2022 Engineering

Program CIP: 14.0101—Engineering, General

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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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Sam Watts, the curriculum manager for the RCU

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 engineering curriculum is aligned to the following standards:

International Technology and Engineering Education Association (ITEEA)-Standards for Technological Literacy

The *International Technology and Engineering Educators Association* (ITEEA) is the professional organization for technology, innovation, design, and engineering educators. The mission is to promote technological and engineering literacy for all by supporting the teaching of technology and engineering and promoting the professionalism of those engaged in these pursuits. ITEEA strengthens the profession through leadership, professional development, membership services, publications, and classroom activities.
iteea.org/stel.aspx

International Society for Technology in Education Standards (ISTE)

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iste.org

College- and Career-Readiness Standards

College- and career-readiness 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-Readiness Standards (MCCRS) to provide a consistent, clear understanding of what students are expected to learn and so teachers and parents know what they need to do to help them.
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

Engineering is a program in pre-engineering, robotics, and automated manufacturing for high school students. 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 engineering and STEM-related workforce or programs offered by Mississippi community and junior colleges, as well as institutions of higher education.

College, Career, and Certifications

Most engineering bachelor's degree programs involve a concentration of study in an engineering specialty along with courses in both mathematics and the physical and life sciences. Many programs also include courses in general engineering. A design course, sometimes accompanied by a computer or laboratory class or both, is part of the curriculum of most programs. General courses not directly related to engineering, such as those in the social sciences or humanities, are also often required.

In addition to the standard bachelor's engineering degree, many colleges offer two-year or four-year degree programs in engineering technology (ET). These programs, which usually include various hands-on laboratory classes that focus on current issues in the application of engineering principles, prepare students for practical design and production work, rather than for jobs that require more theoretical and scientific knowledge. Graduates of four-year technology programs may get jobs like those obtained by graduates with a bachelor's degree in engineering. Engineering technology graduates, however, are not qualified to register as professional engineers under the same terms as graduates with degrees in engineering.

Some employers regard technology program graduates as having skills between those of a technician and an engineer. A two-year study by the National Academy of Engineering (2016) found that despite a high (and increasing) demand for ET graduates in many fields, there "appears to be little awareness of ET as a field of study or a category of employment." This curriculum attempts to shed some light on these areas as the number of modern, high-tech, and well-paying ET jobs continues to increase in Mississippi, the United States, and internationally.

Although most engineering jobs require a degree, some entry level/base positions that support professionals in engineering and STEM fields require only certifications. One industry certification example (emphasized in this course) signifies skills in using 3D drafting software and can benefit students applying for jobs in the field. These certifications are applicable in both college and careers. Interested students are encouraged to sharpen and expand upon the skills learned in this course in pursuit of a widely recognized certification. Specific 3D drafting certificates depend on the industry sector or company, but the two most valued certifications for high school students at this point are:

- The Certified SolidWorks Associate - Academic (CSWA - Academic)
- AutoDesk Certified User certificate in AutoDesk Inventor (offered by Certiport)

Grade Level and Class Size Recommendations

It is recommended that students enter this program as a 10th grader. Exceptions to this are a district-level decision based on class size, enrollment numbers, student maturity and CTE delivery method. This is a hands-on, lab- or shop-based course. Therefore, a maximum of 15 students is recommended per class.

Student Prerequisites

For students to experience success in the program, the following student prerequisites are suggested:

1. C or higher in English (the previous year)
2. C or higher in high school-level math (last course taken, or the instructor can specify the level of math instruction needed)
3. Instructor approval and TABE reading score (eighth grade or higher)

or

1. TABE reading and math score (eighth grade or higher)
2. Instructor approval

or

1. Instructor approval

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 of the training sessions provided, please contact the RCU at 662.325.2510.

Course Outlines

Option 1—Four 1-Carnegie Unit Courses

This curriculum consists of four 1-credit courses that should be completed in the following sequence:

1. **Engineering Fundamentals—Course Code: 994002**
2. **Engineering Applications—Course Code: 994003**
3. **Engineering Design—Course Code: 994004**
4. **Engineering Systems—Course Code: 994005**

Course Description: Engineering Fundamentals
Engineering Fundamentals introduces students to the engineering career field, ethics, safety, the engineering design process, and Computer-Aided Design (CAD). Utilizing a team-based, hands-on, minds-on approach to foster reasoning, students will progress from completing teacher-led guided activities to more challenging student-led open-ended projects and problems that will require planning, organization, communication, team building, and technical writing skills.

