CURRICULUM

FOR

ADVANCED COMPUTER AIDED DRAFTING

GRADES 10 - 12

This curriculum is part of the Educational Program of Studies of the Rahway Public Schools.

ACKNOWLEDGMENTS

Dr. Susan Dube, Program Supervisor Science/Technology Education

The Board acknowledges the following who contributed to the preparation of this curriculum.

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Subject/Course Title:
Technology/Advanced Computer Aided Drafting
Grades 10-12

Date of Board Adoptions:
September 17, 2019

RAHWAY PUBLIC SCHOOLS CURRICULUM

Advanced Computer Aided Drafting – Grades 10-12

PACING GUIDE

Unit	Title	Pacing
1	Introduction to Rapid Prototyping	3 weeks
2	Orthographic & Isometric Representation	4 weeks
3	2D Computer Aided Drafting	4 weeks
4	Introduction to 3D Computer Drafting	5 weeks
5	Complex 3D Solid Drafting	5 weeks
6	Preparing & Printing 3D Objects	3 weeks
7	Advanced Solid Generation Tools	4 weeks
8	Structural Design & 3D Printing	4 weeks
9	Building Multi-part systems	6 weeks

ACCOMMODAITONS

504 Accommodations:

- Provide scaffolded vocabulary and vocabulary lists.
- Provide extra visual and verbal cues and prompts.
- Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
- Provide links to audio files and utilize video clips.
- Provide graphic organizers and/or checklists.
- Provide modified rubrics.
- Provide a copy of teaching notes, especially any key terms, in advance.
- Allow additional time to complete assignments and/or assessments.
- Provide shorter writing assignments.
- Provide sentence starters.
- Utilize small group instruction.
- Utilize Think-Pair-Share structure.
- Check for understanding frequently.
- Have student restate information.
- Support auditory presentations with visuals.
- Weekly home-school communication tools (notebook, daily log, phone calls or email messages).
- Provide study sheets and teacher outlines prior to assessments.
- Quiet corner or room to calm down and relax when anxious.
- Reduction of distractions.
- Permit answers to be dictated.
- Hands-on activities.
- Use of manipulatives.
- Assign preferential seating.
- No penalty for spelling errors or sloppy handwriting.
- Follow a routine/schedule.
- Provide student with rest breaks.
- Use verbal and visual cues regarding directions and staying on task.
- Assist in maintaining agenda book.

IEP Accommodations:

- Provide scaffolded vocabulary and vocabulary lists.
- Differentiate reading levels of texts (e.g., Newsela).
- Provide adapted/alternate/excerpted versions of the text and/or modified supplementary materials.
- Provide extra visual and verbal cues and prompts.
- Provide links to audio files and utilize video clips.
- Provide graphic organizers and/or checklists.
- Provide modified rubrics.
- Provide a copy of teaching notes, especially any key terms, in advance.
- Provide students with additional information to supplement notes.
- Modify questioning techniques and provide a reduced number of questions or items on tests.
- Allow additional time to complete assignments and/or assessments.
- Provide shorter writing assignments.
- Provide sentence starters.
- Utilize small group instruction.
- Utilize Think-Pair-Share structure.
- Check for understanding frequently.
- Have student restate information.
- Support auditory presentations with visuals.
- Provide study sheets and teacher outlines prior to assessments.
- Use of manipulatives.
- Have students work with partners or in groups for reading, presentations, assignments, and analyses.
- Assign appropriate roles in collaborative work.
- Assign preferential seating.
- Follow a routine/schedule.

Gifted and Talented Accommodations:

- Differentiate reading levels of texts (e.g., Newsela).
- Offer students additional texts with higher lexile levels.
- Provide more challenging and/or more supplemental readings and/or activities to deepen understanding.
- Allow for independent reading, research, and projects.
- Accelerate or compact the curriculum.
- Offer higher-level thinking questions for deeper analysis.
- Offer more rigorous materials/tasks/prompts.
- Increase number and complexity of sources.
- Assign group research and presentations to teach the class.
- Assign/allow for leadership roles during collaborative work and in other learning activities.

ELL Accommodations:

- Provide extended time.
- Assign preferential seating.
- Assign peer buddy who the student can work with.
- Check for understanding frequently.
- Provide language feedback often (such as grammar errors, tenses, subject-verb agreements, etc…).
- Have student repeat directions.
- Make vocabulary words available during classwork and exams.
- Use study guides/checklists to organize information.
- Repeat directions.
- Increase one-on-one conferencing.
- Allow student to listen to an audio version of the text.
- Give directions in small, distinct steps.
- Allow copying from paper/book.
- Give student a copy of the class notes.
- Provide written and oral instructions.
- Differentiate reading levels of texts (e.g., Newsela).
- Shorten assignments.
- Read directions aloud to student.

