PUBLIC SCHOOLS OF EDISON TOWNSHIP
DIVISION OF CURRICULUM AND INSTRUCTION

STEM 4 – Senior Design & Capstone Experience

Length of Course:	Full Year
Elective/Required:	STEM Academy
Schools:	EHS
Eligibility:	Grade 12
Credit Value: (High School Only)	5 credits
Date Approved:	2/27/17

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Statement of Purpose

This course provides students with the opportunity to integrate K-12 subject matter to design and develop a solution to solve a real world engineering design problem. The students use prior knowledge of the design process and drawing techniques such as hand sketching and computer aided drafting to design and solve problems related to the solution. Emphasis is placed on research, documentation and evaluation of the solution to the design problem. The organizational structure of this course is based on a “Student Driven Project” and a “Central Project” philosophy to provide a realistic and meaningful experience and to allow for guidance and support through the community and industry.

The course will allow students to *apply* the basic concepts for design, problem solving, technical writing, computer application, engineering and material processing skills. Students will design, develop and construct an entire single solution to a problem or an integral part of a system that must be integrated with other student work to produce a solution to a larger design problem. All solutions are tested, evaluated and redesigned as needed as time permits.

Senior Design & Capstone Experience Course Philosophy

Any system, product or service requires the integration of many elements. The designer or engineer must have the ability to work and communicate with others to integrate these many elements of a system, product or service while designing, modeling and testing. This type of integration requires the ability to predict outcomes and work out problems and details for a design solution.

In order to function in a technological world and be prepared for the new millennium, students must be better problem solvers, critical thinkers, and communicators. They must be able to gather, process, analyze and synthesize information. The course is designed to engage the learner in the problem solving procedure and design process used in higher education and industry. The problem solving procedure and design process naturally reinforces communication skills and critical thinking. Integration of subject matter in the STEM academy is a main focus. This course provides the student with an opportunity to function as a designer and engineer with a specific focus. Each student will be responsible for designing and producing a solution to a chosen senior design problem. The students will work together with teachers, mentors and professionals to integrate the many elements of the design solution to a problem.

Course Objectives

The student will be able to:

The course will provide an understanding of the roles of engineers, scientists, designers, and technicians through actually taking on these roles in the lab and interfacing students with filed professionals as mentors. The objectives of the course are to:

- Create a learning environment that allows students to integrate K-12 and AP subject matter.
- Instill the philosophy that lifelong learning is a way of life.
- Provide students with an opportunity to *apply* creative and critical thinking and problem solving skills.
- Provide students with an opportunity to *apply* research skills employing the design process and the scientific method.
- Involve the community and industry in student education.
- Demonstrate integration of educational technology (CCCS 8.1) whenever applicable
- Demonstrate knowledge of higher education and career pathways related to chosen area of competence (CCCS 9)
- Present a realistic approach to express and communicate ideas through written and graphic communication.
- Allow students to work independently and cooperatively while experiencing large and small group dynamics.
- Provide an opportunity to design and develop system components integrated into a complex project.
- Provide an opportunity for individuals to design and develop an entire solution to a design problem.
- Individualize student experience through choice of component project involvement.
- Develop solutions with a socially conscious and sustainable focus.

Timeline

Marking period 1

Unit 1

- Independent Projects / Identifying Problems

Unit 2

- Criteria / Constraints

Unit 3

- Final Project Design Proposal

Marking period 2

Unit 4

- Brainstorm, Generate Multiple Solutions, Select One and Provide a Rationale

Marking Period 3

Unit 5

- Developmental Work

Unit 6

- Modeling and Prototyping

Marking Period 4

Unit 7

- Testing (Evaluation & Analysis)

Unit 8

- Documentation and Presentation

Unit 1: Independent Projects / Identifying Problems

Targeted Standards:

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: Evaluate the positive and negative impacts in design by providing a digital overview of a chosen product and suggest potential modifications to address the negative impacts.
8.2.12.B.3: Analyze the full costs, benefits, trade-offs and risks related to the use of technologies in a potential career path
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.
9.4.12.B.(1).2 Employ appropriate representational media to communicate concepts and design.
9.4.12.B.54 Apply ethical reasoning to a variety of situations in order to make ethical decisions

Unit Objectives/Conceptual Understandings: While students in this course have undertaken design challenges many times before using the design process, they have never spent an entire school year on a single activity. Furthermore, they have always been asked to solve the problems identified and assigned by the teacher, and are rarely responsible for doing so on their own. As such, they must be introduced to the concept of an independent study. Together, the teacher and the students will look at how college students typically engage in an independent study on a single design challenge, and how much more involved they are as compared to the projects they have done in the past.

