Introduction to Engineering Design

Grade 9, 10, 11, or 12

Prerequisite: None

Credit Value: 5

ABSTRACT

The Introduction to Engineering Design course is the first in the Project Lead The Way pre-engineering sequence. Students are introduced to the design process, build individual portfolios, and use Autodesk Inventor to model, create sketches, and engineer designs. Hands-on activities augment computer technology in studying engineering projects. Benchmark assessments are employed to track individual student progress.

Adopted by the Somerville Board of Education on July 25, 2017
# Introduction to Engineering Design

**Grade 9, 10, 11, or 12**

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**Essential Question:**
- How does engineering transform an idea into a product?
- Why are mathematical applications necessary to the design process?
- How is software used to design prototypes?
- How are geometric properties used to model real-world examples?
- What is the significance of modeling in developing prototypes?

**Content:**
- Introduction to the Design Process
- Technical Sketching, Drawing, Measurement, and Statistics
- The Puzzle Cube Project
- Geometric Constraints
- Advanced Modeling

**Skills and Topics:**
- Explore the design processes that guide professionals from different career areas.
- List and provide examples of the steps of the design process used by engineers (e.g., identify the problem, conduct research, develop a design brief, brainstorm ideas, model, optimize, present, qualify, manufacture, and communicate results).
- Demonstrate recording and communication skills through engineering sketches.
- Apply engineering sketches to investigate ideas.
- Use pictorials and tonal shading techniques to enhance sketches.
- Develop skills in creating isometric, oblique, perspective, and multi-view sketches.
- Use sketches to maintain an object’s visual proportions.
- Derive 3-dimensional forms from plane figures.
- Display physical models resulting from the design process.
- Define the shape and size of objects using geometric and numeric constraints.
- Use Computer Aided Design (CAD) to model systems.
- Explore the use of the Inventor software to quickly generate and annotate working drawings.
- Use appropriate mathematical terminology to describe 2- or 3-dimensional contours that characterize an object.
- Discuss geometric constraints (e.g., parallel, perpendicular, horizontal, vertical, fixed, coincident, colinear, concentric, tangent, equal).
- Apply geometric constraints to real-world modeling.
- Create sketches, models, and virtual representations of objects and products.
- Use solid modeling programs to create designs for production.
- Compare and contrast solid modeling programs with traditional design methods.
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<td><strong>Skills and Topics:</strong></td>
<td>• compare and contrast the engineering design process and the scientific method</td>
<td>• evaluate the various sketching techniques for communication value</td>
<td>• recognize that packaging serves multiple purposes (e.g., protects, as well as markets the product)</td>
<td>• evaluate CAD systems as both additive and subtractive processes</td>
<td>• use models to evaluate an object or product on the basis of:</td>
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<td>• research the types of problems engineers seek to resolve</td>
<td>• insert accurate dimensions to drawings to communicate appropriate size information</td>
<td>• assemble individual objects systematically removing degrees of freedom</td>
<td>• use the Inventor software to demonstrate the additive and subtractive process in product design</td>
<td>o problems in the design</td>
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<td>• generate engineering drawings, including isometric, orthographic sections, and detailed views leading to complete engineering drawings</td>
<td>• identify the challenges presented when manufacturing products in different countries</td>
<td>• insert title blocks to provide the engineer and manufacturer with information regarding the object and its creator</td>
<td>• develop working drawings, including overall dimensions and center marks</td>
<td>o functional limitations</td>
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<td>• perform dimensional analysis to convert dimensions between systems of measurement</td>
<td>• determine the amount of variation based upon the precision of the measurement tool</td>
<td>• use parts lists and balloons to identify individual components in an assembly drawing</td>
<td>• distinguish among specialized dimensions and symbols used to communicate technical information (e.g., line type, size)</td>
<td>o communication of information</td>
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<td>• determine the amount of variation based upon the precision of the measurement tool</td>
<td>• perform statistical analysis on measurements to verify the quality of a design or process</td>
<td>• discuss tolerances to indicate the amount of dimensional variation without adversely affecting function</td>
<td>• explore and discuss real-world examples of tolerances for mating part features</td>
<td>• compare and contrast inclined surfaces represented in auxiliary views with their basic multi-view drawings</td>
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<td>• perform statistical analysis on measurements to verify the quality of a design or process</td>
<td>• recognize graphics used to communicate patterns in reports</td>
<td>• create mathematical formulas to establish geometric and functional relationships within designs</td>
<td>• use sectional views to communicate interior features difficult to visualize from outside views</td>
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<td><strong>Integration of Technology:</strong></td>
<td><em>Autodesk Inventor</em> software, Internet, Web Quests, wireless laptop computers, computer laboratory, portable language, laboratory, classroom computers, SMART Boards, multimedia presentations, simulations, video streaming, podcasting</td>
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<td><strong>Writing:</strong></td>
<td>Open-ended responses, conclusions and analysis of exploratory activities</td>
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<td><strong>Formative Assessments:</strong></td>
<td>Warm-up activities, exploratory activities, class discussions, student participation, quizzes, design briefs, sketches, Inventor research, benchmark assessments</td>
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<td><strong>Summative Assessments:</strong></td>
<td>Quizzes, tests, authentic assessments, projects, midterm examination, benchmark assessments</td>
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| **Performance Assessments:** | Projects:  
- locker organizer  
- enviable styrofoam cup  
Portfolio  
*PowerPoint* presentation: the history of design, organizations, and careers  
Student participation Assessments | Project: series of isometric-oblique-orthographic sketches  
Student participation Assessments | Project: puzzle cube  
Student participation Assessments | Project: geometric shapes  
Student participation Assessments | Project: modeling tutorials  
Student participation Assessments |
| **Interdisciplinary Connections:** | *ELA: RST.9-10.1-10, RST.11-12.1-10, WHST.9-10.1-2, 4-10, WHST.11-12.1-2, 4-10, SL.9-10.1-6, SL.11-12.1-6, L.9-10.1-6, L.11-12.1-6  
*Mathematics: N-Q.1-3, N-VM.1-5, F-IF.1-2, F-IF.4-7, F-BF.1.a-c, F-LE.1-5  
Arts: The Arts are exemplified through the implementation of the elements of design applied while developing industrial solutions via prototypes.  
World Language: 7.1.A.L.B.5  
21st Century Life/Careers: 9.2.12.C.1, 9.2.12.C.5-7* | | | | |
| **21st Century Themes:** | ☒Global Awareness ☐Civic Literacy ☐Financial, Economic, Business, and Entrepreneurial Literacy ☐Health Literacy | | | | |
| **21st Century Skills:** | ☒Creativity and Innovation ☐Media Literacy ☐Critical Thinking and Problem Solving ☐Life and Career Skills ☒Information and Communication Technologies Literacy ☐Communication and Collaboration ☐Information Literacy | | | | |
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*2016 NJSLS:

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- WHST: Writing in History, Science, and Technical Subjects
- SL: Speaking and Listening
- L: Language

- N: Real Number System
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- MD: Measurement and Data
- N-Q: Quantities
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- A- SSE: Seeing Structure in Expressions
- A-REI: Reasoning with Equations and Inequalities
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- F-TF: Trigonometric Functions
- G-CO: Congruence
- G-SRT: Similarity, Right Triangles, and Trigonometry
- G-C: Circles
- G-GPE: Expressing Geometric Properties with Equations
- S-ID: Interpreting Categorical and Quantitative Data
- S-IC: Making Inferences and Justifying Conclusions
- S-CP: Conditional Probability and the Rules of Probability
- S-MD: Using Probability to Make Decisions
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### Essential Question:
- How are moving parts of assemblies put into motion?
- How can functional analysis facilitate rapid design and development?
- How do engineers work and communicate as a team?
- How does the design process facilitate real-world design?
- How are designs engineered to be earth friendly?

### Content:
- Assembly Modeling
- Functional Analysis
- Reverse Engineering
- Real-world Product Design
- Design Ethics and Teams

### Skills and Topics:
- **conduct research to enhance basic knowledge of a problem or need, to stimulate creative ideas for solutions to the problem, and to make informed decisions**
- **create design solutions individually and as a team**
- **use design briefs to explain the problem, identify solution expectations, and establish project constraints**
- **use the design process to create solutions to existing problems**
- **apply structural and functional design principles and elements as a purposeful vocabulary to describe an object independent of its formal title and structural and functional qualities**
- **manipulate tangible design elements according to conceptual design principles**
- **adjust the interplay between design principles and elements for functional appeal**
- **perform reverse engineering on products to study their visual, functional, and structural qualities**
- **delineate the sequence of the operations of a product’s function**
- **identify the inputs and outputs of product operations within a system**
- **explore the methods of securing objects (e.g., adhesives, fasteners, joinery) review precision measurement tools and techniques used to accurately record the**
- **research problems in industrial design to evaluate shortcomings and identify opportunities for possible innovations use brainstorming techniques to generate ideas apply matrices to data analysis and decision making**
- **explore the nature of technical reports explaining project information to various audiences design a solution to a problem, including:**
  - geometry
  - assembly
- **examine all parameters of a potential material to be used in manufacturing evaluate environmental impact of material usage recognize legal guidelines established to protect humans and the global environment investigate recycling as a solution to the future saturation of landfills self-regulate a team of students through brainstorming and consensus**
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<td><strong>Skills and Topics:</strong></td>
<td>• generate and annotate working drawings (e.g., dot inventor assembly model drawing)</td>
<td>• reflect the visual characteristics of a design through structural and functional requirements</td>
<td>• geometry of an object</td>
<td>• discover, evaluate, and conclude the importance of standardization and implement in engineering design</td>
<td>• explore the implementation of a Gantt chart to plan, manage, and control team actions on projects with definitive due dates</td>
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<td>• import assembly pieces and parts into the top-level assembly drawing</td>
<td>• create the assembly using assembly constraints:</td>
<td>• examine specific parameters to determine the material composition of a design (e.g., operational conditions, material properties, manufacturing methods)</td>
<td>• present, defend, and evaluate a final project using all the tools learned to solve an engineering problem</td>
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<td>• create the assembly using assembly constraints:</td>
<td>• put moving parts in motion through the use of driven constraints</td>
<td>• calculate the mass properties of designed objects using reference sources and the Inventor software program</td>
<td>• explore the use of mechanisms in simple machines to move loads through the input of applied effort forces</td>
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• use fluid power concepts to enhance design solutions |   |   |   |   |
| **Integration of Technology:** | Autodesk Inventor software, Internet, Web Quests, wireless laptop computers, computer laboratory, portable language, laboratory, classroom computers, SMART Boards, multimedia presentations, simulations, video streaming, podcasting |   |   |   |   |