	• Give oral clues or prompts. • Record or type assignments. • Adapt worksheets/packets. • Create alternate assignments. • Have student enter written assignments in criterion, where they can use the planning maps to help get them started and receive feedback after it is submitted. • Allow student to resubmit assignments. • Use small group instruction. • Simplify language. • Provide scaffolded vocabulary and vocabulary lists. • Demonstrate concepts possibly through the use of visuals. • Use manipulatives. • Emphasize critical information by highlighting it for the student. • Use graphic organizers. • Pre-teach or pre-view vocabulary. • Provide student with a list of prompts or sentence starters that they can use when completing a written assignment. • Provide audio versions of the textbooks. • Highlight textbooks/study guides. • Use supplementary materials. • Give assistance in note taking • Use adapted/modified textbooks. • Allow use of computer/word processor. • Allow student to answer orally, give extended time (time-and-a-half). • Allow tests to be given in a separate location (with the ESL teacher). • Allow additional time to complete assignments and/or assessments. • Read question to student to clarify. • Provide a definition or synonym for words on a test that do not impact the validity of the exam. • Modify the format of assessments. • Shorten test length or require only selected test items. • Create alternative assessments. • On an exam other than a spelling test, don't take points off for spelling errors.

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Advanced Computer Aided Drafting and Modeling

Unit Title: Unit 1 - Introduction to Rapid Prototyping

Target Course/Grade Level: 9-12

Unit Summary: Students will learn about the process behind designing and creating a prototype (functional test model). Throughout the unit students will observe different rapid prototyping methods and compare the benefits between each device. Teacher examples and videos will be used to demonstrate the abilities of each machine. Students will also learn about manipulating and troubleshooting 3D printers.

Approximate Length of Unit: About 3 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

- 8.1.12.E.2 Research and evaluate the impact on society of the unethical use of digital tools and present your research to peers.
- 8.1.12.F.1 Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.
- 8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system
- 8.2.12.C.3 Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).
- 8.2.12.C.1 Explain how open source technologies follow the design process.
- 8.2.12.B.2 Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation and maintenance of a chosen product.

21st Century Life and Career Skills:

- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.

Interdisciplinary Connections and Standards:

- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.8. Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

Unit Understandings:

Students will understand that…

- engineers follow the engineering design process to create products
- prototypes are functional product models that are tested and evaluated
- 3D printers, CNC machines, and laser engravers are all examples of rapid prototyping machines
- computer made designs can be exported for rapid production
- each rapid prototyping machine has unique abilities and benefits

Unit Essential Questions:

- How do ideas become inventions?
- What makes something a prototype?
- What is the difference between form and function? Can the two work together?
- How do dimensions form flat and solid objects?
- How can 2D drawings be made into 3D objects?
- What makes a rapid prototyping device right for a design?
- What steps need to be taken to properly and safely 3D print?

Knowledge and Skills:

Students will know…..

- the definition of prototyping and rapid prototyping
- the engineering design loop (all steps)
- elements of engineering design, such as constraints, limitations, and demographic
- the difference between 2D and 3D objects
- the difference between additive and subtractive prototyping devices
- how 3D printers, laser cutters, and CNC mills function as rapid prototyping devices
- how generic 3D printers work and the common errors can be remedied

Performance Expectations:

Students will be able to …

- identify the steps of the engineering design process
- synthesize a basic design for a product to solve a given problem
- construct a 3D prototype shape from a series of thin 2D parts (Lego)
- determine the best prototyping method for a part based on a general description
- model how to level a 3D printer bed
- demonstrate the process for changing a 3D printer's filament
- evaluate and troubleshoot a non-functioning 3D printer

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- **End of Unit Assessment:**
  - Students will identify different prototyping machines and discuss their uses.
  - Students will also identify the steps of the engineering design loop and what they mean.
  - Students will construct a 3D prototype shape from given materials.
- Student participation in class discussions
- Classwork Assignments (worksheets, note sheets)
- Practical 3D printer troubleshooting assessment (observed)

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Various presentations of content
- Videos and live demonstrations of 3D printers
- Research based activities on rapid prototyping methods
- One on one lessons on troubleshooting 3D printers
- Analysis and comparison of 3D printed objects

RESOURCES

Teacher Resources:

- Teacher developed worksheets
- Teacher developed note sheets
- Teacher developed example 3D prints

Equipment Needed:

- Classroom computers
- 3D printers
- Class projector

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Advanced Computer Aided Drafting and Modeling

Unit Title: Unit 2-Orthographic and Isometric Representation

Target Course/Grade Level: 9-12

Unit Summary: Students will learn the foundations of engineering hand drafting by learning both orthographic (2D) and isometric (3D) styles. This unit will focus on drawing 3D objects clearly in 2D formats. By the end of the unit students will be able to analyze basic engineering drawings and draw accurate plans of their own. This unit will heavily emphasize measuring correctly and using proper measurement units.

