The Principles of Engineering course advances students’ knowledge of engineering through a firm and in-depth exploration of multiple engineering fields. Students learn about simple and advanced machines and the design and build of such machines, including a freight elevator and a marble sorting machine. Computer-integrated manufacturing is explored through programming, virtual design, manufacturing, and automating original student designs using the Computer Numerically Controlled (CNC) mill and robotic arm. Principles of Engineering focuses on identifying, designing, building, and testing bridges. Benchmark assessments are employed to track individual student progress.

Adopted by the Somerville Board of Education on July 25, 2017
## Principles of Engineering
### Grade 10, 11, or 12

<table>
<thead>
<tr>
<th>Month/Marking Period</th>
<th>September</th>
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</table>

### Essential Question:
- How do simple machines improve society in everyday life?
- How do open-loop and closed-loop systems compare?
- How can programming machines perform and enhance the roles of engineers in society?
- What is Computer Integrated Manufacturing (CIM) and how does it relate to a CNC machine?
- How can a CNC machine improve the efficiency of manufacturing parts?

### Content:
- Simple Machines
  - Open-loop and Closed-loop Systems
  - Systems and Systems Programming
  - CNC Programming and Engineering Dimensioning
  - Manufacturing

### Skills and Topics:
- Explore simple machines and the work they accomplish
- Review the contributions of Rube Goldberg to the science of simple machines
- Research the interactions among simple machines:
  - Interactions
  - Virtual
  - Calculations
  - Construction
  - Evaluation
- Understand the Fischertechnik Interface
- Explore the implementation of the ROBO Pro program
- Distinguish between the terms digital and analog
- Create, evaluate, compare, and contrast the characteristics of input and output in:
  - Open-loop and closed-loop systems in the real world
  - Programming motors and switches
  - Counting programs
- Select and use sub-programs appropriate to the task
- Exhibit decisions while working within computer programs
- Write the computer code to operate a robotic vehicle with a decision maker and sub-programs
- Investigate the applications served by elevators in the real world
- Identify the components of the design brief and practice using as a form of documenting formulations
- Sketch, construct, and program a three-floor elevator
- Place the history of the development of CIM and CNC machines into a timeline perspective
- Understand the basic codes, operation, and motion programming of CNC machines
- Use the basic codes to engrave a design as a prototype on the CNC machine
- Construct hole and pocket Computer Aided Design (CAD) drawings using the CNC machine
- Use basic engineering dimensioning for manufacturing prototype projects
- Use CNC advanced codes, operations, and programming to improve upon the prototype projects manufactured
- Implement circular interpolations of code
- Use Yin Yang circular drawing as related to the CNC machine
- Practice using circular and arc-dimensioning commands
- Coordinate between designer/machinist design and dimensioning
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<td><strong>Skills and Topics:</strong></td>
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<td></td>
<td>• investigate applications for marble sorters in the real world</td>
<td>• construct multi-sheet engineering drawings with detail and section views</td>
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<tr>
<td><strong>Integration of Technology:</strong></td>
<td></td>
<td></td>
<td>• construct and program a marble sorter</td>
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<tr>
<td><a href="http://www.edheads.org/activities/simple-machines">www.edheads.org/activities/simple-machines</a>, Internet, Web Quests, wireless laptop computers, computer laboratory, portable language, laboratory, classroom computers, ROBO Pro programming software, Fischertechnik Engineering Kit, CNC programming software, proLIGHT 1000 CNC Machine, Autodesk Inventor software, Vernier calipers, SMART Boards, multimedia presentations, video streaming, podcasting</td>
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<td><strong>Performance Assessments:</strong></td>
<td>Student participation Assessments Simple machine projects</td>
<td>Student participation Assessments Design briefs Written evaluations</td>
<td>Student participation Assessments Chart of points Design briefs Written evaluations</td>
<td>Student participation Assessments Chart of points Design briefs Written evaluations Multi-sheet engineering drawings, engineering dimensions, and evaluations</td>
<td>Student participation Assessments Chart of points Design briefs Written evaluations Multi-sheet engineering drawings Designer/Machinist revision drawings</td>
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# Principles of Engineering

**Grade 10, 11, or 12**

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<td>☑ Financial, Economic, Business, and Entrepreneurial Literacy</td>
<td>☐ Health Literacy</td>
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<td><strong>Careers:</strong></td>
<td>Applicable career options are discussed as they arise throughout the pre-engineering program. Career options include, but are not limited to, the following career clusters: Architecture and Construction Career Cluster; Arts, A/V Technology, and Communications Career Cluster; Business, Management, and Administration Career Cluster; Education and Training Career Cluster; Finance Career Cluster; Government and Public Administration Career Cluster; Health Science Career Cluster; Human Services Career Cluster; Information Technology Career Cluster; Law, Public Safety, Correction, and Security Career Cluster; Manufacturing Career Cluster; Marketing Career Cluster; Science, Technology, Engineering and Mathematics Career Cluster; Transportation, Distribution, and Logistics Career Cluster.</td>
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*2016 NJSLS:*

- RL: Reading Literature
  - N: Real Number System
- RI: Reading Informational Text
  - A: Algebra
- W: Writing
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- SL: Speaking and Listening
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  - S: Statistics and Probability
- MD: Measurement and Data
### Principles of Engineering
#### Grade 10, 11, or 12

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**Essential Question:**
- When is clear communication between a designer and a machinist important?
- Why are the properties and variance of materials critical to daily life?
- Why are geometric shapes and figures critical to the construction of bridges?
- How do the internal member forces affect the design of a bridge?
- Why is the efficiency of a bridge more important than the actual strength?