Essential Questions: What great products can be achieved through an independent study?

Unit Assessment: At the end of the unit, students will have made individual presentations of their research to the rest of the class depicting the evolutionary stages of independent projects – and their final resulting products. Given a series of case studies about independent design projects undertaken by college students, the high school students will be able to match each stage in the design process with the corresponding events in the case study.

The class will engage in a two-day discussion to address expectations, concerns, fears and hopes for this course.

	Core Content Objectives		**Instructional Actions**	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
• Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day	The teacher is a facilitator during an independent project and the student is accountable for his/her own progress and success.	• Create a document with text using a word processing program. • Create a document with text formatting and graphics using a word	Higher Education Pathways – students will study the depth/breadth and scope/sequence of college-based independent study project.	At the end of the unit, students will have made individual presentations of their research to the rest

Unit 1: Independent Projects / Identifying Problems (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
or two) for a range of tasks, purposes, and audiences. • Engage in online discussions with learners in the United States or from other countries to understand their perspectives on a global problem or issue. • Produce clear and coherent writing in which the development, organization, and style are compliant and clear to the reader. • Synthesize and publish information about a local or global issue or event on a collaborative, web-based service (also known as a shared hosted service).	Time management skills are crucial to an independent project. An independent project will result in a well-planned and thoughtful final product that is never really totally finished given the nature of the design process.	processing program. • Create and present a multimedia presentation that includes graphics. Synthesize and publish information about a local or global issue or event on a collaborative, web-based service (also known as a shared hosted service).	Communication – students must share their research with the class and participate in group discussions	of the class depicting the evolutionary stages of independent projects – and their final resulting products. Given a series of case studies about independent design projects undertaken by college students, the high school students will be able to match each stage in the design process with the corresponding events in the case study. The class will engage in a two-day discussion to address expectations, concerns, fears and hopes for this course.
Resources: Internet web quests, Educational technology Software, Mentorship meetings			**Instructional Adjustments:** individualized and custom projects that challenge each student.	

Unit 2: Criteria / Constraints

Targeted Standards:
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. F.2: Explain how material science impacts the quality of products.
8.2.12.C.3 Evaluate the positive and negative impacts in a design by providing a digital overview of a chosen product and address the negative impacts
8.2.12.F.3 Select and utilize resources that have been modified by digital tools in the creation of a technological product or system (CNC equipment, CAD software.
9.4.12.B.7 Demonstrate use of the concepts, strategies, and systems for obtaining and conveying ideas and information to enhance communication.
9.4.12.B.74 Read, interpret, and use technical drawings, documents, and specifications to plan a project.
9.4.12.B.75 Use and maintain appropriate tools, machinery, equipment, and resources to accomplish project goals.

Unit Objectives/Conceptual Understandings: (Students will understand that)
Critical Thinking – students think critically about the problems caused by technology in society and how technology could be used address those problems within the course constraints.
Communication & Collaboration – students must engage in inquiry with members of the community to identify problems
Interpersonal Skills – students will interview others

Essential Questions: What constitutes a good technological problem?

Unit Assessment: During this unit, students will explore multiple areas of the designed world and contexts for identifying problems defined using specific terms. Using a matrix rubric for guidance, students will maintain a daily blog to document their exploration, thought processes, and list of potential problems in these terms:

- Motivation and Interests
- Areas of the designed world
- Contextual relevance
- Human Needs
- Problems and Opportunities
- Preliminary thoughts about feasibility

Unit 2: Criteria / Constraints (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
• Present resources and data in a format that effectively communicates the meaning of the data and its implications for solving problems, using multiple perspectives. • Create and respond to a feedback loop when problem solving. • Assist in the development of innovative solutions to an onsite problem by incorporating multiple perspectives and applying effective problem-solving strategies during structured learning experiences, service learning, or volunteering.	• Motivation and Interests • Areas of the designed world • Contextual relevance • Human Needs • Problems and Opportunities • Preliminary thoughts about feasibility • Sustainability • Socially conscious design	• Gathering and evaluating knowledge and information from a variety of sources, including global perspectives, fosters creativity and innovative thinking.	Critical Thinking – students think critically about the problems caused by technology in society and how technology could be used address those problems within the course constraints. Communication & Collaboration – students must engage in inquiry with members of the community to identify problems Interpersonal Skills – students will interview others	During this unit, students will explore multiple areas of the designed world and contexts for identifying problems defined using specific terms. Using a matrix rubric for guidance, students will maintain a daily blog to document their exploration, thought processes, and list of potential problems in these terms: • Motivation and Interests • Areas of the designed world • Contextual relevance • Human Needs • Problems and Opportunities • Preliminary thoughts about feasibility.
Resources: Internet web quests, Educational technology Software, Mentorship meetings Access to WordPress Blogs Problem Identification Matrix Rubric			**Instructional Adjustments:** Individual project meetings, direction and advice, personalized for each project	

