FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

OFFICE OF CURRICULUM AND INSTRUCTION

TECHNOLOGY EDUCATION DEPARTMENT

HONORS ENGINEERING GRAPHICS 2

Grade Level: 10-12

Credits: 5

BOARD OF EDUCATION ADOPTION DATE:

AUGUST 29, 2016

FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

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HONORS ENGINEERING GRAPHICS II

COURSE PHILOSOPHY

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. Learning advanced drawing and computer-aided design techniques (solids, wiring, layering, and animation) are a necessity for college and career readiness for anyone considering the fields of engineering or design.

COURSE DESCRIPTION

In *Honors Engineering Graphics II*, students will master advanced traditional drafting techniques in addition to learning advanced functions within industry-standard CAD (computer-aided design) software. Students will be tasked with designing solutions to real-world problems with emphasis placed on working drawings that show the use of revolutions, auxiliary views, section views, assemblies, and fastening devices. These designs will be brought to life as models via advanced rapid prototyping such as 3D printing and laser engraving. Students will explore ergonomic design, industrial design, and product redesign throughout the course. Students wishing to pursue college degrees or a license in engineering, design, or architecture should take this course.

COURSE SUMMARY

COURSE GOALS

CG1: Students will communicate their ideas through professional-caliber oral and visual presentations.
CG2: Students will apply 2D/3D concepts in a visual medium to effectively create professional, elegant solutions to engineering problems.
CG3: Students will create functional models and assemblies based on the design specifications provided by a client.
CG4: Students will make safe and informed decisions when selecting and using equipment and tools.

COURSE ENDURING UNDERSTANDINGS	COURSE ESSENTIAL QUESTIONS
CEU1: Models and assemblies help explain a design to clients.	CEQ1a: How does the way you communicate with a client vary by audience? CEQ1b: Why is it important for an engineer or designer to communicate their solution to a client?
CEU2: Following safety procedures and using PPE (personal protection equipment) will reduce the risk of injury.	CEQ2a: How should someone conduct themselves in a technology lab setting? CEQ2b: How does the saying “Never let your guard down!” apply to the lab? CEQ2c: Can any procedure be completely safe?
CEU3: Engineers need to be good designers as well as good marketers of ideas.	CEQ3a: What does “good design” look like? CEQ3b: Why is marketing an important skill for designers and engineers?
CEU4: Visually advanced renderings and accurate drawings are essential to the design process.	CEQ4: How do drawings influence the final product?
CEU5: The choice of materials and the process of manufacturing must be fully understood in order to develop real-world solutions.	CEQ5a: Should you choose quality or cost when choosing final product design? When should material exploration begin? CED5b: When, how, and why will your product fail?
CEU6: Both manual and computer-aided drawings have their purpose in the design world.	CEQ6a: How are working drawings used in the real world? CEQ6b: Are there instances where it is better to use one method of creating working drawings over another?
CEU7: Original and redesigned products are patentable.	CEQ7a: What are the differences between invention and innovation? CEQ7b: Why should a product be redesigned?

UNIT GOALS & PACING		
UNIT TITLE	**UNIT GOALS**	**RECOMMENDED DURATION**
Unit 1: Design & Self-Management	LG1: Students will apply concepts of the design process to develop solutions to engineering problems. CG4: Students will make safe and informed decisions when selecting and using equipment and tools.	3 weeks
Unit 2: Professional Responsibilities & Portfolio Development	LG1: Students will analyze differences between the fields of engineering and the role that engineering graphics plays. LG2: Students will design and create a portfolio of completed work to showcase their abilities. CG1: Students will communicate their ideas through professional-caliber oral and visual presentations.	3 weeks
Unit 3: Advanced Drawing Techniques	LG1: Students will use mechanical drawing tools and drafting techniques to apply concepts of measurement and scale in order to create accurate section drawings, exploded drawings, and auxiliary views. CG2: Students will apply 2D/3D concepts in a visual medium to effectively create professional, elegant solutions to engineering problems.	6 weeks
Unit 4: Materials & Manufacturing	LG1: Students will test and analyze different materials to identify the best material choice for a specific task based on the design need. LG2: Students will utilize multiple different traditional and computer numerical control (CNC) manufacturing techniques to create models and prototypes with different materials. CG4: Students will make safe and informed decisions when selecting and using equipment and tools.	3 weeks
Unit 5: Advanced CAD	LG1: Students will construct highly detailed and rendered 3D representations of complex problems utilizing CAD software. LG2: Students will create interconnected 3D solids that meet design criteria and will be presented as a solution to various engineering problems. CG3: Students will create functional models and assemblies based on the design specifications provided by a client.	9 weeks
Unit 6: Engineering Design Project: Mechanisms	LG1: Students will design and create functional mechanisms by using in-depth 3-D prototyping. LG2: Students will redesign and further develop mechanical prototypes after being critiqued and critiquing the work of others.	6 weeks
Unit 7: Patent or Produce?	LG1: Students will apply concepts of drawing and product design to create a solution within an area of opportunity over multiple iterations. LG2: Students will investigate a small manufacturing run and market research for their design.	4 weeks

