Madison Public Schools

Technology, Engineering, and Design I Curriculum

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Course Overview

Description

This semester course focuses on the application of integrated STEM (Science, Technology, Engineering, and Mathematics) principles and the design process to invent solutions to real world technological problems. Students will spend the first half of the course learning how to operate various industrial grade prototyping/manufacturing machines and their software, such as 3D Printers, CNC Mills, CNC Lathes, Laser Engravers, CAD software, and GCODE. In the second half of the course, students will use their newly acquired prototyping skills and integrate them with analog electronics.

Goals

This course aims to:

- Introduce students to the engineering design process through hands on projects and demonstrations.
- Introduce students to the use of 3D printing to make functional parts for their projects.
- Introduce students to a variety of mechanical engineering concepts.
- Introduce students to analog electronics.

Materials

Core: Sparkfun Learning
Supplemental:

- Electronic Schematics
  - http://fritzing.org/home/
- Prototyping Equipment
  - https://www.lulzbot.com/
  - https://www.ulsinc.com/
- Adafruit Learning
  - https://learn.adafruit.com/
- CNC/G-Code
  - https://www.autodesk.com/industry/manufacturing/resources/manufacturing-engineer/g-code
  - https://www.tormach.com/
  - https://www.bantamtools.com/
- Sparkfun Learning
  - https://www.sparkfun.com/
- Autodesk Inventor/Fusion
  - https://www.autodesk.com/

Resources

Suggested activities and resources page

Benchmark Assessments

This course will consist of two benchmark assessments that will be given at the end of each major unit, this includes, introduction to prototyping, and introduction to analog electronics.

Modifications and Adaptations for Special Needs Learners

(Gifted and Talented Students, English Language Learners, Students with Special Needs, At-Risk Students, and Students with 504 Plans)

Scope and Sequence
(Pacing Guide)

Unit Number	Topic of Study	Duration (Weeks Taught)
1	Room Orientation/Safety Training	1
2	Introduction to the Engineering Design Process	1
3	Introduction to Gearing and Mechanical Advantage	1
4	Introduction to 3D Modeling	1
5	Mechanical Systems Design	4
6	Introduction to Analog Electronics	3
7	Introduction to PCB Design	2
8	Final Electronics Project	6

Unit 1 Overview

Unit Title: Room Orientation & Machine Safety

Unit Summary:
In this unit, students will be learning where supplies and tools are located in the engineering lab. Students will also be trained on the proper techniques and procedures for using the different production machinery. Students will then be certified for use of these machines after successful completion of ITEEA's machine safety quizzes.

Suggested Pacing: 4-5 Lessons

Learning Targets

Unit Essential Questions:

- When is the proper time to wear eye safety?
- Who should know the lab safety procedures?
- How can I ensure my safety in the lab?
- What are the ramifications for not following lab safety procedures?
- How do I efficiently and safely operate the prototyping equipment?

Unit Enduring Understandings:

- Lab safety is important to everyone at all times.
- Safety is the most critical component of an optimum work environment.
- Understanding how to properly operate machines is a lifelong skill.

Evidence of Learning

Formative Assessments: Students will be assessed based on their cooperation and participation in class discussions and safety demonstrations.

Summative Assessment: Students will be assessed based on the scores they receive after completing the ITEEA safety test for each machine.

Alternative Assessments: Students will demonstrate their ability to properly follow safety procedures through a series of hand on test of their skills.

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Identify the proper times that they should be wearing eye protection. Identify situations where secondary eye protection may be required.	General lab safety procedures. Eye safety procedures. How to identify potential hazards. Vocabulary: Machine Guards, Primary Protectors, Machine Shields, Adjustments, Spectacles, Goggles, Welding Helmet	Students will be assessed based on their cooperation and participation in the class discussions, safety demonstrations, and the ITEEA safety test for general lab safety.	**RST.9-10.3.** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text. **RST.11-12.7.** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in

			order to address a question or solve a problem. **9.3.MN-HSE.1** Demonstrate the safe use of manufacturing equipment.
Efficiently and safely use the portable, and stationary power and hand tools. Identify when a machine is operating properly and when it may need adjustment.	How to identify a machine that is functioning properly and one that is not. How to follow a proper procedure in order to safely and effectively use hand and power tools.	Students will be assessed based on their cooperation and participation in the class discussions, safety demonstrations, and the ITEEA safety tests for each of the stationary and portable machines in the engineering lab.	

Unit 2 Overview

Unit Title: Introduction to the Design Process

Unit Summary:
In this unit, students will be learning where supplies and tools are located in the engineering lab. Students will also be trained on the proper techniques and procedures for using the different production machinery. Students will then be certified for use of these machines after successful completion of ITEEA's machine safety quizzes.

