2022 Computer Science and Engineering

Course Code: 000287

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The Research and Curriculum Unit (RCU), located in Starkville, as part of Mississippi State University (MSU), was established to foster educational enhancements and innovations. In keeping with the land-grant mission of MSU, the RCU is dedicated to improving the quality of life for Mississippians. The RCU enhances intellectual and professional development of Mississippi students and educators while applying knowledge and educational research to the lives of the people of the state. The RCU works within the contexts of curriculum development and revision, research, assessment, professional development, and industrial training.

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Acknowledgments

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Dr. Carey M. Wright, state superintendent of education
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Standards

Standards and alignment crosswalks are referenced in the appendices. Depending on the curriculum, these crosswalks should identify alignment to the standards mentioned below, as well as possible related academic topics as required in the Subject Area Testing Program in Algebra I, Biology I, English II, and U.S. History from 1877, which could be integrated into the content of the units. Mississippi's CTE CSE curriculum is aligned to the following standards:

International Society for Technology in Education Standards (ISTE)
Reprinted with permission from *ISTE Standards for Students* (2016). All rights reserved. Permission does not constitute an endorsement by ISTE.
iste.org

Technology and Engineering Literacy Framework for the 2018 National Assessment of Educational Progress (NAEP)
"The 2018 NAEP Technology and Engineering Framework is a statement about what should be expected of students in terms of their knowledge and skills with technology, written to be the basis for an assessment of technology and engineering literacy appropriate for all students. It opens the door to seeing what our K-12 students know about technology and engineering, in the same way that NAEP already assesses their knowledge and capabilities in reading, mathematics, science, and other subjects."
nationsreportcard.gov

2018 Mississippi College- and Career-Readiness Standards (MCCRS) for Computer Science
In an effort to closely align instruction for students who are progressing toward postsecondary study and the workforce, the 2018 MCCRS for Computer Science includes grade- and course-specific standards for K-12 computer science. Mississippi has adapted these standards from the nationally developed Computer Science Teachers Association K-12 Computer Science Standards (Revised 2017).
mdek12.org/oae/college-and-career-readiness-standards

Framework for 21st Century Learning
In defining 21st-century learning, the Partnership for 21st Century Skills has embraced key themes and skill areas that represent the essential knowledge for the 21st century: global awareness; financial, economic, business, and entrepreneurial literacy; civic literacy; health literacy; environmental literacy; learning and innovation skills; information, media, and technology skills; and life and career skills. *21 Framework Definitions* (2019).
battelleforkids.org/networks/p21/frameworks-resources

Preface

Secondary CTE programs in Mississippi face many challenges resulting from sweeping educational reforms at the national and state levels. Schools and teachers are increasingly being held accountable for providing applied learning activities to every student in the classroom. This accountability is measured through increased requirements for mastery and attainment of competency as documented through both formative and summative assessments. This document provides information, tools, and solutions that will aid students, teachers, and schools in creating and implementing applied, interactive, and innovative lessons. Through best practices, alignment with national standards and certifications, community partnerships, and a hands-on, student-centered concept, educators will be able to truly engage students in meaningful and collaborative learning opportunities.

The courses in this document reflect the statutory requirements as found in Section 37-3-49, *Mississippi Code of 1972*, as amended (Section 37-3-46). In addition, this curriculum reflects guidelines imposed by federal and state mandates (Laws, 1988, Ch. 487, §14; Laws, 1991, Ch. 423, §1; Laws, 1992, Ch. 519, §4 eff. from and after July 1, 1992; Strengthening Career and Technical Education for the 21st Century Act, 2019 [Perkins V]; and Every Student Succeeds Act, 2015).

Mississippi Teacher Professional Resources

The following are resources for Mississippi teachers:

Curriculum, Assessment, Professional Learning

Program resources can be found at the RCU's website, rcu.msstate.edu.

Learning Management System: An Online Resource

Learning management system information can be found at the RCU's website under Professional Learning.

Should you need additional instructions, call the RCU at 662.325.2510.

Executive Summary

Pathway Description

CSE is a project-based course designed to instruct students through activities that require modeling, physical design, and coding, leading them to discover how computing and engineering work together to solve problems. This course offers students exposure to the engineering design process which introduces them to problem solving and critical thinking as well as the basics of project management and teamwork. This knowledge will assist them in making informed and meaningful decisions about high school coursework and broaden their horizons for career opportunities.

This course was combined with the STEM Applications course in 2021 to create a single course that would provide an opportunity for students to learn how computer science and engineering are connected. The competencies and objectives allow students to become familiar with two different areas of the science, technology, engineering, and math (STEM) occupations cluster giving them insight into numerous career fields.

Grade Level and Class Size Recommendations

It is recommended that students enter this course as an eighth grader. Exceptions to this are a district-level decision based on class size, enrollment numbers, and student maturity. A maximum of 24 students is recommended for this classroom-based course.

Student Prerequisites

Currently, no prerequisites are required to take this course.

Assessment

The latest assessment blueprint for the curriculum can be found at rcu.msstate.edu/curriculum/curriculumdownload.

Applied Academic Credit

The latest academic credit information can be found at mdek12.org/ese/approved-course-for-the-secondary-schools.

Teacher Licensure

The latest teacher licensure information can be found at mdek12.org/oel/apply-for-an-educator-license.

Professional Learning

If you have specific questions about the content of any training sessions provided, please contact the RCU at 662.325.2510.

Course Outlines

This curriculum consists of one 1-credit course that should be completed in the eighth grade or above.

Computer Science and Engineering—Course Code: 000287

Unit	Title	Hours
1	Orientation, Safety, and Student Organizations	10
2	Project Design	20
3	Exploring Newton's Laws	20
4	Introduction to Modeling and 3D Printing	20
5	Coding	25
6	Introduction to Electronics	20
7	Introduction to Robotics & Microcontrollers	25
Total		**140**

Career Pathway Outlook

Overview

Professionals working in computer science and engineering apply principles of science, technology, engineering, and mathematics to develop economical solutions for society. Whether it is working on scientific discoveries or commercial applications, employees in these rapidly changing fields are expected to continuously pursue further education to remain current in knowledge and skill. Licensing requirements for computer science and engineering professionals vary widely depending on the field or sector. Credentials may involve a professional degree, industry certifications, training, and/or practical work experience. The 2018-2028 occupational employment projections and wage estimates for Mississippi were used to determine where computer science and engineering employment needs would be in the population over a 10-year period.

Needs of the Future Workforce

Data for this synopsis was compiled from the Mississippi Department of Employment Security (2021). Employment opportunities in Mississippi representative of various engineering occupations are listed below.

Table 1.1: Current and Projected Occupation Report

Description	Jobs, 2018	Projected Jobs, 2028	Change (Number)	Change (Percent)	Average Hourly Earnings, 2021
Computer and Mathematical Occupations	13,300	14,340	1,040	7.8%	$34.48
Architecture and Engineering Occupations	14,710	15,280	570	3.9%	$37.43
Health Care Practitioners and Technical Occupations	82,360	91,270	8,910	10.8%	$32.13
Life, Physical, and Social Science Occupations	7,430	7,740	310	4.2%	$31.15
Installation, Maintenance, and Repair Occupations	54,860	56,400	1,540	2.8%	$22.02
Transportation and Material Moving Occupations	105,930	111,460	5,530	5.2%	$16.64

Source: Mississippi Department of Employment Security; mdes.ms.gov (2021).

Perkins V Requirements and Academic Infusion

The CSE curriculum meets Perkins V requirements of introducing students to and preparing them for high-skill, high-wage occupations in computer science fields. It also offers students a program of study, including secondary, postsecondary, and institutions of higher learning courses, that will further prepare them for computer science careers. Additionally, this curriculum is integrated with academic college- and career-readiness standards. Lastly, it focuses on ongoing and meaningful professional development for teachers as well as relationships with industry.

Transition to Postsecondary Education

The latest articulation information for secondary to postsecondary can be found at the Mississippi Community College Board website, mccb.edu.

Best Practices

Innovative Instructional Technologies

Classrooms should be equipped with tools that will teach today's digital learners through applicable and modern practices. The CSE educator's goal should be to include teaching strategies that incorporate current technology. To make use of the latest online communication tools—wikis, blogs, podcasts, and social media platforms, for example—the classroom teacher is encouraged to use a learning management system that introduces students to education in an online environment and places more of the responsibility of learning on the student.

Differentiated Instruction

Students learn in a variety of ways, and numerous factors—students' background, emotional health, and circumstances, for example—create unique learners. By providing various teaching and assessment strategies, students with various learning preferences can have more opportunities to succeed.

CTE Student Organizations

Teachers should investigate opportunities to sponsor a student organization. There are several here in Mississippi that will foster the types of learning expected from the CSE curriculum. Skills USA and Technology Student Association (TSA) are examples of student organizations for computer science. Student organizations provide participants and members with growth opportunities and competitive events. They also open the doors to the world of computer science careers and scholarship opportunities.

Cooperative Learning

Cooperative learning can help students understand topics when independent learning cannot. Therefore, you will see several opportunities in the CSE curriculum for group work. To function in today's workforce, students need to be able to work collaboratively with others and solve problems without excessive conflict. The CSE curriculum provides opportunities for students to work together and help each other complete complex tasks. There are many field experiences within the CSE curriculum that will allow and encourage collaboration with professionals currently in the computer science field.

Work-Based Learning

Work-based learning is an extension of understanding competencies taught in the CSE classroom. This curriculum is designed in a way that necessitates active involvement by the students in the community around them and the global environment. These real-world connections and applications link all types of students to knowledge, skills, and professional dispositions. Work-based learning should encompass ongoing and increasingly more complex involvement with local companies and computer science professionals. Thus, supervised collaboration and immersion into computer science around the students are keys to students' success, knowledge, and skills development.

Professional Organizations

For students:
SkillsUSA
skillsusa.org

Technology Student Association
tsaweb.org

For teachers:
Association of Career and Technical Education
acteonline.org

Computer Science Teachers Association
csteachers.org

International Society for Technology in Education
iste.org

Mississippi Association of Career and Technical Education
mississippiacte.com

Mississippi Business Education Association
ms-mbea.com

Mississippi Educational Computing Association
ms-meca.org

Student Competitions

Teachers are encouraged to charter one of the student organizations on the previous page and participate in a competition hosted by that organization or at least one of the following student competitions (student organization charter and competition may occur in tandem):

BEST Robotics
bestinc.org

FIRST Robotics (LEGO League or Tech Challenge)
firstinspires.org

SeaPerch National Challenge
seaperch.org/index

Transportation and Civil Engineering (TRAC™) Bridge Challenge developed by the Mississippi Department of Transportation (MDOT)
mdot.ms.gov/stemeducation/programs/trac.html

VEX Robotics Competition (I.Q. or EDR through TSA, REC, or both)
vexrobotics.com

Using This Document

Competencies and Suggested Objectives

A competency represents a general concept or performance that students are expected to master as a requirement for satisfactorily completing a unit. Students are expected to receive instruction on all competencies. The suggested objectives represent the enabling and supporting knowledge and performances that will indicate mastery of the competency at the course level. Teachers are welcome to teach the competencies in other ways than the listed objectives if it allows for mastery of the competencies. Teachers are also allowed to teach the units and competencies in the order that they prefer, as long as they teach necessary material allotted for that specific course or credit they are teaching at the time.

Teacher Resources

Teacher resources for this curriculum may be found in multiple places. Many program areas have teacher resource documents that accompany the curriculum and can be downloaded from the same site as the curriculum. The teacher resource document contains references, lesson ideas, websites, teaching and assessment strategies, scenarios, skills to master, and other resources divided by unit. This document could be updated periodically by RCU staff. Please check the entire document, including the entries for each unit, regularly for new information. If you have something you would like to add or have a question about the document, call or email the RCU's instructional design specialist for your program. The teacher resource document can be downloaded at rcu.msstate.edu/curriculum/curriculumdownload.aspx.

All teachers should request to be added to the "*Canvas Resource Guide for Middle School.*" This is where all resources will be housed, including pacing guides and unit-by-unit activity suggestions.

To be added to the guide, send a Help Desk ticket to the RCU by emailing helpdesk@rcu.msstate.edu. In the email, request an MDE Canvas account and to be added to the course called "Resource Guides for Middle School."

Unit 1: Orientation, Safety, and Student Organizations

Competencies and Suggested Objectives
1. Identify expectations, school policies, student organizations, and program policies related to this course. DOK1 a. Identify school rules, policies, and procedures. b. Identify and establish classroom guidelines and procedures. c. Review course standards.
2. Analyze general safety in the project-based learning classroom. DOK2 a. Identify, describe, and demonstrate the importance of safety and the proper use of equipment (ongoing). b. Construct a diagram of the classroom/lab to scale, including the location of safety equipment. c. Complete a safety test exhibiting 100% mastery of safety practices and procedures.
3. Identify and demonstrate the proper file storage, sharing, and maintenance techniques for student work. DOK2 a. Identify, describe, and demonstrate the proper use of classroom management tools. b. Be familiar with the **required** Student Competency Profile form for this course.
4. Describe the technology student organizations available and demonstrate an ongoing understanding of teamwork and leadership strategies. DOK2 a. Describe the importance of effective communication skills. • Demonstrate verbal and nonverbal communication skills. • Apply appropriate speaking and listening skills to class- and work-related situations. b. Apply leadership skills to class- and work-related situations. • Define leadership. • Discuss the attributes of a leader. • Identify the roles a leader can assume. c. Utilize team-building skills in class- and work-related situations. • Define team building. • Discuss the attributes of a team. • Identify the roles included in a team. d. Discuss the various competitions offered through a program area student organization. • Describe each of the competitions and the skills needed to accomplish the tasks. • Perform the tasks needed to complete an assigned requirement for a competition.
5. Demonstrate proper digital citizenship concepts (ongoing). DOK2 a. Understand the ethical use of materials created by others. b. Understand how cyber bullying can impact teamwork and collaboration.

Note: Competencies marked as "ongoing" will be covered throughout the year. Time allotted for these competencies will be distributed over the entire course.

Unit 2: Project Design

Competencies and Suggested Objectives
1. Analyze and become familiar with the use of basic tools and techniques to plan, organize, and manage a project. DOK3 a. Define a project timeline. b. Create and calculate a sample project budget. c. Construct communications (e.g., emails, letters, texts, etc.) to interact with others regarding design and computational thinking. d. Demonstrate the principles and practice of leadership and teamwork.
2. Demonstrate knowledge and understanding of the NASA's BEST Engineering Design Process, or a similar design process (ongoing). DOK3 a. Identify the steps of the Engineering Design Process. i. Ask • Objectives • Challenges and limitations ii. Imagine • Brainstorming iii. Plan • Sketches and/or scaled drawings • Materials list • Limitations iv. Create • Artifacts/work samples • Pictures and/or videos v. Experiment • Analytical (physical science and mathematics) calculations and data • Results vi. Improve • Reflective writing including items such as: o Trade-offs/unintended consequences o Design/product evaluation o Project reviews (e.g., peer, teacher, industry, community) vii. Improvement plan for continuation b. Apply the steps of the Engineering Design Process to a specific project. c. Explain how each step of the Engineering Design Process relates to a specific project.
3. Establish essential elements of the course portfolio. DOK 3 a. Describe the purpose of a digital portfolio. b. Create a cumulative portfolio which includes the following: • Title page • Table of contents (pages must be numbered) • Section for all included projects detailing each step of the design process for each project, including reflective writing and peer reviews • Photos documenting steps of the design process for each project

• Works cited/references, if relevant (e.g., photo credit)
4. Synthesize research to understand project needs and limitations. DOK4 a. Identify and describe engineering needs and limitations. b. Identify and describe client needs and limitations.
5. Assess client needs to understand the purposes of design. DOK3 a. Express opinions respectfully and effectively. b. Critically evaluate an object for how well its design meets a given set of needs. c. Identify empathy for the client as an important component of the design process. d. Distinguish between creator needs and client needs.
6. Investigate careers in different engineering fields (e.g., electrical, mechanical, computer, industrial, etc.). DOK3

Note: Competencies marked as "ongoing" will be covered throughout the year. Time allotted for these competencies will be distributed over the entire course.

Unit 3: Exploring Newton's Laws

Competencies and Suggested Objectives
1. Demonstrate problem-solving and teamwork skills using the engineering design process by completing a complex challenge (Newton Project). DOK 3 a. Complete a complex challenge using the engineering design process (MDOT Bridge Challenge, balsa wood gliders, Rube Goldberg machine, catapult, or equivalent). b. Document project in student digital portfolio, emphasizing scaled drawings and materials lists. c. Demonstrate proper safety knowledge while completing project.
2. Apply appropriate physical and mathematical principles to Newton Project tasks (include in portfolio). DOK 3 a. Conduct a student-led project to include the following physical and mathematical principles: • Simple machines to include: o Wedge o Pulley o Inclined plane o Screw o Wheel and axle o Lever • Distance • Displacement (d=change in x/change in time) • Speed (s=distance/time) • Velocity (v=change in displacement/change in time) • Acceleration (a=change in velocity/change in time) • Equilibrium • Forces o Friction o Gravity o Normal o Tension o Torsion o Compression o Shear (force/area) • Newton's Laws of Motion (F=ma) • Measurement (metric and imperial) • Geometry (Pythagorean theorem, finding unknown angles or sides of triangles) • Ratios (strength to weight)

3. Engage with STEM industry and business professionals. DOK 2 a. Arrange a field trip, professional visit, or virtual interaction with a STEM professional and inquire about: • Career fields and availability (considering automation trends) • Education and training • Certifications • Average salaries • Job descriptions and daily tasks b. Complete a reflective writing exercise that includes career interests and add to the student's portfolio.

Enrichment
1. Apply the continuous improvement model of the engineering design process to improve an existing product. Include tradeoff (sustainability and efficiency) concepts frequently used in industry.

Unit 4: Introduction to Modeling and 3D Printing

Competencies and Suggested Objectives
1. Review the importance of safety and the proper use of lab equipment when using 3D printers and associated supplies. DOK2
2. Demonstrate the use of computer-aided design (CAD) software to create 3D models. DOK2 a. Use appropriate resources to become familiar with a CAD workspace. b. Communicate CAD terms using multiple formats (e.g., verbally, textually, graphically). c. Complete online tutorials to create an object that includes the following parts: • Holes • Fillets • Lettering • Manipulation of pieces
3. Design a 3D model for rapid prototyping using a 3D printer. DOK3 a. Use CAD software to design and create multiple objects. b. Use CAD software to edit/remix a design created by someone else. (Note: If 3D printers are not available, all objectives can be met with free software and by creating models with other materials.)
4. Slice and 3D print an object created with CAD software. DOK3 a. 3D print one of the designated projects or build a project from other materials (3D print as time and resources allow, having at least one example from each class). b. Identify and demonstrate use of the following terms while using slicing software: layer height, infill, support, and adhesion.
5. Develop a cost analysis based on time and materials. DOK3
6. Investigate 3D printing industry careers and examine how those careers use this technology. DOK2

Unit 5: Coding

Competencies and Suggested Objectives
1. Examine the use of Booleans and conditionals. DOK3 a. Demonstrate proper use of *if*, *then*, and *else* statements. b. Demonstrate proper use of Boolean logic (e.g., true/false, on/off, etc.). c. Understand that all coding languages use common concepts, such as conditionals. d. Understand that conditionals are statements that are carried out when certain criteria are met. e. Evaluate a conditional statement and predict the outcome using the given input. f. Write conditional statements, defining criteria for when a program should take certain actions.
2. Apply the use of loops. DOK2 a. Understand the effective use of loops. b. Understand and predict the behavior of a loop. c. Write valid loops with proper indention. d. Describe and give an example of the conditional part of a loop. e. Explain the standard flowchart representation for loops.
3. Investigate the use of variables. DOK2 a. Identify a variable as a way to label and reference a value in a program. b. Use variables in a program to store a piece of information that is used multiple times. c. Correct common errors encountered when programming with variables.
4. Summarize the purpose of functions. DOK2 a. Explain the purpose of a function. b. Demonstrate the proper use of a function.
5. Demonstrate an understanding of debugging and identify syntax errors. DOK2
6. Investigate careers in software development and coding. DOK3

Unit 6: Introduction to Electronics

Competencies and Suggested Objectives
1. Review the importance of safety and the proper use of lab equipment when using electronics and associated tools. DOK2
2. Identify, analyze, and create models to explore electronics and their applications. DOK3 a. Review the importance of electronics safety and the proper use of lab equipment. b. Communicate electrical terms and their units of measure using multiple formats (e.g., verbally, graphically, textually, etc.), including: • Alternating current • Direct current • Voltage • Amperage • Resistance c. Learn symbols for the following electronic components included on the Institute of Electronics and Electronics Engineers (IEEE) chart: • Resistor • Capacitor • Diode • Inductor • LED • Sensor (e.g., temperature and humidity, ultrasonic, photo resistor, etc.)
3. Create a physical or simulation model showing different configurations using the required components (e.g., battery, light-emitting diode [LED], light sensor, switch, etc.). DOK4
4. As part of the Electronics and Mechanics Project, create models to explore mechanics and its applications. DOK 3 a. Collect, organize, and interpret data from the basic principles of energy through simulation or hands-on project to include: • Simple machines such as: o Wedge o Pulley o Inclined plane o Screw o Wheel and axle o Levers • Electrical energy • Kinetic energy ($KE=1/2mv^2$) • Potential energy (U=mgh) • Work • Work-energy theorem (W=KE) • Conservation of energy • Momentum (P=mv) • Conservation of momentum

5. Investigate careers in electrical engineering and the electronics industry and examine how those careers use this technology. DOK3

Unit 7: Introduction to Robotics & Microcontrollers

Competencies and Suggested Objectives
1. Review the importance of safety and the proper use of lab equipment when using robots and microcontrollers. DOK2
2. Research current, past, and future applications of robots. DOK2 a. Using scholarly articles or other reputable sources, research the types and applications of robots, including: • Current, past, and future applications of robots • Advantages and disadvantages of robots b. Communicate technical information found in research using multiple formats (e.g., verbally, graphically, textually, mathematically, etc.).
3. Design and build a simple, functional robotic system using the required components (e.g., motor, battery, wires, and body/case/chassis). DOK4 a. On paper, virtually, or with hands-on components, design a robot with proper connections and functionality. b. Identify the components of a robotic system. c. Explain the purpose/function of each component.
4. Identify common microcontroller terms. DOK1 a. Communicate microcontroller terms using multiple formats (e.g., verbally, textually, graphically). b. Identify and label the components of a hands-on or simulation microcontroller from the list below: • Power sources • Inputs • Switches • Push buttons • Sensors • Joysticks and remotes • Outputs • Buzzers • LEDs • LCD modules • Motors
5. Use programming to manipulate microcontroller inputs and outputs. DOK2 a. Incorporate the following methods/concepts in the programming: • Different languages (e.g., Scratch, SNAP, Python, etc.) • Logic statements (e.g., *if*, *and*, *or*, *not*, etc.) • Loops (e.g., *for*, *if*, *while*, etc.)
6. Use a microcontroller for a specified purpose. DOK2 a. Demonstrate the proper use of a microcontroller for a specified purpose. b. Explain how microcontrollers are used to manipulate a robotic system.
7. Investigate careers in robotics and examine industries that use robotics. DOK2

Student Competency Profile

Student's Name: ____

This record is intended to serve as a method of noting student achievement of the competencies in each unit. It should be duplicated for each student, and it can serve as a cumulative record of competencies achieved in the course. This document is required for each student and may be requested during an audit.

In the blank before each number, place the date on which the student mastered the competency.

Unit 1: Orientation, Safety, and Student Organizations		
	1.	Identify expectations, school policies, student organizations, and program policies related to this course.
	2.	Analyze general safety in the project-based learning classroom.
	3.	Identify and demonstrate the proper file storage, sharing, and maintenance techniques for student work.
	4.	Describe the technology student organizations available and demonstrate an ongoing understanding of teamwork and leadership strategies.
	5.	Demonstrate proper digital citizenship concepts (ongoing).
Unit 2: Project Design		
	1.	Analyze and become familiar with the basic tools and techniques to plan, organize, and manage a project.
	2.	Demonstrate knowledge and understanding of the NASA's BEST Engineering Design Process, or a similar design process (ongoing).
	3.	Establish essential elements of the course portfolio.
	4.	Synthesize research to understand project needs and limitations.
	5.	Assess client needs to understand the purposes of design.
	6.	Investigate careers in different engineering fields (e.g., electrical, mechanical, computer, industrial, etc.).
Unit 3: Exploring Newton's Laws		
	1	Demonstrate problem-solving and teamwork skills using the engineering design process by completing a complex challenge (Newton Project).
	2.	Apply appropriate physical and mathematical principles to Newton Project tasks (include in portfolio).
	3.	Engage with STEM industry and business professionals.
Unit 4: Introduction to Modeling and 3D Printing		
	1.	Review the importance of safety and the proper use of lab equipment when using 3D printers and associated supplies.
	2.	Demonstrate the use of computer-aided design (CAD) software to create 3D models.

	3.	Design a 3D model for rapid prototyping using a 3D printer.
	4.	Slice and 3D print an object created with CAD software.
	5.	Develop a cost analysis based on time and materials.
	6.	Investigate 3D printing industry careers and examine how those careers use this technology.
Unit 5: Coding		
	1.	Examine the use of Booleans and conditionals.
	2.	Apply the use of loops.
	3.	Investigate the use of variables.
	4.	Summarize the purpose of functions.
	5.	Demonstrate an understanding of debugging and identify syntax errors.
	6.	Investigate careers in software development and coding.
Unit 6: Introduction to Electronics		
	1.	Review the importance of safety and the proper use of lab equipment when using electronics and associated tools.
	2.	Identify, analyze, and create models to explore electronics and their applications.
	3.	Create a physical or simulation model showing different configurations using the required components.
	4.	As part of the Electronics and Mechanics Project, create models to explore mechanics and its applications.
	5.	Investigate careers in electrical engineering and the electronics industry and examine how those careers use this technology.
Unit 7: Introduction to Robotics & Microcontrollers		
	1.	Review the importance of safety and the proper use of lab equipment when using robots and microcontrollers.
	2.	Research current, past, and future applications of robots.
	3.	Design and build a simple, functional robotic system using the required components.
	4.	Identify common microcontroller terms.
	5.	Use programming to manipulate microcontroller inputs and outputs.
	6.	Use a microcontroller for a specified purpose.
	7.	Investigate careers in robotics and examine industries that use robotics.