Course Description: Engineering Applications
Engineering Applications will allow students the opportunity to move beyond showing to creating as they implement their CAD designs and see their ideas become a reality, generating excitement and a deeper understanding of the engineering design process. Students will explore additive manufacturing, subtractive manufacturing, robotics, and apply concepts learned in the classroom at local, regional, state, and/or national competition.

Course Description: Engineering Design
Engineering Design will allow students the opportunity to complete a capstone project where students will solve an open-ended student-led problem. As students work through the capstone project, they will review basic CAD concepts and build upon their knowledge to design and test models and predict how they will behave under various loads and conditions.

Course Description: Engineering Systems
Engineering Systems is a course that will allow students the opportunity to move beyond the basic physical and operational concepts of robotics to programming. Students will also explore robotics resources such as electrical, fluid, and thermal systems as they build an autonomous and a user-controlled robot to solve a competitive manufacturing challenge.

Engineering Fundamentals—Course Code: 994002

Unit	Unit Title	Hours
1	Orientation and Student Organizations	10
2	Ethics and Safety	15
3	Engineering Design Process and Technical Writing	40
4	Computer-Aided Design and Drafting	75
Total		**140**

Engineering Applications—Course Code: 994003

Unit	Unit Title	Hours
5	Modern Manufacturing Systems	45
6	Introduction to Mechanical Systems and Robotics	95
Total		**140**

Engineering Design—Course Code: 994004

Unit	Unit Title	Hours
7	Safety Review	10
8	Capstone	65
9	Advanced Computer-Aided Design	65
Total		**140**

Engineering Systems—Course Code: 994005

Unit	Unit Title	Hours
10	Advanced Robotics	90
11	Introduction to Electrical Systems	25
12	Introduction to Fluid Power Systems	15
13	Introduction to Thermal Systems	10
Total		**140**

Option 2—Two 2-Carnegie Unit Courses

This curriculum consists of two 2-credit courses that should be completed in the following sequence:

1. **Engineering I—Course Code: 994000**
2. **Engineering II—Course Code: 994001**

Course Description: Engineering I
Engineering I teaches students about student organizations and introduces them to the engineering design process along with ethical and safe practice standards. Concepts of 3D sketching and modeling by hand and with CAD software are introduced within the context of engineering design and prototype development. Robotics concepts in engineering are covered with understanding catalyzed by student competitions. This course also focuses on several fields of engineering and engineering technology specialization to include technical writing and analysis.

Course Description: Engineering II
Engineering II is a comprehensive course that focuses on advanced CAD modeling and simulations. Additionally, it is a course that teaches students advanced robotics concepts. The capstone unit will allow students to learn valuable workforce readiness skills in the field of engineering, which will be demonstrated with all other parts of the course. Electrical, fluid, and thermal systems are covered in detail due to their relevance to real-world applications and industry.

Engineering I—Course Code: 994000

Unit	Unit Title	Hours
1	Orientation and Student Organizations	10
2	Ethics and Safety	15
3	Engineering Design Process and Technical Writing	40
4	Computer-Aided Design and Drafting	75
5	Modern Manufacturing Systems	45
6	Introduction to Mechanical Systems and Robotics	95
Total		**280**

Engineering II—Course Code: 994001

Unit	Unit Title	Hours
7	Safety Review	10
8	Capstone	70
9	Advanced Computer-Aided Design	65
10	Advanced Robotics	85
11	Introduction to Electrical Systems	25
12	Introduction to Fluid Power Systems	15
13	Introduction to Thermal Systems	10
Total		**280**

Career Pathway Outlook

Overview

Engineers and Engineering Technology (ET) professionals apply principles of science, mathematics, and technology to develop economical solutions for society. Whether it is working on scientific discoveries or commercial applications, engineering employees are expected to pursue continuing education as technology evolves. Engineering professionals are typically required to obtain a bachelor's degree, though several other ET options with variable course and degree requirements are offered. Licensing requirements for engineers usually include a professional degree and at least 3–4 years of practical work experience, but ET careers 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 large employment needs would be in the population over a 10-year period. The research also includes information from industry publications, the Mississippi Department of Education, institutions of higher learning, and community and junior colleges regarding articulation agreements and degree requirements. The pathways were affirmed through existing Mississippi curriculum blueprints and the expectations provided in industry interviews.

