

FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

OFFICE OF CURRICULUM AND INSTRUCTION

TECHNOLOGY EDUCATION DEPARTMENT

ENGINEERING GRAPHICS 1

Grade Level: 9-12

Credits: 5

BOARD OF EDUCATION ADOPTION DATE:

AUGUST 31, 2015

[SUPPORTING RESOURCES AVAILABLE IN DISTRICT RESOURCE SHARING](#)

APPENDIX A: ACCOMMODATIONS AND MODIFICATIONS

APPENDIX B: ASSESSMENT EVIDENCE

APPENDIX C: INTERDISCIPLINARY CONNECTIONS

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.....-ENGINEERING GRAPHICS I

COURSE PHILOSOPHY

Every product starts with a design. Every manufactured item first had to be designed using a universally understood language. Creating and designing innovative products and systems is the foundation for the future of our society. The utilization of design sketching, 3D modeling, and prototyping are critical skills necessary for 21st century engineering.

COURSE DESCRIPTION

In *Engineering Graphics I*, students will master traditional drafting and sketching techniques in addition to learning to use industry-standard CAD (computer-aided design) software. Students will be tasked with designing solutions to real-world problems. These designs will be brought to life as models via 3D printing and laser engraving. Students will explore ergonomic design, industrial design, and product redesign throughout the course.

COURSE SUMMARY

COURSE GOALS

- CG1: Students will effectively communicate their ideas through oral and visual presentations.
- CG2: Students will connect the design/engineering process to applications in various careers and authentic situations.
- CG3: Students will apply 2D/3D concepts in a visual medium to effectively create professional and elegant solutions to engineering problems.
- CG4: Students will create appearance models and prototypes utilizing their own product designs.
- CG5: Students will make safe and informed decisions when selecting and using equipment or tools.

COURSE ENDURING UNDERSTANDINGS

COURSE ESSENTIAL QUESTIONS

CEU1: Communicating an engineering design requires effective visual representation.	CEQ1a: How do engineers communicate the elements of their designs? CEQ1b: Why do I have to communicate about my design to others?
CEU2: The design/engineering process is a series of steps taken in order to create a product or solve a problem.	CEQ2: If there are multiple solutions to an engineering problem, how is it that one is more elegant than another?
CEU3: Computer-aided design and traditional drafting each have their place in the world of engineering and design.	CEQ3a: How do I know when to use each tool in engineering drawing? CEQ3b: How do I determine when to use CAD versus traditional drafting?
CEU4: Dimensioned and rendered CAD creations are used by modern industry to create prototype models of new products.	CEQ4a: Why do we build prototypes when we can model them on a computer? CEQ4b: Is there a best way to create prototype models?
CEU5: Following safety procedures and using personal protection equipment will reduce the risk of injury.	CEQ5a: How does the saying "Never let your guard down!" apply to the lab? CEQ5b: Can any procedure be completely safe?

UNIT GOALS & PACING

UNIT TITLE	UNIT GOALS	RECOMMENDED DURATION
Unit 1: Introduction to Design & Self-Management	CG5: Students will make safe and informed decisions when selecting and using equipment or tools. LG1: Students will apply concepts of the design process in order to develop solutions to engineering problems.	2 weeks
Unit 2: 2D Drawing	LG1: Students will use mechanical drawing tools and drafting techniques to synthesize orthographic drawings. LG2: Students will apply concepts of measurement and scale perspective in order to create accurate visual representations of engineered objects.	4-5 weeks
Unit 3: 3D Drawing	Students will apply concepts of isometric, perspective, and texture rendering in order to create accurate visual representations of engineered objects.	3-4 weeks
Unit 4: Ergonomics & Materials	Students will create and defend ergonomic designs and models by utilizing appropriate materials and synthesizing their knowledge of human factor guidelines.	3-4 weeks
Unit 5: Computer-Aided Design	LG1: Students will construct unique 3D representations of complex problems utilizing CAD software. LG2: Students will assess client needs, design an appropriate solution, and present their design.	11-12 weeks
Unit 6: Prototyping & Presentations	LG1: Students will create functional and visually realistic 3D prototypes by safely utilizing CNC machines, 3D printers, or laser engravers. LG2: Students will effectively self-critique and critique the work of others.	3-4 weeks
Unit 7: Product Design	LG1: Students will design a product through the analysis and revision of multiple iterations of a product concept. LG2: Students will apply concepts of drawing and product design to create a solution within an area of opportunity.	5-6 weeks