Approximate Length of Unit: About 4 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

- 8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled
- 8.2.12.C.2 Analyze a product and how it has changed or might change over time to meet human needs and wants
- 8.2.12.B.3 Analyze ethical and unethical practices around intellectual property rights as influenced by human wants and/or needs.

21st Century Life and Career Skills:

- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects.

Interdisciplinary Connections and Standards:

- 8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled
- G-CO-D12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.
- G-SRT-A1 Understand similarity in terms of similarity transformations
    - a. Verify experimentally the properties of dilations given by a center and a scale factor: a. A dilation takes a line not passing through the center of the dilation to a parallel line, and leaves a line passing through the center unchanged.
    - b. The dilation of a line segment is longer or shorter in the ratio given by the scale factor

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

Unit Understandings:

Students will understand that…

- engineering designs need to have dimensions in order to be replicated/produced
- X, Y, and Z are the dimensions that shape 3D objects
- different drafting styles allow for different representation of objects
- accurate measurements are essential for engineering design

Unit Essential Questions:

- How can a 3D object be represented on a 2D medium?
- Why are proper measurements so essential for engineering design?
- What are the benefits of orthographic representation?

Knowledge and Skills:

Students will know…..

- why measurements are essential to engineering design
- how dimensions like length, width, and height form 3D objects
- the difference between 2D and 3D shapes
- the difference between orthographic and isometric representations

Performance Expectations:

Students will be able to …

- demonstrate how to read and analyze an orthographic drawing
- synthesize orthographic and isometric drawings of given objects
- compare and contrast engineering drawing styles
- model how to properly use a ruler and caliper to measure objects
- identify need for clean and accurate engineering designs
- create isometric drawings from given orthographic drawings
- create orthographic drawings from isometric drawings

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- **End of Unit Assessment:**
  - Students will identify drafting elements (hidden lines, views, etc.).
  - Students will also correct incorrect drawings.
  - Students will synthesize their own orthographic and isometric drawings.
- Student participation in class discussions
- Classwork Assignments (worksheets, note sheets)
- Student Orthographic/Isometric Drawings

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Various presentations of content
- Teacher examples and demonstrations of drawing methods
- Orthographic design practice packet

- Isometric design practice packet
- Both physical (solid objects) and 2D (drawing) 3D drawing practice prompts

RESOURCES

Teacher Resources:

- Teacher developed drawing examples
- Teacher developed practice packets
- Teacher developed measurement models
- Teacher developed practice worksheets

Equipment Needed:

- Classroom drafting supplies
- Scanner (for teacher examples)

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Advanced Computer Aided Drafting and Modeling

Unit Title: Unit 3 - 2D Computer Aided Drafting (AutoCAD)

Target Course/Grade Level: 9-12

Unit Summary: Students will learn the basics of using AutoCAD to draft 2D designs on the computer. This unit will rely heavily on the previous unit's examples in order to help students transition to drafting in a digital setting. Students will use the computers to construct accurate 2D models of given objects. After the students have had ample practice they will work on designing a drag racer in the program. The dragsters will be 3D printed and students will race to determine who made the best design.

Approximate Length of Unit: 4 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

- 8.2.12.A.1 Propose an innovation to meet future demands supported by an analysis of the potential full costs, benefits, trade-offs and risks, related to the use of the innovation.
- 8.2.12.B.3 Analyze ethical and unethical practices around intellectual property rights as influenced by human wants and/or needs.
- 8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system
- 8.2.12.C.1 Explain how open source technologies follow the design process.

21st Century Life and Career Skills:

- 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects.
- 9.3.MN-QA.3 Coordinate work teams to create a product that meets quality assurance standards.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.

Interdisciplinary Connections and Standards:

- G-CO-D12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.
- G-CO.A4 Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.

- G-CO.A5 Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

Unit Understandings:

Students will understand that…

- drafting software allows for easily legible designs to be produced
- drafting software can generate precise and accurate designs
- multiple tools may be combined to draw shapes in AutoCAD
- drafting relies on basic trigonometry
- lines (in drafting programs) refer to both an angle and length

Unit Essential Questions:

- What are the benefits of using drafting software over drafting by hand?
- How can a 3D object be transferred to a 2D digital medium?
- Is there one specific way to draw a shape in AutoCAD?
- What is scale and why is it important for engineering design?

Knowledge and Skills:

Students will know…..