Needs of the Future Workforce

Data for this synopsis were 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 (State of Mississippi)

Occupations (Alphabetical)	**Employment**		**Projected Growth 2018-2028**		**Average Wage 2021**	
	Current (2018)	**Projected (2028)**	**Number**	**Percent**	**Hourly**	**Annual**
Aerospace Engineers	100	100	0	0%	$47.07	$97,890
Chemical Engineers	250	260	10	4%	$52.15	$108,480
Civil Engineers	1,590	1,670	80	5%	$42.84	$89,120
Civil Engineering Technicians	1,060	1,090	30	2.8%	$18.72	$39,940
Electrical and Electronic Engineering Technicians	1,040	1,060	20	1.9%	$33.80	$70,300
Electrical Engineers	1,120	1,140	20	1.8%	$47.14	$98,050
Industrial Engineers	1,870	2,050	180	9.6%	$39.97	$83,140
Mechanical Engineers	1,130	1,200	70	6.2%	$40.61	$84,460
Mechanical Engineering Technicians	330	350	20	6.1%	$29.39	$61,130
Surveyors	390	420	30	7.7%	$25.28	$52,590

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

Perkins V Requirements and Academic Infusion

The engineering curriculum meets Perkins V requirements of introducing students to and preparing them for high-skill, high-wage occupations in engineering fields. It also offers students a program of study, including secondary, postsecondary, and institutions of higher learning courses, that will further prepare them for engineering 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 engineering 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 engineering curriculum. Technology Student Association (TSA) and Skills USA are examples of student organizations with many outlets for Engineering. Student organizations provide participants and members with growth opportunities and competitive events. They also open the doors to the world of industry 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 engineering 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 engineering curriculum provides opportunities for students to work together and help each other complete complex tasks. There are many field experiences within the engineering curriculum that will allow and encourage collaboration with professionals currently in the engineering field.

Work-Based Learning
Work-based learning is an extension of understanding competencies taught in the Engineering 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 industry professionals. Thus, supervised collaboration and immersion into the industry around the students are keys to students' success, knowledge, and skills development.

Professional Organizations

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

SkillsUSA
skillsusa.org

Technology Student Association
tsaweb.org

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 their course. This is where all resources will be housed in the future if they are not already. To be added to the guide, send a Help Desk ticket to the RCU by emailing helpdesk@rcu.msstate.edu.

Perkins V Quality Indicators and Enrichment Material
Some of the units may include an enrichment section at the end. If the Engineering program is currently using the Mississippi Career Planning and Assessment System (MS-CPAS) as a measure of accountability, the enrichment section of material will not be tested. If this is the case, it is suggested to use the enrichment material when needed or desired by the teacher and if time allows in the class. This material will greatly enhance the learning experiences for students. If, however, the engineering program is using a national certification, work-based learning, or other measure of accountability that aligns with Perkins V as a quality indicator, this material could very well be tested on that quality indicator. It is the responsibility of the teacher to ensure all competencies for the selected quality indicator are covered throughout the year.

Unit 1: Orientation and Student Organizations

Competencies and Suggested Objectives
1. Identify course expectations, school policies, student organizations, and program policies related to this course. DOK1 a. Identify school rules, policy, and procedures. b. Identify and establish classroom guidelines and procedures. c. Review course standards and affiliated national standards.
2. Relate student organization elements to the National Society of Professional Engineers.DOK2 a. Describe the importance of effective communication skills. • Demonstrate verbal and nonverbal communication skills. • Apply appropriate speaking 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 teambuilding skills in class and work-related situations. • Define teambuilding • 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 e. Perform the tasks needed to complete an assigned requirement for a competition.
3. Explore educational and occupational opportunities in the field of engineering, specifically those within the state of Mississippi. DOK2 a. Explore careers in a variety of engineering fields, including but not limited to: • Mechanical engineering • Civil engineering • Electrical engineering • Computer engineering • Chemical engineering b. Research and report on emerging technologies in the field of engineering.

