General Brown Junior Senior High School

Design & Drawing for Production/Introduction to Engineering

Content Standards

Analyze how an interdisciplinary (STEM) approach to problem solving will yield more successful results.

Standards for Mathematical Practice:

- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Construct viable arguments and critique the reasoning of others.
- Model with mathematics.
- Use appropriate tools strategically.
- Attend to precision.
- Look for and make use of structure.
- Look for and make sense of regularity in repeated reasoning.

Standards for Writing in Science and Technical Subjects:

- Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently
- Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Enduring Understandings	Essential Questions
• Using a multi-disciplinary (STEM) approach to problem solving will yield greater results in all fields of study • Science Technology Engineering and Math all go together. • Every lesson is a STEM lesson. • STEM is how things get done in the real world. • STEM is fun!	• How can I solve this problem? • What is the engineering design process? • What are some practical applications of math and science? • How are technical ideas communicated and applied to real world problems? • What does precision mean in engineering and design?

Related Misconception

Science, Technology, Engineering and Math are different subjects that do not relate to one another.

Knowledge/Concepts Students will know…	Skills/Competencies Students will be able to…
• How to use the engineering design process to solve problems. • Math and science need to be applied to solve real world problems. All STEM content areas are dependent upon one another. • Teamwork is essential for solving STEM problems	• Use the engineering design process to solve real-world problems. • Apply math and science in the solution of authentic, real-world problems. • Communicate technical ideas and engineering design solutions verbally, in writing, and through models and prototypes. Measure and model within appropriate parameters and precision.

Assessments Strategies & Tools

Formative Assessment	Summative Assessment
• Peer conferencing • Teacher conferencing • Engineering Journals • Questioning • Exit/Admit Tickets • "Beachball" discussions	• Quizzes • Project and Activity Rubrics • Engineering Journals • E-portfolio • "Shark Tank"

COURSE DESCRIPTION

DDP/Introduction to Engineering 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 course is to expose students to design process, research and analysis, teamwork, communication methods, global and human impacts, engineering standards, and technical documentation.

DDP/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.

The course assumes no previous knowledge. Students will employ engineering and scientific concepts in the solution of engineering design problems. In addition, students use 3D solid modeling and design software 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 community.

General Course Goals and Objectives

Upon successful completion of this course students will be able to:

- Apply the engineering design process
- Create technical sketches and drawings
- Document the process and solution of an engineering design problem
- Demonstrate proper measurement and tool use
- Collect and analyze data
- Apply mathematics and science principles in the solution of and engineering design problem
- Create 3D solid models
- Complete a reverse engineering project and improve the product design
- Solve an authentic engineering problem based on a client's needs/wants
- Demonstrate presentation design and delivery

Course Structure

The course will be structured around the following 6 design principles:

- Design Principle #1 **Scaffolded Learning**
  - The engineering learning objectives in each unit are specific and useful in subsequent units.
- Design Principle #2 **Engineering Design Process is Central**
  - The curriculum employs a standardized engineering design process as an instructional framework.
- Design Principle #3 **Authentic Engineering Practices**
  - Students are engaged in meaningful (if simplified) version of the practices of engineers.
- Design Principle #4 **Math and Science are the Tools of the Engineering Design Process**
  - Student work is contextualized within STEM design challenges that can only be completed through the purposeful application of engineering principles and relevant science and mathematics concepts that are clearly necessary for the successful completion of the projects.
- Design Principle #5 **The Message Matters**
  - The STEM design challenges make clear engineering's potential to impact in a positive manner human health and the environment.
- Design Principle #5 **There are NO Right Answers**
  - All STEM design challenges have multiple successful solutions.

General Standards Alignment

NYS Standard 1 – Analysis, Inquiry and Design
Framework for 21st Century Leaning
Common Core Standards for ELA (Writing, Science, and Technical Subjects)
Next Generation Science Standards for High School Engineering
Common Career Technical Core

UNIT #1 DESIGN AND MODELING

Concept: Introduction to a Design Process

Concepts Addressed in Lesson:

- There are many design processes that guide professionals in developing solutions to problems.
- 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.
- Design teams use brainstorming techniques to generate large numbers of ideas in short time periods.
- Engineers conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.
- A designer uses an engineer's notebook to chronologically document all aspects of a design project.

Performance Objectives Addressed: 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 and develop a visual 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.

.

Concept: Introduction to Technical Sketching and Drawing

Concepts Addressed in Lesson:

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

Performance Objectives Addressed: It is expected that students will:

- Identify, sketch, and explain the function of points, construction lines, object lines, and hidden lines in a mechanical/technical drawing.
- 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.
- Describe the concept of proportion as it relates to freehand sketching.
- Sketch multi-view drawings of simple geometric solids.
- Determine the front view for a given object.

Concept: Measurement and Statistics

Concepts Addressed in Lesson:

- Measurement systems were developed out of a need for standardization.
- Engineers apply dimension and tolerances to drawings to communicate manufacturing information.
- Manufactured parts are often created in different locals, even countries.
- Here are various tools of measurement that offer varying degrees of precision.
- Statistical analysis of measurements can help to verify the quality of a design, product, or process.
- Engineers use graphics to communicate patterns in recorded data.

