West Windsor - Plainsboro Regional School District
Graphic Engineering

Unit 0: Technology Education

Content Area: Technology Education

Course & Grade Level: Technology Education – Grades 9-12

Summary and Rationale

The West Windsor-Plainsboro Regional School District recognizes the importance of the study 21st Century Life and Careers standards. Additionally, it is also believed this learning should not be taught in isolation and cross curricular and career ready practices are embedded in every unit of study. Unit 0 is incorporated into each unit of study of this curricular document.

Recommended Pacing:

ELA Companion Standards and Career Ready Practices will be integrated throughout all units of study.

Interdisciplinary Connections

Grades 9-10

Progress Indicators Reading Science and Technical Subjects

Key Ideas and Details

RST.9-10.1. Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.

RST.9-10.2. Determine the central ideas, themes, or conclusions of a text; trace the text's explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text.

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.

Craft and Structure

RST.9-10.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 9-10 texts and topics*.

RST.9-10.5. Analyze the relationships among concepts in a text, including relationships among key terms (e.g., *force, friction, reaction force, energy*).

RST.9-10.6. Determine the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.

Integration of Knowledge and Ideas

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.
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.9-10.9. Compare and contrast findings presented in a text to those from other sources (including their own experiments), noting when the findings support or contradict previous explanations or accounts.

Range of Reading and Level of Text Complexity:

RST.9-10.10. By the end of grade 10, read and comprehend science/technical texts in the grades 9-10 text complexity band independently and proficiently.

Career Ready Practices

CRP1. Act as a responsible and contributing citizen and employee.

CRP2. Apply appropriate academic and technical skills.

CRP4. Communicate clearly and effectively and with reason.

CRP5. Consider the environmental, social and economic impacts of decisions.

CRP6. Demonstrate creativity and innovation.

CRP7. Employ valid and reliable research strategies.

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.

CRP9. Model integrity, ethical leadership and effective management.

CRP10. Plan education and career paths aligned to personal goals.

CRP11. Use technology to enhance productivity.

CRP12. Work productively in teams while using cultural global competence.

Competencies for 21st Century Learners			
X	Collaborative Team Member	X	Effective Communicator
X	Globally Aware, Active, & Responsible Student/Citizen	X	Information Literate Researcher
X	Innovative & Practical Problem Solver	X	Self-Directed Learner

Unit 1: Creative Design

Content Area: Engineering

Course & Grade Level: Graphic Engineering, 9-12

Summary and Rationale

Engineering is the study of the designed world. Designers use a variety of elements and techniques to make informed design decisions and create intentional solutions. This foundational unit looks at the principles of design as related to practical products, systems, and environments and how they are developed within the 21st century society. In order for students to engage themselves in such processes, they must first be introduced to the fundamentals of design and creative thinking. This includes skills such as ideation, critical thinking, problem solving, and collaboration.

Recommended Pacing

10-15 Days

State Standards

8.2: Technology Education, Engineering, and Design: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.

Strand D - Abilities for a Technological World: The designed world is the product of a design process that provides the means to convert resources into products and systems.

CPI #	Cumulative Progress Indicator (CPI)
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

NGSS

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.

Standards for Tech. Literacy

Standard 8: Students will develop an understanding of the attributes of design.	
9-12.H	The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.
Standard 9: Students will develop an understanding of engineering design.	
9-12.I	Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.
Standard 11: Students will develop the abilities to apply the design process.	
9-12.Q	Develop and produce a product or system using a design process.

Instructional Focus

Unit Enduring Understandings

- The development of a product or system requires proper planning and the consideration of multiple solutions and resources.
- Different types of products or systems require various applications of design principles in order to meet human needs.
- Design decisions should be made by gathering and analyzing relevant information that intentionally develops the product or system as whole.
- The design process is a collaborative effort that requires a consistent exchange of feedback and ideas for improvement and optimization.

Unit Essential Questions

- How do we develop design solutions that are efficient in terms of resources, cost, and time?
- How do human needs and wants influence design decisions?
- How do designers make informed solutions when endless possibilities exist?
- Why are multiple perspectives essential to the design and development of products and systems?

Objectives

Students will know:

- How to apply the design process through the development of a product.
- The principles of design and how they are applied in innovation.
- How to get from conceptualizing ideas to representing ideas in visual form.

Students will be able to:

- Generate multiple solutions to a design problem.
- Apply critical thinking and problem-solving skills to develop a product or system that meets human needs.
- Construct a representation of an idea using specific tools and resources.
- Demonstrate their ability to work in a collaborative and creative environment.