Unit 3: Final Project Design Proposal

Targeted Standards:

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: Evaluate the positive and negative impacts in design by providing a digital overview of a chosen product and suggest potential modifications to address the negative impacts.
8.2.12.B.3: Analyze the full costs, benefits, trade-offs and risks related to the use of technologies in a potential career path
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.
9.4.12.B.(1).2 Employ appropriate representational media to communicate concepts and design.
9.4.12.B.54 Apply ethical reasoning to a variety of situations in order to make ethical decisions

Unit Objectives/Conceptual Understandings:

Once students have narrowed their focus to address a single problem with the potential for multiple solutions, they are ready to frame or develop a design brief so that they can think very precisely about the problem at hand, but also be open to open up a number of possible solutions that can be approached creatively. Students will learn about the definition, purpose and contents of a design brief; and, engage in lessons about technical writing before writing their first draft.

Essential Questions: What are the benefits of a well written design brief and how are they used in industry to guide the design process

Unit Assessment:

Students will present a complete design brief to the class and document it on their blog. Rubrics for technical writing and design brief will address:

- Technical Wiring

Questions relating to function, human factors, budget, materials, other resources, environmental impact, aesthetics, time and production.

	Core Content Objectives		**Instructional Actions**	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
• The design process is a systematic approach to solving problems. • The ability to recognize a problem and apply critical thinking and problem-solving skills	Critical Thinking – students think critically about the problems caused by technology in society and how technology could be used. Address those problems	• Brainstorm and devise a plan to repair a broken toy or tool using the design process • Investigate the influence	Language Arts Literacy – students must follow technical writing guidelines Science, Math and Civic Literacy – students must address questions about	Students will present a complete design brief to the class and document it on their blog. Rubrics for technical writing and design brief will

Unit 3: Final Project Design Proposal

Cumulative Progress Indicators	Concepts *What students will know.*	Skills *What students will be able to do.*	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points
	within the course constraints. Digital Citizenry – students must document and share their work, as it progresses, on a blog Ethical Decision Making – student must consider ethical constraints while developing a design brief Financial, Economic, Business & Entrepreneurial Literacy – students consider monetary constraints on their design brief Technical writing protocols	of a specific technology on the individual, family, community, and environment. • Identify the design constraints and trade-offs involved in designing a prototype (e.g., how the prototype might fail and how it might be improved) by completing a design problem and reporting results in a multimedia presentation. • Recognize a problem and brainstorm ways to solve the problem individually or collaboratively. • Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience • Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.	constraints to design specifications across in each of these areas	address: • Technical Wiring Questions relating to function, human factors, budget, materials, other resources, environmental impact, aesthetics, time and production.
Resources: Internet web quests, Educational technology Software, Mentorship meetings Access to WordPress Blogs Problem Identification Matrix Rubric			**Instructional Adjustments:** Individual project meetings, direction and advice, personalized for each project	

Unit 4: Brainstorm, Generate Multiple Solutions, Select One and Provide a Rationale

Targeted Standards:

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: Evaluate the positive and negative impacts in design by providing a digital overview of a chosen product and suggest potential modifications to address the negative impacts.
8.2.12.B.3: Analyze the full costs, benefits, trade-offs and risks related to the use of technologies in a potential career path
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.
9.4.12.B.(1).2 Employ appropriate representational media to communicate concepts and design.
9.4.12.B.54 Apply ethical reasoning to a variety of situations in order to make ethical decisions

Unit Objectives/Conceptual Understandings:

Once students have conducted research about their problem, they must brainstorm ideas for possibly solving the problem without letting design constraints influence their creativity. Once students have teased out as many ideas as possible, even down to the subsystems and interdependent parts that may exist in a product or system, they are read to generate multiple ideas or concepts that could potentially solve the problem. After comparing and contrasting each possible solution in many different terms (required resources, constraints, usability, manufacturing, impact on layers of society, product life-cycle, ethics, etc.) The student picks a single solution and writes a rationale explaining why it is the best solution to the problem.

