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Morris School District
31 Hazel Street
Morristown, NJ 07960

**Morris School District**

# 3D CAD & Engineering Design Curriculum
# Grades 10 through 12

Dr. Thomas Ficarra, Superintendent
Submitted by: Jack Rizzo
Date: February 2013
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Introduction

Course Rationale:

As current CAD technologies evolve, there is a need for the education of them to evolve as well. The content of this course is part of the natural evolution of CAD and related technologies and the basic content of college majors relating to engineering, all areas of technical design, manufacturing and many other technical-related majors. Students wishing to enter the workforce from high school would be able to gain entry level positions as CAD Drafters or similar positions.

The application of 3D CAD to drawing and engineering problems is the focus of this course. CAD is the design industry standard for producing design documentation. Students will communicate their ideas to others in the design and presentation of solutions to problems in engineering. In some cases working drawings will be the solution. In most problems students will conceive, design, model and create working prototypes for testing by applying 3D printing technologies.

It is a full year course worth 5 credits.

Philosophical Tenets:

Technology Education is defined as: “The application of knowledge to satisfy human wants and needs, and to extend human capabilities.” To study Technology Education, therefore, is to analyze available resources, how these resources are interrelated, and what can be expected as a result. The main purpose of Technology Education is to provide students with experiences which teach students to apply process thinking and problem solving skills so that they may become technologically literate citizens.
The CADD program accomplishes this by assigning design problems. The goal of these design problems is to provide solutions to technological problems, or problems which require students to apply knowledge. It is taught by an activity oriented methodology of problem solving related to design projects. The courses involve the application of physical processes, experiences with materials and processes. This course will also, address the needs of all learners through the application of design based activities in which the teacher becomes a facilitator of learning rather than the primary source of information. This class also requires the application of knowledge from other areas such as math and science.
This class is not just about learning 3D CAD, however, it is an important skill, but it’s really about using state-of-the-art tools to exercise more important skills. This is a course that develops students’ ability to write technically, take an idea from concept to product, and to express their creative thoughts in specific manner. This course includes in its goals learning how to manage time and space. This course is more about processes than product. The product is the vehicle to learn and practice the process. However, product quality is important and craftsmanship is also assessed.

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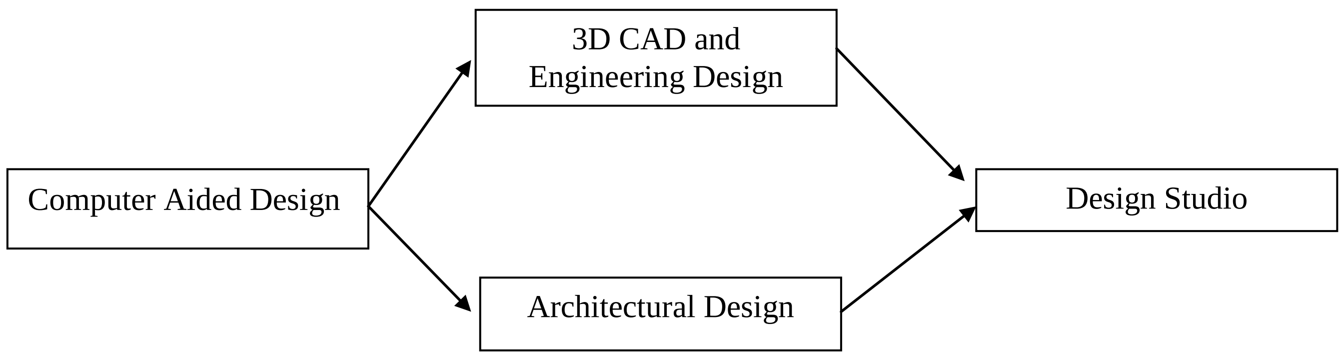
Course Description:

Prerequisite: Computer Aided Design

Students enrolled in **3D CAD and Engineering Design**, complete activities in creative design, materials analysis, technical research and documentation. Students will also, be given the opportunity to apply engineering principals to create designs and prototypes to substantiate their ideas. Students will apply their new foundation of knowledge to direct applications, and utilization of 3D CAD to create technical drawings consistent with industry standards.   Students will use solid modeling CAD programs to create solutions, based on real-life problems and continue the design process through the prototyping level. Finally, students will be able to visualize, realize, and redefine the solutions' characteristics so they can re-design and finish with an optimal solution by applying model making and/or 3D printing to their 3D CAD designs.

CAD Course Sequence 2013:



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Units of Study

Unit: 1 Safety

Safety issues are a special concern for STEM-based (science, technology, engineering and mathematics) activities and courses. Teachers must be knowledgeable and proactive in providing a safe learning environment. Students will receive safety instructions relevant to the topics being taught. Assessments will accompany the lessons on safety, and records are kept on student results. The teacher will always supervise students while they are working. The teacher must inspect and maintain equipment and tools to ensure they are in proper working condition.