HONORS ENGINEERING GRAPHICS II
UNIT 1: DESIGN & SELF-MANAGEMENT **SUGGESTED DURATION: 3 WEEKS**

UNIT OVERVIEW	
UNIT LEARNING GOALS	
LG1: Students will apply concepts of the design process to develop solutions to engineering problems. CG4: Students will make safe and informed decisions when selecting and using equipment or tools.	
UNIT LEARNING SCALE: LG1	
4	In addition to score 3 performances, the student can describe how the design process was used in a real-world scenario.
3	The student can: • 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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.
UNIT LEARNING SCALE: CG4	
4	In addition to score 3 performances, the student can safely intervene and assist a peer who is not following appropriate safety protocols.
3	The student can: • independently follow classroom procedures and interact responsibly; • maintain a safe, clean lab environment; • identify and perform proper use and maintenance of tools; • utilize 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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
CEU2: Following safety procedures and using PPE (Personal protection equipment) will reduce the risk of injury.	CEQ2a: How should someone conduct themselves in a technology lab setting? CEQ2b: How does the saying “Never let your guard down!” apply to the lab? CEQ2c: Can any procedure be completely safe?
CEU4: Visually advanced renderings and accurate drawings are essential to the design process.	CEQ4: How do drawings influence the final product? Why are renderings so important to the final product?

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG1, CG4 CEU2, 4 CEQ2a-c, CEQ4 8.2.12.A.1 8.2.12.C.3, 7 11-12.WHST.6 DOK 3	After passing the safety test, students will use the design process to create a multimedia project demonstrating technology lab safety. The project should include common issues, troubleshooting, and safe procedures. The project will be used to help instruct the Engineering Graphics I students about safe tool usage and appropriate behavior.

TARGETED STANDARDS		
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO FURTHER DEVELOP
3D printing CNC machines design process hot glue gun hot wire cutter laser cutter personal protective equipment	Compare and contrast different engineering technologies and propose changes that will lead to a more effective design (DOK 3)	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.
	Analyze a product in order to evaluate its viability and effectiveness (DOK 3) Utilize tools and materials in a safe manner (DOK 2)	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).
	Use the engineering design process to design and create a solution to a “real-world” problem (DOK 3)	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.
	Use technology to produce, publish, and update individual or shared writing products (DOK 3)	11-12.WHST.6 Using technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

HONORS ENGINEERING GRAPHICS II
UNIT 2: PROFESSIONAL RESPONSIBILITIES & PORTFOLIO MANAGEMENT **SUGGESTED DURATION: 3 WEEKS**

UNIT OVERVIEW	
UNIT LEARNING GOALS	
LG1: Students will analyze differences between the fields of engineering and the role that engineering graphics plays therein. LG2: Students will design and create a digital portfolio of completed work to showcase their abilities. CG1: Students will communicate their ideas through professional-caliber oral and visual presentations.	
UNIT LEARNING SCALE: LG1	
4	In addition to score 3 performances, the student can assist other students with appropriate client communication and use of software.
3	The student can: • describe various fields of engineering; • demonstrate fundamentals of engineering graphics techniques; • demonstrate appropriate communication with clients.
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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.
UNIT LEARNING SCALE: LG2	
4	In addition to score 3 performances, the student can create their portfolio using or including a unique methodology (i.e. a video, a website, etc.)
3	The student can: • select a variety of completed assignments that showcase their varied talents and skills; • organize their portfolio in a professional manner; • compare assignments and arrange them in a portfolio; • demonstrate creative, original thinking within their design 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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.
UNIT LEARNING SCALE: CG1	
4	In addition to score 3 performances, the student creates and presents a design for a real client.
3	The student can: • create visual presentations that describe their design clearly and thoroughly; • defend their design choices and provide thorough explanation of their reasoning; • document their design through each of the steps of the design process that can be added to a portfolio.
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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
CEU1: Models and assemblies help to explain the design to clients.	CEQ1a: How would a designer or engineer defend their design choices? CEQ1b: Why is it important for an engineer or designer to communicate their solution to a client?
CEU3: Engineers need to be good designers as well as good marketers of ideas.	CEQ3b: Why is marketing an important skill for designers and engineers?