Evidence of Learning

Assessment

Common Assessment 1.1

Competencies for 21st Century Learners

x	Collaborative Team Member	x	Effective Communicator
x	Globally Aware, Active, & Responsible Student/Citizen	x	Information Literate Researcher
x	Innovative & Practical Problem Solver	x	Self-Directed Learner

Resources

Suggested Resources:

- Universal Principles of Design - By William Lidwell
- https://www.lynda.com/Graphic-Design-tutorials/4-Welcome/193717/610692-4.html?autoplay=true
- Engineering Design: An Introduction (Karsnitz, O'Brien, Hutchinson)
- The Art of Invention - By Steven J. Paley

Materials
● Cardboard ● Foam Core Sheets ● Masking tape ● Hot glue guns / glue ● Craft knives ● Rulers ● Popsicle sticks ● Scissors ● Manilla paper/folders ● Construction and cardstock paper ● Index cards

Unit 2: Digital Illustrations and Design Applications

Content Area: Engineering

Course & Grade Level: Graphic Engineering, 9-12

Summary and Rationale

In engineering design, the process of brainstorming typically starts with conveying ideas in the form of two-dimensional drawings or sketches, which become the basis for a final design. On the contrary, in the world of graphic design, two-dimensional design is often the final product. It is the goal of this unit to explore how technological literacy can be applied to merge the worlds of graphic design and engineering design. Students will learn a variety of digital tools and techniques to not only express their ideas in a 2D digital form but to create original and functional graphics that effectively convey meaning and purpose.

Recommended Pacing

40 days

State Standards

8.2 Technology Education, Engineering, and Design: All students will develop an understanding of the nature and impact of technology, engineering, technological design, and the designed world, as they relate to the individual, global society, and the environment.
Strand C - Design: The design process is a systematic approach to solving problems.
Strand D - Abilities for a Technological World: The designed world is the product of a design process that provides the means to convert resources into products and systems.

CPI #	Cumulative Progress Indicator (CPI)
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.

NGSS

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.

Standards for Tech. Literacy	
Standard 8: Students will develop an understanding of the attributes of design.	
9-12.H	The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.
9.128.J	The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.
Standard 9: Students will develop an understanding of engineering design.	
9-12.9I	Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.
Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.	
9-12.17P	There are many ways to communicate information, such as graphic and electronic means.

Instructional Focus

Unit Enduring Understandings

- Digital illustration software offers many options, tools and commands to modify basic objects in order to create complex visual representation.
- Digital designers develop techniques to enhance their creative process and improve productivity.
- Design influences how we perceive and interact with the world and therefore can shape individuals, groups, organizations, and society.

Unit Essential Questions

- How can digital tools and techniques be used to create a design that has a purpose and conveys meaning?
- How can design impact individuals, organizations, communities, and systems?
- How do you develop an understanding of essential tools, techniques, and processes that are used in visual design?
- How can visual representations enhance the overall communication of an idea or concept?
- Why is visual communication important in the 21st century?

Objectives

Students will know:

- There are a variety of digital software applications to meet diverse needs of designers.
- Various tools paired with creative techniques are used to create meaningful visual design solutions.

Students will be able to:

- Solve visual design problems using digital applications.
- Create and save design files in appropriate formats for desired production outcomes.
- Transform a digital design into a physical product.

Evidence of Learning

Assessment

Common Assessment 1.1

Competencies for 21st Century Learners

X	Collaborative Team Member	X	Effective Communicator
X	Globally Aware, Active, & Responsible Student/Citizen	X	Information Literate Researcher
X	Innovative & Practical Problem Solver	X	Self-Directed Learner

Resources

Suggested Resources:

- Adobe Illustrator Creative Cloud Revealed by Chris Botello
- How To Use Inventables Easel Software - https://www.youtube.com/watch?v=bCUHsJ4Ktj0

Materials

- Computer
- Adobe Illustrator
- Inventables Easel
- Additional 2D digital drawing softwares (if needed)
- Color printer
- Vinyl cutter
- Vinyl sheets
- Transfer tape
- Cutting mat
- Cardstock paper
- Adhesives
- Cutting tools

Unit 3: Digital 3D Modeling and Rapid Prototyping

Content Area: Engineering

Course & Grade Level: Graphic Engineering, 9-12

Summary and Rationale

All physical things exist within three-dimensional space. Basic shapes are the building blocks for the designed world. Today, we are able to represent these objects not only in the physical realm but in cyberspace as well. 3D modeling is comprised of a balanced mix of math, geometry and design principles. 3D graphics will allow students the opportunity to investigate design in more ways than they perhaps could in the real world. The combination of 3D modeling applications in conjunction with digital fabrication tools (ex. 3D printers, CNC mills, etc.) will allow students to investigate the process of rapid prototyping and how it bridges the gap between the digital and physical design realms.

Recommended Pacing

40 days

State Standards

8.2 Technology Education, Engineering, and Design: All students will develop an understanding of the nature and impact of technology, engineering, technological design, and the designed world, as they relate to the individual, global society, and the environment.
Strand C - Design: The design process is a systematic approach to solving problems
Strand D - Abilities for a Technological World: The designed world is the product of a design process that provides the means to convert resources into products and systems.

CPI #	Cumulative Progress Indicator (CPI)
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.

NGSS

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.

