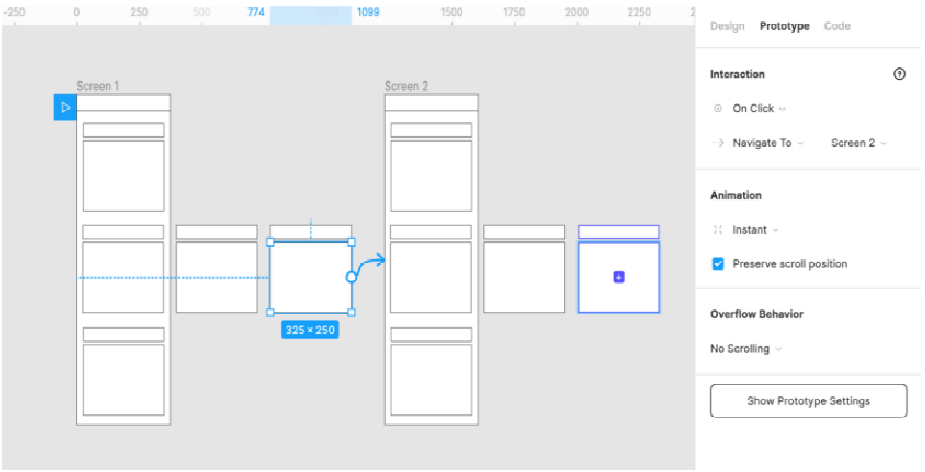
Using a design system

A design system is a collection of elements that can be combined and reused to build products. Using a

design system is a really effective way of speeding up your design workflow and it allows you to maintain consistency across your designs. You can find more examples of design systems built by other companies by visiting this list of design systems. For an in-depth tutorial on how to create a design system in Figma, watch this tutorial.

Prototyping

To create interactions and transition states between screens, connect them together using nodes (i.e. the blue dots). You can specify the animations by editing the settings in Prototype > Interaction and Animation. To learn more on how to prototype in Figma, watch this tutorial.



Previewing your prototype

If you've created a mobile prototype, you can use Figma Mirror to view and interact with the prototype on your mobile device. Simply go to the Play Store and download Figma Mirror. Select a frame on your Figma desktop app and watch it appear on your phone!

5. Test the solution with users

Usability testing is an important part of the design process as it allows us to get feedback from users during the ideation phase before anything gets built or shipped. This is crucial as it allows you to identify any usability issues upfront before you invest more time in developing the solution.

Depending on the stage of the design process, choose the method that minimises work and maximises learning. Don't be afraid to test low-fidelity prototypes.

Some examples of usability testing methods and tools include:

- **Moderated usability testing.** With moderated usability testing, a real person will be there to

help facilitate the test either in person or remotely. To learn how to conduct moderated usability tests, refer to these usability testing templates.

- **Unmoderated usability testing.** Unmoderated forms of testing occurs when the participant is not monitored or guided. These can be conducted remotely via websites such as Usertesting.com or UsabilityHub where participants can be recruited via these platforms.

- **Guerrilla testing.** Guerrilla testing is a process where test subjects are selected at random in public places and asked to perform a quick usability test. It's commonly used to test a wide cross-section of users with no previous connection to the product and collect a large amount of data to quickly validate designs.

- **Dog-fooding**. Dog-fooding is a common way to test your product in-house before you release your product to the public. "Eating your own dog food" is a popular technique of testing as it allows your team to develop empathy and identify any critical issues.

When it comes to recruiting participants, according to Jakob Nielsen's research, observing 5 participants using your product is enough to identify up to 85% of core usability problems.

Measuring success

Once you've shipped your product, that's not it — it's only just the beginning! You need to track how well it's performing now that it's out in the wild and in the hands of your users. Some key metrics that you should monitor include adoption, activation, drop off, churn, and retention rates.

Some examples of tracking tools include Hotjar, Google Analytics and Mode Analytics. If data analytics is not your strength, get an engineer or a data analyst to help you out when setting up the tracking events.

You should get into a regular habit of performing A/B testing on design changes and iterations before you roll them out to all users as this gives you confidence in what performs better in terms of conversions and success metrics.

However, don’t solely rely on analytics. You should also aim to get user feedback from email surveys, in-product questionnaires and even hallway tests. Analytics alone may not always provide you with the insights that you could get from just having a conversation with your users.

Key takeaways

It’s not a linear process

Whilst we went through a very structured and linear design process, the reality is that you may find yourself jumping back and forth to learn more about the problem space.

There’s no one size fits all

The product design process should morph to fit the project, not the other way round. Your design process will depend on the stage of the product development lifecycle that the feature or product is at. In other words, if the product is in its early stage, you may want to spend more time doing user research; whereas if it has been shipped, your priorities might lie in growing and optimising your product.

It’s a never ending process

Continual improvement is at the core of what we do, so keep refining and improving your product! Once a product has been shipped, never assume that it is finished. Continue to get feedback and refine your product as your users’ needs may change over time.

Final words

Finally, the most important thing to remember when designing products is that we are ultimately designing a product for people to use. As product designers, we play an important role in shaping our

future. The products we create have the power to transform how societies think, feel and behave as you may have seen in the recent.
Video Content / Details of website for further learning (if any): **https://www.netsolutions.com/insights/everything-about-new-product-development/**
Important Books/Journals for further learning including the page nos: **1.** A text book of Product Design – Kevin Otto – 3-9; 112-145

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LECTURE HANDOUTS

L 01

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **I**

Date of Lecture :

Topic of Lecture: Product life cycle

Introduction : (Maximum 5 sentences)

- A product life cycle is the length of time from a product first being introduced to consumers until it is removed from the market.
- A product's life cycle is usually broken down into four stages; introduction, growth, maturity, and decline.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- To determine when newer products are ready to push older ones from the market.
- It integrates the needs of people, technological possibilities and business requirements.

Detailed content of the Lecture:

Product life cycles

are used by management and marketing professionals to help determine advertising schedules, price points, expansion to new product markets, packaging redesigns, and more. These strategic methods of supporting a product are known as product life cycle management. They can also help determine when newer products are ready to push older ones from the market.

product life cycle

The product life cycle is the length of time from when a product is introduced to the consumer market up until it declines or is no longer being sold. This cycle can be broken up into different stages, including—development, introduction, growth, maturity, saturation, and decline. The life cycle of a product is typically used to determine when it's appropriate to increase advertising, adjust pricing, explore new markets, redesign packaging and even adjust your messaging.

the stages of the product life cycle

Each stage has its costs, opportunities, and risks, and individual products differ in how long they remain at any of the life cycle stages. While there are differing opinions regarding if there are four, five, or six stages of the product life cycle, each option includes the following steps.

1. Development

The product development stage is the research phase before a product launch. Technically, this falls outside the definition of the product life cycle, but it's a vital step to be aware of. In short, it's used to determine the viability of a product, confirm when it should go to market and how to approach your official launch.

At this stage, costs are accumulating with no corresponding revenue. Some products require years and large capital investment to develop and then test their effectiveness. Since risk is high, outside funding sources are limited.

Existing companies often fund research and development from revenue generated by current products. For startup businesses, this stage is typically funded by the entrepreneur from their own personal resources. For those developing a new product, it may be wise to land on a minimum viable product (MVP) as early as possible.

This can be as minimal as a sketch or as complex as a sample or prototype version of the product itself. You just need enough to show how your product will work to potential investors and customers. The earlier you can validate its market potential, the more likely you'll be to land investment and launch.

2. Introduction

The introduction stage is when your product is first launched in the marketplace. It's where you step beyond the product itself to develop a market for the product and build product awareness. Here, you'll work to carve out a target market, conduct a market analysis to understand the competitive landscape, and ideally land your first few sales.

Marketing costs are high at this stage, as it is necessary to reach out to potential customers. The best approach when promoting a new product is to focus on testing distribution channels and messaging. While your advertising budget may be hefty, you can strategically leverage it to identify marketing channels that lead to higher conversions.

This is also the stage where intellectual property rights protection is obtained. Depending on your market position, product pricing may be high to recover costs associated with the development stage. It also may be lower, meaning you'll initially be running at a loss until you gain traction. This is where landing initial funding efforts and mapping out your cash runway are vital to the success of your product.

3. Growth

In the growth stage, the product has been accepted by customers, and you are now striving to increase market share. That means that demand and revenue are growing, ideally at a steady rate. How long you achieve steady growth fully depends on your product, the current market landscape, and the adoption rate of customers.

If you're entering an already crowded market with a product, you'll likely see competitors react fairly quickly. If you've entered a market with less competition or are first to market in a breakout industry, you'll likely see a slower response by new or current entrants.

In either case, your response during this phase is to fine-tune your messaging, solidify your brand presence and expand into new distribution channels. This also may be the time to consider adding additional services to support and further differentiate your product. Things like support services, add-ons, or insurance packages are just a few options to consider. Having these additions available, or at least in progress, can better help you react to competitors and extend the return on investment (ROI) from a given customer.

4. Maturity and saturation

The mature stage is when sales will level off. This doesn't mean you aren't still growing, you just won't see the same level of rapid growth as before. Typically at this point, you will begin to lower prices, offer free additions or make other adjustments to keep your products competitive.

At the same time, you've also become more efficient. Production costs tend to decline, costly mistakes in the manufacturing process can now be avoided. Even your marketing expenditure is likely more refined and effective at this stage. So, while you may not be growing in volume, you're likely at your most profitable in this stage.

However, it's worth remembering that your competitors have likely now solidified their own offerings in this stage. This means that they have taken a portion of the market, further leading to the flattened growth of your own product. Most consumers are likely already using a version of your product and have begun developing brand preferences.

This is when any adjustments to advance your product or the services that accompany it, should be made. If you've hit the point where any real adjustments simply aren't possible, then your messaging, services, and add-ons should take full focus.

You may only be able to make incremental changes but can still look to market it as a refresh accompanied by new features or benefits. Video game consoles are a great example of this, where incremental updates to hardware are often touted to sell new consoles. The Nintendo Switch OLED edition is the latest example, where the only update is a new, slightly larger, and crisper screen.

5. Decline

The decline stage of the product life cycle is associated with decreasing revenue due to market saturation, high competition, and changing customer needs. Companies at this stage have several options:

- Discontinue the product
- Sell the manufacturing rights to another business
- Find new uses for the product
- Tap into new markets

It's at this stage, where you'll really need to weigh the costs and benefits associated with each option. Are you really capable of revising the product? Are there other features you simply haven't tapped into? Is there a market you haven't looked into that could benefit from your product?

If you can, look to run different forecasting scenarios during this time to see what each decision could lead to depending on product performance. Hopefully, you have other products to help support your business when one declines. Ideally, you'll have multiple products or iterations running at different points in the product lifecycle.

Video Content / Details of website for further learning (if any):

https://uxplanet.org/what-is-product-design-and-the-product-design-process-41b41a5bf795

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design – Kevin Otto – 3-9; 112-145

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LECTURE HANDOUTS

L 01

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **I**

Date of Lecture :

Topic of Lecture: Generic product development process

Introduction : (Maximum 5 sentences)

- A Generic Product Development Process Concept Development System-Level Design Detail Design Testing and Refinement Production Ramp-Up Product Launch Mission Statement Product Planning.
- A generic brand is a consumer product without a widely recognized name or logo because it typically isn't advertised. Generic brands are known for their very basic packaging and labels, and lower prices. A generic drug or pharmaceutical brand may be created when the patent of a name brand drug expires.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- This process helps break down tasks and organize cross-departmental collaboration.
- This will allow all team members to have a clear understanding of the initial product features and the objectives of the new product launch.

Detailed content of the Lecture:

The product development process describes the six steps needed to take a product from initial concept to final market launch. This includes identifying a market need, researching the competition, ideating a solution, developing a product roadmap, and building a minimum viable product (MVP).

1. Idea generation (Ideation)

The initial stage of the product development process begins by generating new product ideas. The initial idea stage is where you brainstorm product concepts based on customer needs, pricing, and market research.

It's a good idea to consider the following factors when initiating a new product concept:

Target market: Your target market is the consumer profile you're building your product for. This is important to identify in the beginning in order to build your product concept around your target

market.

Existing products: When you have a new product concept, it's a good idea to evaluate your existing product portfolio. Are there existing products that solve a similar problem? If so, is the new concept different enough to be viable? Answering these questions can ensure the success of your new concept.

Functionality: While you don't need a detailed report of the product functionality just yet, you should have a general idea of what functions it will serve. Consider the look and feel of your product and why someone would be interested in purchasing it.

SWOT analysis: Analyzing your product strengths, weaknesses, opportunities, and threats early in the process can help you build the best version of your new concept. This will ensure your product is different from competitors and solves a market gap.

SCAMPER method: In order to refine your idea, use brainstorming methods like SCAMPER, which involves substituting, combining, adapting, modifying, putting to another use, eliminating, or rearranging your product concept.

To validate a product concept, consider documenting ideas in the form of a business case. This will allow all team members to have a clear understanding of the initial product features and the objectives of the new product launch.

2. Product definition

Once you've completed the business case and discussed your target market and product functionality, it's time to define the product. This is also referred to as scoping or concept development, and focuses on refining the product strategy.

During this stage, it's important to define specifics including:

Business analysis: A business analysis consists of mapping out distribution strategy, ecommerce strategy, and a more in-depth competitor analysis. The purpose of this step is to begin building a clearly defined product roadmap.

Value proposition: The value proposition is what problem the product is solving. Consider how it differs from other products in the market. This value can be useful for market research and for developing your marketing strategy.

Success metrics: It's essential to clarify success metrics early so you can evaluate and measure success once the product is launched. Are there key metrics you want to look out for? These could be basic KPIs like average order value, or something more specific like custom set goals relevant to your organization.

Marketing strategy: Once you've identified your value proposition and success metrics, begin brainstorming a marketing strategy that fits your needs. Consider which channels you want to promote your product on—such as social media or a blog post. While this strategy may need to be revised depending on the finished product, it's a good idea to think about this when defining your product to begin planning ahead of time.

Once these ideas have been defined, it's time to begin building your minimum viable product (MVP) with initial prototyping.

3. Prototyping

During the prototyping stage, your team will intensively research and document the product by creating a more detailed business plan and constructing the product.

These early-stage prototypes might be as simple as a drawing or a more complex computer render of the initial design. These prototypes help you identify areas of risk before you create the product.

During the prototyping phase, you will work on specifics like:

Market risk research: It's important to analyze any potential risks associated with the production of your product before it's physically created. This will prevent the product launch from being derailed later on. It will also ensure you communicate risks to the team by documenting them in a risk register.

Development strategy: Next, you can begin working through your development plan. In other words, understand how you'll be assigning tasks and the timeline of these tasks. One way you can plan tasks and estimate timeline is by using the critical path method.

Feasibility analysis: The next step in the process is to evaluate your product strategy based on feasibility. Determine if the workload and estimated timeline are possible to accomplish. If not, adjust your dates accordingly and request help from additional stakeholders.

MVP: The final outcome of the prototyping stage is a minimum viable product. Think of your MVP as a product that has the features necessary to go to launch with and nothing above what's necessary for it to function. For example, an MVP bike would include a frame, wheels, and a seat, but wouldn't contain a basket or bell. Creating an MVP can help your team execute the product launch quicker than building all the desired features, which can drag launch timelines out. Desired features can be added down the road when bandwidth is available.

4. Initial design

During the initial design phase, project stakeholders work together to produce a mockup of the product based on the MVP prototype. The design should be created with the target audience in mind and complement the key functions of your product.

A successful product design may take several iterations to get just right, and may involve communicating with distributors in order to source necessary materials.

To produce the initial design, you will:

Source materials: Sourcing materials plays an important role in designing the initial mockup. This may entail working with various vendors and ordering materials or creating your own. Since materials can come from various places, you should document material use in a shared space to reference later if needed.

Connect with stakeholders: It's important to keep tight communication during the design phase in order to verify your initial design is on the right track. Share weekly or daily progress reports to share updates and get approvals as needed.

Receive initial feedback: When the design is complete, ask senior management and project stakeholders for initial feedback. You can then revise the product design as needed until the final design is ready to be developed and implemented.

Once the design is approved and ready to be handed off, move onto the validation phase for final testing before launching the product.

5. Validation and testing

In order to go live with a new product, you first need to validate and test it. This ensures that every part of the product—from development to marketing—is working effectively before it's released to the public.

To ensure the quality of your product, complete the following:

Concept development and testing: You may have successfully designed your prototype, but you'll still need to work through any issues that arise while developing the concept. This could involve software development or the physical production of the initial prototype. Test functionality by enlisting the help of team members and beta testers to quality assure the development.

Front-end testing: During this stage, test the front-end functionality for risks with development code or consumer-facing errors. This includes checking the ecommerce functionality and ensuring it's stable for launch.

Test marketing: Before you begin producing your final product, test your marketing plan for functionality and errors. This is also a time to ensure that all campaigns are set up correctly and ready to launch.

Once your initial testing is complete, you're ready to begin producing the final product concept and launch it to your customer base.

6. Commercialization

Now it's time to commercialize your concept, which involves launching your product and implementing it on your website.

By now, you've finalized the design and quality tested your development and marketing strategy. You should feel confident in your final iteration and be ready to produce your final product.

In this stage you should be working on:

Product development: This is the physical creation of your product that will be released to your customers. This may require production or additional development for software concepts. Give your team the final prototype and MVP iterations to produce the product to the correct specifications.

Ecommerce implementation: Once the product has been developed and you're ready to launch, your development team will transition your ecommerce materials to a live state. This may require additional testing to ensure your live product is functioning as it was intended during the

previous front-end testing phase.
Video Content / Details of website for further learning (if any): **https://asana.com/resources/product-development-process**
Important Books/Journals for further learning including the page nos: **1.** A text book of Product Design – Kevin Otto – 3-9; 112-145

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LECTURE HANDOUTS

L 01

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **I**

Date of Lecture :

Topic of Lecture: Strategic planning for new products

Introduction : (Maximum 5 sentences)

- Strategic product planning is the process of defining how you will achieve your vision. By working backward from your desired end state, you can set goals and initiatives to guide your strategy and a timeline to achieve them. That timeline is often referred to as a product roadmap.
- Product planning, by definition, is the strategizing process that spans from idea conception to product market launch. Strong product planning is crucial for the company – if any step fails, then the entire initiative might be doomed.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- To identify the issues that need to be addressed.
- Document your organization's internal strengths and weaknesses, along with external opportunities (ways your organization can grow in order to fill needs that the market does not currently fill) and threats (your competition).

Detailed content of the Lecture:

The strategic planning process is the method that organizations use to develop plans to achieve overall, long-term goals.

This process differs from the project planning process, which is used to scope and assign tasks for individual projects, or strategy mapping, which helps you determine your mission, vision, and goals.

Strategic planning process steps

1. Determine your strategic position

This preparation phase sets the stage for all work going forward. You need to know where you are to determine where you need to go and how you will get there.

Get the right stakeholders involved from the start, considering both internal and external sources. Identify key strategic issues by talking with executives at your company, pulling in customer insights, and collecting industry and market data to get a clear picture of your position in the market and in the

minds of your customers.

As a framework for your initial analysis, use a SWOT diagram. With input from executives, customers, and external market data, you can quickly categorize your findings as Strengths, Weaknesses, Opportunities, and Threats (SWOT) to clarify your current position.

As you synthesize this information, your unique strategic position in the market will become clear, and you can start solidifying a few key strategic objectives. Often, these objectives are set with a three- to five-year horizon in mind.

2. Prioritize your objectives

Once you have identified your current position in the market, it is time to determine objectives that will help you achieve your goals. Your objectives should be in line with your company mission and vision.

Objectives should be distinct and measurable to help you reach your long-term strategic goals and initiatives outlined in step one. Potential objectives can be updating website content, improving email open rates, and new leads in the pipeline.

SMART goals are useful to determine a timeline and identify the resources needed to achieve the goals, as well as key performance indicators (KPIs) to make your success measurable.

3. Develop a plan

This step requires determining the tactics necessary to attain your objectives and designating a timeline and clear communication of responsibilities.

Strategy mapping is an effective tool to visualize your entire plan. Working from the top-down, strategy maps make it simple to view business processes and identify gaps for improvement.

4. Execute and manage the plan

Once you have the plan, you're ready to implement it. First, communicate the plan to the organization by sharing relevant documentation. Then, the actual work begins.

Turn your broader strategy into a concrete plan by mapping your processes. Use KPI dashboards to clearly communicate team responsibilities. this granular approach illustrates the completion process and ownership for each step of the way.

Set up regular reviews with individual contributors and their superiors and determine check-in points to make sure you're on track.

5. Review and revise the plan

The final stage of the plan—to review and revise—gives you an opportunity to reevaluate your priorities and course-correct based on past successes or failures.

On a quarterly basis, determine which KPIs your team has met and how you can continue to meet them, adapting your plan as necessary. On an annual basis, it's important to reevaluate your priorities and strategic position to ensure that you stay on track for success in the long run.

Track your progress using balanced scorecards to provide a comprehensive understanding of your business's performance and execute strategic goals.

Video Content / Details of website for further learning (if any): https://www.lucidchart.com/blog/5-steps-of-the-strategic-planning-process
Important Books/Journals for further learning including the page nos: **1.** A text book of Product Design – Kevin Otto – 3-9; 112-145

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LECTURE HANDOUTS

L 01

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **I**

Date of Lecture :

Topic of Lecture: Market opportunity for new products

Introduction : (Maximum 5 sentences)

- A market opportunity is a newly identified need that a company can use to grow; usually, because it's not being addressed by competitors.
- Opportunity identification is the collection of three main factors, which are the entrepreneur's background, the business influence and the general business environment.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Identifying a niche market idea is essential when it comes to exploiting new opportunities for innovation.
- The more targeted your market becomes, the more gaps that will start to appear and the less competition you will face.

Detailed content of the Lecture:
6 Ways to Identify Market Opportunities for Business Growth

To stand out from the competition, your company needs to develop skills to identify market opportunities that will help your business to grow.
Before developing this framework, you must first understand your company's vision and determine your team's capability to take on new ventures and expand its operations.

1. Conduct thorough market research

While not a groundbreaking idea, conducting market research is the simplest and most effective way to learn about your market and give direction to your advertising strategy. The process of market research is similar to that of any research project and involves five principal steps:

Defining the opportunity(s)

Developing a possible marketing research plan

Data collection (qualitative and quantitative data)

Analysis of accrued data and reporting

Piloting the opportunity with the intent to scaling up

2. Check out international markets

Business growth may also mean that you explore international markets. From business maturity to

home-market saturation, there are a myriad of reasons why your company may be considering expanding into foreign markets. The advantages of going global include:

New investment opportunities

More revenue

New talent acquisition

Product diversification

Before deciding which countries you'd like to branch out into, you need to research their economy and your legal responsibilities.

When you take your business overseas, you may need to hire more staff. Getting the right kind of talent is a concern for any entrepreneur, but there are resources out there that can help. The countries you expand to, such as Singapore, will most likely have an employer of record, such as NH Global Partners**,** to assist you in managing your liabilities and other employment duties.

You may also need to contract a professional translation service provider to ensure smooth communications between your new business partners and customer base.

3. Study your consumers

You should study your current customers to find out what other services or products they may benefit from. This knowledge may inform which products or services you offer in the future. You may wish to expand to other services that your customers currently need or those that they will need in the future so that you can keep your customers, even as their lives change.

For instance, if your company manufactures and distributes baby food, you ought to find out what other products you can introduce that parents and carers of these infants will be interested in as their kids get older, such as snacks for children's lunchboxes.

You should strive to collect information such as client characteristics ranging from age, education status, and income to attitude and lifestyle. These variables influence customers' purchasing decisions, preferences, and power.

4. Check out your competitors

Being up to speed on what your competitors are doing is just as essential as understanding your customers. You can learn a great deal from evaluating the successes and failures of other businesses on the market.

This is particularly useful if your company plans to diversity or launch a new product or service. Are there other company's out there offering a similar service? What is successful about it, and what could be improved? Take this knowledge and use it to ensure your business has a leg up.

5. Leverage social evolutions

Although your customers may be very loyal to your brand, they won't think twice about moving to one of your competitors as their needs change. It's vital, therefore, to stay on top of how the consumers shift their purchasing patterns. This information will provide you with the strategies to evolve to meet your customer's needs.

You should be informed about general changes in society, new trends, and how they could impact your customers' needs. A great example of this is our new awareness of and concern about the environment. These days consumers want to know what businesses are doing to reduce their carbon footprint and are more likely to give their money to companies that take measures such as using recycled packaging. Keep up with these changes, and your business will grow.

6. Use social media

We cannot overstate the value of social media for business marketing. Not only should you be using

various social media platforms to advertise your products and services and target your ideal customer, but you can also mine it for invaluable information about said customer.

By following social media trends and discussions, you can see what the public really thinks about your services, as well as those of your competitors. You can also engage directly with your customers by running fun surveys and polls about new or existing products and get unedited opinions straight from the horse's mouth. This kind of input can help you refine your ideas. In a nutshell, this strategy is one of the best ways to identify market opportunities for your business growth.

Video Content / Details of website for further learning (if any):

https://www.lucidchart.com/blog/5-steps-of-the-strategic-planning-process

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design – Kevin Otto – 3-9; 112-145

Course Faculty

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LECTURE HANDOUTS

L 01

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **I**

Date of Lecture :

Topic of Lecture: Customer needs and survey

Introduction : (Maximum 5 sentences)

- A consumer's wants usually reflect the desired preferences for specific ways of satisfying a need. Thus, people usually want particular products, brands, or services that satisfy their needs in a specific way.
- Customer needs refer to a customer's motives for purchasing a product, brand or service, or alternatively the attributes of a product, brand or service that tempt them to buy. And it's these customer needs that every business or organisation is striving to identify.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Information gathered can help in validating decisions and demonstrates to your existing and loyal customer base that you are interested in serving their needs.
- Customer satisfaction surveys are important tools for improving your business and ensuring your customers remain with you.

Detailed content of the Lecture:
Customer Needs Assessment

Survey Design & Analysis recommends conducting a customer needs assessment prior to initiating any customer survey or customer satisfaction survey in order to ensure that you are starting with a clear picture of what is most important to your customers and what they feel their most critical needs are. This makes sure that your customer survey talks to your customer and asks the right questions of the right people in the right way.

Customer Needs

Customer needs are defined as the influential factors that trigger them to buy your product or service. In order to identify customer needs, it is important to understand the reasons behind their decision making.

In order to understand customer needs better, it's very important to know who your customers are. By defining your target audience and segmenting them based on their industry or other attributes, you not only get a clear view of what's your selling proposition but also identify their needs.

Here are four simple steps to follow in order to meet customer needs successfully.

- **Identify** – Follow customer needs analysis via surveys, interviews, focus groups, or social listening.
- **Distribute** – Once identified the needs, you can distribute it across the right teams and departments.
- **Create** – Tailor product features, create detailed content that speaks about customer needs.
- **Collect** – Obtain customer feedback regularly to learn how your efforts meet their expectations.

Types of customer needs

When it comes to customer needs, there are two main types to consider; internal and external:

Internal customer needs

When we are referring to internal customers, we're essentially talking about the stakeholders that work within your organisation, namely your employees.

The needs of this internal audience group are reliant on the assistance they receive from other individuals or departments to complete their work.

For example, a marketing department typically has to liaise with then complete collateral for various departments within a company. These departments are essentially the marketing team's own internal customers, and they need to provide a good service if they are to keep these audiences happy and retain their own jobs.

External customer needs

In contrast, your external customers are those people and businesses that pay for your products and services and not directly connected to your organisation.

Unlike internal customers that have no choice about who they have to work alongside, external customers have both a choice and influence over who they choose to liaise with and ultimately buy from.

For example, let's say you were a support provider of IT services. Given the freedom an external customer has over partnering with you. Unless you're consistently delivering timely, high-quality support, they may decide to take their business elsewhere.

That's why it's essential that you're able to identify and best meet the needs of your customers.

Understand customer needs

The customer is at the heart of every successful business. So, the better you know and understand your customer needs, the more they're likely to buy from you, the longer they will stay with you and the more successful you'll be in attracting new customers.

By contrast, the less capable you are in meeting their needs, the more likely they'll be to leave you for a competitor business.

Identify customer needs

There are three key ways to better pinpoint the needs of your customers namely customer needs analysis, customer needs surveys and voice of the customer programs.

Customer needs analysis

Customer needs analysis is all about trying to identify the customer's primary requirements for a product or service. Besides improving their understanding of customer requirements, customer needs analysis can help those running it to better identify their position in the overall market.

Armed with this information, manufacturers and providers will be better able to ensure that their product or service offers the benefits, attributes and features needed to provide the customer with value.

Customer needs surveys

For the best results customer needs analysis needs to be carried out by running customer needs surveys. These surveys can also help manufacturers and providers to better identify how well they stack up in terms of meeting their target customers' needs.

Any survey should ask questions about your brand and competitors, as well as the customers' product awareness and brand attitudes in general.

Questions can include:

- Questions about positive and negative word associations with your brand
- Questions where customers are asked to group your brand in with similar and/or competing brands
- Questions where brands are compared and sorted according to their preferences for usage

To get more detailed customer feedback with regards to how customers feel about their experiences with your brand and what you can improve, you might want to run further customer surveys with them. In addition, more specialist surveys can help you decide on the best direction to take next.

For example, if you were to run a product survey, you could test different concepts with customers to better understand what they liked and disliked, to improve your next product launch.

Voice of the Customer programs

Research methods and techniques are improving all the time. And today market leading organisations are employing voice of the customer programmes to gain a deeper understanding of their customers' needs and requirements. This is also extremely valuable for those operating in highly competitive or crowded marketplaces, where customer experience (CX) is the key to driving greater sales.

The idea behind these programs, is that by running voice of the customer surveys throughout the customer journey, organisations will be better able to understand what matters most to customers and the exact actions they need to take to improve satisfaction, loyalty and maximise profitability.

From NPS surveys to CES and CSAT surveys. To maximise the success of your voice of the customer programs, it's also vital to include these key CX metrics, to measure how your customers feel and be able to identify the exact improvements you need to make.

Video Content / Details of website for further learning (if any): https://www.revechat.com/blog/customer-needs/ https://www.smartsurvey.co.uk/articles/identifying-customer-needs
Important Books/Journals for further learning including the page nos: **1.** A text book of Product Design – Kevin Otto – 3-9; 112-145

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LECTURE HANDOUTS

L 10

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **II**

Date of Lecture :

Topic of Lecture: Need for design creativity

Introduction : (Maximum 5 sentences)

- Creative design involves using computer-generated imagery and digital animation to visualise a product.
- It aims to produce unique and memorable designs that stand out so that customers may easily identify a brand or product.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Basic Information about Creativity of a product
- Product Concepts
- Design Creativity

Creativity and Innovation Enhance Business Growth and Development

- Creativity and innovation lead to higher overall success in organizations, even more so than raw intelligence. Traditional companies and educational institutions tend to prize intelligence as the most important factor in problem-solving.
- To keep pace with this environment of rapid change, companies must establish a creative culture that **strongly encourages spending time on new ideas, concepts, and solutions**.
- Creative ideas, concepts, and solutions are turned into products and services through the product design and development process.
- Creativity also encourages people to grow in their ways of thinking. Divergent thinking, or exploration of numerous unconventional possible solutions to a problem, is a hallmark of the creative process.

Create a Creative Workplace

- Creative thinking can also lead to innovation that will grow your business through increased productivity.
- When you "focus on what things you can streamline and what things you need to cut out" while keeping the systems that perform well, you'll build a simpler, more efficient workplace.

Reach New Heights

- Creativity and innovation can be the pathways for your business to reach new heights of product value, process improvement, productivity, marketing success, and internal harmony. The creative process can lead to novel ideas and concepts.

Important Benefits of Innovation in Business

By innovation, we mean changing your business model and making changes in the existing environment to deliver better products or services. Successful innovation should be a part of your business strategy, where you can create a culture of innovation and make a way for creative thinking.

1. Solve Problems Easily

You need to come up with creative answers to solve certain problems in your business. Many times you'll face problems that don't seem to go away. You need to think outside the box to find an answer you've never come up with. This way you can make your product, store your inventory and find a creative solution to make your business better.