Appendix A: ISTE National Educational Technology Standards for Students (NETS-S)

	Unit	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7
Standards								
T1			X	X	X	X	X	X
T2		X	X	X	X	X	X	X
T3			X		X	X	X	X
T4			X	X	X	X	X	X
T5		X	X		X	X	X	X
T6		X	X		X	X	X	X

T1 Creativity and Innovation

Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students do the following:

a. Apply existing knowledge to generate new ideas, products, or processes.
b. Create original works as a means of personal or group expression.
c. Use models and simulations to explore complex systems and issues.
d. Identify trends and forecast possibilities.

T2 Communication and Collaboration

Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. Students do the following:

a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.
b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats.
c. Develop cultural understanding and global awareness by engaging with learners of other cultures.
d. Contribute to project teams to produce original works or solve problems.

T3 Research and Information Fluency

Students apply digital tools to gather, evaluate, and use information. Students do the following:

a. Plan strategies to guide inquiry.
b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
d. Process data and report results.

T4 Critical Thinking, Problem Solving, and Decision Making

Students use critical-thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Students do the following:

a. Identify and define authentic problems and significant questions for investigation.
b. Plan and manage activities to develop a solution or complete a project.
c. Collect and analyze data to identify solutions and/or make informed decisions.
d. Use multiple processes and diverse perspectives to explore alternative solutions.

T5 Digital Citizenship

Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students do the following:

a. Advocate and practice safe, legal, and responsible use of information and technology.
b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.
c. Demonstrate personal responsibility for lifelong learning.
d. Exhibit leadership for digital citizenship.

T6 Technology Operations and Concepts

Students demonstrate a sound understanding of technology concepts, systems, and operations. Students do the following:

a. Understand and use technology systems.
b. Select and use applications effectively and productively.
c. Troubleshoot systems and applications.
d. Transfer current knowledge to learning of new technologies.

Appendix B: National Association of Educational Progress (NAEP) Technology and Engineering Literacy Framework

NAEP Standard	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7
T.8.1							X
T.8.2							X
T.8.3							X
T.8.4							X
T.8.5							X
T.8.6							X
T.8.7							X
T.8.8		X					
T.8.9							X
T.8.10							X
T.8.11		X			X	X	X
T.8.12		X		X	X	X	X
T.8.13		X					
T.8.14		X					
T.8.15	X						
T.12.3			X				
D.8.1		X					
D.8.2		X					
D.8.3		X					X
D.8.4		X					
D.8.5		X					
D.8.6		X					
D.8.7		X		X		X	X
D.8.8		X					
D.8.9		X		X			
D.8.10		X					
D.8.11						X	X
D.8.12						X	X
D.8.13		X				X	X
D.8.14						X	X
D.8.15						X	X
D.8.16						X	
D.8.17		X				X	
D.8.18						X	
D.8.19		X					
D.12.4			X				
D.12.6			X				
D.12.7			X				
D.12.8			X				
D.12.9			X				
D.12.10			X				
D.12.11			X				
D.12.13			X				
D.12.14			X				
D.12.15			X				
D.12.17			X				
I.8.1	X	X		X	X	X	X
I.8.2		X		X	X	X	X
I.8.3		X		X	X	X	X
I.8.4	X						

I.8.5		X				X	X
I.8.6							
I.8.7		X					
I.8.8							
I.8.9						X	
I.8.10	X				X		
I.8.11	X						
I.8.12	X	X					
I.8.13		X		X	X	X	X
I.12.1			X				
I.12.2			X				
I.12.3			X				
I.12.4			X				
I.12.5			X				
I.12.6			X				
I.12.8			X				

NAEP Technology and Engineering Literacy Framework

Students know that:
T.8.1: Economic, political, social, and cultural aspects of society drive improvements in technological products, processes, and systems.
T.8.2: Technology interacts with society, sometimes bringing about changes in a society's economy, politics, and culture, and often leading to the creation of new needs and wants.

Students are able to:
T.8.3: Describe and analyze positive and negative impacts on society from the introduction of a new or improved technology, including both expected and unanticipated effects.
T.8.4: Compare the impacts of a given technology on different societies, noting factors that may make a technology appropriate and sustainable in one society but not in another.

Students know that:
T.8.5: Some technological decisions involve trade-offs between environmental and economic needs, while others have positive effects for both the economy and environment.
T.8.6: Resources such as oceans, fresh water, and air—which are essential for life and shared by everyone—are protected by regulating technologies in such areas as transportation, energy, and waste disposal.

Students are able to:
T.8.7: Compare the environmental effects of two alternative technologies devised to solve the same problem or accomplish the same goal and justify which choice is best, taking into account environmental impacts as well as other relevant factors.

Students know that:
T.8.8: Information technologies are developing rapidly so that the amount of data that can be stored and made widely accessible is growing at a faster rate each year.
T.8.9: Information technologies make it possible to analyze and interpret data—including text, images, and sound—in ways that are not possible with human senses alone. These uses may result in positive or negative impacts.
T.8.10: The large range of personal and professional information technologies and communication devices allows for remote collaboration and rapid sharing of ideas unrestricted by geographic location.

Students are able to:
T.8.11: Use appropriate information and communication technologies to collaborate with others on the creation and modification of a knowledge product that can be accessed and used by other people.

Students know that:
T.8.12: Technology by itself is neither good nor bad, but its use may affect others; therefore, decisions about products, processes, and systems must take possible consequences into account.
T.8.13: People who live in different parts of the world have different technological choices and opportunities because of such factors as differences in economic resources, location, and cultural values.

Students are able to:
T.8.14: Explain that it is important for citizens to reduce the negative impacts and increase the positive impacts of their technologies on people in another area or on future generations.
T.8.15: Explain why it is unethical to infect or damage other people's computers with viruses or "hack" into other computer systems to gather or change information.

Students are able to:
T.12.3: Choose an appropriate technology to help solve a given societal problem, and justify the selection based on an analysis of criteria and constraints, available resources, likely trade-offs, and relevant environmental and cultural concerns.

Students know that:
D.8.1: Science is the systematic investigation of the natural world. Technology is any modification of the environment to satisfy people's needs and wants. Engineering is the process of creating or modifying technologies and is constrained by physical laws and cultural norms, and economic resources.
D.8.2: Technology advances through the processes of innovation and invention. Sometimes a technology developed for one purpose is adapted to serve other purposes.
D.8.3: Tools have been improved over time to do more difficult tasks and to do simple tasks more efficiently, accurately, or safely. Tools further the reach of hands, voices, memory, and the five human senses.

Students are able to:
D.8.4: Simulate tests of various materials to determine which would be best to use for a given application.
D.8.5: Redesign an existing tool to make it easier to accomplish a task.

Students know that:
D.8.6: Engineering design is a systematic, creative, and iterative process for meeting human needs and wants. It includes stating the challenge, generating ideas, choosing the best solution, making and testing models and prototypes, and redesigning. Often there are several possible solutions.
D.8.7: Requirements for a design are made up of the criteria for success and the constraints, or limits, which may include time, money, and materials. Designing often involves making tradeoffs between competing requirements and desired design features.

Students are able to:
D.8.8: Carry out a design process to solve a moderately difficult problem by identifying criteria and constraints, determining how they will affect the solution, researching and generating ideas, and using trade-offs to choose between alternative solutions.
D.8.9: Construct and test a model and gather data to see if it meets the requirements of a problem.
D.8.10: Communicate the results of a design process and articulate the reasoning behind design decisions by using verbal and visual means. Identify the benefits of a design as well as the possible unintended consequences.

Students know that:
D.8.11: Technological systems are designed to achieve goals. They incorporate various processes that transform inputs into outputs. They all use energy in some form. These processes may include feedback and control.
D.8.12: Technological systems can interact with one another to perform more complicated functions and tasks than any individual system can do by itself.

Students are able to:
D.8.13: Examine a product or process through reverse engineering by taking it apart step by step to identify its systems, subsystems, and components, describing their interactions, and tracing the flow of energy through the system.
D.8.14: Measure and compare the production efficiency of two machines, a simple machine and a complex machine, designed to accomplish the same goal.
D.8.15: Construct and use a moderately complicated system, given a goal for the system and a collection of parts, including those that may or may not be useful in the system.

Students know that:
D.8.16: Many different kinds of products must undergo regular maintenance, including lubrication and replacement of parts before they fail so as to ensure proper functioning.

Students are able to:
D.8.17: Diagnose a problem in a technological device using a logical process of troubleshooting. Develop and test various ideas for fixing it.
D.8.18: Modify a moderately complicated system so that it is less likely to fail. Predict the extent to which these modifications will affect the productivity of the system.
D.8.19: Trace the life cycle of a repairable product from inception to disposal or recycling in order to determine the product's environmental impact.
Students are able to:
D.12.4: Take into account trade-offs among several factors when selecting a material for a given application.

Students know that:
D.12.6: Engineering design is a complicated process in which creative steps are embedded in content knowledge and research on the challenge. Decisions on trade-offs involve systematic comparisons of all costs and benefits, and final steps may involve redesigning for optimization.
D.12.7: Specifications involve criteria, which may be weighted in various ways, and constraints, which can include natural laws and available technologies. Evaluation is a process for determining how well a solution meets the requirements.

Students are able to:
D.12.8: Meet a sophisticated design challenge by identifying criteria and constraints, predicting how these will affect the solution, researching and generating ideas, and using trade-offs to balance competing values in selecting the best solution.
D.12.9: Construct and test several models to see if they meet the requirements of a problem. Combine features to achieve the best solution.
D.12.10: Communicate the entire design process from problem definition to evaluation of the final design, taking into account relevant criteria and constraints, including aesthetic and ethical considerations as well as purely logical decisions.

Students know that:
D.12.11: The stability of a system depends on all of its components and how they are connected, with more complicated systems tending to require more energy and to be more vulnerable to error and failure. Negative feedback loops tend to increase the stability and efficiency of systems.

Students are able to:
D.12.13: Examine a system to predict how it will perform with a given set of inputs in each situation and how performance will change if the components or interactions of the system are changed.
D.12.14: Redesign a complex machine by modifying or rearranging its subsystems to optimize its efficiency.
D.12.15: Construct and test a manufacturing system composed of several machines to accomplish a given goal. Redesign the system to optimize its efficiency.

Students are able to:
D.12.17: Analyze a system malfunction using logical reasoning (such as a fault tree) and appropriate diagnostic tools and instruments. Devise strategies and recommend tools for fixing the problem.

Students know that:
I.8.1: Collaboration can take many forms. Pairs or teams of people can work together in the same space or at a distance, at the same time or at different times, and on creative projects or on technical tasks. Different communications technologies are used to support these different forms of collaboration.

Students are able to:
I.8.2: Provide feedback to a (virtual) collaborator on a product or presentation, taking into account the other person's goals and using constructive, rather than negative, criticism.
I.8.3: Communicate information and ideas effectively using a variety of media, genres, and formats for multiple purposes and a variety of audiences.

Students know that:
I.8.4: Increases in the quantity of information available through electronic means and the ease by which knowledge can be published have heightened the need to check sources for possible distortion, exaggeration, or misrepresentation.

Students are able to:
I.8.5: Select and use appropriate digital and network tools and media resources to collect, organize, analyze, and display supporting data to answer questions and test hypotheses.
I.8.6: Search media and digital resources on a community or world issue and identify specific examples of distortion, exaggeration, or misrepresentation of information.

Students are able to:
I.8.7: Use digital tools to identify a global issue and investigate possible solutions. Select and present the most promising sustainable solution.
I.8.8: Use digital tools to gather and display data in order to test hypotheses of moderate complexity in various subject areas. Draw and report conclusions consistent with observations.
I.8.9: Use a digital model of a system to conduct a simulation. Explain how changes in the model result in different outcomes.

Students know that:
I.8.10: Style guides provide detailed examples for how to give appropriate credit to others when incorporating their ideas, text, or images in one's own work.

Students are able to:
I.8.11: Identify or provide examples of fair use practices that apply appropriate citation of sources when using information from books or digital resources.

Students know that:
I.8.12: Certain digital tools are appropriate for gathering, organizing, analyzing, and presenting information, while other kinds of tools are appropriate for creating text, visualizations, and models and for communicating with others.

Students are able to:
I.8.13: Use appropriate digital tools to accomplish a variety of tasks, including gathering, analyzing, and presenting information as well as creating text, visualizations, and models and communicating with others.

Students know that:
I.12.1: Effective collaboration requires careful selection of team members, monitoring of progress, strategies for reaching agreement when there are opposing points of view, and iterative improvement of collaborative processes. Information and communication technologies can be used to record and share different viewpoints and to collect and tabulate the views of groups of people.

Students are able to:
I.12.2: Work through a simulation of a collaborative process. Negotiate team roles and resources, draw upon the expertise and strengths of other team members and remote experts, monitor progress toward goals, and reflect on and refine team processes for achieving goals.
I.12.3: Synthesize input from multiple sources to communicate ideas to a variety of audiences using various media, genres, and formats.

Students know that:
I.12.4: Advanced search techniques can be used with digital and network tools and media resources to locate information and to check the credibility and expertise of sources.

Students are able to:
I.12.5: Select digital and network tools and media resources to gather information and data on a practical task, and justify choices based on the tools' efficiency and effectiveness for a given purpose.
I.12.6: Search media and digital resources on a community or world issue and evaluate the timeliness and accuracy of the information as well as the credibility of the source.

Students are able to:
I.12.8: Use digital tools to collect, analyze, and display data in order to design and conduct complicated investigations in various subject areas. Explain rationale for the design and justify conclusions based on observed patterns in the data.

Appendix C: 2018 MS CCR Standards for Computer Science

	Units	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7
Standards								
CS.2.1								X
CS.2.2			X					
CS.2.3			X					
NI.2.1								
NI.2.2		X						
NI.2.3						X		
DA.2.1			X					
DA.2.2			X					
DA.2.3			X					
AP.2.1			X					
AP.2.2						X		X
AP.2.3						X		X
AP.2.4			X		X	X	X	X
AP.2.5						X		X
AP.2.6			X		X	X	X	X
AP.2.7			X		X	X	X	X
AP.2.8					X	X	X	X
AP.2.9			X		X	X	X	X
AP.2.10						X		X
IC.2.1		X						
IC.2.2					X	X	X	X
IC.2.3						X		X
IC.2.4		X				X		

Level 2: GRADES 6-8 - Computing Systems (CS.2)

Conceptual understanding: People interact with a wide variety of computing devices that collect, store, analyze, and act upon information in ways that can affect human capabilities both positively and negatively. The physical components (hardware) and instructions (software) that make up a computing system communicate and process information in digital form. An understanding of hardware and software is useful when troubleshooting a computing system that does not work as intended.

CS.2.1 **Recommend improvements to the design of computing devices based on an analysis of how users interact with the devices. [DEVICES] (P3.3)**
The study of human-computer interaction (HCI) can improve the design of devices, including both hardware and software.

CS.2.1a **Students should make recommendations for existing devices (e.g., a laptop, phone, or tablet) or design their own components or interface (e.g., create their own controllers).** Teachers can guide students to consider usability through several lenses, including accessibility, ergonomics, and learnability. For example, assistive devices provide capabilities such as scanning written information and converting it to speech.

CS.2.2 **Design projects that combine hardware and software components to collect and exchange data. [HARDWARE & SOFTWARE] (P5.1)**
Collecting and exchanging data involves input, output, storage, and processing. When possible, students should select the hardware and software components for their project designs by considering factors such as functionality, cost, size, speed, accessibility, and aesthetics.

CS.2.2a **Students will design projects that use both hardware and software to collect and exchange data.** For example, components for a mobile app could include accelerometer, GPS, and speech recognition. The choice of a device that connects wirelessly through a Bluetooth connection versus a physical USB connection involves a tradeoff between mobility and the need for an additional power source for the wireless device.

CS.2.3 Systematically identify and fix problems with computing devices and their components. [TROUBLESHOOTING] (P6.2)

Since a computing device may interact with interconnected devices within a system, problems may not be due to the specific computing device itself but to devices connected to it.

CS.2.3a **Students will use a structured process to troubleshoot problems with computing systems and ensure that potential solutions are not overlooked.** Examples of troubleshooting strategies include following a troubleshooting flow diagram, making changes to software to see if hardware will work, checking connections and settings, and swapping in working components.

Level 2: GRADES 6-8 - Networks and the Internet (NI.2)

Conceptual Understanding: Computing devices typically do not operate in isolation. Networks connect computing devices to share information and resources and are an increasingly integral part of computing. Networks and communication systems provide greater connectivity in the computing world by providing fast, secure communication and facilitating innovation.

NI.2.1 Model the role of protocols in transmitting data across networks and the Internet. [NETWORK COMMUNICATION & ORGANIZATION] (P4.4)

Protocols are rules that define how messages between computers are sent. They determine how quickly and securely information is transmitted across networks and the Internet, as well as how to handle errors in transmission.

NI.2.1a **Students should model how data is sent using protocols to choose the fastest path, to deal with missing information, and to deliver sensitive data securely.** For example, students could devise a plan for resending lost information or for interpreting a picture that has missing pieces. The priority at this grade level is understanding the purpose of protocols and how they enable secure and errorless communication. Knowledge of the details of how specific protocols work is not expected.

NI.2.2 Explain how physical and digital security measures protect electronic information. [CYBERSECURITY] (P7.2)

Information that is stored online is vulnerable to unwanted access. Examples of physical security measures to protect data include keeping passwords hidden, locking doors, making backup copies on external storage devices, and erasing a storage device before it is reused. Examples of digital security measures include secure router admin passwords, firewalls that limit access to private networks, and the use of a protocol, such as HTTPS, to ensure secure data transmission.

NI.2.2a **Students will explain how physical and digital security measures protect electronic information.**

NI.2.3 Apply multiple methods of encryption to model the secure transmission of information. [CYBERSECURITY] (P4.4)

Encryption can be as simple as letter substitution or as complicated as modern methods used to secure networks and the Internet.

NI.2.3a **Students should encode and decode messages using a variety of encryption methods, and they should understand the different levels of complexity used to hide or secure information.** For example, students could secure messages using methods like Caesar cyphers or steganography (i.e., hiding messages inside a picture or other data). They can also model more complicated methods, such as public key encryption, through unplugged activities.

Level 2: GRADES 6-8 - Data and Analysis (DA.2)

Conceptual Understanding: Computing systems exist to process data. The amount of digital data generated in the world is rapidly expanding, so the need to process data effectively is increasingly important. Data is collected and stored so that it can be analyzed to better understand the world and make more accurate predictions.

DA.2.1 **Represent data using multiple encoding schemes. [STORAGE] (P4.0)**
Data representations occur at multiple levels of abstraction, from the physical storage of bits to the arrangement of information into organized formats (e.g., tables).

DA.2.1a **Students should represent the same data in multiple ways.** For example, students could represent the same color using binary, RGB values, hex codes (low-level representations), as well as forms understandable by people, including words, symbols, and digital displays of the color (high-level representations).

DA.2.2 **Collect data using computational tools and transform the data to make it more useful and reliable. [COLLECTION, VISUALIZATION, & TRANSFORMATION] (P6.3)**
As students continue to build on their ability to organize and present data visually to support a claim, they will need to understand when and how to transform data for this purpose.

DA.2.2a **Students should transform data to remove errors, highlight or expose relationships, and/or make it easier for computers to process.** The cleaning of data is an important transformation for ensuring consistent format and reducing noise and errors (e.g., removing irrelevant responses in a survey). An example of a transformation that highlights a relationship is representing males and females as percentages of a whole instead of as individual counts.

DA.2.3 **Refine computational models based on the data they have generated. [INFERENCE & MODELS] (P5.3, P4.4)**
A model may be a programmed simulation of events or a representation of how various data is related.

DA.2.3a **Students will refine computational models by considering which data points are relevant, how data points relate to each other, and if the data is accurate.** For example, students may make a prediction about how far a ball will travel based on a table of data related to the height and angle of a track. The students could then test and refine their model by comparing predicted versus actual results and considering whether other factors are relevant (e.g., size and mass of the ball). Additionally, students could refine game mechanics based on test outcomes in order to make the game more balanced or fair.

Level 2: GRADES 6-8 - Algorithms and Programming (AP.2)

Conceptual understanding: An algorithm is a sequence of steps designed to accomplish a specific task. Algorithms are translated into programs, or code, to provide instructions for computing devices. Algorithms and programming control all computing systems, empowering people to communicate with the world in new ways and solve compelling problems. The development process to create meaningful and efficient programs involves choosing which information to use and how to process and store it, breaking apart large problems into smaller ones, recombining existing solutions, and analyzing different solutions.

AP.2.1 **Use flowcharts and/or pseudocode to address complex problems as algorithms. [ALGORITHMS] (P4.4, P4.1)**
Complex problems are problems that would be difficult for students to solve computationally.

AP.2.1a **Students will use pseudocode and/or flowcharts to organize and sequence an algorithm that addresses a complex problem, even though they may not actually program the solutions.** For example, students might express an algorithm that produces a recommendation for purchasing sneakers based on inputs such as size, colors, brand, comfort, and cost. Testing the algorithm with a wide range of inputs and users allows students to refine their recommendation algorithm and to identify other inputs they may have initially excluded.

AP.2.2 **Create clearly named variables that represent different data types and perform operations on their values. [VARIABLES] (P5.1, P5.2)**

A variable is like a container with a name, in which the contents may change, but the name (identifier) does not.

AP.2.2a **When planning and developing programs, students should decide when and how to declare and name new variables.** Examples of operations include adding points to the score, combining user input with words to make a sentence, changing the size of a picture, or adding a name to a list of people.

AP.2.2b **Students should use naming conventions to improve program readability.**

AP.2.3 **Design and iteratively develop programs that combine control structures, including nested loops and compound conditionals. [CONTROL] (P5.1, P5.2)**

Control structures can be combined in many ways. Nested loops are loops placed within loops. Compound conditionals combine two or more conditions in a logical relationship (e.g., using AND, OR, and NOT), and nesting conditionals within one another allows the result of one conditional to lead to another.

AP.2.3a **Students will design and develop programs that combine control structures.** For example, when programming an interactive story, students could use a compound conditional within a loop to unlock a door only if a character has a key AND is touching the door.

AP.2.4 **Decompose problems and subproblems into parts to facilitate the design, implementation, and review of programs. [MODULARITY] (P3.2)**

Decomposition facilitates aspects of program development by allowing students to focus on one piece at a time (e.g., getting input from the user, processing the data, and displaying the result to the user). Decomposition also enables different students to work on different parts at the same time.

AP.2.4a **Students should break down problems into subproblems, which can be further broken down to smaller parts.** For example, animations can be decomposed into multiple scenes, which can be developed independently.

AP.2.5 **Create procedures with parameters to organize code and make it easier to reuse. [MODULARITY] (P4.1, P4.3)**

AP.2.5a **Students will create procedures and/or functions that are used multiple times within a program to repeat groups of instructions.** These procedures can be generalized by defining parameters that create different outputs for a wide range of inputs. For example, a procedure to draw a circle involves many instructions, but all of them can be invoked with one instruction, such as “drawCircle.” By adding a radius parameter, the user can easily draw circles of different sizes.

AP.2.6 **Seek and incorporate feedback from team members and users to refine a solution that meets user needs. [PROGRAM DEVELOPMENT] (P2.3, P1.1)**

Development teams that employ user-centered design create solutions (e.g., programs and devices) that can have a large societal impact, such as an app that allows people with speech difficulties to translate hard-to-understand pronunciation into understandable language.

AP.2.6a **Students should begin to seek diverse perspectives throughout the design process to improve their computational artifacts.** Considerations of the end user may include usability, accessibility, age-appropriate content, respectful language, user perspective, pronoun use, color contrast, and ease of use.

AP.2.7 **Incorporate existing code, media, and libraries into original programs and give attribution. [PROGRAM DEVELOPMENT] (P4.2, P5.2, P7.3)**

Building on the work of others enables students to produce more interesting and powerful creations.

AP.2.7a **Students should use portions of code, algorithms, and/or digital media in their own programs and websites.** At this level, they may also import libraries and connect to web application program interfaces (APIs). For example, when creating a side-scrolling games, students may incorporate portions of code that create a realistic jump movement from another person’s game, and they may also import Creative Commons-lessened images to use in the background.

AP.2.7b **Students should give attribution to the original creator’s contributions.**

AP.2.8 **Systematically test and refine programs using a range of test cases. [PROGRAM DEVELOPMENT] (P6.1)**

Test cases are created and analyzed to better meet the needs of users and to evaluate whether programs function as intended. At this level, testing should become a deliberate process that is more iterative, systematic, and proactive than at lower levels.

AP.2.8a **Students will test programs by considering potential errors, such as what will happen if a user enters invalid input (e.g., negative numbers and zero instead of positive numbers).**

AP.2.9 **Distribute tasks and maintain a project timeline when collaboratively developing computational artifacts. [PROGRAM DEVELOPMENT] (P2.2)**

Collaboration is a common and crucial practice in programming development. Often, many individuals and groups work on the interdependent parts of a project together.

AP.2.9a **Students will work collaboratively in groups.**

AP.2.9b **Students should assume predefined roles within their teams and manage the project workflow using structured timelines.** With teacher guidance, they will begin to create collective goals, expectations, and equitable workloads. For example, students may divide the design stage of a game into planning the storyboard, flowchart, and different parts of the game mechanics. They can then distribute tasks and roles among members of the team and assign deadlines.

AP.2.9c **Students should give attribution to the original creators to acknowledge their contributions.**

AP.2.10 **Document programs in order to make them easier to follow, test, and debug. [PROGRAM DEVELOPMENT] (P7.2)**

Documentation allows creators and others to more easily use and understand a program.

AP.2.10a **Students should provide documentation for end users that explains their artifacts and how they function.** For example, students could provide a project overview and clear user instructions.

AP.2.10b **Students should incorporate comments in their product (comments in the code).**

AP.2.10c **Students should communicate their process using design documents, flowcharts, and presentations.**

Level 2: GRADES 6-8 - Impacts of Computing (IC.2)

Conceptual understanding: Computing affects many aspects of the world in both positive and negative ways at local, national, and global levels. Individuals and communities influence computing through their behaviors and cultural and social interactions, and in turn, computing influences new cultural practices. An informed and responsible person should understand the social implications of the digital world, including equity and access to computing.

