**DEN 432**

**January 2024**

**Week 2 Mid-term Study Guide**

**1. Introduction to the Mechanical Design Process**

Key Questions

1. What is the stage-gate design process?

2. What are the phases?

3. What are the gates?

4. What are the stages of the Product Life Cycle?

5. What is the design process?

6. What are the phases of product design?

7. What makes design hard?

8. What is the design process paradox?

9. What are the Hanover Principles.

* The design process is the organization and management of people and the information they develop in the evolution of a product.
* The success of the design process can be measured in the cost of the design effort, the cost of the final product, the quality of the final product, and the time needed to develop the product.
* Cost is committed in the design process, so it is important to pay attention to early phases.
* Cross-functional engineering integrates all the stakeholders from the beginning of the design process and emphasizes both the design of the product and concern for all processes-the design process, the manufacturing process, the assembly process, and the distribution process.
* All products have a life cycle beginning with establishing a need and ending with retirement.
* The mechanical design process is a problem-solving process that transforms an ill-defined problem into a final product. Design problem have more than one satisfactory solution.
* In problem solving there are seven actions to be taken: establish need, plan, understand, evaluate, decide, and communicate.
* As knowledge is gained design freedom is diminished.
* The design process includes project definition, product definition, conceptual design, and product development.
* Design for sustainability is the necessary component of every design process.

**2. Understanding Mechanical Design**

Key Questions

1. Why is it that design costs so little yet have such a big impact on product cost?

2. What can you learn from reversed engineering?

3. Who determines product quality? Should six-sigma always be the key objective?

4. Is the lowest cost always the design requirement? Should it be?

5. Is the quickest time to market always the key objective? Should it be?

6. What is the fuzzy-front end process?

7. What are the challenges associated with the concept of “Crossing the Chasm”?

* A product can be divided into functionally oriented elements. These are made-up of mechanical assemblies, electronic circuits, and computer programs. Mechanical assemblies are built of various components.
* The important form and function aspects of mechanical devices are called features.
* Function and behavior tell what a device does; form describes how it is accomplished.
* Function relates desired behavior.
* One component may play a role in many functions, and a single function may require many different components.
* There are many different types of mechanical design problems: selection, configuration, parametric, original, redesign, routine, and mature.
* Mechanical objects can be described semantically, graphically, analytically, or physically.
* The design process is a continuous constraining of the potential product designs until one product finally evolves. This constraining of the design space is made through repeated comparison with the design requirements.
* Mechanical design is the refinement from abstract representation to a final physical artifact.
* The most valuable information is the decisions that are communicated to others.
* Product decomposition (reversed) engineering is a useful way to understand the structure and the architecture of a product.

**3. Designers and Design Teams**

Key Questions

1. What are the key cognitive characteristics of designers?

2. Can creativity be learned?

3. Are people rational?

4. Who makes better decisions: a team or an individual?

5. Who should lead a design team?

6. Is a process design a problem-design process?

7. Who was Dr. Edward deBono? What is the meaning of concept of lateral thinking?

8. What is the purpose of cross-functional integration?

9. When would you implement each of these team structures: light, medium, heavy, or stealth?

* The human mind uses the long-term memory, the short- term memory, and a controller in the internal environment in problem solving.
* Knowledge can be considered composed of chunks of information that are general, domain-specific, or procedural in content.
* The short-term memory is a small and fast processor. Its properties determine how we solve problems. We use the external environment to augment the size of the short-term memory.
* The long-term memory is the permanent storage facility in the brain. IT is slow to remember, it is fast to recall, and it never gets full.
* Creative designers are people of average intelligence, they are visualizers, hard workers, constructive nonconformists with knowledge about the problem domain. Creativity takes hard work and van be aided by a good environment, practice, and design procedures.
* Because of the size and complexity of most products, design work is usually accomplished by teams rather than individuals.
* Working in teams requires attention to every team member’s problem-solving style-introvert or extrovert, fact or possibility oriented, objective or subjective, decisive or flexible.