ENGINEERING GRAPHICS I**UNIT 1: Introduction to Design & Self-Management****SUGGESTED DURATION: 2 weeks****UNIT OVERVIEW****UNIT LEARNING GOALS**

CG5: Students will make safe and informed decisions when selecting and using equipment or tools.

LG1: Students will apply concepts of the design process in order to develop solutions to engineering problems.

UNIT LEARNING SCALE: CG5

4	In addition to level 3 performances, the student can safely intervene and assist a peer who is not following appropriate safety protocols.
3	The student can: <ul style="list-style-type: none"> • follow classroom procedures and interact responsibly; • maintain a safe, clean lab environment; • identify and perform proper use and maintenance of tools; • wear personal protective equipment (PPE) as needed; • analyze safety protocols and the reasoning behind the protocols.
2	The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.
1	The student needs assistance or makes larger errors in attempting to reach level 3.
0	Even with help, the student does not exhibit understanding of performances listed in score 3.

UNIT LEARNING SCALE: LG1

4	In addition to score 3 performances, the student can describe a real-world scenario where the design process was used.
3	The student can: <ul style="list-style-type: none"> • identify and describe all steps of the design process; • apply all steps of the design process in order to develop solutions.
2	The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.
1	The student needs assistance or makes larger errors in attempting to reach level 3.
0	Even with help, the student does not exhibit understanding of performances listed in score 3.

ENDURING UNDERSTANDINGS

CEU2: The design/engineering process is a series of steps taken in order to create a product or solve a problem.

CEU5: Following safety procedures and using personal protection equipment will reduce the risk of injury.

ESSENTIAL QUESTIONS

CEQ2: If there are multiple solutions to an engineering problem, how is it that one is more elegant than another?

CEQ5a: How does the saying "Never let your guard down!" apply to the lab?
CEQ5b: Can any procedure be completely safe?**NJCCCS & COMMON CORE STANDARDS****NJCCCS:**

8.1.12.C.1 Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.

8.2.12.A.1 Design and create a technology product or system that improves the quality of life and identify trade-offs, risks, and benefits.

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).





NJCCCS & COMMON CORE STANDARDS

- 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.E.4 Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).
- 8.2.12.G.1 Analyze the interactions among various technologies and collaborate to create a product or system demonstrating their interactivity.
- 9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences.
- 9.1.12.A.4 Justify problem-solving strategies used in the development of a particular innovative product or practice in the United States and in another country.

- CCSS:**
- 9-10.RST.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific science or technical context relevant to grades 9-10 text and topics.
- 9-10.RST.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.
- 9-10.RST.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.
- 9-10.WHST.9 Draw evidence from informational texts to support analysis, reflection, and research.
- 9-10.WHST.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

COMMON ASSESSMENT

ALIGNMENT	DESCRIPTION
CG5 CEU5, CEQ5a, b 8.2.12.C.3 9-10.RST.4,.7, 9 9-10.WHST.7, 9 DOK 3	Students demonstrate the ability to effectively select and use equipment and tools through a performance task in which they complete specific procedures, operations, and applications. This will include the creation of a border and title block.
LG1 CEU2, CEQ2 8.1.12.C.1 8.2.12.A.1 8.2.12.C.3, 7 8.2.12.E.4 8.2.12.G.1 9.1.12.A.1, 4 9-10.RST.4,.7, 9 9-10.WHST.7, 9 DOK 3	Students complete a hands-on lab practical assessment in which they solve a problem while documenting each step of the design process.