2. Increase Your Productivity

If you ever feel that you are bogged down with work and struggle to get everything done, it's time that you should become more productive. To do this, start finding a new process.

In order to work smarter, think creatively. Focus on what things you should streamline and what things you need to cut out. Also, focus on the programs and workflows that you can use to increase productivity.

For example, You can use a homegrown project tracker system to assign, monitor and prioritize tasks. You may use other methods to do this, but building one to meet your specific demands is recommended. As your needs changes, you can update the software anytime to remain productive.

In businesses, it is always preferred to test new ideas. You will be surprised by the combination of ideas that work together to make productivity plans that work for your company.

3. Market Your Business

You can use various creative ideas and innovation to make your business stand out from the crowd. Here, small business marketing comes in. In order to make people remember your business, you need innovative ideas. You can create a new brand, develop a quirky business or can work with any non-profit organization.

Once you develop a unique character in your business, you should market it. Just innovate a marketing plan that suits your business' personality. Stand out from all other businesses and this will help you make a unique identity among customers.

4. Beat Your Competitors

When you think innovatively, it becomes very easy to beat out your competition. You just need to put in a little creativity and you can easily come up with better ways to design products and connect with customers. Along with this, creativity will help you figure out the right marketing techniques that will help your business grow.

Now that you have read about some various advantages of innovation, you need to add it to your business. It is not a one-time deal. It must be non-stop so that you have a continuous stream of ways to improve your business.

Video Content / Details of website for further learning (if any):
https://medium.com/swlh/4-important-benefits-of-innovation-in-business-64ed0d78d150

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 91-94

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LECTURE HANDOUTS

L 11

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **II**

Date of Lecture :

Topic of Lecture: Creative thinking

Introduction : (Maximum 5 sentences)

- Creative thinking is usually most predominant during the beginning of the design process, when searching for solutions to a particular problem is the priority.
- Creative thinking suggests answers, solutions and ideas that can be quite unexpected, unique and unorthodox.
- Brainstorming is a common activity associated with creative thinking.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Creative thinking **provides a structured process that helps innovators break free of counterproductive tendencies that thwart innovation**.

Detailed content of the Lecture:

Creative thinking techniques

Creative thinking (a companion to critical thinking) is an invaluable skill for college students. It's important because **it helps you look at problems and situations from a fresh perspective**. Creating thinking is a way to develop novel or unorthodox solutions that do not depend wholly on past or current solutions.

Some of the best examples of creative thinking skills may include: lateral-thinking, visual reading, out-of-the-box thinking, copywriting, artistic creativity, problem-solving, analytical mind, and divergent thinking.

Brainstorming

This technique can be very useful in small or large-scale problems that require a creative solution. The main goal is to form a group of people and throw around ideas without interference.

The general idea of brainstorming is that, by having an **excess of creative potential solutions**, it gets easier to reach one with the highest level of quality.

Lateral thinking

Lateral thinking involves looking in less obvious areas and lines of reasoning**. It can work well if**

you and your partners try to put yourselves under different perspectives or reverse the problem to look at it differently.

Mind mapping

he process of mind mapping helps you connect ideas you never imagined could be combined. Because of that, it might help you reach appropriate solutions while using creative thinking skills

Examples of creativity skills

Besides these creative thinking techniques we presented in this chapter, there are several skills you'll need to develop to enjoy the advantages of the techniques. Some of the creativity skills may include:

experimentation
opposing views
asking questions
communication
organization

The main benefits of creative thinking

Developing your creative thinking skills is highly beneficial for any field of work. After all, every area needs people that can come up with the best solutions to the everyday problems that arise and creativity is critical to do that.

- ability to create the best solutions to daily demands, which provides value to clients and your own business;
- improvement on problem-solving for not only work-related matters but also those in your personal life;
- higher workplace involvement in daily activities and engagement, which is beneficial to a healthier environment;
- a better understanding of data — also known as data literacy — and how to present it through data storytelling;
- focus on self-improvement as you and your teammates will develop more soft skills.
- more effective teamwork and bonding, since people grow used to bouncing off original ideas and learn each other's creative traits.

To develop creative thinking skills

Creative thinking skills are, the next step in this process involves learning how to work on them. After all, **stagnation can be the biggest threat to your creativity**, as it requires constant stimulation.

Consume different kinds of content

- the information we absorb can be combined, remixed, and repurposed in several ways to provide solutions
- you can **make use of the internet's vast selection of content types**. Try to visit different blogs, YouTube channels, and social media profiles

- This means engaging with different types of media, like text, videos, audio, and even more specific ones like e-books, podcasts, infographics, and others.

Keep up with the trends

- Much of your creative thinking can be influenced by the trends that are influencing the market right now and the ones that are **coming up in the future**.
- It is also necessary to develop a keen eye to distinguish what has the creative potential to get

viral or not. This ability will be essential to the success of your strategies in marketing.

Try to create something every day

- make sure to try to create something new daily. It does not have to be something large or significant, just anything new that derives from **all the new references you are absorbing**.
- Such creations might also serve as solutions to everyday problems you or your community face.
- The most important part of this process is creating a habit of coming up with new things so it begins to come naturally to you.

Build a network for creativity

- Interacting with your peers is a great way to **exercise your creativity**. It is even better when these people are also creatively-oriented and contributes to coming up with original ideas as a network.
- Try to come up with group projects to create a solution to a common problem or innovate on a certain aspect of work.
- Get help from others to keep your creative thinking and technical skills in constant development.
- You can build a network of people with the same goals and put all these tips in action as a group.

Video Content / Details of website for further learning (if any):
https://rockcontent.com/blog/creative-thinking-skills/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 95-99

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LECTURE HANDOUTS

L 12

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **II**

Date of Lecture :

Topic of Lecture: Creativity & problem solving

Introduction : (Maximum 5 sentences)

- Creative problem solving (CPS) is a **way of using your creativity to develop new ideas and solutions to problems**.
- The process is based on separating divergent and convergent thinking styles, so that you can focus your mind on creating at the first stage, and then evaluating at the second stage.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- To keep pace with this environment of rapid change, companies must establish a creative culture that **strongly encourages spending time on new ideas, concepts, and solutions**.
- Creative ideas, concepts, and solutions are turned into products and services through the product design and development process.

- **Detailed content of the Lecture:**

- Creative problem solving (CPS) is a way of using your creativity to develop new ideas and solutions to problems. The process is based on separating divergent and convergent thinking styles, so that you can focus your mind on creating at the first stage, and then evaluating at the second stage.

- The process of problem solving begins with the identification of the actual problem and the source of it.

  - The steps of problem solving process is identifying the actual problem and its source, being eager to solve the problem rather than finding excuses, contribute innovative ideas, make a through research and collect information, prepare a list of solution plan, analyze and execute the best solution, monitor the outcome attentively, if outcome is unsatisfactory then try another solution.

9 Steps of problem solving process

1. Identify the actual problem
2. Discover the source of the problem
3. Be truly willing to solve the problem
4. Think creatively and contribute innovation
5. Make a research and collect knowledge from different resources
6. List all the solution plans

7. Evaluate and enforce the best solution option
8. Attentively monitor the result
9. Try another solution plan if needed

1. Identify the actual problem

In the process of problem solving the first step is where you analyse the problem and get a clear understanding of the real problem.

2. Discover the source of the problem

Finding out the actual source of the problem is not always an easy task,rather it can be too complicated to find out the actual source of the problem in many cases.

If you face a real critical problem, you may need to spend several hours to find out the actual source of the problem. do not hurry in the process of finding out the actual source of the problem.

Now let me make it clear that the actual or the real problem and the source of the problem are not the same thing, both are completely different.

3. Be truly willing to solve the problem

A Genuine will for solving the problem is very necessary in order to be a successful problem solver. You should know that problem solving is a skill that you need to develop, so if you think that you will solve a problem just by duty, it may not be so effective. In order to be a real problem solver you actually need to be a truly willing person.

If you have a real willingness to be a problem solver, you will actually gain a lot of understanding. Moreover, you will get a variety of Creative new ideas, but it is only possible if you are really willing to be a problem solver.

4. Think creatively and contribute innovation

Creative thinking and innovative ideas are great skills to possess as a professional. Almost every problem requires some sort of critical thinking and creative way of bringing ideas.

5. Make a research and collect knowledge from different resources

It is very important that you understand the value of research and gathering knowledge from different sources. As you Research and gather information from different sources, you will find that all these are helping you in solving even a critical problem in a much more effective manner and easier way.

In order to go through a thorough research you can take help from the internet, offline resources and even take ideas from experienced people. You will find that the more research you do, the better it becomes to solve the problem that you are trying to solve.

6. List all the solution plans

As you have gathered sufficient information and knowledge from different sources, now you need to create at least three solution plans.

create the solution plans keep in mind the risk factors and other necessary matters in mind that can affect your business or area where you faced the problem.

7. Evaluate and enforce the best solution option

Analyse all the solution plans that you have created and enforce the best one first. You must think ahead about the consequences that can occur after you implement your plan. So, prepare to face the situation.

Make sure you know what you are going to do and how you will handle the situation afterward.

8. Attentively monitor the result

Do not forget to monitor the result after you implement the solution plan. You will not understand the progress or effectivity of the plan unless you monitor the result and evaluate continuously.

As you monitor and evaluate the result, measure the progress periodically. If you find the positive result then go ahead with it, but in case of a negative result, you need to take another decision now.

9. Try another solution plan if needed

In case you find that your first solution plan did not work as you intended. Then, it is the time to go for another solution plan and repeat the process of monitoring, evaluating and measuring the result. Continue this process unless you find the actual solution plan that is perfect and eradicate the source of the problem and fix it.

Video Content / Details of website for further learning (if any):

1. https://resumeskillforjobs.com/what-are-the-steps-of-problem-solving-process/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 165-167

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LECTURE HANDOUTS

L 13

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **II**

Date of Lecture :

Topic of Lecture: Creative thinking methods

Introduction : (Maximum 5 sentences)

- A designing methodology is a **method for generating ideas and coming up with creative designs**.
- Creativity and innovation are two significant outcomes of any designing process.
- Persistent and consistent thinking helps to generate them both.
- The definition of product design describes **the process of imagining, creating, and iterating products that specific needs in a given market**.
- The key to successful product design is understanding the end-user customer, the person for whom the product is b

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Concept generation, **getting the ideas**, is the most critical step in the engineering design process.
- Starting with a set of customer needs and target specifications, the process concludes with an array of product alter selected.
- A systematic approach to the different sides of a product journey pays dividends at the end.

Detailed content of the Lecture:

Creative Thinking

Creative thinking is the process of coming up with something new; looking at a problem from a new light and finding an i hasn't been thought of before.

Creative Thinking Techniques

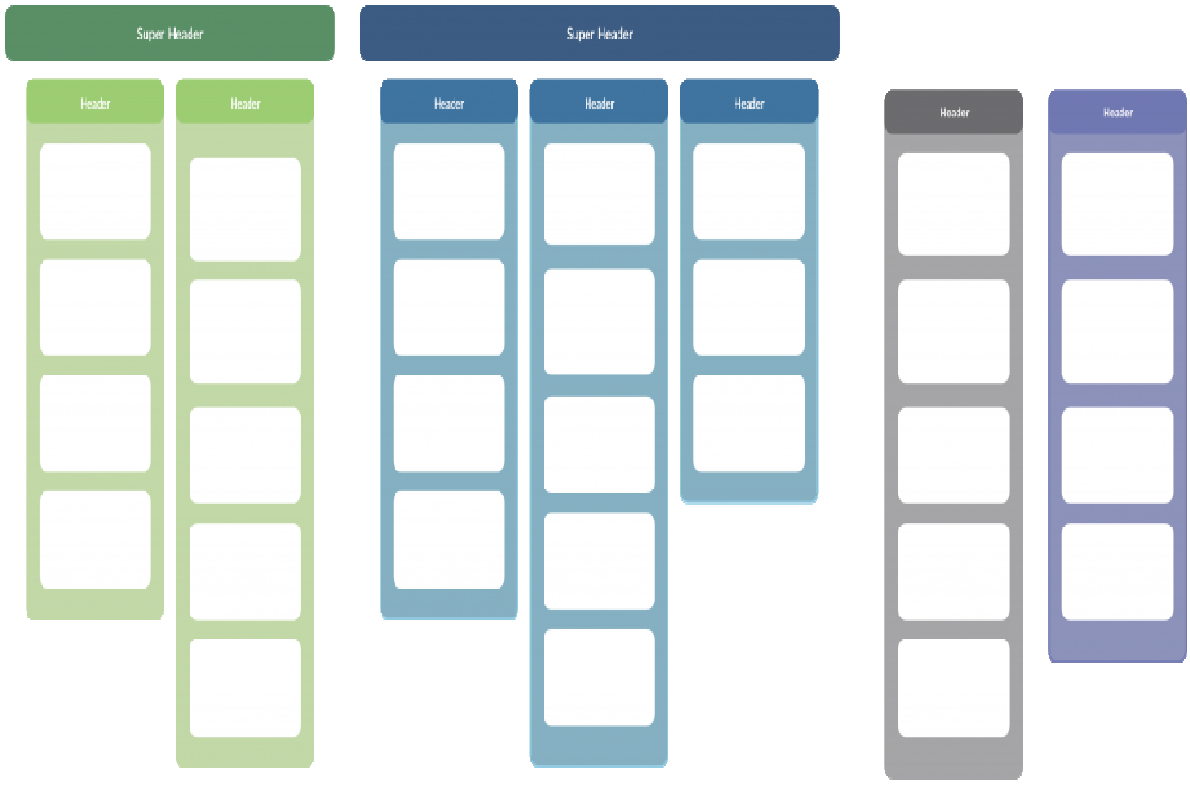
We have listed below several creative thinking techniques that you can use to come up with creative ideas faster. The temp even collaborate with others from your team on editing them during a brainstorming session.

1. Affinity Diagrams

After a brainstorming session, meeting or research you end up with a load of information that needs to be sorted through a the affinity diagram comes.

The affinity diagram helps you group your data based on themes. This makes it easier to detect patterns and connections a gathered, thus allowing you to come up with new ideas or solutions.

Don’t know how to use the affinity diagram? We’ve got you covered with this complete guide to affinity diagrams.



Affinity Diagram Template

2. Brainstorming

Brainstorming is one of the most popular methods of idea generation. You can go about this individually or with a group o

In group brainstorming, you have the ability to collect many creative ideas from people with diverse skills and experience

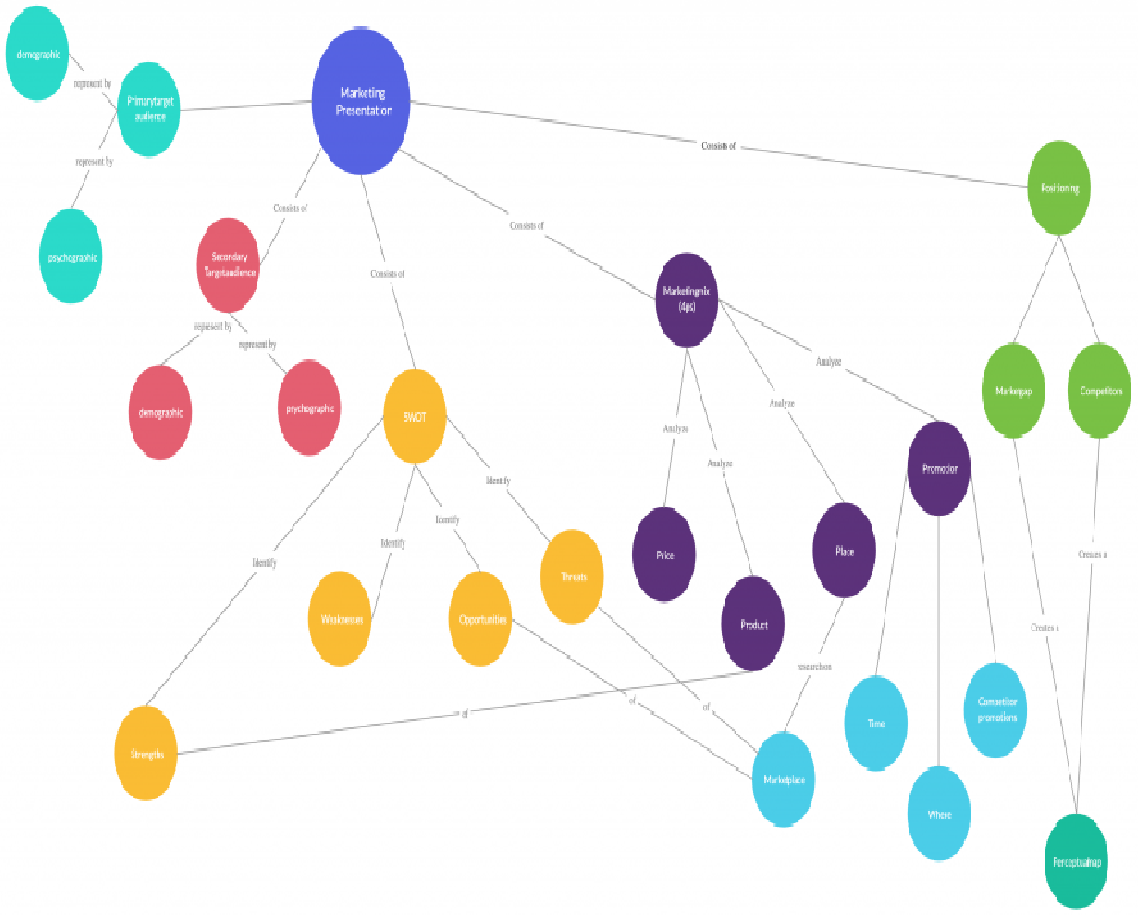
There are many brainstorming techniques out there, and some handy visual brainstorming techniques are listed in this pos about how to carry out a successful brainstorming session step-by-step.

3. Concept Map

The concept map is a teaching and learning techniques that help visualize the connections between concepts and ideas.

It helps organize thoughts and discover new relationships, ideas or concepts.

Check out our guide to concept maps to learn about how to use it in more detail.



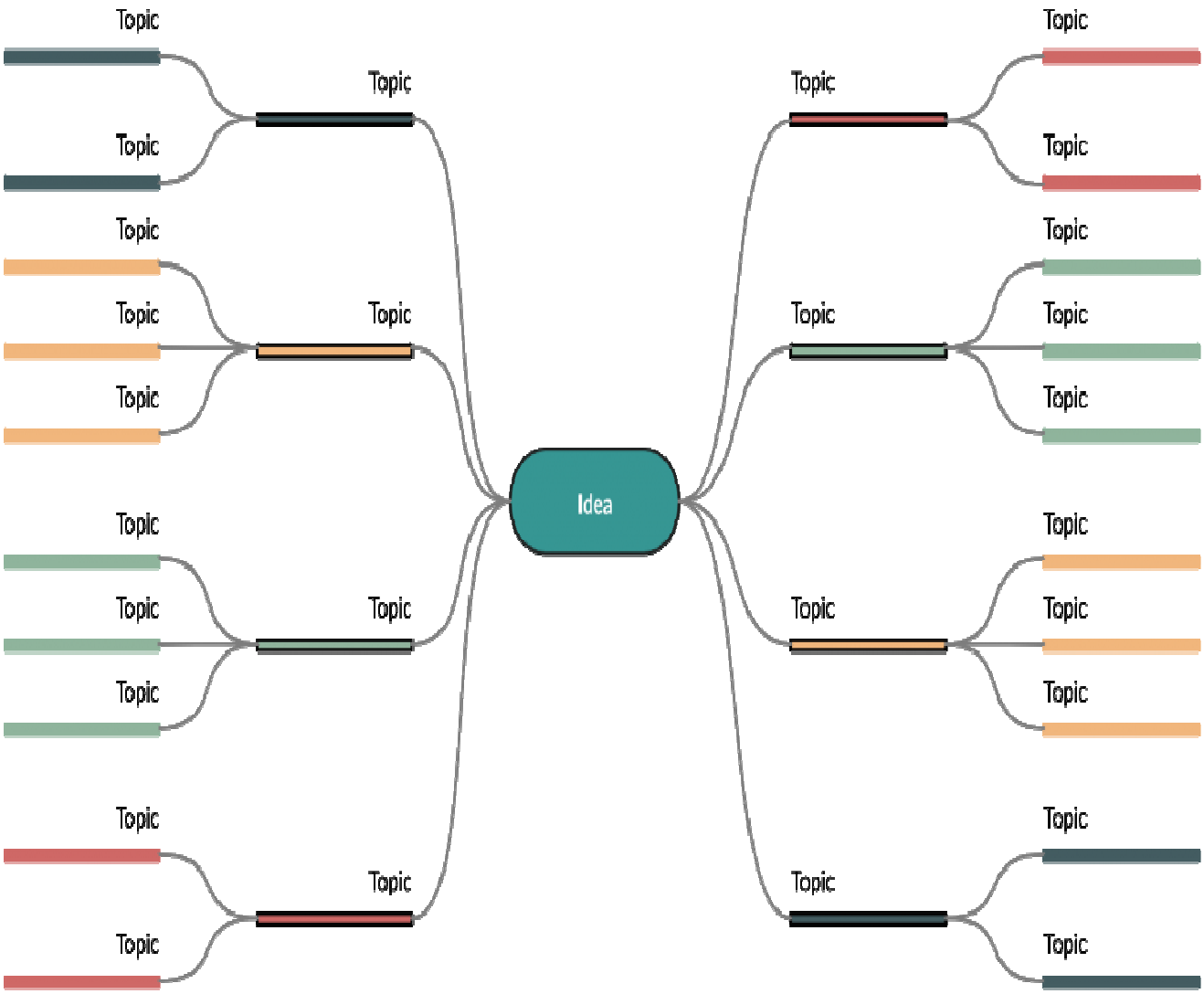
Concept Map Template

4. Mind Map

The mind map starts with the key concept you are brainstorming around in the center. Related ideas are connected to the c

It helps you capture your free flow of thoughts and organize them on a canvas in a way that will later allow you to discove arrive at a possible solution.

Because it connects both text and a visual layout, it allows for a more creative style of thinking.

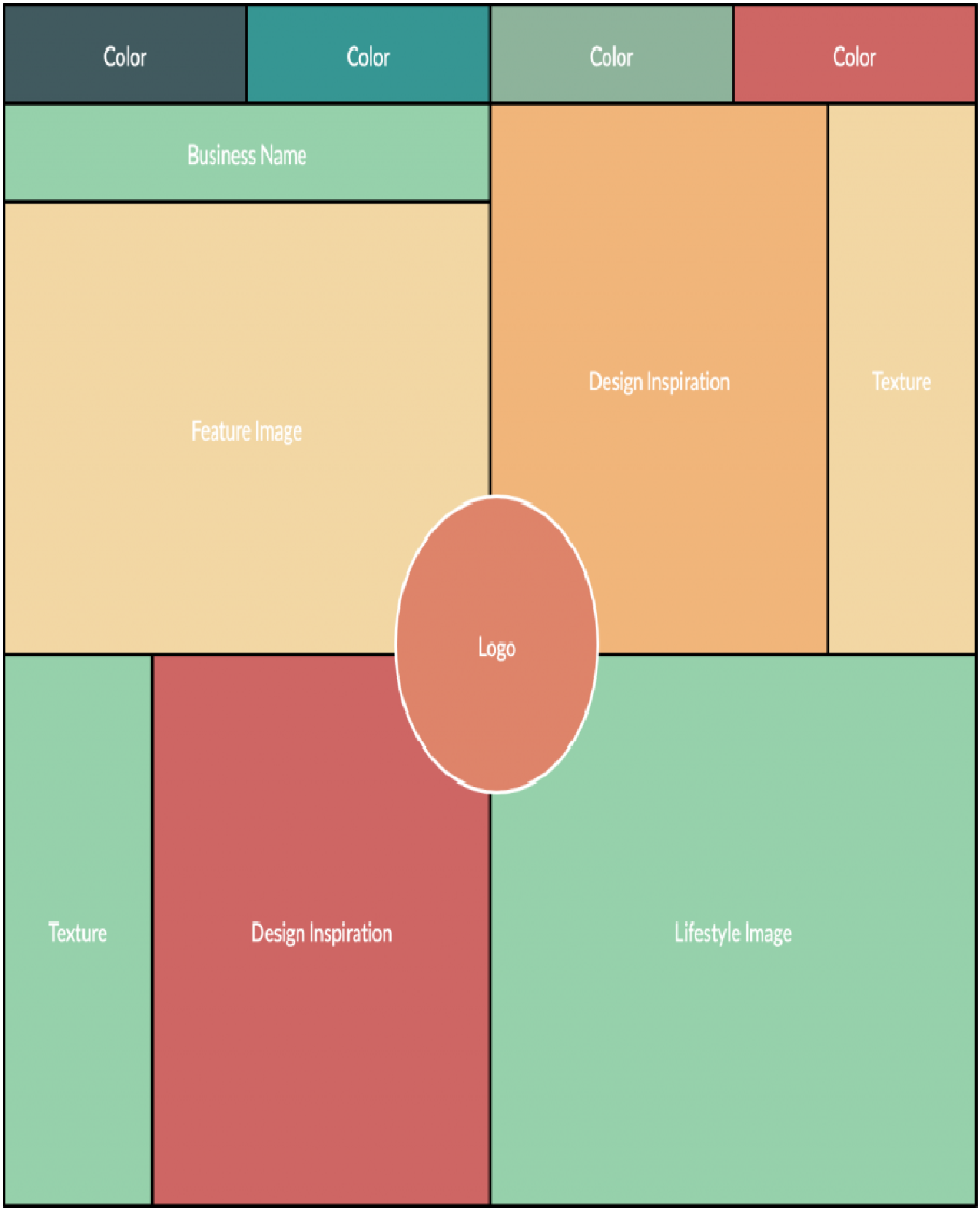


Mind Map Template for Creative Thinking

5. Mood Board

A mood board – like a collage – is a collection of images, fonts, icons colors, etc. that is representative of a particular then known as inspiration boards and commonly used in design projects.

Here's how to use a mood board.



Mood Board Template

6. SCAMPER Technique

SCAMPER is another successful creative thinking technique that is used to spark creativity during brainstorming.

SCAMPER stands for seven thinking approaches,

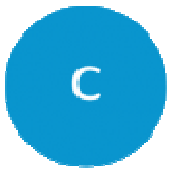
- Substitute
- Combine

- Adapt
- Modify
- Put to another use
- Eliminate
- Reverse

SCAMPER TECHNIQUE

Substitute

1. Enteryourtexthere
2. Enteryourtexthere



Combine

1. Enteryourtexthere
2. Enteryourtexthere

Adapt

1. Enteryourtexthere
2. Enteryourtexthere

Modify/Magnify

1. Enteryourtexthere
2. Enteryourtexthere

Purpose

1. Enteryourtexthere
2. Enteryourtexthere

Eliminate

1. Enteryourtexthere
2. Enteryourtexthere

Rearrange/Reverse

1. Enteryourtexthere
2. Enteryourtexthere

7. Six Thinking Hats

Each hat in the six thinking hats method represents a different perspective. It is used during meetings or brainstorming ses
at possible solutions from different perspectives or thinking directions.

Each hat represents a different thinking angle, and during the session, each member will get to put it on in turn.

White hat – facts and information

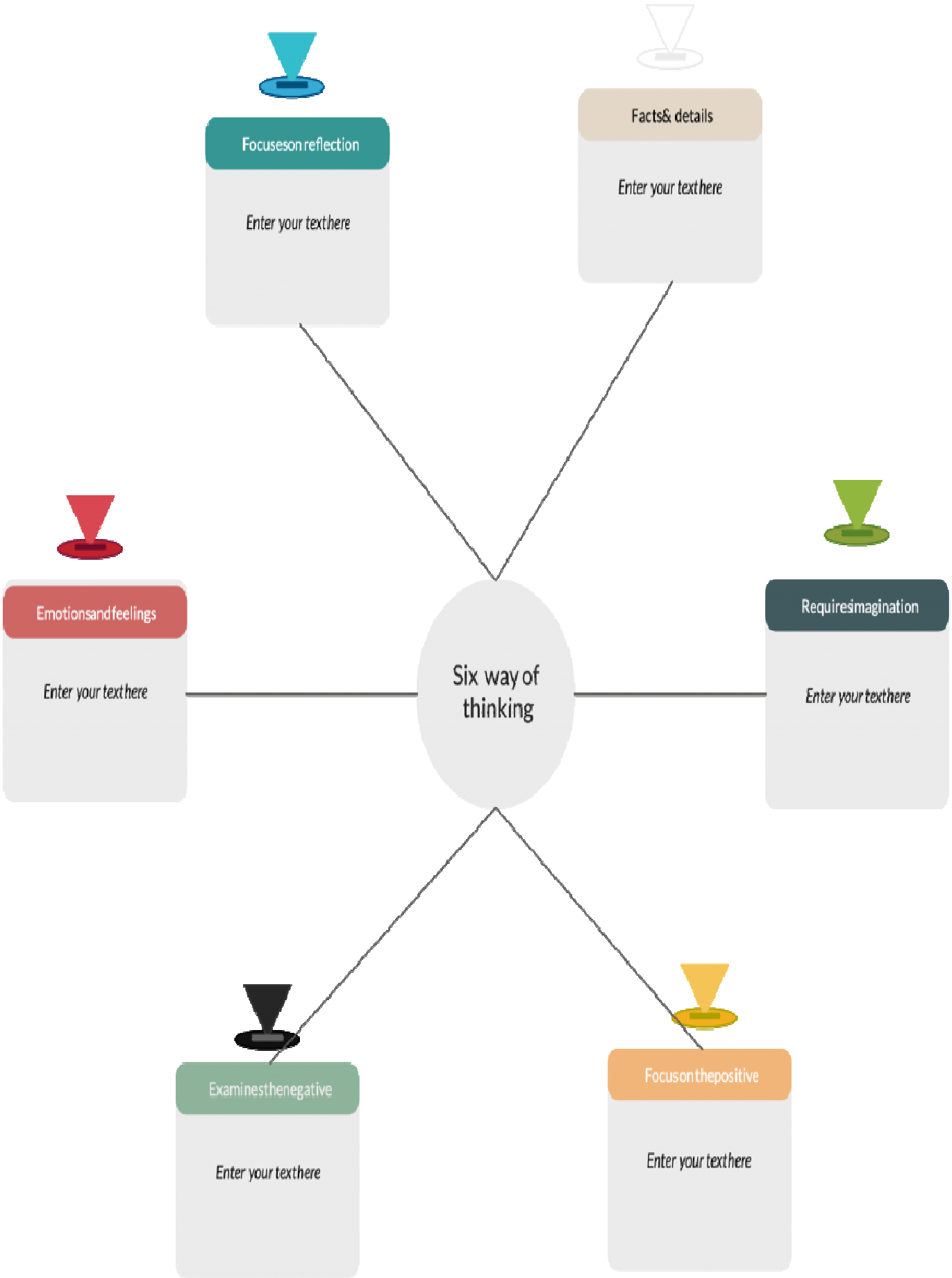
Red hat – feelings, intuitions, emotions, and hunches

