PROJECT LEAD THE WAY PLTW

IED

IED Course Description

Introduction to Engineering Design™ (IED) is a high school level course that is appropriate for 9th or 10th grade students who are interested in design and engineering. The major focus of the IED course is to expose students to design process, research and analysis, teamwork, communication methods, global and human impacts, engineering standards, and technical documentation. IED gives students the opportunity to develop skills and understanding of course concepts through activity-, project-, and problem-based (APPB) learning. Used in combination with a teaming approach, APPB-learning challenges students to continually hone their interpersonal skills, creative abilities and understanding of the design process. It also allows students to develop strategies to enable and direct their own learning, which is the ultimate goal of education.

The course assumes no previous knowledge, but students should be concurrently enrolled in college preparatory mathematics and science. Students will employ engineering and scientific concepts in the solution of engineering design problems. In addition, students use a state of the 3D solid modeling design software package to help them design solutions to solve proposed problems. Students will develop problem-solving skills and apply their knowledge of research and design to create solutions to various challenges that increase in difficulty throughout the course. Students will also learn how to document their work, and communicate their solutions to their peers and members of the professional community.

Introduction to Engineering Design™ is one of three foundation courses in the Project Lead The Way® high school pre-engineering program. The course applies and concurrently develops secondary level knowledge and skills in mathematics, science, and technology.

The course of study includes:

- Design Process
- Modeling
- Sketching
- Measurement, Statistics, and Applied Geometry
- Presentation Design and Delivery
- Engineering Drawing Standards
- CAD Solid Modeling
- Reverse Engineering
- Consumer Product Design Innovation
- Marketing
- Graphic Design

- Engineering Ethics
- Virtual Design Teams

Introduction to Engineering Design Detailed Outline

Unit 1: Design Process
Time Days: 49 days

Lesson 1.1: Introduction to a Design Process (11 days):

Concepts Addressed in Lesson:

1. There are many design processes that guide professionals in developing solutions to problems.
2. A design process most used by engineers includes defining a problem, brainstorming, researching, identifying requirements, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing, refining, making, and communicating results.
3. Design teams use brainstorming techniques to generate large numbers of ideas in short time periods.
4. Engineers conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.
5. A designer uses an engineer's notebook to chronologically document all aspects of a design project.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Apply engineering notebook standards and protocols when documenting their work during the school year.
- Identify and apply group brainstorming techniques and the rules associated with brainstorming.
- Research a product's history, develop a PowerPoint presentation, list chronologically the major innovations to a product, and present findings to a group.
- Use online and published works to research aspects of design problems.
- Identify the design process steps used in given scenarios and be able to list the steps, if any are missing.

Lesson 1.2: Introduction to Technical Sketching and Drawing (11 days):

Concepts Addressed in Lesson:

1. Engineers create sketches to quickly record, communicate, and investigate ideas.
2. Pictorials and tonal shading techniques are used in combination to give sketched objects a realistic look.
3. Designers use isometric, oblique, perspective, and multiview sketching to maintain an object's visual proportions.
4. A multiview projection is the most common method of communicating the shape and size of an object that is intended for manufacture.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Identify, sketch, and explain the function of points, construction lines, object lines, and hidden lines.
- Plot points on grid paper to aid in the creation of sketches and drawings.
- Explain the concepts of technical sketching and drawing.
- Sketch an isometric view of simple geometric solids.
- Explain how an oblique view of simple geometric solids differs from an isometric view.
- Sketch one-point, two-point, and three-point perspectives of simple geometric solids.
- Describe the concept of proportion as it relates to freehand sketching.
- Sketch multiview drawings of simple geometric solids.
- Determine the front view for a given object.

