Madison Public Schools
Introduction to Computer Science Curriculum

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Course Overview

Description

Introduction to Computer Science is a two marking period, or single semester course that is offered as an elective to 9th, 10th, 11th, and 12th grade students. Introduction to Computer Science provides students with an intermediate and adaptive understanding and skill set in computer programming systems design. Students will have the opportunity to grow on prior introductory programming skills from beginner languages, such as processing, as they become prepared for more advanced programming opportunities that may be offered in higher education courses and their careers.

Introduction to Computer Science allows for students to utilize Java-based programming languages in order to complete real-world and open-ended design challenges within computer science applications through the use of the engineering design process. Students will be challenged to learn how to design and create circuits as they learn about the differences between analog and digital circuitry. Students will use technology to support and share their ideas and projects as they work collaboratively throughout the class in order to provide feedback and suggestions to their peers. Each student will have the opportunity to reflect upon one's own work and undergo methods of redesign and improvement as they continue to develop their skills by learning from the course and their peers. Computer programming is one of the fastest growing fields and learning a computer programming language can improve thinking and reasoning abilities regardless of career path.

Goals

This course aims to:

- Provide students with an opportunity to use the engineering design process in order to solve real-world problems
- Challenge students to design and create both analog and digital circuits
- Students will become familiar with the methods used to create an integrated system through computer programming
- Students will understand the fundamental syntax of code and how we (humans) interact with computers
- Students will acquire the necessary skills to design, create, and test their own programs using a java-based programming language

Resources

The resources that will be utilized within this course are:

- Official Arduino Education
  - https://www.arduino.cc/en/Main/Education
- The Arduino Classroom
  - http://www.arduinoclassroom.com/index.php/arduino-101/chapter-1
- Adafruit Learning
  - https://learn.adafruit.com/

Modifications and Adaptations for Special Needs Learners
(Gifted and Talented Students, English Language Learners, Special Education Students, At-Risk Students)

Unit 1 Overview

Unit Title: Introduction to Computer Systems

Unit Summary:
In this unit, students will be introduced to computer science and how it is used in the world around them. Students will identify different ways that computer programming has changed the products we buy. Different types of computer programming will be covered, as well as their roles in our modern society. In group form, students will also review the role that STEM fields play in the computer programming industry.

Suggested Pacing: 3-4 lessons

Learning Targets

Unit Essential Questions:

- What is computer programming?
- Where does computer programming exist in today's world?
- How can learning computer programming impact my life?
- How does computer programming work?

Unit Enduring Understandings:

- Computer programming is all around us in today's life, nearly every modern digital device incorporates some level of computer programming.
- Computer programming is one of the fastest growing fields, however learning a computer programming language can improve thinking and reasoning abilities regardless of career path.
- While there are many different computer programing languages, they all share a common method of writing, or syntax.

Evidence of Learning

Unit Benchmark Assessment Information:
Students will be assessed based on their cooperation and participation in the class discussions and activities that are to be completed as a group.

Objectives (Students will be able to...)	**Essential Content/Skills**	**Suggested Assessments**	**Standards** (NJCCCS CPIs, CCSS, NGSS)	**Pacing**
• Define STEM • Define computer programming • Identify areas computer programming is used in today's world	Content: • Computer programming • Applications for computer programing • STEM Skills: • Utilize digital resources to acquire information	• Students will be assessed based upon their participation and completion for group lead discussion activities Possible Assessments: • Areas of Programming investigation activity	**8.2.12.A.2** Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste. **8.2.12.C.2** Analyze a product and how it has changed or might change over time to meet human needs and wants.	1 lesson

• Identify the process in which we will use to solve the assignments throughout this course • Develop a rudimentary program by assembling specific words and phrases	Content: • The Design Process • Syntax Skills: • Solve a problem using a problem solving process • Develop a list of instructions utilizing specific words	• Students will be assessed based upon their participation and completion for group lead discussion activities Possible Assessments: • Intro to syntax • The Role of the Programmer	**HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **8.2.12.E.4** Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).	2-3 lessons

Unit 2 Overview

Unit Title: Analog Circuitry

Unit Summary:
In this unit, students will become familiar with the fundamental components used to create an electrical circuit. Students will be introduced to analog systems as they use the engineering design process to solve real-world problems by designing an electric system or prototype. Students will be introduced to various tools and electronic instruments as they design and create their systems. This unit will provide students with the necessary foundation of knowledge needed before moving onto computer programmed digital circuitry.

Suggested Pacing: 7-10 lessons

Learning Targets

Unit Essential Questions:
- What is electricity?
- How do we utilize electricity through an analog circuit?
- What is the difference between polar and nonpolar components?