SUGGESTED STRATEGIES		
ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
<p>Students will identify possible safety concerns that can occur in a lab/classroom setting. Students will analyze these concerns and create safety posters to display in the room in order to facilitate proper lab behavior.</p> <p> Students can choose the safety concern they would like to address.</p> <p> Students create the poster using graphics software.</p>	<p>goggles personal protective equipment hot glue T-square compass hot wire cutter CNC machines</p>	<p>Assess safety concerns</p> <p>Design safety posters</p> <p>Present equipment procedures</p> <p>DOK 3</p>
<p>Students will analyze the design process to determine its effectiveness. After analyzing the design process, students will describe how each step will be applied to solve a specific technical problem.</p> <p> Students research examples of products that follow the design process.</p>	<p>engineering design process prototyping research iterations brainstorming developmental work</p>	<p>Infer relationships between users and systems</p> <p>Use concepts to solve a problem</p> <p>Formulate a plan for using the design process to create a product</p> <p>DOK 3</p>
<p>Students will use various tools to accurately measure objects in the classroom. After honing their skills, students will draw shapes with specific dimensions.</p> <p> Students can choose which objects they want to measure. Advanced students can be required to increase accuracy to 1/16". Students who have difficulty can reduce accuracy to 1/4".</p>	<p>accuracy precision standard vs metric scale ruler dimension fraction</p>	<p>Construct shapes via measurement techniques</p> <p>Create scale drawings</p> <p>Create accurately measured objects</p> <p>DOK 2</p>

ENGINEERING GRAPHICS I**UNIT 2: 2D Drawing****SUGGESTED DURATION: 4-5 weeks****UNIT OVERVIEW****UNIT LEARNING GOALS**

LG1: Students will use mechanical drawing tools and drafting techniques to synthesize orthographic drawings.

LG2: Students will apply concepts of measurement and scale perspective in order to create accurate visual representations of engineered objects.

UNIT LEARNING SCALE: LG1

4	In addition to level 3 performances, the student can teach other students how to use an advanced tool.
3	The student can: <ul style="list-style-type: none"> • identify drafting tools; • select the correct tool for the task; • demonstrate proper technique for each tool used; • construct a 2D drawing with correct scale, dimension, and line weight.
2	The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.
1	The student needs assistance or makes larger errors in attempting to reach level 3.
0	Even with help, the student does not exhibit understanding of performances listed in score 3.

UNIT LEARNING SCALE: LG2

4	In addition to score 3 performances, the student can convert an existing scale drawing to another scale.
3	The student can: <ul style="list-style-type: none"> • add and subtract fractions with precision down to 1/32"; • measure with accuracy and precision using imperial and metric units; • accurately represent an object in a scaled drawing.
2	The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.
1	The student needs assistance or makes larger errors in attempting to reach level 3.
0	Even with help, the student does not exhibit understanding of performances listed in score 3.

ENDURING UNDERSTANDINGS

CEU1: Communicating an engineering design requires effective visual representation.

CEU3: Computer-aided design and traditional drafting each have their place in the world of engineering and design.

ESSENTIAL QUESTIONS

CEQ1a: How do engineers communicate the elements of their designs?

CEQ3a: How do I know when to use each tool in engineering drawing?

CEQ3b: How do I determine when to use CAD versus traditional drafting?

NJCCCS & COMMON CORE STANDARDS**NJCCCS:**

8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review.

8.1.12.C.1 Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.

8.2.12.A.1 Design and create a technology product or system that improves the quality of life and identify trade-offs, risks, and benefits.

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

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.

NJCCCS & COMMON CORE STANDARDS



- 8.2.12.E.4 Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).
- 8.2.12.G.1 Analyze the interactions among various technologies and collaborate to create a product or system demonstrating their interactivity.
- 9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences.
- 9.1.12.A.4 Justify problem-solving strategies used in the development of a particular innovative product or practice in the United States and in another country.

- CCSS:**
- 9-10.RST.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific science or technical context relevant to grades 9-10 text and topics.
- 9-10.RST.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.
- 9-10.RST.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.
- 9-10.WHST.9 Draw evidence from informational texts to support analysis, reflection, and research.
- 9-10.WHST.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.