Unit 2: Ethics and Safety

Competencies and Suggested Objectives
1. Utilize proper safety procedures in a laboratory setting. DOK1 a. Identify, describe, and demonstrate the importance of safety and the proper use of lab equipment. b. Describe safe operating procedures for the equipment utilized in the course. c. Adhere to applicable Occupational Safety and Health Administration (OSHA) 10-Hour General Industry Guidelines and Material Safety Data Sheet (MSDS) in the laboratory setting d. Demonstrate understanding of Lockout/Tagout procedures. e. Complete lab safety assessment with 100% mastery prior to accessing and operating laboratory equipment.
2. Recognize the importance of ethical teamwork in the field of engineering. DOK1 a. Using the National Society of Professional Engineers (NSPE) Code of Ethics, engage in arguments from workplace scenarios addressing safe and ethical practices including considerations of environmental (sustainability), social, and personal impacts. b. Apply the NSPE Code of Ethics to current or future technological advancements for potential ethical implications c. Relate student organization central tenets to the NSPE.

Enrichment
1. Research various emerging technologies to include impacts on society and changing technological cultures.

Unit 3: Engineering Design Process and Technical Writing

Competencies and Suggested Objectives
1. Implement the National Aeronautics and Space Administration (NASA) Beginning Engineering, Science, and Technology (BEST) engineering design process. DOK 2 a. Apply the engineering design process in the development of a student project. b. Conduct a student-to-student peer review of a project.
2. Apply the standards of technical writing to the student project using industry standards. DOK4 a. Apply industry standards for technical writing for engineers (e.g., Google technical writing standards for engineers, or similar). b. Discuss the differences in technical writing along various fields or audiences. (e.g., executives, technical scientific report, etc.)
3. Investigate and apply elements of technical writing to produce documents that include clarity, conciseness, accessibility, audience recognition, and accuracy. DOK4 a. Analyze and interpret an existing technical document from an authoritative source to assess relevant information pertaining to a specific real-world project. b. Create a technical document from a class project that employs multiple formats (verbally, graphically, textually, and/or mathematically); include cost analysis, data collection, communication, marketing, and presentation elements.

Unit 4: Computer-Aided Design and Drafting

Competencies and Suggested Objectives
1. Explain the purpose of technical drawing and freehand technical sketches. DOK1 a. Research and evaluate appropriate techniques for technical drawing and freehand technical sketches.
2. Identify and demonstrate proper use of measurement tools. DOK2 a. Select and use appropriate tools or instruments to collect qualitative and quantitative data and record and represent that data in an appropriate form to include: • Calipers • Engineering scales • Micrometers • Protractors • Rulers
3. Create an appropriately scaled technical drawing. DOK4 a. Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to engineering questions and problems related to measurement. b. Convert fractions to decimals and decimals to fractions to test and compare proposed solutions to an engineering design problem to include: • 1/16 • 1/8 • 1/4 • 1/2 c. Hand draw a 2D technical drawing within the following views: • Orthographic views • Isometric views • Section view d. Create a 3D object from a 2D technical drawing.

4. Use CAD software to create 3D models. DOK4 a. Create a part using CAD software. b. Identify and demonstrate appropriate application of the following CAD software concepts: • Axis • Boss • Center lines • Chamfer • Constraints • Construction lines • Cut • Dimension lines • Extrude • Fillet • Hole • Invisible and visible lines • Loft • Mates • Origin • Pattern • Plane • Revolve • Rib • Section lines • Shell • Sweep
5. Use CAD software to create 2D drawings and 3D assemblies. DOK4 a. Create an assembly using CAD software. b. Create a detailed drawing using CAD software. c. Integrate a CAD drawing into technical documents. d. Analyze real world engineering drawings to distinguish between the need for orthographic and isometric drawing views.