Essential Questions: How do designers and engineers around the world generate and defend solutions to technological problems?

Unit Assessment:

Students will document and present their:

- Morphologic Chart of Brainstorming Process with six variations for six project attributes.
- Evidence of at least three different solutions to the same problem.
- Select a single solution and provide a rationale in a five-page paper defending why their choice is the best design to solve the problem expressed in terms of the four outputs or outcomes of technology as they relate to society (user, environment, economy, government, ethics, etc.)

	Core Content Objectives		**Instructional Actions**	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
Brainstorming requires an open mind and may ignore many of the constraints in	Critical Thinking – students think critically about variations, pros,	Design and create a prototype for solving a global problem,	History - students consider the impact of related technological solutions throughout history	**Summative Assessment**

Unit 4: Brainstorm, Generate Multiple Solutions, Select One and Provide a Rationale (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
a design brief. Brainstorming may break a possible solution into individual parts or subsystems and does not have to address the entire product or system as a whole. Every potential solution will have desire, undesirable, intended and unintended outcomes or consequences. It is important to generate multiple solutions and assess (in as many terms as possible) which design is the best for solving the problem given the original constraints and specifications in the design brief. A rationale explains why a solution is the best choice based on many considerations including: usability, manufacturing, required resources, potential outcomes/consequences, costs, trade- offs, benefits, impacts on layers of society,	cons, tradeoffs, and impacts of a technological solution Digital Citizenry – students must document and share their work, as it progresses, on a blog Ethical Decision Making – student must consider ethical issues associated with solutions Financial, Economic, Business & Entrepreneurial Literacy – students must weigh the costs of a solution, and the monetary value of a solution to all parties involved Global Awareness – Students must consider the global impact of a given solution Creativity and Innovation - Use a wide range of idea creation techniques (such as brainstorming) Create new and worthwhile ideas	documenting how the proposed design features affect the feasibility of the prototype through the use of engineering, drawing, and other technical methods of illustration. Evaluate ethical considerations regarding the sustainability of resources that are used for the design, creation, and maintenance of a chosen product. Identify the resources needed to create technological products and systems. Explain the impact of resource selection and processing in the development of a common technological product or system. Explain how the resources and processes used in the production of a current technological product can be modified to have a more	Math & Economics - students calculate costs of resources to develop and see a solution through its life cycle Educational Technology – (NJCCCS 8.1) students will use online tools for conducting, tracking, storing, tagging and retrieving research and data Language Arts Literacy – Using Technology to express and share ideas	Students will document and present their: ● Morphologic Chart of Brainstorming Process with six variations for six project attributes. ● Evidence of at least three different solutions to the same problem. ● Select a single solution and provide a rationale in a five page paper defending why their choice is the best design to solve the problem expressed in terms of the four outputs or outcomes of technology as they relate to society (user, environment,

Unit 4: Brainstorm, Generate Multiple Solutions, Select One and Provide a Rationale (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
product life cycle, and ethics.	(both incremental and radical concepts) Elaborate, refine, analyze and evaluate their own ideas in order to improve and maximize creative efforts.	positive impact on the environment (e.g., by using recycled metals, alternate energy sources) and the economy. Evaluate available resources that can assist in solving problems. Brainstorm variations of ideas to solve subsystems or parts of a larger product or system. Generate multiple solutions to a single problem. Choose a solutions and provide a thoughtful rationale, explaining in depth, all of the considerations that could be involved with the intended solution at all stages of its life in the product lifecycle, as well as its impacts on various layers of society		economy, government, ethics, etc.)
Resources: Internet web quests, Educational technology Software, Mentorship meetings Access to WordPress Blogs Problem Identification Matrix Rubric Rubric for Morph Chart Rubric for Multiple Solutions Rubric for Selecting and identifying a single solution and writing a rationale defending the decision.			**Instructional Adjustments:** Individual project meetings, direction and advice, personalized for each project	

Unit 5: Developmental Work

Targeted Standards:

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. F.2: Explain how material science impacts the quality of products.
8.2.12.C.3 Evaluate the positive and negative impacts in a design by providing a digital overview of a chosen product and address the negative impacts
8.2.12.F.3 Select and utilize resources that have been modified by digital tools in the creation of a technological product or system (CNC equipment, CAD software.
9.4.12.B.7 Demonstrate use of the concepts, strategies, and systems for obtaining and conveying ideas and information to enhance communication.
9.4.12.B.74 Read, interpret, and use technical drawings, documents, and specifications to plan a project.
9.4.12.B.75 Use and maintain appropriate tools, machinery, equipment, and resources to accomplish project goals.