Unit 2: Engineering Methodology & History

When spelled with the little "e" - engineering - describes the pragmatic and deliberate approach to problem solving that any student or person can be engaged in universally. In comparison, the big "E" – Engineering – refers specifically to the vocation or career cluster.

Engineers design and invent solutions to human challenges. In a real sense, there have been "engineers" throughout human history, because people have always designed and built tools and other devices. Today, however, the word "Engineer" is used in a more specific sense to refer to a member of the engineering profession, which has evolved over the past 300 to 400 years.
The word engineer is derived from the Medieval Latin verb *ingeniare,* meaning to design or devise. Going back further in time, *ingeniare* is derived from the Latin word for engine, *ingenium*, meaning a clever invention. Thus, a short definition of engineering is the process of designing the human-made world.

Another useful way to think about engineering is as "design under constraint." One set of constraints is the laws of nature, or science. Engineers designing a solution to a particular problem must, for instance, take into account how physical objects behave while in motion. Other constraints include such things as time, money, available materials, ergonomics, environmental regulations, manufacturability, reparability, and so on.

Unit 3: The Problem Solving/ Design Loop/Engineering Design Process

Most engineering designs can be classified as invention-devices or systems that are created by human effort and did not exist before or are improvements over existing devices or systems. Inventions, or designs, are the result of bringing together technologies to meet human needs or to solve problems. Sometimes a design is the result of someone trying to do a task more quickly or efficiently. Design activity occurs over a period of time and requires a step-by-step methodology.

We describe engineers primarily as problem solvers. What distinguishes design from other types of problem solving is the nature of both the problem and the solution. Design problems are open ended in nature, which means they have more than one correct solution. The result or solution to a design problem is a system that possesses specified properties. Design problems are usually more vaguely defined than analysis problems.

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Solving design problems is often an iterative process: As the solution to a design problem evolves, students will find themselves continually refining the design. While implementing the solution to a design problem, they may discover that the solution they've developed is unsafe, too expensive, or will not work. You they "go back to the drawing board" and modify the solution until it meets the requirements of the specified problem.

In this class students will apply an iterative process to solving open-ended design problems. Students will apply 3D CAD software during the design phases and should in most cases have a prototype or mock-up of a finished product when completed along with design documentation for each activity.

Unit 4: Role of sketching and types of sketches in technical fields

Without the ability to communicate well, engineers and designers cannot function in a team and are of limited value to industry. Technical drawing and sketching are essential communication tools. Using established sketching conventions (orthographic projections and isometric sketches), students will learn how to quickly convey their design ideas to others. The ability to sketch ideas is not only *important* to engineers it is absolutely *essential*. Even if an engineer was stranded alone on an island, the ability to sketch would help to work out details in ideas and help to identify potential problems. Technical sketching and drawing does not require any artistic ability. Once one is made aware of the basic techniques, it is no longer the "ability to draw" that will limit his/her sketches. But rather, the limitation is one's "ability to think through the details of their design." In industry sketching is used to quickly document rough ideas and identify general needs for improvement. Sketches and drawings are composed of the same basic information, but there is a tradeoff between the time required to generate it verses the level of design detail (and accuracy). The basics of technical sketching can be learned in a single sitting. However, it will take considerable practice to achieve the fluency that really facilitates team discussions in the future.

Orthographic Projection is a generally accepted convention for representing 3D objects using multiple 2D views of the front, top, bottom, back, and sides of the object. In practice, the minimal number of views possible is used to describe all the details of the object. Usually, the Front View, Top View, and a single Side View are sufficient and are oriented on the paper according to accepted convention. Isometric Projection attempts to represent 3D objects using a single view. Instead of the observer viewing the object perpendicular to the object, the object is rotated both horizontally and vertically relative to the observer. Additionally, either of them can be supplemented with various types of dimensions. Whether sketching or drawing, the goal is the same. The goal is to communicate the necessary detail to the intended audience.

Sketching will be done in most activities. Before CAD drawings are done they will be done for idea generation and conveyance as well as to relate and refine details.

Unit 5: Technical Writing

As an engineer, students will need to share their work. Professionally, this is commonly done through thesis, journal papers, and books. Any information-based society necessitates good writing in all careers as well. There are two fundamental characteristics of technical communication-- that it is addressed to a particular audience and that it has a specific purpose—to help that audience understand and use a body of information.

Technical writing has a different purpose than creative story telling or other types of writing students have done. There are rules, standards, and formats which are commonly used. The purpose of this unit is for students to become familiar with these types of writing and their standards. The goal of this unit is to help students become better able to accomplish the writing and communication that they are asked to do in various forms of documentation and in life generally.

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Unit 6: 3D CAD

3D CAD in this class introduces students to parametric design through a hands-on, practice-intensive, problem solving approach. Students acquire the knowledge needed to complete the process of designing models from conceptual sketching, through to solid modeling, assembly design, and drawing production.