Suggested Pacing: 1-2 Lessons

Learning Targets

Unit Essential Questions:

- What is the design process?
- How can we use the design process to help us invent & design?
- Why is it important to document our work?

Unit Enduring Understandings:

- The design process gives us a procedure to follow when problem-solving.
- There is always room for improvement when using the design process.
- Documentation helps us have the ability to recreate and improve our designs or the processes used to create them.

Evidence of Learning

Formative Assessments: Students will be assessed based on their cooperation and participation in class discussions.

Summative Assessment: Students will be asked to identify the different steps in the design process and the tasks that they should be performing during each step. Scoring will be done using the provided rubric.

Alternative Assessments: Students will complete the design process template with examples of different tasks that should be completed at each step.

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Use the design process to aid them in designing and creating their projects. Understand that documenting their work is one of the most important things engineers do.	The steps in the MHS design process. The proper format to follow when documenting their work. How to evaluate their work using the SWOT method. Vocabulary: Documentation, Design Process, SWOT Method, Evaluation, Constraint, Prototype, Viable	Students will be assessed based on their cooperation and participation in the class discussions.	**ITEEA: Standards for Technological Literacy 8H:** The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.

			8.2.12.E.4: Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types, and conditional statements). **8.2.12.C.7** Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials.

Unit 3 Overview

Unit Title: Introduction to Gearing and Mechanical Advantage

Unit Summary:
This unit will introduce students to the idea of using gears and other mechanical devices to create mechanical advantage. Students will be given a variety of different sized gears and will use them to create the most possible mechanical advantage. Students will apply this information in the Mechanical Systems Design Project.

Suggested Pacing: 3-4 Lessons

Learning Targets

Unit Essential Questions:
- Why is mechanical advantage important?
- Why would we consider mechanical advantage and speed to be a balancing act?
- What is an idler gear?
- What is torque?

Unit Enduring Understandings:
- Mechanical Advantage plays a huge role in our everyday lives.
- Mechanical advantage make our lives easier.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of projects through the use of a provided class participation rubric.

Summative Assessments: Students will be assessed based on their ability to design and create a gear train that falls under a specific set of criteria and constraints. Scoring will be done using the provided rubric.

Alternative Assessments: N/A

Objectives (Students will be able to...)	**Key Concepts** (Students will know...)	**Suggested Assessments**	**Standards (NJSLS)**
Identify the tradeoffs between speed and torque. Identify the different types of gears and mechanical devices. Understand how input, output, and idler gears work together in a gear train. Identify the importance of mechanical advantage.	Speed and torque are closely related in a gear train. The differences between the types of gears. The inner working of a gear train.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**8.2.12.C.3** Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics). **ITEEA: Standards for Technological Literacy 16N:** Power systems must have a source of energy, a process, and loads. Usually feedback is part of this system. For example, the output of the system is sampled and provides a signal back to the input or process phase of the system in order to modify it. Power systems convert energy from one form to another and may transfer energy from one place to another. An example would be to burn coal in order to heat water and make steam, which turns a turbine and ultimately generates electricity.

Unit 4 Overview

Unit Title: Introduction to 3D Modeling

Unit Summary:
In this unit, students will be given an introduction to 3D modeling software. This software will be the foundation of this course and it is imperative that the students become familiar with the tools and processes to be successful. In this unit, we will go over the standard functions, processes, and tools that the software has to offer by doing a set of tutorials. Students will also learn how to use measuring tools such as micrometers and calipers.

Suggested Pacing: 3-4 Lessons

Learning Targets

Unit Essential Questions:
- What is the purpose of 3D modeling software?
- What are the basic features of our 3D modeling software?
- How can I ensure accurate measurements of the software?
- How can the following basic procedures ensure I am drawing the parts of my device correctly?

Unit Enduring Understandings:
- 3D modeling software is designed to help users convert 2D sketches into functional parts.
- The basic features of 3D modeling software will allow us to draw the majority of our device.
- Measuring and planning are imperative to a successful model.
- Following basic procedures help improve drawing efficiency.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of tutorials.

Summative Assessments: Students will be assessed by their ability to accurately measure and digitally recreate 4 given objects. Scoring will be completed using the given rubric.