Unit Objectives/Conceptual Understandings:

Once students have selected the general direction they would like to take for creating a single solution to solve the problem, they must develop specific plans that clarify and communicate every last detail about the creation of the project. These plans would include, but are not limited to: color drawings, sketches, CAD drawings, orthographic projections and isometric renderings; video simulations; 2D models that demonstrate or confirm mechanical action or movement; and, 3D models that help work out size, shape, appearance or other important factors in the design.

Upon completion of developmental work, students can present their progress in any number of formats, (in the form of a DVD, video, blog or printed portfolio) to local businesses and international corporations for the purpose of securing donations and other resources. When companies donate to a non-profit, such as a school, it is good for their Public Relations plan and qualifies them for tax write-offs to a non-profit organization. Students could also publicize the assistance they receive from a company by writing about it on their blog and any publications they release to the press or professional journals.

Essential Questions: Why is it important for industry to adhere to standards for 2D and 3D Design, and animation?

Unit Assessment:

Students will document and present their:

- Hand drawn thumbnail sketches, orthographic projections and perspective/isometric drawings.
- CAD files of orthographic projections, isometric views, renderings, animations and simulations

Unit 5: Developmental Work (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
Create professional documents (e.g., newsletter, personalized learning plan, business letter or flyer) using advanced features of a word processing program. Design and create a prototype for solving a global problem, documenting how the proposed design features affect the feasibility of the prototype through the use of engineering, drawing, and other technical methods of illustration. Assist in the development of innovative solutions to an onsite problem by incorporating multiple perspectives and applying effective problem-solving strategies during structured learning experiences, service learning, or volunteering. Work in collaboration with peers and experts in the field to develop a product using the design process, data analysis and trends, and trends, and maintain a digital log with annotated sketches to record the development cycle.	Critical Thinking – students think critically about variations, pros, cons, trade-offs, and impacts of a technological solution Digital Citizenry – students must document and share their work, as it progresses, on a blog Problem Solving – Solve design problems as they surface during the developmental work stage. Collaboration – Students collaborate with their teacher and possibly a mentor during this stage of the design process.	When developing designs in 2D, students should produce the following by hand and on computer/ Internet software: Orthographic Sketches, Orthographic Projections, Thumbnails, Storyboards, and Charts/Diagrams explaining inputs/ processes/outputs/ feedback for a Systems Model. When developing designs in 3D, students should produce the following by hand and on computer/Internet software: One and Two Point Perspective Drawings; Isometric Views and Renderings; and, Physical models depicting mechanisms and form. When developing plans for a solution, animations and simulations can be produced in CAD software that will show how a product or system will function and interact with its intended users or environment.	Math – (NJCCCS-4.2.12) Be able to apply basic geometric and measurement concepts to drawings, sketches and models. Science – (NJCCCS-5) Apply science principles to solving sub-problems within the context of the overarching problem. Educational Technology- (NJCCCS – 8.1) Use CAD/CAM software to generate designs.	Students will document and present their: ● Hand drawn thumbnail sketches, orthographic projections and perspective/isometric drawings. ● CAD files of orthographic projections, isometric views, renderings, animations and simulations

Unit 5: Developmental Work (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
The use of technology and digital tools requires knowledge and appropriate use of operations and related applications Gathering and evaluating knowledge and information from a variety of sources, including global perspectives, fosters creativity and innovative thinking. Technological products and systems are created through the application and appropriate use of technological resources.				
Resources: Internet web quests, Educational technology Software, Mentorship meetings Access to WordPress Blogs Problem Identification Matrix Rubric CAD/CAM Software in the Computer Lab Documentation Software - Adobe			**Instructional Adjustments:** Individual project meetings, direction and advice, personalized for each project	

Unit 6: Modeling and Prototyping

Targeted Standards:

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: Evaluate the positive and negative impacts in design by providing a digital overview of a chosen product and suggest potential modifications to address the negative impacts.
8.2.12.B.3: Analyze the full costs, benefits, trade-offs and risks related to the use of technologies in a potential career path
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.
9.4.12.B.(1).2 Employ appropriate representational media to communicate concepts and design.
9.4.12.B.54 Apply ethical reasoning to a variety of situations in order to make ethical decisions

Unit Objectives/Conceptual Understandings:

Once students have developed detailed plans during the developmental work stage of the design process, they will move forward and produce models and prototypes. This is the longest unit and requires the most hands-on work. An important part of this unit is the selection of which types of models and prototypes to produce. During this stage, students will be back and forth between the design lab and the fabrication lab, using a variety of tools, machines, software applications, processes and Internet applications. Storage is particularly important, also, as student begin accumulating models, materials and prototypes. Once finished, the students will have completed prototypes that can be used by target stakeholders or users during the testing phase of the design process.