Students will learn various approaches to part design applying different commands and techniques. Specific advanced part modeling techniques covered include multi-body design, advanced lofts, advanced sweeps, coils, and surface modeling. Additional material aimed at increasing efficiency is also included: iFeatures for frequently needed design elements, iParts for similar designs, iLogic for automating designs, translation options for importing data, and the design documentation for communication. The class also covers some miscellaneous drawing tools such as custom sketches symbols, working with title blocks and borders, and documenting iParts. With an understanding of these tools, students can begin to streamline the design and documentation process as well.

It is important that the parallels between CAD operations and manufacturing operations be identified here as well so students learn how objects are created in a manufacturing environment. After all, designing a virtual object that cannot be built is a major problem. To help towards this end students will create prototypes of some designs and discuss the manufacturing process’ that would be involved in their creation.

Unit 7: Industrial Design

Industrial design encompasses the conceptual thinking, drawing, drafting, and modeling that goes into the design of products. That includes everything from planes, trains, and automobiles to toothbrushes and water bottles. Their role is twofold. They are asked to create new contributions to product lines. For this aspect of their work, they need to be aesthetically minded, keeping up with current fashion and trends and producing work that is elegant, sharp, and unique. In contrast, a designer will also need to know how much materials cost and weigh, how durable they are, and how to piece together components to achieve the desired effect. They also need to perform or compile research, build models, test, etc. They have to think about products that will function in the real world and look good while doing so.

In this unit, students will learn how to create a product from conception to reality. They will do this by applying the design process steps first hand in the creation of a product. Students will take on the role of industrial designer and create a solution to a problem that exists or for a made up company. Final solutions will be prototyped in whatever manner is considered most appropriate for their design.

Unit 8: 3D Scanning

A 3D scanner is a device that analyzes a real-world object or environment to collect data on its shape and its appearance (i.e. color). The collected data can then be used to construct digital, three dimensional models.

Many different technologies can be used for 3D scanning. Each technology comes with its own limitations, advantages and costs. Many limitations in the kind of objects that can be digitized are still present, for example, Our NextGen 3D Laser Scanner, encounters many issues with shiny, mirroring or transparent objects. Autodesk’s 123D app uses pictures that are uploaded to their cloud service where they construct a 3d solid model that you download from their site. They avoid many clarity errors but resolution is an issue.

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Collected 3D data is useful for a wide variety of applications. These devices are used extensively by the entertainment industry in the production of movies and video games. Other common applications of this technology include industrial design, orthotics and prosthetics, reverse engineering and prototyping, quality control/inspection and documentation of cultural artifacts.
In our class we will use it as a start point in some 3D drawings. Rather than draw a complex shape or object we will scan it in where in the CAD drawing it can be manipulated or added to. It will also be used in reverse engineering activities.

Unit 9: 3D Printing

3D Printing is a form of additive manufacturing where a 3-dimensional object is created by laying down multiple layers of a material. In contrast to traditional manufacturing, additive manufacturing refers to any process that adds on layers instead of cutting them away. Additive manufacturing has been used for decades for 'rapid-prototyping'. Each 3D-printed object begins with a digital Computer Aided Design (CAD) file, created with a 3D modeling program, or which was scanned into a 3D modeling program with a 3D scanner. Such printing of 3D objects currently enables engineers to check the fit of different parts long before they commit to costly production. Whilst most 3D printers are currently used for prototyping and in pre-production mould making processes, the use of 3D printing to manufacture end-use parts is also now occurring. This is becoming known as direct digital manufacturing (DDM).

In class 3D printing will be mostly used as proof of concept and as the prototype step in the design process. Having a tangible item from a CAD file provides students with feedback that is otherwise not possible for certain types of design activities. Students are able to make more informed design decisions and to synthesize information using this technology.

Unit 10 CNC Milling

Computer Numeric Control machines is a subtractive process where a part is milled based on exact xy and z coordinates. A cad file is processed into a G code by pre-processing software and fed to the machine where its internal computer cuts a precise part from various materials. The materials that the machine is limited to are only limited by the available cutter heads. For our purposes we use high density foam and wood since they are inexpensive and readily available.

In this class student are introduction to basic CNC milling operations. Upon completion of this course the student will have an understanding of CNC milling practices as well as gain knowledge in tooling, machining practices and applied mathematics. Teamwork, critical thinking, and problem solving are emphasized. Much like 3D printing it is used for proof of concept and prototyping of students' original designs.

Unit 11: Reverse Engineering

This unit examines the way in which products and machines work: their physical operation, the manner in which they are constructed, and the design and societal considerations that determine the difference between success and failure in the marketplace. Reverse engineering is done via product dissection and the investigation of the individual parts that make up the system.