Balck hats – judgment, legality, morality

Yellow hat – optimism, benefits

Green hat – new ideas, opportunities

Blue hat – conclusions, action plans, next steps

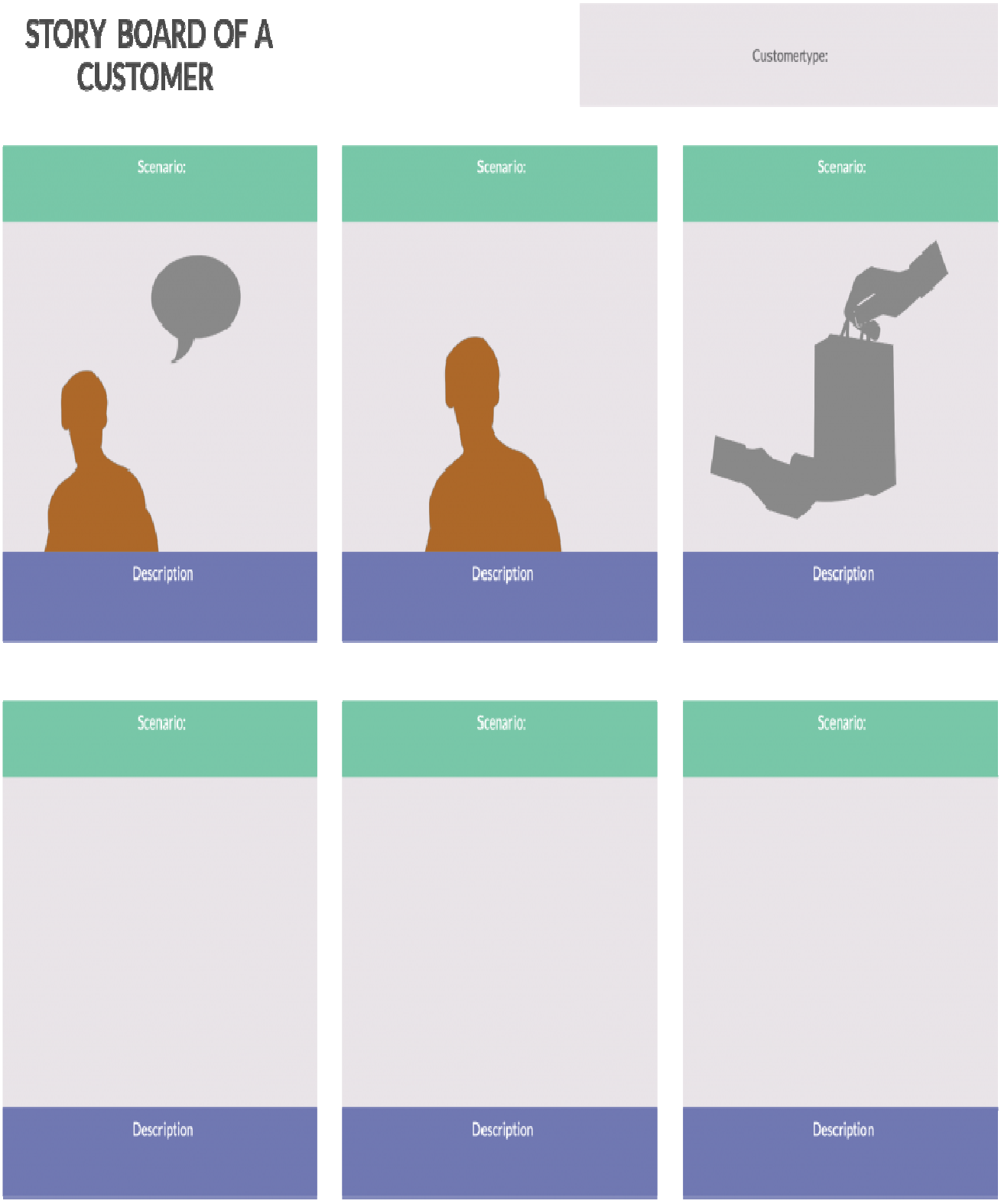


Six Thinking Hats Diagram

8. Storyboards

Storyboards are a way to visually organize ideas. It's a common tool used in video planning. Say you are planning a TV a

a storyboard to graphically organize the ideas in your head. As you lay them out on a storyboard, you'd be able to quickly

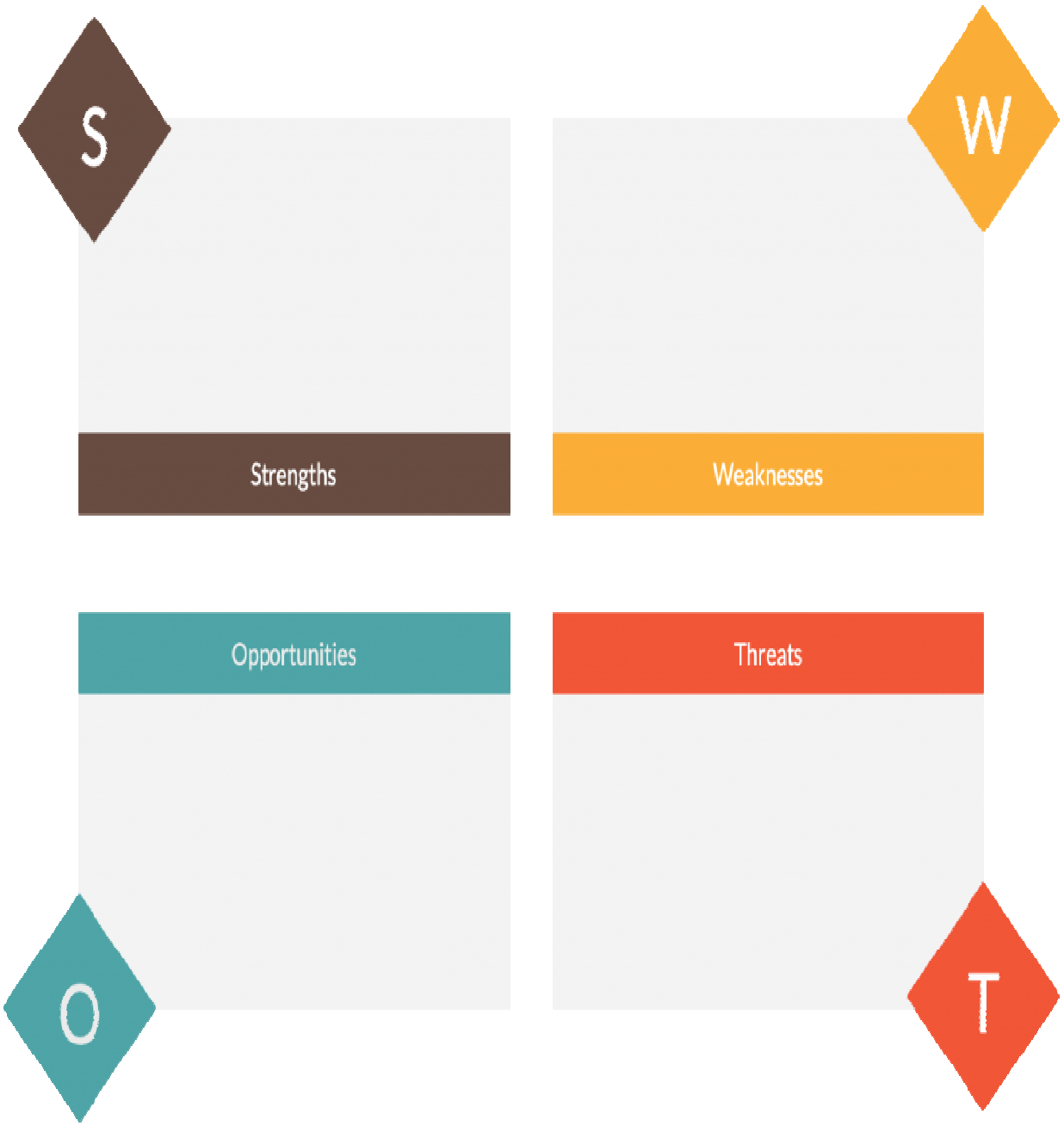


Storyboard Template

9. SWOT Analysis

SWOT stands for Strengths, Weaknesses, Opportunities, and Threats. In business planning, the SWOT analysis is applied analysis, situation analysis, strategic planning, personal evaluation, etc.

It can be used to identify effective innovative opportunities, mitigate threats using strengths, etc.



Steps for Creating Concepts
The conceptualisation phase itself is a step in the larger engineering process, which goes like this:

- Identifying customer needs
- Defining the problem and objectives
- **Concept generation**
- Drafting and analysis
- Detailed design and drawings
- Creating a prototype
- Testing

Product concept generation steps are as follows:

- Understanding the problem
- Researching established solutions
- Brainstorming & ideation
- Assessing the ideas & solutions

- Picking the winner & start working on it

Step 1 – Understanding the Problem
The first step is the basis for all the next ones. Not managing to get this one right will render the whole development process f

Bear in mind that you are the engineer and the customer may not always know what kind of information is actually necessary which ignores many important details.

Step 2 – Researching Established Solutions

Before getting to generating your own designs, expose yourself to the available information. Researching solutions for the sa to kickstart the product development process

Step 3 – Brainstorming and Ideation
Now we get to put the research phase behind us to move on to the creative side of the design process. As we outlined in o advise generating at least 3 solutions to choose from.

Step 4 – Assessing the Ideas and Solutions
Now you have a wide range of different proposals on the table. Sure, most of them cannot solve your problem. But out of th good ones. How to sift through them all?
First, go over the ideas and choose a few that look like great candidates – 3 to 5 concepts would be great.
Secondly, do some sketching for the select few. Besides being just illustrations, sketching can bring out the pros and cons of n
Next, build up an assessment form or scoring matrix. It can include everything that is necessary for this project. Every ide scoring points can include manufacturing cost, manufacturability, time to design, efficiency, durability, aesthetics, etc.

Step 5 – Pick the Winner and Start Working on It
During that phase, you should also know the material or at least the material class because it determines the thicknesses and not least comes the making of production drawings. Unless you can manufacture your parts straight from 3D files.
Techniques for Producing Concepts

Engineers are famous for their ability of critical thinking. We are also notorious for the ability to shoot down ideas that do not

Video Content / Details of website for further learning (if any):
https://www.google.com/search?q=nine+concepts+in+creative+method&ei=Q55KYrjiCpiV4-EP-vWByA8&ved=0ah

Important Books/Journals for further learning including the page nos:
1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 155-158

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LECTURE HANDOUTS

L 14

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **II**

Date of Lecture :

Topic of Lecture: Generating design concepts

Introduction : (Maximum 5 sentences)

- Concept generation is a procedure that begins with a set of customer needs and target specifications and results in an array of product concept design alternatives from which a final design will be selected. This step requires a more abstract style of thinking than perhaps most engineers are used to.
- Product concept generation is a process that starts with a list of parameters set by the customer regarding his needs and specifications. Based on the requirements, concept generation helps to pinpoint a variety of possible solutions and ideas that answers those needs.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Concept generation, **getting the ideas**, is the most critical step in the engineering design process.
- Starting with a set of customer needs and target specifications, the process concludes with an array of product alternatives from which a final design is selected.

Detailed content of the Lecture:
Generating Concepts for Product Design

Product concept generation is a process that starts with a list of parameters set by the customer regarding his needs and specifications. Based on the requirements, concept generation helps to pinpoint a variety of possible solutions and ideas that answers those needs.

Steps for Creating Concepts

The conceptualisation phase itself is a step in the larger engineering process, which goes like this:

- Identifying customer needs
- Defining the problem and objectives
- **Concept generation**
- Drafting and analysis
- Detailed design and drawings
- Creating a prototype
- Testing
- Final delivery

Concept process is of help when looking to provide the best possible solution to answer the need. This,

however, does not mean that you should skip everything other than customer needs, engineering drawings and manufacturing. It only means that you are probably more restricted when it comes to trying out wholly new ideas because you cannot test if they actually work out as planned.

Product concept generation steps are as follows:

1. Understanding the problem
2. Researching established solutions
3. Brainstorming & ideation
4. Assessing the ideas & solutions
5. Picking the winner & start working on it

Step 1 – Understanding the Problem
The customer may not always know what kind of information is actually necessary. They may have a vision for a solution which ignores many important details.
Thus, you have to be really methodical at this stage. Visit the site (e.g. production facilities), ask about the project goals, who must benefit and how, what are the requirements for the design, etc.
Step 2 – Researching Established Solutions
Whatever the answer, there will be solutions similar enough. Exposing yourself to them is necessary before going on to the next stage.
That is also why seasoned engineers are so valuable. Even if they have not worked on a project with a similar scope, bringing in the experience from a variety of different projects will help immensely. Implementing an idea that answers a similar problem may need some adjusting, but it's a good start.
Step 3 – Brainstorming and Ideation
The research phase behind us to move on to the creative side of the design process. As we outlined in our tips for engineers article, we always advise generating at least 3 solutions to choose from.
Techniques for Producing Concepts
Engineers are famous for their ability of critical thinking.
Brainstorming
An important aspect here is that the brainstorming session can, and maybe should, include people from outside the circle of design engineers. These people can bring in a fresh view without much of the restricting logic. Big companies often have this type of people on the team who will never make the next step with the project. Their goal is to contribute solely at this stage.
It is the product development team's task to later assess these ideas and choose whether using them in the concept is realistic or not.
Reverse Brainstorming
This is a combination of brainstorming and a technique called reversing.
Once you have created a set of reverse questions, you can start solving them. If your brainstorming buddies come up with ingenious ideas for breaking things, they may stumble upon something that is also actually useful for preventing this from happening.
Mind mapping

Mind mapping is a great tool for someone who likes organised thinking. Someone like… an engineer.
You can take your main problem as the central word and write it down on paper. Then you just start writing down everything that relates to this word. And do the same, in turn, for those newly written-down words.
6-3-5 Method
Another team effort that requires 6 people. Each writes down 3 ideas over a 5-minute period. Now you know what the numbers stand for.
First, each individual writes down 3 ideas for a solution. Again, the problem has to be clearly defined from the start.
Next, they pass their paper along to the person sitting next to them. He can then further develop these ideas or add new ones based on the ideas he sees. Seeing another person's perspective can be a strong ignitor of a wholly new concept.
The same process will be done until each person gets their original paper back after a full circle. And now you have 108 ideas in total. Yes, some of them are very raw and partial. But you just spent less than an hour (including

setting up the meeting and explaining what is going to happen) to generate a wide range of concepts for your product.

Lateral Thinking vs Vertical Thinking

Lateral thinking is definitely one of the most important elements of product design concept generation. Although we have already addressed it in principle, it will not hurt to lay it out.

Lateral thinking refers to a broad search for a large number of possibilities and ideas. The aim is to avoid going in-depth with any of this or even pass judgment. Sure, passing the opportunity to make a joke about your colleague's lack of intelligence may be tough to resist, but do your best.

Step 4 – Assessing the Ideas and Solutions

Now you have a wide range of different proposals on the table. Sure, most of them cannot solve your problem. But out of the plethora of ideas, there must be some good ones. How to sift through them all?

Secondly, do some sketching for the select few. Besides being just illustrations, sketching can bring out the pros and cons of many of these ideas. Also, turn your attention to the more difficult aspects of each concept and try to come up with the general idea of how to solve them. This will help to assess many of the crucial points here.

Next, build up an assessment form or scoring matrix. It can include everything that is necessary for this project. Every idea gets a rating which is weighed. The scoring points can include manufacturing cost, manufacturability, time to design, efficiency, durability, aesthetics, etc.

Maybe cost is the most important aspect, so give it a weight of 1 while aesthetics is a nice-to-have and comes with a weight of 0.25. After scoring each aspect in the same scale (e.g. 10 points max), you get your winning concept.

Step 5 – Pick the Winner and Start Working on It

So here you have it – the winning concept. Now it's time to start the process of product development. Next comes specific design selection. There, you can also make use of powerful CAD software features like generative design to aid in the process of creating highly optimised designs.

During that phase, you should also know the material or at least the material class because it determines the thicknesses and overall geometry of the part. Last but not least comes the making of production drawings. Unless you can manufacture your parts straight from 3D files.

Engineering is all about problem solving. The customer has a need for something and he turned to you to get it solved. Doing your best entails putting it all out on at every stage of the process.

Video Content / Details of website for further learning (if any):

1. https://fractory.com/product-design-concept-generation/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 157-160

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LECTURE HANDOUTS

L 15

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **II**

Date of Lecture :

Topic of Lecture: Systematic methods for designing

Introduction : (Maximum 5 sentences)

- Design methodology is the broader study of method in design: the study of the principles, practices and procedures of designing.
- This allows the designer to reduce one large problem into several smaller ones, and structure those problems in such a way that they are capable of being described in a formal language.
- Design methodology includes the study of the princi- ples, practices and procedures of design. Its primary focus is to develop a deep and practical understand- ing of the design process and how this process can be modified, made more effective and transparent and be managed to achieve sustainable design outcomes.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Design methodology refers to the development of a system or method for a unique situation.
- The key to design methodology is finding the best solution for each design situation.
- Design methodology also employs basic research methods, such as analysis and testing.

Detailed content of the Lecture:

Methodologies of System Design

Physical design

The physical design relates to the actual input and output processes of the system. This is explained in terms of how data is input into a system, how it is verified/authenticated, how it is processed, and how it is displayed as In Physical design, the following requirements about the system are decided.

1. Input requirement,
2. Output requirements,
3. Storage requirements,
4. Processing Requirements,
5. System control and backup or recovery.

Put another way, the physical portion of systems design can generally be broken down into three sub-tasks:

1. User Interface Design
2. Data Design
3. Process Design

1. User Interface Design is concerned with how users add information to the system and with how the system presents information back to them.
2. Data Design is concerned with how the data is represented and stored within the system.
3. Process Design is concerned with how data moves through the system, and with how and where it is validated, secured and/or transformed as it flows into, through and out of the system. At the end of the systems design phase, documentation describing the three sub-tasks is produced and made available for use in the next phase.

Design Methods

Engineering design types can be divided into several categories and, depending on a project, more than one type can simultaneously be part of the design process.

- **Axiomatic Design**

A system design methodology using matrix methods to systematically analyze the transformation of customer needs into functional requirements, design parameters, and process variables. Axiomatic Design uses two basic axioms to support the design theory:

• Axiom 1. To maintain the independence of functional requirements;

• Axiom 2. To minimize the information content of the resulting design solution.

The act of design consists of the mapping of functional requirements (FRs) to design parameters (DPs), and eventually, to arrive at a solution, which satisfies these two axioms.

- **Biomimetic Design**

A type of design accomplished using natural materials, mechanisms and processes, and even by mimicking of the strategies found in nature to solve human design challenges.

- **Concurrent Engineering**

A method of designing and developing products, also known as simultaneous engineering, in which the different stages run simultaneously, rather than consecutively. It decreases product development time and the time to market, leading to improved productivity and reduced costs.

- **Design for Assembly (DFA)**

A type of design when a designer makes efforts to develop a system that will be as easy as possible to assemble. This approach is especially important in computer design. For example, in a CAD modelling software it is easy to insert any component into any position connecting them by a fastener, while elaborating a nicely looking and elegant shape. However, after machining all elements of the assembly, one may run into a problem when there is no enough room for the technician to reach the fastener with a tool, or even with a hand, to tighten it. In principle, the DFA principle should be considered during any type of engineering design.

- **Design for Manufacturability (Design for Manufacture and Assembly)**

A complex approach using computer representations of the constructional parts and their arrangement, by generating some characteristic numbers that can guide redesign to optimize manufacture and assembly with respect to cost. This approach helps reduce cost and complexity of a (mechanical) system, reduce number of constructional parts, simplify forms, ease assembly, and so forth.

- **Design for Manufacture (DFM)**

While designing a product, you, as an engineer must remember about manufacturing methods and processes that will be used for production. The goal in this case is to better accommodate these manufacturing processes. Here, a few important aspects can be highlighted:

- **Design for Properties and Life Cycle**

A design approach collecting information about favorable principles, forms, and arrangements that will optimize the system to be designed for each property (cost, functional integration or separation, assembly and disassembly, testing, maintenance, reliability, safety, serviceability, ergonomics, environment, and so forth), each phase (process) of its life cycle, and each operator of these life-cycle processes. This approach reveals itself in a best way at the stage of concept generation and evaluation.

- **Design for Scale**

A design principle that states that new inventions and techniques should be useful to many people. It is a key principle for mass production. Since mass production requires high production rate at minimum time, the product design should be simplified as much as possible. Simplified design reduces production expenditures, however, simultaneously product quality often drops. This leads to lower reliability of the product, its shorter lifetime, but at an affordable cost. As a result, the customer must replace the faulty product more often and, correspondingly, maintains the need of mass production.

- **Design for Six Sigma**

Design for Six Sigma (DFSS) is not a design method, but rather a powerful program management technique. DFSS is an enhancement to a new product development process, not a replacement for it. Properly applied, it generates the right product or service at the right time at the right cost.

- **Design for Social Innovation**

A design of new products, services, processes, and policies that meet a social need more effectively than existing solutions. Social innovation solutions often leverage or amplify existing resources. It takes place through a co-design process in which designers work as facilitators and catalysts within interdisciplinary teams.

- **Mixed Use Design**

A concept in sustainable architecture and urban planning that combines three or more uses into one structure such as residential, hotel, retail, parking, transportation, cultural, and entertainment. It is a model that minimizes the impact of transportation on quality of life and the environment.

- **Modular Design**

A design approach that creates products out of independent parts with standard interfaces, whereas the product components are interchangeable. This allows customers to customize, repair and reuse products by simple replacement of a faulty component. Products that can be customized and reused may develop a culture of creativity around them that is valuable to a brand.

- **Parallel Design**

A process of producing several solutions for the same project. The idea is to explore multiple options and approaches to produce more valuable outputs or solve intractable problems. For example, parallel design can be used by a company in a competition for the contract; in crowd-sourced contests in a search for new ideas or technologies; in a mechanical design project for generation of several concepts, their evaluation and selection of the one to be developed further.

- **Regenerative Design**

A process-oriented approach to design. The term describes processes that restore, renew or revitalize their own sources of energy and materials. E.g., regenerative brake systems on a train or an electric car generate electricity and charge a battery while slowing down. Regenerative buildings are designed and

engineered to improve their surrounding environment such as restoring a site's natural hydrology or providing natural plant habitat.

- **Restorative Design**

A design that reverses damage that has been caused by either nature or humans. For example, a design providing on-site energy storage to enhance disaster resilience and maximize use of on-site solar energy; a design of a facility for low maintenance and prioritization of durable materials for a harsh coastal environment (resistance to moisture, wind and salt).

- **Reverse Engineering**

A process that starts with an existing product, disassembles it, and defines its design characteristics by analyzing its components. The aim is to acquire all possible information on the product as a basis for re-designing it to improve performance. Phases of reverse engineering: product analysis, generation of technical data, design verification, development and implementation of modifications.

- **Safety by Design**

A concept (a.k.a. Prevention through design) of applying methods to minimize occupational hazards early in the design process, with an emphasis on optimizing employee health and safety throughout the life cycle of materials and processes, e.g., a vehicle with an automated accident avoidance system (blind spot monitor, distance sensor, automatic braking system, etc.).

- **Strategic Design**

An application of future-oriented design principles by looking at design from a big-picture and long-term viewpoint.

- **Sustainable Design**

A practice of designing products, services and processes to be sustainable (a.k.a. environmentally conscious design, eco design, etc.). Firstly, this means that designs minimize environmental impact and improve life quality for human throughout product's entire lifecycle. Secondly, sustainable designs are based on the environmentally friendly practices, principles and techniques. Among the factors, commonly used for sustainable design – to name a few – are aesthetics, small-scale solutions, local culture, economy and ecology, natural materials, mechanisms and processes.

- **System Design**

Systems design is the process of creating architecture, interfaces, and data for information systems. The term system suggests a complex approach that provides fundamental services as opposed to an application that can be reasonably simple. System design is divided into two types. These two types may constitute two consecutive phases of the overall system design process:

- **Transition Design**

An emerging area of design practice, research, and study aimed at re-conceiving entire lifestyles to be more sustainable. It is based upon the belief that the transition to a sustainable society is one of the biggest design challenges and addresses complex problems such as pollution, poverty, loss of biodiversity, the economic crises, and privacy issues, etc., that are interconnected and interdependent systems problems existing at multiple levels of scale within the social and environmental spheres.

Video Content / Details of website for further learning (if any):

1. https://specialties.bayt.com/en/specialties/q/223867/what-are-methodologies-of-system-design/
2. **https://www.mcgill.ca/engineeringdesign/engineering-design-process/design-methods**

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 143-145

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LECTURE HANDOUTS

L 16

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **II**

Date of Lecture :

Topic of Lecture: Morphological methods

Introduction : (Maximum 5 sentences)

- Morphological analysis (MA) is a method for identifying, structuring and investigating the total set of possible relationships contained in a given multidimensional problem complex.
- A Morphological chart is a method that splits a product/solution into smaller chunks that can then be analyzed and ideated for independently. Afterwards those ideas can be mixed and matched to develop different solutions.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Morphology addresses the innovative aspect of product design.
- Morphology considers the computational and optimisation aspect of product design. In conclusion, an integrated approach which reconciles both morphologies is suggested.

Detailed content of the Lecture:

The morphology of design refers to the study of the chronological structure of design projects. It is defined by the phases and their constituent steps./The various steps involved in the design phases will be discussed in detail in the following sections.

Morphological analysis is invented by Fritz Zwicky, a Swedish astrophysicist who used the morphological analysis to solve a lot of wicked aerospace and astronomical problems. He used it to develop jet and rocket propulsion systems, in the classification of the astrophysical object, and other complex aspects like legal aspect of colonizing space.

General Morphological Analysis Better Than Mathematical Modeling

In wicked problems where there are multiple governing factors, using a mathematical model which you have created by breaking the problem into different components and dropping trivial components, fails. The trivial components which were considered insignificant during the analysis become significant and the model collapses.

General Morphological Analysis (GMA), on the other hands, is a sound method to deal with such wicked non-quantifiable problems. Every component of a problem gets considered and thoroughly

investigated. In essence, GMA turns a mess into structured problems.

How To Perform Morphological Analysis?

We can divide the entire morphological analysis into 4 different steps which are as follows:

Problem (Identifying And Defining The Parameters)

The morphological analysis investigates all the possible set of parameters a wicked problem. Hence, the first step is defining the wicked problem in a clear and concise manner and breaking it down into different parameters it has and possible values of those parameters.

Constructing The Zwicky Box

The next step involves the construction of an n-dimensional matrix. Numbers of columns in the matrix are equal to the number of parameters of a wicked problem. Cells under each column contain the value of a parameter.

For example, consider a publisher contemplating various parameters before publishing a book. Let's say his problem complex has five parameter bind type, cover type, size, paper color, and interior which have 3,3,2,2,2 values respectively. This will lead to a Zwicky box of the below type having 3*3*2*2*2=72 cells with each cell having 5 parameters — one value from each column. For example, Saddle Stich, digest, hardcover, colored, cream.

Bind	**Size**	**Type**	**papercolor**	**interior**
Saddle stitch	Pocket	hardcore	White	Coloured
dustjacket	Digest	paperback	cream	B&W
Case laminate	landscape			

Cross Consistency Assessment

This is the vital step of the GMA. CCA helps you reduce the pairs of combination in a Zwicky Box which are inconsistent. For example, in our case, the combinations where colored and paperbacks are appearing together and where spiral and paperback are appearing together could be nixed from the final set of analysis. CCA can reduce a Zwicky Box to 90% or even in some problem complex to 99%. In essence, CCA acts as a garbage detector in a Zwicky Box.

There are three principal types of inconsistencies involved in the cross-consistency assessment: purely logical contradictions (i.e. "contradictions in terms"); empirical constraints (i.e. relationships judged to be highly improbable or implausible on practical, empirical grounds), and normative constraints (although these must be used with great care, and clearly designated as such).

Input/Output

After you have reduced the Zwicky Box to consistent combinations, you move ahead with the final step of the analysis where you lock a particular variable(input) under a parameter and find the number

of combination that exists.

Bind	Size	Type	papercolor	interior
Saddle stitch	Pocket	hardcore	White	Coloured
dustjacket	Digest	paperback	cream	B&W
Case laminate	landscape			
			output	input

n our problem, we locked paperback and asked Zwicky Box to help us find possible combinations. The blue cells are corresponding outputs. You can even have multiple inputs. For example, in Zwicky Box (2) we locked Paperback, white.

Bind	Size	Type	papercolor	interior
Saddle stitch	Pocket	hardcore	White	Coloured
dustjacket	Digest	paperback	cream	B&W
Case laminate	landscape			
			output	input

ı Morphological Analysis Steps

1. Determine suitable problem characteristics. The individual problem solver or a facilitated group brainstorms to define problem characteristics, also refered to as parameters.

2. Make all the suggestions visible to everyone and group them in various ways until consensus is reached regarding the groupings.

3. Label the groups reduce them to manageable number. Rather than reaching for a recommended number, consider the capabilities of the group and the time available. Consider also that there are computer applications and other tools that can assist the process. When working with the tangible aspects of something like a consumer product, for example, the labels gleaned from the groupings might include parameters such as product ingredients, color, textures, temperature, and flavor as well as package size, shape, function, and graphics. In the case of manufacturing issues, parameters might include material, function, process, construction, maintenance, and the like.

4. The next step is to fill a grid or grids with lists of parameters arranged along the axes. Now combinations can be identified within the grid. Depending on the number of items in play, great numbers of combinations may be available.

5. Eliminate those combinations that are impossible or undesirable to execute, put aside those that you do not want to eliminate but do not want to execute, and develop as many of the rest as possible.

Video Content / Details of website for further learning (if any):

1. https://northstar.greyb.com/morphological-analysis/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 145-149

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LECTURE HANDOUTS

L 17

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **II**

Date of Lecture :

Topic of Lecture: TRIZ methodology

Introduction : (Maximum 5 sentences)

- TRIZ, also known as the theory of inventive problem solving, is a technique that fosters invention for project teams who have become stuck while trying to solve a business challenge.
- TRIZ is a methodology used by companies such as NASA, Siemens, General Motors, Procter & Gamble, Schneider Electric, BMW, Apple and many others. The method can be applied to every industry and every branch of service.
- The primary idea behind TRIZ approach to solving problems is that information about a specific problem must be first generalized, a solution concept has to be generated, and then the concept should be specialized in terms of a feasible solution.
-

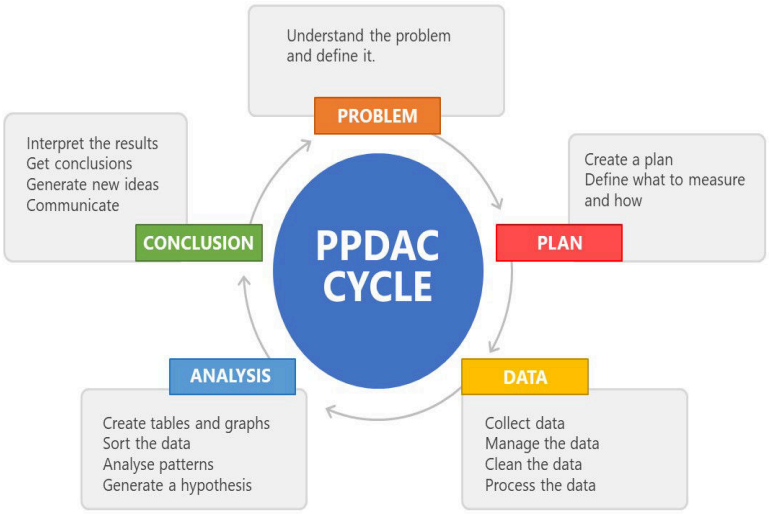
Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- TRIZ provides data on similar past projects that can help teams find a new path forward.
- TRIZ Matrix is a technique developed by Russian scientists to formalise the process of innovations.
- TRIZ increases the speed of system development and evolution.
- This is a primary a global function of TRIZ because technological evolution reflects and propels the development of our civilization.
- TRIZ helps model problems that are not well defined into a specific problem that can be solved by any engineer.

Detailed content of the Lecture:

TRIZ Method for Problem Solving

TRIZ is a Russian acronym for "*teoriya resheniya izobretatelskikh zadatch*", which translates in English as the "**theory of inventive problem solving**".
TRIZ is widely used in design engineering, process management and the development of products. Some of the world's most renowned companies that have used TRIZ in projects include Ford, General Electric, Samsung, LG, Intel, Kodak, Procter & Gamble, Motorola, HP Rolls-Royce..



Central Concepts of TRIZ

Let's explore the two central concepts associated with the theory of inventive problem solving, i.e. generalizing problems and solutions & contradictions.

Generalizing Problems and Solutions

The basic concept behind TRIZ, based on research findings, implies that problems and solutions repeat themselves, they repeat across industries. These problems are contradictions that can be resolved using creative solutions. TRIZ is used for understanding these patterns of contradictions and solutions for developing new methods.