In some cases, students may require access to tools, machines and materials not provided here at Gateway. Whenever possible, they will rely on donations and resources available through mentors and partnerships solicited during unit 5 (developmental work).

Essential Questions: How do models and prototypes inform the design of the final product or system?

Unit Assessment:

Students will produce, document and present their:

- Functional and Aesthetic Models, built and finished by hand and by rapid prototyping CAM equipment.
- Functional and Aesthetic Prototypes, built and finished hand and by rapid prototyping CAM equipment.

Using one or more items, students should be able to make models and prototypes that address the designs ability to adhere to all constraints and meet all specifications named in the student's individual design brief such as, but not limited to:

- Function of materials
- Durability
- Appearance
- Function of subsystems
- Performance

Unit 6: Modeling and Prototyping (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
Design and create a technology product or system that improves the quality of life and identify trade-offs, risks, and benefits. Design an alternative use for an existing product. Design and create a prototype for solving a global problem, documenting how the proposed design features affect the feasibility of the prototype through the use of engineering, drawing, and other technical methods of illustration. Evaluate the function, value, and aesthetics of a technological product, system, or environment from the perspective of the user and the producer. Use the design process to devise a technological product or system that addresses a global issue, and provide	Models can take the form of 2D, 3D, Computer and Mathematical. Appearance models do not function but are intended to show what a product will look like when it is produced. Functional models may not look like the end product, but they are operational (e.g., mechanical or electrical systems). Prototypes are models that function and look like the finished product, but are usually hand built – unless rapid prototypes are created using CAM (computer assisted manufacturing) equipment such as a 3D plastic printer or CNC Router, Laser Engraver <u>Critical Thinking</u> – students think critically about the best tools, machines, materials and processes necessary to produce models and prototypes.	Models can take the form of 2D, 3D, Computer and Mathematical. Appearance models do not function but are intended to show what a product will look like when it is produced. Functional models may not look like the end product, but they are operational (e.g., mechanical or electrical systems). Prototypes are models that function and look like the finished product, but are usually hand built – unless rapid prototypes are created using CAM (computer assisted manufacturing) equipment such as a 3D plastic printer or CNC Router, Laser Engraver	<u>Math</u> – (NJCCCS-4.2.12) Be able to apply basic geometric and measurement concepts to models and prototypes <u>Science</u> – (NJCCCS-5) Apply science principles to models and prototypes, identify appropriate materials, and select appropriate processes. <u>Educational Technology</u>- (NJCCCS – 8.1) Document and share work using digital video/photography, editing software, and graphic design software.	Students will produce, document and present their: ● Functional and Aesthetic Models, built and finished by hand and by rapid prototyping CAM equipment. ● Functional and Aesthetic Prototypes, built and finished hand and by rapid prototyping CAM equipment. Using one or more items, students should be able to make models and prototypes that address the designs ability to adhere to all constraints and meet all specifications named in the student's individual design brief such as, but not limited to: ● Function of materials

Unit 6: Modeling and Prototyping (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
documentation through drawings, data, and materials, taking the relevant cultural perspectives into account throughout the design and development process.	Digital Citizenry – students must document and share their work, as it progresses, on a blog Problem Solving – Solve design problems as they surface during the modeling and prototyping stage. Collaboration – Students collaborate with their teacher and possibly a mentor during this stage of the design process. Innovation- Students innovate existing models and prototypes to solve the problem and sub-problems			• Durability • Appearance • Function of subsystems • Performance
Resources: Internet web quests, Educational technology Software, Mentorship meetings Access to WordPress Blogs Problem Identification Matrix Rubric Design Laboratory software and CAM equipment. Fabrication Laboratory software and equipment			**Instructional Adjustments:** Individual project meetings, direction and advice, personalized for each project	

Unit 7: Testing (Evaluation & Analysis)

Targeted Standards:

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. F.2: Explain how material science impacts the quality of products.
8.2.12.C.3 Evaluate the positive and negative impacts in a design by providing a digital overview of a chosen product and address the negative impacts
8.2.12.F.3 Select and utilize resources that have been modified by digital tools in the creation of a technological product or system (CNC equipment, CAD software.
9.4.12.B.7 Demonstrate use of the concepts, strategies, and systems for obtaining and conveying ideas and information to enhance communication.
9.4.12.B.74 Read, interpret, and use technical drawings, documents, and specifications to plan a project.
9.4.12.B.75 Use and maintain appropriate tools, machinery, equipment, and resources to accomplish project goals.

