Hoboken Public Schools

PLTW Engineering Curriculum

PLTW Engineering

HOBOKEN PUBLIC SCHOOLS

Course Description

Introduction to Engineering Design (IED) is a high school level course 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 the 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 (APP) learning. Used in combination with a teaming approach, APP-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.

In addition, the students will use Inventor, which is a state of the art 3-D design software package from AutoDesk, to help design solutions to different design projects. Then take the designs to manufacturing with the use of state of the art 3D printers. Students will learn about documenting your solutions, solving problems, and communicating your solutions to other students and members of the professional community.

The class will consist of lecture and note taking, demonstration, small group activity and the use of activities-based, project based, and problem based learning (APB-Learning)

Course Resources

1:1 computers with CAD software

Engineering Notebook

Pacing Guide

Unit Titles	Time Frame
Unit One: Design Process	**3 Weeks**
Unit Two: Technical Sketching and Drawing	**2-3 Weeks**
Unit Three: Measurement and Statistics	**2-3 Weeks**
Unit Four: Modeling Skills	**3-4 Weeks**
Unit Five: Geometry Design	**3-4 Weeks**
Unit Six: Reverse Engineering	**3-4 Weeks**
Unit Seven: Documentation	**5 Weeks**
Unit Eight: Advanced Computer Modeling	**2-3 Weeks**
Unit Nine: Design Team	**6-7 Weeks**
Unit Ten: Design Challenges	**2-3 Weeks**

Unit 1 – Design Process

Three Weeks

Unit 1 Overview Students will identify the steps in an engineering design process and describe the activities involved in each step of the process. Students will Identify and differentiate between the various engineering disciplines. Students will be able to utilize an engineering notebook to clearly and accurately document the design process. Students will demonstrate an understanding of professional and ethical responsibility.

Essential Questions

- When solving an engineering problem, how can we be reasonably sure that we have created the BEST solution possible? What is the evidence?
- What is the most effective way to generate potential solutions to a problem? How many alternate solutions are necessary to ensure a good final solution?
- How has engineering accomplishments of the 20th century impacted our society? Justify your answer.
- What will be the biggest impact that engineering will have on society and your life in the 21st century? Justify your answer.
- How is engineering tends to be a male-dominated profession. Why is that?

Essential Learning Outcomes

- Students will identify the steps in an engineering design process and describe the activities involved in each step of the process.
- Students will Identify and differentiate between the various engineering disciplines. Students will be able to utilize an engineering notebook to clearly and accurately document the design process.
- Students will demonstrate an understanding of professional and ethical responsibility.

Technology Infusion

- 8.1.12.A.1: Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resource
- 8.2.12.C.5: Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled

Standards Addressed

- 9-10.WHST.1 - Writing HS/S/T
  Write arguments focused on discipline-specific content.
- 9-10.WHST.2 - Writing HS/S/T
  Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- 9-10.WHST.2.a - Writing HS/S/T
  Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
- 9-10.WHST.2.b - Writing HS/S/T
  Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.

- 9-10.WHST.2.d - Writing HS/S/T
  Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.

Differentiation

- **Time**: Extra time for assigned tasks, adjust length of assignment, timeline with due dates for reports and projects, communication system between home and school and provide lecture notes/outline.
- **Processing**: Extra Response time, verbalize steps, repeat, clarify or reword directions, Mini-breaks between tasks, Provide a warning for transitions, and partnering.
- **Recall**: Teacher-made checklist, Use visual graphic organizers, reference resources to promote independence and visual/verbal reminders
- **Tests/Quizzes/Grading:** Extended time, Study guides, shortened tests, and read directions aloud.
- **Behavior/Attention:** Consistent daily structured routine, simple and clear classroom rules, and frequent feedback.
- **Organization:** Individual daily planner, display a written agenda, note-taking assistance, and Color code materials

Assessments

- Engineering notebook
- Portfolio of design project
- Design Challenge results
- Test/quizzes/vocabulary

21st Century Learning Connection

- 9.3.ST.1: Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.1: Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4: Apply the elements of the design process

Unit 2 Technical Sketching and Drawing

Two-Three Weeks

Unit 2 Overview

In this unit, students will identify and define technical drawing representation including isometric, orthographic projection and oblique and perspective views.

Essential Questions

- How is technical drawing similar to and different from artistic drawing?
- How can a technical drawing to be misinterpreted or to be inadequate when conveying the intent of a design to someone unfamiliar with the original problem or solution?
- How can technical drawings help or hinder the communication of problem solution in a global community?