- the primary tools in AutoCAD (button location and keyboard command)
- Pythagorean theorem and its use in drafting
- the uses of CAD software in the engineering field
- the definition of scale and how it affects drafting plans and object production
- there is no set process or path to create an object in CAD (different tools can still make the same shape)

Performance Expectations:

Students will be able to …

- demonstrate how to utilize the line, rectangle, circle, and shape tool in AutoCAD
- analyze and correct CAD plans
- construct orthographic and isometric drafting plans in AutoCAD
- analyze CAD plans to determine missing measurements
- debate the benefits and flaws of CAD
- utilize hidden lines in AutoCAD

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- **End of Unit Assessment:**
  - Students will identify the use of each tool.
- **Practical CAD End of Unit Assessment:**
  - Using AutoCAD, students will create two orthographic drawings of two given objects.

- Student participation in class discussions
- Classwork Assignments (worksheets, note sheets)

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Various presentations of content
- Teacher examples and demonstrations of drawing methods
- Both physical (solid objects) and 2D (drawing) 3D drawing practice prompts
- Worksheets

RESOURCES

Teacher Resources:

- Teacher developed measurement objects
- Teacher designed practice packets
- Teacher designed worksheets
- Teacher designed note sheets

Equipment Needed:

- Classroom computers with AutoCAD

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Advanced Computer Aided Drafting and Modeling

Unit Title: Unit 4 - 2D Computer Aided Drafting (AutoCAD)

Target Course/Grade Level: 9-12

Unit Summary: Students will learn the basics of using AutoCAD to draft 2D designs on the computer. This unit will rely heavily on the previous unit's examples in order to help students transition to drafting in a digital setting. Students will use the computers to construct accurate 2D models of given objects. Students will use tool within AutoCAD to add dimensions and properly lay out CAD build plans.

Approximate Length of Unit: About 4 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

- 8.2.12.A.1 Propose an innovation to meet future demands supported by an analysis of the potential full costs, benefits, trade-offs and risks, related to the use of the innovation.
- 8.2.12.B.3 Analyze ethical and unethical practices around intellectual property rights as influenced by human wants and/or needs.
- 8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system
- 8.2.12.C.1 Explain how open source technologies follow the design process.

21st Century Life and Career Skills:

- 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects.
- 9.3.MN-QA.3 Coordinate work teams to create a product that meets quality assurance standards.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.

Interdisciplinary Connections and Standards:

- G-CO-D12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.
- G-CO.A4 Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.

- G-CO.A5 Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy)

Unit Understandings:

Students will understand that…

- drafting software allows for easily legible designs to be produced
- drafting software can generate precise and accurate designs
- multiple tools may be combined to draw shapes in AutoCAD
- drafting relies on basic trigonometry
- lines (in drafting programs) refer to both an angle and length

Unit Essential Questions:

- What are the benefits of using drafting software over drafting by hand?
- How can a 3D object be transferred to a 2D digital medium?
- Is there one specific way to draw a shape in AutoCAD?
- What is scale and why is it important for engineering design?

Knowledge and Skills:

Students will know…..

- the primary tools in AutoCAD (button location and keyboard command)
- Pythagorean theorem and its use in drafting
- the uses of CAD software in the engineering field
- the definition of scale and how it affects drafting plans and object production
- there is no set process or path to create an object in CAD (different tools can still make the same shape)

Performance Expectations:

Students will be able to …

- demonstrate how to utilize the line, rectangle, circle, and shape tool in AutoCAD
- analyze and correct CAD plans
- construct orthographic and isometric drafting plans in AutoCAD
- analyze CAD plans to determine missing measurements
- debate the benefits and flaws of CAD
- utilize hidden lines in AutoCAD

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- **End of Unit Assessment**:
  - Students will identify TinkerCAD tools and will state what they are used for.
  - Students will select the best tools and processes needed to create certain shapes.

- **Practical CAD End of Unit Assessment**:
    - Students will need to follow a strict list of instructions in order to develop an identical shape (designed by the teacher).
- Student participation in class discussions
- Classwork Assignments (worksheets, note sheets)

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Various presentations of content
- Teacher examples and demonstrations of drawing methods
- Both physical (solid objects) and 2D (drawing) 3D drawing practice prompts
- Worksheets

RESOURCES

Teacher Resources:

- Teacher developed practice packets
- Teacher developed 3D printed measurement models
- Teacher developed worksheets
- Teacher developed note sheets and program tool guides

Equipment Needed:

- Classroom computers with AutoCAD
- Calipers
- Rulers
- Teacher screencast software

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Advanced Computer Aided Drafting and Modeling

Unit Title: Unit 5 - Introduction to 3D Computer Drafting (TinkerCAD)

Target Course/Grade Level: 9-12

Unit Summary: Students will learn the basics of using TinkerCAD (a web browser based 3D design program). Students will learn about shaping, sizing, combing, and subtracting 3D shapes to create a final product. The unit will begin with students designing small copies of teacher models and will culminate with students planning, designing, and fabricating drag racers. Students will learn about quality control and design evaluation and utilize that information to analyze their projects.