**4. The Design Process**

Key Questions

1. What are the phases of the mechanical process design?

2. What is needed for a successful design review?

3. Having a standard design process necessary?

4. Should quality be designed-in or tested out of a product?

5. What is a product definition phase?

6. What is a project definition phase?

7. What is a conceptual design phase?

8. What is a product development phase?

9. What is the product support phase?

* There are specific design process techniques to support the planning, specification development, conceptual design, and product design phases of the design cycle.
* The techniques help to design effort in its earliest stages, where the major decisions are made. Additionally, the techniques encourage communication, force documentation, and encourage data gathering to support creativity.
* Communication is an integral part of the design process.
* The design process consists of a series of decisions.
* The design process focuses effort on early stages, when the major decisions are made, and quality benchmarks are defined.
* The project definition phase of the design process includes activities to discover, choose, and plan design projects.
* The conceptual design phase of the design process focuses on concept generation, evaluation, and decision making.
* The product development phase of the design process includes activities that help refine a concept into a product.
* The product support phase includes activities that occur after the product is in production and includes its support, changes, and retirement.

**5. Project Definition**

Key Questions

1. Does one type of plan fit all design projects?

2.What is a difference between a waterfall and a spiral plan?

3.How can a plan be developed when the future is so uncertain?

4.What are the sources of new concept ideas?

5. What does it mean for product to be mature?

6. What is a decision tree approach to project planning?

7. What is a Gantt chart?

8. What is a PERT chart?

* Planning is an important engineering activity
* Progressive companies have a generic product development process that serves as a basis for planning each product development activity.
* Design projects commonly fall into one of four types: variation of an existing product. Improvement of an existing product, development of a new product for low volume production, and development of new products for high volume production.
* Design teams may have representatives from many different disciplines, and they may be organized in one of five different structures.
* The use of prototypes and models is important to consider during planning.
* There are five planning steps: identify the task, state their objectives, estimate the resources needed, develop a sequence, and estimate costs.
* Design projects originate from market pull, technology push, or product design
* Choosing which projects to undertake is critical to the efficient use of resources.
* The goal is to design a plan to meet the needs of the project.
* There are six basic decision-making activities: clarify the issue, generate alternatives, develop criteria, identify criteria importance, evaluate the value of the alternatives, and decide what to do next.

**6. Product Definition**

Key Questions

1. How can you identify the “customers” for a product?

2. Why is it so important to understand the voice of the customer and work to translate this into engineering specifications?

3. How can you best benchmark the competition to understand design and business opportunities?

4. How can you justify taking time at the beginning of a project to do specification development instead of developing concepts immediately?

* Understanding the design problem is best accomplished through a technique called quality function deployment (QFD). This method transforms consumers requirements into targets for measurable engineering requirements.
* Important information to be developed at the beginning of the problem includes consumers’ requirements, competition benchmarks, and engineering specifications complete with measurable benchmarks.
* Time spent completing the QFD is more than recovered later in the design process.
* There are many customers for most design problems.
* All design problems are poorly defined
* Your decisions, good or bad, affect everyone downstream.

**7. Concept Generation**

Key Questions

1. How can understanding the function help developing form?

2. What does flow have to do with function?

3. How can patents aid in generation of new ideas?

4. How do contradictions lead to new ideas?

5. What is morphology and what does it do?

6. What is a function?

7. What is brainstorming?

8. How can contradictions used to generate new ideas?

* The two techniques: functional decomposition and generating concept from function-force the generation of many conceptual ideas to meet the functional requirements.
* Functional decomposition encourages breaking down the needed function of a device as finely as possible, with a few assumptions about the form as possible.
* The functional decomposition of existing products is a good method to understanding them.
* Functional decomposition involves breaking down the needed function of device as finely as possible, with a few assumptions about the form as possible.
* Exploring contradictions can lead to new ideas.
* Listing concepts for each function helps generate ideas; this list is often called a morphology.
* Source for conceptual ideas come primarily from the designer’s own expertise; this expertise can be enhanced using patent searches, reference books, experts, brainstorming, etc.
* Listing concepts for each function helps generate ideas; this list is often called a morphology.