Unit Enduring Understandings:
- Electricity is a type of energy that can be generated and stored
- There are different components that can be connected together to create a circuit
- Different conductor and insulator materials must be combined to develop a product or system

Evidence of Learning

Unit Benchmark Assessment Information:
Students will work collaboratively to design and create their own electronic circuit as they combine components in order to solve real-world problems. Students will be assessed based on their participation and completion of activities based on a provided evaluation rubric.

Objectives **(Students will be able to…)**	**Essential Content/Skills**	**Suggested Assessments**	**Standards** **(NJCCCS CPIs, CCSS, NGSS)**	**Pacing**
• Define energy and its components • Determine various ways generating	Content: • Electricity • Renewable Energy Skills:	• Students will be assessed based upon their participation and	**HS-PS3-3.** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.	1 lesson

electricity impacts society • Explore the differences between renewable and nonrenewable energy sources	• Research information on the internet to create an argument • Use electronic instruments to measure electricity	completion for group lead discussion activities Possible Assessments: • Renewable Redesign • Solar vs Motor with a multimeter	**8.2.12.E.4** Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).	
• Identify the three components of electricity • Define a circuit • Define a component • Determine the difference between a conductor and insulator • Create a simple circuit	Content: • Electricity ○ Current ○ Voltage ○ Resistance • Circuits • Components ○ Power ○ Path ○ Control ○ Load • Conductors vs Insulators Skills: • Create a simple circuit by combing conductors and insulators with components	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • Simple circuits • Lightsaber design challenge	**HS-PS3-3.** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.	2-3 lessons
• Identify the differences between a series and parallel circuit • Define polar and nonpolar components	Content: • Series Circuits • Parallel Circuits • Polar vs nonpolar components Skills: • Create a series and parallel circuit utilizing a variety of polar and nonpolar components in order to solve a real-world challenge	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • Analog Circuit Design challenge	**HS-PS3-3.** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.	4-6 lessons

Unit 3 Overview

Unit Title: Digital Electronics

Unit Summary:
In this unit, students will learn how computer programming languages can be used to control electrical systems through digital circuitry. Students will identify the similarities and differences between analog and digital circuits as they learn to write basic computer programs. Students will utilize Arduino, a Java-based programming language, to design and control their own computer systems.

Suggested Pacing: 5 lessons

Learning Targets

Unit Essential Questions:

- What are digital components?
- What is a microcontroller?
- How do digital components work with analog components in a circuit?
- What is the relationship between hardware and software in computer systems?

Unit Enduring Understandings:

- All forms of computer programming rely on an electrical circuit to function
- Even in a digital circuit, analog components are still needed
- Troubleshooting is a necessary step with the engineering design process

Evidence of Learning

Unit Benchmark Assessment Information:
Students will work collaboratively to design and create their own prototypes as they combine electrical components with computer programming in order to solve real-world problems. Students will be assessed based on their participation and completion of activities based on a provided evaluation rubric.

Objectives (Students will be able to...)	**Essential Content/Skills**	**Suggested Assessments**	**Standards** (NJCCCS CPIs, CCSS, NGSS)	**Pacing**
• Define microcontroller • Write a simple program using a java-based programming language	Content: • Arduino Skills: • Write a basic program using the arduino programming language	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • Hello World	**8.2.12.E.2:** Analyze the relationships between internal and external computer components. **8.2.12.C.1** Explain how open source technologies follow the design process. **8.2.12.C.2** Analyze a product and how it has changed or might change over time to meet human needs and wants. **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.E.3** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).	2 lessons
• Utilize time within a program to add a higher level of autonomy • Determine the pros and cons with using a time delay in a program • Utilize analog and digital components when create a circuit	Content: • Time • Delays Skills: • Use a breadboard to wire a circuit that combines both analog and digital components	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • Blink LED • Sleep Fade LED • Traffic Light	**8.2.12.E.3** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).	3 lessons

Unit 4 Overview

Unit Title: Collecting Data and Inputs

Unit Summary:
In this unit, students will learn to collect and create data through variables in their programs. Students will utilize digital and analog components as inputs on their circuits in order to control

their systems. Students will be challenged to develop more complex circuits in order to incorporate physical inputs into their programs.

Suggested Pacing: 7-9 lessons

Learning Targets

Unit Essential Questions:

- How do we interactive computers?
- What is an input?
- What data does a computer collect every time an input is pressed?