IC.2.1 **Compare tradeoffs associated with computing technologies that affect people's everyday activities and career options. [CULTURE] (P7.2)**

Advancements in computer technology are neither wholly positive nor negative; however, the ways that people use computing technologies have tradeoffs.

IC.2.1a **Students should consider current events related to broad ideas, including privacy, communication, and automation.** For example, driverless cars can increase convenience and reduce accidents, but they are also susceptible to hacking. The emerging industry will not only reduce the number of taxi and shared-ride drivers but also create more software engineering and cybersecurity jobs.

IC.2.2 **Discuss issues of bias and accessibility in the design of existing technologies. [CULTURE] (P1.2)**

IC.2.2a **Students should test and discuss the usability of various technology tools (e.g., apps, games, and devices) with the teacher's guidance.** For example, facial recognition software that works better for lighter skin tones was likely developed with a homogeneous testing group and could be improved by sampling a more diverse population. When discussing accessibility, students may notice that allowing a user to change font sizes and colors will not only make an interface usable for people with low vision but also benefits users in various situations, such as in bright daylight or a dark room.

IC.2.3 **Collaborate with many contributors through strategies such as crowdsourcing or surveys when creating a computational artifact. [SOCIAL INTERACTIONS] (P2.4, P5.2)**

Crowdsourcing is gathering services, ideas, or content from a large group of people, especially from the online community. It can be done at the local level (e.g., classroom or school) or global level (e.g., age-appropriate online communities, like Scratch and Minecraft).

IC.2.3a **Students should collaborate with many contributors.** For example, a group of students could combine animations to create a digital community mosaic. They could also solicit feedback from many people though use of online communities and electronic surveys.

IC.2.4 **Describe tradeoffs between allowing information to be public and keeping information private and secure. [SAFETY, LAW, & ETHICS] (P7.2)**

Sharing information online can help establish, maintain, and strengthen connections between people. For example, it allows artists and designers to display their talents and reach a broad audience; however, security attacks often start with personal information that is publicly available online. Social engineering is based on tricking people into revealing sensitive information and can be thwarted by being wary of attacks, such as phishing and spoofing.

IC.2.4a **Students should discuss and describe the benefits and dangers of allowing information to be public or kept private and secure.**

MISSISSIPPI DEPARTMENT OF EDUCATION

Ensuring a bright future for every child

2019 STEM Applications

Mississippi Department of Education

Course code: 000273

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The Research and Curriculum Unit (RCU), located in Starkville, MS, as part of Mississippi State University, was established to foster educational enhancements and innovations. In keeping with the land grant mission of Mississippi State University, the RCU is dedicated to improving the quality of life for Mississippians. The RCU enhances intellectual and professional development of Mississippi students and educators while applying knowledge and educational research to the lives of the people of the state. The RCU works within the contexts of curriculum development and revision, research, assessment, professional development, and industrial training.

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Standards

Standards in the *STEM Applications Curriculum Framework and Supporting Materials* are based on the following research-based standards and frameworks:

College and Career-Ready Standards
The College and Career-Ready Standards emphasize critical thinking, teamwork and problem-solving skills. Students will learn the skills and abilities demanded by the workforce of today and the future. Mississippi adopted Mississippi College- and Career-Ready Standards (MCCRS) because they provide a consistent, clear understanding of what students are expected to learn so that teachers and parents know what they need to do to help them. Reprinted from mdek12.org/OAE/college-and-career-readiness-standards

The Mississippi STEM Applications Curriculum Framework is *partially aligned* to the College and Career Readiness Standards for Mathematics and English Language Arts. An alignment crosswalk can be viewed in the appendix of this document. It is also more specifically aligned with portions of the Physical Science course within the College and Career Readiness Standards for Science.

The Mississippi STEM Applications Curriculum Framework is *partially aligned* to the Physical Science course in the 2018 Mississippi College and Career Readiness Standards for Science. Alignment crosswalks to Science, English Language Arts, and Mathematics can be viewed in the appendix of this document.

International Society for Technology in Education Standards (ISTE)
Reprinted with permission from *National Educational Technology Standards for Students: Connecting Curriculum and Technology*, Copyright 2007, International Society for Technology in Education (ISTE), 800.336.5191 (U.S. and Canada) or 541.302.3777 (International), iste@iste.org, iste.org. All rights reserved. Permission does not constitute an endorsement by ISTE.

21st Century Skills and Information and Communication Technologies Literacy Standards
In defining 21st-century learning, the Partnership for 21st Century Skills (P21) has embraced five content and skill areas that represent the essential knowledge for the 21st century: global awareness; civic engagement; financial, economic, and business literacy; learning skills that encompass problem-solving, critical-thinking, and self-directional skills; and Information and Communication Technology (ICT) literacy.

Technology and Engineering Literacy Framework for the 2014 National Assessment of Educational Progress (NAEP)
"…The 2014 NAEP Technology and Engineering Framework is a statement about what should be expected of students in terms of their knowledge and skills with technology, written to be the basis for an assessment of technology and engineering literacy

appropriate for all students. It opens the door to seeing what our K-12 students know about technology and engineering, in the same way that NAEP already assesses their knowledge and capabilities in reading, mathematics, science, and other subjects."

permanent.access.gpo.gov/gpo44683/naep_tel_framework_2014.pdf. Accessed August 28, 2018.

**An alignment crosswalk can be viewed in the appendix of this document showing alignment to all of the above standards.*

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: The National Academies Press.

Rothwell, Jonathan. (2013). *The Hidden STEM Economy.* The Metropolitan Policy Program at BROOKINGS.

Noonan, Ryan. (2017). *STEM Jobs: 2017 Update.* United States Department of Commerce, Office of Economics & Statistics Administration. March 30, 2017.

Preface

Secondary Career and Technical Education programs in Mississippi are faced with many challenges and opportunities resulting from ongoing educational reforms at the national and state levels. School districts, administrators, and teachers are increasingly being held accountable for providing appropriate and relevant learning activities to every student in the classroom. For some courses, this accountability is measured through increased requirements for mastery and attainment of competency as documented through both formative and summative assessments. There are also rising calls for more hands-on, applied techniques related to the real world, developing 21st Century skills essential to success in college and career. CTE is well positioned to meet these needs because it provides a relevant, hands-on approach that is aligned to industry needs and national frameworks. CTE courses pique student interest because they allow students to connect with their communities to create real solutions to real world problems. Career and Technical education provides an opportunity for secondary students to remind us how capable they really are.

The courses in this document reflect the statutory requirements as found in Section 37-3-49, Mississippi Code of 1972, as amended (Section 37-3-46). In addition, this curriculum reflects guidelines imposed by federal and state mandates (Laws, 1988, ch. 487, §14; Laws, 1991, ch. 423, §1; Laws, 1992, ch. 519, §4 eff. from and after July 1, 1992; Carl D. Perkins Vocational Education Act IV, 2007; and Every Student Succeeds Act 2015.)

~~Mississippi Teacher Professional Resources~~

~~The following are resources for Mississippi teachers.~~

~~Curriculum, Assessment, Professional Learning, and other program resources can be found at The Research and Curriculum Unit's website: rcu.msstate.edu~~

~~Learning Management System: An online resource~~
~~Learning Management System information can be found at the RCU's website, under Professional Learning.~~

~~Should you need additional instructions, please call 662.325.2510.~~

Executive Summary

Pathway Description

Science, Technology, Engineering, and Mathematics (STEM) Applications is an innovative instructional program that prepares students to engage in future academic and career and technical courses of study in high school, community college, and institutions of higher learning. The purpose of the program is to provide pupils with expanded knowledge of the use of critical thinking, analysis, problem solving, and technological skills and to enable them to apply knowledge in a technological context. Hands-on experiences related to the application of engineering concepts in the workplace are central to all portions of this course. Students will develop academic, 21st-century and human relations skills and competencies that accompany technical skills for job success to help foster lifelong learning. Students who complete the program will be better prepared to enter and succeed in the STEM workforce, or programs offered by Mississippi community and junior colleges and institutions of higher education.

College, Career, and Certifications

STEM integrates science, technology, engineering, and mathematics to solve problems, often requiring high-tech skills. While STEM professional industries account for around 6 percent of U.S. employment (Noonan, 2017), 20 percent of all jobs require a high level of knowledge in any one STEM field (Rothwell, 2013). This means that one in five workers entering non-STEM fields will still require a high level of knowledge in at least one STEM-related area (e.g. engineering, electronics, functional mathematics, computer programming). If the past ten years is any indicator, requirements for workers to have some level of STEM proficiency will continue to grow. STEM jobs encompass a wide variety of occupations from biomedical technology, to mechanical engineering, to computer system administration, to statistics, to paleontology. A U.S. Department of Commerce study found that employment in STEM occupations over the last decade grew at 24.4 percent versus 4.0 percent for non-STEM occupations, but this growth is showing some signs of slowing. From 2014-2024, STEM careers are expected to grow by 8.9 percent versus 6.4 percent for non-STEM fields. Careers in computer science will see a marked growth with a 12.5 percent increase from 2014-2024, which should account for half a million new jobs. The second largest increase in jobs will be seen in the engineering sector with 65,000 new jobs from 2014-2024. Not all STEM or STEM-related fields should be considered a sure-thing however as some fields, such as drafters and mapping technicians, are projected to decline.

There is also a shift underway in degree requirements for STEM professionals. A study by BROOKINGS found that half of all STEM jobs do not require a four-year degree (Rothwell, 2013). In fact, some of the fastest growing STEM occupations require an associate degree in engineering technology, which includes the following fields: electrical and electronics drafters, civil engineering technicians, environmental engineering technicians, and aerospace engineering and operations technicians. STEM occupations with projected growth rates requiring a bachelor's degree include: statisticians, operations research analysts, cartographers and photogrammetrists, forensic science technicians, and biomedical engineers.

The 2019 STEM Applications course takes the above information into account by offering students exposure to a wide variety of skills using a project-based approach. This exposure can lead to students choosing from a growing list of STEM high school coursework and associated diploma options, college degrees, and career fields. Even if STEM degree holders choose not to practice in a STEM field, they'll still command an earnings premium of 12 percent over non-STEM degree holders (Noonan, 2017). STEM degree holders working in a STEM field will earn 29 percent more than their non-STEM counterparts. So whether it's increasing student agency, building high-tech 21st-century workforce skills, aligning to higher-skill and higher-wage jobs, or helping to direct students toward Mississippi's workforce needs, this course is one of the first official foundational STEM courses offered by the state. In the future, we hope that exposure to highly engaging, hands-on, project-based STEM material will continue to expand among K-8 grades. Early exposure to STEM has been shown by many studies to improve interest and likelihood of entering a related field, especially among girls and minorities.

Grade Level and Class Size Recommendations

It is recommended that students enter this program as an eighth-grader. Exceptions to this are a district level decision based on class size, enrollment numbers, and maturity of student. The classroom and lab is designed to accommodate a maximum of 20 students.

Student Prerequisites

It is suggested that students enrolled in STEM Applications should be classified as eighth-grade students. Any exception to this rule should be discussed with the Mississippi Department of Education.

Applied Academic Credit

The latest academic credit information can be found at

mdek12.org/OAE/college-and-career-readiness-standards

Once there, click the "Mississippi Public School Accountability Standards Year" tab.

Review the appendices for graduation options and superscript information regarding specific programs receiving academic credit.

Licensure Requirements

The most current teacher licensure information can be found at mdek12.org/OTL/OEL

Professional Learning

If you have specific questions about the content of any of training sessions provided, please contact the Research and Curriculum Unit at 662.325.2510 and ask for a professional-learning specialist.

Course Outlines

This curriculum consists of a single, one-credit course, which should be completed in the eighth or ninth grade.

Course Description: STEM Applications is a one-credit course that introduces students to emergent technologies and careers using a project-based approach. Students will learn valuable 21st-century workforce skills while solving problems through low-tech and high-tech means. Safety, Newton's laws, electronics and mechanics, and robotics are among the exciting and relevant topics offered in this course. Students will complete a comprehensive e-portfolio and capstone project to help demonstrate their mastery of course content.

STEM Applications—Course Code: 000273

Unit	Unit Name	Hours
1	Introduction Project, Orientation, and Student Organizations	10
2	Safety and Course Portfolio	10
3	Exploring Newton's Laws	20
4	Applied Electronics and Mechanics	30
5	Capstone	55
Total		125

Research Synopsis

Introduction

STEM professionals apply principles of science, technology, engineering, and mathematics to develop economical solutions for society. Whether it is working on scientific discoveries or commercial applications, STEM employees are expected to pursue further education as technology evolves. Licensing requirements for STEM professionals vary widely depending on the field or sector. Credentials may involve a professional degree, industry certifications, training, and/or practical work experience. The 2010-2020 occupational employment projections and wage estimates for Mississippi were used to determine where STEM employment needs would be in the population over a 10-year period.

Needs of the Future Workforce in Mississippi

Data for this synopsis were compiled from the Mississippi Department of Employment Security (2017). Employment opportunities in Mississippi representative of various engineering occupations are listed below.

Table 1.1: Current and Projected Occupation Report (State of Mississippi)

Occupations (Grouped)	**Employment**		**Projected Growth 2014-2024**		**Average Wage 2017**	
	Current (2014)	**Projected (2024)**	**Number**	**Percent**	**Hourly**	**Annual**
Computer and Mathematical Occupations	10,630	11,530	900	8.5	$31.94	$66,430
Architecture and Engineering Occupations	15,710	15,990	280	1.8	$34.60	$71,960
Healthcare Practitioners and Technical Occupations	74,570	80,000	5,430	7.3	$30.87	$64,210
Life, Physical, and Social Science Occupations	7,310	7,530	220	3.0	$28.54	$59,360
Installation, Maintenance, and Repair Occupations	51,460	54,490	3,030	5.9	$19.63	$40,840
Production Occupations	104,480	107,390	2,910	2.8	$16.35	$34,210
Transportation and Material Moving Occupation	92,010	96,750	4,740	5.2	$15.46	$32,160

Source: Mississippi Department of Employment Security; www.mdes.ms.gov (accessed April 2018)

Perkins IV Requirements

The STEM Applications curriculum meets Perkins IV requirements of high-skill, high-wage, and/or high-demand occupations by introducing students to and preparing students for occupations. It also offers students a program of study including secondary, postsecondary, and Institutes of Higher Learning (IHL) courses that will prepare them for occupations in these fields. Additionally, the STEM Applications curriculum is integrated with the College- and Career-Readiness Standards (CCRS) and focuses on ongoing and meaningful professional development for teachers as well as relationships with industry.

Curriculum

The following national standards were referenced for this curriculum:

- 21st-Century Skills and Information and Communication Technologies Literacy Standards
- Mississippi College- and Career-Readiness Standards (CCSS) for Math, English Language Arts, and Science (Physical Science)
- ISTE's National Educational Technology Standards (NETS-S) for Students
- National Assessment of Educational Progress (NAEP) Technology and Engineering Literacy Framework
- The National Research Council's *A Framework for K-12 Science Education*

Best Practices

Innovative Instructional Technologies

Recognizing today's digital learners and the increasing role of technology in industry, the classroom should be equipped with flexible tools that reflect the needs of the student and industry alike. The STEM Applications curriculum includes content that incorporates current technology. Each classroom should incorporate one teacher desktop or laptop computer as well as student computers in a networked environment. Each classroom is suggested to be equipped with the best, most current educational technology possible, thus facilitating customized and efficient interactions between students and teachers during class. Project-based instruction infusing technology is an essential approach to grow autonomous, 21st-century learners. Teachers are encouraged to investigate Dr. Ruben Puentedura's SAMR (Substitution, Augmentation, Modification, Redefinition) Model to better understand how to infuse technology into lessons. In addition, teachers should make use of the latest online communication tools such as online file sharing, wikis, blogs, vlogs, websites, and podcasts. They are also encouraged to teach using an online Learning Management System (LMS) such as Canvas, which allows for increased student access, interaction, lesson customization, and assessment and grading automation. Finally, students are encouraged to engage in Maker Ed's Open Portfolio Project to document skill mastery for workforce or college entry.

Differentiated Instruction and Student Agency

While some research suggests that students learn in different ways, certain approaches appeal to a wider array of learners and should be considered by more educators. Research suggests that applied, hands-on methods tied to solving real-world problems are more impactful, leading to deeper understanding, more connections to existing knowledge, and greater independence as a learner and problem solver. Combining possible learning styles or preferences, personality types, and other conditions such as student background, emotional health, and home/support circumstances shows that a very unique learner profile emerges for every student. To meet more students where they are with an appropriate level of rigor, the STEM Applications curriculum is written around a progressively complicated series of projects to include a variety of performance objectives. This approach will build skills in problem solving, communication, collaboration, and creativity through an array of hands-on activities and projects. By encouraging various teaching, learning, and assessment strategies, students with different learning profiles are more likely to experience success in the classroom, lab, college, and career. The goal is to increase student agency, providing learners more of a voice and choice in how they learn.

Career and Technical Education Student Organizations

At least two student organizations are relevant for this curriculum. Teachers are encouraged to charter one of these organizations if one is not already available to students. The suggested organizations for this course are Technology Student Association (TSA) or SkillsUSA, which both feature appropriate projects and/or outputs for STEM Applications. The point is not necessarily the student organization itself, but the spirit and associated soft skills that develop over an extended period through a nationally recognized outlet. Contact information for these organizations and supplemental applications/outputs are listed under the "Student Organizations and Student Competitions" sections of this document. In addition to an ongoing and proactive charter in one of these organizations, teachers are encouraged to engage in at least one student competition depending on what is most appropriate and relevant for the students.

Conclusion

Based on information presented above, Mississippi's updated STEM Applications curriculum will provide many opportunities for students to develop workforce skills and a foundation for further education in STEM classes such as:

- Engineering
- Drafting
- Digital Media Technology
- Information Technology
- Simulation, Animation, and Design
- Exploring Computer Science or Computer Science Principles

Applied approaches such as projects, student organization competitions, and hands-on activities will continue to be central to the course. At some point in the near future, anticipated project approaches could include unmanned aerial systems or virtual reality. Regardless of the selected project, the approach will help to prepare students for the applied, hands-on skills essential to their success in the workforce. This curriculum document will be updated regularly to reflect changing technologies, pedagogical methods, and the needs of the STEM workforce.

Student Organizations

Teachers are encouraged to charter one student organization (SkillsUSA or TSA), which are listed immediately below:

SkillsUSA
14001 SkillsUSA Way
Leesburg, VA 20176
703.777.8810
skillsusa.org/

Technology Student Association
1914 Association Drive
Reston, VA 20191-1540
888.860.9010
tsaweb.org/

Student Competitions

Teachers are encouraged to charter one student organization (above) and at least one of the following student competitions (student org charter and competition may occur in tandem):

BEST Robotics
P.O. Box 1024
Georgetown, TX 78627
bestinc.org

FIRST Robotics (LEGO League or Tech Challenge)
200 Bedford Street
Manchester, NH 03101
firstinspires.org

SeaPerch National Challenge
2700 Quincy Street, Suite 400
Arlington, VA 22206
seaperch.org/index

Transportation and Civil Engineering (TRAC™) Bridge Challenge
Mississippi Department of Transportation (MDOT)
401 Northwest Street
Jackson, MS 38829
mdot.ms.gov/stemeducation/programs/trac.html

VEX Robotics Competition (I.Q. or EDR through TSA, REC, or both)
1519 Interstate 30 West
Greenville, TX 75402
vexrobotics.com

Using This Document

Suggested Time on Task

This section indicates an estimated number of clock hours of instruction that should be required to teach the competencies and objectives of the unit. A minimum of 140 hours of instruction is required for each Carnegie unit credit. The curriculum framework should account for approximately 75–80% of the time in the course. The remaining percentage of class time will include instruction in non-tested material, review for end of course testing, and special projects.

Competencies and Suggested Objectives

A competency represents a general concept or performance that students are expected to master as a requirement for satisfactorily completing a unit. Students will be expected to receive instruction on all competencies. The suggested objectives represent the enabling and supporting knowledge and performances that will indicate mastery of the competency at the course level.

Integrated Academic Topics, 21st-Century Skills and Information and Communication Technology Literacy Standards, ACT College Readiness Standards, and Technology Standards for Students

This section identifies related academic topics as required in the Subject Area Testing Program (SATP) in Algebra I, Biology I, English II, and U.S. History from 1877, which are integrated into the content of the unit. Research-based teaching strategies also incorporate ACT College Readiness standards. This section also identifies the 21st-Century Skills and Information and Communication Technology Literacy skills. In addition, national technology standards for students associated with the competencies and suggested objectives for the unit are also identified.

Unit 1: Introductory Project, Orientation, and Student Organizations

Competencies and Suggested Objectives
1. Demonstrate problem solving and teamwork skills by completing a complex challenge (Intro Project). DOK 3 a. Complete a complex challenge (e.g. Paper Tower, Collapsing Columns, Spaghetti Tower/Bridge, or Strawbees Marshmallow challenge) applying the following to solve a problem: i. Use a teacher-generated rubric outlining group work guidelines and including habits of work elements. ii. Brainstorm solutions to the problem and show evidence of group work using concept maps or similar graphic organizers. iii. Research and discuss possible solutions and submit a brief written report. iv. Choose and implement a solution to address a given problem and in accord with all elements of the assigned rubric. v. Create a chart comparing and contrasting tradeoffs. vi. Engage in a teacher-led classroom discussion to debrief on the introductory project to include: • Safety • Group/team rubric • Problem solving
2. Identify course expectations, school policies, student organizations, and program policies related to this course. DOK 1 a. Identify school rules, policy and procedures. b. Identify and establish classroom guidelines and procedures. c. Review course standards and affiliated national standards. d. Demonstrate principles of digital citizenship and acceptable use in all course projects.
3. Identify and utilize common student organization elements. DOK 1 a. Describe the importance of effective communication skills. i. Demonstrate verbal and nonverbal communication skills. ii. Apply appropriate speaking and listening skills to class- and work-related situations. b. Apply leadership skills to class- and work-related situations. i. Define leadership. ii. Discuss the attributes of a leader. c. Utilize team building skills in class- and work-related situation. i. Define team building. ii. Discuss the attributes of a team. iii. Identify the roles included in a team. d. Discuss the various competitions offered through a program area student organization.

i. ~~Describe appropriate/aligned competitions and the skills needed to accomplish the tasks.~~
ii. ~~Discuss tasks needed to complete an assigned requirement for a competition.~~

~~Unit 2: Safety and Course Portfolio~~

~~**Competencies and Suggested Objectives**~~
~~1. Analyze proper safety procedures in a project-based STEM classroom.~~ ~~DOK 2~~ ~~a. Identify, describe, and demonstrate the importance of safety and the proper use of tools and equipment.~~ ~~b. Construct a scale diagram of the classroom/lab to include locations of safety equipment.~~ ~~c. Review and demonstrate proper use of the school's Acceptable Use Policy.~~ ~~d. Demonstrate 100% mastery of safety practices and procedures with safety test and/or practical.~~
~~2. Establish essential elements of the course portfolio.~~ ~~DOK 3~~ ~~a. Identify and demonstrate proper file storage, sharing, and maintenance techniques.~~ ~~b. Create a digital portfolio according to instructor outline.~~ ~~c. The course portfolio should include the following general elements:~~ ~~i. Title page~~ ~~ii. Table of contents (pages must be numbered)~~ ~~iii. Works cited/References~~ ~~d. Create a cumulative portfolio documenting mastery of each course project to include the following:~~ ~~i. Introduction/Purpose~~ ~~ii. Evidence of mastery of NASA's BEST engineering design process~~ ~~1. Ask~~ ~~a. Objectives~~ ~~b. Challenges and limitations~~ ~~2. Imagine~~ ~~a. Brainstorming~~ ~~3. Plan~~ ~~a. Sketches and/or scaled drawings~~ ~~b. Materials list~~ ~~c. Limitations~~ ~~4. Create~~ ~~a. Artifacts/work samples~~ ~~b. Pictures and/or videos~~ ~~5. Experiment~~ ~~a. Analytical (physical science and mathematics) calculations and data~~ ~~b. Results~~ ~~6. Improve~~ ~~a. Reflective writing including items such as:~~ ~~i. Trade-offs/unintended consequences~~

ii. ~~Design/product evaluation~~ iii. ~~Project reviews (e.g. peer, teacher, industry, community)~~ b. ~~Improvement plan for continuation~~
~~**Enrichment (optional):**~~ 1. ~~Research breakthroughs in various STEM fields to include:~~ a. ~~Biomedical research (stem cells, immunotherapy, polymerase chain reaction - PCR - drug development, etc.)~~ b. ~~Biotechnology (CRISPR, genetically modified organisms, cloning, etc.)~~

Unit 3: Exploring Newton's Laws

Competencies and Suggested Objectives
1. Demonstrate proper safety procedures in a laboratory setting for the Newton Project. DOK 2 a. Create a safety plan to be implemented throughout the project and document it in course portfolio. b. Organize a basic safety meeting at the beginning of each class to review the plan, go over previous work, and discuss the strategy for that day. c. Demonstrate safe and proper use of tools and equipment.
2. Apply the National Aeronautics and Space Administration (NASA) Beginning Engineering, Science and Technology (BEST) engineering design process to the Newton Project. DOK 2 a. Document mastery of each part of the design process for the Newton Project in the digital portfolio, emphasizing scaled drawings and materials lists. (Use outline in Unit 2)
3. Demonstrate problem solving and teamwork skills by completing a complex challenge (Newton Project). DOK 3 a. Complete a complex challenge (MDOT Bridge Challenge, balsa wood gliders, Rube Goldberg machine, catapult or equivalent) applying the following to solve a problem: i. Develop and use a student-generated rubric outlining group work guidelines and includes habits of work elements. ii. Brainstorm solutions to the problem and show evidence of group work using concept maps or similar graphic organizers (include in portfolio). iii. Research and discuss possible solutions and submit a brief written report and/or presentation (include in portfolio). iv. Choose and implement a solution to address a given problem and in accord with all elements of the assigned rubric. v. Create a chart comparing and contrasting tradeoffs (include in portfolio). vi. Engage in a teacher-led classroom discussion to debrief on the Newton Project to include: • Safety • Group/team rubric • Problem solving
4. Apply appropriate physical and mathematical principles to Newton Project tasks (include in portfolio). DOK 3 a. Conduct a student-led project to include the following physical and mathematical principles: i. Distance ii. Displacement (change in x) iii. Speed (distance/time) iv. Velocity (displacement/time)

v. Forces 1. Friction 2. Gravity 3. Normal 4. Tension 5. Torsion 6. Compression 7. Shear (force/area) vi. Newton's Laws of Motion (F=ma) vii. Measurement (metric and imperial) viii. Geometry (Pythagorean theorem, finding unknown angles or sides of triangles) ix. Ratios (strength to weight) *Competencies 3 and 4 above are not necessarily listed in the order they should be taught.
5. Engage with STEM industry and business professionals. DOK 2 a. Arrange a field trip, professional visit, or virtual interaction with a STEM professional and inquire about: i. Career fields and availability (considering automation trends) ii. Education and training iii. Certifications iv. Average salaries v. Job descriptions and daily tasks b. Complete a reflective writing exercise that includes career interests (include in portfolio).
Enrichment (optional): 1. Apply the continuous improvement model of the engineering design process to improve an existing product. Include tradeoff (sustainability and efficiency) concepts frequently used in industry.