| **Writing:** | Open-ended responses, conclusions and analysis of exploratory activities |   |   |   |   |
| **Formative Assessments:** | Warm-up activities, exploratory activities, class discussions, student participation, quizzes, design briefs, sketches, Inventor research, benchmark assessments |   |   |   |   |
| **Summative Assessments:** | Quizzes, tests, authentic assessments, projects, final examination, benchmark assessments |   |   |   |   |
| **Performance Assessments:** | Project: train tutorials  
Student participation Assessments | Project: house parameters  
Student participation Assessments | Student participation Assessments | Project: the classified project  
Student participation Assessments | Student participation Assessments |
| **Interdisciplinary Connections:** | *ELA: RST.9-10.1-10, RST.11-12.1-10, WHST.9-10.1-2, 4-10, WHST.11-12.1-2, 4-10, SL.9-10.1-6, SL.11-12.1-6, L.9-10.1-6, L.11-12.1-6  
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Arts: The Arts are exemplified through the implementation of the elements of design applied while developing industrial solutions via prototypes.  
World Language: 7.1.AL.B.5  
| **21st Century Themes:** | ☒Global Awareness ☑Civic Literacy  
☐Financial, Economic, Business, and Entrepreneurial Literacy ☐Health Literacy |   |   |   |   |
| **21st Century Skills:** | ☒Creativity and Innovation ☑Media Literacy  
☒Critical Thinking and Problem Solving ☑Life and Career Skills  
☒Information and Communication Technologies Literacy ☑Communication and Collaboration ☐Information |   |   |   |   |
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G-P: Expressing Geometric Properties with Equations  
S-ID: Interpreting Categorical and Quantitative Data  
S-IC: Making Inferences and Justifying Conclusions  
S-MD: Using Probability to Make Decisions
Introduction to Engineering Design
Course Requirements

Grade: 9, 10, 11, or 12  Prerequisite: None  Credit Value: 5
Length of Course: Academic Year

Course Description

The Introduction to Engineering Design course is the first in the Project Lead The Way pre-engineering sequence. Students are introduced to the design process, build individual portfolios, and use Autodesk Inventor to model, create sketches, and engineer designs. Hands-on activities augment computer technology in studying engineering projects. Benchmark assessments are employed to track individual student progress.

Course Content

This course will consist of the following units of study:
- Introduction to the Design Process
- Technical Sketching, Drawing, Measurement, and Statistics
- The Puzzle Cube Project
- Geometric Constraints
- Advanced Modeling
- Assembly Modeling
- Functional Analysis
- Reverse Engineering
- Real-world Product Design
- Design Ethics and Teams

Course Objectives

The student will demonstrate the ability to answer in detail the following essential questions:
- How does engineering transform an idea into a product?
- Why are mathematical applications necessary to the design process?
- How is software used to design prototypes?
- How are geometric properties used to model real-world objects?
- What is the significance of modeling in developing prototypes?
- How are moving parts of assemblies put into motion?
- How can functional analysis facilitate rapid design and development?
- How do engineers work and communicate as a team?
Course Objectives (continued)

- How does the design process facilitate real-world design?
- How are designs engineered to be earth friendly?
- What are the post-graduation and/or career options that apply to the course content?

Evaluation Process

A final average of 65% or better is required to be awarded course credit. Throughout the length of this course, students may be evaluated on the basis of, but not limited to:

- Formative Assessments, such as writing prompts, journals, and portfolios
- Summative Assessments, such as quizzes, tests, and midterm and final examinations
- Performance Assessments, such as projects and presentations
- Technology-based Applications, such as electronic portfolios, Web Quests, ThinkQuest, and podcasting
- Class Participation
- Homework

Specific weights will be determined by course and level.
Introduction to Engineering Design
Student Agreement

STUDENT NAME: ____________________________________________________________

Last Name                           First Name

GRADE: __________________________

My signature below indicates that I have received a copy of the
Somerville Public Schools Course Requirements for Introduction to
Engineering Design.

I acknowledge my responsibility to read and understand all of the
information contained in the Introduction to Engineering Design
Course Requirements information and syllabus packet.

_________________________________________  ___________________________
Student Signature                      Date

Note: Please share the course requirements for Introduction to Engineering Design with your
parents.