Problem Identification: Contradictions

The basic concept of TRIZ identifies contradictions as the primary issue related to a problem, and eliminating them can lead to a solution. Two categories of contradictions exist in TRIZ:

1. Technical Contradictions

Technical Contradictions occur when improving something leads to something else suffering from a negative effect.

Example 1: Processing power for a computer increases (good), but it uses hardware, making it bulkier (bad). .

Old computers were bulkier, with fewer features; however, overtime, innovation in hardware resolved this problem with smaller processors, with increased processing speed, incorporated in lightweight computers.

Example 2: A business customizes service for its customers (good); however, the service is now suffering from delays and a long waiting time for customers (bad).

Many businesses employ many methods to resolve such contradictions, such as using AI-powered online services, portals, and shopping carts to offer customized service, with an estimated delivery time.

2. Physical Contradictions

Physical Contradictions are inherent. An object or system might have requirements that are contrary, resulting in Physical Contradictions.

Example 1: An operating system should be complex so that it can offer many features to the end user; however, it needs to be easy enough to use without many command lines.

A primary example of this is the need for command lines in most Linux based operating systems. Many Microsoft based client and server operating systems resolve this contradiction by offering an easy to use Graphical User Interface or GUI. Easy search features also aid this within the OS.

Example 2: A cupboard should be large enough to accommodate many items but not take up too much space.

There are a number of cupboards which are either detachable or can be folded to free up space. Smart cupboards for instance, provide combined solutions for storing more items in less space.

Inventive Principles and Standard Solutions

There are 40 Inventive Principles and 76 Standard Solutions of TRIZ which can be used for resolving problems.

The 40 Inventive Principles of TRIZ

The database of TRIZ has a collection of user compiled resources. This open source database consists of 40 principles. These principles provide the basis for resolving problems. These principles include the following:

Segmentation, extraction, local quality, asymmetry, combination, universality, nesting, counterweight, prior counteraction, prior action, cushion in advance, equipotentiality, inversion, spheroidality, dynamicity, partial, overdone or excessive action, moving to a new dimension, mechanical vibration, periodic action, continuity of useful action, rushing through, convert harm into benefit, feedback, mediator, self-service, copying, inexpensive short life, replacement of a mechanical system, use pneumatic or hydraulic systems, flexible film or thin membranes, use of porous materials, changing the colour, homogeneity, rejecting and regenerating parts, transforming physical or chemical states, phase transition, thermal expansion, use strong oxidisers, inert environment and composite materials.

Example: The first principle in the list, called "segmentation", proposes breaking down objects into independent parts. This might include manufacturing an object so that it becomes easier to disassemble or use segmentation to resolve a technical issue. This might be done by using a trailer and truck instead of one large truck or by designing cubicles for an open plan office to enable easy reshuffling of the office layout according to need.

For more details, see these **40 TRIZ Principles** with detailed explanations.

76 Standard Solutions of TRIZ

There are 76 Standard Solutions which were compiled by none other than Genrich Altshuller and his comrades over ten years between 1975-1985. These standard solutions are categorized in five broad categories.

1. There are 13 standard solutions for "improving the system" with little or no change.

2. There are 23 standard solutions for "improving the system" by changing the system.

3. There are 6 standard solutions for "system transitions".

4. There are 17 standard solutions for "detection and measurement".

5. There are 17 standard solutions for "simplification and improvement"

For more details, see these **76 Standard Solutions** with examples.

Applying TRIZ for Problem Solving

If you wish to use TRIZ for problem-solving, you can use the following steps to resolve a problem.

1. Define the Problem: You can get started by defining the problem. You can assess if the issue suffers from a Physical or Technical contradiction.

2. Find the TRIZ Generalized Problem to Match your Problem: You can match the generalized problem to match your issue. Since problems are often repeating themselves across industries and sciences.

3. Find the Generalized Solution to Solve the Generalized Problem: You can match the generalized problem to a generalized solution to see how it resolved the former.

4. Use the Identified Solution to Resolve Your Problem: You can use the generalized problem and its generalized solution as an example and adapt it to your specific issue to resolve it.

Video Content / Details of website for further learning (if any):

1. https://www.ntu.edu.sg/home/mkhheng/mp4011/Design_Synthesis.pdf

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 150-153

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LECTURE HANDOUTS

L 18

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **II**

Date of Lecture :

Topic of Lecture: Concept testing methods

Introduction : (Maximum 5 sentences)

- Concept testing is defined as a research method that involves asking customers questions about your concepts and ideas for a product or service before actually launching it..
- The definition of concept testing is the process of getting an idea evaluated by your target audience before it becomes available to the public. It includes anything from product concepts to ad campaigns.
- The process of concept testing involves stages such as defining the goal of the study, choosing the sample population, deciding upon a survey format, communicating the concept, measuring consumer response and interpreting the results.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- The purpose of concept testing, fundamentally, is to see if customers like your product, to gauge whether they'll actually buy it.
- It is essentially asking customers to design their ideal product while balancing features, price, and usability. We are gathering information upstream to sell downstream.

Detailed content of the Lecture:

Concept Testing

Concept testing happens during the preliminary stage of product development. It combines quantitative and qualitative research methods for evaluating new product ideas before they hit the market.

Why should organizations bother about concept testing? Simply put, pushing ideas to your audience before implementation helps you avoid pitfalls and save resources. You'd know if they are sold in on a new concept and when there's no reason to change what exists.

A concept can be anything, literally—think of error messages on 404 pages, rebranded logos, new product packages, and even ad messages. These ideas can sway the market, so you should take time to test them before going ahead.

Types of Concept Testing

There are four standard methods of concept testing, based on the number of ideas on play:

1. Monadic Testing

2. Sequential Monadic Testing

3. Proto Monadic Testing

4. Comparison testing

Monadic Testing

Monadic testing entails breaking your target audience into subsets. Each group tests a single product feature and provides feedback on why an idea is more valid than the others. Here, answer questions like, "Does this concept provide value for money?" and "How would you rate the overall feature satisfaction?"

Although there's a benchmark, the audience doesn't have to compare this feature against existing ideas in the market. Instead, they conduct an in-depth analysis of the concept's specific feature.

Pros of Monadic Testing

1. Monadic testing surveys are short and flexible.
2. It provides a comprehensive overview of the look, feel and, value of the product.
3. It allows you to target specific groups one at a time.

Cons of Monadic Testing

1. Monadic testing requires a large survey sample size.
2. It is an expensive concept testing method.

Sequential Monadic Testing

In sequential monadic testing, the researcher breaks the target audience into groups. Each group evaluates the concepts in a random, rotating sequence. For example, Group A examines a feature and passes it to Group B, while Group B passes another idea to Group D.

The idea here is to give everyone in the target audience the chance to examine all the concepts and provide feedback. After the examination, each group responds to the same set of questions in a survey or questionnaire.

Pros of Sequential Monadic Testing

1. Sequential monadic testing is cost-effective and easy to administer.
2. It requires a small survey sample size.

Cons of Sequential Monadic Testing

1. It is commonly affected by survey response bias.
2. Lengthy surveys and questionnaires can discourage respondents.

Proto Monadic Testing

Proto monadic testing merges sequential tests with comparison tests. The idea here is for respondents to examine ideas, compare the unique features and choose the best fit after evaluation.

Pros of Proto Monadic Testing

1. Researchers can gather first-hand feedback on the market's preferences.
2. It allows the researcher to validate results from post-testing surveys.

Cons of Proto Monadic Testing

1. Time-consuming
2. Survey response bias

Comparison Testing

Also called comparative testing, this method is used to weigh multiple concepts to know how they measure against each other.

Typically, respondents rate these concepts against a fixed set of criteria. In other cases, they only have to select the better feature or answer related ranking questions.

Pros of Comparison Testing

1. Comparative testing helps you to identify the most relevant concepts.
2. It gives you clear and understandable results.

Con of Comparison Testing

1. It doesn't provide enough insights and contexts for the audience's choices.

How to Conduct Concept Testing Surveys

1. Choose a suitable concept testing method

Since there are four primary methods for concept testing, you need to determine the right one for your product. For instance, if you're trying out multiple features, opt for the comparison method or proto monadic testing.

Here, you should also consider how much time you have for the process. For instance, if you need to launch the product within a short time, consider the concept selection method. But if there's more time, other methods can come in handy.

So, weigh the pros and cons of each method and choose what works best.

2. Determine the suitable survey method

Now that you have decided on the concept testing method, the next step is choosing the proper survey method.

What should be top of mind here? You should go for a survey method that matches your objectives. These objectives would guide your overall decision-making, including your survey design, survey questions, and question format.

A few things to have in mind when designing your survey include:

- Use survey blocks to organize your form fields and questions.
- Prioritize Likert scale questions that allow respondents to rate how they feel about a specific feature using a 3-point, 5-point, or 7-point scale.
- Ask demographic survey questions to provide background information about your survey participants.

- Use images to create appealing visual presentations for different survey questions.

3. Administer your survey and analyze responses

The presentation of your survey questions can make or mar your overall concept testing process. First, ensure that your survey questions are easy to understand and straightforward. Stick with good survey questions like rating and ranking scales and avoid vague or leading questions.

It would help if you asked the demographic questions first before going into the core of your concept testing process. Your audience would most likely be familiar with these types of questions and can respond to them quickly.

Next, ease into baseline research questions like:

- What do you know about this product or brand?
- How often have you used this product or a similar product?

After this point, you can introduce the specific concept and its distinct features. Ask your respondents to compare the idea against what is already in the market, then round off with questions that emphasize their preferences, such as, "how would you rate this concept's value for money?"

4. Discover the most viable concept

Organizing and analyzing your data is the most critical part of the process. Here, it would be best if you split the data sets into overall results and individual results. A tool like Formplus can handle preliminary data analysis, allowing you to categorize your data faster.

Importance of Conducting Concept Testing

1. Concept testing is a cost-effective product development solution: By gathering feedback before launching a new product or implementing an idea, organizations can reduce waste and enjoy more value for money. You can pump in resources into a viable idea to ensure that it is what your target market needs.

2. It helps you improve your product or concept: Before concept testing, you probably thought it was a great idea to use a serif text on your logo. Now that the results are in, you see that your audience isn't interested in a serif logo, and you can make a u-turn on time. This scenario shows how concept testing can help you optimize your product or service.

More than this, concept testing also provides feedback on why an idea isn't viable. Maybe the serif logo doesn't fit the market's conception of your brand, or it is too similar to your competitor's logo. With concept testing, you'd know why the market doesn't favor an idea.

3. It serves as a quality check for an organization's ideas and concepts at different points: Every insight you receive from your audience provides a fresh perspective on your product offerings and concepts.

4. Concept testing surveys bridge the gap between customers and the organization: It allows customers to become a part of the organization's decision-making process, which increases the brand's equity value.

5. In product development, concept testing helps you to streamline key product features for a better customer experience.

Concept Testing Examples

Concept testing looks good on paper but does it work in real life? Yes! Some of the biggest brands you know leverage concept testing to build great products that people like you love. Let's look at a few

examples.

1. In 2018, up-and-coming fashion brand, **Shinola**, was ready to introduce a new collection of wristwatches to the market. Seeing that this was a considerable investment, they conducted a concept testing survey on which watches to feature in their spring 2018 collection.

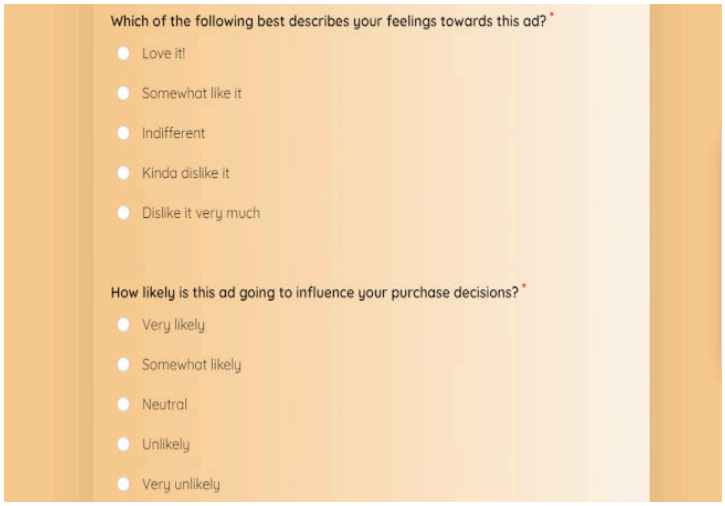
2. **Tesla** used concept testing as part of the launch strategy for its Model 3 in 2017. To prepare the target market for the new product, the Tesla product team got a handful of them to try out new features and benefits. This move was largely successful, allowing the company to raise an additional $400 million for investors.

3. After a significant shift in its car racing model, **NASCAR** decided to collect feedback from its viewers as part of concept testing. They gathered more than 200 responses from viewers cutting across viewing experience, high points, and dislikes. These data sets helped the company to improve its car racing model.

Top Templates for Concept Testing

Ad Testing Survey

Do you want to know which of your adverts has the best conversion prospects? Set up an ad testing survey with Formplus, and let your target audience help you make the right ad choice.



Video Content / Details of website for further learning (if any):

1. https://www.questionpro.com/blog/what-is-concept-testing/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 253-256

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LECTURE HANDOUTS

L 19

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **Product Architecture**

Date of Lecture :

Topic of Lecture: Product Development Management

Introduction : (Maximum 5 sentences)

- Product specifications are important since it provides clear instructions on the intent, performance and construction of the project.
- It can be used to support the costing of a project: not only the materials and products but also the performance and workmanship.
- Purpose of specification is to highlight the necessary information which cannot be obtained from drawing.
- Further main purposes of writing specifications are, to show the strength of construction material or construction work

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Basic Information about Product
- Product Concepts
- Design Creativity

Detailed content of the Lecture:

1. A product specification (also referred to as "product specs") is a document with a set of requirements that provides product teams the information they need to build out new features or functionality.
2. A good product spec doesn't micro-manage product development. Rather, it gives them relevant context about users, business needs and other criteria to help them make informed decisions as they design and build a solution.
3. Product specs don't have been long or overly technical. In fact, the most effective product specs are actually pretty brief.
4. Product specs are blueprints that describe exactly what the product will be, what it should look like, and what function it will perform. Additionally, these guidelines might include information about the target audience that will help product management teams optimize the product's features.
5. The purpose of product specs is to outline all the information about the product so that any member of the product development team will know exactly what to create.
6. The product specs document should be all-encompassing and in a language that can be understood by any employee who has access to it.
7. Doing so will eliminate miscommunication and make the product development process go quickly since the specifications don't have to be explained verbally.

8. Product specs typically contain the following elements.
    - **Product Summary:** First, begin with a description of the product idea. This section should briefly introduce the product's concept to the reader as well as why you're creating this product. Summarize what the final product should look like, what features it will include, and the expected time it will take to develop it.
    - **Business Case:** Next, you should include the business case for developing the product. This is a written document which outlines the benefit or advantage that the product will provide for the company. Additionally, the business case should also highlight the budget and resources that will be needed to complete the project.
    - **User Stories:** User stories are brief messages that are told from the perspective of the product's users. They describe the features that users want to see included in the new product. These stories can be written using a simple template from User Stories Applied: For Agile Software Development: As a feature, I want [goal] so that [benefit].
    - **User Personas:** Next, you should detail who the product is being built for. Who is your target audience? An effective user persona describes a specific character that fits into the target demographic and has a problem that will be solved by the product. Being able to visualize the intended target for the product can help you remain customer-centric with your design.
    - **Product Design:** You'll need to create a physical design for your product, so start by sketching out a technical drawing. As you continue to progress through product development, you can tweak your design to reflect any changes you wish to make. Even if it's not perfect, a visual representation of the final product will help guide product management through the development process.
    - **Functional Spec:** Lastly, you'll want to include a functional spec. A function spec is a written document that includes the intended appearance and capabilities of the product, as well as how it should interact with its users. This document will provide a reference point for product developers as they begin programming.

Video Content / Details of website for further learning (if any):

https://www.prodpad.com/resources/guides/product-management-process/specifications/

https://blog.hubspot.com/service/product-specs

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 91-94

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LECTURE HANDOUTS

L 20

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **III**

Date of Lecture :

Topic of Lecture: creation - clustering

Introduction :

- Generate alternatives
- Preliminary design is an iterative process and multi-disciplinary throughout the layout development process.
- Increase the probability of an early quality product
- Familiarize our unit with planning and design problems
- Help the project manager evaluate solutions

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Product Concepts
- Basic Information about Product
- Design Creativity

Detailed content of the Lecture:
Creation

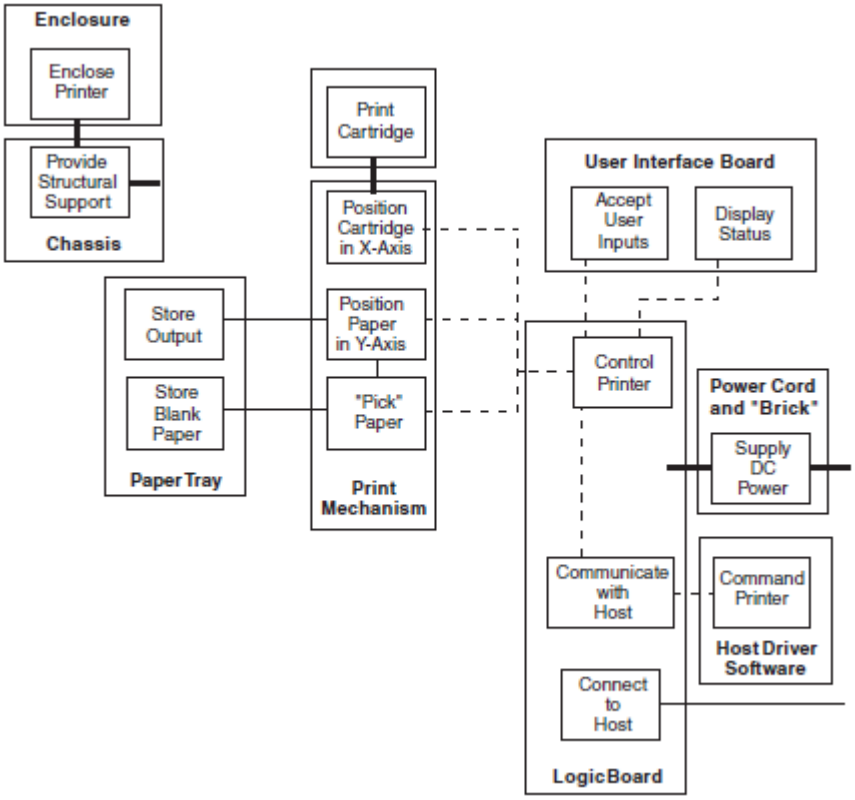
- A schematic is a diagram representing the team's understanding of the constituent elements of the product.
- At the end of the concept development phase, some of the elements in the schematic are physical concepts, such as the front-in/front-out paper path. Some of the elements correspond to critical components, such as the print cartridge the team expects to use.
- However, some of the elements remain described only functionally. These are the functional elements of the product that have not yet been reduced to physical concepts or components.
- For example, "display status" is a functional element required for the printer, but the particular approach of the display has not yet been decided. Those elements that have been reduced to physical concepts or components are usually central to the basic product concept the team has generated and selected. Those elements that remain unspecified in physical terms are usually ancillary functions of the product.
- The schematic should reflect the team's best understanding of the state of the product,
- but it does not have to contain every imaginable detail, such as "sense out-of-paper Print Cartridge Supply DC Power Control Printer Communicate with Host Command Printer

Position Paper in Y-Axis Position Cartridge in X-Axis Store Output Store Blank Paper Provide Structural Support Enlose Printer Accept User Inputs Display Status Connect to Host "Pick" Paper flow of forces or energy flow of material flow of signals or data EXHIBIT 10-6 Schematic of the DeskJet printer. Note the presence of both functional elements (e.g., "Store Output") and physical elements (e.g., "Print Cartridge").

- For clarity, not all connections among elements are shown. Product Architecture condition" or "shield radio frequency emissions." These and other more detailed functional elements are deferred to a later step.
- A good rule of thumb is to aim for fewer than 30 elements in the schematic, for the purpose of establishing the product architecture. If the product is a complex system, involving hundreds of functional elements, then it is useful to omit some of the minor ones and to group some others into higher-level functions to be decomposed later.

Cluster the Elements of the Schematic

- The challenge of step 2 is to assign each of the elements of the schematic to a chunk. One possible assignment of elements to chunks where nine chunks are used. Although this was the approximate approach taken by the DeskJet team, there are several other viable alternatives. At one extreme, each element could be assigned to its own chunk, yielding 15 chunks.
- At the other extreme, the team could decide that the product would have only one major chunk and then attempt to physically integrate all of the elements of the product. In fact, consideration of all possible clusterings of elements would yield thousands of alternatives.
- One procedure for managing the complexity of the alternatives is to begin with the assumption that each element of the schematic will be assigned to its own chunk, and then to successively cluster elements where advantageous. To determine when there are advantages to clustering,



consider these factors, which echo the implications discussed in the previous section:

1. Geometric integration and precision
2. Function sharing
3. Capabilities of vendors
4. Similarity of design or production technology:
5. Localization of change
6. Accommodating variety
7. Enabling standardization
8. Portability of the interfaces

Video Content / Details of website for further learning (if any):

http://www.dot.state.mn.us/design/geometric/

https://www.coursehero.com/file/p2trvmk/3-System-level-design-Includes-a-geometric-layout-of-the-product-a-functional/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 194-196

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LECTURE HANDOUTS

L 21

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **III**

Date of Lecture :

Topic of Lecture: Geometric Layout Development

Introduction :

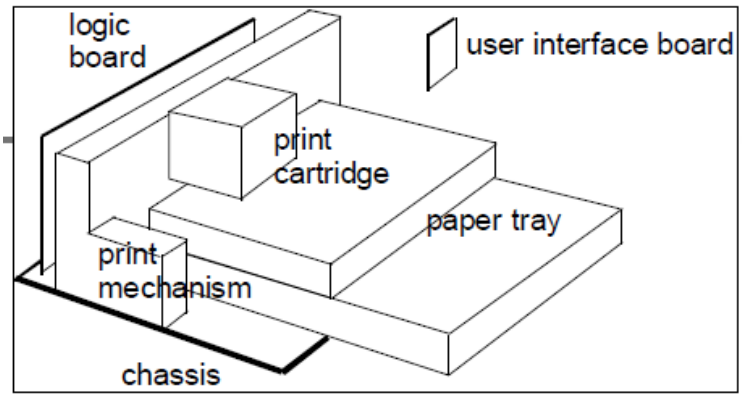
- Preliminary design is an iterative process and multi-disciplinary throughout the layout development process. The initial review can
- Increase the probability of an early quality product
- Generate alternatives
- Familiarize our unit with planning and design problems
- Help the project manager evaluate solutions

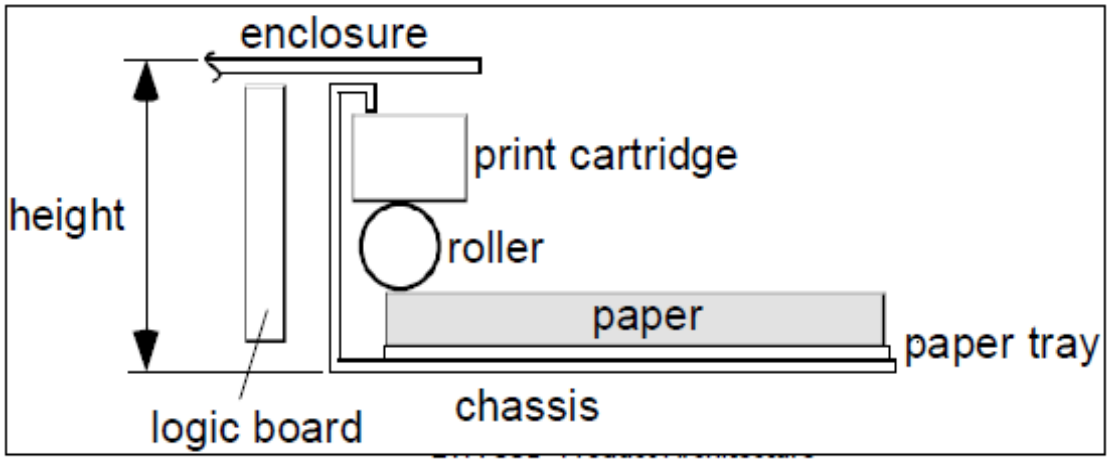
Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Basic Information about Product
- Product Concepts
- Design Creativity

Detailed content of the Lecture:

1. Key considerations when creating a rough geometric layout include: „ Identification of fundamental and incidental interactions „ Fundamental interactions „ Ex.: H-P printer Sheets of paper flow from the paper tray to print mechanism. „
2. Incidental interactions „ Ex.: Vibration induced by the actuators in paper tray may interfere with precision positioning of print cartridge (x-axis)





3. 3 system level design includes a geometric layout of
   System-level design: Includes a geometric layout of the product, a functional specification of each of the product's subsystems, and a preliminary process flow diagram for the final assembly Process.
4. Detail design: Geometry specification, materials and tolerances of all of the unique parts and standard parts to be purchased from suppliers. Tooling is designed for each part to be fabricated.
5. Testing and refinement: Early (alpha) prototypes are usually production intent parts for customer verification (customer needs). Later (beta) prototypes are usually built with parts supplied by the intended production processes.

Video Content / Details of website for further learning (if any):

http://www.dot.state.mn.us/design/geometric/

https://www.coursehero.com/file/p2trvmk/3-System-level-design-Includes-a-geometric-layout-of-the-product-a-functional/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 95-99

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LECTURE HANDOUTS

L 22

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **III**

Date of Lecture :

Topic of Lecture: Fundamental Interactions and Incidental Interactions

Introduction :

Fundamental Interactions are: those interactions corresponding to the lines on the schematic that connect the chunks to one another.

Incidental Interactions are: interactions that arise because of the particular physical implementation of functional elements or because of the geometric arrangement of the chunks.

Functional Elements: Individual operations and transformations that contribute to the overall performance of the product.

Physical Elements: The parts, components and subassemblies that ultimately implement the product's functions. They become more defined as development progresses.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Basic Information about Product
- Product Concepts
- Design Creativity

Detailed content of the Lecture:

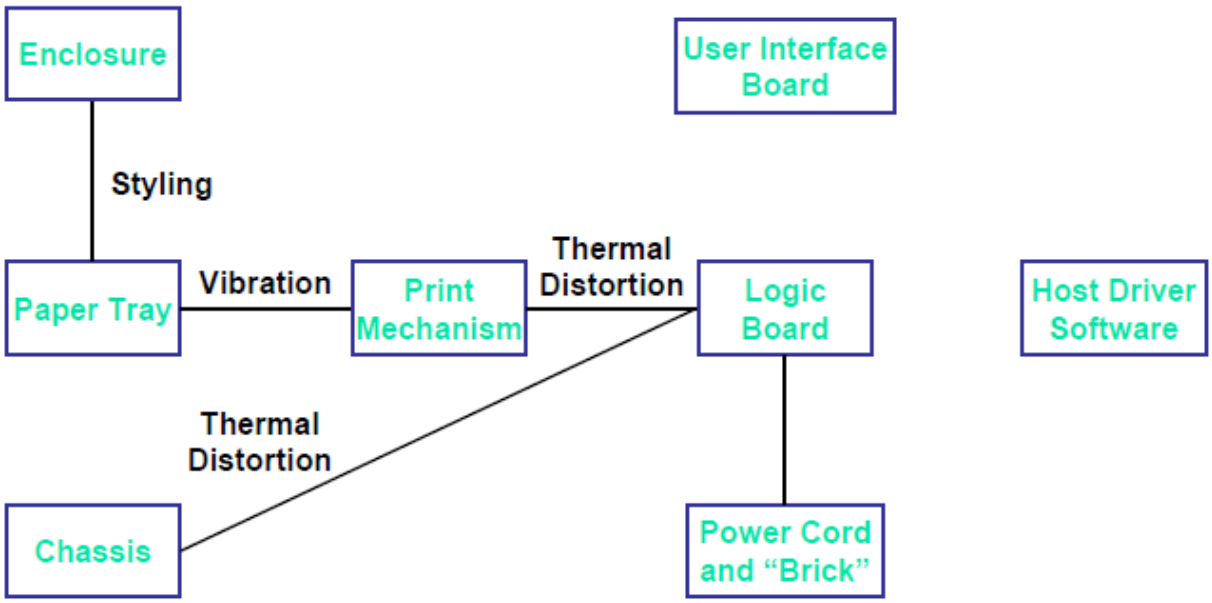
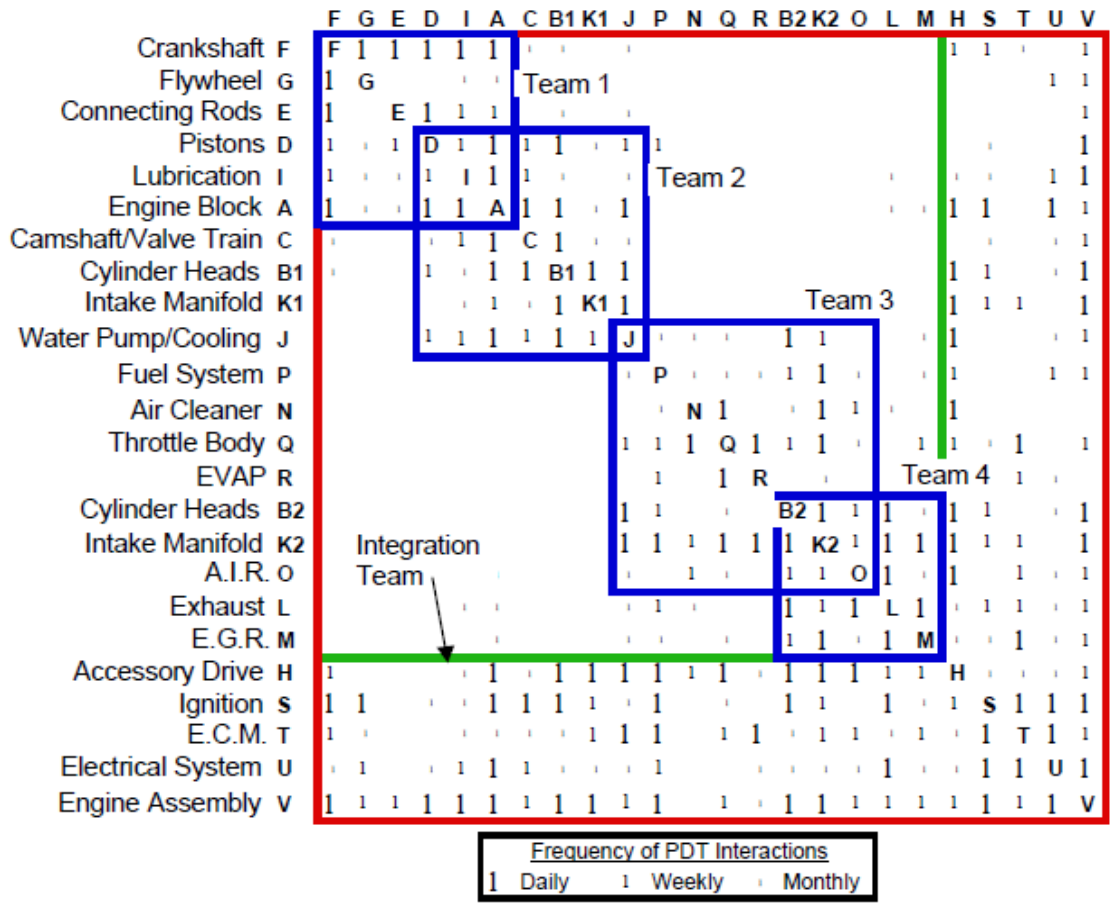


Figure: Incidental Interactions



Video Content / Details of website for further learning (if any):
https://quizlet.com/15971588/product-architecture-flash-cards/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 196-197

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LECTURE HANDOUTS

L 23

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **III**

Date of Lecture :

Topic of Lecture: system level design issues

Introduction :

1. The organization of physical elements of a product into several major physical "building blocks"
2. Each chunk is made up of a collection of components that implement the functions of the product.
3. Chunks implement one or a few functional elements in their entirety (each functional element is implemented by exactly one physical chunks)
4. The interactions between chunks are well defined and are generally fundamental to the primary functions of the products.