Unit 4: Applied Electronics and Mechanics

Competencies and Suggested Objectives
1. Demonstrate proper safety procedures in a laboratory setting for the Newton Project. DOK 2 a. Create a safety plan to be implemented throughout the project and document it in course portfolio. b. Organize a basic safety meeting at the beginning of each class to review the plan, go over previous work, and discuss the strategy for that day. c. Demonstrate safe and proper use of tools and equipment.
2. Apply the NASA BEST engineering design process to the Electronics and Mechanics Project. DOK 2 a. Using instructor feedback from the Newton Project, refine the approach of the design process for this project. b. Document mastery of each part of the design process for the Electronics and Mechanics project in the digital portfolio emphasizing mathematics and physics concepts and reflective writing. (Use outline in Unit 2)
3. Demonstrate problem solving and teamwork skills by completing a complex challenge (Electronics & Mechanics Project). DOK 3 a. Complete a complex challenge (e.g. TSA Animatronics, high-tech egg drop, Rube Goldberg machines, or equivalent) applying the following to solve a problem: i. Develop and use a student-generated rubric outlining group work guidelines and including habits of work elements. ii. Brainstorm solutions to the problem and show evidence of group work using concept maps or similar graphic organizers. iii. Research and discuss possible solutions and submit a brief written report. iv. Create a chart comparing and contrasting tradeoffs. v. Engage in a student-led classroom discussion to debrief on the introductory project to include: • Safety • Group/team rubric • Problem solving b. Construct a device that integrates electronics and mechanics that completes a task to include the following: i. A sensor system that reacts to stimulus and collects data ii. Create models and communicate basic electrical principles in multiple formats (verbally, graphically, textually, and/or mathematically) to include: 1. Ohm's law (Voltage = Current x Resistance) 2. Current (Alternating and Direct)

3. Circuits (Series and Parallel) iii. A system regulated by a microcontroller to include any or all of the following: 1. Capacitors 2. LEDs 3. Power sources (batteries) 4. Resistors iv. A computer program/application to control a mechanical part via microcontroller v. A project analysis to modify system based on data collected
4. As part of the Electronics and Mechanics Project, create models to explore mechanics and its applications. DOK 3 a. Collect, organize, and interpret data from the basic principles of motion through simulation or hands-on project to include: (PHS.5.2, PHS.5.3 PHS.5.4) i. Simple machines to include: 1. Wedge 2. Pulley 3. Inclined plane 4. Screw 5. Wheel and axle 6. Levers ii. Vector vs. Scalar iii. Displacement (d=change in x/change in time) iv. Speed (s = distance/time) v. Velocity (v =change in displacement/change in time) vi. Acceleration (a = change in velocity/change in time) vii. Forces (friction, gravity, normal) viii. Equilibrium ix. Newton's Laws of Motion b. Collect, organize, and interpret data from the basic principles of energy through simulation or hands-on project to include: i. Electrical Energy ii. Kinetic Energy ($KE = 1/2mv^2$) iii. Potential Energy (U=mgh) iv. Work v. Work-energy theorem (W= KE) vi. Conservation of Energy vii. Momentum (P = mv) viii. Conservation of momentum
5. Engage with STEM industry and business professionals. DOK 2

a. ~~Arrange a field trip, professional visit, or virtual interaction with a STEM professional and inquire about:~~
    i. ~~Career fields and availability (considering automation trends)~~
    ii. ~~Education and training~~
    iii. ~~Certifications~~
    iv. ~~Average salaries~~
    v. ~~Job descriptions and daily tasks~~

b. ~~Complete a reflective writing exercise that includes career interests and document in the course portfolio.~~

~~Enrichment (optional):~~

1. ~~Research various emerging technologies to include impacts on society and changing technological cultures that includes any of the following:~~
    a. ~~Biomimicry~~
    b. ~~The link between artificial intelligence and quantum computing~~
    c. ~~Wearable electronics and 'soft circuits' in fashion~~
2. ~~Link technological breakthroughs in materials to advancements in any of the following:~~
    a. ~~Architecture and engineering (manmade structures)~~
    b. ~~Textiles~~
    c. ~~Manufacturing~~
    d. ~~Energy production~~
    e. ~~Transportation~~

Unit 5: Capstone

Note: Teachers have the option to do the 21st-Century City **and/or** Robotics capstone project.

Competencies and Suggested Objectives
1. Demonstrate proper safety procedures in a laboratory setting for the project. DOK 2 a. Create a safety plan to be implemented throughout the project and document it in course portfolio. b. Organize a basic safety meeting at the beginning of each class to review the plan, go over previous work, and discuss the strategy for that day. c. Demonstrate safe and proper use of tools and equipment.
2. Where appropriate, implement the National Aeronautics and Space Administration (NASA) Beginning Engineering, Science and Technology (BEST) engineering design process to the project. DOK 2 a. Summarize the use of the design process in Project 1-3. b. Develop an improvement plan for this project using feedback from Project 1-3 and document in course portfolio.
3. As part of the student portfolio, display workforce readiness elements to include: DOK 1 a. Resume b. Mock interviews in an authentic workplace scenario c. Portfolio presentation to local business and industry representatives d. Training, education, and career plan to include: • High school coursework • Post-secondary training options • Certifications • Career field average salaries
STEM Applications Capstone Project Option 1: **4A.** Research, design, and create a scale model of a 21st-century city. DOK 4 *Required element (include in portfolio) a. Research and design a model city to scale that includes the following i. Research 21st-century (international) city planning and development* ii. Research the Americans with Disabilities Act (ADA) and develop a plan for accessibility iii. Design part or all of the city using drafting or modeling software that includes the following: 1. Zoning and districts* 2. Circulation (vehicular, pedestrian, bicycle, mass transit, etc.)* 3. Access to important places (school, hospital, etc.)* 4. Parks and public recreation areas* 5. High tech public transportation* 6. 21st-century architecture (e.g. new styles, Leadership in Energy and Environmental Design or other sustainable approach) iv. Design and build parts of the city plan to include*: 1. Hospital

2. Fire department 3. Library 4. School 5. Police station 6. Shopping center 7. Grocery store 8. Fueling/recharging station 9. Power and water utilities and additional city amenities set by groups b. Construct all model structures to scale. i. Construct 3D model buildings to the same scale as designed. ii. Use appropriate measuring units and tools for model construction. c. Apply electrical properties to the 21st-century model. i. Design and build an electrical system (to include lighting)*. ii. Design a power system for your city. iii. Create the wiring diagram for the model city. iv. Build the power system for the city, v. Using Ohm's law, analyze the major components of the power system. vi. Design and create one of the following using sensors: 1. Sequenced or sensing traffic lights switch 2. Mechanical railway stop arms utilizing pressure sensors to make rail arms operational d. Create budget document in a spreadsheet format. i. Determine the materials needed to construct the model city. ii. Investigate the cost of materials required to build a scale model of city from a local or online source. e. Research current and future environmental implications and develop an environmental plan to include: i. Environmental impact ii. Renewable energy production iii. Water harvesting iv. Urban farming and forestry
STEM Applications Capstone Project Option 2: **4B.** Research, design, and create a fully functional robotics system (e.g. VEX, FIRST, Best, or equivalent) (include in portfolio). DOK 4 *All elements of this project are required. 1. Explore principles of robotic systems in a student project or competition. a. Ask questions from observations to determine how mass, weight and center of gravity affect the operation of a robot. b. Create a robot within size and material parameters (set by teacher, student organization, or competition). c. Create scale drawings of robot (with CAD or by hand).

d. Analyze mathematical and physical concepts to include calculating:
    i. Torque
    ii. Speed
    iii. Wheel rollout
    iv. Gears
    v. Angular velocity
e. Design and assemble elements of a robot to include:
    i. Motor controllers
    ii. Wiring system
    iii. Fabricated elements (e.g. 3D printed)
f. Develop and demonstrate proper use of programming elements to control a robot that include the following concepts:
    i. Loops
    ii. Variables
    iii. Constants
    iv. If/then statements
g. Develop or utilize an existing remote/manual control system for robot.
h. Develop an autonomous program to control a robot.
i. Use sensors to control a robot based on environmental stimuli.
j. Enter the robot in a competition setting (student organization, classroom competition, or other specified purpose).
k. Make improvements to robot based on competition results.

5. Develop essential elements of the course portfolio for the Capstone Project in Unit 2.

6. Engage with STEM industry and business professionals.
   c. Arrange a field trip, professional visit, or virtual interaction with a STEM professional and inquire about:
       i. Career fields and availability (considering automation trends)
       ii. Education and training
       iii. Certifications
       iv. Average salaries
       v. Job descriptions and daily tasks
   d. Complete a reflective writing exercise that includes career interests and document in the course portfolio.

Enrichment (optional):

1. Research various emerging technologies to include impacts on society and changing technological cultures that includes any of the following:
   a. Characteristics of the world's top modernized cities
   b. Advancements in personal and mass transportation
   c. Fusion of materials, architecture, technology, and environmental sustainability
   d. Industrial applications of robotics, recent developments, and automation

Student Competency Checklist

Student Name: ____

This record is intended to serve as a method of noting student achievement of the competencies in each unit. It can be duplicated for each student, and it can serve as a cumulative record of competencies achieved in the course.

In the blank before each competency, place the date on which the student mastered the competency.

Unit 1: Introductory Project, Orientation, and Student Organizations		
	1.	Demonstrate problem solving and teamwork skills by completing a complex challenge (Intro Project).
	2.	Identify course expectations, school policies, student organizations, and program policies related to this course.
	3.	Identify and utilize common student organization elements.
Unit 2: Safety and Course Portfolio		
	1.	Analyze proper safety procedures in a project-based STEM classroom.
	2.	Establish essential elements of the course portfolio.
Unit 3: Exploring Newton's Laws		
	1.	Demonstrate proper safety procedures in a laboratory setting for the Newton Project.
	2.	Apply the National Aeronautics and Space Administration (NASA) Beginning Engineering, Science and Technology (BEST) engineering design process to the Newton Project.
	3.	Demonstrate problem solving and teamwork skills by completing a complex challenge (Newton Project).
	4.	Apply appropriate physical and mathematical principles to Newton Project tasks. (Include in portfolio)
	5.	Engage with STEM industry and business professionals.
Unit 4: Applied Electronics and Mechanics		
	1.	Demonstrate proper safety procedures in a laboratory setting for the Electronics and Mechanics Project.
	2.	Apply the NASA BEST engineering design process to the Electronics and Mechanics Project.
	3.	Demonstrate problem solving and teamwork skills by completing a complex challenge (Electronics & Mechanics Project).
	4.	As part of the Electronics and Mechanics Project, create models to explore mechanics and its applications.
	5.	Engage with STEM industry and business professionals.
Unit 5: Capstone		

	~~1.~~	~~Demonstrate proper safety procedures in a laboratory setting for the project.~~
	~~2.~~	~~Where appropriate, implement the National Aeronautics and Space Administration (NASA) Beginning Engineering, Science and Technology (BEST) engineering design process to the project.~~
	~~3.~~	~~As part of the student portfolio, display workforce readiness elements.~~
	~~4a.~~	~~Research, design, and create a scale model of a 21st-century city.~~
	~~4b.~~	~~Research, design, and create a fully functional robotics system (e.g. VEX, FIRST, Best, or equivalent).~~
	~~5.~~	~~Develop essential elements of the course portfolio for the Capstone Project detailed in Unit 2.~~
	~~6.~~	~~Engage with STEM industry and business professionals.~~

Appendix A: National Assessment of Educational Progress (NAEP) Technology and Engineering Literacy Framework

NAEP Standard	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
T.12.1					
T.12.2		X		X	X
T.12.3		X	X	X	X
T.12.4		X		X	X
T.12.5					X
T.12.6					X
T.12.7					X
T.12.8	X	X		X	X
T.12.9	X	X		X	X
T.12.10	X	X		X	X
T.12.11	X	X		X	X
T.12.12	X	X		X	X
T.12.13	X	X		X	X
T.12.14					
T.12.15					
D.12.1	X	X		X	X
D.12.2					X
D.12.3					X
D.12.4	X	X	X	X	X
D.12.5					
D.12.6	X	X	X	X	X
D.12.7	X	X	X	X	X
D.12.8	X	X	X	X	X
D.12.9	X	X	X	X	X
D.12.10	X	X	X	X	X
D.12.11			X	X	X
D.12.12					X
D.12.13			X	X	X
D.12.14			X	X	X
D.12.15			X	X	X
D.12.16					
D.12.17			X	X	X
D.12.18					
D.12.19					X
I.12.1	X	X	X	X	X
I.12.2	X	X	X	X	X
I.12.3	X	X	X	X	X
I.12.4	X	X	X	X	X
I.12.5	X	X	X	X	X
I.12.6	X	X	X	X	X
I.12.7		X		X	X
I.12.8		X	X	X	X
I.12.9					
I.12.10	X				
I.12.11	X				
I.12.12		X			
I.12.13					

~~**Students know that:**~~
~~**T.12.1:** The decision to develop a new technology is influenced by societal opinions and demands. These driving forces differ from culture to culture.~~

~~**T.12.2**: Changes caused by the introduction and use of a new technology can range from gradual to rapid and from subtle to obvious and can change over time. These changes may vary from society to society as a result of differences in a society's economy, politics, and culture.~~

~~**Students are able to:**~~
~~**T.12.3:** Choose an appropriate technology to help solve a given societal problem, and justify the selection based on an analysis of criteria and constraints, available resources, likely trade-offs, and relevant environmental and cultural concerns.~~

~~**T.12.4:** Analyze cultural, social, economic, or political changes (separately or together) that may be triggered by the transfer of a specific technology from one society to another. Include both anticipated and unanticipated effects.~~

~~**Students know that:**~~
~~**T.12.5:** Many technologies have been designed to have a positive impact on the environment and to monitor environmental change over time to provide evidence for making informed decisions.~~

~~**T.12.6**: Development and modification of any technological system needs to take into account how the operation of the system will affect natural resources and ecosystems.~~

~~**Students are able to:**~~
~~**T.12.7:** Identify a complex global environmental issue, develop a systematic plan of investigation, and propose an innovative sustainable solution.~~

~~**Students know that:**~~
~~**T.12.8:** Information technology allows access to vast quantities of data, expertise, and knowledge through a wide array of devices and formats to answer questions, solve problems, and inform the decision-making process.~~

~~**T.12.9:** Information technologies such as artificial intelligence, image enhancement and analysis, and sophisticated computer modeling and simulation, create new types of information that may have profound effects on society. These new types of information must be evaluated carefully.~~

~~**T.12.10:** The development of communication technologies that enable people to access vast quantities of information and publish their ideas globally has implications for governments, organizations, and individuals.~~

~~**Students are able to:**~~
~~**T.12.11:** Give examples to illustrate the effects on society of the recording, distribution, and access to information and knowledge that have occurred in history, and discuss the effects of those revolutions on societal change.~~
~~**Students know that:**~~

~~**T.12.12:** Decisions made about the use of a technology may have intended and unintended consequences, and these consequences may be different for different groups of people and may change over time. Decisions about the use of a technology should consider different points of view.~~

~~**T.12.13:** Disparities in the technologies available to different groups of people have consequences for public health and prosperity, but deciding whether to introduce a new technology should consider local resources and the role of culture in acceptance of the new technology.~~

~~**Students are able to:**~~
~~**T.12.14:** Analyze responsibilities of different individuals and groups, ranging from citizens and entrepreneurs to political and government officials, with respect to a controversial technological issue.~~

~~**T.12.15:** Demonstrate the responsible and ethical use of information and communication technologies by distinguishing between kinds of information that should and should not be publicly shared and describing the consequences of a poor decision.~~

~~**Students know that:**~~
~~**D.12.1:** Advances in science have been applied by engineers to design new products, processes, and systems, while improvements in technology have enabled breakthroughs in scientific knowledge.~~

~~**D.12.2:** Engineers use science, mathematics, and other disciplines to improve technology, while scientists use tools devised by engineers to advance knowledge in their disciplines. This interaction has deepened over the past century.~~

~~**D.12.3:** The evolution of tools, materials, and processes has played an essential role in the development and advancement of civilization, from the establishment of cities and industrial societies to today's global trade and commerce networks.~~

~~**Students are able to:**~~
~~**D.12.4:** Take into account trade-offs among several factors when selecting a material for a given application.~~

~~**D.12.5:** Design a new tool to accomplish a task more efficiently.~~

~~**Students know that:**~~
~~**D.12.6:** Engineering design is a complicated process in which creative steps are embedded in content knowledge and research on the challenge. Decisions on trade-offs involve systematic comparisons of all costs and benefits, and final steps may involve redesigning for optimization.~~

~~**D.12.7:** Specifications involve criteria, which may be weighted in various ways, and constraints, which can include natural laws and available technologies. Evaluation is a process for determining how well a solution meets the requirements.~~

~~**Students are able to:**~~
~~**D.12.8:** Meet a sophisticated design challenge by identifying criteria and constraints, predicting how these will affect the solution, researching and generating ideas, and using trade-offs to balance competing values in selecting the best solution.~~

~~**D.12.9:** Construct and test several models to see if they meet the requirements of a problem. Combine features to achieve the best solution.~~

~~**D.12.10:** Communicate the entire design process from problem definition to evaluation of the final design, taking into account relevant criteria and constraints, including aesthetic and ethical considerations as well as purely logical decisions.~~

~~**Students know that:**~~
~~**D.12.11:** The stability of a system depends on all of its components and how they are connected, with more complicated systems tending to require more energy and to be more vulnerable to error and failure. Negative feedback loops tend to increase the stability and efficiency of systems.~~

~~**D.12.12:** Technological systems are embedded within larger technological, social, natural, and environmental systems.~~

~~**Students are able to:**~~
~~**D.12.13:** Examine a system to predict how it will perform with a given set of inputs in a given situation and how performance will change if the components or interactions of the system are changed.~~

~~**D.12.14:** Redesign a complex machine by modifying or rearranging its subsystems in order to optimize its efficiency.~~

~~**D.12.15:** Construct and test a manufacturing system composed of several machines to accomplish a given goal. Redesign the system to optimize its efficiency.~~

~~**Students know that:**~~
~~**D.12.16:** Products and structures of various kinds can be redesigned to eliminate frequent malfunctions and reduce the need for regular maintenance.~~

~~**Students are able to:**~~
~~**D.12.17:** Analyze a system malfunction using logical reasoning (such as a fault tree) and appropriate diagnostic tools and instruments. Devise strategies and recommend tools for fixing the problem.~~

~~**D.12.18:** Analyze a complicated system to identify ways that it might fail in the future. Identify the most likely failure points and recommend safeguards to avoid future failures.~~

D.12.19: Taking into account costs and current trends in technology, identify how long a product should be maintained and repaired and how it might be redesigned to lessen negative environmental impacts.

Students know that:
I.12.1: Effective collaboration requires careful selection of team members, monitoring of progress, strategies for reaching agreement when there are opposing points of view, and iterative improvement of collaborative processes. Information and communication technologies can be used to record and share different viewpoints and to collect and tabulate the views of groups of people.

Students are able to:
I.12.2: Work through a simulation of a collaborative process. Negotiate team roles and resources, draw upon the expertise and strengths of other team members and remote experts, monitor progress toward goals, and reflect on and refine team processes for achieving goals.

I.12.3: Synthesize input from multiple sources to communicate ideas to a variety of audiences using various media, genres, and formats.

Students know that:
I.12.4: Advanced search techniques can be used with digital and network tools and media resources to locate information and to check the credibility and expertise of sources.

Students are able to:
I.12.5: Select digital and network tools and media resources to gather information and data on a practical task, and justify choices based on the tools' efficiency and effectiveness for a given purpose.

I.12.6: Search media and digital resources on a community or world issue and evaluate the timeliness and accuracy of the information as well as the credibility of the source.

Students are able to:
I.12.7: Use digital tools and resources to identify a complicated global issue and develop a systematic plan of investigation. Present findings in terms of pros and cons of two or more innovative sustainable solutions.

I.12.8: Use digital tools to collect, analyze, and display data in order to design and conduct complicated investigations in various subject areas. Explain rationale for the design and justify conclusions based on observed patterns in the data.

I.12.9: Having conducted a simulation of a system using a digital model, draw conclusions about the system, or propose possible solutions to a problem or ways to reach a goal based on outcomes of the simulation. Critique the conclusions based on the adequacy of the model.

~~**Students know that:**~~
~~**I.12.10:** Legal requirements governing the use of copyrighted information and ethical guidelines for appropriate citations are intended to protect intellectual property.~~

~~**Students are able to:**~~
~~**I.12.11:** Identify or provide examples of responsible and ethical behavior that follow the letter and spirit of current laws concerning personal and commercial uses of copyrighted material as well as accepted ethical practices when using verbatim quotes, images, or ideas generated by others.~~

~~**Students know that:**~~
~~**I.12.12:** A variety of digital tools exist for a given purpose. The tools differ in features, capacities, operating modes, and style. Knowledge about many different ICT tools is helpful in selecting the best tool for a given task.~~

~~**Students are able to:**~~
~~**I.12.13:** Demonstrate the capability to use a variety of digital tools to accomplish a task or develop a solution for a practical problem. Justify the choice of tools, explain why other tools were not used based on specific features of the tools, and summarize the results.~~

Appendix B: 21st Century Skills

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
21st Century Standards					
CS1	X		X	X	X
CS2					X
CS3					
CS4	X		X	X	X
CS5					X
CS6	X		X	X	X
CS7	X		X	X	X
CS8	X		X	X	X
CS9	X		X	X	X
CS10		X	X	X	X
CS11	X	X	X	X	X
CS12	X	X	X	X	X
CS13	X	X	X	X	X
CS14	X	X	X	X	X
CS15	X	X	X	X	X
CS16	X	X	X	X	X

CSS1-21st Century Themes

CS1 Global Awareness

1. Using 21st century skills to understand and address global issues
2. Learning from and working collaboratively with individuals representing diverse cultures, religions, and lifestyles in a spirit of mutual respect and open dialogue in personal, work, and community contexts
3. Understanding other nations and cultures, including the use of non-English languages

CS2 Financial, Economic, Business, and Entrepreneurial Literacy

1. Knowing how to make appropriate personal economic choices
2. Understanding the role of the economy in society
3. Using entrepreneurial skills to enhance workplace productivity and career options

CS3 Civic Literacy

1. Participating effectively in civic life through knowing how to stay informed and understanding governmental processes
2. Exercising the rights and obligations of citizenship at local, state, national, and global levels
3. Understanding the local and global implications of civic decisions

CS4 Health Literacy

1. Obtaining, interpreting, and understanding basic health information and services and using such information and services in ways that enhance health
2. Understanding preventive physical and mental health measures, including proper diet, nutrition, exercise, risk avoidance, and stress reduction
3. Using available information to make appropriate health-related decisions
4. Establishing and monitoring personal and family health goals

~~5. Understanding national and international public health and safety issues~~

~~**CS5 Environmental Literacy**~~

~~1. Demonstrate knowledge and understanding of the environment and the circumstances and conditions affecting it, particularly as relates to air, climate, land, food, energy, water, and ecosystems.~~
~~2. Demonstrate knowledge and understanding of society's impact on the natural world (e.g., population growth, population development, resource consumption rate, etc.).~~
~~3. Investigate and analyze environmental issues, and make accurate conclusions about effective solutions.~~
~~4. Take individual and collective action toward addressing environmental challenges (e.g., participating in global actions, designing solutions that inspire action on environmental issues).~~

~~CSS2 Learning and Innovation Skills~~

~~**CS6 Creativity and Innovation**~~

~~1. Think Creatively~~
~~2. Work Creatively with Others~~
~~3. Implement Innovations~~

~~**CS7 Critical Thinking and Problem Solving**~~

~~1. Reason Effectively~~
~~2. Use Systems Thinking~~
~~3. Make Judgments and Decisions~~
~~4. Solve Problems~~

~~**CS8 Communication and Collaboration**~~

~~1. Communicate Clearly~~
~~2. Collaborate with Others~~

~~CSS3 Information, Media and Technology Skills~~

~~**CS9 Information Literacy**~~

~~1. Access and Evaluate Information~~
~~2. Use and Manage Information~~

~~**CS10 Media Literacy**~~

~~1. Analyze Media~~
~~2. Create Media Products~~

~~**CS11 ICT Literacy**~~

~~1. Apply Technology Effectively~~

~~CSS4 Life and Career Skills~~

~~**CS12 Flexibility and Adaptability**~~

~~1. Adapt to change~~
~~2. Be Flexible~~

~~**CS13 Initiative and Self-Direction**~~

~~1. Manage Goals and Time~~
~~2. Work Independently~~
~~3. Be Self-directed Learners~~

