Technology, Engineering and Design
Unit 4: Design
Class Notes - Mr. Dion

Big Idea: The Engineering Design process is a systematic, iterative problem solving method that produces solutions to meet human wants and desires.

Key concept:

1. This unit will enable students to apply the engineering design process as they solve a variety of problems.

Unit Vocabulary:

Engineering Design Process - Systematic, iterative problem solving method which produces solutions to meet human wants and desires

- Problem-solving process that is used to generate, model and test, and communicate new products and processes
- Series of 12 sequential steps
- This process is iterative (can go back and repeat steps several time)

Universal Design – Universal Design is the idea that all new environments and products, to the greatest extent possible, should be usable by everyone regardless of their age, ability, or circumstance.

Science - Science is the study of the history of the natural world and how the natural world works, based on observable physical evidence.

Scientific Method - Processes of discovery and demonstration including; observation of phenomena, formulation of a hypothesis, experimentation and conclusion.

Engineering Design - Engineering design is a systematic application of mathematical, scientific and technical principles that produces tangible end products that meet our needs and desires.

Engineering Design Process - Is a systematic, iterative, problem-solving strategy, with criteria and constraints, used to develop many possible solutions to a problem to satisfy human needs and wants.

Criteria - Specifications and requirements that must be included in a product.

Constraint – A limitation in a product or device, requirements or specifications that could not be implemented due to cost or some other trade-off. Constraints may include physical, biological, economic, political, social, ethical, and aesthetic concerns but almost always involve time, budget, and safety issues.

Trade-off - A trade-off is a decision process recognizing the need for careful compromises among competing factors. Requirements of a design (criteria and constraints) sometimes compete with each other.

Designers – Characteristics of designers include creativity, resourcefulness, the ability to visualize and to think abstractly when engaged in engineering design.

Lesson 1: Design Principles

Big Idea: Engineers and designers must incorporate design principles when generating solutions to problems.

Key Concepts:

1. Engineers and designers must incorporate design principles when generating solutions to problems. To solve problems engineers, architects, designers use scientific knowledge and mathematical applications.
2. Design requires taking **constraints** into account; Physical, Biological, Economic, Political, Social, Ethical, Aesthetic.
3. Established design principles are used to create designs across all technologies and to evaluate designs
   - **Flexibility:** the material properties or flexibility related to the purpose of an object
   - **Balance:** the position of elements in relation to each other. Balance is the concept of visual equilibrium, and relates to our physical sense of balance.
   - **Function:** the purpose of an object
   - **Proportion:** the size of different elements in relation to each other
   - **Emphasis**: Emphasis is also referred to as point of focus, or interruption. It marks the locations in a composition which most strongly draw the viewer's attention
   - **Unity**: Unity is the underlying principle that summarizes all of the principles and elements of design. It refers to the coherence of the whole, the sense that all of the parts are working together to achieve a common result; a harmony of all the parts.
   - **Rhythm**: Rhythm can be described as timed movement through space; an easy, connected path along which the eye follows a regular arrangement of motifs.
4. Characteristics of designers include creativity, resourcefulness, the ability to visualize and to think abstractly when engaged in engineering design.
5. Designers identify and consider human values and limitations solving practical design problems.
6. Universal Design is the idea that all new environments and products, to the greatest extent possible, should be usable by everyone regardless of their age, ability, or circumstance.
7. Design is the result of a formal, sequential process.
8. Design problems seldom arise in a clearly defined form.
9. Design is driven by profit motive and market.
10. Design requirements sometimes compete with each other.
11. Design is the result of goal-oriented research.
12. Designs must be continually checked, refined, and improved.

Lesson 2: Design Process

Big Idea: The Engineering Design Process is a systematic, iterative problem solving method which produces solutions to meet human wants and desires.

Key Concepts:

1. Science is the study of the history of the natural world and how the natural world works, based on observable physical evidence.
2. The Scientific Method is the process of discovery and demonstration
    a. Observation of phenomena
    b. Formulation of a hypothesis
    c. Experimentation
    d. Conclusion
3. Steps of the scientific method
    a. Name the problem or question
    b. Form a hypothesis and make a prediction
    c. Test hypothesis
    d. Interpret your results/hypothesis
    e. Report your results
4. Engineering Design is the systematic application of mathematical, scientific and technical principles
    a. Tangible end products that meet our needs and desires.
    b. The process of engineering design takes into account a number of factors.
5. The Engineering Design Process is a systematic, iterative, problem-solving strategy, with criteria and constraints, used to develop many possible solutions to a problem to satisfy human needs and wants. There are twelve steps in the Engineering Design Process.
    a. <u>Define the problem</u> - Designer clearly outlines what human need or want exists to solve the problem.
    b. <u>Brainstorm possible solutions</u> - Designers generate ideas without consideration of limitations to the design.
    c. <u>Generate ideas</u> - This is a step where designers can let their imaginations run free with suggestions from the brainstorming session
    d. <u>Research ideas and explore possibilities</u> - Research to determine if a solution to the problem already exists.
    e. <u>Specify criteria and identify constraints</u> - Identifying criteria and specifying constraints will provide the basis for what the design
    f. <u>Consider alternative solutions</u> - Other solutions could work just as well as the one selected by the designer.

g. Select an approach - Based on the analysis, the designer chooses the solution that best meets the criteria and constraints.
h. Develop written design proposal - A design proposal is a written plan that specifies what the design will look like and what resources are needed to develop it.
i. Make models/prototypes - Models allow designers to make a smaller version to save time and money. A prototype performs exactly as the final solution and is used for testing.
j. Test and evaluate - Data is collected from testing to assist in the next step.
k. Refine the design - Based on the evaluation and testing results, designers refine the design of the product.
l. Communicate results - Designers need to communicate their results to perpetuate innovation and so others with similar problems can learn from their design process.