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
CG1 LG2 CEU1, 3 CEQ1a-b, 3b 8.1.12.A.1,2 9.2.12.C.1, 2 11-12.WHST.2, 5 DOK 3	Students will determine a field in engineering graphics that best represents their expertise. They will collect and organize all original, digital drawings, creating a digital portfolio for their chosen field that showcases updated drawings. Students will then review and critique each other's portfolios with an appropriate rubric.

TARGETED STANDARDS		
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO INTRODUCE
appearance model brainstorming client relations conceptual model design process developmental work iterations portfolio professionalism prototyping working drawing	Self-critique to determine if their work represents their interests and career aspirations (DOK 3)	8.1.12.A.1 Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resources.
	Create a portfolio of exceptional assignments for use in a professional or academic interview (DOK 4)	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.
	Identify career goals related to engineering (DOK 2)	9.2.12.C.1 Review career goals and determine steps necessary for attainment.
	Revise career plans and prioritize goals as necessary (DOK 2)	9.2.12.C.2 Modify Personalized Student Learning Plans to support declared career goals.
	Write explanatory texts to examine and convey complex design ideas and choices clearly and accurately (DOK 3)	11-12.WHST.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
	Edit, revise, and rewrite design proposals and presentations to address what is most significant for the client (DOK 3)	11-12.WHST.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

HONORS ENGINEERING GRAPHICS II
UNIT 3: ADVANCED DRAWING TECHNIQUES **SUGGESTED DURATION: 6 WEEKS**

UNIT OVERVIEW	
UNIT LEARNING GOALS	
LG1: Students will use mechanical drawing tools and drafting techniques to apply concepts of measurement and scale in order to create accurate section drawings, exploded drawings, and auxillary views. CG2: Students will apply 2D/3D concepts in a visual medium to effectively create professional, elegant solutions to engineering problems.	
UNIT LEARNING SCALE: LG1	
4	In addition to score 3 performances, the student can create additional views of drawings using a scale not previously practiced in class.
3	The student can: • create accurate scaled drawings of exploded views; • create accurate scaled drawings of auxiliary views; • demonstrate correct use of all drafting tools.
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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.
UNIT LEARNING SCALE: CG2	
4	In addition to score 3 performances, the student can assist other students with advanced drawing technique such as shading or texture rendering.
3	The student can: • create a solution to a design problem that meets constraints; • use the design process to arrive at a final solution; • design a solution to a real-world problem that follows the principles of good design; • demonstrate proper shading and texture rendering.
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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
CEU4: Visually advanced renderings and accurate drawings are essential to the design process.	CEQ4: How do drawings influence the final product?
CEU6: Both manual and computer-aided drawings have their purpose in the design world.	CEQ6a: How are working drawings used in the real world? CEQ6b: Are there instances where it is better to use one method of creating working drawings over another?

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
CG2, LG1 CEU4, 6 CEQ4, 6a-b 8.1.12.C.1 8.1.12.D.5 8.1.12.F.1 8.2.12.C.5 8.2.12.E.4 9.2.12.C.3 11-12.RST.3, 4 DOK 3	Students will create models of original design work. These models will include renders of completed drawing, sectioned views, exploded assemblies, and auxillary views. These will be digitized and added to the ongoing digital portfolio and will be organized for printing on a large format printer.