Lesson 1.3: Measurement and Statistics (10 days):

Concepts Addressed in Lesson:

1. Measurement systems were developed out of the need for standardization.
2. Engineers apply dimensions to drawings to communicate size information.
3. Manufactured parts are often created in different countries, where dimensional values are often converted from one standard unit to another.
4. The amount of variation that can be measured depends on the precision of the measuring tool.
5. Statistical analysis of measurements can help to verify the quality of a design or process.
6. Engineers use graphics to communicate patterns in recorded data.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Research and design a CD cover or book jacket on the origins of the measurement systems.
- Measure and record linear distances using a scale to a precision of 1/16 inch and 1 mm.
- Measure and record linear distances using a dial caliper to a precision of 0.001 inch.
- Add and subtract U.S. standard and metric linear measurements.
- Convert linear distance measurements from inches to millimeters and vice versa.
- Apply linear dimensions to a multiview drawing.
- Calculate the mean, mode, median, and range of a data set.
- Create a histogram of recorded measurements showing data elements or class intervals, and frequency.

Lesson 1.4: Puzzle Cube (17 days):

Concepts Addressed in Lesson:

1. Three-dimensional forms are derived from two-dimensional shapes.
2. The results of the design process are commonly displayed as a physical model.
3. Engineers develop models to communicate and evaluate possible solutions.
4. Geometric and numeric constraints are used to define the shape and size of objects in Computer Aided Design (CAD) modeling systems.
5. Engineers use CAD modeling systems to quickly generate and annotate working drawings.
6. Packaging not only protects a product, but contributes to that product's commercial success.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Brainstorm and sketch possible solutions to an existing design problem.
- Select an approach that meets or satisfies the constraints given in a design brief.
- Create simple extruded solid Computer Aided Design (CAD) models from dimensioned sketches.
- Generate dimensioned multiview drawings from simple CAD models.
- Measure and Fabricate parts for a functional prototype from the CAD multiview drawings.
- Assemble the product using the CAD modeling software.
- Test and evaluate the prototype and record results.
- Apply geometric and numeric constraints to CAD sketches.
- Identify the purpose of packaging in the design of consumer products.

Unit 2: Design Exercises
Time Days: 50 days

Lesson 2.1: Geometric Shapes and Solids (10 days):

Concepts Addressed in Lesson:

1. Geometric shapes describe the two or three dimensional contours that characterize an object.
2. The properties of volume and surface area are common to all designed objects and provide useful information to the engineer.
3. CAD systems are used to increase productivity and reduce design costs.
4. Solid CAD models are the result of both additive and subtractive processes.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Identify common geometric shapes and forms by name.
- Calculate the area of simple geometric shapes.
- Calculate the surface area and volume of simple geometric forms.
- Identify and explain the various geometric relationships that exist between the elements of two-dimensional shapes and three-dimensional forms.
- Identify and define the axes, planes, and sign conventions associated with the Cartesian coordinate system.
- Apply geometric and numeric constraints to CAD sketches.
- Utilize sketch-based, work reference, and placed features to develop solid CAD models from dimensioned drawings.
- Explain how a given object's geometry is the result of sequential additive and subtractive processes.

Lesson 2.2: Dimensions and Tolerances (9 days):

Concepts Addressed in Lesson:

1. Working drawings should contain only the dimensions that are necessary to build and inspect an object.
2. Object features require specialized dimensions and symbols to communicate technical information, such as size.
3. There is always a degree of variation between the actual manufactured object and its dimensioned drawing.
4. Engineers specify tolerances to indicate the amount of dimensional variation that may occur without adversely affecting an object's function.
5. Tolerances for mating part features are determined by the type of fit.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Explain the differences between size and location dimensions.
- Differentiate between datum dimensioning and chain dimensioning.
- Identify and dimension fillets, rounds, diameters, chamfers, holes, slots, and screw threads in orthographic projection drawings.
- Explain the rules that are associated with the application of dimensions to multiview drawings.
- Identify, sketch, and explain the difference between general tolerances, limit dimensions, unilateral, and bilateral tolerances.
- Differentiate between clearance and interference fits.