Lesson 3: Criteria and Constraints

Big Idea: Throughout the design process, designers must constantly compare the solution to the criteria and constraints of the problem.

Key Concepts:

1. Criteria are the desired elements and features of a product or system.
2. Criteria includes what the design is supposed to do, related to function, aesthetics, efficiency, etc
3. Constraints are the limitations on a design and almost always include time, budget, and safety concerns.
4. A trade-off is a decision process recognizing the need for careful compromises among competing factors. Requirements of a design (criteria and constraints) sometimes compete with each other.

Lesson 4: Prototypes and Modeling

Big Idea: At various intervals of the engineering design process, conceptual, physical, and mathematical models ae used to evaluate the design solution.

Key Concepts:

1. Modeling - there are three different ways to represent our world
   a. Written & Spoken
   b. Mathematical
   c. Graphical
2. Conceptual models allow designs to quickly be checked and critiqued.
3. Types of technical sketches:
   a. <u>Isometric</u> - 3D drawings of objects using true measurements. Front & side drawn at 30 degrees from horizontal.
   b. <u>Oblique</u> - 3D drawings with the width represented as a horizontal line. Side view of object drawn at 45 degrees from horizontal
   c. <u>Perspective</u> - 3D drawings of objects where lines converge on one or more points. Intended to be close to the human eye in observation.
   d. Orthographic – 2D drawings showing the object from one side.
4. Physical models include mock ups and prototypes. A prototype is a working model to test a design concept through observation and adjustment. A mock up simulates the look of an object and not the function.
5. Mathematical models create representations to organize, record, and communicate ideas. Symbolic algebra to represent and explain mathematical relationships Computers improved power and use of mathematical models by performing long, complicated, or repetitive calculations.
6. Calculating Area - Area is the amount of surface of a 2D object. Formulas are below.
   a. Rectangle: A = length x width
   b. Triangle: A = ½ base x height
   c. Circle: A = ∏ x radius 2(squared)
7. Calculating Volume - Volume is amount of space a 3D object takes up. Formulas below.
   a. Rectangle Box: V = length x width x height
   b. Pyramid: V = 1/3 Area of Base x Perpendicular Height
   c. Sphere: V = ∏ x radius 3(cubed)

    d. Cylinder: V = Area of the Base x Height

8. Calculating Surface Area - Surface area, the measure of how much exposed area a 3D object has. Formulas below
    a. Rectangle Box: SA = (H x W x 2) (H x D x 2) (D x W x 2)
    b. Pyramid: SA = (Perimeter of Base x ½ Slant Height) + (area of base)
    c. Sphere: SA = Diameter2 x 3.1416
    d. Cylinder: SA= (Diameter x Length of curved surface x 3.1416) + (area of bottom + area of top)

Lesson 5: Collecting and Processing Information

Big Idea: Computers assist in organizing and analyzing data used in the engineering design process.

Key Concepts:

1. Throughout the design process, the design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.
2. Statistics can be used to help optimization of designs and improve efficiency. Collect information and evaluate its quality.
    a. Mean - The mean represents the average of a set of data. To calculate mean you sum all the given elements in a data set and divide by the number of items in the data set.
    b. Median - Median is the middle number in a given data set. When the data set has an even number of elements, the median is the average of the two middle numbers.
    c. Mode - Mode is the most frequently occurring number in a data set. It is possible to have more than one mode.
    d. Standard Deviation - Standard deviation represents the spread of a set of data. The higher the number, the larger the spread of data. Standard deviation is calculated using the following formula:
    e. Range - Range represents the maximum value in the data set subtracted by the minimum value in the data set.
    f. Tolerance - Tolerance represents the possibility of error in measurements for a data set. Tolerance is calculated by half of the range.

g. Upper Specification Limits - Upper specification limit is the largest measurement a part of clearance space is allowed, so that the part still functions.

h. Lower Specification Limits - Lower specification limit is the smallest measurement a part of clearance space is allowed, so that the part still functions.

Lesson 6: Documenting the Process

Big Idea: The Engineering Design Process is incomplete until the solution to the design problem has been communicated to its intended audience.

Key Concepts:

1. Engineers and designers communicate with different audiences
    a. Clients
    b. Manufacturing companies
    c. Government agencies
    d. Marketing companies
2. The purpose of this communication is to
    a. Reflect on the process
    b. Gather ideas and feedback from others
    c. Communicate successes and failures during the design process
    d. Communicate the final design to the target market
3. Questions that need to be answered to effectively prepare a presentation:
    a. What is the purpose of your presentation?
    b. Are you trying to educate, persuade, inform, etc.?
    c. Who is the audience?
    d. What is their background knowledge?
    e. What will they want to know?
    f. How will the audience stay engaged?
    g. Do you want audience interaction?

h. How will you present visuals related to your topic?

i. How much time do you have for the presentation?

j. Where will the presentation be held?

k. Do you have access to technology such as a computer, projector, etc.?

4. It is important to choose your presentation format
   a. PowerPoint slides
   b. Video
   c. Internet site
   d. Podcast
   e. Demonstration
   f. Performance (such as role playing, dancing, etc.)
   g. Table Display
   h. Poster
   i. Brochure
5. Prepare the content of your presentation
   a. Beginning of the Presentation
      i. Introduce yourself and your objectives
   b. Middle of the Presentation
      i. Discuss your design process including any successes or failures
      ii. Leave room for questions
      iii. Use visual aids as appropriate
   c. End of the Presentation
      i. Summarize your points (refer back to objectives)
      ii. Ask for any additional questions (be prepared)