Unit 5: Modern Manufacturing Systems

Competencies and Suggested Objectives
1. Use additive machining methods to create objects that serve a specific purpose. DOK3 a. Research and analyze the components of various types of 3D printers and their operation to include: • Electronic beam melting • Fused deposition modeling • Selective laser sintering b. Create a part using a 3D printer that serves a specific purpose. c. Explore the role of additive machining in industry and emerging technologies.
2. Use subtractive machining methods to create objects that serve a specific purpose. DOK3 a. Research and analyze the components of various types of subtractive machines and their operation (e.g., CNC, plasma cutter, water jet, laser engraver/cutter, etc.) b. Use a subtractive machining method to create a part for a specific purpose. c. Explore the role of subtractive machining in industry and emerging technologies.

Unit 6: Introduction to Mechanical Systems and Robotics

Competencies and Suggested Objectives

1. Introduce physical and operational concepts related to robotics or similar mechanical devices. [DOK1]
    a. Introduce a competition utilizing robotics or similar mechanical devices (e.g., Sea Perch, Vex, First, Best, Lego, Skills, TSA, etc.).
    b. Build a robot or a similar mechanical device utilizing various physical and operational elements including but not limited to:
        - Actuators
        - Autonomous versus user control
        - Drive train/mechanism
        - Electronic controls
        - Manipulators and end effectors
        - Motors/servos
        - Power supply
        - Programming languages
        - Sensors
2. Explore physics or physical concepts as they relate to robotics or similar mechanical devices. [DOK2]
    a. Design and conduct experiments to generate evidence of the relationships between distance, velocity, and acceleration through motion.
    b. Interpret motion graphs to explain or describe phenomena contained within them.
    c. Construct an explanation of observed relationships between variables by applying Newton's Laws of Motion to various real-world scenarios; include F=ma.
    d. Ask questions to generate hypotheses based on empirical evidence and observations to apply principles of physics involved in gears and gear trains.
    e. Evaluate various models to calculate gear ratios and use the results to justify use of specific ratios in real-world or laboratory scenarios.
    f. Recognize fundamentals of:
        - Angular velocity
        - Motors
        - Rotational dynamics
        - Torque
    g. Compare, integrate, and evaluate the following concepts related to robotics:
        - Actual mechanical advantage
        - Efficiency
        - Energy
        - Ideal mechanical advantage
        - Power
        - Work
    h. Recognize the fundamentals of degrees of freedom as it relates to robotic arms.

3. Explore concepts associated with computer programming as it relates to robotics. DOK2 a. Recognize the fundamentals of computer programming in real-world applications to include: • Comments • Flow charts • Pseudocode • Appropriate use of variable names b. Demonstrate proper use of programming techniques in multiple settings to include: • Conditional statements • Constants • Loops • Variables c. Differentiate between analog and digital sensors. d. Differentiate between open and closed loop control. e. Use appropriate programming concepts to autonomously control an end effector.
4. Engage in one or more student competitions that include elements from this unit according to the student organization and/or competition guidelines. DOK4

Unit 7: Safety Review

Competencies and Suggested Objectives
1. Identify and/or review course expectations, school policies, and program policies related to this course. DOK1 a. Identify school rules, policy, and procedures. b. Identify and establish classroom guidelines and procedures. c. Review course standards and affiliated national standards.
2. Review and utilize proper safety procedures in a laboratory setting. DOK2 a. Identify, describe, and demonstrate the importance of safety and the proper use of lab equipment. b. Describe safe operating procedures for the equipment utilized in the course. c. Adhere to applicable MSDS and OSHA 10-Hour General Industry Guidelines in the laboratory setting. d. Demonstrate understanding of Lockout/Tagout procedures. e. Complete lab safety assessment with 100% mastery prior to accessing and operating laboratory equipment.

Unit 8: Capstone

It is important to understand that the Capstone is not to be completed as an isolated unit, but rather an ongoing project that will address, teach, and utilize the other competencies in this course.