Standards for Tech. Literacy	
Standard 8: Students will develop an understanding of the attributes of design.	
9-12.8H	The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.
9.12.8J	The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.
Standard 9: Students will develop an understanding of engineering design.	
9.12.9J	Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.

Instructional Focus

Unit Enduring Understandings

- Successful 3D design requires you to select the most appropriate software and application techniques.
- 3D modeling opens the designer to an infinite realm of representing ideas and design possibilities.
- It is the responsibility of the designer to determine suitable metrics of a technology including cost, rate, quality, and flexibility.
- A product developed on a digital fabrication device allows for iterative interpretation of a physical design.

Unit Essential Questions

- What informs a designer's decisions about software and application techniques most appropriate for an optimal solution?
- How does a designer or engineer successfully represent ideas using parametric modeling?
- How does one evaluate 3D design in terms of cost effectiveness and product suitability?
- What are the limitations of certain rapid prototyping techniques in terms of time management and production material?
- How can a designer use rapid prototyping to better inform and enhance the success of their design?

Objectives

Students will know:

- Parametric modeling and rapid prototyping are useful tools for representing ideas and evaluating the effectiveness of a design concept.
- All three-dimensional models are constructed using basic geometry and mathematical reasoning.

Students will be able to:

- Use CAD software to design a product.
- Interpret a 3D object in a virtual environment.
- Create and save design files in appropriate formats for desired production outcomes.
- Develop digital ideas into physical ones using techniques such as 3D printing or CNC carving.

Evidence of Learning

Assessment

Common Assessment 1.1

Competencies for 21st Century Learners

X	Collaborative Team Member	X	Effective Communicator
X	Globally Aware, Active, & Responsible Student/Citizen	X	Information Literate Researcher
X	Innovative & Practical Problem Solver	X	Self-Directed Learner

Resources

Suggested Resources:

- Autodesk Fusion 360 YouTube Channel: contains dozens of comprehensive learning tutorials from the makers of the software - https://www.youtube.com/user/AutodeskFusion360?disable_polymer=true

Materials

- Computer
- Autodesk Fusion 360
- SketchUp
- Other 3D modeling program (if applicable)
- 3D printer
- CNC milling machine
- Basic hand tools (hammer, screwdriver, sandpaper, etc.)

Unit 4: Digital Fabrication

Content Area: Engineering

Course & Grade Level: Graphic Engineering, 9-12

Summary and Rationale

Modern skills in digital design enhances students' ability to translate their ideas into 2D and 3D form. Digital fabrication has transformed the creative workflow and increased the capacity for creative problem-solving in technology education. Integrating digital fabrication into design projects requires and understanding of optimal materials and key considerations for specific machines. Students will dive into different digital fabrication systems and explore creative applications of digital fabrication techniques. Students will gain hands-on experience using modern technologies to turn creative designs into tangible products.

Recommended Pacing

40 days

State Standards

8.2 Technology Education, Engineering, and Design: All students will develop an understanding of the nature and impact of technology, engineering, technological design, and the designed world, as they relate to the individual, global society, and the environment.
Strand C - Design: The design process is a systematic approach to solving problems.
Strand D - Abilities for a Technological World: The designed world is the product of a design process that provides the means to convert resources into products and systems.

CPI #	Cumulative Progress Indicator (CPI)
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.

NGSS

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.

Standards for Tech. Literacy	
Standard 8: Students will develop an understanding of the attributes of design.	
9-12.8H	The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.
9.12.J	The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.
Standard 9: Students will develop an understanding of engineering design.	
9.12.9K	A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.
Standard 11: Students will develop the abilities to apply the design process.	
9.12.O	Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.

Unit Enduring Understandings

- Just like any other tool, digital fabrication machines come in many forms and each are capable of different functions.
- Digital fabrication leaves much to the imagination but design limitations must still be considered and analyzed thoroughly.
- It is up to the designer to determine which digital fabrication techniques will best suit their purpose and how those techniques can work in tandem with one another.

Unit Essential Questions

- What digital tools, materials and techniques are used in the manufacturing of different products?
- How can you create a successful design within certain limitations?
- Why is it important for a designer to understand various resources and their applications before selecting the best option?

Objectives

Students will know:

- Each digital fabrication machine has specific considerations.
- Determining the appropriate resources to achieve a desired end result requires a thoughtful analysis of possible options that exist.

Students will be able to:

- Understand how hardware and software applications work together to produce a product.
- Create products using additive and subtractive manufacturing processes.
- Apply assembly techniques to create original and functional products.
- Develop free shape design projects by applying spatial thinking.

Evidence of Learning			
Assessment			
Common Assessment 1.1			
Competencies for 21st Century Learners			
X	Collaborative Team Member	X	Effective Communicator
X	Globally Aware, Active, & Responsible Student/Citizen	X	Information Literate Researcher
X	Innovative & Practical Problem Solver	X	Self-Directed Learner

Resources

Suggested Resources:

- See Unit 1 - 3 resource lists

Materials

- See Unit 1 - 3 material lists