Lesson 2.3: Advanced Modeling Skills (19 days):

Concepts Addressed in Lesson:

1. Solid modeling programs allow the designer to create quality designs for production in far less time than traditional design methods.
2. Engineers use CAD models, assemblies, and animations to check for design problems, verify the functional qualities of a design, and communicate information to other professionals and clients.
3. Auxiliary views allow the engineer to communicate information about an object’s inclined surfaces that appear foreshortened in basic multiview drawings.
4. Designers use sectional views to communicate an object’s interior features that may be difficult to visualize from the outside.
5. As individual objects are assembled together, their degrees of freedom are systematically removed.
6. Engineers create mathematical formulas to establish geometric and functional relationships within their designs.
7. A title block provides the engineer and manufacturer with important information about an object and its creator.
8. A parts list and balloons are used to identify individual components in an assembly drawing.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Sketch and model an auxiliary view of a given object to communicate the true size and shape of its inclined surface.
- Describe the purpose and demonstrate the application of section lines and cutting plane lines in a section view drawing.
- Sketch a full and half section view of a given object to communicate its interior features.

- Identify algebraic relationships between the dimensional values of a given object.
- Apply assembly constraints to individual CAD models to create mechanical systems.
- Perform part manipulation during the creation of an assembly model.
- Explain how assembly constraints are used to systematically remove the degrees of freedom for a set of components in a given assembly.
- Create an exploded model of a given assembly.
- Determine ratios and apply algebraic formulas to animate multiple parts within an assembly model.
- Create and describe the purpose of the following items: exploded isometric assembly view, balloons, and parts list.

Lesson 2.4: Advanced Designs (12 days):

Concepts Addressed in Lesson:

1. Design solutions can be created as an individual or in teams.
2. Engineers use design briefs to explain the problem, identify solution expectations, and establish project constraints.
3. Teamwork requires constant communication to achieve the goal at hand.
4. Engineers conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.
5. Engineers use a design process to create solutions to existing problems.
6. Engineers use CAD modeling systems to quickly generate and annotate working drawings.
7. Fluid Power Concepts could be used to enhance design solutions.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Brainstorm and sketch possible solutions to an existing design problem.
- Create a decision making matrix.
- Select an approach that meets or satisfies the constraints given in a design brief.
- Create solid computer-aided design (CAD) models of each part from dimensioned sketches using a variety of methods.
- Apply geometric numeric and parametric constraints to form CAD modeled parts.
- Generate dimensioned multiview drawings from simple CAD modeled parts.
- Assemble the product using the CAD modeling software.
- Explain what constraints are and why they are included in a design brief.

- Create a three-fold brochure marketing the designed solution for the chosen problem, such as a consumer product, a dispensing system, a new form of control system, or extend a product design to meet a new requirement.
- Explain the concept of fluid power, and the difference between hydraulic and pneumatic power systems.

Unit 3: Reverse Engineering
Time Days: 43 days

Lesson 3.1: Visual Analysis (8 Days):

Concepts Addressed in Lesson:

1. Visual design principles and elements constitute an aesthetic vocabulary that is used to describe any object independent of its formal title, structural, and functional qualities.
2. Tangible design elements are manipulated according to conceptual design principles.
3. Aesthetic appeal results from the interplay between design principles and elements.
4. Though distinctly different, a design’s visual characteristics are influenced by its structural and functional requirements.
5. Visual appeal influences a design’s commercial success.
6. Graphic designers are concerned with developing visual messages that make people in a target audience respond in a predictable and favorable manner.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Identify visual design elements within a given object.
- Explain how visual design principles were used to manipulate design elements within a given object.
- Explain what aesthetics is, and how it contributes to a design’s commercial success.
- Identify the purpose of packaging in the design of consumer products.
- Identify visual design principles and elements that are present within marketing ads.
- Identify the intent of a given marketing ad and demographics of the target consumer group for which it was intended.