In this class a reverse engineering activity will provide an opportunity for students to take apart a common device that includes electrical and mechanical elements. They will then use the knowledge they have gained to create a systems diagram for the complete device. Students will create reassembly instructions and diagrams to share with partner groups of students. Partner groups will attempt to reassemble the device using the instructions provided.

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Unit 12: Technology Learning Activities

This unit is designed to combine the knowledge and information learned in the previous units with new understandings to an open ended design problem. Students will apply the design process to create a solution to a problem that currently exists or one that is posed by the teacher. Students will also learn that by-products are created as a result of the solution, and what impacts they have on the environment and society. The students may also in some cases be asked to market their product. They may also work in teams to complete some of the tasks.

Unit 13: Engineering Related Careers

Engineering consists of a variety of specialist sub-fields, with each contributing in different ways to the design and development of solutions to different types of problems. Engineering careers are threaded recurring themes during the individual units. In their documentation for some specific design problems students will identify related careers and research the education necessary as well as current job openings.

Unit: 14: Structured Learning Experiences

According to the NJDOE "Structured learning experience (SLE)" means experiential, supervised, in-depth learning experiences that are designed to offer students the opportunity to more fully explore career interests within one or more of the Career Clusters. SLEs are designed as rigorous activities that are integrated into the curriculum and that provide students with opportunities to: demonstrate and apply a high level of academic attainment; develop career goals; and develop personal/social goals. They are linked to the Core Curriculum Content Standards and are made to provide students with exposure to the requirements and responsibilities of specific job titles or job groups, and are intended to assist them in gaining employment skills and making career and educational decisions. A structured learning experience may be either paid or unpaid, depending on the type of activities in which the student is involved.

Students who choose to participate in SLE's related to the CAD program will have a written, signed individual student training plan that identifies learning activities as well as prohibitions. They will be graded based upon formative and summative assessment strategies that include employer/mentor input. They will also include regular site supervision.

Unit 15: Portfolios

The purpose of this unit is to help students develop an electronic portfolio of their work from the course. The intent is for the portfolio to be used to showcase their best work to potential employers or as an application for college or university entrance. This unit covers some of the basic content students need to know when creating electronic portfolios. The tools and software used to deliver this unit will vary between school systems; however, every student should have access to some means of creating a basic electronic portfolio.

Also included in this unit will be basic desktop publishing. With the demand on drafters to stay on top of the latest publishing techniques, the ability to exchange drawing as well as image files and converting DWG files to image files is almost a necessity. So we will include these in this unit as well.

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COURSE: 3D CAD and Engineering Design **MSD CURRICULUM MAP** **GRADE LEVEL(S): 10-12**

Time Frame: Months or # of Days	Content/Topic	Observable Proficiencies/Skills	**NJCCS**	Performance Benchmarks/Assessments	**Materials Used**
Pacing	Key learning items/concepts to be covered. Essential questions that students will answer	What they need to know? What specific skills are necessary for success? The skills commence with an action verb.	Subject specific National Core NJCCCS plus cross references to other relevant NJCCS areas	What will be assessed? How well should students perform? What are the mastery skills and concepts to be assessed? What will be used to assess students? Assessments are listed as specific nouns	
Unit 1: Safety					
	Why is it important to follow all the rules and procedures in a work environment? Why must you pass tool and machine safety tests with a score of 100%?	Students need to know and comply with the general safety rules and regulations related to the CAD lab as well as specific tool and machine safety.	8.2.12.A.1 9.1, 9.4	Students will attain a score of 100% on a written safety test for each tool, machine or device they use during class. Students will be able to identify and implement proper safety in a work environment.	Safety quiz Signed safety contract Safety Glasses Smock Gloves http://agedweb.org/courses/aget120/Shop%20Safety.doc http://www.nj.gov/education/schools/safeschools/
Unit 2: Engineering Methodology & History					
	Why is it important to understand the engineering process, hierarchical system diagrams and engineering economics?	Covering a brief timeline of engineering history using specific examples, students will be able to	8.2.12.A.1 8.2.12.E.1 8.2.12.F.1-3, 9.3, 9.4	The student will be able to answer questions about the history of engineering.	Computer Projector Internet