Unit Objectives/Conceptual Understandings:

Once students have finalized their prototypes, they are ready to be tested to see how well they solve the initial problem. This can be as simple as applying the specifications laid out in the design brief to the end product to see if it does all the things that it is supposed to do. But more often it is performance testing, as in the case of a practical device. In the case of an aid for a disabled person, testing may involve giving the device to an appropriate individual to use for a time. An interview at the conclusion of the test would provide invaluable feedback on the performance of the device in the real world and could lead to possible improvements or modifications. This phase is important to the design process because it tells you how well you have accomplished your goal and whether more development work is needed.

Essential Questions: How can tests be designed to measure the success of a technological product or system?

Unit Assessment: Students will produce, document and present their:

- Tests designed to evaluate the efficacy of the product or system.
- Qualitative and Quantitative data to be collected measured and interpreted.
- Evaluation of data as it relates to the final solution as well as the decisions made by the student managing the overall design process. This can also be considered a written piece of critical self-reflection.

	Core Content Objectives		**Instructional Actions**	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
Create a simple spreadsheet, enter data, and interpret the information.	Tests will vary depending on the type of product or system produced, but will typically involve an	Apply design specifications to the testing stage of the design process in order to collect and evaluate data	Math – (NJCCCS-4) Devise tests that can be used to track, monitor, collect, measure, analyze and interpret	Students will produce, document and present their: • Tests designed to

Unit 7: Testing (Evaluation & Analysis) (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
information. Plan and create a simple database, define fields, input data, and produce a report using sort and query. Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results. Communicate with students in the United States or other countries using digital tools to gather information about a specific topic and share results. Evaluate the function, value, and aesthetics of a technological product, system, or environment from the perspective of the user and the producer. Evaluate ethical considerations regarding the sustainability of resources that are used for the design,	application of the design specifications. Data is qualitative and quantitative and can take the form of interviews, checklists, numbers, descriptions, testimonials. During evaluation, both the product/system and the process of design (design and management decisions made by the student designer throughout the process) can be evaluated in the following terms: Aesthetics, Ergonomics, Performance, Durability, Cost, and Impacts. Critical Thinking – students think critically about creating tests and experiments that apply design specifications. Digital Citizenry – students must document and share their work, as it progresses, on a blog		quantitative data to suggest how well the given solution solves the problem. Science – (NJCCCS-5) Apply science principles to create experiments and tests that allow students to track, monitor, collect, measure, analyze and interpret both qualitative and quantitative data to suggest how well the given solution solves the problem. Educational Technology - (NJCCCS – 8.1) Document and share work using digital video/photography, editing software, and graphic design software; and, use educational technologies to assist with the testing stage of the design process. Language Arts Literacy - Editing	evaluate the efficacy of the product or system. ● Qualitative and Quantitative data to be collected, measured and interpreted. ● Evaluation of data as it relates to the final solution as well as the decisions made by the student managing the overall design process. This can also be considered a written piece of critical self reflection.

Unit 7: Testing (Evaluation & Analysis) (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
creation, and maintenance of a chosen product. Evaluate the function, value, and aesthetics of a technological product, system, or environment from the perspective of the user and the producer.	Collaboration – Students collaborate with their progresses, on a blog Collaboration – Students collaborate with their teacher, mentor(s), and field test subjects (if any) during this stage of the design process. Innovation- Students may innovate existing tests to create tests that fit the exact needs of their final product or solution.			
Resources: Internet web quests, Educational technology Software, Mentorship meetings Access to WordPress Blogs Problem Identification Matrix Rubric Design Laboratory software and CAM equipment. Fabrication Laboratory software and equipment			**Instructional Adjustments:** Individual project meetings, direction and advice, personalized for each project	

Unit 8: Documentation and Presentation

Targeted Standards: (local, district, state or national)

Unit Objectives/Conceptual Understandings:
Students will be taught to organize and display each section of the portfolio, maximizing its potential as a communication tool.