~~**CS14 Social and Cross-Cultural Skills**~~

~~1. Interact Effectively with others~~
~~2. Work Effectively in Diverse Teams~~

~~**CS15 Productivity and Accountability**~~

~~1. Manage Projects~~
~~2. Produce Results~~

~~**CS16 Leadership and Responsibility**~~

~~1. Guide and Lead Others~~

Appendix C: College and Career Readiness Standards

College and Career Readiness Standards for English Language Arts

	Units	1	2	3	4	5
Standards						
RL.9.1		X	X	X	X	X
RL.9.2			X			
RL.9.3						
RL.9.4						
RL.9.5						
RL.9.6						
RL.9.7						
RL.9.8						
RL.9.9						
RL.9.10						
RL.9.10						
RI.9.3						
RI.9.5						
RI.9.6						
RI.9.7						
RI.9.8						
RI.9.9						
W.9.1		X	X	X	X	X
W.9.2		X	X	X	X	X
W.9.3		X	X	X	X	X
W.9.4		X	X	X	X	X
W.9.5		X	X	X	X	X
W.9.6		X	X	X	X	X
W.9.7		X	X	X	X	X
W.9.8		X	X	X	X	X
W.9.9		X	X	X	X	X
W.9.10		X	X	X	X	X
SL.9.1		X	X	X	X	X
SL.9.2			X	X	X	X
SL.9.3						
SL.9.4				X		X
SL.9.5		X	X	X	X	X
SL.9.6		X	X	X	X	X
L.9.1		X	X	X	X	X
L.9.2		X	X	X	X	X
L.9.3		X	X	X	X	X
L.9.4		X	X	X	X	X
L.9.5						
L.9.6		X	X	X	X	X
RL.10.10						
RH.9-10.1						
RH.9-10.2						
RH.9-10.3						
RH.9-10.4						
RH.9-10.5						
RH.9-10.6						
RH.9-10.7						
RH.9-10.8						
RH.9-10.9						
RH.9-10.10						
RST.9-10.1			X	X	X	X
RST.9-10.2		X	X	X	X	X
RST.9-10.3		X	X	X	X	X
RST.9-10.4		X	X	X	X	X

RST.9-10.5		X	X	X	X	X
RST.9-10.6						X
RST.9-10.7		X	X	X	X	X
RST.9-10.8						
RST.9-10.9		X	X	X	X	X
RST.9-10.10						X
WHST.9-10.1						
WHST.9-10.2		X	X	X	X	X
WHST.9-10.3						
WHST.9-10.4		X	X	X	X	X
WHST.9-10.5		X	X	X	X	X
WHST.9-10.6		X	X	X	X	X
WHST.9-10.7		X	X	X	X	X
WHST.9-10.8		X	X	X	X	X
WHST.9-10.9		X	X	X	X	X
WHST.9-10.10		X	X	X	X	X
RL.11.1		X	X	X	X	X
RL.11.2						
RL.11.3						
RL.11.4						
RL.11.5						
RL.11.6						
RL.11.7						
RL.11.8						
RL.11.9						
RL.11.10						
RI.11.3						
RI.11.4						
RI.11.5						
RI.11.6						
RI.11.7		X	X	X	X	X
RI.11.8						
RI.11.9						
RI.11.10						
W.11.1				X	X	X
W.11.2		X	X	X	X	X
W.11.3		X	X	X	X	X
W.11.4		X	X	X	X	X
W.11.5		X	X	X	X	X
W.11.6		X	X	X	X	X
W.11.7		X	X	X	X	X
W.11.8		X	X	X	X	X
W.11.9						
W.11.10		X	X	X	X	X
SL.11.1		X	X	X	X	X
SL.11.2		X	X	X	X	X
SL.11.3						
SL.11.4		X		X	X	X
SL.11.5		X	X	X	X	X
SL.11.6		X	X	X	X	X
L.11.1		X	X	X	X	X
L.11.2		X	X	X	X	X
L.11.3		X	X	X	X	X
L.11.4		X	X	X	X	X
RL.12.10						
RH.11-12.1						
RH.11-12.2						
RH.11-12.3						
RH.11-12.4						
RH.11-12.5						
RH.11-12.6						
RH.11-12.7						
RH.11-12.8						
RH.11-12.9						
RH.11-12.10						

RST.11-12.1		X	X	X	X	X
RST.11-12.2						
RST.11-12.3		X	X	X	X	X
RST.11-12.4		X	X	X	X	X
RST.11-12.5			X	X	X	X
RST.11-12.6			X	X	X	X
RST.11-12.7		X	X	X	X	X
RST.11-12.8						
RST.11-12.9			X	X	X	X
RST.11-12.10		X	X	X	X	X
WHST.11-12.1			X	X	X	X
WHST.11-12.2						
WHST.11-12.6		X	X	X	X	X
WHST.11-12.8		X	X	X	X	X

Reading Standards for Literature (11-12)
College and Career Readiness Anchor Standards for *Reading Literature*
Key Ideas and Details

RL.11.1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.

RL.11.2. Determine two or more themes or central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to produce a complex account; provide an objective summary of the text.

RL.11.3. Analyze the impact of the author's choices regarding how to develop and relate elements of a story or drama (e.g., where a story is set, how the action is ordered, how the characters are introduced and developed).

Craft and Structure

RL.11.4. Determine the meaning of words and phrases as they are used in the text, including figurative and connotative meanings; analyze the impact of specific word choices on meaning and tone, including words with multiple meanings or language that is particularly fresh, engaging, or beautiful. (Include Shakespeare as well as other authors.)

RL.11.5. Analyze how an author's choices concerning how to structure specific parts of a text (e.g., the choice of where to begin or end a story, the choice to provide a comedic or tragic resolution) contribute to its overall structure and meaning as well as its aesthetic impact.

RL.11.6. Analyze a case in which grasping point of view requires distinguishing what is directly stated in a text from what is really meant (e.g., satire, sarcasm, irony, or understatement).

Integration of Knowledge and Ideas

RL.11.7. Analyze multiple interpretations of a story, drama, or poem (e.g., recorded or live production of a play or recorded novel or poetry), evaluating how each version interprets the source text. (Include at least one play by Shakespeare and one play by an American dramatist.)

RL.11.8. (Not applicable to literature)

RL.11.9. Demonstrate knowledge of eighteenth-, nineteenth- and early-twentieth-century foundational works of American literature, including how two or more texts from the same period treat similar themes or topics.

Range of Reading and Level of Text Complexity

RL.11.10. By the end of grade 11, read and comprehend literature, including stories, dramas, and poems, in the grades 11–CCR text complexity band proficiently, with scaffolding as needed at the high end of the range.
By the end of grade 12, read and comprehend literature, including stories, dramas, and poems, at the high end of the grades 11–CCR text complexity band independently and proficiently.

Reading Standards for Informational Text (11-12)
College and Career Readiness Anchor Standards for *Informational Text*

Key Ideas and Details

RI.11.1. Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain.

RI.11.2. Determine two or more central ideas of a text and analyze their development over the course of the text, including how they interact and build on one another to provide a complex analysis; provide an objective summary of the text.

RI.11.3. Analyze a complex set of ideas or sequence of events and explain how specific individuals, ideas, or events interact and develop over the course of the text.

Craft and Structure

RI.11.4. Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze how an author uses and refines the meaning of a key term or terms over the course of a text (e.g., how Madison defines faction in Federalist No. 10).

RI.11.5. Analyze and evaluate the effectiveness of the structure an author uses in his or her exposition or argument, including whether the structure makes points clear, convincing, and engaging.

~~RI.11.6. Determine an author's point of view or purpose in a text in which the rhetoric is particularly effective, analyzing how style and content contribute to the power, persuasiveness, or beauty of the text.~~

~~Integration of Knowledge and Ideas~~

~~RI.11.7. Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.~~

~~RI.11.8. Delineate and evaluate the reasoning in seminal U.S. texts, including the application of constitutional principles and use of legal reasoning (e.g., in U.S. Supreme Court majority opinions and dissents) and the premises, purposes, and arguments in works of public advocacy (e.g., The Federalist, presidential addresses).~~

~~RI.11.9. Analyze seventeenth-, eighteenth-, and nineteenth-century foundational U.S. documents of historical and literary significance (including The Declaration of Independence, the Preamble to the Constitution, the Bill of Rights, and Lincoln's Second Inaugural Address) for their themes, purposes, and rhetorical features.~~

~~Range of Reading and Level of Text Complexity~~

~~RI.11.10. By the end of grade 11, read and comprehend literary nonfiction in the grades 11–CCR text complexity band proficiently, with scaffolding as needed at the high end of the range.~~

~~By the end of grade 12, read and comprehend literary nonfiction at the high end of the grades 11–CCR text complexity band independently and proficiently.~~
~~College and Career Readiness Anchor Standards for *Writing*~~

~~Text Types and Purposes~~

~~W.11.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.~~

~~a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences claim(s), counterclaims, reasons, and evidence.~~

~~b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level, concerns, values, and possible biases.~~

~~c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.~~

~~d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.~~

~~e. Provide a concluding statement or section that follows from and supports the argument presented.~~

~~W.11.2. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.~~

~~a. Introduce a topic; organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.~~

~~b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.~~

~~c. Use appropriate and varied transitions and syntax to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.~~

~~d. Use precise language, domain-specific vocabulary, and techniques such as metaphor, simile, and analogy to manage the complexity of the topic.~~

~~e. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.~~

~~f. Provide a concluding statement or section that follows from and supports the information or explanation presented (e.g., articulating implications or the significance of the topic).~~

~~W.11.3. Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.~~

~~a. Engage and orient the reader by setting out a problem, situation, or observation and its significance, establishing one or multiple point(s) of view, and introducing a narrator and/or characters; create a smooth progression of experiences or events.~~

~~b. Use narrative techniques, such as dialogue, pacing, description, reflection, and multiple plot lines, to develop experiences, events, and/or characters~~

~~c. Use a variety of techniques to sequence events so that they build on one another to create a coherent whole and build toward a particular tone and outcome (e.g., a sense of mystery, suspense, growth, or resolution).~~

~~d. Use precise words and phrases, telling details, and sensory language to convey a vivid picture~~

of the experiences, events, setting, and/or characters.

e. Provide a conclusion that follows from and reflects on what is experienced, observed, or resolved over the course of the narrative.

Production and Distribution of Writing

W.11.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3 above.)

W.11.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (Editing for conventions should demonstrate command of Language standards 1–3 up to and including grades 11–12 on page 54.)

W.11.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge

W.11.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

W.11.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

W.11.9. Draw evidence from literary or informational texts to support analysis, reflection, and research.

a. Apply grades 11–12 Reading standards to literature (e.g., "Demonstrate knowledge of eighteenth-, nineteenth- and early-twentieth-century foundational works of American literature, including how two or more texts from the same period treat similar themes or topics").

b. Apply grades 11–12 Reading standards to literary nonfiction (e.g., "Delineate and evaluate the reasoning in seminal U.S. texts, including the application of constitutional principles and use of legal reasoning [e.g., in U.S. Supreme Court Case majority opinions and dissents] and the premises, purposes, and arguments in works of public advocacy [e.g., The Federalist, presidential addresses]").

Range of Writing

W.11.10. Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

College and Career Readiness Anchor Standards for *Speaking and Listening*

Comprehension and Collaboration

SL.11.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11–12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.

a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.

b. Work with peers to promote civil, democratic discussions and decision-making, set clear goals and deadlines, and establish individual roles as needed.

c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.

d. Respond thoughtfully to diverse perspectives; synthesize comments, claims, and evidence made on all sides of an issue; resolve contradictions when possible; and determine what additional information or research is required to deepen the investigation or complete the task.

SL.11.2. Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.

SL.11.3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric, assessing the stance, premises, links among ideas, word choice, points of emphasis, and tone used.

Presentation of Knowledge and Ideas

SL.11.4. Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.

SL.11.5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and

~~interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.~~

~~SL.11.6. Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate. (See grades 11–12 Language standards 1 and 3 on page 54 for specific expectations.)~~

~~College and Career Readiness Anchor Standards for *Language*~~

~~**Conventions of Standard English**~~

~~L.11.1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.~~

~~a. Apply the understanding that usage is a matter of convention, can change over time, and is sometimes contested.~~

~~b. Resolve issues of complex or contested usage, consulting references (e.g., Merriam-Webster's Dictionary of English Usage, Garner's Modern American Usage) as needed.~~

~~L.11.2. Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.~~

~~a. Observe hyphenation conventions.~~

~~b. Spell correctly.~~

~~**Knowledge of Language**~~

~~L.11.3. Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.~~

~~a. Vary syntax for effect, consulting references (e.g., Tufte's Artful Sentences) for guidance as needed; apply an understanding of syntax to the study of complex texts when reading.~~

~~**Vocabulary Acquisition and Use**~~

~~L.11.4. Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grades 11–12 reading and content, choosing flexibly from a range of strategies.~~

~~a. Use context (e.g., the overall meaning of a sentence, paragraph, or text; a word's position or function in a sentence) as a clue to the meaning of a word or phrase.~~

~~b. Identify and correctly use patterns of word changes that indicate different meanings or parts of speech (e.g., conceive, conception, conceivable).~~

~~c. Consult general and specialized reference materials (e.g., dictionaries, glossaries, thesauruses), both print and digital, to find the pronunciation of a word or determine or clarify its precise meaning, its part of speech, its etymology, or its standard usage.~~

~~d. Verify the preliminary determination of the meaning of a word or phrase (e.g., by checking the inferred meaning in context or in a dictionary).~~

~~L.11.5. Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.~~

~~a. Interpret figures of speech (e.g., hyperbole, paradox) in context and analyze their role in the text.~~

~~b. Analyze nuances in the meaning of words with similar denotations.~~

~~L.11.6. Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.~~

~~Reading Standards for Literacy in History/Social Studies (11-12)~~

~~Key Ideas and Details~~

~~RH.11.1 Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.~~

~~RH.11.2. Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas~~

~~RH.11.3. Evaluate various explanations for actions or events and determine which explanation best accords with textual evidence, acknowledging where the text leaves matters uncertain~~

~~Craft and Structure~~

~~RH.11.4. Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10).~~

~~RH.11.5. Analyze in detail how a complex primary source is structured, including how key sentences, paragraphs, and larger portions of the text contribute to the whole.~~

~~RH.11.6. Evaluate authors' differing points of view on the same historical event or issue by assessing the authors' claims, reasoning, and evidence.~~

Integration of Knowledge and Ideas

RH.11.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

RH.11.8. Evaluate an author's premises, claims, and evidence by corroborating or challenging them with other information.

RH.11.9. Integrate information from diverse sources, both primary and secondary, into a coherent understanding of an idea or event, noting discrepancies among sources.

Range of Reading and Level of Text Complexity

RH.11.10. By the end of grade 12, read and comprehend history/social studies texts in the grades 11–CCR text complexity band independently and proficiently.

Reading Standards for Literacy in Science and Technical Subjects (11-12)

Key Ideas and Details

RST.11.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11.2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

RST.11.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

Craft and Structure

RST.11.4. 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.

RST.11.5. Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

RST.11.6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.

Integration of Knowledge and Ideas

RST.11.7. 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.~~

~~RST.11.8. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.~~

~~RST.11.9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.~~

~~Range of Reading and Level of Text Complexity~~

~~RST.11.10. By the end of grade 12, read and comprehend science/technical texts in the grades 11–CCR text complexity band independently and proficiently.~~

~~Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects (11-12)~~

~~Text Types and Purposes~~

~~WHST.11.1. Write arguments focused on discipline-specific content.~~

~~a. Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.~~

~~b. Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.~~

~~c. Use words, phrases, and clauses as well as varied syntax to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.~~

~~d. Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.~~

~~e. Provide a concluding statement or section that follows from or supports the argument presented.~~

~~ST.11.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.~~
~~a. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g.,~~

headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.

b. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.

c. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.

d. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.

e. Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

WHST.11.3. (Not applicable as a separate requirement)

Production and Distribution of Writing

WHST.11.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

WHST.11.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.11.6. Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

Research to Build and Present Knowledge

WHST.11.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

WHST.11.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

WHST.11.9. Draw evidence from informational texts to support analysis, reflection, and

~~research.~~

~~Range of Writing~~

~~WHST.11.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.~~

College and Career Readiness Standards for Mathematics

	Units	1	2	3	4	5
Standards						
N-Q.1		X	X	X	X	X
N-Q.2		X	X	X	X	X
N-Q.3		X	X	X	X	X
8.EE.8						
A-SSE.1		X		X	X	X
A-SSE.2						
A-SSE.3						
A-SSE.4						
A-CED.1						
A-CED.2		X		X	X	X
A-CED.3				X	X	X
A-CED.4				X	X	X
A-REI.2						
A-REI.3		X		X	X	X
A-REI.4						
A-REI.5						
A-REI.6						
A-REI.7						
A-REI.8						
A-REI.9						
A-REI.10				X	X	X
A-REI.11						
A-REI.12						
8.F.1						
8.F.2						
8.F.3				X	X	X
8.F.4						
8.F.5						
F-IF.1						
F-IF.2						
F-IF.3						
F-IF.4				X	X	X
F-IF.5				X	X	X
F-IF.6				X	X	X
F-IF.7				X	X	X
F-IF.8						
F-IF.9						
F-BF.1						
F-BF.2						
F-BF.3						
F-BF.4						
F-BF.5						
F-LE.1				X	X	X
F-LE.2				X	X	X
F-LE.3				X	X	X
F-LE.4				X	X	X
F-LE.5				X	X	X
8.G.6						
8.G.7				X	X	X
8.G.8				X	X	X
G-CO.1						
G-CO.2				X	X	X
G-CO.3						
G-CO.4						
G-CO.5				X	X	X
G-CO.6						
G-CO.7						X
G-CO.8						

G-CO.9						
G-CO.10						
G-CO.11						
G-CO.12						
G-CO.13						
8.SP.1						
8.SP.2						
8.SP.3						
8.SP.4						
S-ID.1						
S-ID.2						
S-ID.3						
S-ID.4						
S-ID.5						
S-ID.6						
S-ID.7				X	X	X
S-ID.8				X	X	X
S-ID.9				X	X	X
N-RN.1						
N-RN.2						
N-RN.3						
N-Q.1		X		X	X	X
N-Q.2		X		X	X	X
N-Q.3		X		X	X	X
A-APR.				X	X	X
A-APR.2						
A-APR.3						
A-APR.4						
A-APR.5						
A-APR.6						
A-APR.7						
G-SRT.1						X
G-SRT.2						X
G-SRT.3						X
G-SRT.4						
G-SRT.5						X
G-SRT.6				X	X	X
G-SRT.7						
G-SRT.8						
G-SRT.9						
G-SRT.10						
G-SRT.11						
G-C.1						
G-C.2						
G-C.3						
G-C.4						
G-C.5						
G-GPE.1						
G-GPE.2						
G-GPE.3						
G-GPE.4						
G-GPE.5						
G-GPE.6						
G-GPE.7						
G-GMD.1						
G-GMD.2						
G-GMD.3						X
G-GMD.4						
G-MG.1						
G-MG.2						
G-MG.3				X	X	X
N-CN.1						
N-CN.2						
N-CN.3						
N-CN.4						

~~N-CN.5~~						
~~N-CN.6~~						
~~N-CN.7~~						
~~N-CN.8~~						
~~N-CN.9~~						
~~F-TF.1~~				~~X~~		~~X~~
~~F-TF.2~~						
~~F-TF.3~~						
~~F-TF.4~~						
~~F-TF.5~~						
~~F-TF.6~~						
~~F-TF.7~~						
~~F-TF.8~~						
~~F-TF.9~~						
~~S-IC.1~~						
~~S-IC.2~~						
~~S-IC.3~~						
~~S-IC.4~~						
~~S-IC.5~~						
~~S-IC.6~~						
~~S-CP.1~~						
~~S-CP.2~~						
~~S-CP.3~~						
~~S-CP.4~~						
~~S-CP.5~~						
~~S-CP.6~~						
~~S-CP.7~~						
~~S-CP.8~~						
~~S-CP.9~~						
~~N-VM.1~~				~~X~~	~~X~~	~~X~~
~~N-VM.2~~				~~X~~	~~X~~	~~X~~
~~N-VM.3~~				~~X~~	~~X~~	~~X~~
~~N-VM.4~~				~~X~~	~~X~~	~~X~~
~~N-VM.5~~						
~~N-VM.6~~						
~~N-VM.7~~						
~~N-VM.8~~						
~~N-VM.9~~						
~~N-VM.10~~						
~~N-VM.11~~						
~~N-VM.12~~						
~~S-MD.1~~						
~~S-MD.2~~						
~~S-MD.3~~						
~~S-MD.4~~						
~~S-MD.5~~						
~~S-MD.6~~						
~~S-MD.7~~						

Mathematics (High School)

Number and Quantity

The Real Number System
N-RN.1. Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents.

N-RN.2. Rewrite expressions involving radicals and rational exponents using the properties of exponents.

N-RN.3. Explain why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a nonzero rational number and an irrational number is irrational.

Quantities

N-Q.1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N-Q.2. Define appropriate quantities for the purpose of descriptive modeling.

N-Q.3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

The Complex Number System

N-CN.1. Know there is a complex number i such that i2=−1, and every complex number has the form a + bi with a and b real.

N-CN.2. Use the relation i2=−1 and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers.

N-CN.3. (+) Find the conjugate of a complex number; use conjugates to find moduli and quotients of complex numbers.

N-CN.4. (+) Represent complex numbers on the complex plane in rectangular and polar form (including real and imaginary numbers), and explain why the rectangular and polar forms of a given complex number represent the same number.

N-CN.5. (+) Represent addition, subtraction, multiplication, and conjugation of complex numbers geometrically on the complex plane; use properties of this representation for computation. For example, (−1 + √3 i)3= 8 because (−1 + √3 i) has modulus 2 and argument 120°.

~~N-CN.6. (+) Calculate the distance between numbers in the complex plane as the modulus of the difference, and the midpoint of a segment as the average of the numbers at its endpoints.~~

~~N-CN.7. Solve quadratic equations with real coefficients that have complex solutions.~~

~~N-CN.8. (+) Extend polynomial identities to the complex numbers. For example, rewrite x2+ 4 as (x + 2i)(x – 2i).~~

~~N-CN.9. (+) Know the Fundamental Theorem of Algebra; show that it is true for quadratic polynomials.~~

~~Vector and Matrix Quantities~~

~~N-VM.1. (+) Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g., v, |v|, ||v||, v).~~

~~N-VM.2. (+) Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point.~~

~~N-VM.3. (+) Solve problems involving velocity and other quantities that can be represented by vectors.~~

~~N-VM.4. (+) Add and subtract vectors~~

~~N-VM.4.a. Add vectors end-to-end, component-wise, and by the parallelogram rule. Understand that the magnitude of a sum of two vectors is typically not the sum of the magnitudes.~~

~~N-VM.4.b. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum.~~

~~N-VM.4.c. Understand vector subtraction v – w as v + (–w), where –w is the additive inverse of w, with the same magnitude as w and pointing in the opposite direction. Represent vector subtraction graphically by connecting the tips in the appropriate order, and perform vector subtraction component-wise.~~

~~N-VM.5. (+) Multiply a vector by a scalar.~~

~~N-VM.5.a. Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise, e.g., as c(vx, vy) = (cvx, cvy).~~

~~N-VM.5.b. Compute the magnitude of a scalar multiple cv using ||cv|| = |c|v. Compute the direction of cv knowing that when |c|v ≠ 0, the direction of cv is either along v (for c > 0) or against v (for c < 0).~~

~~N-VM.6. (+) Use matrices to represent and manipulate data, e.g., to represent payoffs or~~

~~incidence relationships in a network.~~

~~N-VM.7. (+) Multiply matrices by scalars to produce new matrices, e.g., as when all of the payoffs in a game are doubled.~~

~~N-VM.8. (+) Add, subtract, and multiply matrices of appropriate dimensions.~~

~~N-VM.9. (+) Understand that, unlike multiplication of numbers, matrix multiplication for square matrices is not a commutative operation, but still satisfies the associative and distributive properties~~

~~N-VM.10. (+) Understand that the zero and identity matrices play a role in matrix addition and multiplication similar to the role of 0 and 1 in the real numbers. The determinant of a square matrix is nonzero if and only if the matrix has a multiplicative inverse.~~

~~N-VM.11. (+) Multiply a vector (regarded as a matrix with one column) by a matrix of suitable dimensions to produce another vector. Work with matrices as transformations of vectors.~~

~~N-VM.12. (+) Work with 2 × 2 matrices as transformations of the plane, and interpret the absolute value of the determinant in terms of area.~~

~~Algebra~~

~~Seeing Structure in Expressions~~

~~A-SSE.1. Interpret expressions that represent a quantity in terms of its context.~~

~~A-SSE.1.a. Interpret parts of an expression, such as terms, factors, and coefficients.~~

~~A-SSE.1.b. Interpret complicated expressions by viewing one or more of their parts as a single entity. For example, interpret P(1+r)n as the product of P and a factor not depending on P.~~

~~A-SSE.2. Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.~~

~~A-SSE.3. Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.~~

~~A-SSE.3.a. Factor a quadratic expression to reveal the zeros of the function it defines.~~

~~A-SSE.3.b. Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines.~~

~~A-SSE.3.c. Use the properties of exponents to transform expressions for exponential functions.~~
~~A-SSE.4. Derive the formula for the sum of a finite geometric series (when the common ratio is not 1), and use the formula to solve problems. For example, calculate mortgage payments.~~

~~Arithmetic with Polynomials and Rational Expressions~~

~~A-APR.1. Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials~~

~~A-APR.2. Know and apply the Remainder Theorem: For a polynomial p(x) and a number a, the remainder on division by x – a is p(a), so p(a) = 0 if and only if (x – a) is a factor of p(x).~~

~~A-APR.3. Identify zeros of polynomials when suitable factorizations are available, and use the zeros to construct a rough graph of the function defined by the polynomial.~~

~~A-APR.4. Prove polynomial identities and use them to describe numerical relationships.~~

~~A-APR.5. (+) Know and apply the Binomial Theorem for the expansion of (x+ y)n in powers of x and y for a positive integer n, where x and y are any numbers, with coefficients determined for example by Pascal's Triangle.~~

~~A-APR.6. Rewrite simple rational expressions in different forms; write a(x)/b(x)in the form q(x) + r(x)/b(x), where a(x), b(x), q(x), and r(x) are polynomials with the degree of r(x) less than the degree of b(x), using inspection, long division, or, for the more complicated examples, a computer algebra system.~~

~~A-APR.7. (+) Understand that rational expressions form a system analogous to the rational numbers, closed under addition, subtraction, multiplication, and division by a nonzero rational expression; add, subtract, multiply, and divide rational expressions.~~

~~Creating Equations~~

~~A-CED.1. Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.~~

~~A-CED.2. Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.~~

~~A-CED.3. Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.~~

~~A-CED.4. Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V =IR to highlight resistance R.~~

~~Reasoning with Equations and Inequalities~~

~~A-REI.1. Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.~~

~~A-REI.2. Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.~~

~~A-REI.3. Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.~~

~~A-REI.4. Solve quadratic equations in one variable.~~

~~A-REI.4.a. Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x - p)^2 = q$ that has the same solutions. Derive the quadratic formula from this form.~~

~~A-REI.4.b. Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers a and b.~~

~~A-REI.5. Prove that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.~~

~~A-REI.6. Solve systems of linear equations exactly and approximately (e.g., with graphs), focusing on pairs of linear equations in two variables.~~

~~A-REI.7. Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically. For example, find the points of intersection between the line $y = -3x$ and the circle $x^2 + y^2 = 3$.~~

~~A-REI.8. (+) Represent a system of linear equations as a single matrix equation in a vector variable.~~

~~A-REI.9. (+) Find the inverse of a matrix if it exists and use it to solve systems of linear equations (using technology for matrices of dimension 3×3 or greater).~~

~~A-REI.10. Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).~~

~~A-REI.11. Explain why the x-coordinates of the points where the graphs of the equations $y = f(x)$ and $y = g(x)$ intersect are the solutions of the equation $f(x) = g(x)$; find the solutions approximately, e.g., using technology to graph the functions, make tables of values, or find successive approximations. Include cases where $f(x)$ and/or $g(x)$~~

~~are linear, polynomial, rational, absolute value, exponential, and logarithmic functions.~~

~~A-REI.12.Graph the solutions to a linear inequality in two variables as a half plane (excluding the boundary in the case of a strict inequality), and graph the solution set to a system of linear inequalities in two variables as the intersection of the corresponding half-planes.~~

~~**Functions**~~

~~**Interpreting Functions**~~

~~F-IF.1. Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then f(x) denotes the output of f corresponding to the input x. The graph of f is the graph of the equation y = f(x).~~

~~F-IF.2. Use function notation, evaluate functions for inputs in their domains, and interpret statements that use function notation in terms of a context.~~

~~F-IF.3. Recognize that sequences are functions, sometimes defined recursively, whose domain is a subset of the integers. For example, the Fibonacci sequence is defined recursively by f(0) = f(1) = 1, f(n+1) = f(n) + f(n-1) for n ≥ 1.~~

~~F-IF.4. For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.~~

~~F-IF.5. Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a~~
~~factory, then the positive integers would be an appropriate domain for the function.~~

~~F-IF.6. Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.~~

~~F-IF.7. Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.~~

~~F-IF.7.a. Graph linear and quadratic functions and show intercepts, maxima, and minima.~~

~~F-IF.7.b. Graph square root, cube root, and piecewise-defined functions, including step functions and absolute value functions.~~
~~F-IF.7.c. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior.~~

F-IF.7.d. (+) Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior.