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	How did engineering evolve in the handicraft/industrial eras? What are some key historical events and their impacts on engineering and technology? Who are the key persons who have contributed to technological change?	identify if asked milestones in the evolution of engineering fields. Using a list of different tasks done by engineers, formulate a definition of what engineering is based on the type of jobs they do.		The student will be able to state the broad definition of engineering.	
Unit 3: Problem Solving					
	Why is a design process so important to follow when creating a solution to a problem? Why would an engineer need to identify the criteria and constraints required for a design solution? What are the five primary methods through which technological problems are solved and how do they differ (i.e., troubleshooting, research and development, experimentation, invention and innovation, design problem solving)? How are decisions made regarding information that should be discarded or ignored? What do you do if testing shows that the prototype will not solve	Students will illustrate that technological design is a systematic process used to initiate and refine ideas, solve problems, and maintain products and systems by completing several Technology Learning Activities. Students will write design briefs and note the constraints for several different problems. Students will apply several different problem solving methods to engineering design problems creating a portfolio that illustrates the processes.	8.2.12.A.1 8.2.12.B.1-3 8.2.12.C.2-3 8.2.12.E.1 8.2.12.F.1-3 8.2.12.G. 9.4	Students will demonstrate that finding a good solution is an iterative process. Students will create documentation that supports and enhances their overall project. Students will be assessed using a combination of -- activity portfolios, rubrics, peer assessments and/or self-reflections depending on the activity. Identify and differentiate between engineering fields by discussing all the different types of engineering fields which go into a given problems solution.	Activity Portfolios Rubric Assessment Self and Peer Assessment Performance Assessment Mid Terms Final Exam Various Project Materials

	the problem?				
Unit 4: Sketching					
	Why is sketching an important engineering skill? What information is pertinent on a sketch for it to be effective? What are the common representations of physical objects and when are they applied? Why do we use both pictorial and orthographic representations of objects? What are the different tools and resources that are available for idea generation?	The student will be able to freehand sketch various geometric and everyday objects deciding what information is pertinent to convey their design ideas. Students will sketch 3-D objects in oblique and isometric views for inclusion in their design documentation. Students will use color pencils to show shading and give objects a 3-D appearance. Students will utilize sketching techniques to achieve appearance of texture and material.	8.2.12.A.1 8.2.12.E.1 8.2.12.F.1-3 9.4	Sketches will be assessed as part of design documentation based on the activities rubric. Demonstrate an understanding of proper sketching techniques, view selection, and provide sketches to clearly and neatly illustrate their design ideas. Create drawings or diagrams as representations of objects, ideas, events, or systems as part of the solution to a design problem and to illustrate the importance of sketching skills in various engineering fields.	Pencils Color Pencils Paper Erasers Drawing Boards
Unit 5: Technical Writing					
	What are the elements of a technical report? Why is it important to have clear, concise directions for the assembly of a product? How is technical writing different	Students will convey information to their classmates in the form of objective writing for the purpose of documenting a solution to a TLA. Students will augment their	8.2.12.C.2-3 8.2.12.A.1 8.2.12.D.1 8.2.12.E.1 8.2.12.F.1-3 8.2.12.G.1 9.4	Prepare a technical report and presentation documenting their design, implementation. Students will generate a detailed technical report and presentation, which documents the evolution of	Computer Microsoft Office Adobe Suite CAD Software

	from creative and other types of writing styles?	documentation with any necessary tables, charts, graphs and drawings to help illustrate their solution. Students will clearly and accurately document and report their work using technical writing practice in multiple forms.		their designs. The report will include CAD drawings, simulation results, modifications, prototype testing and results, and analysis. Provide a written summary in conjunction with an assembly/exploded view drawing.	
Unit 6: 3D CAD					
	For what reasons might an engineer need to know the volume and surface area of an object? What is a working drawing? How do assembly constraints differ from geometric and numeric constraints? What is an assembly drawing?	Students will be able to produce engineering drawings based on 3d models and parts. Create parts from solid objects by removing material via cutouts, holes, rounds, thin walls, etc. Create an assembly drawing using existing part drawings in order to learn how to define relationships between parts within the drawing. Create an exploded view from an existing assembly drawing. Students will create surface	8.2.12.A.1 8.2.12.B.1-3 8.2.12.C.2-3 8.2.12.D.1 8.2.12.E.1 8.2.12.F.1-3 8.2.12.G.1 9.3 9.4	Construct a three-dimensional part from engineering drawings. Create and constrain 2D sketches Create extrude and revolved features Create detail and assembly drawings from 3D models. Create presentation drawings from 3D solid models for design documentation. Animate assembly components using proper constraint methods. Demonstrate the principles of	Computers Software Printers 3D Printers Milling Machine Various tools and machines based on activity solution

		models by applying Lofting skills and techniques. Physical models will be created to represent and evaluate possible solutions using prototyping technique(s) chosen based on the presentation needs or testing requirements of a potential solution.		assigning properties to model part files . Create drawings of parts including projected views, section views, and annotations. Students will create parts and assemblies and create several types of technical drawings. They will be used to efficiently and accurately detail parts and assemblies according to standard engineering practice. Output designs in several different formats and media as part of an open ended design activity or TLA. Analyze the performance of a design during testing and judge the solution as viable or non-viable with respect to meeting the design requirements.	
Unit 7: Industrial Design					
	What is ergonomics? How are visual design principles and elements used to capture a consumer's attention?	Students will be able to apply ergonomic principles and anthropometric measurements in the design	8.2.12.A.1 8.2.12.B.1-3 8.2.12.C.2-3 8.2.12.D.1 8.2.12.E.1	Students will be able to redesign a product for humans with various modality issues.	Computers Software Printers 3D Printers Milling Machine