- Strong spatial-visualization skills have been linked to success in engineering. How are spatial-visualization skills so important to engineering success?

Essential Learning Outcomes

- Students will identify and define technical drawing representation including isometric, orthographic projection and oblique and perspective views.

Technology Infusion

- 8.2.8C.4: Identify steps in the design process that would be used to solve a designated problem.
- 8.2.12.C.5: Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled

Standards Addressed

- 9-10.RST.4 - Reading Science/Technical Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics

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Assessments

- Worksheets of isometric, orthographic and multiview drawings
- Engineering notebook entries
- Test/quizzes/vocabulary

21st Century Learning Connection

- 9.3.ST.1: Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.1: Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4: Apply the elements of the design process

Unit 3 – Measurement and Statistics

Two-Three Weeks

Unit 3 Overview

In this unit, students will identify general rules for dimensioning on technical drawings used in standard engineering practice. Students will explore dimension orthographic projections of simple objects or parts

according to a set of dimension standards and accepted practices. Students will be able to calculate statistics related central tendency *mean, median, mode) and variation of data (standard deviation and range). Students will be able to use a spreadsheet program to process data, create graphs and utilize formulas.

Essential Questions

- How can statistics be interpreted to justify conflicting viewpoints? Can this affect how we use statistics to inform, justify and validate a problem solution?
- How is error unavoidable when making a measurement?
- When recording measurement data, how is the use of significant figures important?
- What strategy would you use to teach another student how to use units and quantitative reasoning to solve a problem involving quantities?
- What would happen if engineers did not follow accepted dimensioning standards and guidelines but, instead, used their own individual dimensioning methods?

Essential Learning Outcomes

- Students will identify general rules for dimensioning on technical drawings used in standard engineering practice.
- Students will explore dimension orthographic projections of simple objects or parts according to a set of dimension standards and accepted practices.
- Students will be able to calculate statistics related central tendency *mean, median, mode) and variation of data (standard deviation and range).
- Students will be able to use a spreadsheet program to process data, create graphs and utilize formulas.

Technology Infusion

- 8.2.12.C.5: Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.

Standards Addressed

- 9-10.RST.4 - Reading Science/Technical Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics
- 9-10.RST.7 - Reading Science/Technical Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

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Assessments

- Statistic excel file with calculations
- Measurement worksheets
- Dial caliper stations assessment

21st Century Learning Connection

- 9.3.ST.6: Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-SM.1: Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.

Unit 4 – Modeling Skills

Three-Four Weeks

Unit 3 Overview

In this unit, students will be able to become more familiar with the terminology related to and the use of a 3D modeling program in the creation of solid models and technical drawings. Students will develop and/or use graphical, computer, physical and mathematical models as appropriate to represent or solve problems. Students will create 3D solid models with CAD from sketches or dimensioned drawings and generate multi-view technical drawings. Students will construct a testable prototype of a problem solution. Students will interpret functions to solve problems in the context of the data.

Essential Questions

- How should one decide what information and/or artifacts to include in a portfolio? Should a portfolio always include documentation on the complete design process?
- How did you use every possible type of model during the design and construction of your puzzle cube? Describe each model that you used?
- How reliable is a mathematical model?

Essential Learning Outcomes

- Students will be able to become more familiar with the terminology related to and the use of a 3D modeling program in the creation of solid models and technical drawings.
- Students will develop and/or use graphical, computer, physical and mathematical models as appropriate to represent or solve problems.
- Students will create 3D solid models with CAD from sketches or dimensioned drawings and generate multi-view technical drawings.
- Students will construct a testable prototype of a problem solution. Students will interpret functions to solve problems in the context of the data.

Technology Infusion

- 8.2.12.D.1: Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for review.

Standards Addressed

- 9-10.RST.4 - Reading Science/Technical Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.
- 9-10.RST.7 - Reading Science/Technical Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

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Assessments

- Puzzle piece combination isometric drawings
- Puzzle cube design isometric drawings
- Puzzle cube physical prototype
- Puzzle piece drawings in CAD including isometric and multiview drawings and assemblies.
- Engineering notebook

21st Century Learning Connection

- 9.3.ST.6: Demonstrate technical skills needed in a chosen STEM field
- 9.3.ST-ET.1: Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4: Apply the elements of the design process

Unit 5 – Geometry of Design

Three-Four Weeks

Unit 5 Overview

In this unit, students need to identify types of polygons. Students will distinguish between the meanings of the terms weight and mass. Students will use critical thinking skills in order to solve real world and mathematical problems involving area and surface area of two and three dimensional objects.