Competencies and Suggested Objectives
1. Using digital and/or traditional fabrication methods, apply the engineering design process to solve a student-selected, instructor approved, industry/community relevant problem (individual, small group, or large group). DOK4 a. Research a problem that can be developed into an appropriate and manageable project. b. Create a project proposal that must be approved by the instructor before starting the project. c. Use a highly iterative design process including freehand sketching/drawing and/or a CAD program to design, test, or simulate, and assemble models for the project. d. Apply numerical calculations whenever appropriate to aide in development of the solution. e. Utilize graphs, charts, and tables to analyze and display the data. f. Follow technical writing guides to convey project data and results. g. Using appropriate tools and materials, create a physical or digital product or prototype while considering sustainability, trade-offs, (e.g., safety, cost, reliability, aesthetics, maintenance) and manufacturability. h. Develop the project in a way that can easily be shared with others so that they can retrace steps and build on successes. i. Demonstrate effective interpersonal communication skills in a team or professional setting.
2. Create a project management schedule to track progress and ensure completion. DOK4 a. Discuss and utilize various project management tools (e.g., Gantt chart, software applications, etc.) b. Plan for and conduct mid-project check-ins.
3. Present and justify a final proposal/product to an authentic audience. DOK4 a. Produce professional quality technical documents with the following elements (Based on NASA BEST Engineering Design Process): • Problem definition • Brainstorming documentation • Project plan and specifications • Project design and methods • Project results • Conclusion and future work b. Using appropriate technology and professional manner, present project elements to an authentic audience (industry, and/or community stakeholders). c. Collect the following work materials in a portfolio to demonstrate proper use of the design process to include: • Project goals

- Pertinent research findings
- Sketches
- CAD drawings
- Prototypes (images or renderings of prototypes)
- Working diagrams
- Product specifications and analysis
- Testing methodology and results
- Technical writing samples

4. Exhibit or present the project in a public setting (e.g., maker fair, school fair, school board meeting, community STEM/STEAM night, or online). DOK 3

Suggested Capstone Ideas

1. Augment the capstone project by crossing curricular boundaries, integrating one or more maker-style domains: DOK4
    - Architecture
    - Composites
    - Construction
    - Deconstruction and repair or repurposing/tinkering
    - Energy/electricity (e.g., alternative energy)
    - Flight
    - Farming/gardening/food production
    - Food and culinary arts
    - Launching/propulsion (rockets and projectiles)
    - Light and circuits (e.g., LED and electroluminescent wire)
    - Materials and their life cycles (i.e., material origins, uses, recycling, reuse, repurpose—cradle-to-cradle or cradle-to-grave)
    - Mechanics, motors, and switches (including robotics)
    - Musical instruments and/or music production
    - Papercraft/cardboard construction
    - Programming, microcontrollers, soft circuits/wearables, and sound circuits
    - Sensors and robots (e.g., sensing and interactions)
    - Smart home technologies and IoT
    - Textiles
    - Vehicles/transportation (e.g., bicycles)
    - Water
    - Woodworking/carpentry and metal fabrication
2. Work collaboratively with an engineer to solve a real-world industry problem or apply the engineering process to an issue in your community. DOK4
    a. Work under the guidance of the engineering instructor and the sponsoring engineer.
    b. Observe and record the engineers' work environment, tasks, and procedures.

Unit 9: Advanced Computer-Aided Design

Competencies and Suggested Objectives
1. Review and create 3D models within CAD software. (See previous CAD unit.) DOK4
2. Review 2D drawings and 3D assemblies. (See previous CAD unit.) DOK2
3. Use CAD analysis tools to manipulate variables and collect data to formulate decisions about prototypes or design solutions. DOK3 a. Determine physical properties of a CAD model including: • Center of gravity • Mass • Volume b. Use CAD simulations to calculate the following for a model: • Displacements • Factor of safety • Strains • Stresses c. Redesign a model based on data collected from CAD analysis.
4. Demonstrate proficiency in CAD software simulations. DOK3 a. Use animation to analyze an assembly for: • Collision • Moti • Rotation b. Use flow simulations to evaluate fluid dynamics around an object. c. Conduct an analysis of a CAD assembly, draw conclusions about the system, and critique the conclusions based on the adequacy of the model.
5. Incorporate sustainable methodologies. DOK3 a. Explore CAD sustainability tools and tutorials to include materials, manufacturing, and environmental impact. b. Reevaluate previous designs using sustainable methodologies.