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	Why do people associate a design's aesthetic value with its functional efficiency and structural resilience? What are the key factors that cause designers to make decisions about tradeoffs, limitations, and constraints when designing new products and systems? What global and human impacts must be considered by everyone involved with the design, manufacturing and distribution of products?	of a product. Students will be able to describe how anthropometric data changes by age, gender, and demographics.	8.2.12.F.1-3 8.2.12.G. 9.3 9.4	Students will design or redesign a product for children. Students will be able to design and construct a model by correctly and safely using tools, materials, and resources.	Various tools and machines based on activity solution
Unit 8: 3D Scanning					
	What is the role of 3D laser scanning in engineering and design?	The student will in their portfolio explain the working principals of 3D laser scanning. The student will create digital representations of physical objects for the purpose of: Reverse engineering, Industrial design, Product design, 3D Printing Use 3D laser scanning software to import and export data to and from CAD software.	8.2.12.A.1 8.2.12.B.1-3 8.2.12.E.1 8.2.12.F.1-3 9.4	Apply 3D laser scanning knowledge to aid in solving problems in engineering and various areas of design. Prepare documentation, drawings, and 3D-models for various applications.	Computers Software Printers 3D Printers Milling Machine Various tools and machines based on activity solution

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		Using post-processing software students will refine the scan to align with their design brief.			
Unit 9: 3D Printing					
	What kind of additive and subtractive processes are used to manufacture actual physical objects? What role does design and manufacturing play in today's society? What factors need to be in place for new technologies to viable in the national and international marketplace? What are the advantages and disadvantages of utilizing synthetic materials designed by engineers? Why would you create a prototype of a product before the actual production takes place? How have technological innovations caused paradigm shifts throughout history and what are these major shifts?	Students will apply the design processes to produce prototypes and products for a wide variety of problems and purposes'. Students will get proof of concept for a product design activity by printing a prototype of an original design idea.	8.2.12.A.1 8.2.12.B.1-3 8.2.12.C.2-3 8.2.12.D.1 8.2.12.E.1 8.2.12.F.1-3 9.4	Students will reflect critically when evaluating and modifying their ideas and proposals to improve products throughout their development and manufacture. Students will compare 3D Printing to the production line and other manufacturing techniques in their documentation.	Computers Software—design, preprocessing, post processing Printers 3D Printers Various tools and machines based on activity solution

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Unit 10: CNC Milling	content	observable		performance	
	How is technological instrumentation used to measure, calculate, manipulate, and predict the actions of technological devices and systems? What factors influence the selection of materials to make a product? How do jigs, fixtures, and automation influence the efficiency of production systems?	Students will create a 3D CAD design for the purpose of exporting and machining to produce an original project/product. Students will apply awareness of a 3 axis CNC machine by processing a part. Students will illustrate an awareness of the limitations of 3 axis CNC machining and how this influences designs.	8.2.12.A.1 8.2.12.B.1-3 8.2.12.C.2-3 8.2.12.D.1 8.2.12.E.1 8.2.12.F.1-3 9.4	Identify and demonstrate the use of common work-holding attachments. Importing their geometry from a 3D CAD program students, will illustrate the process of production by machining an original design on a CNC milling machine. Students will Enable machine controller, pre-process file, preview the tool path, fixture the material and cut the part.	Computers Software—design, preprocessing, post processing Printers Milling machine Various tools and machines based on activity solution
Unit 11: Reverse Engineering					
	What is the purpose of reverse engineering? What is the difference between a product's visual and functional qualities? What role does reverse engineering play in product development and innovation? How are products made today? How do the production methods vary?	Students will work in groups to reverse engineer a common device or product. Students will create a systems diagram to describe the operation and control of the device. Each member of each group will create an assembly drawing of the dissected device.	8.2.12.A.1 8.2.12.B.1-3 8.2.12.C.2-3 8.2.12.D.1 8.2.12.E.1 8.2.12.F.1-3 8.2.12.G.1 9.4	Students participate in a reverse engineering activity in which they disassemble a common product such as a mechanical pencil. Students complete pre and post project assessment. Dissect a multi-part device. Measure each of the key parts. Each group member will model one part on the computer to create a systems assembly diagram of the device.	http://www.ciese.org/curriculum/seproject/index.html