**Content:**
- CNC Programming and Engineering Dimensioning
- Materials, Statistics, and the Stress-Strain Diagram
- Bridge Design
- Statics, Bridges, and Mathematical Models
- Statics, Bridges, and Mathematical Models

**Skills and Topics:**
- Discuss the importance of robust communication between designers and machinists
- Create an engineering drawing for a 3rd party
- Generate CNC code from a 3rd party drawing
- Revise an engineering drawing
- Thoroughly inspect a manufactured part for inherent design flaws
- Research and design a personalized jewelry box
- Create engineering drawings and CNC code using Edgecam software
- Research solid material usages
- Mathematically substantiate the application of materials’ tension and compression to serve a function
- Determine the Modulus of Elasticity of different materials
- Describe and use the stress-strain curve to select materials to serve a purpose
- Perform tensile testing on representative metals (e.g., aluminum, brass, steel) and present collected data in an organized form
- Use the West Point Bridge software to design a bridge
- Research a brief history of bridges
- Recognize and define bridge types using appropriate terminology
- Engage in a bridge-type simulation
- Review the strengths afforded to bridges through the implementation of shapes within the design
- Evaluate forces as applied to bridges
- Create free-body diagrams to calculate the forces as vectors in trusses
- Identify and evaluate force vectors as applied to trusses
- Calculate the internal member forces for trusses
- Identify the beneficial properties of beams in the design of bridges
- Calculate and evaluate:
  - Centroids
  - Moment of inertia
  - Modulus of elasticity
  - Loads as applied to bridges
- Compare and contrast the design of different bridges
- Determine the strength and efficiency of a model bridge
- Apply the West Point Bridge software to design and evaluate sample model bridges
- Apply the MD Solids software to evaluate and test model bridges
## Principles of Engineering
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<td>• recognize the relationship between the margin of error inherent in measuring tensile strength and quality control assuredness of the products</td>
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<td><a href="http://www.buildingbig.org">www.buildingbig.org</a>, <a href="http://www.sodaplay.com">www.sodaplay.com</a>, Internet, Web Quests, wireless laptop computers, computer laboratory, portable language, laboratory, classroom computers, SMART Boards, multimedia presentations, video streaming, podcasting</td>
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<td>Student participation Assessments Chart of points CNC code Final product, inspection, and written evaluation Jewelry box design brief <em>Autodesk Inventor</em> drawings Designer/Machinist engineering drawings <em>Edgecam</em> program and evaluation</td>
<td>Student participation Assessments Materials activity presentation Tension and compression problem-solving packet Tensile test spreadsheet analysis Margin of error and measuring statistics and quality control activity</td>
<td>Student participation Assessments <em>West Point Bridge</em> competition Bridge activities Strength of shapes activity Forces activity Free-body diagrams Vector problems</td>
<td>Student participation Assessments Internal member forces Loads activity MD solids internal member forces activity Properties of beams activity 2x4 scale activity Centroid activity</td>
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- **L:** Language
- **S:** Statistics and Probability
- **MD:** Measurement and Data
Principles of Engineering
Course Requirements

Grade: 10, 11, or 12  Prerequisite: Introduction to Engineering Design  Credit Value: 5
Length of Course: Academic Year

Course Description

The Principles of Engineering course advances students’ knowledge of engineering through a firm and in-depth exploration of multiple engineering fields. Students learn about simple and advanced machines and the design and build of such machines, including a freight elevator and a marble sorting machine. Computer-integrated manufacturing is explored through programming, virtual design, manufacturing, and automating original student designs using the Computer Numerically Controlled (CNC) mill and robotic arm. Principles of Engineering focuses on identifying, designing, building, and testing bridges. Benchmark assessments are employed to track individual student progress.

Course Content

This course will consist of the following units of study:

- Simple Machines
- Open-loop and Closed-loop Systems
- Systems and Systems programming
- CNC Programming and Engineering Dimensioning
- Manufacturing
- CNC Programming and Engineering Dimensioning
- Materials, Statistics, and the Stress-strain Diagram
- Bridge Design
- Statics, Bridges, and Mathematical Models

Course Objectives

The student will demonstrate the ability to answer in detail the following essential questions:

- How do simple machines improve society in everyday life?
- How do open-loop and closed-loop systems compare?
- How can programming machines perform and enhance the roles of engineers in society?
- What is Computer Integrated Manufacturing (CIM) and how does it relate to a CNC machine?
- How can a CNC machine improve the efficiency of manufacturing parts?
Course Objectives (continued)

- When is clear communication between a designer and a machinist important?
- Why are the properties and variance of materials critical to daily life?
- Why are geometric shapes and figures critical to the construction of bridges?
- How do the internal member forces affect the design of a bridge?
- Why is the efficiency of a bridge more important than the actual strength?
- 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.
Principles of Engineering
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 Principles of
Engineering.

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

________________________________________  _______________________
Student Signature              Date

Note: Please share the course requirements for Principles of Engineering with your parents.