Approximate Length of Unit: About 4 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

- 8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled
- 8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system
- 8.2.12.D.5 Explain how material processing impacts the quality of engineered and fabricated products.
- 8.2.12.A.2 Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.

21st Century Life and Career Skills:

- 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects.
- 9.3.ST-ET.4 Apply the elements of the design process.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.

Interdisciplinary Connections and Standards:

- G-GMD.B4 Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.
- G-GMG.A1 Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder)
- G-CO.A5 Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

Unit Understandings:

Students will understand that…

- 3D shapes can be viewed and manipulated from any angle
- complex shapes are made up of smaller, easier to manipulate shapes
- 3D shapes' dimensions can be modified by measurement changes or manual changes
- shapes can be added to a given base to create unique modifications

Unit Essential Questions:

- How can typical shapes be altered to create complex shapes?
- How can two 3D objects be combined to create a singular object?
- What is the difference between additive and subtractive shape grouping?
- What makes a design unique and original?

Knowledge and Skills:

Students will know…..

- the primary tools in TinkerCAD
- the designed usage of simple 3D CAD programs
- the benefits and faults of simple 3D CAD programs
- the process for combining shapes to either add or subtract features

Performance Expectations:

Students will be able to …

- demonstrate how place shapes and navigate a basic 3D environment
- determine and correct errors in a given 3D object
- synthesize simple 3D objects in CAD software
- combine 3D objects to remove or add features
- create a model prototype for a competition based project

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- **End of Unit Assessment:**
  - Students will identify TinkerCAD tools and will state what they are used for.
  - Students will identify the best tools and processes needed to create certain shapes.
- **Practical CAD End of Unit Assessment:**
  - Students will need to follow a strict list of instructions in order to develop an identical shape (designed by the teacher).
- Student participation in class discussions
- Classwork Assignments (worksheets, note sheets)

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Teacher examples and demonstrations of TinkerCAD tools and methods
- Practice design problems

- Creativity based mini design projects
- Observation and correct of 3D models

RESOURCES

Teacher Resources:

- Teacher developed 3D printed models
- Teacher developed tutorial guides
- Teacher developed drag racer track
- Teacher developed drag racer base model

Equipment Needed:

- Classroom computers with web browser access
- Teacher screencast software

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Advanced Computer Aided Drafting and Modeling

Unit Title: Unit 6 - Complex 3D Solid Drafting (Inventor)

Target Course/Grade Level: 9-12

Unit Summary: Students will learn how to use Autodesk Inventor as a method to digitally design prototypes. This unit will begin with basic information on the program layout and tools. Students will then learn how to extrude a 2D sketch into a 3D shape. Students will learn how to use tools like round, chamfer, subtract, and add to modify extruded solids. Practice designs will heavily be used to reinforce proper program usage. Design projects will also be used to promote creativity and skill utilization.

Approximate Length of Unit: About 4 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

- 8.2.12.A.2 Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
- 8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled
- 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 peer review.
- 8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system
- 8.2.12.E.1 Demonstrate an understanding of the problem-solving capacity of computers in our world.

21st Century Life and Career Skills:

- 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects.
- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.

Interdisciplinary Connections and Standards:

- G-SRT-C8 Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.
- G-GMD.B4 Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.
- G-GMG.A1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder)

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

Unit Understandings:

Students will understand that…

- 3D shapes are initially created from 2D sketches
- 3D objects can easily be sent to 3D printers for rapid production
- CAD programs like Inventor allow you to create "blue print" plans from 3D shapes
- multiple processes can create the same shape
- solid shapes must be completely sided off
- solid shapes can become the base for additional sketches/extrusions

Unit Essential Questions:

- Why do measurements need to be accurate in 3D design?
- How can a 3D shape be formed in Inventor?
- What are the benefits of designing prototypes in 3D CAD software?
- What makes products appealing to potential buyers?
- How can you make accurate orthographic representations out of solids designed in Inventor?

Knowledge and Skills:

Students will know…..

- the primary tools in Inventor
- the process of designing a prototype for rapid production
- how the process of sketching and extruding generates 3D objects
- the file system and settings used to create solids in Inventor
- the definitions of planes, extrusions, features, and objects in Inventor

Performance Expectations:

Students will be able to …

- create simple objects from single sketch extrusions
- modify objects by adding sketches and additional extrusions
- create 3D solids from given orthographic sketches
- utilize shapes like squares, rectangles, triangles, and circles to create different prism solids
- analyze and fix broken sketches
- construct both geometric and simple organic solids to meet specifications and constraints

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- **End of Unit Assessment:**
  - Students will match key tools and their uses.
  - Students will also observe and fix incorrect CAD drawings.
- **Practical CAD End of Unit Assessment**:
  - Students will make an identical copy of a 3D object provided by the teacher.