F-IF.7.e. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.

F-IF.8. Write a function defined by an expression in different but equivalent forms to reveal and explain different properties of the function.

F-IF.8.a. Use the process of factoring and completing the square in a quadratic function to show zeros, extreme values, and symmetry of the graph, and interpret these in terms of a context.

F-IF.8.b. Use the properties of exponents to interpret expressions for exponential functions.

F-IF.9. Compare properties of two functions each represented in a different way (algebraically, graphically, numerically in tables, or by verbal descriptions). For example, given a graph of one quadratic function and an algebraic expression for another, say which has the larger maximum.

Building Functions

F-BF.1. Write a function that describes a relationship between two quantities.

F-BF.1.a. Determine an explicit expression, a recursive process, or steps for calculation from a context.

F-BF.1.b. Combine standard function types using arithmetic operations. For example, build a function that models the temperature of a cooling body by adding a constant function to a decaying exponential, and relate these functions to the model.

F-BF.1.c. (+) Compose functions. For example, if T(y) is the temperature in the atmosphere as a function of height, and h(t) is the height of a weather balloon as a function of time, then T(h(t)) is the temperature at the location of the weather balloon as a function of time.

F-BF.2. Write arithmetic and geometric sequences both recursively and with an explicit formula, use them to model situations, and translate between the two forms.

F-BF.3. Identify the effect on the graph of replacing f(x) by f(x) + k, k f(x), f(kx), and f(x + k) for specific values of k (both positive and negative); find the value of k given the graphs. Experiment with cases and illustrate an explanation of the effects on the graph using technology. Include recognizing even and odd functions from their graphs and algebraic expressions for them.

F-BF.4. Find inverse functions.

F-BF.4.a. Solve an equation of the form f(x) = c for a simple function f that has an inverse and

write an expression for the inverse.
F-BF.4.b. (+) Verify by composition that one function is the inverse of another.

F-BF.4.c. (+) Read values of an inverse function from a graph or a table, given that the function has an inverse.

F-BF.4.d. (+) Produce an invertible function from a non-invertible function by restricting the domain.

F-BF.5. (+) Understand the inverse relationship between exponents and logarithms and use this relationship to solve problems involving logarithms and exponents.

Linear, Quadratic, and Exponential Models

F-LE.1. Distinguish between situations that can be modeled with linear functions and with exponential functions.

F-LE.1.a. Prove that linear functions grow by equal differences over equal intervals, and that exponential functions grow by equal factors over equal intervals.

F-LE.1.b. Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.

F-LE.1.c. Recognize situations in which a quantity grows or decays by a constant percent rate per unit interval relative to another

F-LE.2. Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).

F-LE.3. Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.

F-LE.4. For exponential models, express as a logarithm the solution to ab ct = d where a, c, and d are numbers and the base b is 2, 10, or e; evaluate the logarithm using technology.

F-LE.5. Interpret the parameters in a linear or exponential function in terms of a context.

Trigonometric Functions

F-TF.1. Understand radian measure of an angle as the length of the arc on the unit circle subtended by the angle.

F-TF.2. Explain how the unit circle in the coordinate plane enables the extension of trigonometric functions to all real numbers, interpreted as radian measures of angles traversed

~~counterclockwise around the unit circle.~~

~~F-TF.3. (+) Use special triangles to determine geometrically the values of sine, cosine, tangent for π/3, π/4 and π/6, and use the unit circle to express the values of sine, cosine, and tangent for π–x, π+x, and 2π–x in terms of their values for x, where x is any real number.~~

~~F-TF.4. (+) Use the unit circle to explain symmetry (odd and even) and periodicity of trigonometric functions.~~

~~F-TF.5. Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline.~~

~~F-TF.6. (+) Understand that restricting a trigonometric function to a domain on which it is always increasing or always decreasing allows its inverse to be constructed.~~

~~F-TF.7. (+) Use inverse functions to solve trigonometric equations that arise in modeling contexts; evaluate the solutions using technology, and interpret them in terms of the context.~~

~~F-TF.8. Prove the Pythagorean identity sin2 (θ) + cos 2 (θ) = 1 and use it to find sin(θ), cos(θ), or tan(θ) given sin(θ), cos(θ), or tan(θ) and the quadrant of the angle.~~

~~F-TF.9. (+) Prove the addition and subtraction formulas for sine, cosine, and tangent and use them to solve problems.~~

~~Geometry~~

~~Congruence~~

~~G-CO.1. Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, distance along a line, and distance around a circular arc.~~

~~G-CO.2. Represent transformations in the plane using, e.g., transparencies and geometry software; describe transformations as functions that take points in the plane as inputs and give other points as outputs. Compare transformations that preserve distance and angle to those that do not (e.g., translation versus horizontal stretch).~~

~~G-CO.3. Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations and reflections that carry it onto itself.~~

~~G-CO.4. Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.~~
~~G-CO.5. Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another.~~

G-CO.6. Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent.

G-CO.7. Use the definition of congruence in terms of rigid motions to show that two triangles are congruent if and only if corresponding pairs of sides and corresponding pairs of angles are congruent.

G-CO.8. Explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motions.

G-CO.9. Prove theorems about lines and angles. Theorems include: vertical angles are congruent; when a transversal crosses parallel lines, alternate interior angles are congruent and corresponding angles are congruent; points on a perpendicular bisector of a line segment are exactly those equidistant from the segment's endpoints.

G-CO.10. Prove theorems about triangles. Theorems include: measures of interior angles of a triangle sum to 180°; base angles of isosceles triangles are congruent; the segment joining midpoints of two sides of a triangle is parallel to the third side and half the length; the medians of a triangle meet at a point.

G-CO.11. Prove theorems about parallelograms. Theorems include: opposite sides are congruent, opposite angles are congruent, the diagonals of a parallelogram bisect each other, and conversely, rectangles are parallelograms with congruent diagonals.

G-CO.12. Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.). Copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.

G-CO.13. Construct an equilateral triangle, a square, and a regular hexagon inscribed in a circle.

Similarity, Right Triangles, and Trigonometry

G-SRT.1. Verify experimentally the properties of dilations given by a center and a scale factor:

G-SRT.1.a. A dilation takes a line not passing through the center of the dilation to a parallel line, and leaves a line passing through the center unchanged.

G-SRT.1.b. The dilation of a line segment is longer or shorter in the ratio given by the scale factor.

G-SRT.2. Given two figures, use the definition of similarity in terms of similarity transformations to decide if they are similar; explain using similarity transformations the meaning of similarity for triangles as the equality of all corresponding pairs of angles and the proportionality of all corresponding pairs of sides.

G-SRT.3. Use the properties of similarity transformations to establish the AA criterion for two triangles to be similar.

G-SRT.4. Prove theorems about triangles. Theorems include: a line parallel to one side of a triangle divides the other two proportionally, and conversely; the Pythagorean Theorem proved using triangle similarity.

G-SRT.5. Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures.

G-SRT.6. Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles.

G-SRT.7. Explain and use the relationship between the sine and cosine of complementary angles.

G-SRT.8. Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.

G-SRT.9. (+) Derive the formula A = 1/2 ab sin(C) for the area of a triangle by drawing an auxiliary line from a vertex perpendicular to the opposite side.

G-SRT.10. (+) Prove the Laws of Sines and Cosines and use them to solve problems.

G-SRT.11. (+) Understand and apply the Law of Sines and the Law of Cosines to find unknown measurements in right and non-right triangles (e.g., surveying problems, resultant forces).

Circles

G-C.1. Prove that all circles are similar.

G-C.2. Identify and describe relationships among inscribed angles, radii, and chords. Include the relationship between central, inscribed, and circumscribed angles; inscribed angles on a diameter are right angles; the radius of a circle is perpendicular to the tangent where the radius intersects the circle.

G-C.3. Construct the inscribed and circumscribed circles of a triangle, and prove properties of angles for a quadrilateral inscribed in a circle.

G-C.4. (+) Construct a tangent line from a point outside a given circle to the circle.
G-C.5. Derive using similarity the fact that the length of the arc intercepted by an angle is proportional to the radius, and define the radian measure of the angle as the constant of proportionality; derive the formula for the area of a sector.

Expressing Geometric Properties with Equations

G-GPE.1. Derive the equation of a circle of given center and radius using the Pythagorean Theorem; complete the square to find the center and radius of a circle given by an equation.

G-GPE.2. Derive the equation of a parabola given a focus and directrix.

G-GPE.3. (+) Derive the equations of ellipses and hyperbolas given the foci, using the fact that the sum or difference of distances from the foci is constant.

G-GPE.4. Use coordinates to prove simple geometric theorems algebraically. For example, prove or disprove that a figure defined by four given points in the coordinate plane is a rectangle; prove or disprove that the point (1, √3) lies on the circle centered at the origin and containing the point (0, 2).

G-GPE.5. Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point).

G-GPE.6. Find the point on a directed line segment between two given points that partitions the segment in a given ratio.

G-GPE.7. Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula.

Geometric Measurement and Dimension

G-GMD.1. Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone. Use dissection arguments, Cavalieri's principle, and informal limit arguments.

G-GMD.2. (+) Give an informal argument using Cavalieri's principle for the formulas for the volume of a sphere and other solid figures.

G-GMD.3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.

G-GMD.4. Identify the shapes of two-dimensional cross-sections of three dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects.

Modeling with Geometry

G-MG.1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).

G-MG.2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).

~~G-MG.3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios).~~

~~**Statistics and Probability**~~

~~**Interpreting Categorical and Quantitative Data**~~

~~S-ID.1. Represent data with plots on the real number line (dot plots, histograms, and box plots).~~

~~S-ID.2. Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.~~

~~S-ID.3. Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).~~

~~S-ID.4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.~~

~~S-ID.5. Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.~~

~~S-ID.6. Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.~~

~~S-ID.6.a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models.~~

~~S-ID.6.b. Informally assess the fit of a function by plotting and analyzing residuals.~~

~~S-ID.6.c. Fit a linear function for a scatter plot that suggests a linear association.~~

~~S-ID.7. Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.~~
~~S-ID.8. Compute (using technology) and interpret the correlation coefficient of a linear fit.~~

~~S-ID.9. Distinguish between correlation and causation.~~

~~**Making Inferences and Justifying Conclusions**~~

~~S-IC.1. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.~~

S-IC.2. Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation. For example, a model says a spinning coin falls heads up with probability 0.5. Would a result of 5 tails in a row cause you to question the model?

S-IC.3. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.

S-IC.4. Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.

S-IC.5. Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.

S-IC.6. Evaluate reports based on data.

Conditional Probability and the Rules of Probability

S-CP.1. Describe events as subsets of a sample space (the set of outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events ("or," "and," "not").

S-CP.2. Understand that two events A and B are independent if the probability of A and B occurring together is the product of their probabilities, and use this characterization to determine if they are independent.

S-CP.3. Understand the conditional probability of A given B as P(A and B)/P(B), and interpret independence of A and B as saying that the conditional probability of A given B is the same as the probability of A, and the conditional probability of B given A is the same as the probability of B.

S-CP.4. Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities. For example, collect data from a random sample of students in your school on their favorite subject among math, science, and English. Estimate the probability that a randomly selected student from your school will favor science given that the student is in tenth grade. Do the same for other subjects and compare the results.

S-CP.5. Recognize and explain the concepts of conditional probability and independence in everyday language and everyday situations. For example, compare the chance of having lung cancer if you are a smoker with the chance of being a smoker if you have lung cancer.

S-CP.6. Find the conditional probability of A given B as the fraction of B's outcomes that also belong to A, and interpret the answer in terms of the model.

~~S-CP.7. Apply the Addition Rule, P(A or B) = P(A) + P(B) – P(A and B), and interpret the answer in terms of the model.~~

~~S-CP.8. (+) Apply the general Multiplication Rule in a uniform probability model, P(A and B) = P(A)P(B|A) = P(B)P(A|B), and interpret the answer in terms of the model.~~

~~S-CP.9. (+) Use permutations and combinations to compute probabilities of compound events and solve problems.~~

~~Using Probability to Make Decisions~~

~~S-MD.1. (+) Define a random variable for a quantity of interest by assigning a numerical value to each event in a sample space; graph the corresponding probability distribution using the same graphical displays as for data distributions.~~

~~S-MD.2. (+) Calculate the expected value of a random variable; interpret it as the mean of the probability distribution.~~

~~S-MD.3. (+) Develop a probability distribution for a random variable defined for a sample space in which theoretical probabilities can be calculated; find the expected value. For example, find the theoretical probability distribution for the number of correct answers obtained by guessing on all five questions of a multiple-choice test where each question has four choices, and find the expected grade under various grading schemes.~~

~~S-MD.4. (+) Develop a probability distribution for a random variable defined for a sample space in which probabilities are assigned empirically; find the expected value. For example, find a current data distribution on the number of TV sets per household in the United States, and calculate the expected number of sets per household. How many TV sets would you expect to find in 100 randomly selected households?~~

~~S-MD.5. (+) Weigh the possible outcomes of a decision by assigning probabilities to payoff values and finding expected values.~~

~~S-MD.5.a. Find the expected payoff for a game of chance. For example, find the expected winnings from a state lottery ticket or a game at a fast-food restaurant.~~

~~S-MD.5.b. Evaluate and compare strategies on the basis of expected values. For example, compare a high-deductible versus a low-deductible automobile insurance policy using various, but reasonable, chances of having a minor or a major accident.~~

~~S-MD.6. (+) Use probabilities to make fair decisions (e.g., drawing by lots, using a random number generator).~~

~~S-MD.7. (+) Analyze decisions and strategies using probability concepts (e.g., product testing, medical testing, pulling a hockey goalie at the end of a game).~~

Appendix D: ISTE National Educational Technology Standards for Students (NETS-S)

Standards	Unit	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
T1		X		X	X	X
T2		X		X	X	X
T3				X	X	X
T4		X		X	X	X
T5			X	X	X	X
T6			X	X	X	X

T1 Creativity and Innovation

Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students do the following:

a. Apply existing knowledge to generate new ideas, products, or processes.
b. Create original works as a means of personal or group expression.
c. Use models and simulations to explore complex systems and issues.
d. Identify trends and forecast possibilities.

T2 Communication and Collaboration

Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. Students do the following:

a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.
b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats.
c. Develop cultural understanding and global awareness by engaging with learners of other cultures.
d. Contribute to project teams to produce original works or solve problems.

T3 Research and Information Fluency

Students apply digital tools to gather, evaluate, and use information. Students do the following:

a. Plan strategies to guide inquiry.
b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
d. Process data and report results.

~~**T4** Critical Thinking, Problem Solving, and Decision Making~~

~~Students use critical-thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Students do the following:~~

~~a. Identify and define authentic problems and significant questions for investigation.~~
~~b. Plan and manage activities to develop a solution or complete a project.~~
~~c. Collect and analyze data to identify solutions and/or make informed decisions.~~
~~d. Use multiple processes and diverse perspectives to explore alternative solutions.~~

~~**T5** Digital Citizenship~~

~~Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students do the following:~~

~~a. Advocate and practice safe, legal, and responsible use of information and technology.~~
~~b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.~~
~~c. Demonstrate personal responsibility for lifelong learning.~~
~~d. Exhibit leadership for digital citizenship.~~

~~**T6** Technology Operations and Concepts~~

~~Students demonstrate a sound understanding of technology concepts, systems, and operations. Students do the following:~~

~~a. Understand and use technology systems.~~
~~b. Select and use applications effectively and productively.~~
~~c. Troubleshoot systems and applications.~~
~~d. Transfer current knowledge to learning of new technologies.~~

Appendix E: Physical Science Academic Standards

Mississippi College and Career Readiness Standards – Physical Science

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
MS Science Standards					
PHS 1.1					
PHS 1.2					
PHS 1.3					
PHS 1.4					
PHS 1.5					
PHS 1.6					
PHS 2.1					
PHS 3.1					
PHS 3.2					
PHS 3.3					
PHS 3.5					
PHS 4.1					
PHS 4.2					
PHS 4.3					
PHS 4.4					
PHS 4.5					
PHS 4.6					
PHS 5.1			x	x	x
PHS 5.2			x	x	x
PHS 5.3			x	x	x
PHS 5.4			x	x	x
PHS 5.5			x	x	x
PHS 5.6				x	
PHS 5.7				x	x
PHS 5.8					
PHS 6.1					
PHS 6.2					
PHS 6.3					
PHS 6.4					
PHS 6.5					
PHS 6.6					
PHS 6.7					
PHS 6.8					
PHS 7.1			x	x	x
PHS 7.2				x	x
PHS 7.3				x	x
PHS 7.4				x	x
PHS 8.1					

~~*PHS 8.2*~~					
~~*PHS 8.3*~~					
~~*PHS 8.4*~~					
~~*PHS 9.1*~~				~~x~~	~~x~~
~~*PHS 9.2*~~				~~x~~	~~x~~
~~*PHS 9.3*~~					
~~*PHS 9.4*~~					

~~**PHS.1 Nature of Matter**~~

~~Conceptual Understanding: To actively develop scientific investigation, reasoning, and logic skills, this standard develops basic ideas about the characteristics and structure of matter. Matter is anything that has mass and occupies space. All matter is made up of small particles called atoms. Matter can exist as a solid, liquid, gas, or plasma~~

~~**PHS.1 Students will demonstrate an understanding of the nature of matter.**~~

~~PHS.1.1 Use contextual evidence to describe particle theory of matter. Examine the particle properties of solids, liquids, and gases.~~

~~PHS.1.2 Use scientific research to generate models to compare physical and chemical properties of elements, compounds, and mixtures.~~

~~PHS.1.3 Conduct an investigation to determine the identity of unknown substances by comparing properties to known substances.~~

~~PHS.1.4 Design and conduct investigations to explore techniques in measurements of mass, volume, length, and temperature.~~

~~PHS.1.5 Design and conduct an investigation using graphical analysis (e.g., line graph) to determine the density of liquids and/or solids.~~

~~PHS.1.6 Use mathematical and computational analysis to solve density problems. Manipulate the density formula to determine density, volume, or mass or use dimensional analysis to solve problems~~

~~**PHS.2 Atomic Theory**~~

~~Conceptual Understanding: Many scientists have contributed to our understanding of atomic structure. The atom is the basic building block of matter and consists of subatomic particles (proton, neutron, electron, and quark) that differ in their location, charge, and relative mass.~~

~~PHS.2 Students will demonstrate an understanding of both modern and historical theories of atomic structure.~~

~~PHS.2.1 Research and develop models (e.g., 3-D models, online simulations, or ball and stick) to investigate both modern and historical theories of atomic structure. Compare models and contributions of Dalton, Thomson, Rutherford, Bohr, and of modern atomic theory.~~

~~**PHS.3 Periodic Table**~~

~~Conceptual Understanding: The organization of the periodic table allows scientists to obtain information and develop an understanding of concepts of atomic interactions. Developing scientific investigations increases logical reasoning and deduction skills to present the nature of science in the context of key scientific concepts.~~

~~PHS.3 Students will analyze the organization of the periodic table of elements to predict atomic interactions.~~

~~PHS.3.1 Use contextual evidence to determine the organization of the periodic table, including metals, metalloids, and nonmetals; symbols; atomic number; atomic mass; chemical families/groups; and periods/series.~~

~~PHS.3.2 Using the periodic table and scientific methods, investigate the formation of compounds through ionic and covalent bonding.~~

~~PHS.3.3 Using naming conventions for binary compounds, write the compound name from the formula, and write balanced formulas from the name (e.g., carbon dioxide-CO2, sodium chloride -NaCl, iron III oxide -Fe2O3, and calcium bromide-CaBr2).~~

~~PHS.3.4 Use naming conventions to name common acids and common compounds used in classroom labs (e.g., sodium bicarbonate (baking soda), NaHCO3; hydrochloric acid, HCl; sulfuric acid, H2SO4; acetic acid (vinegar), HC2H3O2; and nitric acid, HNO3).~~

~~PHS.3.5 Use mathematical and computational analysis to determine the atomic mass of binary compounds.~~

~~PHS.4 The Law of Conservation of Matter and Energy~~

~~Conceptual Understanding: The law of conservation of matter and energy states that matter and energy can be transformed in different ways, but the total amount of mass and energy will be conserved. These concepts should be investigated and further developed in the classroom.~~

~~PHS.4 Students will analyze changes in matter and the relationship of these changes to the law of conservation of matter and energy.~~

~~PHS.4.1 Design and conduct experiments to investigate physical and chemical changes of various household products (e.g., rusting, sour milk, crushing, grinding, tearing, boiling, and freezing) and reactions of common chemicals that produce color changes or gases.~~

~~PHS.4.2 Design and conduct investigations to produce evidence that mass is conserved in chemical reactions (e.g., vinegar and baking soda in a Ziploc©bag).~~

PHS.4.3 Apply the concept of conservation of matter to balancing simple chemical equations.

PHS.4.4 Use mathematical and computational analysis to examine evidence that mass is conserved in chemical reactions using simple stoichiometry problems (1:1 mole ratio) or atomic masses to demonstrate the conservation of mass with a balanced equation.

PHS.4.5 Research nuclear reactions and their uses in the modern world, exploring concepts such as fusion, fission, stars as reactors, nuclear energy, and chain reactions.

PHS.4.6 Analyze and debate the advantages and disadvantages of nuclear reactions as energy sources.

PHS.5 Newton's Laws of Motion

Conceptual Understanding: Kinematics (contact forces) describe the motion of objects using words, diagrams, numbers, graphs, and equations. The goal of any study of kinematics is to develop scientific models to describe and explain the motion of real-world objects. Newton's laws of motion are an example of a tool that can aid in the explanation of motion.

PHS.5 Students will analyze the scientific principles of motion, force, and work.

PHS.5.1 Research the scientific contributions of Newton, and use models to communicate Newton's principles.

PHS.5.2 Design and conduct an investigation to study the motion of an object using properties such as displacement, time of motion, velocity, and acceleration.

PHS.5.3 Collect, organize, and interpret graphical data using correct metric units to determine the average speed of an object.

PHS.5.4 Use mathematical and computational analyses to show the relationships among force, mass, and acceleration (i.e., Newton's second law).

PHS.5.5 Design and construct an investigation using probe systems and/or online simulations to observe relationships between force, mass, and acceleration (F=ma).

PHS.5.6 Use an engineering design process and mathematical analysis to design and construct models to demonstrate the law of conservation of momentum (e.g., roller coasters, bicycle helmets, bumper systems).

PHS.5.7 Use mathematical and computational representations to create graphs and formulas that describe the relationships between force, work, and energy (i.e., W=Fd, KE=½ mv2, PE=mgh, W=KE).

PHS.5.8 Research the efficiency of everyday machines, and debate ways to improve their economic impact on society (e.g., electrical appliances, transportation vehicles).

PHS.6 Waves

Conceptual Understanding: Waves are everywhere in nature. Understanding of the physical world is not complete until we understand the nature, properties, and behaviors of waves. Students have experienced transverse and horizontal waves in their everyday lives. The exploration of waves in greater depth will allow students to conceptualize these waves. The goal is to develop various models of waves and apply those models to understanding wave interactions.

PHS.6 Students will explore the characteristics of waves.

PHS.6.1 Use models to analyze and describe examples of mechanical waves' properties (e.g., wavelength, frequency, speed, amplitude, rarefaction, and compression).