COMMON ASSESSMENT

ALIGNMENT	DESCRIPTION
LG1, LG2 CEU1, CEQ1a, CEU3, CEQ3a, CEQ3b 8.1.12.C.1, 5, 7 9.1.12.A.1 9-10.RST.4, 7 9-10.WHST.9 DOK 3	Students receive an engineering design brief that requires them to complete a drawing to scale. To complete the drawing, the students must demonstrate the ability to draw horizontal lines, vertical lines, circles, ellipses, angles, lettering, and a variety of line types. Students will also demonstrate the use of a variety of tools including: drafting scales, T-squares, triangles, and compasses.

SUGGESTED STRATEGIES

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students will copy a 2D image of an engineering gasket by sketching and using machines and tools to make a precise scale drawing.	line weight curve compass dimension line scale title block ink triangle	Accurately use drafting tools and machines Create precise lines using scales and triangles Create a clean engineering drawing with accurate dimension DOK 3
 Give students a choice between different gaskets that vary in difficulty or provide students with a specific gasket based on their ability level.		
 Students will use drafting machines where available.		

SUGGESTED STRATEGIES

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
<p>Students will measure and sketch a gear, screw, or bolt and complete a 2D engineering drawing of the object.</p> <p> Give students a choice between a gear, screw, and bolt, as each vary in difficulty in regards to both measurement and drawing or provide students with a specific object based on their ability level.</p> <p> Students use drafting machines where available.</p>	dimension radius degree thread tpi hex fraction inch	Accurately measure using different tools Properly record measurements of 3D objects Sketch to describe dimensions Draw 2D engineering drawings of 3D objects using tools and machines DOK 3

ENGINEERING GRAPHICS I**UNIT 3: 3D Drawing****SUGGESTED DURATION: 3-4 weeks****UNIT OVERVIEW****UNIT LEARNING GOALS**

Students will apply concepts of isometric, perspective, and texture rendering in order to create accurate visual representations of engineered objects.

UNIT LEARNING SCALE: LG1

4	In addition to level 3 performances, the student can apply concepts of texture rendering to a three point perspective object that includes a light source.
3	The student can: <ul style="list-style-type: none"> • create accurate and precise isometric images from orthographic projections; • construct one- and two-point perspective drawings; • apply textures, shading, and shadows to drawings.
2	The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.
1	The student needs assistance or makes larger errors in attempting to reach level 3.
0	Even with help, the student does not exhibit understanding of performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
CEU1: Communicating an engineering design requires effective visual representation.	CEQ1b: Why do I have to communicate about my design to others?
EU1: Textured and rendered images are valuable visual aids and required for effective product communication.	EQ1: Why are various artistic techniques applied to engineering drawings?





NJCCCS & COMMON CORE STANDARDS**NJCCCS:**

- 8.1.12.C.1 Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.
- 8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
- 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.E.4 Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).
- 8.2.12.G.1 Analyze the interactions among various technologies and collaborate to create a product or system demonstrating their interactivity.
- 9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences.
- 9.1.12.A.4 Justify problem-solving strategies used in the development of a particular innovative product or practice in the United States and in another country.

CCSS:

- 9-10.RST.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific science or technical context relevant to grades 9-10 text and topics.
- 9-10.RST.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.
- 9-10.RST.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.
- 9-10.WHST.9 Draw evidence from informational texts to support analysis, reflection, and research.
- 9-10.WHST.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG1, LG2 CEU1, CEQ1b, EU1, EQ1 8.1.12.C.1, 5, 7 9.1.12.A.1 9-10.RST.4, 7 9-10.WHST.9 9-10.WHST.7 DOK 3	Students receive a design brief that requires them to complete orthographic projections and isometric drawings. Students must demonstrate the ability to utilize various techniques including: shading, perspective, and line weight.