TARGETED STANDARDS		
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO INTRODUCE
assembly drawing ellipse exploded view isometric orthographic section view shading tolerance	Design a solution to a real world problem that meets or exceeds client expectations while following the design process (DOK 3)	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.
	Compare the capabilities of current and emerging technology resources as they apply to a specific design issue (DOK 3)	8.1.12.D.5 Analyze the capabilities and limitations of current and emerging technology resources and assess their potential to address personal, social, lifelong learning, and career needs
	Evaluate the strengths and limitations of materials and technologies in the creation of a design solution (DOK 3)	8.1.12.F.1 Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.
	Create scaled engineering drawings that provide detail for the manufacture of a product (DOK 4)	8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
	Elaborate on appropriate drawing vocabulary as it relates to engineering design (DOK 2)	8.2.12.E.4 Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).
	Demonstrate transferrable career skills for a technology-related field and adjust career plans as needed (DOK 2)	9.2.12.C.3 Identify transferable career skills and design alternate career plans.
	Follow a complex multi-step procedure when taking measurements and creating a detailed working drawing (DOK 2)	11-12.RST.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
	Elaborate on the meaning of symbols and key terms as they relate to engineering drawings (DOK 2)	11-12.RST.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 11–12 texts and topics.

DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO FURTHER DEVELOP
cost analysis design process professionalism trade-offs working drawings	Evaluate personal and academic interests and determine if designs represent their interests and career aspirations (DOK 3)	8.1.12.A.1 Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resources.
	Create a portfolio of exceptional scale drawings for use in a professional or academic application (DOK 3)	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.
	Compare and contrast different solutions and design changes that will lead to a more effective design (DOK 3)	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
	Use the engineering design process to design and create a solution to a “real-world” problem (DOK 4)	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.
	Modify career goals related to engineering as skills progress (DOK 3)	9.2.12.C.2 Modify Personalized Student Learning Plans to support declared career goals.

HONORS ENGINEERING GRAPHICS II
UNIT 4: MATERIALS & MANUFACTURING **SUGGESTED DURATION: 3 WEEKS**

UNIT OVERVIEW	
UNIT LEARNING GOALS	
LG1: Students will test and analyze different materials to identify the best material choice for a specific task based on the design need. LG2: Students will utilize multiple different traditional and computer numerical control (CNC) manufacturing techniques to create models and prototypes with different materials. CG4: Students will make safe and informed decisions when selecting and using equipment or tools.	
UNIT LEARNING SCALE: LG1	
4	In addition to score 3 performances, the student can find a unique use for a material.
3	The student can: • select appropriate materials for a specific task; • compare different materials for the same task; • assess material qualities including strength; • analyze existing uses of given materials.
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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.
UNIT LEARNING SCALE: LG2	
4	In addition to score 3 performances, the student can create a manufacturing plan for a product.
3	The student can: • use CNC manufacturing techniques such as a CNC router or laser cutter; • use traditional equipment such as a band saw, drill press, and sander to create a model or prototype; • assess the appropriate tool to manufacture a product; • create models and prototypes.
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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.
UNIT LEARNING SCALE: CG4	
4	In addition to score 3 performances, the student can safely intervene and assist a peer who is not following appropriate safety protocols.
3	The student can: • independently follow classroom procedures and interact responsibly; • maintain a safe, clean lab environment; • identify and perform proper use and maintenance of tools; • utilize 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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
CEU2: Following safety procedures and using PPE (Personal protection equipment) will reduce the risk of injury.	CEQ2a: How should someone conduct themselves in a technology lab setting? CEQ2b: How does the saying "Never let your guard down!" apply to the lab? CEQ2c: Can any procedure be completely safe?
CEU5: The choice of materials and the process of manufacturing must be fully understood in order to develop real-world solutions.	CEQ5a: Should you choose quality or cost when choosing final product design? When should material exploration begin?
CEU6: Both manual and computer-aided drawings have their purpose in the design world.	CEQ6b: Are there instances where it is better to use one method of creating working drawings over another?

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
CG4, LG1, 2 CEU2, 5, 6 CEQ2a-c, 5a, 6b 8.2.12.A.2, 3 8.2.12.C.2 8.2.12.D.3, 5 DOK 3	After passing the safety test, students will use the CNC machine to create a physical model of an original design utilizing multiple materials and manufacturing techniques. The design should be appropriate for CNC milling and contain a variety of exterior edges and contours but is not overly detailed in interior elements.