Unit 10: Advanced Robotics

Competencies and Suggested Objectives
1. Create an autonomous or manual control robotics system that solves a competitive challenge with student teams. DOK 4 a. Develop and/or use a complex model that allows for manipulation and testing of a proposed process or system using advanced programming languages and concepts to include: • Digital inputs and outputs • Analog inputs and outputs • Remote control vs. autonomous • Timers • Servos • Encoders • Thresholds • Contact and non-contact sensors • Subroutines, loops, and counters • Switch cases • While loops • If … else statements • Variables • Global variables
2. Use the engineering design process to solve real-world manufacturing challenges with robotics. DOK3 a. Employ the engineering design process to develop an autonomous system that solves or simulates a real-world challenge using conveyors and mechanical drives while utilizing the following: • Programming languages • Manipulators • Sensory feedback • Subroutines

Enrichment
1. Ask questions to determine the relationships between Programmable Logic Controllers (PLCs) and autonomous robotics systems to include: • AND logic • Examining input/output relationships • Latching and unlatching outputs • NOT logic • OR logic

- PLC monitoring tools
- Project: controlling a sorting system
- Timer on delay and timer off delay
- Writing and simulating a basic ladder diagram

2. Explore practical applications of kinematic pairs, cam and follower, and linkages.

Unit 11: Introduction to Electrical Systems

Competencies and Suggested Objectives
1. Examine electrical systems in engineering. DOK1 a. Safely demonstrate the law of electrical charges b. Magnetism and electricity c. Compare and contrast the electrical components and their uses/purposes • Conductors • Insulators • Semiconductors • Resistors • Capacitor • Potentiometer d. Develop, revise, or use a model based on evidence to predict the relationships between alternating and direct current circuits.
2. Examine principles of electrical circuits. DOK1 a. Using the Institute of Electrical and Electronics Engineers (IEEE STD 315-1975, reaffirmed1993) standards, identify standard schematic symbols for: • A/C source • Ammeter • Battery (D/C) • Bulb (lamp) • Capacitor • Circuit ground (power ground – common) • Conductor (connected and unconnected) • Diode • Fixed resistor • Light emitting diode • Motor • N.O. pushbutton switch • Potentiometer • Transformer • Voltmeter b. Develop schematics to explain the parts in 2a that make up simple electrical circuits (i.e., series and parallel circuits). c. Introduce Ohm's Law and formulate an application with it.

3. Construct both series and parallel circuits from the schematics and prove Ohm's law and Watt's law. DOK3
   a. Apply appropriate safety practices and precautions to multi-meter use in various applications including OSHA standard familiarity related to electrical systems.
   b. Demonstrate proper meter setup for specified measurements.
   c. Build series and parallel circuit to prove Ohm's law.
   d. Apply Ohm's law to solve for circuit parameters of voltage, current, and resistance.
   e. Apply Watt's Law to solve for circuit parameters of voltage, current, and power.

Unit 12: Introduction to Fluid Power Systems

Competencies and Suggested Objectives
1. Examine fluid power systems in engineering. DOK1 a. Examine how Pascal's laws are applied in fluid systems b. Explain what the measurement unit psi is describing c. Calculate force output when given incoming pressure and piston diameter (F = PA) d. Use mathematical representations to explain absolute pressure and gauge pressure. e. Identify and use tables, graphs, or digital tools to select a proper hydraulic or pneumatic component for a certain task.
2. Discuss the components of a typical fluid system. DOK1 a. Identify and describe the following cylinder types and associated elements: • Single-acting type • Double-acting type • Control valves • Filters • Hoses • Hydraulic fluid • Pumps • Tanks
3. Investigate industrial applications to communicate differences between pneumatic and hydraulic devices and functions. DOK3 a. Identify and discuss applications of fluid power within the industry. b. Demonstrate the force ratio multiplier advantage of hydraulic system using a student fabricated device.

Unit 13: Introduction to Thermal Systems

Competencies and Suggested Objectives
1. Investigate the principles of thermodynamics. DOK1 a. Explain the following concepts: • Heat • Temperature • Entropy • Specific heat b. Describe the following three modes of heat transfer: • Conduction • Convection • Radiation c. Describe the four laws of thermodynamics and understand the applications of each law. • Zeroth • First • Second • Third d. Use mathematical concepts to solve real world problems involving specific heat and heat capacity.

Enrichment: Student projects (possible Capstone project ideas)
1. Apply the laws of thermodynamics to analyses of heat engines and refrigerators and develop a presentation to showcase the project. 2. Develop, revise, and/or use a model based on evidence to demonstrate thermal conductivity of materials and develop a presentation to showcase the project. 3. Design an energy efficient home using modes of heat transfer and laws of thermodynamics and develop a presentation to showcase the project.