SUGGESTED STRATEGIES		
ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
<p>Students will draw an orthographic projection of an isometric block by using machines and tools to make a precise scale drawing.</p> <p> Give students a choice between blocks with curves or challenging angles or provide students with a specific block based on their ability level.</p> <p> Students use drafting machines where available.</p>	line quality ellipse template dimension measurement layout vertical angle degree	Use drafting tools and machines Create precise lines using scales and triangles Properly layout top, front, and right-side views on a title block Create a clean engineering drawing DOK 3
<p>Students will analyze, sketch, and draw an accurate isometric image based on information given in an orthographic.</p> <p> Give students a choice between an orthographic that contain hidden lines or an orthographic that contains curves.</p> <p> Students use drafting machines where available.</p>	orthographic isometric cabinet cavalier ellipse box shading shadowing	Sketch and draw a 2D representation of a 3D object using appropriate tools Using line identification to determine what shape object an orthographic represents Draw isometrics using tools and machines Enhance realism by applying line weight, texture, shading, and shadowing techniques DOK 3

ENGINEERING GRAPHICS I**UNIT 4: Ergonomics & Materials****SUGGESTED DURATION: 3-4 weeks****UNIT OVERVIEW****UNIT LEARNING GOALS**

Students will create and defend ergonomic designs and models by utilizing appropriate materials and synthesizing their knowledge of human factor guidelines.

UNIT LEARNING SCALE: LG1

4	In addition to level 3 performances, the student can critique their peers' designs and cite evidence to defend their critique.
3	The student can: <ul style="list-style-type: none"> • identify and expand on ergonomic terms and concepts; • design an ergonomic piece of furniture; • present and defend an ergonomic model; • revise equipment and tools to adjust to a 95% human form; • accurately measure to determine length of joint to joint body parts.
2	The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.
1	The student needs assistance or makes larger errors in attempting to reach level 3.
0	Even with help, the student does not exhibit understanding of performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
CEU2: The design/engineering process is a series of steps taken in order to create a product or solve a problem.	CEQ2: If there are multiple solutions to an engineering problem, how is it that one is more elegant than another?
CEU4: Dimensioned and rendered CAD creations are used by modern industry to create prototype models of new products.	CEQ4a: Why do we build prototypes when we can model them on a computer? CEQ4b: Is there a best way to create prototype models?

NJCCCS & COMMON CORE STANDARDS**NJCCCS:**

- 8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review.
- 8.1.12.C.1 Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.
- 8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
- 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.E.4 Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).
- 8.2.12.D.5 Explain how material processing impacts the quality of engineered and fabricated products.

CCSS:

- 9-10.RST.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific science or technical context relevant to grades 9-10 text and topics.

NJCCCS & COMMON CORE STANDARDS





9-10.WHST.9 Draw evidence from informational texts to support analysis, reflection, and research.

9-10.RST.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.

COMMON ASSESSMENT

ALIGNMENT	DESCRIPTION
LG1, CEU2, CEQ2, CEU4, CEQ4a, CEQ4b 8.1.12.A.2 8.1.12.C.1, 5,7 8.2.12.D.1 9-10.RST.4 9-10.WHST.9 9-10.RST.7 DOK 3	Students will create an accurate model of their own body. Students will use this ergonomic model as a reference for the redesign of a classroom desk, chair, and computer setup in order to ensure proper adjustability and satisfactory fit to their personal human factors while using appropriate materials. Students will defend the choices they made in their design solution.

SUGGESTED STRATEGIES

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
<p>Students will examine human factors design by creating an object or device that will be comfortable for up to the 95th percentile of humans. Students will take measurements and complete research before beginning to design their solution.</p> <p> Let students choose the problem they wish to explore or provide students with a problem based on their ability level.</p> <p> Students will use CAD software to create and render their final product designs.</p>	human factors norms percentile ergonomic	Measure the human body Research human factors design concepts Design and create a 3D model DOK 4
<p>Students will pick a product they have recently used that was awkward or uncomfortable. Students will examine why this item caused discomfort and research solutions. They will then create a 3D assembly drawing of their more ergonomic, redesigned product.</p> <p> Let students choose the object or product they wish to redesign or provide students with a product based on their ability level.</p> <p> Students will use CAD software to create and render their final product designs.</p>	redesign repetitive stress injury assembly drawing DOK 1	Examine an objects design for potential flaws Research human factors design concepts Redesign products Create a 3D model DOK 4

ENGINEERING GRAPHICS I**UNIT 5: Computer-Aided Design****SUGGESTED DURATION: 11-12 weeks****UNIT OVERVIEW****UNIT LEARNING GOALS**

LG1: Students will construct unique 3D representations of complex problems utilizing CAD software.