TARGETED STANDARDS		
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO INTRODUCE
assembly line craft extrusion fixture jig machine manufacturing materials modeling processes product prototyping repurpose thermoplastic thermoset	Research and analyze the production of a manufactured product (DOK 3)	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.
	Analyze the function and capabilities of products and design modifications for repurposing (DOK 3)	8.2.12.A.3 Research and present information on an existing technological product that has been repurposed for a different function.
	Assess popular products and assess their limitations with regard to emerging technologies and predict required modifications (DOK 3)	8.2.12.C.2 Analyze a product and how it has changed or might change over time to meet human needs and wants.
	Analyze a product and design modifications to be generated on a rapid prototyping device (DOK 3)	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.
	Determine how quality controls and manufacturing regulations effect the final product (DOK 2)	8.2.12.D.5 Explain how material processing impacts the quality of engineered and fabricated products.
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO FURTHER DEVELOP
audience community engineering careers environment portfolio safety social needs	Design a solution to a real world problem, choose appropriate manufacturing materials and processes, and defend the overall design (DOK 4)	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.
	Analyze newer products and their limitations, especially as they pertain to quality of material, and their effect on the global market (DOK 4)	8.1.12.F.1 Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.
	Analyze materials and manufacturing processes in order to evaluate their viability and effectiveness (DOK 3)	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).
	Follow computer drawing tutorials and make modifications to designs in order to properly produce them on rapid prototyping machines (DOK 2)	11-12.RST.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
	Create appropriate labels and tags for components as designed and program prototyping machines to transfer these (DOK 3)	11-12.RST.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 11-12 texts and topics.

HONORS ENGINEERING GRAPHICS II
UNIT 5: ADVANCED CAD **SUGGESTED DURATION: 9 WEEKS**

UNIT OVERVIEW	
UNIT LEARNING GOALS	
LG1: Students will construct highly detailed and rendered 3D representations of complex problems utilizing CAD software. LG2: Students will create interconnected 3D solids that meet design criteria and will be presented as a solution to various engineering problems. CG3: Students will create functional models and assemblies based on the design specifications provided by a client.	
UNIT LEARNING SCALE: LG1	
4	In addition to score 3 performances, the student can create a texture for a composite material that doesn't currently exist within the CAD software.
3	The student can: • use advanced features of CAD (lofting or sweeping along a path); • create highly detailed renderings of design solutions; • design a solution to a complex, realistic problem; • use of precise measurement in design 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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.
UNIT LEARNING SCALE: LG2	
4	In addition to score 3 performances, the student can reverse engineer a product within a specific tolerance.
3	The student can: • create a 3D model that uses mating in assemblies to articulate different components; • create a 3D model that is assembled within the CAD program; • create an animated 3D model; • create a 3D model that can be shown in an exploded view • analyze different 3D models to assess their solution to design criteria.
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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.
UNIT LEARNING SCALE: CG3	
4	In addition to score 3 performances, the student can assist other students with advanced drawing technique such as shading or texture rendering.
3	The student can: • create a solution to a design problem that meets constraints • use the design process to arrive at a final solution. • design a solution to a real-world problem that follows the principles of good design. • demonstrate proper shading and texture rendering
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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
CEU1: Models and assemblies help to explain the design to clients.	CEQ1a: How would a designer or engineer defend their design choices?
CEU4: Visually advanced renderings and accurate drawings are essential to the design process.	CEQ4: How do drawings influence the final product?

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
CG3, LG1, 2 CEU1, 4 CEQ1a, 4 8.1.12.C.1 8.2.12.C.5 8.2.12.E.4 11-12.RST.3 DOK 3	Students will create a 3D drawing of an original engineering design containing multiple components for a teacher-determined. These components will not be static but instead be parts of a mechanism. The mechanism should be a straight-forward design that incorporates multiple simple machines to accomplish a specific goal for the client. The design will be communicated via the digital portfolio and as a presentation to the class/company.

TARGETED STANDARDS		
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO INTRODUCE
constraints light source linkage prototype surface texture trade-off	Design an appropriate mechanical solution to an engineering design challenge involving a real world problem (DOK 4)	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.
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO FURTHER DEVELOP
brainstorming evaluation investigation planning problem identification redesign research testing	Use CAD software to design a solution to a real world problem to be reviewed by instructor and peers, and elicit feedback from professionals (DOK 4)	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.
	Use CAD software to create scaled engineering drawings (including auxiliary and exploded views) that provide all of the details for the manufacture of a product (DOK 3)	8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
	Use the engineering design process to design and create a solution to a “real-world” problem using CAD software, then re-design based on feedback (DOK 4)	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.
	Discuss engineering design concepts and program, and render final drawings in multiple software environments (DOK 3)	8.2.12.E.4 Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).
	Generate a step-by-step guide for going through the design process and generating a model on a rapid prototyping device (DOK 3)	11-12.RST.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
	Create a ley for unique, user-generated symbols that are used in original CAD drawings (DOK 3)	11-12.RST.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 11-12 texts and topics.