- Student participation in class discussions
- Classwork Assignments (worksheets, note sheets)
- Design based projects

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Teacher examples and demonstrations of Inventor tools and methods
- Practice design problems
- Student led demonstrations of practice designs
- Creativity based mini design projects
- Observation and correction of faulty sketches

RESOURCES

Teacher Resources:

- Teacher developed worksheets
- Teacher developed note sheets and tool guides
- Teacher developed design challenges
- Inventor video tutorials
- Teacher developed Inventor tutorials

Equipment Needed:

- Classroom computers with Autodesk Inventor
- Teacher screen cast software
- Calipers
- Rulers

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Advanced Computer Aided Drafting and Modeling

Unit Title: Unit 7 - Preparing and Printing 3D Objects

Target Course/Grade Level: 9-12

Unit Summary: Students will learn how to export models designed in Inventor in order to be 3D printed. After exporting an STL file from Inventor students will observe several demonstrations on how to import the file in a pre-fabrication program. The class will explore the different settings and how they affect how an object is printed. At the end of this unit students will be able to completely set up and print their own designs efficiently and effectively.

Approximate Length of Unit: About 3 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

- 8.2.12.E.1 Demonstrate an understanding of the problem-solving capacity of computers in our world.
- 8.2.12.D.5 Explain how material processing impacts the quality of engineered and fabricated products.
- 8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system
- 8.2.12.C.4 Explain and identify interdependent systems and their functions.
- 8.2.12.C.3 Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).

21st Century Life and Career Skills:

- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.
- 9.3.ST.6 Demonstrate technical skills needed in a chosen STEM field.
- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.

Interdisciplinary Connections and Standards:

- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impact.
- G-GMD.B4 Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.
- G-CO.A5 Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.7. 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.

Unit Understandings:

Students will understand that…

- pre-fabrication programs are essential when attempting to 3D print
- different infill, layer, and support settings affect how an object will be printed
- objects' print settings are depended on the shape of the object and how it will be used
- there is an inverse relationship between 3D printing speed and quality
- factors like object placement, total material amount, and layer height all affect printing speed

Unit Essential Questions:

- Why are pre-fabrication programs necessary for 3D printing?
- What are the best settings for printing high quality small parts?
- What happens if the settings an object was printed with do not match the object's intended use?
- How can the process of 3D printing be optimized for time and material efficiency?
- Why do some objects need support to be 3D printed**?**

Knowledge and Skills:

Students will know…..

- the definition of:
    - STL Files
    - OBJ Files
    - Pre-Fabrication Programs
    - Infill
    - Layer Height
    - Support
    - Adhesion
    - Extruder Temperature
- the process for exporting files to pre-fabrication programs
- high quality print settings
- fast quality print settings
- the relationship between infill and object integrity

Performance Expectations:

Students will be able to …

- export objects from Inventor to a pre-fabrication program
- compare and contrast the benefits of altering infill, layer height, and support settings
- modify print settings in a pre-fabrication program
- determine the proper print settings for teacher designed prints based on their design and purpose
- design a product and print it with proper settings

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- **End of Unit Assessment:**
  - Students will use the main setting in Cura and explain how print settings affect a print.
  - Students will have to justify why settings will or won't work for given uses.
- Student participation in class discussions
- Classwork Assignments (worksheets, note sheets)
- Design based project
  - Students will design their own key chain and properly print it for maximum quality.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Teacher examples and demonstrations of pre-fabrication process
- Worksheets based on determining proper print settings
- Student led demonstrations of proper printing settings
- Hands on practice printing basic objects
- Independent project-Designing, Pre-Fabricating, and Printing a Key Chain

RESOURCES

Teacher Resources:

- Teacher developed design challenges
- Teacher designed Cura tutorials
- Teacher developed note sheets
- Teacher made 3D printed models

Equipment Needed:

- Classroom computers with Autodesk Inventor
- Cura pre-fabrication software
- Teacher screen cast software
- 3D printers

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Advanced Computer Aided Drafting and Modeling

Unit Title: Unit 8 - Advanced Solid Generation Tools

Target Course/Grade Level: 9-12

Unit Summary: Students will learn how to use more advanced settings in Inventor. Lectures, demonstrations, and projects will require students to use tools like chamfer, fillet, new plane, and pattern. This unit will emphasize utilizing different combinations of tools and techniques to create a variety of 3D printed prototypes. There will be a heavy focus on not only designing based on dimensions, but also on demographic desires.