Essential Questions

- What advantage(s) do Computer Aided Design (CAD) and Drafting provide over traditional paper and pencil design? What advantages does paper and pencil design provide over CAD?
- Which high school math topic/course, Algebra or Geometry, is more closely related to engineering? Justify your answer.
- How does the material chosen for a product impact the design of the product?

Essential Learning Outcomes

- Students will be able to identify types of polygons.
- Students will distinguish between the meanings of the terms weight and mass.

- Students will use critical thinking skills in order to solve real world and mathematical problems involving area and surface area of two and three dimensional objects.

Technology Infusion

- 8.1.12.A.1: Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resource

Standards Addressed

G.MG - Modeling with Geometry

A. Apply geometric concepts in modeling situations

- Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).⋆
- Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).⋆
- Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).⋆

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Assessments

- Activity worksheets for calculating area, volume and physical properties of various geometric shapes
- CAD models of geometric figures used in the real world
- Finding the physical properties of various materials manually and via the CAD program
- Design Challenge - design a holder for popcorn that meets the design requirements
- Engineering notebook
- ePortfolio

21st Century Learning Connection

- 9.3.ST.1: Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.1: Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4: Apply the elements of the design process

Unit 6 – Reverse Engineering

Three to Four Weeks

Unit 3 Overview

In this unit, students will identify and describe the visual principles and elements of design apparent in a natural or manmade objects. Students will describe the process of reverse engineering. Students will perform a functional analysis of a product in order to determine the purpose, inputs and outputs, and the operation of a product or system.

Essential Questions

- How are consumer product designs deemed not commercially successful?
- When, if ever, is it acceptable for a company to reverse engineer and reproduce a successful consumer product designed by another person/company?

Essential Learning Outcomes

- Students will identify and describe the visual principles and elements of design apparent in a natural or manmade objects.
- Students will describe the process of reverse engineering.
- Students will perform a functional analysis of a product in order to determine the purpose, inputs and outputs, and the operation of a product or system.

Technology Infusion

- 8.1.12.A.1: Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resource
- 8.2.12.C.6; Research an existing product, reverse engineer and redesign it to improve form and function.

Standards Addressed

- 9-10.WHST.2.a - Writing HS/S/T
- Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
- 9-10.WHST.2.b - Writing HS/S/T
- Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic

Differentiation

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- **Recall**: Teacher-made checklist, Use visual graphic organizers, reference resources to promote independence and visual/verbal reminders
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- **Organization:** Individual daily planner, display a written agenda, note-taking assistance, and Color code materials

Assessments

- Product redesign project
- ePortfolio
- Automoblox vehicle

21st Century Learning Connection

- 9.3.ST.1: Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.1: Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4: Apply the elements of the design process

Unit 7 – Documentation

5 Weeks

Unit 7 Overview

In this unit, students will be able to Identify and differentiate between size dimensions and location dimensions. Students will generate section views using CAD according to standard engineering practice. Students will create assemblies of parts in CAD, then create assembly drawings that identify each component of the assembly. Students will utilize their critical thinking skills in order to write a design brief to communicate the problem, constraints and solution criteria. Students will create a set of working drawings to detail a design project.

Essential Questions

- What are the consequences to the final solution if the design problem is poorly communicated? How does one know that a given design solution is the best possible solution?
- Engineering is described as the application of math, science and technology to solve problems. How does this description imply that designing an enhancement to an Automoblox vehicle is the work of an engineer? Justify your answer.
- Is it always necessary to indicate a tolerance for every dimension on a technical drawing? Justify your answer.

Essential Learning Outcomes

- Students will be able to Identify and differentiate between size dimensions and location dimensions.
- Students will generate section views using CAD according to standard engineering practice.
- Students will create assemblies of parts in CAD, then create assembly drawings that identify each component of the assembly.
- Students will utilize their critical thinking skills in order to write a design brief to communicate the problem, constraints and solution criteria
- Students will create a set of working drawings to detail a design project.

Technology Infusion

- 8.1.12.A.1: Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resource

Standards Addressed

- 9-10.RST.4 - Reading Science/Technical
  Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.
- 9-10.RST.7 - Reading Science/Technical
  Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

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- **Organization:** Individual daily planner, display a written agenda, note-taking assistance, and Color code material

Assessments

- Drawings
- ePortfolio of Automoblox vehicle
- Engineering notebook
- Test/quizzes/vocabulary Test/quizzes/vocabulary

21st Century Learning Connection

- 9.3.ST.6: Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST-ET.1: Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4: Apply the elements of the design process

Unit 8 – Advanced Computer Modeling

Two-Three Weeks

Unit 8 Overview

In this unit, students will use a CAD application to create relationships among part features and dimensions using parametric formulas. Students will perform a peer review of technical drawings and offer constructive feedback based on standard engineering practices.