HONORS ENGINEERING GRAPHICS II
UNIT 6: ENGINEERING DESIGN PROJECT: MECHANISMS **SUGGESTED DURATION: 6 WEEKS**

UNIT OVERVIEW	
UNIT LEARNING GOALS	
LG1: Students will design and create functional mechanisms by using in-depth 3-D prototyping. LG2: Students will redesign and further develop mechanical prototypes after being critiqued and critiquing the work of others.	
UNIT LEARNING SCALE: LG1	
4	In addition to score 3 performances, the student can assist and teach another student how to utilize machinery safely.
3	The student can: • design a product to be created on a CNC machine within a tolerance range; • evaluate task needs in order to identify and select the correct tool/equipment; • demonstrate proper and safe procedures for CNC machines, 3D printers, and laser engravers; • 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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.
UNIT LEARNING SCALE: LG2	
4	In addition to score 3 performances, the student can further develop another's work with a sketch or quick mockup.
3	The student can: • appraise and defend their own design work; • assess a mechanical design and provide meaningful feedback; • modify a design based on feedback; • redesign a prototype based on feedback and testing.
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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
CEU3: Engineers need to be good designers as well as good marketers of ideas.	CEQ3b: Why is marketing an important skill for designers and engineers?
CEU4: Visually advanced renderings and accurate drawings are essential to the design process.	CEQ4: How do drawings influence the final product?
CEU5: The choice of materials and the process of manufacturing must be fully understood in order to develop real-world solutions.	CEQ5a: Should you choose quality or cost when choosing final product design? When should material exploration begin? CED5b: When, how, and why will your product fail?

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG1, 2 CEU3, 4, 5 CEQ3b, 4, 5a-b 8.1.12.D.1 8.1.12.E.1 8.2.12.C.4, 6 11-12.WHST.9 DOK 4	Students will use the design process to create a product that utilizes at least two different functional mechanisms and at least two different materials. Students will document the project online as a set of instructions for public use, review, and critique (i.e. Instructables.com, diy.com, hackaday.com, howto.com, etc.). This project will allow students to gain insight to the need for clear documentation of the material testing, troubleshooting, design process, and visual representation of a product for others to recreate a specific design.

TARGETED STANDARDS		
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO INTRODUCE
appearance brainstorming cams conceptual model copyright design process developmental work exploded view gantt chart gears hinge interdependent isolated iterations levers mechanisms model prototype prototyping ramp Rube Goldberg screw systems thread wedge working drawing	Create a design and register it under Creative Commons OR modify a design and cite the changes made via Creative Commons (DOK 4)	8.1.12.D.1 Demonstrate appropriate application of copyright, fair use and/or Creative Commons to an original work.
	Identify a real world problem and propose a solution (DOK 3)	8.1.12.E.1 Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.
	Analyze the functions of different components of a product through deconstruction (DOK 3)	8.2.12.C.4 Explain and identify interdependent systems and their functions.
	Compare different elements of a product's functions and materials to improve its design (DOK 3)	8.2.12.C.6 Research an existing product, reverse engineer and redesign it to improve form and function.
	Research mechanisms that allow users to accomplish the same goal in different ways (DOK 2)	WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO FURTHER DEVELOP
career research client relations manufacturing plan pivot point portfolio professionalism project management reverse engineer teamwork	Design interdependent mechanisms utilizing both sketching and CAD techniques (DOK 3)	8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
	Critique and be critiqued by peers to assist in a design problem involving multiple stages (DOK 3)	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.
	Analyze a product to identify the process in which it can be redesigned using a different method (DOK 3)	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.
	Apply the same material process to two different products and describe how the products can be created to higher standards (DOK 4)	8.2.12.D.5 Explain how material processing impacts the quality of engineered and fabricated products.
	Research and describe the career choices and goals needed to attain a position with a design company (DOK 2)	9.2.12.C.1 Review career goals and determine steps necessary for attainment.
	Network with engineers and designers to complete a project that is of their own design (DOK 4)	9.2.12.C.2 Modify Personalized Student Learning Plans to support declared career goals.
	Self-evaluate existing transferrable career skills and modify career plan (DOK 3)	9.2.12.C.3 Identify transferable career skills and design alternate career plans.
	Evaluate evidence of successful mechanisms that are utilized in a design (DOK 2)	11-12.WHST.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
	Revise plans for the design and manufacturing of a product (DOK 3)	11-12.WHST.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

HONORS ENGINEERING GRAPHICS II
UNIT 7: PATENT OR PRODUCE? **SUGGESTED DURATION: 4 WEEKS**

UNIT OVERVIEW

UNIT LEARNING GOALS

LG1: Students will apply concepts of drawing and product design to create a solution within an area of opportunity over multiple iterations.
LG2: Students will investigate a small manufacturing run and market research to identify product viability.