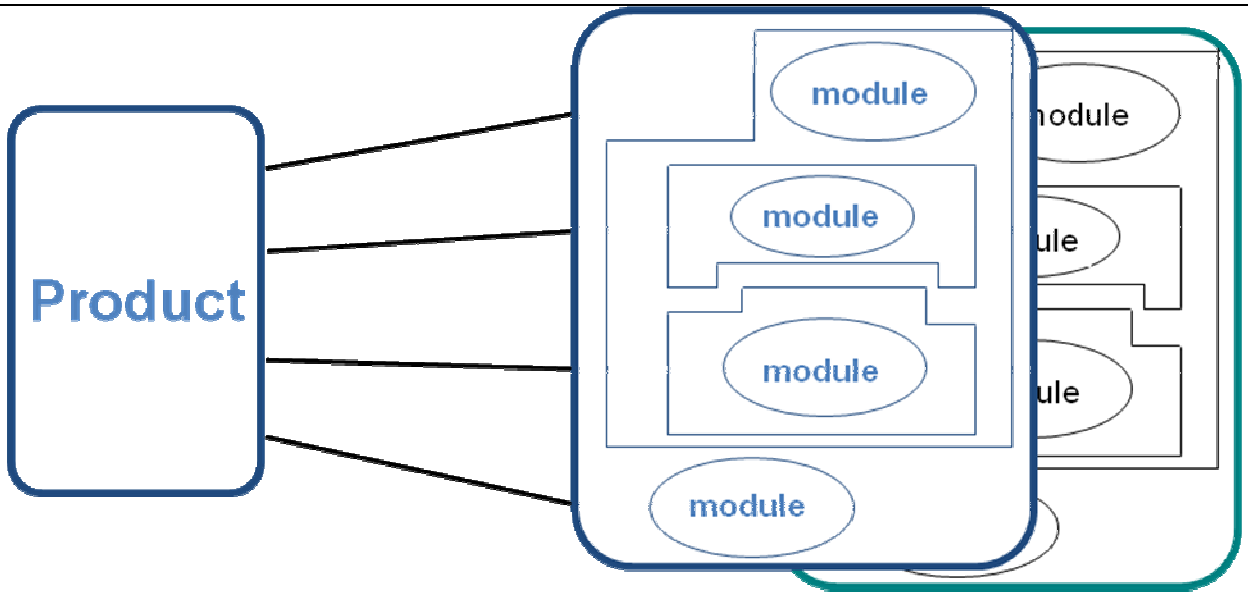
Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Basic Information about Product
- Product Concepts
- Design Creativity

Detailed content of the Lecture:

Modular

1. Chunks implement one or a few functional elements in their entirety (each functional element is implemented by exactly one physical chunk). The interactions between chunks are well defined and are generally fundamental to the primary functions of the products.
2. Functional elements of the product are implemented using more than one chunk. A single chunk implements many functions. The interaction between chunks is ill defined and may be incidental to the primary functions of the products.
3. Factors affecting architecture modularity
    - Product changes
    - Product variety
    - Component standardization
    - Product performance
    - Manufacturability
    - Product development management



For modular architecture- Allows minimizing the physical changes required to achieve a functional change.

Reasons for product changes

- upgrades
- add-ons
- adaptation (adapt to different operation environments)
- wear (e.g., razors, tires, bearings)
- consumption (for example, toner cartridges, battery in cameras)
- flexibility in use (for users to reconfigure to exhibit different capabilities)
- re-use in creating subsequent products

Factors affecting architecture modularity (product variety):

- The range of products (models) concurrently available in the market
- Modular can vary without adding tremendous complexity to the manufacturing system.

Video Content / Details of website for further learning (if any):

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 203-204

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LECTURE HANDOUTS

L 24

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **III**

Date of Lecture :

Topic of Lecture: Secondary Systems

Introduction :

1. The organization of physical elements of a product into several major physical "building blocks"
2. Each chunk is made up of a collection of components that implement the functions of the product.
3. Chunks implement one or a few functional elements in their entirety (each functional element is implemented by exactly one physical chunks)
4. The interactions between chunks are well defined and are generally fundamental to the primary functions of the products.

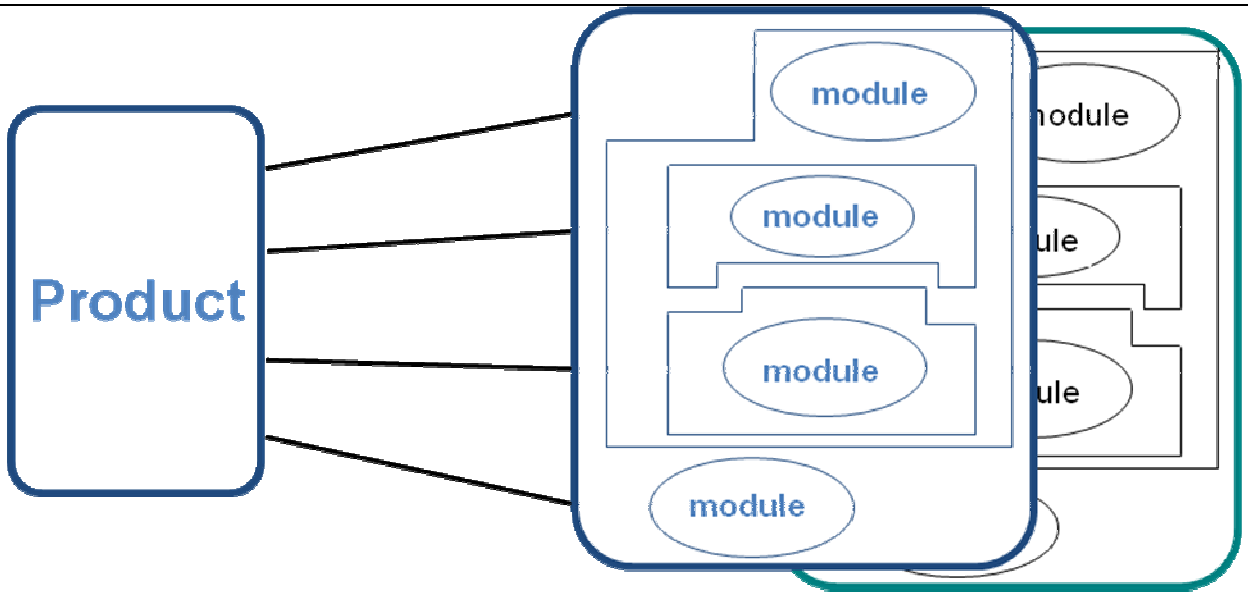
Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Basic Information about Product
- Product Concepts
- Design Creativity

Detailed content of the Lecture:

Modular

1. Chunks implement one or a few functional elements in their entirety (each functional element is implemented by exactly one physical chunk). The interactions between chunks are well defined and are generally fundamental to the primary functions of the products.
2. Functional elements of the product are implemented using more than one chunk. A single chunk implements many functions. The interaction between chunks is ill defined and may be incidental to the primary functions of the products.
3. Factors affecting architecture modularity
    - Product changes
    - Product variety
    - Component standardization
    - Product performance
    - Manufacturability
    - Product development management



For modular architecture- Allows minimizing the physical changes required to achieve a functional change.

Reasons for product changes

- upgrades
- add-ons
- adaptation (adapt to different operation environments)
- wear (e.g., razors, tires, bearings)
- consumption (for example, toner cartridges, battery in cameras)
- flexibility in use (for users to reconfigure to exhibit different capabilities)
- re-use in creating subsequent products

Factors affecting architecture modularity (product variety):

- The range of products (models) concurrently available in the market
- Modular can vary without adding tremendous complexity to the manufacturing system.

Video Content / Details of website for further learning (if any):

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 203-204

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LECTURE HANDOUTS

L 25

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **III**

Date of Lecture :

Topic of Lecture: Architecture of the chunks

Introduction : (Maximum 5 sentences)

- Interfaces are linkages shared among components, modules, sub-systems of a given product architecture.
- Interface specifications define the protocol for the fundamental interactions across all components and interfaces comprising a technological system.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

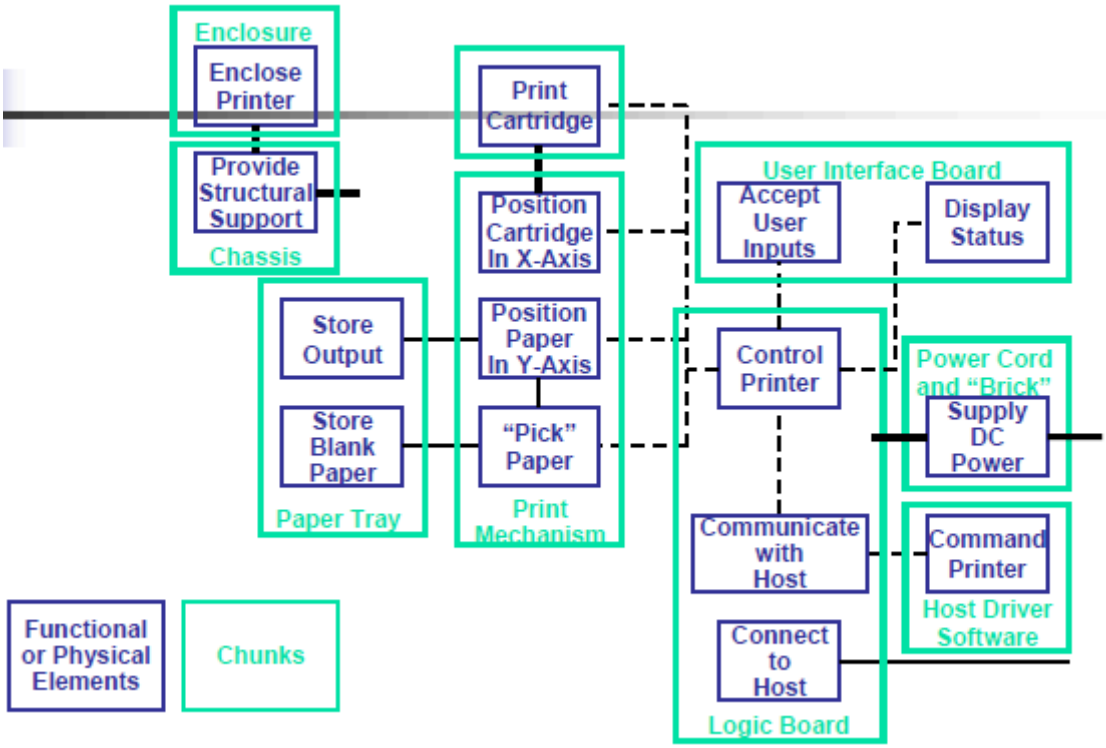
- Basic Information about Product
- Product Concepts
- Design Creativity

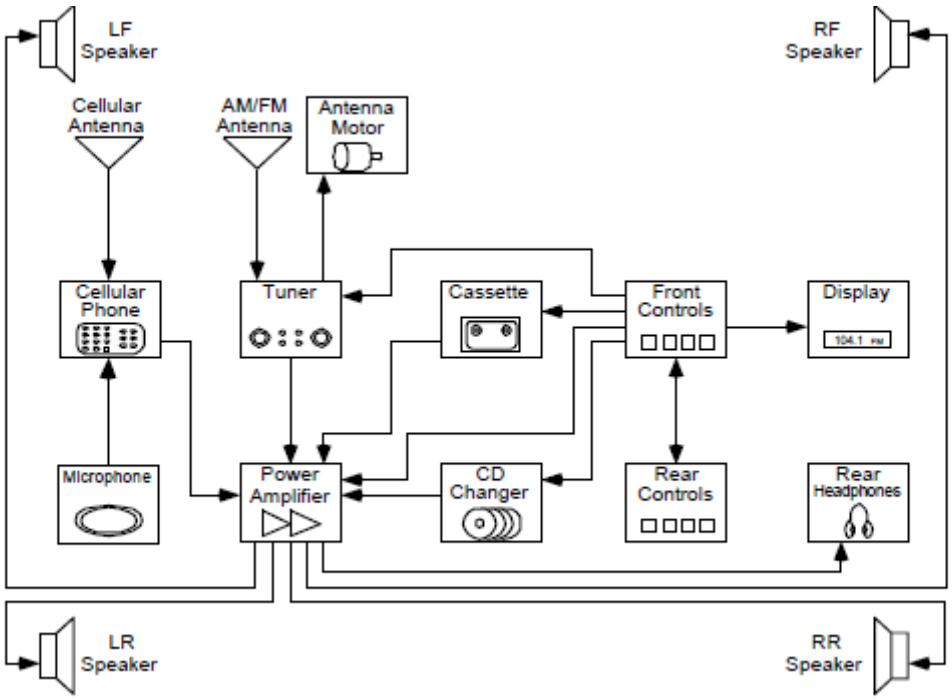
Detailed content of the Lecture:

1. Key considerations when clustering elements (of schematic) into chunks include:

- Geometric integration and precision
- Ex.: H-P clustering for ink-jet printer calls for cartridge positioning on x-axis and paper positioning on y-axis
- Function sharing
  Ex.: Status display and user controls for H-P printer
- Ex.: Transmission for BMW motorcycle Vendor (= Supplier) capabilities
- Ex.: H-P printer
- Ex.: Spring and shock absorber for rear suspension of BMW motorcycle
- Similarity of design or production technology
- Location of change
- Accommodating variety
- Enabling standardization
- Portability of interfaces

- There are many other functional and physical elements not shown, some of which will only be conceived and detailed as the system-level design evolves. These additional elements make up the secondary systems of the product. Examples include safety systems, power systems, status monitors, and structural supports.
- Some of these systems, such as safety systems, will span several chunks. Fortunately, secondary systems usually involve flexible connections such as wiring and tubing and can be considered after the major architectural decisions have been made. .
- Secondary systems cutting across the boundaries of chunks present a special management challenge: Should a single group or individual be assigned to design a secondary system even though the system will be made up of components residing in several different chunks Or should the group or individuals responsible for the chunks be responsible for coordinating among themselves to ensure that the secondary systems will work as needed? The former approach is more typical, where specific individuals or subteams are assigned to focus on the secondary systems.





Video Content / Details of website for further learning (if any):

1. https://www.designsociety.org/publication/40976/CLUSTERING

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 193-195

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LECTURE HANDOUTS

L26

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **III**

Date of Lecture :

Topic of Lecture: Interface Specifications

Introduction : (Maximum 5 sentences)

- Interfaces are linkages shared among components, modules, sub-systems of a given product architecture.
- Interface specifications define the protocol for the fundamental interactions across all components and interfaces comprising a technological system.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Basic Information about Product
- Product Concepts
- Design Creativity

Detailed content of the Lecture:

1. Interfaces are linkages shared among components, modules, sub-systems of a given product architecture. Interface specifications define the protocol for the fundamental interactions across all components and interfaces comprising a technological system.
2. The crystallization and development of interface specifications has a tremendous impact on setting worldwide industry standards (e.g., GSM, TDMA, and AMP). Typical interface specifications for a consumer electronics product at the NPD level, for instance, often includes the tolerance specification of the components with respect to manufacturing processes, operating frequency bandwidths, maximum heat dissipation threshold, voltage and current requirements, housing dimensions, to name a few.
3. Sanchez and Mahoney (1996) explain how modularity intentionally creates a high degree of independence or a 'loose coupling' between component designs by standardizing component interface specifications. Sanchez (1999) furthermore classifies seven different types of interfaces:

   1. **Attachment interfaces** – define how one component physically attaches to another

   2. **Spatial interfaces** – define the physical space (dimension and position) that a component occupies in relation to other components

   3. **Transfer interfaces** – define the way one component transfers electrical or mechanical power, fluid, a bistream, or other primary flow to another

4. Control and communication interfaces – define the way one component informs another of its current state and the way that other components communicate a signal to change the original component's current state.

5. **Environmental interfaces** – define the effects, often unintended, that the presence or functioning of one component can have on the functioning of another (e.g., heat, magnetic fields, corrosive vapors, radiation, etc.)

6. Ambient interfaces – define the range of ambient use conditions (e.g., ambient temperature, humidity, elevation, etc.) in which a component is intended to perform

7. User interfaces – define specific ways in which users will interact with a product

8. Interface constraints are restrictions imposed by the components and how interfaces are shared amongst these components in a given product architecture. When a given product architecture is decomposed into sub-circuits, the interface constraints of these sub-circuits can be evaluated in stages. For example, the so-called components of 'closed assembled systems (e.g., cars, mobile phones, computers, etc.) can often be divided into two groups: electronic (e.g., resistors, capacitors, semiconductors, etc.) and mechanical (e.g., pins, nuts, bolts, housing, etc.).

9. Interface management also deals with the issues of component integration or multiplexing, as opposed to decomposition or de-integration of a system into smaller components.

10. An "architecture" in engineering is a functional description of the transformations that a product applies to its inputs to create its outputs. As a step on the way to a full design, the architecture represents the most detailed description of each level of the system hierarchy before designers start giving form to the product itself.

11. Architectures are important for managing complexity because they allow one to partition functionality of a given system into functional "chunks" (subsystems) with well-understood interactions (system interfaces). This allows individual engineers to focus on specific functionality, knowing that there already exists a "map" to integrate that specific functionality back into a useful whole (the product).

Video Content / Details of website for further learning (if any):

1. https://pdfs.semanticscholar.org/762e/38282152ce198361879433dd179624df19e2.pdf

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 204

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LECTURE HANDOUTS

L 27

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **III**

Date of Lecture :

Topic of Lecture: Portfolio Architecture

Introduction : (Maximum 5 sentences)

- Planning the architecture of a product is one of the most critical tasks facing a design team at the preliminary design phase.
- Deciding which approach to use when implementing a mechanical system has profound impacts on risk, performance, and cost.
- The term product portfolio architecture to describe the way in which members of a portfolio meet market variety by sharing or not sharing features.
- Depending on the target customer population, as well as other factors such as ease of manufacturing and simplicity of design, a product architecture may be configured in various ways.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Basic Information about Product
- Product Concepts
- Design Creativity

Detailed content of the Lecture:

1. As a product consists of many features, a portfolio of products can demonstrate a combination of different portfolio architectures. In the remainder of this thesis, we will concentrate on defining portfolio architecture for an individual feature at a time. As we consider a single feature at a time across a set of products, we find there are three main categories of portfolio architecture: fixed, platform, and adjustable (Figure 1). The difference between these portfolio architectures is in how they offer variety to the market.
2. A set of products exhibiting fixed portfolio architecture for a specific feature offers a single option across the entire set. For example, Henry Ford's famously limited original line of automobiles demonstrated fixed portfolio architecture for color in that black was the only option offered to customers. Offering one feature option may be an advantageous decision when there is limited variety in customer demands, a firm has a monopoly, or multiple options are prohibitively expensive to offer.

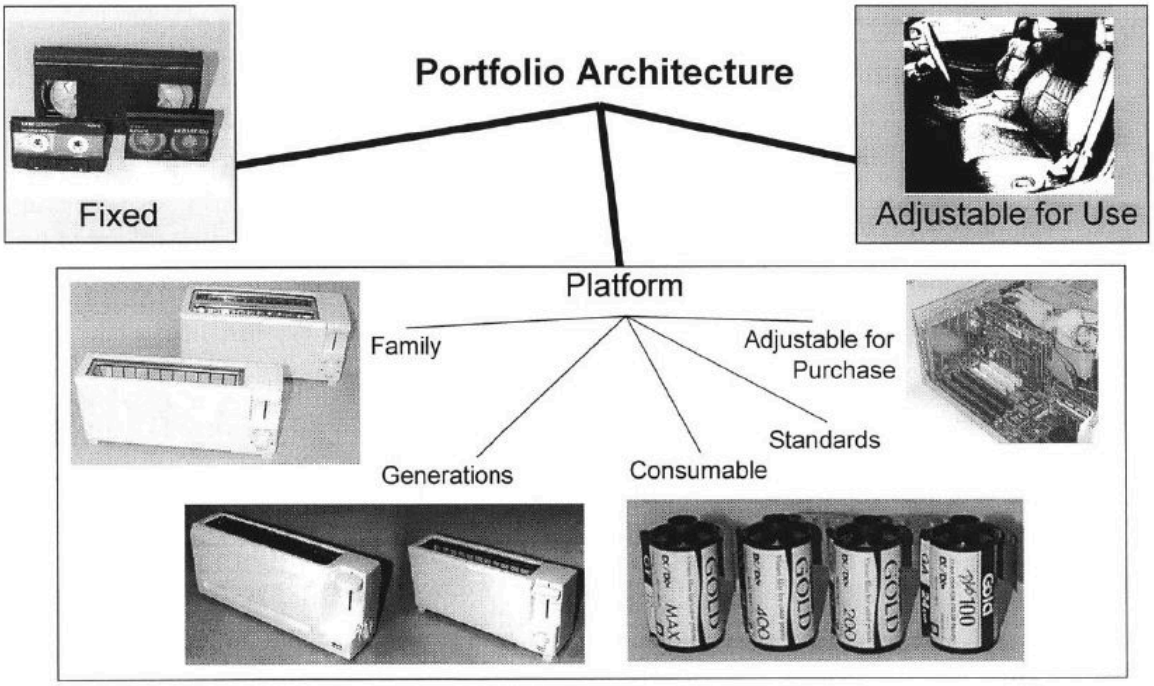
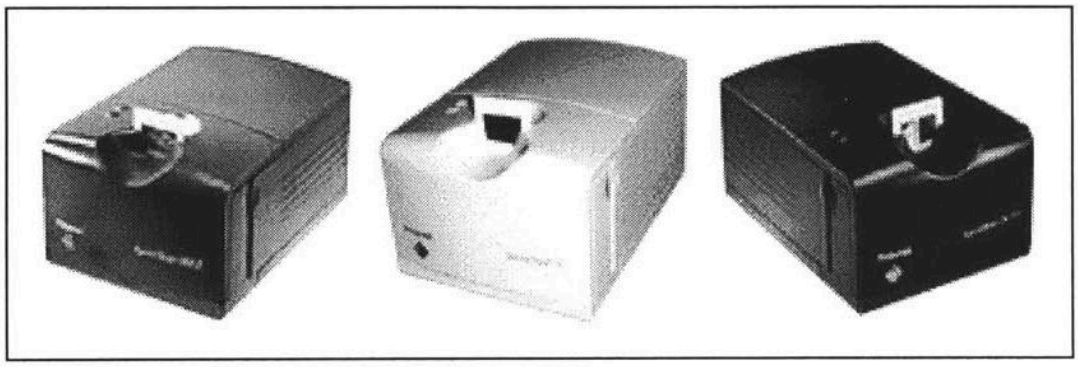


Figure 1: Various Types of Portfolio Architecture.

3. On the other hand, a set of products with *platform* portfolio architecture for a specific feature Offers variety through multiple options across the set. Usually this implies each product variant in the portfolio exhibits some form of modular product architecture. One of the main advantages of modular product architecture lies in the ability to remove or replace modules without affecting the rest of the design, thereby creating different products with minimal investment of time and resources.
4. A product portfolio can capitalize on this advantage in two ways: at one time or over time.
5. *A platform family* consists of several simultaneously existing variants offering different feature options. Offering these options may be as simple as varying color or as deeply embedded as a change in core technologies. Polaroid's family of photographic slide scanners, for instance, offer three different level of scan resolution



Video Content / Details of website for further learning (if any):

1. https://core.ac.uk/download/pdf/16520934.pdf

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 63-64

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LECTURE HANDOUTS

L 28

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **IV**

Date of Lecture :

Topic of Lecture: Design for serviceability

Introduction : (Maximum 5 sentences)

- Design for Serviceability / Maintainability begins with understanding the customer needs related to availability, reliability and service expectations.
- From this requirements will be defined in terms of such factors as availability, mean time between failures (MTBF), mean time to repair (MTTR), lifecycle cost (LCC), warranty period, etc.
- Design for service (DFS) is **a product lifecycle strategy that addresses a product's serviceability attributes**. These attributes, such as reliability, configuration, and ergonomics, have a direct bearing on the cost and efficacy of servicing the product.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Reduce Service Requirements and Frequency
- Facilitate Diagnosis
- Minimize the Time and Effort to Disassemble, Repair/ Replace, and Reassemble the Product as Part of the Service Process
- Reduce Costs of Service Parts

Detailed content of the Lecture:

The key design for serviceability (DFS) guidelines or principles are summarized below.

Simplification. Simplification is one of the most basic principles. The benefits of simplification are:

- Fewer items to fail / wear out
- Fewer items to diagnose
- Less disassembly & reassembly effort
- Lower service parts inventory

Standardization. Standardization not only refers to parts used in the design but also to design approaches, service procedures and methods, and service tools. The benefits of standardization with parts and modules are:

- Standardized parts and modules can be bought or produced at lower cost
- Parts and modules produced in larger quantities generally have better consistency & quality
- More failure & reliability data for better service planning
- Better accessibility of replacement components; less inventory required to obtain the same spare parts stock-out protection

- Easier for customers and field service personnel to maintain inventory of common standard parts

Access. Provide access panels and hatches to gain access to items that need to be serviced and make it easy to open or remove access panels or hatches. Minimize unfastening and re-fastening effort with access panels by using hinged panels and hatches, quick release latches and levers, or integral attachment unfastening and fastening. For items on interior of the system, provide slide-out drawers or rails or put assemblies on hinges to swing out to improve access. Provide physical and visual access to items that need to be serviced with a minimal amount of parts and interconnections that need to be disassembled and removed.

Ergonomics. Consider ergonomics in gaining access for a maintenance task. Avoid the need to lean over, reach into, crawl on top of, crawl under, climb up, repeatedly reposition oneself, or work over your head. Avoid the need for many repetitive motions such as unscrewing many screws or bolts that can lead to strains.

Safety. Shield high voltage terminals or prevent high voltage access when the system is powered. Provide mechanism such as interlocks to insure power disconnected when product opened for service. If interlocks are not possible, rely on lock-out, tag-out procedures. Provide an easy way to bleed stored energy from any system before beginning a maintenance procedure. Avoid sharp edges or parts and protect service personnel from burns due to contact from hot parts by incorporating shields.

Disconnecting/Reconnecting. Minimize the number of connections between modules to facilitate disassembly & assembly. Provide access to disconnect and reconnect. Label and mark interconnections and connectors to insure that only the applicable interconnections are being removed and facilitate correct reconnection. Specify connectors that are easy to remove & reinsert, i.e., large grip surface, pull tabs, release levers, quick disconnect and connect features, etc. Use keyed connectors with external features to define their orientation or maximize connector asymmetry to facilitate proper orientation when re-connecting. Simplify the routing of interconnections; avoid routing that interferes with disassembly and re-assembly.

Unfastening/Refastening. Minimize the number of fasteners; use integral attachment features or features that can provide EMI shielding without a large number of fasteners. Use captive attachment hardware that require no tools for unfastening and fastening ease and avoids loose fasteners getting dropped or lost in the system. Specify fasteners that will be easy to remove as product ages, oxidizes or corrodes (e.g., stainless steel). Use common fasteners with readily available replacements. Use mechanisms that allow removal with a minimum of manipulation and time such as quick release latches and levers and quarter-turn fasteners. Provide access to place and manipulate tools.

Part Handling. Considering what parts or modules may need to be removed or re-assembled as part of service procedures, minimize negative handling characteristics such as very large size, very small size, weight, fragility (breakable, ESD sensitive, etc.), nesting or tangling, toxic materials, etc. Provide gripping features on parts that must be disassembled and re-assembled.

Location and Insertion. Minimize axes of re-assembly and need to reposition service technician; design for top-down assembly. Avoid blind or restricted vision when locating or inserting parts during re-assembly. Provide features to guide parts into proper position, e.g., self-locating features and features to facilitate insertion (chamfers, tapers, lead-in's, guides, etc.). Provide features to align parts to one another during re-assembly. Minimize the number of surfaces or points that need to be simultaneously located. Maximize insertion clearance and minimize insertion or hold-down force.

Mistake-Proofing. Provide features on parts and modules that will only allow the parts or modules to be assembled one way – the correct way. Label, color-code or mark parts to facilitate correct disassembly and re-assembly. Make the design intuitive to facilitate correct dis-assembly, adjustment, and re-assembly. Use a service process FMEA to help identify potential mistakes or failure modes in a service procedure.

Video Content / Details of website for further learning (if any):

1. https://www.npd-solutions.com/dfs.html
2. https://www.npd-solutions.com/value/design-for-serviceability-maintainability

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 207-210

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LECTURE HANDOUTS

L29

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **IV**

Date of Lecture :

Topic of Lecture: Design for Evironment

Introduction : (Maximum 5 sentences)

- Design for environment (DfE) attempts to reduce the impact of product design upon the environment of a product or service.
- It takes into account the whole life cycle - going beyond just the use of recycled materials or proper packaging or disposal.
- Design for the Environment (DfE) is **a design approach to reduce the overall human health and environmental impact of a product, process or service, where impacts are considered across its life cycle**.
- Different software tools have been developed to assist designers in finding optimized products or processes/services.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- It attempts to reduce the impact of product design upon the environment of a product or service
- It takes into account the whole life cycle - going beyond just the use of recycled materials or proper packaging or disposal.
- Environmentally sustainable design (also called environmentally conscious design, eco design, etc.) is the philosophy of designing physical objects, the built environment, and services to comply with the principles of ecological sustainability.

Detailed content of the Lecture:

The DFE approach includes five aspects that follows the life-cycle of a product, and enables companies to be more environmentally friendly in their work.

These five aspects are - (1) Materials, and extraction; (2) Production; (3) Transport, distribution and packaging; (4) Use; and (5) End of life, Design For Disassembly and Design for Recycling.