LG2: Students will assess client needs, design an appropriate solution, and present their design.

UNIT LEARNING SCALE: LG1

4	In addition to level 3 performances, the student can formulate and render 3D images with various textures.
3	The student can: <ul style="list-style-type: none"> • construct accurate 3D images using CAD software; • modify CAD images to specific sizes; • dimension and lay out CAD images into proper isometric and orthographic format.
2	The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.
1	The student needs assistance or makes larger errors in attempting to reach level 3.
0	Even with help, the student does not exhibit understanding of performances listed in score 3.

UNIT LEARNING SCALE: LG2

4	In addition to score 3 performances, the student can develop a presentation that will be sent to an engineering firm for appraisal.
3	The student can: <ul style="list-style-type: none"> • create a walkthrough CAD animation for presentation to a client; • present and defend a set of CAD drawings for a client; • utilize printers, plotters, and websites to display completed CAD projects; • assess client needs.
2	The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.
1	The student needs assistance or makes larger errors in attempting to reach level 3.
0	Even with help, the student does not exhibit understanding of performances listed in score 3.

ENDURING UNDERSTANDINGS

CEU3: Computer-aided design and traditional drafting each have their place in the world of engineering and design.

CEU4: Dimensioned and rendered CAD creations are used by modern industry to create prototype models of new products.

ESSENTIAL QUESTIONS

CEQ3a: How do I know when to use each tool in engineering drawing?

CEQ3b: How do I determine when to use CAD versus traditional drafting?

CEQ4a: Why do we build prototypes when we can model them on a computer?

CEQ4b: Is there a best way to create prototype models?

NJCCCS & COMMON CORE STANDARDS**NJCCCS:**

8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review.

8.1.12.C.1 Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.

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

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.

NJCCCS & COMMON CORE STANDARDS


- 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.
- 8.2.12.E.4 Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).

- CCSS:**
- 9-10.RST.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific science or technical context relevant to grades 9-10 text and topics.
- 9-10.WHST.9 Draw evidence from informational texts to support analysis, reflection, and research.
- 9-10.RST.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.
- 9-10.WHST.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.


COMMON ASSESSMENT

ALIGNMENT	DESCRIPTION
LG1 CEU3, CEQ3a, CEQ3b, CEU4, CEQ4a, CEQ4b 8.2.12.C.5 8.2.12.D.3 8.2.12.E.1, 4 9-10.RST.4, 7 9-10.WHST.7 DOK 4	Students receive a design brief that outlines a specific client. Students must assess the client’s needs and design a solution. Their solution will be a 3D object they create using CAD software using lofts, extrudes, and rounded edges. Students will create a professional presentation that defends their design choices to their classmates.

SUGGESTED STRATEGIES

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students will utilize CAD software to recreate a scaled, dimensioned 2D drawing.  Let students choose the object or provide students with an object based on their ability level.	line circle dimension line scale angle arc parallel	Use basic tools (lines, circles and rectangles) Use dimensioning tools Create a 2D model DOK 3

SUGGESTED STRATEGIES

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
<p>Students will utilize CAD software to render an object in 3D from a scaled, dimensioned 2D drawing.</p>  <p>Students use the laser engraver and/or 3D printer to print their final model.</p>	<p>workplane extrusion chamfer loft revolve intersect</p>	<p>Use tools on multiple axes and workplanes</p> <p>Use 3D tools (extruding, chamfers, revolves, and rounded edges)</p> <p>Photorealistic Rendering</p> <p>Create a 3D model</p> <p>DOK 3</p>

ENGINEERING GRAPHICS I**UNIT 6: Prototyping and Presentations****SUGGESTED DURATION: 3-4 weeks****UNIT OVERVIEW****UNIT LEARNING GOALS**

LG1: Students will create functional and visually realistic 3D prototypes by safely utilizing CNC machines, 3D printers, or laser engravers.

LG2: Students will effectively self-critique and critique the work of others.