Essential Questions

- Are working drawings always necessary in order to communicate the design of a consumer product? Justify your answer.
- Animated assemblies are not typically included as part of the technical documentation of a design. How can 3D animated assembly models of an object or a proposed design be used in the design process? Beyond the design process?

Essential Learning Outcomes

- Students will use a CAD application to create relationships among part features and dimensions using parametric formulas.
- Students will perform a peer review of technical drawings and offer constructive feedback based on standard engineering practices.

Technology Infusion

- 8.1.12.A.1: Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resource
- 8.2.12.C.5: Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled

Standards Addressed

- 9-10.RST.4 - Reading Science/Technical
  Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–10 texts and topics.

Differentiation

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Assessments

- Engineering notebook
- Portfolio of design project
- Design Challenge results
- Test/quizzes/vocabulary

21st Century Learning Connection

- 9.3.ST.1: Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.1: Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4: Apply the elements of the design process

Unit 9 – Design Team

Six-Seven Weeks

Unit 9 Overview

In this unit, students will be able to identify and describe the steps of a typical product lifecycle. Students will be able to assess the development of an engineered product and the impact of the product on society and the environment. Work with the team to develop, document, design and present a product. Students will be able to participate on a virtual team using remote collaboration tools to support team collaboration and problem solving.

Essential Questions

- How is it ever advantageous to create a design or solve a problem individually as opposed to using a team approach? Explain.
- What strategy would you use to form a design team in order to obtain the best solution possible?
- It has been said that, "Having a vision without action is a daydream; Taking action without a vision is a nightmare!" How does this apply to engineering design?

Essential Learning Outcomes

- Students will be able to identify and describe the steps of a typical product lifecycle.
- Students will be able to assess the development of an engineered product and the impact of the product on society and the environment. Work with the team to develop, document, design and present a product. Students will be able to participate on a virtual team using remote collaboration tools to support team collaboration and problem solving.

Technology Infusion

- 8.1.12.A.1: Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resource
- 8.2.12.C.5: Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled

Standards Addressed

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  Write arguments focused on discipline-specific content.
- 9-10.WHST.2 - Writing HS/S/T
  Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
- 9-10.WHST.2.a - Writing HS/S/T
  Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
- 9-10.WHST.2.b - Writing HS/S/T
  Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
- 9-10.WHST.2.d - Writing HS/S/T
  Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.

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Assessments

- Engineering notebook
- Portfolio of design project
- Design Challenge results
- Test/quizzes/vocabulary

21st Century Learning Connection

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- 9.3.ST-ET.1: Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4: Apply the elements of the design process

Unit 10 – Design Challenges
Two-Three Weeks

Unit 10 Overview

In this unit, students will identify the steps in an engineering design process and describe the activities involved in each step. Students will utilize their critical thinking skills in order to develop and document an effective solution to a problem that meets specific design requirements.

Essential Questions

- Engineering has been referred to as the "stealth"profession. How would you as an engineering student label this?
- If you had to describe one strategy that would most help an engineer be a good and effective designer, how would you describe it?

Essential Learning Outcomes

- Students will identify the steps in an engineering design process and describe the activities involved in each step.
- Students will utilize their critical thinking skills in order to develop and document an effective solution to a problem that meets specific design requirements.

Technology Infusion

- 8.1.12.A.1: Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resource
- 8.2.12.C.5: Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled

Standards Addressed

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- **Processing**: Extra Response time, verbalize steps, repeat, clarify or reword directions, Mini-breaks between tasks, Provide a warning for transitions, and partnering.
- **Recall**: Teacher-made checklist, Use visual graphic organizers, reference resources to promote independence and visual/verbal reminders
- **Tests/Quizzes/Grading:** Extended time, Study guides, shortened tests, and read directions aloud.
- **Behavior/Attention:** Consistent daily structured routine, simple and clear classroom rules, and frequent feedback.
- **Organization:** Individual daily planner, display a written agenda, note-taking assistance, and Color code materials

Assessments

- Engineering notebook
- Portfolio of design project
- Design Challenge results
- Test/quizzes/vocabulary

21st Century Learning Connection

- 9.3.ST.1: Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.1: Use STEM concepts and processes to solve problems involving design and/or production.
- 9.3.ST-ET.4: Apply the elements of the design process