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		Students will apply technical writing skills to create documentation for the reassembly of their device or product.		In groups students will follow instructions and diagrams created by others to reassemble a common product. Describe the contributions of engineers from different engineering fields in the design and development of a product, system, or technology.	
Unit 12: Technology Learning Activities					
	Designing Structural Systems: What is the purpose of scale models and design concepts? How has the scientific method been utilized in the engineering process? Is it really impossible; or does it just seem so? Is there a difference between an engineering student and a physics student and how they solve a structural problem within three iterations?	1. Utilize the engineering design process to analyze, design, model, build, test, and evaluate a solution to a technological problem. 2. Student will provide initial drawings to scale for the design they intend to construct. 3. Fabricate a working model of their personal design by utilizing the basic instructions and material allowed, to design and constructs a bridge. 4. Remain completely within the minimum design specifications throughout the assembly of the bridge components. 5. Each student prior to testing the bridge indicating the potential weak points of the structure will make predictions. These predictions will be videotaped and reviewed alongside the video of the actual testing process. 6. Students will manage the process of conducting the stress testing for their own bridge	8.2.12.A.1 8.2.12.B.1-3 8.2.12.C.2-3 8.2.12.E.1 8.2.12.F.1-3 8.2.12.G. 9.3 9.4	Present a basic physics lesson using different shape examples to demonstrate forces and how they act on physical objects and why. Have students work in groups to test different shapes to find out structural strengths and weaknesses of each. Based on physics lesson have students initially hypothesis results. In teams apply the design process and previous research to create a working model of a given structure. Incorporate basic physics concepts into engineering designs. Student teams compete against each other to create the best design. Test each bridge in accordance with the methods describe in class. The HIGHEST ratio of the LOAD to BRIDGE WEIGHT is considered to be the best performing design.	Various tools and machines Wood Glue Dowels

		project. 7. Debrief the findings and discuss how the results would modify the design choices made in each case. 8. Test engineering solutions using mathematical graphs, charts, and equations.			
	Designing Hydrodynamic Systems: How does design and hydrodynamics of ships affect the speed of a ship? What is buoyancy and how can it be affected? What are the relationships between the principles of physics and the designs of ships? How much work can a ship perform? How does stability and size affect carrying capacity of a ship?	1. Explain what factors influence a boat's buoyancy/draft 2. Investigate and gain knowledge of the relationships between the principles of physics and the designs of ships. 3. Design, construct, and test the performance of ship models. 4. Work in a group to design a functional boat that will carry a identified cargo 5. Test and record your data from the boat (hull) activity		Design criteria for ships are examined with reference to concepts and principles of physics. Information on flotation and carrying capacity of ships is supplemented by the teacher and or student research so the students will have sufficient background to carry out the investigations and activities. Students will design and build a full scale boat made completely out of cardboard that will carry two of team members across a swimming pool in the shortest amount of time.	Cardboard Construction adhesive Duct tape pool
Unit 13: Structured Learning Experiences					
	How are experts and mentors valuable to the design process? Why is it important to begin considering career paths during high school? What career opportunities are available to match your specific interests?	The student will be given the opportunity to participate in a job shadowing activity if they so desire. If possible students will be given the opportunity to perform an internship in their desired field of study.	8.2.12.C.1 9.1, 9.3 9.4	If conditions permits students will complete an SLE related to their desired career or college major choice.	Varies depending on activity

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Unit 14: Portfolios					
	Why is a portfolio important? Why is it necessary to display a wide variety of skills in a portfolio? How can a personalized web page help present you at a job or college interview?	Students will create and maintain a web page as an ongoing portfolio of their best work in class. Students will illustrate the steps of the problem solving design loop in their portfolios. Students will illustrate a progression of learning and diverse activities on their web site.	8.2.12.B.1-3 8.2.12.C.1 8.2.12.E.1 8.2.12.F.1-3 9.1,9.3 9.4	Students' portfolios can be used for college entrance or job resume.	Computer Internet Adobe Suite CAD software

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POSSIBLE PROJECT SEQUENCE: 3D CAD & Engineering Design

The sequence below quickly outlines the list of possible projects for the course. A brief description is included along with a guideline that includes the instruction and skill development.