UNIT LEARNING SCALE: LG1

4	In addition to level 3 performances, the student can assist other students with the creation of their prototype.
3	The student can: <ul style="list-style-type: none"> • identify and select the correct tool/equipment for a task; • demonstrate proper and safe procedures for CNC machines, 3D printers, and laser engravers; • apply elements of visual design to a prototype; • create a functional prototype with visual and functional properties.
2	The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.
1	The student needs assistance or makes larger errors in attempting to reach level 3.
0	Even with help, the student does not exhibit understanding of performances listed in score 3.

UNIT LEARNING SCALE: LG2

4	In addition to score 3 performances, the student can synthesize questions and prompts about their designs for others to comment on.
3	The student can: <ul style="list-style-type: none"> • appraise and defend their own design work; • formulate and communicate subjective and objective feedback.
2	The student can complete all score 3 performances with minor mistakes OR the student can complete x out of the n score 3 performances.
1	The student needs assistance in order to reach the learning goal.
0	Even with help, the student does not exhibit understanding of A, B, and C (performances listed in score 3).

ENDURING UNDERSTANDINGS**ESSENTIAL QUESTIONS**

CEU1: Communicating an engineering design requires effective visual representation.	CEQ1a: How do engineers communicate the elements of their designs? CEQ1b: Why do I have to communicate about my design to others?
CEU4: Dimensioned and rendered CAD creations are used by modern industry to create prototype models of new products.	CEQ4a: Why do we build prototypes when we can model them on a computer? CEQ4b: Is there a best way to create prototype models?
CEU5: Following safety procedures and using personal protection equipment will reduce the risk of injury.	CEQ5a: How does the saying "Never let your guard down!" apply to the lab? CEQ5b: Can any procedure be completely safe?

NJCCCS & COMMON CORE STANDARDS**NJCCCS:**

- 8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system.
- 8.2.12.F.2 Explain how material science impacts the quality of products.
- 8.2.12.F.3 Select and utilize resources that have been modified by digital tools (e.g., CNC equipment, CAD software) in the creation of a technological product or system.
- 9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences.
- 9.1.12.A.4 Justify problem-solving strategies used in the development of a particular innovative product or practice in the United States and in another country.

NJCCCS & COMMON CORE STANDARDS

CCSS:
 9-10.RST.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.
 9-10.RST.5 Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).
 9-10.WHST.9 Draw evidence from informational texts to support analysis, reflection, and research.
 9-10.RST.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.
 9-10.WHST.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

COMMON ASSESSMENT

ALIGNMENT	DESCRIPTION
LG1, LG2 CEU1, CEQ1a, CEQ1b, CEU4, CEQ4a, CEQ4b, CEU5, CEQ5a, CEQ5b 8.2.12.F.2, 3 9.1.12.A.1, 4 9-10.RST.3,.5,7 9-10.WHST.7, 9 DOK 4	Students research current cell phone accessories. Students will design and create 3+ iterations of a phone accessory prototype. Students will utilize a 3D printer and/or laser engraver to create advanced components and present it to the class. The class will act as investors and provide the presenter with specific feedback about their design, model, and presentation.

SUGGESTED STRATEGIES

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students will utilize the 3D printer and/or laser engraver to create 3+ iterations of a practical fashion accessory that is comprised of 2+ different components (e.g., bracelet with tweezers built-in, necklace with magnifying glass, watch band with screw bit storage, ring with stylus). They will test their design and document their process and results.	pla filament abs filament acrylic plywood mock-up prototype	Design for vector and/or raster engrave/cut Assess extruding filament flow Create a 3D model Document process and results DOK 4
Students will utilize the 3D printer and/or laser engraver to create 3+ iterations of an add-on or modification to the interior component of a car while keeping to MVC automotive safety guidelines (e.g., dashboard buttons or knobs, shift knob). They will document the process and results with pictures and/or video.	ergonomics motor vehicle safety design CAD rendering	Document process and results Create a 3D model DOK 4

ENGINEERING GRAPHICS I**UNIT 7: Product Design****SUGGESTED DURATION: 5-6 weeks****UNIT OVERVIEW****UNIT LEARNING GOALS**

LG1: Students will design a product through the analysis and revision of multiple iterations of a product concept.

LG2: Students will apply concepts of drawing and product design to create a solution within an area of opportunity.