1. Materials Extraction

Guideline	Reason
Avoid or minimise use of hazardous, toxic or in any other way environmentally unfriendly materials.	Decrease toxic and/or hazardous emissions in later life stages and/or decrease harmful emissions during production
Avoid materials with a high energy	Decrease the amount of energy used

content (Aluminium)	during extraction and/or production
Use materials which are renewable, recyclable and/or recycled, minimise use of thermosets or mixed polymers	Decrease the amount of non-renewable materials to be extracted from the earth
Design products in a way that reduces material use, use better design instead of over- dimensioning	Decrease the amount of materials to be extracted from the earth
Design for minimum waste production during production	Decrease amount of material wasted during production
Minimise number of materials used	Increase recyclability and ease the sorting process

2. Production

Guideline	**Reason**
Avoid or minimise the use of hazardous, toxic or in any other way environmentally unfriendly materials.	Decrease amount of harmful gaseous, liquid or solid emissions during production
Minimise and recycle residues and waste from production processes, within the manufacturing plant or outside it	Decrease amount of raw material required and the amount of waste created by production processes
Minimise use of energy-intensive process steps, such as high heating differentials, heavy motors and extensive cooling	Decrease the amount of energy used by the production processes
Optimise use of heat exchangers and similar devices to utilise otherwise wasted heat	Optimisation of energy flows in production processes
Minimise losses from production facilities by good construction, service and fast repair. Also provide maximum insulation of walls, pipes and ceilings.	Prevention of losses by leaks, oversized boilers and bad insulation

3. Transport, distribution and packaging

Guideline	**Reason**
Optimise efficiency transport modes following these rules: 1. transport by container ship or train is preferable over transport by lorry 2. transport by air is to be avoided	Decrease energy use and emissions from transport and avoid environmentally harmful ways of transport (such as flight)
Minimise long distance transport by maximising work with local suppliers and markets	Decrease long distance transport and all energy use and emissions from such source
Maximise efficiency of transportation by use of standardised transport packaging, bulk packaging, such as Europallets and transport of	Increase efficiency of transport

larger amounts of goods simultaneously	
Minimise amount of packaging material and the number of (virgin) materials in the packaging.	Decrease amount of material needed for packaging reduce contamnalia to aid the recycling of materials
Maximise use of refillable or reusable containers where appropriate	Decrease amount of material needed for packaging by re-use of containers
Avoid use of non-appropriate materials for packaging such as, PVC and Aluminium	Decrease amount of toxic, hazardous or also valuable materials in waste

4. Use

Guideline	**Reason**
Minimise energy consumption during use by: 1. using lowest energy consuming components 2. using default power down mode 3. the insulation of heating components	Decrease energy consumption during life
Minimise amount of consumables used during the use stage by: 1. product design e.g. permanent filters instead of paper filters 2. minimise leakage, e.g. by installing a leak detector 3. reusing consumables, e.g. reuse water from washing facilities to flush toilets 4. clear instructions to prevent misuse, e.g. by providing instructions on the product itself 5. product design to prevent spillage, e.g. provide instructions on how often a product, such as filter cartridges, should be replaced, or by designing the filling inlet large enough to to prevnt spilling 6. use of calibration marks to restrict required amounts of consumables, e.g. dosage for laundry detergents 7. product design that stimulates sustainable behaviour, e.g. only reusable cups and no disposable cups	Decrease the amount consumables used by a product during its life

provided at drinks dispenser or double sides copies default option	
Optimise life time of product by increasing reliability and durability	Decrease need for new products, hence decrease material and energy use for production
Design for easier maintenance and repair by: 1. indicate opening instructions for cleaning and/or repair 2. indicate parts for maintaining by colour codes 3. make location of wear detectable on parts 4. make vulnerable parts easy to dismantle and replace	Increase life span of a product by easier repair and maintenance
Design in modular product structure	Enable upgrading, hence prolonging of life time, of products at a later date
Avoid designs with a technical life span which outdates the aesthetic life span	Decrease disposal of operational products because of outdated aesthetic design
Design product to meet possible future needs of users	Extend possible life span of products
Minimise the use of: 1. periodical consumables such as batteries, cartridges and containers 2. liquid materials for maintenance such as cooling liquid or lubricants 3. any consumables containing toxic or otherwise hazardous materials	Decrease use of consumables in any form during the use stage of the products life span
Minimise generation of gaseous emissions such as CO_2 and tetraethyl lead, odours or any other undesirable emissions	Decrease emissions during usage stage of life span

5. End of life, Design For Disassembly and Design For Recycling

Guideline	**Reason**
Stimulate possible reuse of the product by: 1. classic design 2. sound constructions that does not become prematurely obsolete technically	Extend possible lifetime of a product, therefore decreasing need for new products

Stimulate possible remanufacturing/refurbishing by: 1. hierarchical and modular structure 2. use of detachable points 3. use of standardised joints 4. position joints to minimise necessary movement of product during disassembly 5. indicate opening instructions for non-destructive disassembly	Extend possible life time of part and components and therefore decrease need for new products
Stimulate possible recycling of part and materials by: 1. using recyclable materials with an existing market 2. use tables on compatibility of metals, plastics and glass and ceramics. 3. avoiding polluting elements that interfere with the recycling process 4. mark any part made from synthetic materials with standardised material codes 5. avoid threaded metal inserts in plastic 6. avoid plated metal 7. avoid or minimise painting and fillers	Decrease need for virgin materials
Stimulate safer incineration by concentrating toxic materials and providing easy removal	Decrease hazardous emissions from incineration process

Video Content / Details of website for further learning (if any):
https://www.gdrc.org/uem/lca/guidelines.html

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 311-313

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LECTURE HANDOUTS

L 30

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **IV**

Date of Lecture :

Topic of Lecture: Design for Manufacturing (DFM)

Introduction : (Maximum 5 sentences)

- Design for Manufacturing (DFM) is the process of designing components for ease of manufacturing h quality products at a lower cost. This is done by lowering complexity, optimizing performance, redefining the product.
- DFM is an important part of any product development cycle. It should be applied early in the process fo most cost and time savings.
- A good DFM involves all stakeholders to make sure every need is taken into account and planned for. T are manufacturers, engineers, suppliers, designers.
- It involves optimizing the design of your product for its manufacturing and assembly process, merging design requirements of the product with its production method.
- **Design for Manufacturing (DFM)** and **design** for assembly (DFA) are the integration product **design** and process planning into one common activity.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Minimise the number of components:
- Thereby reducing assembly and ordering costs, reducing work-in-process, and simplifying automation.
- Design for ease of part-fabrication:
- The geometry of parts is simplified and unnecessary features are avoided.

Detailed content of the Lecture:

- The value of DfM analysis lies in the focus placed on **finding practical solutions to project impedim that could jeopardize successful outcomes**. DfM analysis defines opportunities for reducing c improving manufacturability, and increasing speed to market.

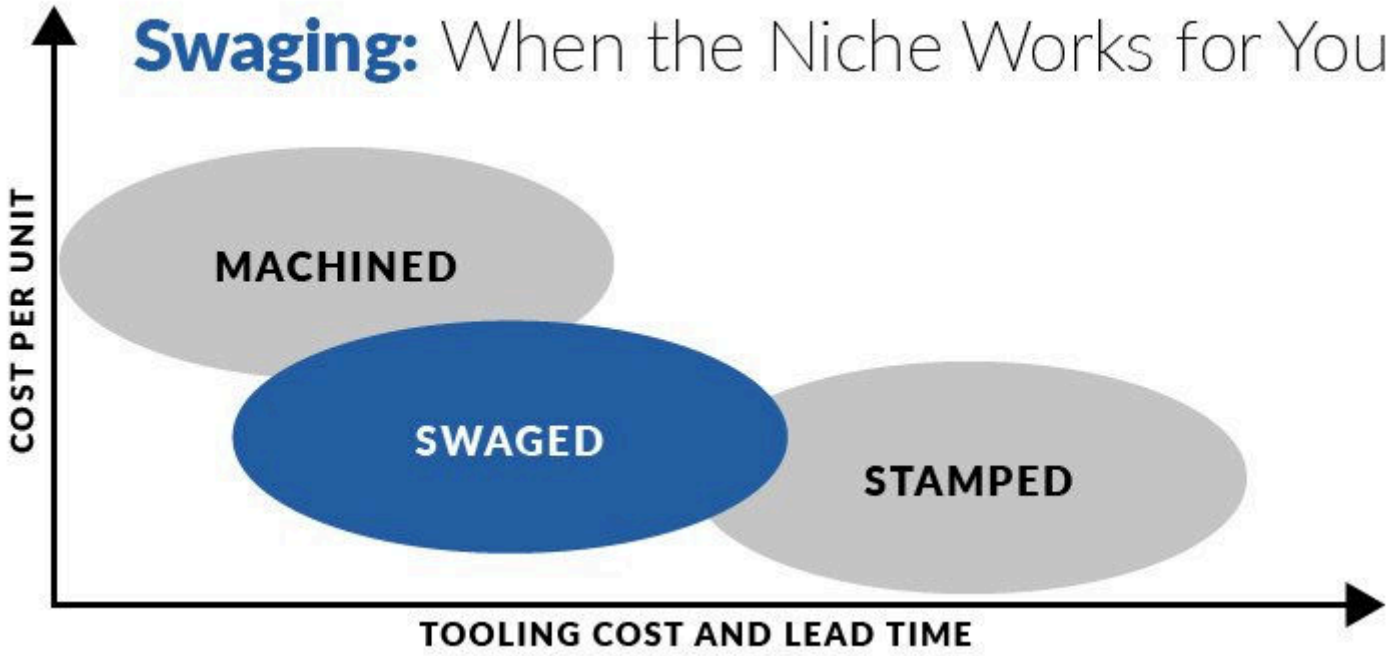
The 5 Principles of DFM

1. PROCESS

Using the right manufacturing process is important. The process should use lower-capitalized methods for cost-effective production. It should be optimized to fit each component. Process should also take tolerances and mate

needed into account.

Swaging is a process that makes DFM quicker and more costs effective.



2. DESIGN

The more complex the design, the higher the risk.

A simple design is usually the best way to go. This is in terms of cost, manufacturing, use, and maintenance. However, all designs should stick to good manufacturing principles. The design must get into more details such a thicknesses, greater specifications for tolerance, texture, and consistency.

3. MATERIALS

Choosing the right materials in the early stages can save you time and money. Your choice of materials has an impact on cost and quality. A few things play a role when choosing materials. A good chat with your contractor c go a long way. Some properties to think about are mechanical properties, flammability, conductance, and therma properties.

4. ENVIRONMENT

Each part of your product must be designed for the environment it will be used. You must take every operating condition into account. All parts of the product must be able to perform in these conditions.

5. TESTING

Finally, testing must be thorough. All products and components must comply with industry standards in each sta These standards can be industry, internal, or company standards. These standards must be considered in all stage DFM.

Lowering Manufacturing Costs with DFM

Over the last decade, supply chains across industries have grown more complex. There is more pressure to lower costs while keeping quality. As such, it is a great time for industries such as Hi-tech and medical devices to use

DFM.

New technology, smart devices, changing consumer needs, and shrinking product life cycles have added to the growing tech world. But these changes come with many problems. Manufacturing companies are finding it harde keep up with the complex supply chain structure. Competitive pricing, and the constant pressure to keep up with industry standards are other problems.

With an inflow of medical devices, manufacturing costs and standards are a growing topic of concern, for examp As the industry grows, medical devices are growing more complex. DFM allows manufacturers to design high-quality medical devices much faster while sticking to safety standards.

How DFM Shortens Product Development Cycles

DFM also leads to operational efficiency and inspires collaboration amongst global suppliers across departments and vendors. As industries across sectors expand and create more complex designs, DFM can be used to achieve launch goals. Companies need methods to simplify processes, reduce costs, increase quality, and get rid of delay

DFM can add value to product designs across industries. Different designs options can be explored, and processe can be optimized to lower costs at higher quality.

Advantages of applying DFMA during product Design

Today products are
– Tending to becoming more complex
– Made/required in increasingly large number
– Intended to satisfy a wide variation in user population
– Required to compete aggressively with similar products
– Required to consistently high quality

Through DFMA it is possible to produce competitively priced, high performance product at a minimal cost.

Reasons for not implementing DFMA

1. No time: Designers are constrained to minimize their "design to manufacture time" for a new product.
2. Not invented here: Very often designers provide enough resistance to adopt new techniques.
3. The ugly baby syndrome: Designer ego crashes if there is some suggestion for design change.
4. Low assembly cost: Since assembly cost of a particular product is less as compared to the total material and manufacturing cost, DFA analysis is not required.
5. Low volume: Often it is expressed that DFMA is applicable for large quantity production.

Video Content / Details of website for further learning (if any):
https://www.beadelectronics.com/blog/the-5-principles-of-design-for-manufacturing-dfm
https://learnmech.com/design-manufacturing-assembly-overviews-steps-advantages/

Important Books/Journals for further learning including the page nos:
A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 220-225

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LECTURE HANDOUTS

L 31

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **IV**

Date of Lecture :

Topic of Lecture: Cost Evaluation

Introduction : (Maximum 5 sentences)

- Design For Cost (DFC) is a design method which analysed and evaluated the product's life cycle cost(include manufacturing cost, sale cost, use cost, maintenance cost, recycle cost, etc.) ,then modified the design to reduce the life cycle cost.
- To generate a comprehensive analysis of cost drivers for a design, design engineers need tools for precisely evaluating a huge range of potential cost drivers.
- Design to Cost has the potential to be so effective because the design engineer can influence 70% of a product's final cost.
- These costs include research and development, prototyping, tooling, and even expedited transport or production lead times

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- This allows for more informed decision making, and allows for changes to be made earlier in the process, while the cost of making changes is minimal.
- Determining the right price for a certain product can help the business to make data-driven decisions in the process.
- Cost accounting is helpful because it can identify where a company is spending its money, how much it earns, and where money is being lost.
- Cost accounting aims to report, analyze, and lead to the improvement of internal cost controls and efficiency.

Detailed content of the Lecture:

A cost estimate that is too low will quickly eat into your profit margins and even wind up with you making a loss per unit.

- The different theoretical approaches to cost estimation
- Why understanding these theories will make your PCE more accurate
- Different factors that affect your costs
- The processes you need to follow that will cost you money
- Things you need to consider when estimating the costs of your product

There are two basic ways to estimate costs, and there have been plenty of models and theories posited

around them.

The Quantitative Approach to PCE

When a cost estimator uses a quantitative approach to their job, they look at:

- The design
- The features that the product will have
- The processes that will go into production

They use this information to analyze variables and resources that will be needed to provide a cost estimate.

A cost estimator will have a database of projects and will look for similar ones in terms of:

- Materials
- Processes
- Design specs

They'll also give you an estimate based on past experience.

This is going to need plenty of research about past projects and also what's already available on the market in terms of:

- Components
- Tools
- Materials
- Skills

Estimating Costs at the Design Stage

The decisions you make really early on in your design and prototyping will affect costs massively. It's at this stage that crucial decisions are being made that will dictate everything else going forward. This is the point where you need to choose priorities such as product quality versus product cost.

Things to take into consideration while estimating the cost of your design are:

- **Design module availability—**This means whether the pieces that you need to realize your design are on the market and how easy they are going to be to procure
- **Manufacturing services—**Are there tools, robots, and factories out there that can make your product?
- **The extent of customization—**You probably don't want to be using all off-the-shelf components for your product, so you need to understand how many things will be custom made for you and how complicated those pieces are
- **Design complexity—**The more moving parts, joints, circuit boards, pieces of software, etc. that you need, the higher your design and prototype costs are going to be

These should be tackled when putting together your preliminary design.

Challenges of Cost Estimation

According to a study out of Aberdeen University, the three biggest challenges when managing costs on a project that is producing a product are:

1. **A lack of overall perspective,** meaning that the big picture is looked at early on so that costs just roll in without having an understanding of where they belong in the process. This is why you need to be assessing your costs at every stage, plugging in your new data into your current

estimates, and moving from qualitative to quantitative estimation as you know more details
2. **Taking too long to understand costs** means that decisions can get held up. For example, if your designer needs to know whether to use aluminum or magnesium alloy to finalize the 3D model but you're having to do a load of calculations in a spreadsheet, things can get held up. Planning ahead and understanding your cost variable early on will make things quicker
3. **Raw material cost fluctuations** aren't really something you can have much of an effect on for some products. However, you can think smart when you're conceptualizing and designing and choose materials that have less volatile market prices

The Costs of New Product Development

1.0 Ideation Process

Ideation is a necessary step before we start on any design. Product development is a very involved process that requires a great deal of planning and experience to do correctly. Without the proper planning in place, projects can end up being many times more costly than initially intended because of design changes and uncertainty.

2.0 Industrial Design

Industrial design is the step in the process that addressed how the product will look and how the user will interact with the product. This is a vital step since it addresses the overall structure of the project and often dictates how well this product will sell on the market. This step utilizes a process called design thinking a problem-solving methodology coined by IDEO.

"Design Thinking is a human-centred approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success."

3.0 Prototyping

Once the shape and functionality of the product has been designed the next step is designing the electronics and the enclosure of the product prototype. This process is done to ensure all the components and pieces can fit together, during this step both the prototype of the Printed Circuit Board (PCB)and the enclosure are created using 3D printing or another rapid prototype technology. The device is then tested with early adopters before moving into the detailed design.

4.0 Electronic Engineering

The electronics for the device are selected and a PCB is designed to integrate all the components together. If the product connects to a mobile app, the firmware has to be created to function wirelessly with the application. Finally the PCB is printed and thoroughly tested to ensure it meets regulatory and quality standards.

5.0 Mechanical Engineering

To design the plastic enclosure as well as the internal electronic mounting, you will have to work with a 3D CAD engineer. The engineer will use the industrial designer's model, however, when they design the part it will be optimized for injection moulding to prevent warping or deform during cooling. The mechanical engineer must also be very diligent in designing for product assembly since if done correctly this can save a lot of money reducing assembly cost and assembly time per unit.

6.0 Certifications & Testing

Before the design can go to mass production it must be tested thoroughly and pass the required product certifications. This step can take up to three months to complete, however; the three months spent can be considered the most important investment during a new product development since it will save cost on RMA's in the future.

Types of product certifications can include:

- FCC certification, for all electrical products sold in the United States, although this certification

is significantly more expensive for wireless products.

- UL certification or CSA certification, for any electrical product sold in the United States and/or Canada that plugs into an electrical outlet.

- CE certification, for most products sold in the European Union. This certification is like the FCC and UL certifications required in the United States.

- RoHS certification ensures that the product is free of lead and is required for products sold in the European Union or California.

7.0 Packaging Design

The retail packaging of a new product is very important since it directly effects if the product will sell. A Graphic designer will design a product packaging then is will be prototyped at a packaging factory. This is a step that is often skipped but ends up costing the entrepreneur or business the success of the product.

8.0 Mold Tooling and Manufacturing Setup

Setting up for mass production will likely be the biggest expenses when producing a new tech product. The major cost will be tooling the injection mold needed for the plastic parts. Once the mold has been tooled and the PCB is set for manufacturing a test run of several products must be done to test for quality control issues. The good news is that once the molds are tooled and the supply chain is set up the unit cost for the products drops to a low unit cost.

9.0 Production Batching & Minimum Order Quantity (MOQ)

A big expense of bringing a new product to market is the cost for the minimum order quantity (MOQ). The minimum order quantity is usually a couple thousand units; however, this is dependent on the factory you have chosen to work with. Unfortunately, the MOQ does not reveal the whole truth, we have found that to maintain a high priority and quality products from a factory it is advisable to strive for higher volume orders.

10.0 Shipping and Import Costs

The importing costs of a product order largely depend on the size and weight of the products being shipped. The most economical method of shipping products from China is via cargo ship. This cost is variable depending on the size of the product you plan for transport, so I would strongly recommend that you do some research before starting your project.

Video Content / Details of website for further learning (if any):

1. https://www.machinedesign.com/learning-resources/basics-of-design/article/21832482/a-simple-cost-evaluator-for-product-design

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 221-222

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LECTURE HANDOUTS

L 32

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **IV**

Date of Lecture :

Topic of Lecture: Category of cost

Introduction : (Maximum 5 sentences)

- Product costs are costs that are incurred to create a product that is intended for sale to customers.
- Product costs include direct material (DM), direct labor (DL), and manufacturing overhead (MOH).
- The three general categories of costs included in manufacturing processes are direct materials, direct labor, and overhead

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- So, knowing product cost is crucial to their success because **they have to manage their costs to be profitable**.
- So many sales decisions have to be made based on COST.
- Occasionally you are faced with a sales opportunity for which only incremental costs and revenues for that one transaction are relevant

Detailed content of the Lecture:

Understanding the Costs in Product Costs

Product costs are the costs directly incurred from the manufacturing process. The three basic categories of product costs are detailed below:

1. Direct material

Direct material costs are the costs of raw materials or parts that go directly into producing products. For example, if Company A is a toy manufacturer, an example of a direct material cost would be the plastic used to make the toys.

2. Direct labor

Direct labor costs are the wages, benefits, and insurance that are paid to employees who are directly

involved in manufacturing and producing the goods – for example, workers on the assembly line or those who use the machinery to make the products.

3. Manufacturing overhead

Manufacturing overhead costs include direct factory-related costs that are incurred when producing a product, such as the cost of machinery and the cost to operate the machinery. Manufacturing overhead costs also include some indirect costs, such as the following:

- **Indirect materials:** Indirect materials are materials that are used in the production process but that are not directly traceable to the product. For example, glue, oil, tape, cleaning supplies, etc. are classified as indirect materials.
- **Indirect labor:** Indirect labor is the labor of those who are not directly involved in the production of the products. An example would be security guards, supervisors, and quality assurance workers in the factory. Their wages and benefits would be classified as indirect labor costs.

Example of Product Costs

Company A is a manufacturer of tables. Its product costs may include:

- **Direct material:** The cost of wood used to create the tables.
- **Direct labor:** The cost of wages and benefits for the carpenters to create the tables.
- **Manufacturing overhead (indirect material):** The cost of nails used to hold the tables together.
- **Manufacturing overhead (indirect labor):** The cost of wages and benefits for the security guards to overlook the manufacturing facility
- **Manufacturing overhead (other):** The cost of factory utilities.

Company A produced 1,000 tables. To produce 1,000 tables, the company incurred costs of:

- $12,000 on wood
- $2,000 on wages for carpenters and $500 on wages for security guards to overlook the manufacturing facility
- $100 for a bag of nails to hold the tables together
- $500 for factory rent and utilities

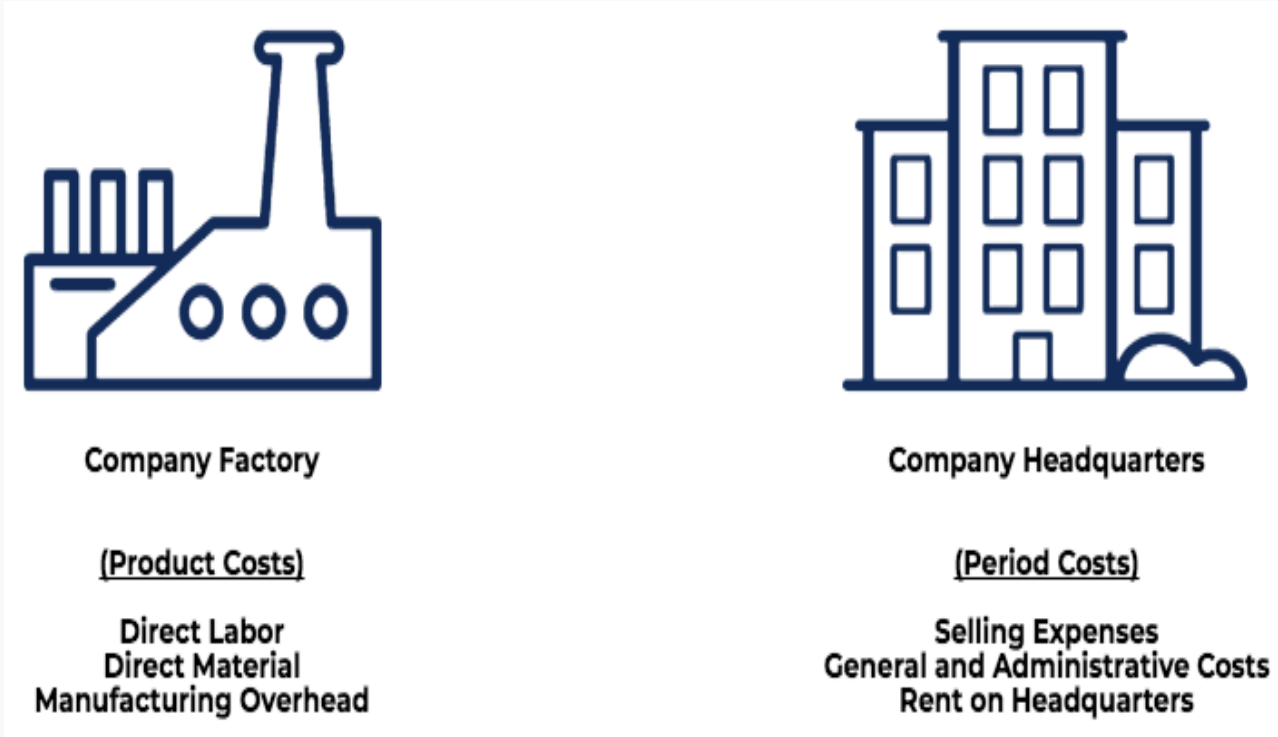
Total product costs: $12,000 (direct material) + $2,000 (direct labor) + $100 (indirect material) + $500 (indirect labor) + $500 (other costs) = $15,100. As this is the cost to produce 1,000 tables, the company has a per unit cost of $15.10 ($15,100 / 1,000 = $15.10).

Period Costs

Product costs are costs necessary to manufacture a product, while period costs are non-manufacturing costs that are expensed within an accounting period.

	Product Costs	Period Costs
Definition	Costs incurred to manufacture a product	Costs that are not incurred to manufacture a product and, therefore, cannot be assigned to the product
Comprises of:	Manufacturing and production costs	Non-manufacturing costs
Examples	Raw material, wages on labor, production overheads, rent on the factory, etc.	Marketing costs, sales costs, audit fees, rent on the office building, etc.

Consider the diagram below:



Costs on Financial Statements

Product costs are treated as inventory (an asset) on the balance sheet and do not appear on the income statement as costs of goods sold until the product is sold.

For example, a company manufactures 50 units of widgets at a unit product cost of $5. On the balance sheet, there would be a $5 x 50 = $250 increase in inventory. If the company sells 20 units of widgets, $5 x 20 = $100 in inventory would be transferred to the cost of goods sold on the income statement while the remaining $150 would remain in inventory on the balance sheet.

Video Content / Details of website for further learning (if any):
https://opentextbc.ca/principlesofaccountingv2openstax/chapter/describe-and-identify-the-three-major-components-of-product-costs-under-job-order-costing/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 217-220

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LECTURE HANDOUTS

L 33

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **IV**

Date of Lecture :

Topic of Lecture: Overhead cost

Introduction : (Maximum 5 sentences)

- Overhead costs, often referred to as overhead or operating expenses, refer to those expenses associated with running a business that can't be linked to creating or producing a product or service.
- They are the expenses the business incurs to stay in business, regardless of its success level.
- Overhead costs are all of the costs on the company's income statement except for those that are directly related to manufacturing or selling a product, or providing a service.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Overhead costs are a major component in determining a company's net income,
- They directly impact profitability, as detailed on their balance sheets
- A company can determine whether to allocate expenses to different projects or services.

Detailed content of the Lecture:

- Overhead is generally allocated (or applied) **to cost items based on a standard methodology that is used consistently from one period to the next**.
- Direct overhead can be defined as **costs that are incurred during the production process, regardless of the output that the company produces**. In other words, this is the cost that the company has to pay, regardless of the level of output they operate.
- Overhead costs do not include operating expenses generated to create a product or service, such as raw materials or labor costs, classified as cost of goods sold (COGS) and cost of services (COS), respectively.

Types of Overhead Costs

There are three types of overhead costs in business:

1. **Fixed overhead costs**: Fixed overhead costs are expenses that do not change in a given period (usually month-to-month), regardless of a business's activity level. Examples of fixed overhead costs include full-time employee salaries, rent for office space, business insurance, property taxes, interest on mortgage payments, depreciation of assets, and government licenses. The company typically reports these expenses on its income statement.
2. **Semi-variable overhead costs**: Semi-variable overhead costs involve an expense that has a

fixed element, such as a baseline cost, and a variable aspect that changes based on business activity levels. Semi-variable costs may include everything from commissions and bonuses to janitorial services.

3. **Variable overhead costs**: As their name suggests, variable costs are overhead expenses that fluctuate according to business activity levels. Variable overhead costs include certain utilities, consulting and legal expenses, office equipment and associated repairs, administrative costs, office supplies, and hiring seasonal or temporary support staff.

Overhead cost examples

Now that we've covered the overhead cost definition, here are some more extensive examples to illustrate each type.

Fixed overhead cost examples:

- Rent and mortgage payments
- Property taxes
- Business insurance
- Monthly cleaning services
- Web hosting
- Monthly phone plan
- Fixed interest payments

Variable overhead cost examples:

- Electricity
- Gas
- Water
- Vehicle maintenance
- Seasonal wages
- Building maintenance and repair
- Special events

Semi-variable overhead cost examples:

- Employee bonuses
- Bookkeeping services
- Some utility bills
- Cleaning bills for services on top of regular maintenance
- Audit fees

Your business may incur all of these costs or just a few, dependent on the type of services you provide and whether you have a brick-and-mortar location. Online or service-oriented businesses will generally have lower overhead costs.

How to calculate overhead

For accounting purposes, it's helpful to group all of these assorted costs into categories. This helps keep costs organised on your financial statements. For example, all manufacturing costs could be grouped together, as could all administrative or research and development costs.

Tracking overhead is also important for keeping on top of business finances. Here's how to calculate

overhead:

Step 1: Track all of your overhead costs for the accounting period in question.

Step 2: Add all overhead expenses together.

Step 3: Calculate overhead rate by dividing the overhead costs by the sales during the same period.

Overhead Rate = Overhead Costs / Sales

For example, if your business had $10,000 in overhead costs this month and generated $50,000 in sales, your overhead rate would be 20% according to the formula:

$10,000 / $50,000 = .20

In other words, you spend 20 cents on overhead for every dollar earned.

Learning how to track, record, and calculate overhead costs holds numerous benefits for any business. You'll be able to get a clearer sense of your profits and look for ways to tighten up overhead for greater efficiency. It's worth looking for new ways to reduce overhead expenses, because this can increase your business's net profit.

Video Content / Details of website for further learning (if any):
https://gocardless.com/en-au/guides/posts/what-are-different-types-of-overhead/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 217-220

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LECTURE HANDOUTS

L 34

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **IV**

Date of Lecture :

Topic of Lecture: Design for Quality

Introduction : (Maximum 5 sentences)

- Design for Quality (DFQ) is a set of principles that encompass a multi-faceted approach to product design that ensures a product will delight the customer, last long and work reliably in service.
- According to Joseph Juran, the term quality of a part (or product or component) should refer to the product features that meet customers' needs and satisfaction, and to avoidance from deficiencies that would minimize the chance of failure of the part

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Good design helps a potential customer understand who your company is, what you do, and why they should choose your product or service.
- It also makes your product or service easily accessible, so that it's easy to convert a potential customer into a repeat client.

Detailed content of the Lecture:

The Design for Quality Process

Design for Quality must have a set of objectives that are measurable or quantifiable such as dimensions on components, fit, form & function of sub-assemblies and critical to quality (CTQ) parameters. The DFQ process utilizes other design tools that are used to guide the product design stage such as Design for Manufacturing (DFM), Critical to Quality (CTQ), Design to Cost (DTC), and Failure Modes and Effects Analysis (FMEA).
Its objectives are split into two, assembly and performance, under which all the other objects are organized.

Some of the basic principles behind DFQ are:

- Understand past issues and learn for mistakes
- Identify issues as early as possible and ensure they are 'designed out' of the product
- Use error-proof design techniques
- Simplify the design, one piece is better than two
- Have robust tolerance understanding for each part
- Standardize parts where possible
- Use the design tools, some of which are mentioned above

- Have a multi-functional team driving the process

The success of a product is determined by its quality, not how much it costs!

Types of Design Quality

D.A. Garvin's classic paper, "What Does Product Quality Really Mean?" lists "eight dimensions of quality." These form a good starting point for a list of desirable attributes for a product design. Garvin's list includes the following:

- **Performance:** How well the product functions
- **Features:** How many secondary characteristics the product has to enhance its basic function
- **Reliability:** Defined by some as quality in the time dimension; how well the product maintains its quality
- **Conformance:** How well the product conforms to the specifications or standards set for it
- **Durability:** How long the product lasts in use
- **Serviceability:** How easy the product is to maintain
- **Aesthetics:** How attractive the product is
- **Perceived quality:** How high the users believe the quality of the product is, that is, quality reputation of the product

To these desirable attributes, manufacturability, how easy and economical the product is to make, should certainly be added. Other desirable characteristics, not mentioned by Garvin, are safety, environmental friendliness, user friendliness or ergonomics, short time to market, and upgradability.

If customers are satisfied with the product after, for example, a year of ownership and at least moderate use and would recommend it to other potential buyers, then perhaps it can be said that the product is of high quality. Other measures, such as whether it conformed to some specifications, whether it had an acceptable reject rate, whether it was made under ISO 9000 conditions, or whether the company producing it got the Malcolm Baldrige award are less meaningful, in the author's opinion, than the customer's evaluation. Customer satisfaction is the prime measure of product quality.

Importance of Design for Quality

Design is more responsible for the quality than anything else. The designers determine the number of component in a specific part/product, decide which are to be procured externally, design the rest of the components and specify indirectly how they can be manufactured, determine how the parts must be assembled, and specify the overall function of the components in the final assembled part. In other words, the designers largely influence the entire procurement, manufacturing and assembly cycles of any small part or large component. Although manufacturing processes are often linked to the final quality of a part, both design and manufacturing are responsible for the final quality inherited by a part or component. If the quality is envisaged appropriately in the design procedure, the quality in manufacturing can also be ensured at lesser expenses and the cost of inspection reduces significantly.