ORDER	PROJECT NAME	PROJECT DESCRIPTION
1	Problem Solving / Design Loop	All activities are the result of the application of a design process/problem solving loop. Each unit will include instruction on different areas, careers related to, and real world applications of these processes as well as related skills and knowledge. This unit is ongoing thought the semester.
2	Line drawing/Pictorial Sketching/Rapid Viz	All activities incorporate the design process and include in the steps, the need for several different types of sketches. In documentation, sketches are used to illustrate the progression of designs. General sketching skills are generally acquired and developed over time by repetition and practice. Students should have basic sketching skills upon entering the course from its prerequisite. Sketching activities in the beginning will be used to reinforce previous learning. Later they will be applied as part of design problems.
3	Pictorial Sketching: Isometric	An Isometric view is a way showing a 3D representation of the object. Applying previously learned sketching skills students will complete several isometric drawings for brainstorming and idea generation as part of a design activity. Some of the activities that students will create design documentation and portfolios for are listed later in this section. They include Game design, Children's toy design, Product design and re-design,
4	3D CAD: Software Introduction	These activities are designed as an introduction and overview of software. Instructor demonstrations and student exercises introduce fundamental workflows and tools in most of the Autodesk Inventor environments. This theme is also threaded through the course. At different times students will be tasked with completing drawings for skill development and then applied to a problem solving situation. Some of the skills are-- Create and constrain 2D sketches , Create extrude and revolved features, Create placed features including fillets, chamfers, holes , Use work planes to create sketch planes, Create drawings of parts including projected views, section views, and annotations, Assemble parts, Document assemblies including assembly drawings and parts lists, Rendering and animation.
5	Intro to Assembly Drawing: Soma Cube	The original Soma Cube is a puzzle made of 7 pieces that come together to form a cube. The puzzle was invented by Danish mathematician Piet Hein in 1927. There are 240 solutions. It has been used for everything from adult brain teasers to psychological testing of intelligence. In this class it is an excellent vehicle for teaching spatial relationships and introductory 3D CAD assembly and animation commands. Students will be tasked with designing their own cube based on the original. As part of the designs solution they will also create a prototype for testing.
6	Technical Writing: Lego's	As an introduction to technical writing students will be tasked with writing assembly directions with accompanying drawings for a Lego toy they create. Students will be given a box of a few thousand Lego's from which they will choose an arbitrary number of parts. They will work in reverse-- first building the prototype, then measuring each piece with a dial caliper to accurately draw an assembly in CAD. Lastly they will write directions on how to make the toy if it were shipped to a consumer as a bag of parts. The 2013 year assignment will be to create a happy meal toy with packaging for inclusion in a McDonalds Happy Meal. The directions must be able to be followed by the average 10 year old.
7	Product Innovation: Redesign	90% of design is redesign. In this unit students will be tasked with bringing in a new object for group discussion each week for a month. Each object they bring in they will document an innovation for it in a technical manner. They will present their item to the class along with a technical analysis of its life cycle, sustainability issues and suggestions for innovation of it. More advanced technical writing is also a part of this unit. In a group discussion at the end of the month they will choose one of their ideas to create a solution for through to the prototyping step.

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8	Toy/Game Design	Students will apply several different advanced 3D drawing commands to design a game or toy. An assembly drawing and animation will be completed as well. An original game or toy will be created as a design problem. Students will either design the toy as an assembly such as a child's pull toy or design a board game and design several different game pieces as part of the activity. Technical writing will be employed in either event as directions for assembly or game play depending on the activity.
9	Industrial Design: Ergonomic study	Students will study ergonomics as it relates to product design. They will create a new or redesigned a product based on given design criteria. They will factor into their design the intended audience for the product and the anthropological data for that population. They will also have to factor in the elements of design. Some possible problems would range from a simple universal remote control to ADA compliant products.
11	Engineering/3D CAD related Competitions	When students reach a certain proficiency in engineering related software and output devices, they will each participate in a minimum of one design competition. At the completion of the portfolio it is at the students' discretion as to whether they want to turn it in for evaluation by the related competition judges. However, they will have their portfolio for the competition graded for class regardless. Some of the competition entered during the 2012-13 school year are—Stratasis extreme redesign rapid prototyping challenge, Redesign challenge of New York City phone booths, The Thomas Edison Invention Challenge, Several different events of the Technology Student Association, PTC 2013 Real World Design Challenge and Make magazine student competitions (various).
12	Reverse Engineering: Common Item	Students will reverse engineer a common product. They will classify each part as recyclable or non-recyclable and write in their documentation about issues with the product relating to sustainability. They will create working drawings and assembly drawings for the reassembly of the product as well as write technically to annotate their drawing with reassembly directions.
13	Team CAD Project	Working cooperatively on a team project is a necessary skill for engineer's in today's work force. Students will work on several group drawing projects where they will create a part of a larger drawing. The individual parts once created will be integrated into an assembly drawing by a designated team captain. Some suggested activities might include—Design a new Mr. Potato head where each group member draws a different part of the character or a simple LEGO toy.
14	Designing Structural Systems	Working in teams, students will get 30 lb. of pine (4-1x6x8 boards) and have to span 10' with a truss structure. The structures will be destructively tested but must hold a minimum of 1000 lb. Students will apply mathematical and physics concepts to the design as part of their evaluation and documentation.
15	Designing Hydrodynamic Systems	Students will be given 3 sheets of 4'x8' cardboard, 1 tube of construction adhesive and 1 roll of duct tape. They will construct a boat to carry 2 team members across the pool and back in the least amount of time. They will study hydrodynamics and apply CAD drawing techniques to their documentation for the activity.
16	Personal Interest Design Project (s)	Reflecting on their personal experiences in the class students will complete a personalized design project related to a college, career or personal interest. They will apply their previous learning as well as integrate into it information from new research. They will write a design brief as well as create a documentation portfolio for the activity.

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