Approximate Length of Unit: About 5 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

- 8.2.12.A.2 Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
- 8.2.12.C.3 Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).
- 8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled
- 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 peer review.
- 8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system
- 8.2.12.E.1 Demonstrate an understanding of the problem-solving capacity of computers in our world.

21st Century Life and Career Skills:

- 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects
- 9.3.ST-ET.4 Apply the elements of the design process.
- 9.3.ST.3 Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces

Interdisciplinary Connections and Standards:

- G-GMG.A1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder)

- G-CO-D12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.
- G-GMD.B4 Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

Unit Understandings:

Students will understand that…

- tools like chamfer and fillet can make 3D objects look more natural while also cutting material usage
- the user needs to be kept in mind when designing a product
- different tools can make the process of designing a 3D model simpler and faster
- print quality depends on printer capability and design intricacy
- patterns can be used to repeat a feature without drawing each feature

Unit Essential Questions:

- What makes a product ergonomic?
- Why do more products have rounded edges?
- How can the process of sketching and extruding be made more efficient?
- How does form relate to function in terms of product design?

Knowledge and Skills:

Students will know…..

- Inventor Tools:
    - Chamfer
    - Fillet
    - Sweep
    - Mirror
    - Pattern
    - Shell
    - Revolve
- the difference between form and function
- how demographic and demands affect potential product design
- the definition of ergonomics

Performance Expectations:

Students will be able to …

- utilize advanced tools in Inventor to expedite the design process

- combine all learned tools for a variety of design scenarios
- compare and contrast methods of creating complex solids
- identify product features needed based on information of a target demographic
- synthesize and defend prototype designs
- identify ergonomic products and how they are used
- design and construct a product to meet ergonomic requirements

EVIDENCE OF LEARNING

Assessment:

What evidence will be collected and deemed acceptable to show that students truly "understand"?

- **End of Unit Assessment:**
  - Students will identify and explain the use of new tools: pattern, rotate, mirror, etc.
  - Students will evaluate example settings and sketch the outcome.
- Student participation in class discussions
- Classwork Assignments (worksheets, note sheets)
- Design based project
  - Students will create several models of given Lego bricks within Inventor. The pieces will be 100% accurate.

Learning Activities:

What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Teacher examples and demonstrations of advanced Inventor techniques
- Independent 3D product design projects based on several different tools/prompts
- Student modeled tool examples (daily do now activity)
- Design process centered discussions based on design prompts

RESOURCES

Teacher Resources:

- Teacher developed worksheets
- Teacher developed note sheets and tool guides
- Teacher developed Inventor tutorials
- Teacher developed design challenges
- Inventor video tutorials

Equipment Needed:

- Classroom computers with Inventor and Cura
- Calipers
- Rulers
- 3D printers

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Advanced Computer Aided Drafting and Modeling

Unit Title: Unit 9 - Structural Design and 3D printing

Target Course/Grade Level: 9-12

Unit Summary: Students will learn about basic structural physics and its relation to 3D printing. Students will examine different prints and how they function structurally. Print orientation, object shape, and print settings all affect the way a 3D printed object either holds together or falls apart. Labs and design projects will teach and reinforce proper design methods for printing stable and strong objects.

Approximate Length of Unit: About 4 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

- 8.2.12.C.4 Explain and identify interdependent systems and their functions.
- 8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled
- 8.2.12.A.2 Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste.
- 8.2.12.C.3 Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics).
- 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 peer review.
- 8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system
- 8.2.12.D.5 Explain how material processing impacts the quality of engineered and fabricated products.
- 8.2.12.E.1 Demonstrate an understanding of the problem-solving capacity of computers in our world.

21st Century Life and Career Skills:

- 9.3.12.AC-DES.3 Describe the requirements of the integral systems that impact the design of buildings.
- 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects.
- 9.3.ST-ET.4 Apply the elements of the design process.

Interdisciplinary Connections and Standards:

- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).

Unit Understandings:

Students will understand that…

- print orientation affects the strength and integrity of a print
- supports and crossbeams can support weight load
- a 3D printed objects strength depends on the direction force is being applied, its physical shape, and how it was printed
- the material used by the 3D printer has a great effect on print strength

Unit Essential Questions:

- How can the print orientation of an object affect its strength?
- If a part has just 3D printed will the top or sides support more force?
- How do support beams and trusses increase structural integrity?
- What are the tradeoffs and benefits from rearranging an object's print orientation?

Knowledge and Skills:

Students will know…..