Unit Enduring Understandings:

- Hardware is often required to make software function
- Inputs vary from buttons, switches, joysticks, knobs, and more
- Data can be collected and recalled within a program in order to complete tasks within a system

Evidence of Learning

Unit Benchmark Assessment Information:
Students will work collaboratively to design and create complex digital systems with digital and analog inputs. Students will be assessed based on their participation and completion of activities based on a provided evaluation rubric.

Objectives (Students will be able to...)	**Essential Content/Skills**	**Suggested Assessments**	**Standards** (NJCCCS CPIs, CCSS, NGSS)	**Pacing**
• Determine how to correctly connect a button to the arduino as a one-zero generator • Create a variable using a computer programming language • Control a program using a digital input component	Content: • Digital Inputs • One-Zero Generator • Variables • Serial-Monitor Skills: • Create a program that responds to a signal from a digital input device	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • One-Zero Generators • Response Timer Game	**8.2.12.E.2** Analyze the relationships between internal and external computer components. **8.2.12.E.3** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).	2 lessons
• Create a program that utilizes an analog input device • Wire a potentiometer to a microcontroller	Content: • Analog Inputs • Mapping • Variables • Serial-Monitor Skills: • Create a program that responds to a signal from an analog input device	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • Dimmer LED • Variable Blink LED	**8.2.12.E.3** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).	2-3 lessons
• Develop a circuit that combines both digital and analog inputs into a program written using a java-based programming language	Content: • Digital Inputs • Analog Inputs • The Engineering Design Process Skills:	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • RGB LED	**8.2.12.E.3** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).	3-4 lessons

	• integrates multiple parts of subsystem in order to create a system	• Lock Box Design		

Unit 5 Overview

Unit Title: Sensors

Unit Summary:
In this unit, students will identify the importance of sensors. Students will correlate sensor design to the human anatomy as we investigate how sensors are based off humans in an effort to replicate our (human's) motions and abilities. Students will then be tasked with completing a series of challenges. They must choose the correct sensor, or collection of sensors to complete complex tasks. They must also create advanced programming functions in order for the sensors to function correctly. Lastly, students will also utilize the engineering design process to design and build their own sensors that are to be integrated into their solutions to real-world design challenges.

Suggested Pacing: 8-10 lessons

Learning Targets

Unit Essential Questions:
- What are the primary senses for humans?
- How do we connect and program each sensor? What are the similarities and differences in the syntax between analog and digital sensors?
- What is a threshold?

Unit Enduring Understandings:
- Sensors are designed to simulate the human senses, allowing for robots to simulated human actions
- Thresholds are powerful methods to calibrate a system, allowing for accurate performance based on a specific situation

Evidence of Learning

Unit Benchmark Assessment Information:
Students will work collaboratively to design and create complex electronic systems and programs. Students will be assessed based on their participation and completion of activities based on a provided evaluation rubric.

Objectives (Students will be able to...)	**Essential Content/Skills**	**Suggested Assessments**	**Standards** (NJCCCS CPIs, CCSS, NGSS)	**Pacing**
• Define sensors and how they are used within a system • Determine the appropriate sensor to use in order to solve a real-world challenge	Content: • Analog Sensors • Threshold • Serial-Monitor Skills: • Create a circuit that utilizes an analog sensor	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • Photoresistor Activity	**8.2.12.E.3** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games). **8.2.12.E.4** Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI,	2-3 lessons

	for an autonomous program		abstraction, variables, data types and conditional statements).	
• Define how analog sensors differ from digital sensors • Develop a program that reads and interacts with data from a digital sensor	Content: • Digital Sensors • Threshold • Serial-Monitor Skills: • Create a circuit that utilizes a digital sensor for an autonomous program	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • Motion Detectors Activity	**8.2.12.E.3** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games). **8.2.12.E.2** Analyze the relationships between internal and external computer components.	2-3 lessons
• Determine how sound is create with a speaker • Develop a program that creates sound frequencies using an analog speaker	Content: • Sound • Pitch • Frequency Skills: • Apply cross-discipline concepts in order to create a program that plays audio through a speaker	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • Hidden Alarm Challenge • Piezo Frequencies	**8.2.12.E.3** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games). **8.2.12.E.2** Analyze the relationships between internal and external computer components.	4 lessons

Unit 6 Overview

Unit Title: Complex Systems

Unit Summary:
In this unit, Students will continue to grow on the abilities they have learned in previous units through the completion of a series of challenges. Students will learn advanced programming functions in order to allow them to create complex systems. Students will then use the engineering design process to create complex circuits that utilize newly learned programming methods.

Suggested Pacing: 8-10 lessons

Learning Targets

Unit Essential Questions:
- How do our prototyping circuits differ from products we buy?
- How can we optimize our programs?
- What is a library?