PHS.6.2 Analyze examples and evidence of transverse and longitudinal waves found in nature (e.g., earthquakes, ocean waves, and sound waves).

PHS.6.3 Generate wave models to explore energy transference.

PHS.6.4 Enrichment: Use an engineering design process to design and build a musical instrument to demonstrate the influence of resonance on music.

PHS.6.5 Design and conduct experiments to investigate technological applications of sound (e.g., medical uses, music, acoustics, Doppler effects, and influences of mathematical theory on music).

PHS.6.6 Research real-world applications to create models or visible representations of the electromagnetic spectrum, including visible light, infrared radiation, and ultraviolet radiation.

PHS.6.7 Enrichment: Use an engineering design process to design and construct an apparatus that forms images to project on a screen or magnify images using lenses and/or mirrors.

PHS.6.8 Enrichment: Debate the particle/wave behavior of light.

PHS.7 Energy

Conceptual Understanding: Concepts about different energy forms and energy transformations continue to be expanded and explored in greater depth, leading to the development of more mathematical applications. Focus should be on students actively developing scientific investigations, reasoning, and logic skills.

PHS.7 Students will examine different forms of energy and energy transformations.

PHS.7.1 Using digital resources, explore forms of energy (e.g., potential and kinetic energy, mechanical, chemical, electrical, thermal, radiant, and nuclear energy).

PHS.7.2 Use scientific investigations to explore the transformation of energy from one type to another (e.g., potential to kinetic energy, and mechanical, chemical, electrical, thermal, radiant, and nuclear energy interactions).

PHS.7.3 Using mathematical and computational analysis, calculate potential and kinetic energy based on given data. Use equations such as PE=mgh and KE=½ mv^2.

PHS.7.4 Conduct investigations to provide evidence of the conservation of energy as energy is converted from one form of energy to another (e.g., wind to electric, chemical to thermal, mechanical to thermal, and potential to kinetic).

PHS.8 Thermal Energy

Conceptual Understanding: Thermal energy is transferred in the form of heat. Heat is always transferred from an area of high heat to low heat. More complex concepts and terminology related to phase changes are developed, including the distinction between heat and temperature.

PHS.8 Students will demonstrate an understanding of temperature scales, heat, and thermal energy transfer.

PHS.8.1 Compare and contrast temperature scales by converting betweenCelsius, Fahrenheit, and Kelvin.

PHS.8.2 Apply particle theory to phase change and analyze freezing point, melting point, boiling point, vaporization, and condensation of different substances.

PHS.8.3 Relate thermal energy transfer to real world applications of conduction (e.g., quenching metals), convection (e.g., movement of air m asses/weather/plate tectonics), and radiation (e.g., electromagnetic).

PHS.8.4 Enrichment: Use an engineering design process to construct a simulation of heat energy transfer between systems. Calculate the calories/joules ofenergy generated by burning food products. Communicate conclusions based on evidence from the simulation.

PHS.9 Electricity

Conceptual Understanding: Electrical energy (both battery and circuit energy) is transformed into other forms of energy. Charged particles and magnetic fields are similar because they both store energy. Magnetic fields exert forces on moving charged particles. Students investigate practical uses of these concepts and develop a working understanding of the basic concepts of magnetism and electricity.

PHS.9 Students will explore basic principles of magnetism and electricity (e.g., static electricity, current electricity, and circuits).

PHS.9.1 Use digital resources and online simulations to investigate the basic principles of electricity, including static electricity, current electricity, and circuits. Use digital resources (e.g., online simulations) to build a model showing the relationship between magnetic fields and electric currents.

PHS.9.2 Distinguish between magnets, motors, and generators, and evaluate modern industrial uses of each.

PHS.9.3 Enrichment: Use an engineering design process to construct a working electric motor to perform a task. Communicate the design process and comparisons of task performance efficiencies.

PHS.9.4 Use an engineering design process to construct and test conductors, semiconductors, and insulators using various materials to optimize efficiency.

2021 Computer Science and Engineering

Course Code: 000287

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The Research and Curriculum Unit (RCU), located in Starkville, as part of Mississippi State University (MSU), was established to foster educational enhancements and innovations. In keeping with the land-grant mission of MSU, the RCU is dedicated to improving the quality of life for Mississippians. The RCU enhances intellectual and professional development of Mississippi students and educators while applying knowledge and educational research to the lives of the people of the state. The RCU works within the contexts of curriculum development and revision, research, assessment, professional development, and industrial training.

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Standards

Standards and alignment crosswalks are referenced in the appendices. Depending on the curriculum, these crosswalks should identify alignment to the standards mentioned below, as well as possible related academic topics as required in the Subject Area Testing Program in Algebra I, Biology I, English II, and U.S. History from 1877, which could be integrated into the content of the units. Mississippi's CTE CSE curriculum is aligned to the following standards:

International Society for Technology in Education Standards (ISTE)
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iste.org

Technology and Engineering Literacy Framework for the 2018 National Assessment of Educational Progress (NAEP)
"…The 2018 NAEP Technology and Engineering Framework is a statement about what should be expected of students in terms of their knowledge and skills with technology, written to be the basis for an assessment of technology and engineering literacy appropriate for all students. It opens the door to seeing what our K-12 students know about technology and engineering, in the same way that NAEP already assesses their knowledge and capabilities in reading, mathematics, science, and other subjects."
nationsreportcard.gov

2018 Mississippi College- and Career-Readiness Standards (MCCRS) for Computer Science
In an effort to closely align instruction for students who are progressing toward postsecondary study and the workforce, the 2018 MCCRS for Computer Science includes grade- and course-specific standards for K-12 computer science. Mississippi has adapted these standards from the nationally developed Computer Science Teachers Association K-12 Computer Science Standards (Revised 2017).
mdek12.org/oae/college-and-career-readiness-standards

Framework for 21st Century Learning
In defining 21st-century learning, the Partnership for 21st Century Skills has embraced key themes and skill areas that represent the essential knowledge for the 21st century: global awareness; financial, economic, business and entrepreneurial literacy; civic literacy; health literacy; environmental literacy; learning and innovation skills; information, media, and technology skills; and life and career skills. 21 *Framework Definitions* (2019).
battelleforkids.org/networks/p21/frameworks-resources

Preface

Secondary CTE programs in Mississippi face many challenges resulting from sweeping educational reforms at the national and state levels. Schools and teachers are increasingly being held accountable for providing applied learning activities to every student in the classroom. This accountability is measured through increased requirements for mastery and attainment of competency as documented through both formative and summative assessments. This document provides information, tools, and solutions that will aid students, teachers, and schools in creating and implementing applied, interactive, and innovative lessons. Through best practices, alignment with national standards and certifications, community partnerships, and a hands-on, student-centered concept, educators will be able to truly engage students in meaningful and collaborative learning opportunities.

The courses in this document reflect the statutory requirements as found in Section 37-3-49, *Mississippi Code of 1972*, as amended (Section 37-3-46). In addition, this curriculum reflects guidelines imposed by federal and state mandates (Laws, 1988, Ch. 487, §14; Laws, 1991, Ch. 423, §1; Laws, 1992, Ch. 519, §4 eff. from and after July 1, 1992; Strengthening Career and Technical Education for the 21st Century Act, 2019 [Perkins V]; and Every Student Succeeds Act, 2015).

Mississippi Teacher Professional Resources

The following are resources for Mississippi teachers:

- Curriculum, Assessment, Professional Learning
  - Program resources can be found at the RCU's website, rcu.msstate.edu.
- Learning Management System: An Online Resource
  - Learning management system information can be found at the RCU's website, under Professional Learning.

Should you need additional instructions, call the RCU at 662.325.2510.

Executive Summary

Pathway Description

Computer science and engineering is a project-based course designed to instruct students through activities that require modeling, physical design, and coding, leading them to discover how computing and engineering work together to solve problems. This course offers students exposure to the engineering design process which introduces them to problem solving and critical thinking as well as the basics of project management and teamwork. This knowledge will assist them in making informed and meaningful decisions about high school coursework and broaden their horizons for career opportunities.

Grade Level and Class Size Recommendations

It is recommended that students enter this course as an eighth grader. Exceptions to this are a district-level decision based on class size, enrollment numbers, and student maturity. A maximum of 24 students is recommended for classroom-based courses.

Student Prerequisites

Currently, no prerequisites are required to take this course.

Assessment

The latest assessment blueprint for the curriculum can be found at rcu.msstate.edu/curriculum/curriculumdownload.

Applied Academic Credit

The latest academic credit information can be found at mdek12.org/ese/approved-course-for-the-secondary-schools.

Teacher Licensure

The latest teacher licensure information can be found at mdek12.org/oel/apply-for-an-educator-license.

Professional Learning

If you have specific questions about the content of any training sessions provided, please contact the RCU at 662.325.2510.

~~Course Outlines~~

~~This curriculum consists of one 1-credit course that should be completed in the eighth grade.~~

~~Computer Science and Engineering — Course Code: 000287~~

~~Unit~~	~~Title~~	~~Hours~~
~~1~~	~~Orientation, Safety, and Student Organizations~~	~~10~~
~~2~~	~~Project Design~~	~~25~~
~~3~~	~~Introduction to Modeling and 3D Printing~~	~~30~~
~~4~~	~~Coding~~	~~10~~
~~5~~	~~Introduction to Electronics~~	~~10~~
~~6~~	~~Introduction to Robotics~~	~~45~~
~~Total~~		~~130~~

Career Pathway Outlook

Overview

Professionals working in computer science and engineering apply principles of science, technology, engineering, and mathematics to develop economical solutions for society. Whether it is working on scientific discoveries or commercial applications, employees in these rapidly changing fields are expected to continuously pursue further education to remain current in knowledge and skill. Licensing requirements for computer science and engineering professionals vary widely depending on the field or sector. Credentials may involve a professional degree, industry certifications, training, and/or practical work experience. The 2016-2026 occupational employment projections and wage estimates for Mississippi were used to determine where computer science and engineering employment needs would be in the population over a 10-year period.

Needs of the Future Workforce

Data for this synopsis was compiled from the Mississippi Department of Employment Security (2020). Employment opportunities in Mississippi representative of various engineering occupations are listed below.

Table 1.1: Current and Projected Occupation Report

Description	Jobs, 2016	Projected Jobs, 2026	Change (Number)	Change (Percent)	Average Hourly Earnings, 2016
Computer and Mathematical Occupations	12,210	13,030	820	6.7	$31.94
Architecture and Engineering Occupations	15,320	16,410	1,090	7.1	$56.90
Health Care Practitioners and Technical Occupations	78,060	84,220	6,160	7.9	$30.87
Life, Physical, and Social Science Occupations	7,260	7,660	400	5.5	$28.54
Installation, Maintenance, and Repair Occupations	54,030	57,420	3,390	6.3	$19.63
Production Occupations	103,140	103,960	820	.8	$16.45
Transportation and Material Moving Occupations	92,550	97,530	4,980	5.4	$15.46

Source: Mississippi Department of Employment Security; mdes.ms.gov (2020).

Perkins V Requirements and Academic Infusion

The CSE curriculum meets Perkins V requirements of introducing students to and preparing them for high-skill, high-wage occupations in computer science fields. It also offers students a program of study, including secondary, postsecondary, and institutions of higher learning courses, that will further prepare them for computer science careers. Additionally, this curriculum is integrated with academic college- and career-readiness standards. Lastly, it focuses on ongoing and meaningful professional development for teachers as well as relationships with industry.

Transition to Postsecondary Education

The latest articulation information for secondary to postsecondary can be found at the Mississippi Community College Board website, mccb.edu.

Best Practices

Innovative Instructional Technologies

Classrooms should be equipped with tools that will teach today's digital learners through applicable and modern practices. The CSE educator's goal should be to include teaching strategies that incorporate current technology. To make use of the latest online communication tools—wikis, blogs, podcasts, and social media platforms, for example—the classroom teacher is encouraged to use a learning management system that introduces students to education in an online environment and places more of the responsibility of learning on the student.

Differentiated Instruction

Students learn in a variety of ways, and numerous factors—students' background, emotional health, and circumstances, for example—create unique learners. By providing various teaching and assessment strategies, students with various learning preferences can have more opportunity to succeed.

CTE Student Organizations

Teachers should investigate opportunities to sponsor a student organization. There are several here in Mississippi that will foster the types of learning expected from the CSE curriculum. Skills USA and TSA are examples of student organizations for computer science. Student organizations provide participants and members with growth opportunities and competitive events. They also open the doors to the world of computer science careers and scholarship opportunities.

Cooperative Learning

Cooperative learning can help students understand topics when independent learning cannot. Therefore, you will see several opportunities in the CSE curriculum for group work. To function in today's workforce, students need to be able to work collaboratively with others and solve problems without excessive conflict. The CSE curriculum provides opportunities for students to work together and help each other complete complex tasks. There are many field experiences within the CSE curriculum that will allow and encourage collaboration with professionals currently in the computer science field.

Work-Based Learning

Work-based learning is an extension of understanding competencies taught in the CSE classroom. This curriculum is designed in a way that necessitates active involvement by the students in the community around them and the global environment. These real-world connections and applications link all types of students to knowledge, skills, and professional dispositions. Work-based learning should encompass ongoing and increasingly more complex involvement with local companies and computer science professionals. Thus, supervised collaboration and immersion into computer science around the students are keys to students' success, knowledge, and skills development.

Professional Organizations

For students:
SkillsUSA
skillsusa.org

Technology Student Association
tsaweb.org

For teachers:
Mississippi Educational Computing Association
ms-meca.org

Mississippi Association of Career and Technical Education
mississippiacte.com

Mississippi Business Education Association
ms-mbea.com

Computer Science Teachers Association
csteachers.org

Association of Career and Technical Education
acteonline.org

International Society for Technology in Education
iste.org

Student Competitions

Teachers are encouraged to charter one of the student organizations on the previous page and at least one of the following student competitions (student organization charter and competition may occur in tandem):

BEST Robotics
bestinc.org

FIRST Robotics (LEGO League or Tech Challenge)
firstinspires.org

SeaPerch National Challenge
seaperch.org/index

Transportation and Civil Engineering (TRAC™) Bridge Challenge developed by the Mississippi Department of Transportation (MDOT)
mdot.ms.gov/stemeducation/programs/trac.html

VEX Robotics Competition (I.Q. or EDR through TSA, REC, or both)
vexrobotics.com

Using This Document

Suggested Time on Task
This section indicates an estimated number of clock hours of instruction that should be required to teach the competencies and objectives of the unit. A minimum of 130 hours of instruction is required for each Carnegie unit credit. The curriculum framework should account for approximately 75-80% of the time in the course. The remaining percentage of class time will include instruction in non-tested material, review for end-of-course testing, and special projects.

Competencies and Suggested Objectives
A competency represents a general concept or performance that students are expected to master as a requirement for satisfactorily completing a unit. Students will be expected to receive instruction on all competencies. The suggested objectives represent the enabling and supporting knowledge and performances that will indicate mastery of the competency at the course level.

Teacher Resources
Teacher resources for this curriculum may be found in multiple places. Many program areas have teacher resource documents that accompany the curriculum and can be downloaded from the same site as the curriculum. The teacher resource document contains references, lesson ideas, websites, teaching and assessment strategies, scenarios, skills to master, and other resources divided by unit. This document could be updated periodically by RCU staff. Please check the entire document, including the entries for each unit, regularly for new information. If you have something you would like to add or have a question about the document, call or email the RCU's instructional design specialist for your program. The teacher resource document can be downloaded at rcu.msstate.edu/curriculum/curriculumdownload.aspx. All teachers should request to be added to the Canvas Resource Guide for their course. This is where all resources will be housed. To be added to the guide, send a Help Desk ticket to the RCU by emailing helpdesk@rcu.msstate.edu.

Unit 1: Orientation, Safety, and Student Organizations

Competencies and Suggested Objectives
1. Identify expectations, school policies, student organizations, and program policies related to this course. DOK1 a. Identify school rules, policies, and procedures. b. Identify and establish classroom guidelines and procedures. c. Review course standards.
2. Analyze general safety in the project-based learning classroom. DOK3 a. Identify, describe, and demonstrate the importance of safety and the proper use of equipment. b. Construct a diagram of the classroom/lab to scale, including the location of safety equipment. c. Complete a safety test exhibiting 100% mastery of safety practices and procedures.
3. Identify and demonstrate the proper file storage, sharing, and maintenance techniques for student work. DOK2
4. Describe the technology student organizations available and demonstrate an ongoing understanding of teamwork and leadership strategies. DOK2 a. Describe the importance of effective communication skills. • Demonstrate verbal and nonverbal communication skills. • Apply appropriate speaking and listening skills to class- and work-related situations. b. Apply leadership skills to class- and work-related situations. • Define leadership. • Discuss the attributes of a leader. • Identify the roles a leader can assume. c. Utilize team-building skills in class- and work-related situations. • Define team building. • Discuss the attributes of a team. • Identify the roles included in a team. d. Discuss the various competitions offered through a program area student organization. • Describe each of the competitions and the skills needed to accomplish the tasks. • Perform the tasks needed to complete an assigned requirement for a competition.
5. Demonstrate proper digital citizenship concepts (ongoing). DOK2 a. Understand the ethical use of materials created by others. b. Understand how cyber bullying can impact teamwork and collaboration.
Note: Competencies marked as “ongoing” will be covered throughout the year. Time allotted for these competencies will be distributed over the entire course.

Unit 2: Project Design

Competencies and Suggested Objectives
1. Analyze and become familiar with the use of basic tools and techniques to plan, organize, and manage a project. DOK3 a. Define a project timeline. b. Create and calculate a sample project budget. c. Construct communications (e.g., emails, letters, texts, etc.) to interact with others regarding design and computational thinking. d. Demonstrate the principles and practice of leadership and teamwork.
2. Demonstrate knowledge and understanding of the Engineering Design Process (ongoing). DOK3 a. Identify the steps of the Engineering Design Process. b. Apply the steps of the Engineering Design Process to a specific project. c. Explain how each step of the Engineering Design Process relates to a specific project.
3. Synthesize research to understand project needs and limitations. DOK4 a. Identify and describe engineering needs and limitations. b. Identify and describe client needs and limitations.
4. Assess client needs to understand the purposes of design. DOK3 a. Express opinions respectfully and effectively. b. Critically evaluate an object for how well its design meets a given set of needs. c. Identify empathy for the client as an important component of the design process. d. Distinguish between creator needs and client needs.
5. Investigate careers in different engineering fields (e.g., electrical, mechanical, computer, industrial, etc.). DOK3
Note: Competencies marked as "ongoing" will be covered throughout the year. Time allotted for these competencies will be distributed over the entire course.

~~Unit 3: Introduction to Modeling and 3D Printing~~

~~**Competencies and Suggested Objectives**~~
~~1. Demonstrate the use of computer-aided design (CAD) software to create 3D models.~~ ~~DOK2~~ ~~a. Use appropriate resources to become familiar with a CAD workspace.~~ ~~b. Communicate CAD terms using multiple formats (e.g., verbally, textually, graphically).~~ ~~c. Complete online tutorials to create an object that includes the following parts:~~ • ~~Holes~~ • ~~Fillets~~ • ~~Lettering~~ • ~~Manipulation of pieces~~
~~2. Design a 3D model for rapid prototyping using a 3D printer.~~ ~~DOK4~~ ~~a. Use CAD software to design and create multiple objects.~~ ~~b. Use CAD software to edit/remix a design created by someone else.~~ ~~(Note: If 3D printers are not available, all objectives can be met with free software and creating models with other materials.)~~
~~3. Slice and 3D print an object created with CAD software.~~ ~~DOK4~~ ~~a. 3D print one of the designated projects or build a project from other materials (3D print as time and resources allow, having at least one example from each class).~~ ~~b. Identify and demonstrate use of the following terms while using slicing software: layer height, infill, support, and adhesion.~~
~~4. Develop a cost analysis based on time and materials.~~ ~~DOK3~~
~~5. Investigate 3D printing industry careers and examine how those careers use this technology.~~ ~~DOK3~~

Unit 4: Coding

Competencies and Suggested Objectives
1. Examine the use of Booleans and conditionals.[DOK3] a. Demonstrate proper use of IF, THEN, and ELSE statements. b. Demonstrate proper use of Boolean logic (e.g., true/false, on/off, etc.). c. Understand that all coding languages use common concepts, such as conditionals. d. Understand that conditionals are statements that are carried out when certain criteria are met. e. Evaluate a conditional statement and predict the outcome using the given input. f. Write conditional statements, defining criteria for when a program should take certain actions.
2. Apply the use of loops.[DOK2] a. Understand the effective use of loops. b. Understand and predict the behavior of a loop. c. Write valid loops with proper indention. d. Describe and give an example of the conditional part of a loop. e. Explain the standard flowchart representation for loops.
3. Investigate the use of variables.[DOK3] a. Identify a variable as a way to label and reference a value in a program. b. Use variables in a program to store a piece of information that is used multiple times. c. Correct common errors encountered when programming with variables.
4. Summarize the purpose of functions.[DOK2] a. Explain the purpose of a function. b. Demonstrate the proper use of a function.
5. Demonstrate an understanding of debugging and identify syntax errors.[DOK2]
6. Investigate careers in software development and coding.[DOK3]

~~Unit 5: Introduction to Electronics~~

~~**Competencies and Suggested Objectives**~~
~~1. Identify, analyze, and create models to explore electronics and their applications.~~ DOK4 ~~a. Review the importance of electronics safety and the proper use of lab equipment.~~ ~~b. Communicate electrical terms and their units of measure using multiple formats (e.g., verbally, graphically, textually,), including:~~ ~~• Alternating current~~ ~~• Direct current~~ ~~• Voltage~~ ~~• Amperage~~ ~~• Resistance~~ ~~c. Learn symbols for the following electronic components included on the Institute of Electronics and Electronics Engineers (IEEE) chart:~~ ~~• Resistor~~ ~~• Capacitor~~ ~~• Diode~~ ~~• Inductor~~ ~~• LED~~ ~~• Sensor (e.g., temperature and humidity, ultrasonic, photo resistor, etc.)~~
~~2. Create a physical or simulation model showing different configurations using the required components (e.g., battery, light-emitting diode [LED], light sensor, switch, etc.).~~ DOK4
~~3. Investigate careers in electrical engineering and the electronics industry and examine how those careers use this technology.~~ DOK3

Unit 6: Introduction to Robotics

Competencies and Suggested Objectives
1. Research current, past, and future applications of robots. DOK2 a. Using scholarly articles or other reputable sources, research the types and applications of robots, including: • Current, past, and future applications of robots • Advantages and disadvantages of robots b. Communicate technical information found in research using multiple formats(e.g., verbally, graphically, textually, mathematically, etc.).
2. Design and build a simple, functional robotic system using the required components (e.g., motor, battery, wires, and body/case/chassis). DOK4 a. Review the importance of safety and the proper use of lab equipment when using robots and microcontrollers.
3. Identify common microcontroller terms. DOK1 a. Communicate microcontroller terms using multiple formats (e.g., verbally, textually, graphically). b. Identify and label the components of a hands-on or simulation microcontroller from the list below: • Power sources • Inputs • Switches • Push buttons • Sensors • Joysticks and remotes • Outputs • Buzzers • LEDs • LCD modules • Motors
4. Use various programming methods/concepts to manipulate microcontroller inputs and outputs. DOK2 a. Incorporate the following methods/concepts in the programming: • Languages (e.g., Scratch, SNAP, Python, etc.) • Logic statements (e.g., IF, AND, OR, NOT, etc.) • Loops (e.g., FOR, IF, WHILE, etc.)
5. Use a microcontroller for a specified purpose. DOK2 a. Demonstrate the proper use of a microcontroller for a specified purpose. b. Explain how microcontrollers are used to manipulate a robotic system.
6. Investigate careers in the robotics industry and examine how those careers use this technology. DOK3

~~Student Competency Profile~~

~~**Student's Name: ____**~~

~~This record is intended to serve as a method of noting student achievement of the competencies in each unit. It can be duplicated for each student, and it can serve as a cumulative record of competencies achieved in the course.~~

~~In the blank before each competency, place the date on which the student mastered the competency.~~

~~**Unit 1: Orientation, Safety, and Student Organizations**~~		
	~~1.~~	~~Identify expectations, school policies, student organizations, and program policies related to this course.~~
	~~2.~~	~~Analyze general safety in the project-based learning classroom.~~
	~~3.~~	~~Identify and demonstrate the proper file storage, sharing, and maintenance techniques for student work.~~
	~~4.~~	~~Describe the technology student organizations available and demonstrate an ongoing understanding of teamwork and leadership strategies.~~
	~~5.~~	~~Demonstrate proper digital citizenship concepts (ongoing).~~
~~**Unit 2: Project Design**~~		
	~~1.~~	~~Analyze and become familiar with the basic tools and techniques to plan, organize, and manage a project.~~
	~~2.~~	~~Demonstrate knowledge and understanding of the Engineering Design Process (ongoing).~~
	~~3.~~	~~Synthesize research to understand project needs and limitations.~~
	~~4.~~	~~Assess client needs to understand the purposes of design.~~
	~~5.~~	~~Investigate careers in different engineering fields (e.g., electrical, mechanical, computer, industrial, etc.).~~
~~**Unit 3: Introduction to Modeling and 3D Printing**~~		
	~~1.~~	~~Demonstrate the use of computer-aided design (CAD) software to create 3D models.~~
	~~2.~~	~~Design a 3D model for rapid prototyping using a 3D printer.~~
	~~3.~~	~~Slice and 3D print an object created with CAD software.~~
	~~4.~~	~~Develop a cost analysis based on time and materials.~~
	~~5.~~	~~Investigate 3D printing industry careers and examine how those careers use this technology.~~

~~**Unit 4: Coding**~~		
	~~1.~~	~~Examine the use of Booleans and conditionals.~~
	~~2.~~	~~Apply the use of loops.~~
	~~3.~~	~~Investigate the use of variables.~~
	~~4.~~	~~Summarize the purpose of functions.~~
	~~5.~~	~~Demonstrate an understanding of debugging and identify syntax errors.~~
	~~6.~~	~~Investigate careers in software development and coding.~~
~~**Unit 5: Introduction to Electronics**~~		
	~~1.~~	~~Identify, analyze, and create models to explore electronics and their applications.~~
	~~2.~~	~~Create a physical or simulation model showing different configurations using the required components.~~
	~~3.~~	~~Investigate careers in electrical engineering and the electronics industry and examine how those careers use this technology.~~
~~**Unit 6: Introduction to Robotics**~~		
	~~1.~~	~~Research current, past, and future applications of robots.~~
	~~2.~~	~~Design and build a simple functional robotic system using the required components.~~
	~~3.~~	~~Identify common microcontroller terms.~~
	~~4.~~	~~Use various programming methods/concepts to manipulate microcontroller inputs and outputs.~~
	~~5.~~	~~Use a microcontroller for a specified purpose.~~
	~~6.~~	~~Investigate careers in the robotics industry and examine how those careers use this technology.~~

Appendix A: ISTE National Educational Technology Standards for Students (NETS-S)

	Unit	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Standards							
T1			X	X	X	X	X
T2		X	X	X	X	X	X
T3			X	X	X	X	X
T4			X	X	X	X	X
T5		X	X	X	X	X	X
T6		X	X	X	X	X	X

T1 Creativity and Innovation
Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students do the following:
a. Apply existing knowledge to generate new ideas, products, or processes.
b. Create original works as a means of personal or group expression.
c. Use models and simulations to explore complex systems and issues.
d. Identify trends and forecast possibilities.