- Vocabulary:
    - force
    - load
    - print orientation
    - truss
    - beam
    - layer direction
- the interaction between print orientation and layer direction
- the benefits of rotating, flipping, and moving objects in the pre-fabrication program before printing

Performance Expectations:

Students will be able to …

- identify general force directions of given problems
- compare and contrast the ideal print orientation for given prompts
- design 3D printed objects with the goal of withstanding high forces
- synthesize a 3D model and test its structural capabilities

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- Student participation in class discussions
- Classwork Assignments (worksheets, note sheets)
- **End of Unit Assessment: Design based project**
    - Students will design a miniature structure with the purpose of supporting maximum weight. Students will need to incorporate knowledge of the printing process and structural design.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Class discussions
- Class analysis of failed 3D printed objects
- Simple design projects to support printing quality objects
- Group design project

RESOURCES

Teacher Resources:

- Teacher developed worksheets
- Teacher developed note sheets and tool guides
- Teacher developed Inventor tutorials
- Teacher developed design challenges
- Inventor video tutorials

Equipment Needed:

- Classroom computers with Inventor and Cura
- Calipers
- Rulers
- 3D printers

RAHWAY PUBLIC SCHOOLS CURRICULUM

UNIT OVERVIEW

Content Area: Advanced Computer Aided Drafting and Modeling

Unit Title: Unit 10 - Building Multi-Part Systems

Target Course/Grade Level: 9-12

Unit Summary: Students will learn how to combine multiple 3D objects into larger assemblies. Individual parts, created in Inventor, can be added to an assembly file. Once in the assembly file parts can be constrained to each other to form a model of a full multi-part prototype. Once students have mastered adding parts into assemblies they will learn how to render and add textures to their designs.

Approximate Length of Unit: About 5 Weeks

LEARNING TARGETS

NJ Student Learning Standards:

- 8.2.12.E.1 Demonstrate an understanding of the problem-solving capacity of computers in our world.
- 8.2.12.C.6 Research an existing product, reverse engineer and redesign it to improve form and function.
- 8.2.12.C.7 Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials.
- 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 peer review.
- 8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system
- 8.2.12.D.5 Explain how material processing impacts the quality of engineered and fabricated products.
- 8.2.12.A.1 Propose an innovation to meet future demands supported by an analysis of the potential full costs, benefits, trade-offs and risks, related to the use of the innovation.

21st Century Life and Career Skills:

- 9.3.12.AC-DES.6 Apply the techniques and skills of modern drafting, design, engineering and construction to projects.
- 9.3.MN-QA.3 Coordinate work teams to create a product that meets quality assurance standards.
- 9.3.ST.1 Apply engineering skills in a project that requires project management, process control and quality assurance.
- 9.3.ST-ET.4 Apply the elements of the design process

Interdisciplinary Connections and Standards:

- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- G-GMD.B4 Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.
- G-CO-D12 Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.

NJ SLS Companion Standards: Reading and Writing Standards for History, Social Studies, Science, and Technical Subjects:

- RST.9-10.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- RST.9-10.7. 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.

Unit Understandings:

Students will understand that…

- individual parts can be combined and interact in a digital assembly
- rendering makes 3D objects look like real materials
- rendered assemblies can be used to advertise and promote a design before mass production
- parts need to be constrained together in an assembly in order to function

Unit Essential Questions:

- What is the purpose of an assembly file?
- Why do objects need to be constrained together?
- Why do objects need at least two constraints to be joined?
- How can digital assemblies be altered to look like realistic materials?
- Why is rendering a design as important as 3D printing it?

Knowledge and Skills:

Students will know…..

- Vocabulary:
    - assembly file
    - constraint
    - render
- how rendering can be used to create an accurate representation of a final product
- the difference between joint connections and hinge connections

Performance Expectations:

Students will be able to …

- demonstrate the process for placing parts, joining, and rendering 3D models
- create a model of a simple multipart system with objects designed by the teacher

- synthesize objects and combine them in a rendered assembly
- export high quality renders of a product to highlight how it functions

EVIDENCE OF LEARNING

Assessment:
What evidence will be collected and deemed acceptable to show that students truly "understand"?

- Student participation in class discussions
- Classwork Assignments (worksheets, note sheets)
- Practice CAD assembly challenges
- **End of Unit Assessment: Design-based Project**:
    - Using the library of Lego parts made by the class, students will make their own Lego object in the computer through a rendered assembly.

Learning Activities:
What differentiated learning experiences and instruction will enable all students to achieve the desired results?

- Class discussions
- Teacher demonstrations of new tools
- Practice assemblies based on teacher designed objects
- Exploration time for different render skins available through Inventor
- Group projects based on designing multipart assemblies

RESOURCES

Teacher Resources:

- Teacher developed worksheets
- Teacher developed note sheets and tool guides
- Teacher developed Inventor tutorials
- Teacher developed design challenges
- Inventor video tutorials

Equipment Needed:

- Classroom computers with Inventor and Cura
- Calipers
- Rulers
- 3D printers