Benefits of Design for Quality (DFQ)

(1) The DFQ process allows the engineer to identify, plan for and manage factors that impact the robustness and reliability of the products in the design process.
(2) DFQ reduces or eliminates the cost of quality that can be envisaged as the cost incurred in the inspection and rework, in the procurement of replacement materials. Appropriate DFQ procedure can also avoid defects and errors, scrap, degradation of factory/machine capacity, re-qualifications/re-certifications expenses, and overhead demands
(3) Improved and consistent quality of parts provide better appeal to the customers that obviously lead to greater stability of the manufacturing shops and can create greater amount of opportunities.

Video Content / Details of website for further learning (if any): https://learnmech.com/design-quality-concept-benefits-design-quality-dfq/
Important Books/Journals for further learning including the page nos: 1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 217-220

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LECTURE HANDOUTS

L35

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **IV**

Date of Lecture :

Topic of Lecture: Reliability in Product Design

Introduction : (Maximum 5 sentences)

- The reliability of a product (system) is the probability that the product (system) will perform its intended function for a specified time period when operating under normal (or stated) environmental conditions
- DfR is a process that ensures a product, or system, performs a specified function within a given environment over the expected lifetime.
- Design for Reliability, DfR, is about making good decisions across the organization concerning reliability.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

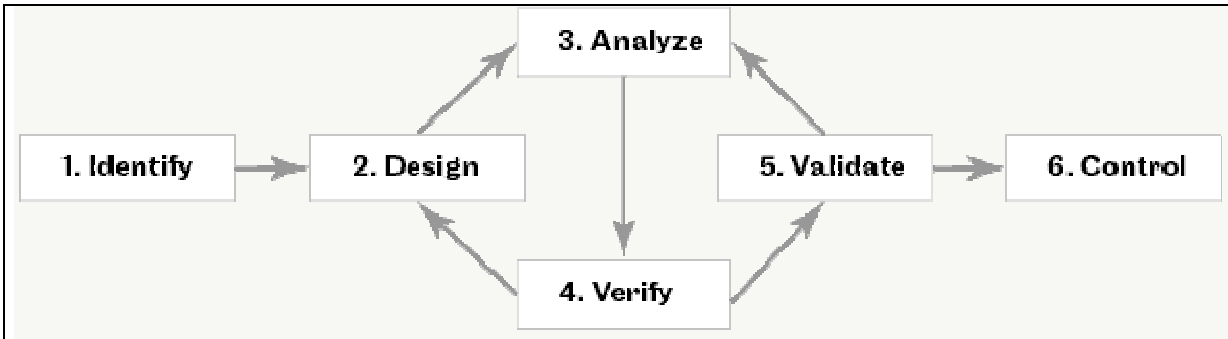
- It determines the value of a psychological test or study.
- It gives value to the field of psychology and other areas in which it has relevance, such as education or business.
- To ensure that data are sound and replicable, and the results are accurate.

Detailed content of the Lecture:

- Reliability is extremely design-sensitive. Very slight changes to the design of a component can cause profound changes in reliability, which is why it is important to specify product reliability and maintainability targets before any design work is undertaken.
- This in turn requires early knowledge of the anticipated service life of the product, and the degree to which parts of the product are to be made replaceable.
- A more reliable product spends less of its time being maintained, so there is often a design trade-off between reliability and maintainability

The Design for Reliability process

Figure 7.2 Design for reliability (DfR) activities flow, from Practical Reliability Engineering, outlines the basic stages or elements of a product generation process.



The six stages span a typical product lifecycle from concept till retirement.

1. Identify – Goals, Requirements, Specifications, Expectations

The decision during the early stages of product development set the framework of goals, objectives, requirements, and specifications.

These documents guide the decision making for the remainder of the process.

Understanding and documenting the customer expectations for reliability performance includes:

- Functional and performance requirements
- Environmental and use profile descriptions
- Duration and Probability of Success expectations

Tools include:

- Benchmarking
- Environment and use studies
- Quality Function Deployment (QFD)
- Risk Assessment Studies
- System Reliability Modeling (RBD, FTA, STA, Petri Nets, Markov, etc.)

2. Design – Creating a Draft Solution

The decisions during the design and development stages involve:

- Material selection
- Component selection
- Industrial design
- Human factors design (user interface and interactions)
- Electrical and Mechanical drawings
- Software/Firmware development

The decision bound the potential future reliability performance.

The DfR tools during this stage focus on enabling each member of the team to make decisions which fully consider the impact of future reliability performance.

Tools include:

- Finite Element Analysis (FEA)
- Computational Fluid Dynamics (CFD) modeling
- Mechanical and Electrical performance modeling
- FMEA, FMECA, FTA, Hazard Analysis
- Stress-Strength Analysis, Derating Analysis

- Tolerance Analysis
- Hazard and Operability Studies (HAZOPS)
- Reviews of part, material and process selections
- Non-material failure modes, common cause failures
- Critical to Reliability/Quality list
- Overstress Protection
- Degradation Protection
- Design Reviews
- Design Review Based on Failure Modes (DRBFM)

3. Analyze – Examine the Solution

During the design process, there may be outstanding questions to address.

Such as an uncertainty concerning the degradation of a coating over time, or the capability of the desired component vendor to meet tolerance requirements.

Many of the tools employed during the design phase also provide a means to refine understanding concerning reliability. FEA, for example, is an essential tool for physics of failure modeling and use.

If material samples, coupons, rough subsystem prototypes are available, initial evaluation, experimentation, characterization may begin.

The focus is to explore, discover, and reveal the design weaknesses in order to allow design changes to improve the product robustness.

Another part of this step is to check and refine the understanding of the customer environment and use conditions.

As the design takes shape the team is likely to discover potential failure mechanisms that require additional environmental and use condition information.

Often new products are an evolution of previous products. The use of past field and warranty data provides insights on how the range of selection elements of a design individually and interactively respond to customer use conditions.

An output of the analysis is a refinement of the areas of focus during the verify step. Areas of high risk or uncertainty may receive additional scrutiny.

Focused or refined measurements provide clearer information for decision making.

4. Verify – Checking the Solution Against the Specifications

This step starts the examination of the question: Is the design meeting the specifications?

If all is well executed to this stage the design and analyze steps created and refined a product that meets the set of specifications created during the first step of the process.

Products are complex. The verify step often finds additional elements of the design requiring improvement.

The information provided includes new failure mechanisms (HALT and margin testing), refined estimates of durability (ALT), and patterns of performance deflation (degradation analysis). The information allows the team to determine if the design meets the internal specifications and likely will

meet customer expectations.

A couple additional tools are:

- FRACAS
- Sample Size Calculations (statistics)
- Waterfall test sequencing
- Document/Configuration Control
- Measurement System Analysis

5. Validate – Checking the Solution with the Customer

The decision during this step requires customers.

Does the product meet customer expectations? This is one way to view validation, another is a detailed refinement of the verification process.

Either way, the intent at this point is to make sure the design and process to create the product based on the design results in products that perform as the customer expects.

The same basic set of tools used during verify may take part in the validate step, yet may focus on customer specified evaluations or production variation concerns. HALT, HASS, ALT, FRACAS, etc all may play a role.

Some customers may require or expect a reliability growth or demonstration testing as part of the validation step.

6. Control – Monitoring and Improving

The decisions during this step focus on supplier and production stability and capability.

Plus, the information coming back from customer provides a means to identify potential design or process improvement projects.

The work in this step begins as the team establishes the supply and production processes. It takes shape beginning during the design step and becomes refined as data and information become available.

Tools such as SPC, control charts, and process capability studies focus on monitoring variation and adjusting or improving to reduce or maintain an acceptable amount of variation.

Tools may include:

- Process FMEA
- HASS
- ORT
- Testability analysis
- Maintainability analysis
- Failure analysis of field returns or production failures
- Customer surveys
- Call center data analysis

Video Content / Details of website for further learning (if any):
https://accendoreliability.com/introduction-design-for-reliability/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 224-226

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LECTURE HANDOUTS

L 36

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **IV**

Date of Lecture :

Topic of Lecture: Warranty in Product Design

Introduction : (Maximum 5 sentences)

- Warranty can be considered as a legal contract which requires the manufacturer to either rectify or compensate for all failures occurring within the warranty period.
- Warranty of any type, since it involves an additional service associated with a product, will lead to potential costs.
- A warranty is a guarantee from a seller that a defective product will be repaired or replaced within a specific time. A guarantee is a seller's promise that a product will meet certain quality or performance standards. If not, it will be repaired or replaced.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- It is an assurance or promise about the quality of goods or services you buy.
- Its purpose is to give you recourse if something you purchase fails to live up to what you were promised.

Detailed content of the Lecture:

Defining Warranty

In commercial and consumer transactions, a warranty is an obligation or guarantee that an article or service sold is as factually stated or legally implied by the seller. A warranty often provides for a specific remedy, such as repair or replacement, in the event the article or service fails to meet the warranty. A product's warranty period can be established based on several factors, including:

The industry standard for the product

What the competition is offering

The period of time during which some percentage of the products will still be functioning correctly.

A warranty is a guarantee provided by the manufacturer of a product. It assures you the things you buy are of good quality and don't contain manufacturing defects. Warranties give consumers the right to ask the manufacturer to deal with any issues according to their terms and conditions. The federal government requires companies to make a warranty easily accessible to prospective buyers and the product brochure must contain complete details of its warranty terms.

Conditional Service

Warranties must clearly state the manufacturer’s conditions. When you shop, compare warranties along with prices and product features. For example, you’ll want to find out whether to contact the company or the retailer for repairs if the product doesn’t perform as it should. You’ll need to know if the company replaces or repairs a defective item, or if you can return it and get your money back. Check out the length of time and the conditions under which the company has to assist you. Find out if you must ship the product back to the company or if you can get services at a local repair shop. Some warranties don’t guarantee the entire product, so determine which parts are covered and which aren't.

2 *Legal Implications*

There are two kinds of implied warranties. The warranty of merchantability states that your product is in working condition, while the warranty of fitness for a particular purpose assures that the product does its intended job. For example, if you bought a sleeping bag and the company claims that it keeps you warm in below-zero temperatures, the bag must be appropriate for those conditions. State laws setting implied warranties vary, so check the duration of the implied warranty your state requires. Examine the product label for the phrase “as is," which indicates the implied warranty doesn’t apply. Some states, such as Kansas, Maine and Maryland, don’t permit this clause.

3 *Extended Protection*

Vendors sometimes offer extended product warranties, service contracts that you pay for aside from the product's cost. In these contracts, the maker typically offers repairs in case your product breaks down. Before you buy this kind of contract, check to see whether it duplicates repairs already covered by the express warranty. Look for the validity period of the contract, usually a set number of years, and the possible cost for repairs. Make sure the company you’re dealing with is reputable. If the vendor makes an oral commitment about services, get it in writing before you proceed.

4 *Taking Action*

If you’re making installment payments on the product when it goes bad and the company refuses to act, you can stop making payments. However, you can do that only if you gave the company a chance to deal with the issue and if you haven’t misused the product. You can also refer the issue to a consumer protection authority or to the Better Business Bureau. You can sue the manufacturer in small-claims court if the disputed amount is below a specified level. or file a lawsuit through an attorney. Check your state laws for the number of years within which you can sue for damages.

OBJECTIVES

Design for Warranty models and methodologies support the development team during the design phase to:

1. Identify the most likely warranty events (failures) for a new product. Using the warranty cost model, projected warranty costs are calculated for each identified warranty event.

2. Identify design alternatives for each warranty event that minimizes the total warranty cost. These design alternatives include component AFR reductions and utilization of less expensive support processes. Dependencies (such as new diagnostic tools and new support process capabilities), feasibility and risk factors are identified.

3. Choice of design from alternatives based on development, manufacturing and warranty costs, as well as risks and feasibility. This information can be used by the Warranty Predictions Service. The estimated warranty cost of the final design is compared to business goals.

VALUE TO YOUR ORGANIZATION

There are two main benefits from Design for Warranty. First, the product is designed from the beginning to minimize warranty and service costs. Secondly, the diagnostic tools and service process capabilities needed to achieve the estimated cost reductions are identified early enough so that they can be realized prior to product launch.

RELIABILITY INTEGRATION

An example of Reliability Integration during the Design for Warranty is as follows:

Reliability Models & Predictions and Failure Modes and Effects Analysis (FMEA) Service deliverables can be important inputs for developing the warranty event cost model.

In combination, these three services enable product teams to make fact based design trade-off decisions very early in the development process.

Warranty expenses are the business tangible of un-reliability. Investments to improve reliability performance result in lower warranty expenses. Design for Warranty and Reliability Predictions provide the basis for warranty predictions.

Warranty Performance Analysis Service often:

1. Identifies the primary support processes (and their costs) used by a company.

2. Develops current product warranty cost Pareto charts to use as an internal benchmark for new products being developed.

3. (optionally) Develops the company's overall warranty strategies and tactics that are used by Design for Warranty when making your design alternatives and choices.

METHODOLOGY

A key to Design for Warranty's methodology is the warranty cost model. This model constructs the cost of warranty events from the support process costs used by your company to resolve the event and from the event's frequency of occurrence. The identification of commonly used support processes and their standard costs can either be estimated with the help from your support and finance teams, or may come from the results of the Warranty Performance Analysis Service.

CASE STUDIES/OPTIONS

The following case studies and options provide example approaches. We shall tailor our approach to meet your specific situation.

1. **Designing a product for less costly support processes**

A large commercial electronic products company was making excellent progress on reducing their product's failure rates as measured by Annual Failure Rate (AFR). The problem was their warranty costs were only decreasing by 1/2 of what they expected. Using the principles of Design for Warranty, they identified the top 10 contributors to their warranty budget and determined that meeting the product's warranty goals would require a shift to less expensive support processes for a number of the 'top 10' event types. They identified design alternatives that relied on both realistic AFR reductions and the use of new call center supported diagnostics with a new customer self-repair support processes. R&D developed the diagnostic tools as part of their development Plan of Record and support the deployment of the new support processes and procedures prior to product launch.

2. **Warranty Performance Analysis**

Some teams may choose to first perform a Warranty Performance Analysis on a current product that is similar in function and design and shares a similar target market. This gives them a warranty cost 'benchmark' to use in the concept phase of the product development process and for competitive benchmarking.

Video Content / Details of website for further learning (if any):
https://classroom.synonym.com/how-to-return-a-battery-at-costco-12084083.html

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 221-222

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LECTURE HANDOUTS

L 37

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **V**

Date of Lecture :

Topic of Lecture: Prototype Basics

Introduction : (Maximum 5 sentences)

- A prototype is a physical manifestation of your idea or concept.
- It will be functional product made of different mediums that serve either for education or informative the function of your idea, and most importantly, the viability of your product.
- Prototypes are made by creating wireframes for each screen as determined by individual user flows, d technical requirements, and an understanding of today's design standards.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Prototypes are especially important for inventors because they allow the creator to remember that ar your mind .
- The most fundamental reason for prototyping your idea is to simple prove that your idea works.
- Make your design needs to translate to a working product.
- Make your design needs to be realistic with what you plan your product idea on doing and your pro should prove that.

Detailed content of the Lecture:

Prototype design is critical to getting closer to the real functionality of your product. Sketches, wire frames blueprints and mock ups are great, but the prototype is what's going to bring your product to life. You, you investors, and your future customers will want to touch, feel, smell, and use the product for a true experien

Advice from a prototype design expert

Todd Zaki Warfel wrote a book on prototyping which outlines some of the benefits of it. These universal b are summed up as the following:

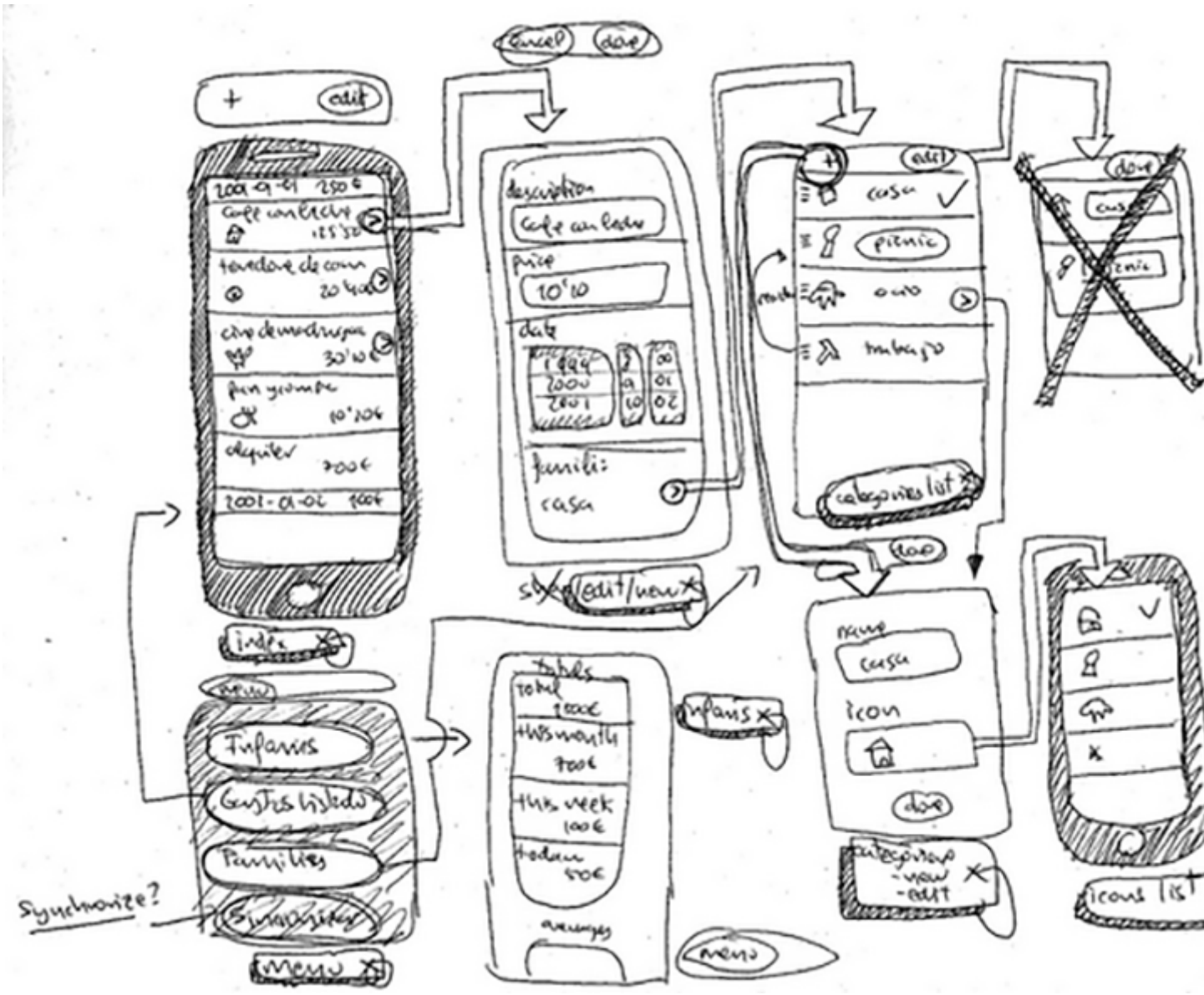
- Assists with communication and collaboration
- Helps gauge feasibility, while reducing waste
- Help you sell your idea
- Tests usability earlier
- Sets your design priorities

These points are expanded on in Todd's book but also here.

Prototype design is a practice that is strongly advised in product development. Although restrictions may co play making prototyping not as attainable for some, it's important to find a way to make it work in order to benefits of setting your product up for success.

The Different Kinds of Prototypes

To the non-designer or engineer, the hardest part about understanding prototypes is learning all the differen of prototypes and what they are all specifically used for. As previously mentioned, when designing a produ redesigning and development of a product idea is inevitably bound to happen and is almost quintessential to product design process, and in so, as the inventor you'll encounter not just one prototype that is being cons redeveloped, but more than one prototype used for different purposes in the process of creating the perfect for your product idea. The different types of prototypes are as follows:

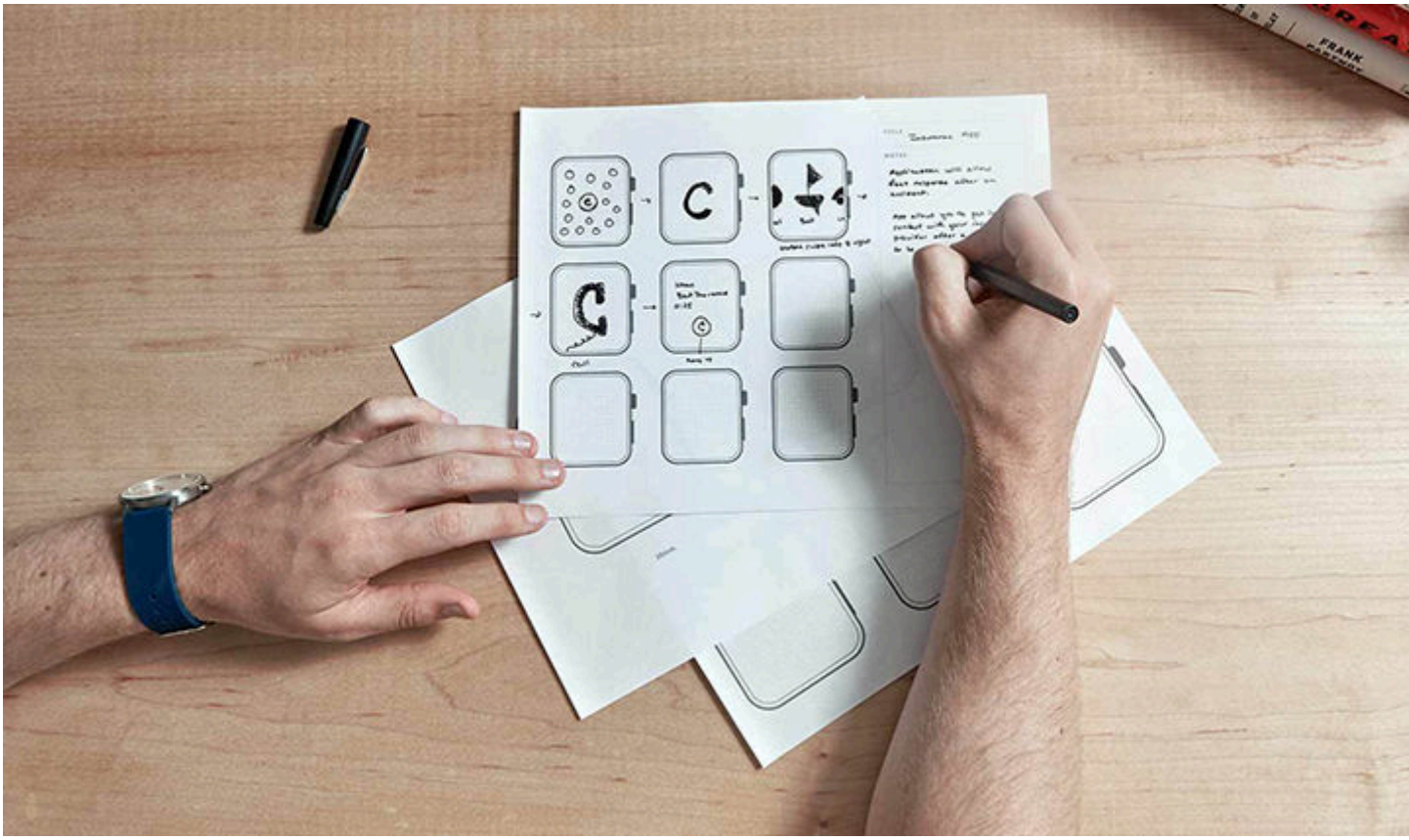


Wireframe Prototype

Usually the first step of every product design, once the idea and concept of the product is laid out on the tab all parties to understand, the industrial designer or engineer will immediately behind drawing out a couple sketches as to how both they, as well as the inventor, imagine would be the best way to design the product desired function. This initial sketch is known as a wireframe is mainly simple illustrations or schematics th out the design of the idea, the layout, architecture or the sequence of the product. This first prototype is the step in visualizing your product idea and imagining where it could change and improve as further correctio made to accommodate everything that should be included within the design.

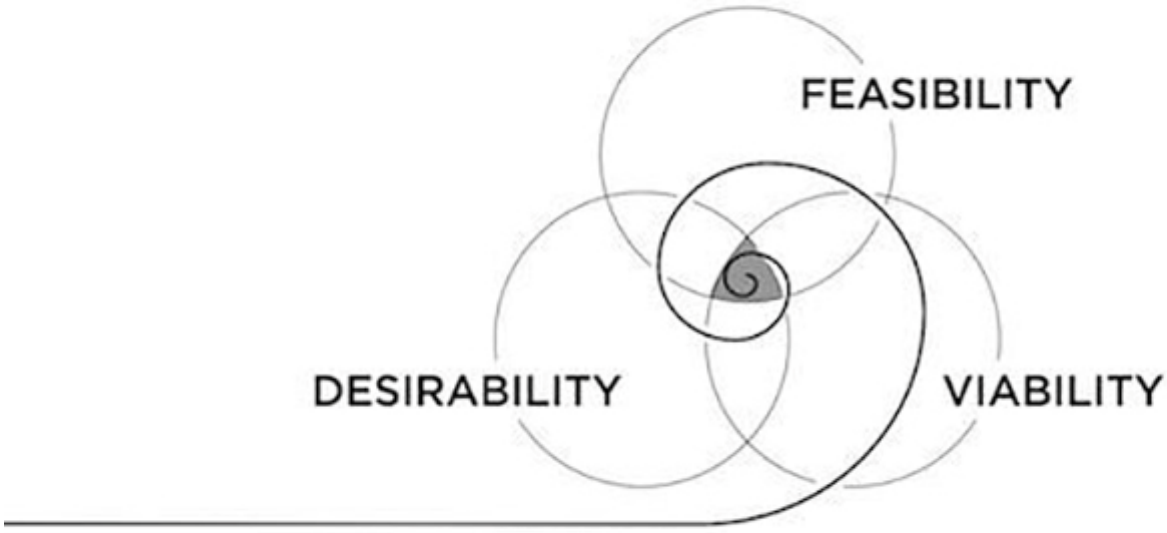
Presentation/Mock – Up Prototype

A presentation or mockup prototype, although not as exciting as the actual concept prototype, is simply a p
demonstrating how the eventual product is going to look. The focus of presentation and mock-up prototype
mainly present to the inventor or client the general outlook of how the envisioned design should turn out or
developed, for this reason, presentation and mock up prototypes almost always have no actual functionality
simply serve as just a vision for the design of the product. A benefit of this type of the prototype allows bot
client and designer to understand which parts go where and how the product will be held or felt in the hand
consumer.



Concept Prototype

The most common of prototypes is the concept prototype. This prototype is the prototype in which both the
designer and inventor get to see how the products functionality works. Not only is the design of the product
into consideration, but the inventor gets to see how their idea works when tested out. This is the most cruci
important part of the prototype process as it provides not only the demonstration of how the product will w
also the viability of the product. This prototype will not only allow the inventor and designer test out the pr
multiple times to see if its design allows the product to do what it was envisioned to do, but also see where
product can be improved, if it has any faults and it *effectively* works. This type of prototype is best for show
both the viability, and communication of the product. You'll most likely encounter this type of prototype in
early stages of the development of the product, and therefore wont always represent the full functionality o
item.



Feasibility Prototype

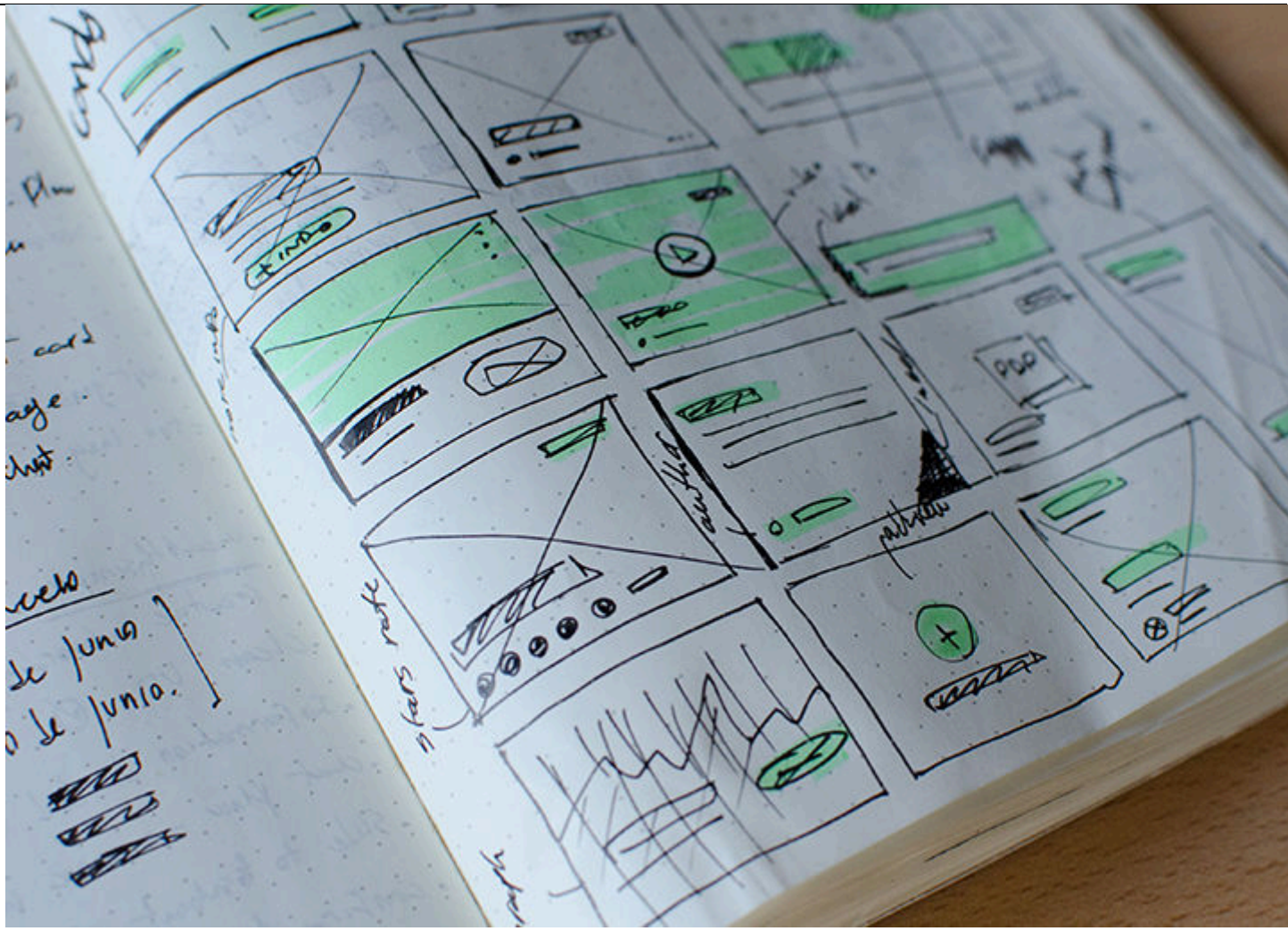
The Feasibility Prototype is simply a prototype developed and presented in order to determine the feasibilit product. This includes figuring out the various solutions to any potential problems that could occur when so uses the product or when testing out the product target functions. In addition, the feasibility prototype is us quickly recognize and fix any technical risks attached to the development of the product. This is especially important to the designer or engineer as they must recognize which parts need to be tweaked or taken back rebuilt. The feasibility prototype is perfect for testing out the performance of the product as well as its com with the components it is geared to be built with.

Horizontal Prototype

Used in the early stages of product design analysis, a horizontal prototype is not presented in physical form rather is a user interface that is presented in the form of screenshots. The goal of the horizontal prototype Is demonstrate what the outer layer of the human interface will look like. This is a good prototype to have bec allows the inventor and designer to clearly view and clarify the scope and requirements of the product. Hor prototypes are helpful in the sense that they allow for full understanding for the range of abilities for the pr and is useful for presenting ideas to investors, going over the products direct requirements and allows for redesigning.