Alternative Assessments: N/A

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Use 3D modeling software to draw simple and complex shapes. Use the basic features of the 3D modeling software. Take accurate measurements using an assortment of measuring tools.	How to use 3D modeling software to create different parts. How to measure to .001" accuracy. How to export their parts to be 3D printed.	Students will be assessed based upon their participation and completion of the different tutorials.	**HS-ETS1-4.**Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. **ITEEA: Standards for Technological Literacy 12 P:** Use computers and calculators to access, retrieve, organize,

	How to create 2D representations of their 3D parts.		process, maintain, interpret, and evaluate data and information in order to communicate. Many resources, such as library books, the Internet, word processing and spreadsheet software, in addition to computer-aided design (CAD) software, can be used to access information.

Unit 5 Overview

Unit Title: Mechanical Systems Design

Unit Summary:
In this unit students will design and build their own mechanical system completes a series of tasks with the least amount of energy input into the system. Students will use the knowledge gained in the two prior units as well as math and science concepts to create these systems.

Suggested Pacing: 16-20 Lessons

Learning Targets

Unit Essential Questions:

- How can we computer modeling software along with our measuring tools and mechanical devices to create a system to solve a given task?
- Why is 3D printing beneficial to this project?
- How does mechanical systems design differ from aesthetic design?
- How can we use math and science concepts to better design our systems?

Unit Enduring Understandings:

- Mechanical Systems design involves precision and ingenuity.
- 3D printing and other CNC manufacturing techniques make creating precision parts much easier.
- Math and science concepts help us plan out our systems.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of projects through the use of a provided class participation rubric.

Summative Assessments: Students will be assessed by their ability to design and create a mechanical system that completes a given series of tasks using the least amount of energy and falls under a specific set of criteria and constraints. Scoring will be completed using the given rubric.

Alternative Assessments: N/A

Objectives (Students will be able to...)	**Key Concepts** (Students will know...)	**Suggested Assessments**	**Standards (NJSLS)**
Create a unique system while keeping in mind the criteria and constraints for the project. Use 3D printers and other CNC technology to aid them in the production of their systems. Use math and science concepts to ensure the success of their systems.	How to design a mechanical system by balancing the criteria and constraints. How to create a prototype that solves the given problem.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**ITEEA: Standards for Technological Literacy 2AA:** Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. Sometimes requirements can be constraints, criteria, or both. Balancing the two is the optimum. **8.2.12.D.1** Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the

			prototype, identify trade-offs made, and present the solution for peer review. **9.3.MN-PPD.2** Research, design and implement alternative manufacturing processes to manage production of new and/or improved products. **CRP11.** Use technology to enhance productivity.
Use math and science concepts to evaluate the success of their systems.	How to use mathematics to calculate the output of their systems	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**MP.4** Model with mathematics.

Unit 6 Overview

Unit Title: Introduction to Analog Electronics

Unit Summary:
In this unit students will be introduced to electricity in the form of analog DC current. Students will be taught the differences between AC and DC as well as the historical significance of the AC Vs. DC electricity race. Students will then complete a variety of tutorials that teach them how to solder along with other importance analog electronics concepts.

Suggested Pacing: 10-12 Lessons

Learning Targets

Unit Essential Questions:

- What determines whether a circuit is wired in series v. parallel?
- What determines whether a circuit is powered with DC or AC power?
- How are the three elements of Ohm's Law (voltage, current, resistance) interrelated?
- What are some means of troubleshooting faulty circuits?
- Explain the difference between voltage and amperage.

Unit Enduring Understandings:

- Electronic components provide elements of control to a system.
- All electronic systems require a load, a power source, and a conduit to conduct current.
- Circuit design requires a fundamental understanding of what components do, how current flows, and sound wiring practice.
- Soldering is a precision skill.
- Systems thinking applies to all areas of technology.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of projects through the use of a provided class participation rubric.

Summative Assessments: Students will be assessed by their completion of 6 tutorials that each require a different skill set to complete. Scoring will be completed using the given rubric.

Alternative Assessments: N/A

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Demonstrate safe practices, as specifically related to power sources, current flow, and soldering. Explore circuit design using various power sources. loads, and switches.	How to properly solder electronic components together The differences between AC and DC electricity. How to design an analog circuit for a given task.	Students will be assessed based upon their participation and completion of the different tutorials using the provided rubric.	**8.2.12.D.3** Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system. **8.2.12.B.4** Investigate a technology used in a given period of history, e.g., stone age,

Explore circuit design using various power sources. loads, and switches.			industrial revolution or information age, and identify their impact and how they may have changed to meet human needs and wants.
Develop schematic diagrams of all circuits using the computer software provided. Apply mathematical principles and an understanding of the relationship between current, voltage, and resistance to solve equations using Ohm's Law.	How to create a schematic diagram for each created circuit. The schematic symbols for each electronic component. How math and science concepts impact electronics systems design.	Students will be assessed based upon their participation and completion of the different tutorials using the provided rubric.	**HS-ETS1-4.** Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Unit 7 Overview

Unit Title: Introduction to PCB Design

Unit Summary:
In this unit students will learn how to design a printed circuit board (PCB) using an electronics design software. Students will then use a CNC milling software and mill to create their PCBs. They will then solder their PCBs to create a professional quality finished board.