T2 Communication and Collaboration
Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. Students do the following:
a. Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.
b. Communicate information and ideas effectively to multiple audiences using a variety of media and formats.
c. Develop cultural understanding and global awareness by engaging with learners of other cultures.
d. Contribute to project teams to produce original works or solve problems.

T3 Research and Information Fluency
Students apply digital tools to gather, evaluate, and use information. Students do the following:
a. Plan strategies to guide inquiry.
b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
d. Process data and report results.

T4 Critical Thinking, Problem Solving, and Decision Making
Students use critical-thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Students do the following:
a. Identify and define authentic problems and significant questions for investigation.
b. Plan and manage activities to develop a solution or complete a project.
c. Collect and analyze data to identify solutions and/or make informed decisions.
d. Use multiple processes and diverse perspectives to explore alternative solutions.

T5 Digital Citizenship
Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students do the following:
a. Advocate and practice safe, legal, and responsible use of information and technology.
b. Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.
c. Demonstrate personal responsibility for lifelong learning.
d. Exhibit leadership for digital citizenship.

T6 Technology Operations and Concepts

Students demonstrate a sound understanding of technology concepts, systems, and operations. Students do the following:

a. Understand and use technology systems.
b. Select and use applications effectively and productively.
c. Troubleshoot systems and applications.
d. Transfer current knowledge to learning of new technologies.

Appendix B: NAEP Technology and Engineering Literacy Framework

NAEP Standard	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
T.8.1						X
T.8.2						X
T.8.3						X
T.8.4						X
T.8.5						X
T.8.6						X
T.8.7						X
T.8.8		X				
T.8.9						X
T.8.10						X
T.8.11		X		X	X	X
T.8.12		X	X	X	X	X
T.8.13		X				
T.8.14		X				
T.8.15	X					
D.8.1		X				
D.8.2		X				
D.8.3		X				X
D.8.4		X				
D.8.5		X				
D.8.6		X				
D.8.7		X	X		X	X
D.8.8		X				
D.8.9		X	X			
D.8.10		X				
D.8.11					X	X
D.8.12					X	X
D.8.13		X			X	X
D.8.14					X	X
D.8.15					X	X
D.8.16					X	
D.8.17		X			X	
D.8.18					X	
D.8.19		X				
I.8.1	X	X	X	X	X	X
I.8.2		X	X	X	X	X
I.8.3		X	X	X	X	X
I.8.4	X					
I.8.5		X			X	X
I.8.6						
I.8.7		X				
I.8.8						
I.8.9					X	
I.8.10	X			X		
I.8.11	X					
I.8.12	X	X				
I.8.13		X	X	X	X	X

National Assessment of Educational Progress (NAEP) Technology and Engineering Literacy Framework

Students know that:
T.8.1: Economic, political, social, and cultural aspects of society drive improvements in technological products, processes, and systems.
T.8.2: Technology interacts with society, sometimes bringing about changes in a society's economy, politics, and culture, and often leading to the creation of new needs and wants.

Students are able to:
T.8.3: Describe and analyze positive and negative impacts on society from the introduction of a new or improved technology, including both expected and unanticipated effects.
T.8.4: Compare the impacts of a given technology on different societies, noting factors that may make a technology appropriate and sustainable in one society but not in another.

Students know that:
T.8.5: Some technological decisions involve trade-offs between environmental and economic needs, while others have positive effects for both the economy and environment.
T.8.6: Resources such as oceans, fresh water, and air—which are essential for life and shared by everyone—are protected by regulating technologies in such areas as transportation, energy, and waste disposal.

Students are able to:
T.8.7: Compare the environmental effects of two alternative technologies devised to solve the same problem or accomplish the same goal and justify which choice is best, taking into account environmental impacts as well as other relevant factors.

Students know that:
T.8.8: Information technologies are developing rapidly so that the amount of data that can be stored and made widely accessible is growing at a faster rate each year.
T.8.9: Information technologies make it possible to analyze and interpret data—including text, images, and sound—in ways that are not possible with human senses alone. These uses may result in positive or negative impacts.
T.8.10: The large range of personal and professional information technologies and communication devices allows for remote collaboration and rapid sharing of ideas unrestricted by geographic location.

Students are able to:
T.8.11: Use appropriate information and communication technologies to collaborate with others on the creation and modification of a knowledge product that can be accessed and used by other people.

Students know that:
T.8.12: Technology by itself is neither good nor bad, but its use may affect others; therefore, decisions about products, processes, and systems must take possible consequences into account.
T.8.13: People who live in different parts of the world have different technological choices and opportunities because of such factors as differences in economic resources, location, and cultural values.

Students are able to:
T.8.14: Explain that it is important for citizens to reduce the negative impacts and increase the positive impacts of their technologies on people in another area or on future generations.
T.8.15: Explain why it is unethical to infect or damage other people's computers with viruses or "hack" into other computer systems to gather or change information.

Students know that:
D.8.1: Science is the systematic investigation of the natural world. Technology is any modification of the environment to satisfy people's needs and wants. Engineering is the process of creating or modifying technologies and is constrained by physical laws and cultural norms, and economic resources.
D.8.2: Technology advances through the processes of innovation and invention. Sometimes a technology developed for one purpose is adapted to serve other purposes.

D.8.3: Tools have been improved over time to do more difficult tasks and to do simple tasks more efficiently, accurately, or safely. Tools further the reach of hands, voices, memory, and the five human senses.

Students are able to:
D.8.4: Simulate tests of various materials to determine which would be best to use for a given application.
D.8.5: Redesign an existing tool to make it easier to accomplish a task.

Students know that:
D.8.6: Engineering design is a systematic, creative, and iterative process for meeting human needs and wants. It includes stating the challenge, generating ideas, choosing the best solution, making and testing models and prototypes, and redesigning. Often there are several possible solutions.
D.8.7: Requirements for a design are made up of the criteria for success and the constraints, or limits, which may include time, money, and materials. Designing often involves making tradeoffs between competing requirements and desired design features.

Students are able to:
D.8.8: Carry out a design process to solve a moderately difficult problem by identifying criteria and constraints, determining how they will affect the solution, researching and generating ideas, and using trade-offs to choose between alternative solutions.
D.8.9: Construct and test a model and gather data to see if it meets the requirements of a problem.
D.8.10: Communicate the results of a design process and articulate the reasoning behind design decisions by using verbal and visual means. Identify the benefits of a design as well as the possible unintended consequences.

Students know that:
D.8.11: Technological systems are designed to achieve goals. They incorporate various processes that transform inputs into outputs. They all use energy in some form. These processes may include feedback and control.
D.8.12: Technological systems can interact with one another to perform more complicated functions and tasks than any individual system can do by itself.

Students are able to:
D.8.13: Examine a product or process through reverse engineering by taking it apart step by step to identify its systems, subsystems, and components, describing their interactions, and tracing the flow of energy through the system.
D.8.14: Measure and compare the production efficiency of two machines, a simple machine and a complex machine, designed to accomplish the same goal.
D.8.15: Construct and use a moderately complicated system, given a goal for the system and a collection of parts, including those that may or may not be useful in the system.

Students know that:
D.8.16: Many different kinds of products must undergo regular maintenance, including lubrication and replacement of parts before they fail so as to ensure proper functioning.

Students are able to:
D.8.17: Diagnose a problem in a technological device using a logical process of troubleshooting. Develop and test various ideas for fixing it.
D.8.18: Modify a moderately complicated system so that it is less likely to fail. Predict the extent to which these modifications will affect the productivity of the system.
D.8.19: Trace the life cycle of a repairable product from inception to disposal or recycling in order to determine the product's environmental impact.

Students know that:
I.8.1: Collaboration can take many forms. Pairs or teams of people can work together in the same space or at a distance, at the same time or at different times, and on creative projects or on technical tasks. Different communications technologies are used to support these different forms of collaboration.

~~**Students are able to:**~~
~~**I.8.2:** Provide feedback to a (virtual) collaborator on a product or presentation, taking into account the other person's goals and using constructive, rather than negative, criticism.~~
~~**I.8.3:** Communicate information and ideas effectively using a variety of media, genres, and formats for multiple purposes and a variety of audiences.~~

~~**Students know that:**~~
~~**I.8.4:** Increases in the quantity of information available through electronic means and the ease by which knowledge can be published have heightened the need to check sources for possible distortion, exaggeration, or misrepresentation.~~

~~**Students are able to:**~~
~~**I.8.5:** Select and use appropriate digital and network tools and media resources to collect, organize, analyze, and display supporting data to answer questions and test hypotheses.~~
~~**I.8.6**: Search media and digital resources on a community or world issue and identify specific examples of distortion, exaggeration, or misrepresentation of information.~~

~~**Students are able to:**~~
~~**I.8.7:** Use digital tools to identify a global issue and investigate possible solutions. Select and present the most promising sustainable solution.~~
~~**I.8.8:** Use digital tools to gather and display data in order to test hypotheses of moderate complexity in various subject areas. Draw and report conclusions consistent with observations.~~
~~**I.8.9:** Use a digital model of a system to conduct a simulation. Explain how changes in the model result in different outcomes.~~

~~**Students know that:**~~
~~**I.8.10:** Style guides provide detailed examples for how to give appropriate credit to others when incorporating their ideas, text, or images in one's own work.~~

~~**Students are able to:**~~
~~**I.8.11:** Identify or provide examples of fair use practices that apply appropriate citation of sources when using information from books or digital resources.~~

~~**Students know that:**~~
~~**I.8.12:** Certain digital tools are appropriate for gathering, organizing, analyzing, and presenting information, while other kinds of tools are appropriate for creating text, visualizations, and models and for communicating with others.~~

~~**Students are able to:**~~
~~**I.8.13:** Use appropriate digital tools to accomplish a variety of tasks, including gathering, analyzing, and presenting information as well as creating text, visualizations, and models and communicating with others.~~

Appendix C: 2018 MS CCR Standards for Computer Science

	Units	1	2	3	4	5	6
Standards							
CS.2.1							X
CS.2.2			X				
CS.2.3			X				
NI.2.1							
NI.2.2		X					
NI.2.3					X		
DA.2.1			X				
DA.2.2			X				
DA.2.3			X				
AP.2.1			X				
AP.2.2					X		X
AP.2.3					X		X
AP.2.4			X	X	X	X	X
AP.2.5					X		X
AP.2.6			X	X	X	X	X
AP.2.7			X	X	X	X	X
AP.2.8				X	X	X	X
AP.2.9			X	X	X	X	X
AP.2.10					X		X
IC.2.1		X					
IC.2.2				X	X	X	X
IC.2.3					X		X
IC.2.4		X			X		

Level 2: GRADES 6-8 - Computing Systems (CS.2)

Conceptual understanding: People interact with a wide variety of computing devices that collect, store, analyze, and act upon information in ways that can affect human capabilities both positively and negatively. The physical components (hardware) and instructions (software) that make up a computing system communicate and process information in digital form. An understanding of hardware and software is useful when troubleshooting a computing system that does not work as intended.

CS.2.1 **Recommend improvements to the design of computing devices based on an analysis of how users interact with the devices. [DEVICES] (P3.3)**

The study of human-computer interaction (HCI) can improve the design of devices, including both hardware and software.

CS.2.1a **Students should make recommendations for existing devices (e.g., a laptop, phone, or tablet) or design their own components or interface (e.g., create their own controllers).** Teachers can guide students to consider usability through several lenses, including accessibility, ergonomics, and learnability. For example, assistive devices provide capabilities such as scanning written information and converting it to speech.

CS.2.2 **Design projects that combine hardware and software components to collect and exchange data. [HARDWARE & SOFTWARE] (P5.1)**

Collecting and exchanging data involves input, output, storage, and processing. When possible, students should select the hardware and software components for their project designs by considering factors such as functionality, cost, size, speed, accessibility, and aesthetics.

CS.2.2a **Students will design projects that use both hardware and software to collect and exchange data.** For example, components for a mobile app could include accelerometer, GPS, and speech recognition. The choice of a device that connects

~~wirelessly through a Bluetooth connection versus a physical USB connection involves a tradeoff between mobility and the need for an additional power source for the wireless device.~~

~~**CS.2.3 Systematically identify and fix problems with computing devices and their components. [TROUBLESHOOTING] (P6.2)**~~

~~Since a computing device may interact with interconnected devices within a system, problems may not be due to the specific computing device itself but to devices connected to it.~~

~~CS.2.3a **Students will use a structured process to troubleshoot problems with computing systems and ensure that potential solutions are not overlooked.** Examples of troubleshooting strategies include following a troubleshooting flow diagram, making changes to software to see if hardware will work, checking connections and settings, and swapping in working components.~~

~~**Level 2: GRADES 6-8 - Networks and the Internet (NI.2)**~~

~~**Conceptual Understanding:** Computing devices typically do not operate in isolation. Networks connect computing devices to share information and resources and are an increasingly integral part of computing. Networks and communication systems provide greater connectivity in the computing world by providing fast, secure communication and facilitating innovation.~~

~~**NI.2.1 Model the role of protocols in transmitting data across networks and the Internet. [NETWORK COMMUNICATION & ORGANIZATION] (P4.4)**~~

~~Protocols are rules that define how messages between computers are sent. They determine how quickly and securely information is transmitted across networks and the Internet, as well as how to handle errors in transmission.~~

~~NI.2.1a **Students should model how data is sent using protocols to choose the fastest path, to deal with missing information, and to deliver sensitive data securely.** For example, students could devise a plan for resending lost information or for interpreting a picture that has missing pieces. The priority at this grade level is understanding the purpose of protocols and how they enable secure and errorless communication. Knowledge of the details of how specific protocols work is not expected.~~

~~**NI.2.2 Explain how physical and digital security measures protect electronic information. [CYBERSECURITY] (P7.2)**~~

~~Information that is stored online is vulnerable to unwanted access. Examples of physical security measures to protect data include keeping passwords hidden, locking doors, making backup copies on external storage devices, and erasing a storage device before it is reused. Examples of digital security measures include secure router admin passwords, firewalls that limit access to private networks, and the use of a protocol, such as HTTPS, to ensure secure data transmission.~~

~~NI.2.2a **Students will explain how physical and digital security measures protect electronic information.**~~

~~**NI.2.3 Apply multiple methods of encryption to model the secure transmission of information. [CYBERSECURITY] (P4.4)**~~

~~Encryption can be as simple as letter substitution or as complicated as modern methods used to secure networks and the Internet.~~

~~NI.2.3a **Students should encode and decode messages using a variety of encryption methods, and they should understand the different levels of complexity used to hide or secure information.** For example, students could secure messages using methods like Caesar cyphers or steganography (i.e., hiding messages inside a picture or other data). They can also model more complicated methods, such as public key encryption, through unplugged activities.~~

~~**Level 2: GRADES 6-8 - Data and Analysis (DA.2)**~~

~~**Conceptual Understanding:** Computing systems exist to process data. The amount of digital data generated in the world is rapidly expanding, so the need to process data effectively is increasingly important. Data is collected and stored so that it can be analyzed to better understand the world and make more accurate predictions.~~

~~**DA.2.1 Represent data using multiple encoding schemes. [STORAGE] (P4.0)**~~
~~Data representations occur at multiple levels of abstraction, from the physical storage of bits to the arrangement of information into organized formats (e.g., tables).~~
~~DA.2.1a **Students should represent the same data in multiple ways.** For example, students could represent the same color using binary, RGB values, hex codes (low-level representations), as well as forms understandable by people, including words, symbols, and digital displays of the color (high-level representations).~~

~~**DA.2.2 Collect data using computational tools and transform the data to make it more useful and reliable. [COLLECTION, VISUALIZATION, & TRANSFORMATION] (P6.3)**~~
~~As students continue to build on their ability to organize and present data visually to support a claim, they will need to understand when and how to transform data for this purpose.~~
~~DA.2.2a **Students should transform data to remove errors, highlight or expose relationships, and/or make it easier for computers to process.** The cleaning of data is an important transformation for ensuring consistent format and reducing noise and errors (e.g., removing irrelevant responses in a survey). An example of a transformation that highlights a relationship is representing males and females as percentages of a whole instead of as individual counts.~~

~~**DA.2.3 Refine computational models based on the data they have generated. [INFERENCE & MODELS] (P5.3, P4.4)**~~
~~A model may be a programmed simulation of events or a representation of how various data is related.~~
~~DA.2.3a **Students will refine computational models by considering which data points are relevant, how data points relate to each other, and if the data is accurate.** For example, students may make a prediction about how far a ball will travel based on a table of data related to the height and angle of a track. The students could then test and refine their model by comparing predicted versus actual results and considering whether other factors are relevant (e.g., size and mass of the ball). Additionally, students could refine game mechanics based on test outcomes in order to make the game more balanced or fair.~~

~~**Level 2: GRADES 6-8 - Algorithms and Programming (AP.2)**~~

~~**Conceptual understanding:** An algorithm is a sequence of steps designed to accomplish a specific task. Algorithms are translated into programs, or code, to provide instructions for computing devices. Algorithms and programming control all computing systems, empowering people to communicate with the world in new ways and solve compelling problems. The development process to create meaningful and efficient programs involves choosing which information to use and how to process and store it, breaking apart large problems into smaller ones, recombining existing solutions, and analyzing different solutions.~~

~~**AP.2.1 Use flowcharts and/or pseudocode to address complex problems as algorithms. [ALGORITHMS] (P4.4, P4.1)**~~
~~Complex problems are problems that would be difficult for students to solve computationally.~~
~~AP.2.1a **Students will use pseudocode and/or flowcharts to organize and sequence an algorithm that addresses a complex problem, even though they may not actually program the solutions.** For example, students might express an algorithm that produces a recommendation for purchasing sneakers based on inputs such as size, colors, brand, comfort, and cost. Testing the algorithm with a wide range of inputs and users allows students to refine their recommendation algorithm and to identify other inputs they may have initially excluded.~~

AP.2.2 **Create clearly named variables that represent different data types and perform operations on their values. [VARIABLES] (P5.1, P5.2)**

A variable is like a container with a name, in which the contents may change, but the name (identifier) does not.

AP.2.2a **When planning and developing programs, students should decide when and how to declare and name new variables.** Examples of operations include adding points to the score, combining user input with words to make a sentence, changing the size of a picture, or adding a name to a list of people.

AP.2.2b **Students should use naming conventions to improve program readability.**

AP.2.3 **Design and iteratively develop programs that combine control structures, including nested loops and compound conditionals. [CONTROL] (P5.1, P5.2)**

Control structures can be combined in many ways. Nested loops are loops placed within loops. Compound conditionals combine two or more conditions in a logical relationship (e.g., using AND, OR, and NOT), and nesting conditionals within one another allows the result of one conditional to lead to another.

AP.2.3a **Students will design and develop programs that combine control structures.** For example, when programming an interactive story, students could use a compound conditional within a loop to unlock a door only if a character has a key AND is touching the door.

AP.2.4 **Decompose problems and subproblems into parts to facilitate the design, implementation, and review of programs. [MODULARITY] (P3.2)**

Decomposition facilitates aspects of program development by allowing students to focus on one piece at a time (e.g., getting input from the user, processing the data, and displaying the result to the user). Decomposition also enables different students to work on different parts at the same time.

AP.2.4a **Students should break down problems into subproblems, which can be further broken down to smaller parts.** For example, animations can be decomposed into multiple scenes, which can be developed independently.

AP.2.5 **Create procedures with parameters to organize code and make it easier to reuse. [MODULARITY] (P4.1, P4.3)**

AP.2.5a **Students will create procedures and/or functions that are used multiple times within a program to repeat groups of instructions.** These procedures can be generalized by defining parameters that create different outputs for a wide range of inputs. For example, a procedure to draw a circle involves many instructions, but all of them can be invoked with one instruction, such as "drawCircle." By adding a radius parameter, the user can easily draw circles of different sizes.

AP.2.6 **Seek and incorporate feedback from team members and users to refine a solution that meets user needs. [PROGRAM DEVELOPMENT] (P2.3, P1.1)**

Development teams that employ user-centered design create solutions (e.g., programs and devices) that can have a large societal impact, such as an app that allows people with speech difficulties to translate hard-to-understand pronunciation into understandable language.

AP.2.6a **Students should begin to seek diverse perspectives throughout the design process to improve their computational artifacts.** Considerations of the end user may include usability, accessibility, age-appropriate content, respectful language, user perspective, pronoun use, color contrast, and ease of use.

AP.2.7 **Incorporate existing code, media, and libraries into original programs and give attribution. [PROGRAM DEVELOPMENT] (P4.2, P5.2, P7.3)**

Building on the work of others enables students to produce more interesting and powerful creations.

AP.2.7a **Students should use portions of code, algorithms, and/or digital media in their own programs and websites.** At this level, they may also import libraries and connect to web application program interfaces (APIs). For example, when creating a side-scrolling games, students may incorporate portions of code that create a realistic jump movement from another person's game, and they may also import Creative Commons-lessened images to use in the background.

AP.2.7b **Students should give attribution to the original creator's contributions.**

AP.2.8 Systematically test and refine programs using a range of test cases. [PROGRAM DEVELOPMENT] (P6.1)

Test cases are created and analyzed to better meet the needs of users and to evaluate whether programs function as intended. At this level, testing should become a deliberate process that is more iterative, systematic, and proactive than at lower levels.

AP.2.8a **Students will test programs by considering potential errors, such as what will happen if a user enters invalid input (e.g., negative numbers and zero instead of positive numbers).**

AP.2.9 Distribute tasks and maintain a project timeline when collaboratively developing computational artifacts. [PROGRAM DEVELOPMENT] (P2.2)

Collaboration is a common and crucial practice in programming development. Often, many individuals and groups work on the interdependent parts of a project together.

AP.2.9a **Students will work collaboratively in groups.**

AP.2.9b **Students should assume predefined roles within their teams and manage the project workflow using structured timelines.** With teacher guidance, they will begin to create collective goals, expectations, and equitable workloads. For example, students may divide the design stage of a game into planning the storyboard, flowchart, and different parts of the game mechanics. They can then distribute tasks and roles among members of the team and assign deadlines.

AP.2.9c **Students should give attribution to the original creators to acknowledge their contributions.**

AP.2.10 Document programs in order to make them easier to follow, test, and debug. [PROGRAM DEVELOPMENT] (P7.2)

Documentation allows creators and others to more easily use and understand a program.

AP.2.10a **Students should provide documentation for end users that explains their artifacts and how they function.** For example, students could provide a project overview and clear user instructions.

AP.2.10b **Students should incorporate comments in their product (comments in the code).**

AP.2.10c **Students should communicate their process using design documents, flowcharts, and presentations.**

Level 2: GRADES 6-8 - Impacts of Computing (IC.2)

Conceptual understanding: Computing affects many aspects of the world in both positive and negative ways at local, national, and global levels. Individuals and communities influence computing through their behaviors and cultural and social interactions, and in turn, computing influences new cultural practices. An informed and responsible person should understand the social implications of the digital world, including equity and access to computing.

IC.2.1 Compare tradeoffs associated with computing technologies that affect people's everyday activities and career options. [CULTURE] (P7.2)

Advancements in computer technology are neither wholly positive nor negative; however, the ways that people use computing technologies have tradeoffs.

IC.2.1a **Students should consider current events related to broad ideas, including privacy, communication, and automation.** For example, driverless cars can increase convenience and reduce accidents, but they are also susceptible to hacking. The emerging industry will not only reduce the number of taxi and shared-ride drivers but also create more software engineering and cybersecurity jobs.

IC.2.2 Discuss issues of bias and accessibility in the design of existing technologies. [CULTURE] (P1.2)

IC.2.2a **Students should test and discuss the usability of various technology tools (e.g., apps, games, and devices) with the teacher's guidance.** For example, facial recognition software that works better for lighter skin tones was likely developed with a homogeneous testing group and could be improved by sampling a more diverse population. When discussing accessibility, students may notice that allowing a user to

~~change font sizes and colors will not only make an interface usable for people with low vision but also benefits users in various situations, such as in bright daylight or a dark room.~~

~~**IC.2.3 Collaborate with many contributors through strategies such as crowdsourcing or surveys when creating a computational artifact. [SOCIAL INTERACTIONS] (P2.4, P5.2)**~~

~~Crowdsourcing is gathering services, ideas, or content from a large group of people, especially from the online community. It can be done at the local level (e.g., classroom or school) or global level (e.g., age-appropriate online communities, like Scratch and Minecraft).~~

~~IC.2.3a **Students should collaborate with many contributors.** For example, a group of students could combine animations to create a digital community mosaic. They could also solicit feedback from many people though use of online communities and electronic surveys.~~

~~**IC.2.4 Describe tradeoffs between allowing information to be public and keeping information private and secure. [SAFETY, LAW, & ETHICS] (P7.2)**~~

~~Sharing information online can help establish, maintain, and strengthen connections between people. For example, it allows artists and designers to display their talents and reach a broad audience; however, security attacks often start with personal information that is publicly available online. Social engineering is based on tricking people into revealing sensitive information and can be thwarted by being wary of attacks, such as phishing and spoofing.~~

~~IC.2.4a **Students should discuss and describe the benefits and dangers of allowing information to be public or kept private and secure.**~~