Unit Enduring Understandings:
- Prototyping circuits often use components that are larger and more versatile than components integrated into a final product or system
- Programming languages can often be enhanced through utilizing libraries developed by programmers

Evidence of Learning

Unit Benchmark Assessment Information:
Students will work collaboratively to design and create complex programs in order to control electronic systems. Students will be assessed based on their participation and completion of activities based on a provided evaluation rubric.

Objectives (Students will be able to...)	Essential Content/Skills	Suggested Assessments	Standards (NJCCCS CPIs, CCSS, NGSS)	Pacing
• Develop a program and circuit that allows for text to be created on a liquid crystal display • Import a library into a java-based program	Content: • Liquid Crystal Displays • Serial Communication • Libraries Skills: • Combine multiple digital components together to develop a real-world system	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • Hello World (LCD)	**HS-PS3-3.** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. **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.E.3** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games). **8.2.12.C.4** Explain and identify interdependent systems and their functions.	2-3 lessons
• Define the difference between servo motors and stepper motors • Create a program that controls a circuit using a motor controller • Create a program that controls a circuit using multiple power supplies	Content: • Servo Motors • Stepper Motors Skills: • Develop a circuit that controls a motor, or motors, in order to complete a real-world challenge • Develop a function within a program	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • MyServo • Autonomous Blinds	**HS-PS3-3.** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. **8.2.12.E.3** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games). **8.2.12.C.4** Explain and identify interdependent systems and their functions.	6-7 lessons

Unit 7 Overview

Unit Title: Autonomous Systems Design

Unit Summary:
In this final unit, students will have the opportunity to apply all previously learned content and skills in order to design their own product or system. Students will be challenged to use the engineering design process to design, develop, and create a prototype to solve a real-world problem. Students will have to write a complex program that incorporates a variety of functions, statements, and loops to control their autonomous integrated circuit. Upon completion of their systems, students will test and evaluate each others prototypes as they complete the design process.

Suggested Pacing: 15-17 lessons

Learning Targets

Unit Essential Questions:

- Rapid prototyping may allow for prototypes to be made quicker, easier, and cheaper than mass production, however mass production techniques are far more cost effective when creating a large quantity of product
- How do designers and engineers create a new product?
- How can hardware and software be integrated to create a product or system?

Unit Enduring Understandings:

- A product is often created using a variety of manufacturing techniques
- In order for a product to function, the hardware and software must be integrated and designed simultaneously

Evidence of Learning

Unit Benchmark Assessment Information:
Students will work individually and collaboratively to design and create their own system in order to solve real-world problems. Students will be assessed based on their participation and completion of activities based on a provided evaluation rubric.

Objectives (Students will be able to...)	**Essential Content/Skills**	**Suggested Assessments**	**Standards** (NJCCCS CPIs, CCSS, NGSS)	**Pacing**
• Research existing solutions in order to identify a problem that can be solved through the development of a product or system	Content: • The Engineering Design Process Skills: • Use researching skills to find a problem that can be solved using the engineering design process	• Students will be assessed based upon their participation and completion for group lead discussion activities Possible Assessments: • Final Project research assignment	**8.2.12.A.3** Research and present information on an existing technological product that has been repurposed for a different function.	1-2 lessons
• Propose a solution to a group of peers • Provide feedback to a group of peers • Brainstorm possible solutions to a real-world problem	Content: • The Engineering Design Process Skills: • Work in groups to propose ideas and provide constructive feedback • Brainstorm multiple solutions to a real-world problem	• Students will be assessed based upon their participation and completion for group lead discussion activities Possible Assessments: • Final Project proposal assignment	**8.2.12.A.3** Research and present information on an existing technological product that has been repurposed for a different function. **8.2.12.E.4** Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).	1 lesson
• Design a complex system that utilizes multiple components in order to solve a real-world problem that meets the specifications and constraints of a design challenge • Write a program using a java-based programming language • Develop a circuit using conductors, insulators, analog, and digital components • Use the Engineering Design Process to solve a real-world problem	Content: • The Engineering Design Process • Arduino • Circuits • Analog Components • Digital Components • Sensors Skills: • Write a program that uses an integrated circuit to autonomously complete a task	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • Final Project	**HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **8.2.12.D.1** Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review. **8.2.12.D.3** Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system. **8.2.12.E.3** Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).	11 lessons

• Present designed solutions to a group of peers • Complete the testing, evaluation, and redesign stages of the engineering design process	Content: • The Engineering Design Process Skills: • Use the engineering design process to solve a real-world problem	• Students will be assessed based upon their participation and completion of projects through the use of a provided evaluation rubric Possible Assessments: • Final Project Methods for Redesign	**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.	2 lessons