Performance Objectives Addressed: It is expected that students will:

- Research and design a presentation on the origins of measurement systems.
- Measure and record linear distances using a scale to a precision of 1/16" and 1mm.
- Measure and record linear and cylindrical distances using a dial caliper to a precision of 0.001".
- Add and subtract U.S. standard and metric linear measurements.
- Convert measurements from U.S. standard to metric and vice versa.
- Apply dimensions and tolerances to a Multiview mechanical drawing.
- Calculate the mean, mode, median, and range of a data set.
- Create a histogram of recorded measurements illustrating data elements or class intervals and frequency.

UNIT PROJECTS

Projects may include, but are not limited to the following:

- Puzzle Cube
- Build Draw Build
- Hammer Toy
- Rube Goldberg Machine
- Adaptive Device
- Product Evolution

UNIT #2 REVERSE ENGINEERING

Concept: Visual Analysis

Concepts addressed in the lesson

- 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.
- Tangible design elements are manipulated according to conceptual design principles.
- Aesthetic appeal results from the interplay between design principles and elements.
- Though distinctly different, a design's visual characteristics are influenced by its structural and functional requirements.
- Visual appeal influences a design's commercial success.
- 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: It is expected that students will:

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

Concept: Functional Analysis

Concepts addressed in the lesson

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

Performance Objectives Addressed: 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).

Concept: Structural Analysis

Concepts addressed in the lesson

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

***Performance Objectives Addressed**:* It is expected that students will:

- Describe the differences between joinery, fasteners, and adhesives.
- Identify the types of structural connections that exist in an 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.
- Perform computer analysis to determine mass, volume, and surface area of a given object.

Concept: Product Improvement by Design

Concepts addressed in the lesson

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

***Performance Objectives Addressed**:* 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 PROJECTS

- **Reverse engineer a simple child's toy**
  - Disassemble, identify, and categorize its componentry
  - Perform visual, function and structural analysis
- **Flashlight Redesign:** gives students the opportunity to think about how someone else designed a common consumer product and how they could improve the design. Students will identify and interview potential consumers, define design requirements and specifications, model and analyze product functionality, generate redesign ideas, and communicate design recommendations.

UNIT #3 ENGINEERING DESIGN EXERCISES

Concept: Geometric Shapes & Solids

Concepts addressed in the lesson

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

***Performance Objectives Addressed**:* 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 2D shapes and 3D forms.
- 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.

Concept: Dimensions & Tolerances

Concepts addressed in the lesson

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

***Performance Objectives Addressed**:* 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 multi-view drawings.
- Identify, sketch, and explain the difference between general tolerances and geometric tolerances
- Differentiate between clearance and interference fits.

Concept: Advanced Modeling Skills

Concepts addressed in the lesson

- Solid modeling programs allow the designer to create quality designs for production in far less time than traditional design methods.
- 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.
- Auxiliary views allow the engineer to communicate information about an object's inclined surfaces that appear foreshortened in basic multi-view drawings.
- Designers use sectional views to communicate an object's interior features that may be difficult to visualize from the outside.
- As individual objects are assembled, their degrees of freedom are systematically removed.
- Engineers create mathematical formulas to establish geometric and functional relationships within their designs.
- A parts list and balloons are used to identify individual components in an assembly drawing.

***Performance Objectives Addressed**:* 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.
- Sketch a full and half section view of a given object to communicate its interior features using proper application of section lines and cutting plane lines.
- 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 each 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.

Concept: Advanced Engineering Designs

Concepts addressed in the lesson

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

Performance Objectives Addressed*:* It is expected that students will:

- Brainstorm and sketch possible solutions to an authentic engineering 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 multi-view 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 "campaign" that will market the designed solution for an authentic engineering design problem.

UNIT PROJECTS

Projects may include, but are not limited to the following:

- 3D Logo Design
- Model Train
- Automaton
- Scale Model Structures (e.g. balsa wood bridges or towers)
- Hydraulic Robotic Arm
- Siege Machine
- Alternative Energy

UNIT #4 OPEN-ENDED ENGINEERING DESIGN PROBLEMS

Concept: Engineering Ethics

Concepts addressed in the lesson

- 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.
- All products made, regardless of material type, may have both positive and negative impacts.
- In addition to economics and resources, manufacturers must consider human and global impacts of various manufacturing process options.
- Laws and guidelines have been established to protect humans and the global environment.
- 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*:* 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.

Concept: Engineering Design Teams

Concepts addressed in the lesson

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

Performance Objectives Addressed: 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.

UNIT PROJECTS

Projects may include, but are not limited to the following:

- Hydroponic/Aquaponic System
- Automated Pet Feeding System
- Sound/Music Engineering Design
- Aerial Imaging
- Solar Food Dehydration System
- Architecture/Landscape Architecture