Lesson 3.2: Functional Analysis (4 Days):

Concepts Addressed in Lesson:

1. Mechanisms use simple machines to move loads through the input of applied effort forces.
2. Engineers perform reverse engineering on products to study their visual, functional, and structural qualities.
3. Through observation and analysis, a product's function can be divided into a sequence of operations.
4. Products operate as systems, with identifiable inputs and outputs.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Identify the reasons why engineers perform reverse engineering on products.
- Describe the function of a given manufactured object as a sequence of operations through visual analysis and inspection (prior to dissection).

Lesson 3.3: Structural Analysis (15 Days):

Concepts Addressed in Lesson:

1. Objects are held together by means of joinery, fasteners, or adhesives.
2. Precision measurement tools and techniques are used to accurately record an object's geometry.
3. Operational conditions, material properties, and manufacturing methods help engineers determine the material makeup of a design.
4. Engineers use reference sources and computer-aided design (CAD) systems to calculate the mass properties of designed objects.

Performance Objectives Addressed in Lesson:

It is expected that students will:

- Describe the differences between joinery, fasteners, and adhesives.
- Identify the types of structural connections that exist in a given object.
- Use dial calipers to precisely measure outside and inside diameter, hole depth, and object thickness.
- Identify a given object's material type.
- Identify material processing methods that are used to manufacture the components of a given commercial product.
- Assign a density value to a material, and apply it to a given solid CAD model.
- Perform computer analysis to determine mass, volume, and surface area of a given object.

Lesson 3.4: Product Improvement By Design (16 Days):

Concepts Addressed in Lesson:

1. Engineers analyze designs to identify shortcomings and opportunities for innovation.
2. Design teams use brainstorming techniques to generate large numbers of ideas in short time periods.
3. Engineers use decision matrices to help make design decisions that are based on analysis and logic.
4. Engineers spend a great deal of time writing technical reports to explain project information to various audiences.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Write design briefs that focus on product innovation.
- Identify group brainstorming techniques and the rules associated with brainstorming.
- Use decision matrices to make design decisions.
- Explain the difference between invention and innovation.

Unit 4: Open-Ended Design Problems
Time: 33 Days

Lesson 4.1: Engineering Design Ethics (8 Days):

Concepts Addressed in Lesson:

1. The material of a product, how the material is prepared for use, its durability, and ease of recycling all impact a product's design, marketability, and life expectancy.
2. All products made, regardless of material type, may have both positive and negative impacts.
3. In addition to economics and resources, manufacturers must consider human and global impacts of various manufacturing process options.
4. Laws and guidelines have been established to protect humans and the global environment.
5. A conscious effort by product designers and engineers to investigate the recyclable uses of materials will play a vital role in the future of landfills and the environment.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Create a brainstorming list of different products made from common materials that are used daily.
- Research and construct a product impact timeline presentation of a product from the brainstorming list and present how the product may be recycled and used to make other products after its lifecycle is complete.
- Identify the five steps of a product's lifecycle and investigate and propose recyclable uses for the material once the lifecycle of the product is complete.

Lesson 4.2: Design Teams (25 Days):

Concepts Addressed in Lesson:

1. Teams of people can accomplish more than one individual working alone.
2. Design teams establish group norms through brainstorming and consensus to regulate proper and acceptable behavior by and between team members.
3. Engineers develop Gantt charts to plan, manage, and control a design team's actions on projects that have definite beginning and end dates.
4. Virtual teams rely on communications other than face-to-face contact to work effectively to solve problems.
5. Each team member's strengths are a support mechanism for the other team members' weaknesses.
6. Conflict between team members is a normal occurrence, and can be addressed using formal conflict resolution strategies.

Performance Objectives Addressed in Lesson:
It is expected that students will:

- Explain why teams of people are used to solve problems.
- Identify group norms that allow a virtual design team to function efficiently.
- Establish file management and file revision protocols to ensure the integrity of current information.
- Use internet resources, such as email, to communicate with a virtual design team member throughout a design challenge.
- Identify strategies for addressing and solving conflicts that occur between team members.
- Create a Gantt chart to manage the various phases of their design challenge.