Suggested Pacing: 6-8 Lessons

Learning Targets

Unit Essential Questions:

- What are the benefits of using a PCB instead of a breadboard?
- How can we use schematics to help us plan out our PCBs?
- How does CNC manufacturing changed the way we produce circuit boards?

Unit Enduring Understandings:

- PCBs are the foundation of all electrical systems.
- Using the correct solder and soldering iron is imperative for each task.
- CNC manufacturing enables us to create PCBs quickly and with ease.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of projects through the use of a provided class participation rubric.

Summative Assessments: Students will be assessed by their completion of the PCB project and their ability to make the PCB under the given set of criteria and constraints. Scoring will be completed using the given rubric.

Alternative Assessments: N/A

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Use PCB design software in order to design a custom pcb for their unique application. Use electronics concepts and schematics to help them correctly create their traces and place components.	How to use PCB design software. How to correctly layout and connect components on a PCB.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**8.2.12.C.7** Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials. **8.2.12.D.5** Explain how material processing impacts the quality of engineered and fabricated products. **CRP11**. Use technology to enhance productivity

Use a CNC mill and its software to create their PCB. Follow the onscreen instructions to safely and effectively change the bits in the CNC mill.	How to import and export their files to the CNC mill program. How to setup the CNC mill to run their PCB job.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**8.2.12.E.4:** Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types, and conditional statements). **RST.9-10.3.** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text. **9.3.MN-HSE.1** Demonstrate the safe use of manufacturing equipment.

Unit 8 Overview

Unit Title: Final Electronics Project

Unit Summary:
In this unit, students will be utilizing all of the skills that they have learned to this point to create an informative electronic sign with a given theme. The sign will incorporate material, mechanical and electronic prototyping and will test their skills. At the conclusion of this unit the signs will be put on display for the next class to see.

Suggested Pacing: 20-24 Lessons

Learning Targets

Unit Essential Questions:

- What are the tradeoffs of using wood v. acrylic as the frame for your structure?
- Explain what measures should be taken to ensure efficient function of your electronic system.
- How will your sign attract attention?
- How can you minimize maintenance of your sign?

Unit Enduring Understandings:

- Electronic systems add complexity and aesthetic appeal to static structures.
- Prototypes must be designed with an attention to craftsmanship, durability, and repeatability.
- The use of proper fasteners helps to ensure prototype stability.
- Proper application of Ohm's Law ensures efficient performance.
- Wiring circuits in parallel provides greater flexibility in design.

Evidence of Learning

Formative Assessments: Students will be assessed based upon their participation and completion of tutorials.

Summative Assessments: Students will be assessed by their ability to create an aesthetically pleasing and high quality electronic sign that falls under the given set of criteria and constraints. Scoring will be completed using the given rubric.

Alternative Assessments: N/A

Objectives (Students will be able to…)	**Key Concepts** (Students will know…)	**Suggested Assessments**	**Standards (NJSLS)**
Demonstrate effective wiring techniques to develop a working electronic sign applying knowledge from previous unit. Measure voltage, current, and resistance using appropriate tools and meters.	How to effectively wire multiple electrical components. How to use electrical tools to troubleshoot a malfunctioning circuit. How to design a schematic to ensure efficient operation of the sign.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**ITEEA: Standards for Technological Literacy 10I:** Research and development is a specific problem-solving approach that is used extensively in business and industry to prepare devices and systems for the marketplace. Research on specific topics of interest to the government or business and industry can provide more information on a subject, and, in many cases, it can provide the knowledge to

Construct working schematic diagrams using the appropriate computer software.			create an invention or innovation. Development helps to prepare a product or system for final production. Product development of this type frequently requires sustained effort from teams of people having diverse backgrounds. **RST.11-12.4.** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. **CRP4.** Communicate clearly and effectively and with reason.
Develop a durable, reliable product using proper materials and fasteners. Present rationale of electronic sign design through documentation of the design process and oral presentation using various forms of technology.	How to select the proper prototyping machinery to help them create their prototype. How to select the appropriate size for their prototype, keeping in mind time management and skill level.	Students will be assessed based upon their participation and completion for a group project using the provided rubric.	**8.2.12.D.3** Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system. **8.2.12.C.4** Explain and identify interdependent systems and their functions. **9.3.MN.6** Demonstrate workplace knowledge and skills common to manufacturing.