UNIT LEARNING SCALE: LG1

4	In addition to level 3 performances, the student assist others in their design.
3	The student can: <ul style="list-style-type: none"> • apply concepts of the design process to modify multiple mock-ups to assist in visualization of form and function of a product; • demonstrate proper selection and use of 3D printers, laser engraving machines, and CNC machines for use in prototyping designs.
2	The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.
1	The student needs assistance or makes larger errors in attempting to reach level 3.
0	Even with help, the student does not exhibit understanding of performances listed in score 3.

UNIT LEARNING SCALE: LG2

4	In addition to score 3 performances, the student can analyze observations of user interactions with a product and apply it to their design.
3	The student can: <ul style="list-style-type: none"> • research and synthesize different problems within current products and identify an area of opportunity; • construct sketches to visualize solutions to different problems.
2	The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.
1	The student needs assistance or makes larger errors in attempting to reach level 3.
0	Even with help, the student does not exhibit understanding of performances listed in score 3.

ENDURING UNDERSTANDINGS**ESSENTIAL QUESTIONS**

CEU1: Communicating an engineering design requires effective visual representation.	CEQ1a: How do engineers communicate the elements of their designs? CEQ1b: Why do I have to communicate about my design to others?
CEU2: The design/engineering process is a series of steps taken in order to create a product or solve a problem.	CEQ2: If there are multiple solutions to an engineering problem, how is it that one is more elegant than another?
CEU3: Computer-aided design and traditional drafting each have their place in the world of engineering and design.	CEQ3a: How do I know when to use each tool in engineering drawing? CEQ3b: How do I determine when to use CAD versus traditional drafting?
CEU4: Dimensioned and rendered CAD creations are used by modern industry to create prototype models of new products.	CEQ4a: Why do we build prototypes when we can model them on a computer? CEQ4b: Is there a best way to create prototype models?

NJCCCS & COMMON CORE STANDARDS**NJCCCS:**

8.2.12.A.1 Design and create a technology product or system that improves the quality of life and identify trade-offs, risks, and benefits.

8.2.12.E.1 Use the design process to devise a technological product or system that addresses a global issue, and provide documentation through drawings, data, and materials, taking the relevant cultural perspectives into account throughout the design and development process.

8.2.12.G.1 Analyze the interactions among various technologies and collaborate to create a product or system demonstrating their interactivity.

9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences.

9.1.12.A.4 Justify problem-solving strategies used in the development of a particular innovative product or practice in the United States and in another country.



NJCCCS & COMMON CORE STANDARDS

CCSS:
 9-10.RST.6 Analyze 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.
 9-10.RST.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.

COMMON ASSESSMENT

ALIGNMENT	DESCRIPTION
LG1, LG2 CEU1, CEQ1a, CEQ1b, CEU2, CEQ2, CEU3, CEQ3a, CEQ3b, CEU4, CEQ4a, CEQ4b 8.2.12.A.1 8.2.12.E.1 9.1.12.A.1, 4 9-10.RST.9 9-10.WHST.7 DOK 4	Students complete a culminating project in which they identify a problem, design a solution, design a prototype, and build an attractive, functional product. Students will create their product using a 3D printer, mill, and/or laser engraver. Students will present their product to the class through a professional presentation. The class will provide the presenter with specific feedback. Use current Technology Student Association (TSA) guidelines for "Engineering Design" or "CAD Engineering" for inspiration.

SUGGESTED STRATEGIES

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students will analyze the design of a current product and determine its effectiveness. Students will modify the design based on their analysis and test their new design. Students must compare the functionality of the old design with their modified design.  Students can use CAD and CNC machines to create their product improvements.	design process renders models prototype looks-like versus works-like model	Construct a hypothesis for a design improvement Use concepts of material relationships to create a design DOK 4
Students will conduct and analyze market research within a specific area of consumer products. Students will then identify an area of opportunity within that market and use the design process to create a visually and mechanically sound product.  Students choose the categories in which to research based on their interests.	observations renders prototype research user interaction	Create a problem brief for a design issue Connect designs from different consumer product areas Critique a design based on user interaction DOK 4