UNIT LEARNING SCALE: LG1

4	In addition to score 3 performances, the student can create multiple iterations of a design during a short time period to further develop it.
3	The student can: • compare elements of a design and identify areas of improvement; • create sketches that build upon the designs that are already developed; • evaluate, redesign, and remake a prototype after testing reveals flaws.
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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

UNIT LEARNING SCALE: LG2

4	In addition to score 3 performances, the student can create a business plan and timeline for the product that they are creating.
3	The student can: • plan out a manufacturing run based on the requirements of the project; • decide if a internal manufacturing run is cost effective; • analyze market potential for their product and figure out final pricing based on profits; • create a build of materials (BOM) for a manufacturing run of 10+ products to be brought to market.
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 to avoid major errors in attempting to reach score 3 performances.
0	Even with assistance, the student does not exhibit understanding of the performances listed in score 3.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
CEU1: Students will understand that models and assemblies help to explain the design to clients.	CEQ1b: Why is it important for an engineer or designer to communicate their solution to a client?
CEU5: The choice of materials and the process of manufacturing must be fully understood in order to develop real-world solutions.	CEQ5a: Should you choose quality or cost when choosing final product design? When should material exploration begin? CED5b: When, how, and why will your product fail?
CEU7: Original and redesigned products are patentable.	CEQ7a: What are the differences between invention and innovation? CEQ7b: Why should a product be redesigned?

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG1, 2 CEU1, 5, 7 CEQ1b, 5a-b, 7a-b 8.2.12.B.3 9.2.12.C.6, 7, 8 DOK 4	Using the knowledge and design skills learned, students will identify a design problem and synthesize a solution though testing and research. After finding this solution utilizing the design process and creating at least two iterations, the students will identify their product as an invention or innovation and will conduct market research to decide if this product should be patented or produced. The student should consider cost versus quality, material choices, final manufacturing methods, and market demands.

TARGETED STANDARDS		
DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO INTRODUCE
copyright crowdsource funding ethics infringement intellectual property investments law patent process straight to manufacture	Compare and analyze different products that accomplish a similar goal (DOK 3)	8.2.12.B.3 Analyze ethical and unethical practices around intellectual property rights as influenced by human wants and/or needs.
	Compare funding sources for patented versus produced products (DOK 3)	9.2.12.C.6 Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources required for owning and managing a business.
	Apply knowledge of the legal ownership of ideas to real-world scenarios (DOK 3) Assess the impact of copyright infringement on a product (DOK 3)	9.2.12.C.7 Examine the professional, legal, and ethical responsibilities for both employers and employees in the global workplace.

DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	STANDARDS TO FURTHER DEVELOP
design process innovation intellectual property invention prototype	Create a prototype to solve a problem while working with people from different fields to help influence designs (DOK 4)	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.
	Identify the correct use of technology and materials to create a prototype (DOK 2)	8.1.12.D.5 Analyze the capabilities and limitations of current and emerging technology resources and assess their potential to address personal, social, lifelong learning, and career needs
	Analyze the pros and cons of a design's material choices (DOK 4)	8.1.12.F.1 Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.
	Create dimensioned design drawings of a product to be created and tested (DOK 4)	8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
	Design, create, and test a marketable prototype for peer review (DOK 4)	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
	Apply concepts of CNC equipment to assist in the creation of a product (DOK 3)	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.
	Identify the correct use of materials for the creation of a product (DOK 2)	8.2.12.D.5 Explain how material processing impacts the quality of engineered and fabricated products.
	Formulate documentation to evaluate current technologies to help guide the design of a prototype (DOK 3)	11-12.WHST.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
	Read several different reviews of the same product and synthesize an argument from a design perspective about the usefulness of that product (DOK 3)	11-12.WHST.9 Draw evidence from informational texts to support analysis, reflection, and research.