Before the school year is finished, there will be a culminating celebration and design expo where the students can invite their friends, family, teachers, mentors, community members and corporate sponsors. There, they will demonstrate the final product and its redesign, and talk about what they did and what they learned throughout the capstone course.

Essential Questions:

What is the value of effective documentation?

Unit Assessment: Once the end product has been redesigned, the steps of the design process are now complete. At this point, the student is going to compile all of their work into a final portfolio that can be presented and critiqued as the final exam for the course. Much of the content for this portfolio will already be in the student's possession or will have been published using digital formats (e.g., iTunes University, WordPress Blogs, or Commercials in the school's morning announcements); and as such, will have been used as formative assessments. However, the compilation and culmination of all of these things is considered a summative assessment.

The student should also be prepared to write an article summarizing the entire capstone experience, and select a journal or magazine to submit it to – hopefully, for publication.

Students will produce:

- A final portfolio
- A journal article for publication
- A compilation of log entries and documentation elements housed, for example, on a WordPress Blog and Flickr Account.
- An oral presentation and demonstration of final solution.
- Commercial for the morning announcements showing off the final product

	Core Content Objectives		**Instructional Actions**	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
Use electronic devices (e.g., computer) to type name and to create stories with	Documentation and presentation is the final stage of the design	Document and present their entire design process and final product using a	Educational Technology- (NJCCCS – 8.1) Document and share work using digital	Once the end product has been redesigned, the steps of the design

Unit 8: Documentation and Presentation (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
pictures and letters/words. Demonstrate the ability to navigate in virtual environments that are developmentally appropriate. Produce and edit a multi-page document for a commercial or professional audience using desktop publishing and/or graphics software. Access materials on a disk, cassette tape, or DVD. Insert a disk, cassette tape, CD-ROM, DVD, or other storage device and press "play" and "stop." 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.	process and pulls together all of the stages of the entire design process and clearly communicates them to a wide audience in a variety of formats. Critical Thinking – students think critically about how to document and present their work as clearly as possible over different mediums using a variety of formats. Digital Citizenry – students must document and share their work, as it progresses, on a blog (or using another online tool) – and make it accessible to as many people as possible. Collaboration – Students collaborate with their teacher, mentor(s), and field test subjects (if any) during this stage of the design process. Leadership – Students take the initiative to write a	variety of formats to a wide audience.	video/photography, editing software, and graphic design software; and, use educational technologies to assist with the documentation and presentation of the entire design process. Language Arts Literacy – (NJCCCS- 3.1) Use the standards and CPI's for collegiate, professional and technical writing when	process are now complete. At this point, the student is going to compile all of their work into a final portfolio that can be presented and critiqued as the final exam for the course. Much of the content for this portfolio will already be in the student's possession or will have been published using digital formats (e.g., iTunes University, WordPress Blogs, or Commercials in the school's morning announcements); and as such, will have been used as formative assessments. However, the compilation and culmination of all of these things is considered a summative assessment. The student should also be prepared to write an article summarizing the entire capstone experience, and select a journal or magazine to

Unit 8: Documentation and Presentation (cont.)

	Core Content Objectives		Instructional Actions	
Cumulative Progress Indicators	**Concepts** *What students will know.*	**Skills** *What students will be able to do.*	**Activities/Strategies** Technology Implementation/ Interdisciplinary Connections	**Assessment Check Points**
Present resources and data in a format that effectively communicates the meaning of the data and its implications for solving problems, using multiple perspectives.	journal article about their independent study and submit it for publication. Innovation- Students will find innovative and creative ways to document and present their project to a wide audience. Communication – This entire stage of the design process is about documenting the story of the design process as clearly and concisely as possible using objective and subjective content over a variety of formats			submit it to – hopefully, for publication. Students will produce: ● A final portfolio ● A journal article for publication ● A compilation of log entries and documentation elements housed, for example, on a WordPress Blog and Flickr Account. ● An oral presentation and demonstration of final solution. ● Commercial for the morning announcements showing off the final product
Resources: Internet web quests, Educational technology Software, Mentorship meetings Access to WordPress Blogs Problem Identification Matrix Rubric Design Laboratory software and CAM equipment. Video Cameras Digital Cameras Portfolio Paper, Color Printer, Comb Bindings, Lamination machine.			**Instructional Adjustments:** Individual project meetings, direction and advice, personalized for each project	