Vertical Prototype

As the name infers, the vertical prototype, in contrast to the horizontal prototype, is sed in the later steps of and design. Vertical prototypes focus on the more technical aspects of the product and give great depth and into diving deeper into the product design to investigate where the product can improve or needs improvem specific features or functions. Vertical prototypes are also handy for looking at aspects such as data, sub-sy and the functioning of key features. A vertical prototype is great for looking into complex designs and prov even though the design looks complicated, its technical aspects can still function.



Conclusion

As product ideas and inventions come and go, an inventor needs to invest their time and creative process in thoroughly understanding both the idea of their product, the design, and most importantly – its initial functi Investing time into creating multiple prototypes are always a secure method in testing out all elements that be considered when creating a new product or when considering the possibility of product development on product that already exists. Prototypes not only benefit the inventor by having a hand on and detailed view their idea or invention will work once in physical form, but having accessibility to the different types of pro will showcase all technical aspects, material, date and possible faults that could have been missed if you we only have an initial concept sketch of the invention.

If you have a great new invention and you'd like to learn more about this process, get in touch with MAKO and visit our website to find out more. Feel free to give us a call at 1-888-MAKO and we can set you up on with our product analyst!

Video Content / Details of website for further learning (if any):
https://www.makodesign.com/blog/2019/06/13/prototypes-importance-in-product-design/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 253-255

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LECTURE HANDOUTS

L 38

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **V**

Date of Lecture :

Topic of Lecture: Principles of prototyping

Introduction : (Maximum 5 sentences)

- A prototype is an early representation of a design used to get feedback and rapidly experiment with ideas. Depending on your product timeline, you create prototypes through a mix of sketches, wirefra mockups, where you are in the design journey, and how robust it needs to be.
- The main goal of prototyping is to create an early version of a product/feature that allows us to get feedba that informs later versions of the product.
- Specifically, if we get valuable feedback and new insight, the quickest way to verify that we have correct understood that feedback is another prototype.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- It will create a shared understanding of expectations.
- We can know our team's principles in the comments.

Detailed content of the Lecture:

Principles of Effective Prototyping

Although each project will have its own prototyping goal and a choice of fidelity that supports your strategy, the following seven principles of effective prototyping should always be kept in mind:

1. Deliver outcomes
2. Fight for Users
3. Own the product
4. Designers as facilitators
5. Spend time wisely
6. Be a Collaborator, Not a Hero
7. Balance Usability & Beauty
8. Play the Baby Genius
9. Create with Intent
10. Teach a Client to Fish

Deliver Outcomes

Start every engagement by understanding what the business needs to be successful. Success shouldn't be subject
Instead, create a plan to measure progress towards achieving specific goals. If the client wants to win new customers, let's talk about how many new customers they need. And at what point do they need them?

Ultimately, our job is to change behaviors and solve problems. Deliverables are just stepping stones to get there.
fact, pretty deliverables are useless unless they help achieve a business goal.

Fight for Users

In the fast paced world of software, demands are high and time is thin. As a result, product companies often cut corners to meet deadlines. Unfortunately, crucial steps like user research and usability testing are often the first t
get cut. We take a strong stance on this topic:

Failing to involve your users in the design process is the biggest mistake you can make.
No one likes risk. But teams drastically increase risk by making product decisions without understanding users' problems and environments. They risk spending ample time and money building something unusable or somethi
no one wants. That's why we always fight the uphill battle for the user — to help the users *and* our clients.

We value learning just as much as we value business growth. Delivering business outcomes is king, but we can't
this without learning about our customers' needs and motivations.

Own the Product

Design specs are useless if the end product looks and functions nothing like the design. We take pride in our deliverables, but we take more pride in shipping awesome products. This drives how we structure our engageme
with clients. If we don't plan formal product reviews, the chance of failing sky rockets. Likewise, without early collaboration between designers and engineers, we risk delays and churn.

Designers = Facilitators

This principle actually came from a talented designer at one of our clients. Digital product teams experience natu
tension. As designers, we will go to bat for the customer's best interests. Engineers will fight for reusable and minimal code, security, and performance. Product owners may prioritize business goals over all else. With so ma
competing interests, compromises are necessary but hard to come by. As designers, it is our job to facilitate these conversations, drive decisions, and focus the team on a common goal.

Spend Time Wisely

User experience work has a stigma of taking too long — especially user research. We fight to win the time neede
make a quality product. If we don't get enough time, we make the best of the time we have. That means there is
place for early perfectionism in our work. Good software is never done; so we continually move towards perfecti
through iteration.

Likewise, don't create a fifty page deliverable when a napkin sketch and a quick conversation will get the job do
Lastly, remember that recreating the wheel does not qualify as innovation. If an existing design solution solves a
problem well, reuse and reappropriate it to your specific context.

Be a Collaborator, Not a Hero

The age of the rockstar/ninja/unicorn designer is over. Product design is an ever growing umbrella of disciplines
While we form our team with designers who can take a project from end-to-end, we encourage designers to gain deep skills within a specialty. If you really love running customer interviews, then work with us to define a caree
path that hones your interview skills. We take this stance because collaborative teams of generalists (with specialties) trump high performing individuals every time.

This is why collaboration is key. As a majority remote-working company, it can be tempting to crawl into a desig
hole because it's comfortable — no annoying differences of opinion or critique. But we must accept that team members will have different opinions. We must embrace critique. Give these perspectives their due diligence and
explore how they might transform your own ideas.

Truly embed in the client team — make it hard for our clients to tell where their team ends and ours begins.

Balance Usability & Beauty

With the rise of Dribbble, it has become increasingly easy to fall victim to employing sexy but unusable design trends. It happens to the best of us. But always remember that you are not designing for yourself.

As designers, we notice the details — the intricacies of typography, the complexity of a layered gradient. But the average user doesn't care about your space age UI. They do, however, care if they can't read that low-contrast te you just put on the screen (ooh it hurts my soul how good it looks and how bad it works!)

Play the Baby Genius

People are naturally bad at explaining *why* things are the way they are. This sucks for us, because that's what we consistently need to uncover to design insightful experiences. But don't give up; be persistent. Ask *why* and then ask *why* again. Ask why five times if you have to, just like a baby. Then do genius things with the information yo uncover.

Create with Intent

Always be able to justify your design decisions, because it's inevitable that people will challenge them. While it' okay to be wrong, it's not okay to just design things with no thought or purpose. After all, our company name, Modus Create, literally translates to "Create with Intent." Be ready to map your decisions back to customer anecdotes, analytics, or business goals. Realize that rules of thumb are often actually subjective and not very convincing. "That's the way Apple does it" is not a compelling sell either.

Teach a Client to Fish

Some studios want to make clients ever dependent on their services. It makes sense right? This means more cash longer periods of time. But we take a different approach. The best gift we can give a client is the ability to never need us again. That means putting just as much emphasis on teaching as we do on delivery.

Conclusion

If you're expanding your design team or have an existing team, creating a list of design principles will create a shared understanding of expectations. We recommend going over your principles with any new hire. Also, just a good software is never done, good product design principles are never done. We're always looking to evolve and improve this list. Feel free to use it as inspiration for your team, and to let us know your team's principles in the comments.

Video Content / Details of website for further learning (if any):
https://openclassrooms.com/en/courses/4544576-learn-sketch-build-a-clickable-prototype-and-test-it-on-your-mobile/4776076-learn-the-principles-of-prototyping#:~:text=The%20main%20goal%20of%20prototyping,that%20feedback%20is%20another%20protot

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 256-260

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L 39

LECTURE HANDOUTS

Mech | **I/II**

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **V**

Date of Lecture :

Topic of Lecture: Prototype technologies

Introduction : (Maximum 5 sentences)

- A prototype is an early sample, model, or release of a product built to test a concept or process. It is a term used in a variety of contexts, including semantics, design, electronics, and software programming. A prototype is generally used to evaluate a new design to enhance precision by system analysts and users.
- Rapid prototyping is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. Construction of the part or assembly is usually done using 3D printing or "additive layer manufacturing" technology.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- The prototype gives the end-user, client, customer, user participants hands-on user experience to get feedback
- Faster new product development – Rapid prototyping plays a vital role in the process of creating successful products because it speeds up the new product development process
- It allows functionality testing to test the objectives of the concept and to finalise the product specification

Detailed content of the Lecture:

Prototyping is a critically important part of every stage in the development of a new product. Early, low-fidelity prototypes can help to refine basic ideas of how a product or system will work, helping to make changes and guide future development from very early in the development process. Early prototyping can save immensely on time and money later on.

Medium-fidelity prototypes can be used to validate shape and form, to gather early design feedback, to test basic functionality, and to help make important design decisions towards finalizing a design.

End-stage, high-fidelity prototypes can be used to do final functional testing, to get feedback from end-users, to help gather outside investments or crowdfunding Backers, and to help while working with manufacturers.

Today, product designers have access to a vast range of technologies for making all kinds of prototypes. These range from old-school methods like pen-and-paper sketching or cutting blocks of foam, to newer technologies like 3D printing and CNC machining.

Different Prototyping Techniques

Each prototyping method and technology comes with its own set of advantages and drawbacks so each has a

unique place depending upon the objectives of a product design team. The first half of the video below, from LinkedIn Learning, shows a product design agency called Prime Studio using a variety of different prototyping methods to design a knife block.

Prime Studio Product Design

This article series provides an overview of some of the most common prototyping methods for a smaller product development team with a look at the pros and cons of each technology.

Sketching Out a Design

Sketching is often the first prototyping method a product designer will use to begin the process of translating an idea into a physical product.

Sketching can be done with a simple pencil and paper or using drafting tools, or with a stylus-enabled tablet or computer.

The point of sketching out prototype ideas is to begin working on the many challenges involved in starting with an idea and building a salable product.

Building a Mockup of the Design

Another method of creating prototypes quickly and with minimal cost or tools is creating product mockups.

Mockups can be made from cardboard, paper, foam, clay, or just about any material that is readily accessible and easy to shape. Again, the point is to explore different ways of bringing a product idea to life.

3D Modeling/Rendering Your Design

3D modeling and rendering is the first step towards making higher fidelity prototypes with computer-driven tools. But 3D modeling and rendering can itself be a prototyping method.

Using CAD software, designers can explore numerous potential design revisions. Many CAD programs also include various design analysis tools that can help refine a design in more technical tools.

3D Printing Prototyped Designs

One of the most accessible technologies used to create functional product prototypes is 3D printing.

A 3D printer capable of producing highly accurate functional prototypes can be purchased for a couple of hundred dollars. 3D printers can be used to create prototype parts from a variety of different types of plastic.

Prototypes From CNC Machining

CNC machining is another computer-driven prototyping technology. There are several types of CNC machines available to product designers depending upon the geometry of the part being produced.

They all have the ability to create parts with extremely tight tolerances and from a vast range of different materials. For some materials, like metals, CNC machining is a more affordable prototyping technology than many other methods.

Laser Cutting

Laser cutting is similar to CNC machining in that a computer-driven cutting tool is used to make parts.

However, laser cutting allows for the production of extremely fine details. Laser cutting is also well suited to certain types of prototypes, like LED diffusers, sheet metal parts, or low-volume production.

Designing Breadboard Electronics

When it comes to prototyping electronics, the process typically begins on a solderless breadboard. A solderless breadboard features a grid of holes into which electrical components can be plugged and electrically connected.

Because no solder is required, parts can quickly and easily be changed or re-oriented. Solderless breadboards are a prototyping technology that allows designers to develop circuit designs more quickly and more cost-effectively than other electronics production methods.

Prototype PCBs

Since solderless breadboards cannot be incorporated into designs, the next phase of electronics prototype development is manufacturing and assembling printed circuit boards.

There are a variety of ways to make PCBs, including CNC milling, quick-turn PCB services, and full-service PCB manufacturers. Just about any electronic product will feature one or more PCBs so prototyping on PCBs means the prototype electronics will be as close as possible to PCBs used in full-scale production.

This article series covers each of these prototyping techniques in-depth to help you decide which technique(s) work best for your idea.

Scott Hatfield

Hello, my name is Scott. I like to take big, complicated projects and break them down into simple steps that anybody can understand.

Video Content / Details of website for further learning (if any):

http://me.gatech.edu/files/capstone/L071ME4182DFA

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 256-263

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LECTURE HANDOUTS

L 40

Mech

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **V**

Date of Lecture :

Topic of Lecture: Planning for protypes

Introduction : (Maximum 5 sentences)

- The main goal of prototyping is to create an early version of a product/feature that allows us to get feedback that informs later versions of the product.
- Specifically, if we get valuable feedback and new insight, the quickest way to verify that we have correctly understood that feedback is another prototype.
- A prototype is **an unfinished and physical test version of a product**, a service or a process and prototypes may be used in order to develop, test and communicate ideas and concepts. ... Prototypes should be tested – preferably several times – during the innovation process and afterwards revised.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Prototyping is an important part of the M-Files design process **because it helps us to identify and formulate the main direction of our design**.
- In addition, prototypes allow us to test which features work and don't work for the users and to spot possible usability problems in advance

Detailed content of the Lecture:

- **Prototyping** is defined as the **process** of developing a working replication of a product or system that has to be engineered. In this **process model**, the system is partially implemented before or during the analysis phase thereby giving the customers an opportunity to see the product early in the life cycle.
- Additionally, why is prototyping important step in design process? **Designing prototypes** is one part of the **process**. This type of prototype helps to make changes easily and quickly. It focuses more on the way of using the system instead of what it will looks like, which makes designers and developers more open to changes based on user feedback

Here are 4 lessons we learned from this mission.

1. Clearly define roles & responsibilities among partners.

Prototype projects often involve working with new partners. And we've learned a number of important aspects with regards to partnership management. The biggest lesson learned is to ensure that roles and responsibilities are clearly understood. Additionally, we've learned that it's important to put accountability mechanisms in place. This should be done through written confirmation that goes beyond an agreement on the Terms of Reference (TORs). When roles and responsibilities are defined, expectations are also better managed.

2. Planning fixed deadlines leads to better decision-making.
Certain fixed deadlines should be included in planning documentation. These should be seen as go/no-go points and linked with project-specific criteria to allow for transparent decision-making and to help hold partners accountable for poor performance. This could be a decision-making tool and may take the form of a check-list.

3. Be prepared.
Preparation is critical to any successful process and project – particularly those focused around training. Preparation measures such as; procurement, development of training materials, and the setup of a training space should be put in place ahead of time. If this is not the case, alternative arrangements should be made until such a time exists that they are. This needs to be linked with expectations and accountability mechanisms outlined above, especially when partners are responsible for preparation activities.

4. Implemented projects should be owned by field operations.
It is essential that proposed solutions are implemented only when there is sufficient local capacity in field operations and it is important to explain exactly what this will entail. This is important not only for implementation, but also with follow-up and, in this case, transition towards ownership and sustainability.

The major challenge for a designer or a developer is that he or she usually has to communicate the look and feel of the product to their product management team. UI/UX has so many aspects that highlighting the underlying core functionality while sharing designs with team members can be a struggle, thus, making it difficult for stakeholders to comment and give feedback. With prototyping you can combat all this along with the following benefits :

- **Better understanding of the design intent**: Prototyping not only presents a strong visualisation of the design to understand the look and feel of the final product but it also helps the team to comprehend better why they are designing, what they are designing and for whom they are designing.
- **Early Feedback** : One of the most important aspect of product building process is to gather feedback. With prototyping you can collect reviews at every stage of developing the product — whether adding new features or redesigning parts of the product. Test what is working for the audience and what is not. Define goals with your team members, the management teams, external stakeholders, SMEs etc. and come to the best collective decision.
- **Early changes save time and cost** : Changes towards the end would mean not just radical restructuring but also more speculation and rework. With a preliminary model ready it is always possible to make the desired changes early, because by that point no investment or effort has gone into creating the full product. Thus, early changes help you achieve your goals faster.
- **Validation before development** : Prototyping allows having multiple discussions between iterations before getting into final development. This iterative process makes it easier for you to have surety in what you are building is actually what is needed.
- **User research and user testing** : Users are supreme. So identifying your prospective user set and collecting their ideas to serve them better is of utmost importance. Prototyping helps you achieve that. In fact, the ultimate intent of creating a prototype is user testing which tells you how usable and valuable your product is to the end user. You can gain inputs and insights about how real users would actually use the product and what you can improve to address their pain points.

Video Content / Details of website for further learning (if any):
https://www.unhcr.org/innovation/how-to-plan-a-prototype-project/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design – Kevin Otto – 3-9; 112-145

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LECTURE HANDOUTS

L 41

Mech

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **V**

Date of Lecture :

Topic of Lecture: Economic analysis

Introduction : (Maximum 5 sentences)

- A replica of a product as it will be manufactured, which may include such details as color, graphics, packaging and instructions. One of the essential early steps in the inventing process is creating a prototype--which, simply defined, is a three-dimensional version of your vision.
-

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Economic analysis can provide the industry with preliminary cost information that can be used at the production design stage.
- To evaluate the cost-effectiveness of continuous processing, economic analysis methods that evaluate innovative processes and compare continuous and batch processes are needed.

Detailed content of the Lecture:

The economies of prototyping is captured in how designers choose the 'cheapest' (lowest cost) way to prototype that is still effective; using fast and inexpensively methods to build prototypes that are sufficient to provide the required information

Steps in Economic Analysis

There are multiple different methods, formulas and approaches for making an analysis. Whichever approach you go with, however, the same basic steps in economic analysis apply.

Define your scope. The use of economic analysis involves multiple related factors. For instance, the costs of increasing your workforce vary depending on whether you expect to use full-time employees, temps or foreign workers on visas. You may need to narrow the number of factors you consider to get usable answers.

Gather data. If you're opening a new restaurant, you'll need projections of both the added costs and the revenue you'll earn. Depending on your scope, you may want short-term economic analysis, a five-year projection or both.

Crunch numbers. Once you have the raw data, you can run it through the relevant formulas to derive useful intel. That could include total revenue, total costs, net revenue, opportunity costs,

return on investment and time to recover your investment.

Make different decisions. If the number crunching takes you to a dead-end, consider some alternatives. For example, if expanding production won't increase widget sales revenue to cover the added cost, will changing widget prices increase revenue enough to fix things?

Economic Analysis Problems

A common problem with the use of economic analysis is looking at issues in a vacuum. Suppose you're thinking about slashing prices on your products and the steps in economic analysis show customers will buy more from you. But you need to consider the possibility your competitors will cut prices to match yours, reducing your advantages.

Another problem is seeing cause and effect that isn't real. If you increase prices and sales go up, that doesn't mean raising prices caused higher sales. However, with many economic analyses, the seeming correlations look much more believable, even though they're unconnected.

Video Content / Details of website for further learning (if any):
https://bizfluent.com/how-6182911-make-economic-analysis.html

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 271

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Topic of Lecture: Patent

Introduction : (Maximum 5 sentences)

- **The patent law provides for the granting of design patents to any person who has invented any new, original and ornamental design for an article of manufacture**.
- A design patent protects only the appearance of the article and not structural or utilitarian features.
- A design patent is a form of legal protection of the unique visual qualities of a manufactured item. A design patent may be granted if the product has a distinct configuration, distinct surface ornamentation or both.

Prerequisite knowledge for Complete understanding and learning of Topic:

(Max. Four important topics)

- Design patents are helpful to the designers as they give them the right to exclude others from making similar goods.
- A designer can obtain a separate design patent for each element of a design which will expand the design protection.

Detailed content of the Lecture:

Understanding the Role of the Design Patent

A design patent may be granted if the product has a distinct configuration, distinct surface ornamentation or both. In other words, a design patent provides protection for the ornamental design of something that has a practical utility.

Design patent covers the ornamental design for an object having practical utility.

When considering patents, most people think of utility patents, which are issued for an apparatus, a process, a product, or a composition of matter. An additional patent category, however, is the design patent, which can be extremely valuable under the right circumstances.

To qualify for a design patent, the subject must be new in the sense that no single, identical design exists in the prior art, it must satisfy the ornamental standards, and it must be original to the inventor or inventors seeking protection. It must also be unobvious on the basis of any previously existing design or combination of designs when viewed through the eyes of a hypothetical designer skilled in the art. Further, design patents cannot be obtained for ornamental features that are not visible when the product is in use. In general, a design patent is obtained for the aesthetically appealing features of a product. It has also been stated that the subject must be a product of aesthetic skill and artistic conception. For example, one would have difficulty obtaining a design patent for a riveting machine, as it would generally not have aesthetic appeal.

How a Design Patent Works

An item or object that is protected by a design patent carries broad protection from copyright infringement. A design that was not intended to be a copy and which was devised independently from an existing, design patent-protected item may still infringe upon that design patent.

Design Patent vs. Utility Patent

A design patent should not be confused with a utility patent, which safeguards an item's unique way of operating or functionality. A design patent protects how an object looks. A single product may have both a design patent and a utility patent at the same time. One of the key differences between the two patents is their lifespan.

Design Patent Examples

Some examples of design patents include ornamental designs on jewelry, automobiles or furniture, as

well as packaging, fonts and computer icons (such as emojis). Some famous design patent objects include the original curvy Coca-Cola bottle (1915) and the Statue of Liberty (1879).

Why Are Design Patents Useful?

Design patents and utility (invention) patents are two very different things. Design patents protect how something looks; utility patents protect how it works. Some people might think it's only important to have a design patent if you have a very strong brand already, so that people would want to make an exact copy of your product. After all, a product that does the same thing but looks different is not protected by a design patent. However, even if you're not (yet) an iconic brand, there are a number of ways in which design patents can be useful.

Key Advantages and Disadvantages of Design Patents

Advantages

Design patents are cheap, quick and simple. One can use a "patent pending" designation immediately after filing, which can act as a marketing tool and deterrent, although the designation provides no actual protection until the patent issues. Further, one can quickly obtain a design patent to coincide with a product rollout, whereas a utility patent might not issue until years after the useful life of the product has expired.

Disadvantages

Design patents historically have been difficult to enforce (although the "ordinary observer" standard has helped on this front) and generally have less scope than a utility patent. Further, design patents protect only one design at a time, although one can file multiple applications to protect multiple, nonobvious variations of a single design.

Video Content / Details of website for further learning (if any):

https://invention-patent-drawings.com/why-are-design-patents-useful/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 291-294

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LECTURE HANDOUTS

L 43

Mech

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **V**

Date of Lecture :

Topic of Lecture: Trademark

Introduction : (Maximum 5 sentences)

- Trademarks are commonly known as names and logos. It may surprise you to learn that 3-dimensional product shapes (aka product configurations) may also be registered as trademarks.
- Trademark law protects businesses from confusingly similar goods or services that interfere with the owner's goodwill of his or her business.
- Trade dress involves the total image or overall design of the product including, the size, shape, color, graphics etc.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- The primary purpose of a trademark or trade dress is to indicate the owner or producer of the commodity and to distinguish it from like articles manufactured by others.
- It identifies the source of the goods or service.

Detailed content of the Lecture:

Trademarks:

A 'trademark' is a word, name, sign, symbol, colour or shape which is used to identify a particular product or service offered by a particular manufacturer or from a particular source.

A trademark distinguishes the product of a particular manufacturer from similar products offered by others. The owner of a registered trademark has the right to prevent others from using the same or similar trademark on their products.

A registered owner of a trademark can prevent use and registration of an infringing mark based on the basic rule: a trademark is not available for use and registration if it resembles a trademark already registered and the resemblance is likely to cause confusion, mistake or deception.

A fanciful mark would be a made-up word like "Penquell" when used by the same book publisher. It is important to note that trademark features, similar to design patents, must be nonfunctional before property rights can exist. Features of trademark or trade dress will be considered functional if they are essential to the purpose of the article or they affect the cost or quality of the article.

Trade dress is a category that originally included only the packaging of a product, but in recent years has been expanded to encompass the design of a product. Trademarks of product designs are entitled to registration if they are inherently distinctive or have acquired secondary meaning. The

This advantage allows the owner of a registered mark to bring a claim of unfair competition along with the claim of infringement. Another benefit of Supplemental Registration is that the registered design can be cited against a later applicant's attempt to register their mark on the Principle Register. Third, after five years of registration on the Supplemental Register the design is presumed to have acquired secondary meaning for registration on the Principle Register. In establishing secondary meaning, the design patent may be used as a source of protection from others using a similar design allowing the patented design the time needed to acquire secondary meaning.

A unique feature of a design trademark is that it can be used to bar a valid patent holder from making his or her patented invention. Although a valid patent constitutes inventive creativity it provides no positive rights to the patent holder. The inventor will be barred from using or making the invention if the invention's design is likely to be confused with an existing trademark as to its origin of manufacture.

Finally, the registered design owner is entitled to use the R in a circle symbol of federal registration. Use of the R in a circle symbol acts as a deterrent to others contemplating use of the registered mark. The principles of dual intellectual property protection are a powerful tool for a business making design product considerations.

Patent protection does not exclude simultaneous trademark protection. Therefore, in the narrow context of a product design an individual can obtain a design patent that protects the item for 14 years during which time the trade dress of the product develops secondary meaning.

At that point, trademark protection can continue to protect the design indefinitely. This coexistence of property rights is possible because the good will of the patentee survives the patent. The protection accorded each property right is separate and distinct. Examples of items having this unique dual property protection include, Volkswagen's patent and trademark of the VW Bug configuration and an Oneida silverware design patent coupled with acquired secondary meaning.

The importance of considering dual property protection in a business's product design cannot be overstated. Until a particular design has acquired secondary meaning worthy of trademark protection business owners should seek the broadest property protection possible.

A patent offers protection for the product while allowing the design to acquire secondary meaning that identifies product with source. Combining patent and trademark rights provides long-term property protection on product design maximizing a businesses return on investment dollars. Business owners should give serious thought to the use of dual intellectual property rights to protect their product market. The success of a business tomorrow may depend on the steps taken today to protect its investment.

Video Content / Details of website for further learning (if any):

https://www.patenttrademarkblog.com/product-design-trademark/

https://higgslaw.com/protect-your-product-design-using-both-patents-and-trademarks/

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 291-301

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LECTURE HANDOUTS

L 44

Mech

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **V**

Date of Lecture :

Topic of Lecture: Trade secrets

Introduction : (Maximum 5 sentences)

- Trade secrets are intellectual property (IP) rights on confidential information which may be sold or licensed. In general, to qualify as a trade secret, the information must be: commercially valuable because it is secret, be known only to a limited group of persons.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Trade secrets protect confidential business information that generally provides a competitive edge to its owner.
- Trade secrets often protect valuable information that cannot be protected under other forms of intellectual property law.
- Trade secrets involve no registration costs.

Detailed content of the Lecture:

Trade secrets include any business information that has commercial value derived from its secrecy. Trade secrets can be very valuable to you, whether you have developed new technology, designed original products, created the perfect recipe or amassed a gold mine of customer data. One of the most famous trade secrets is the Coca Cola formula—a well-guarded secret for over 100 years. The commercial value of the formula is why the company goes to great lengths to keep it secret.
Generally, trade secrets are used to do several things:

1. **Ensure an invention or a design is not disclosed to the public before an application for a patent or an industrial design has been made**
   To obtain a patent for an invention, the invention must be new to the world and not known to the public. Similarly, industrial designs can only be registered if they are original in the world and aren't known to the public. This can be difficult for inventors and designers, especially when they try to commercialize products, test products, launch a business, find financing or seek partners, because they usually have to disclose the invention to other people (the public). To ensure confidentiality before obtaining patent protection, inventors will guard their new inventions as trade secrets.
2. **Protect an invention through means other than patent protection**
   Because securing a patent can be costly and time consuming, some businesses and inventors choose to rely on trade secrets instead. This strategy is often used when the invention has a short lifespan or is difficult to reverse engineer.

3. **Protect valuable business information that is not formally protected through other intellectual property (IP) rights**
   Businesses that have a wealth of consumer data, recipes for food products or cutting-edge market research and analysis want to ensure that competitors do not get their hands on that information. This type of confidential information (IP) is generally not protected through patents, trademarks, industrial designs or copyright. To protect this confidential information, businesses use trade secrets.

There are numerous ways to keep your valuable business information a secret, including the following:

- Non-disclosure or confidentiality agreements: When you disclose your business information to anyone, have them sign a non-disclosure agreement.
- Confidentiality clauses: Include confidentiality clauses in employment agreements.
- Encryption: Encrypt any valuable business information.
- Password protection: Use passwords to access valuable business information.
- Lock and key: Lock up any valuable business information in a safe.

Video Content / Details of website for further learning (if any):
https://www.ic.gc.ca/eic/site/cipointernet-internetopic.nsf/eng/wr03987.html

Important Books/Journals for further learning including the page nos:

1. A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 297-301

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LECTURE HANDOUTS

L 45

Mech

I/II

Course Name with Code : **Concepts in Product Design (21GES19)**

Course Faculty :

Unit : **V**

Date of Lecture :

Topic of Lecture: Copyrights

Introduction : (Maximum 5 sentences)

- Copyright is an automatic right which protects original literary, dramatic, musical and artistic works. A Design right protects the visual appearance of an object or part of an object.
- Copyright refers to the legal right of the owner of intellectual property.
- In simpler terms, copyright is the right to copy. This means that the original creators of products and anyone they give authorization to are the only ones with the exclusive right to reproduce the work.

Prerequisite knowledge for Complete understanding and learning of Topic:
(Max. Four important topics)

- Copyright laws work to control ownership, use, and distribution of creative and expressive works.
- If you create original sketches of your designs, those sketches are protected by copyright law.

Detailed content of the Lecture:

A design for a new product can revolutionize your industry, and the right logo design can help your business stand out in the crowd. Copyright law, however, only protects intellectual property that is fixed in a tangible form -- such as a book, piece of art or movie -- so **many designs can't be copyrighted**.
Many different types of content can be protected by copyright. Examples include books, poems, plays, songs, films, and artwork. **In modern times, copyright protection has been extended to websites and other online content. Therefore, any original content published on the Web is protected by copyright law**

A copyright is a collection of rights automatically vested to you once you have created an original work. To understand how these rights can be used or licensed, it is helpful to analogize them to a bundle of sticks, where each stick represents a separate right vested to you as the owner. These rights include the right to reproduce the work, to prepare derivative works, to distribute copies, to perform the work publicly, and to display the work publicly.

Copyright Laws for Designs

A design for a new product can revolutionize your industry, and the right logo design can help your business stand out in the crowd. Copyright law, however, only protects intellectual property that is fixed in a tangible form -- such as a book, piece of art or movie -- so many designs can't be copyrighted. To determine whether your design is covered by copyright law, you'll need to figure out whether your design

can be fixed in some tangible form.

Copyright-eligible Designs

To be eligible for protection, your design will have to be represented in some tangible object. For example, if you come up with a new purse design and then create the purse, you'll need to copyright the purse. By doing so, you'll also be copyrighting the design. Further, your design will have to be original. You can't, for example, add some glitter to someone else's purse design and then copyright it.

Copyright Process

You don't have to register the rights to your design to copyright it. Since 1978, copyright in the United States has been automatic. However, you'll need to register the rights to your design if you plan to sue someone who infringes on your rights, and registration also creates a public record that you own the design. To apply for copyright protection, complete the copyright registration for the type of design you're registering. For example, if you're copyrighting a sculpture, you'll use Form VA for visual arts. You can register online or through the mail, but the copyright office offers a discount for online registrations. You'll also have to pay a filing fee.

Rights

After your item is copyrighted, you'll have exclusive rights to market, sell and reproduce the product. You can also offer licenses to other businesses that want to sell the product, and many copyright holders charge for these licenses. All copyrighted items registered after 2002 hold a copyright for 70 years after the death of the creator. If the work is created by a corporation, copyright expires 95 years after the work's publication or 120 years after its creation -- whichever period is shorter.

Copyright Alternatives

If your design is an invention or a mock-up for a potential invention, you'll need to patent it instead of copyrighting it. Logo designs, identifying brand marks and similar items are not eligible for copyright protection. Instead, you'll need to register a trademark. Trademarks and patents are governed by the U.S. Patent and Trademark Office, which offers an online application service.

Video Content / Details of website for further learning (if any):
https://www.bu.edu/researchsupport/files/2016/11/55_TechDev_SoftwareDisclosure_P1.pdf

Important Books/Journals for further learning including the page nos:

A text book of Product Design & Development – Karl T.Ulrich ; Steven D.Eppinger – 356-375

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