Student Competency Profile for Engineering

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 and Student Organizations		
	1.	Identify course expectations, school policies, student organizations, and program policies related to this course.
	2.	Relate student organization elements to the National Society of Professional Engineers.
	3.	Explore educational and occupational opportunities in the field of engineering, specifically those within the state of Mississippi.
Unit 2: Ethics and Safety		
	1.	Utilize proper safety procedures in a laboratory setting.
	2.	Recognize the importance of ethical teamwork in the field of engineering.
Unit 3: Engineering Design Process and Technical Writing		
	1.	Implement the National Aeronautics and Space Administration (NASA) Beginning Engineering, Science, and Technology (BEST) engineering design process.
	2.	Apply the standards of technical writing to the student project using industry standards.
	3.	Investigate and apply elements of technical writing to produce documents that include clarity, conciseness, accessibility, audience recognition, and accuracy.
Unit 4: Computer-Aided Design and Drafting		
	1.	Explain the purpose of technical drawing and freehand technical sketches.
	2.	Identify and demonstrate proper use of measurement tools.
	3.	Create an appropriately scaled technical drawing.
	4.	Use CAD software to create 3D models.
	5.	Use CAD software to create 2D drawings and 3D assemblies.
Unit 5: Modern Manufacturing Systems		
	1.	Use additive machining methods to create objects that serve a specific purpose.
	2.	Use subtractive machining methods to create objects that serve a specific purpose.

Unit 6: Introduction to Mechanical Systems and Robotics		
	1.	Introduce physical and operational concepts related to robotics or similar mechanical devices.
	2.	Explore physics or physical concepts as they relate to robotics or similar mechanical devices.
	3.	Explore concepts associated with computer programming as it relates to robotics.
	4.	Engage in one or more student competitions that include elements from this unit according to the student organization and/or competition guidelines.
Unit 7: Safety Review		
	1.	Identify and/or review course expectations, school policies, and program policies related to this course.
	2.	Review and utilize proper safety procedures in a laboratory setting.
Unit 8: Capstone		
	1.	Using digital and/or traditional fabrication methods, apply the engineering design process to solve a student-selected, instructor approved, industry/community relevant problem (individual, small group, or large group).
	2.	Create a project management schedule to track progress and ensure completion.
	3.	Present and justify a final proposal/product to an authentic audience.
	4.	Exhibit or present the project in a public setting (e.g., maker fair, school fair, school board meeting, community STEM/STEAM night, or online).
Unit 9: Advanced Computer-Aided Design		
	1.	Review and create 3D models within CAD software.
	2.	Review 2D drawings and 3D assemblies.
	3.	Use CAD analysis tools to manipulate variables and collect data to formulate decisions about prototypes or design solutions.
	4.	Demonstrate proficiency in CAD software simulations.
	5.	Incorporate sustainable methodologies.
Unit 10: Advanced Robotics		
	1.	Create an autonomous or manual control robotics system that solves a competitive challenge with student teams.
	2.	Use the engineering design process to solve real-world manufacturing challenges with robotics.
Unit 11: Introduction to Electrical Systems		
	1.	Examine electrical systems in engineering.
	2.	Examine principles of electrical circuits.
	3.	Construct both series and parallel circuits from the schematics and prove Ohm's law and Watt's law.

Unit 12: Introduction to Fluid Power Systems		
	1.	Examine fluid power systems in engineering.
	2.	Discuss components of a typical fluid system.
	3.	Investigate industrial applications to communicate differences between pneumatic and hydraulic devices and functions.
Unit 13: Introduction to Thermal Systems		
	1.	Investigate the principles of thermodynamics.

Appendix A: National Standards

	Units	1	2	3	4	5	6	7	8	9	10	11	12	13
Standards														
STL-1		x				x	x		x		x	x	x	x
STL-2		x	x				x		x		x	x	x	x
STL-3		x	x			x	x		x		x	x	x	x
STL-4		x			x				x				x	
STL-5							x		x	x			x	x
STL-6		x	x				x	x	x				x	x
STL-7		x						x	x					
STL-8		x				x	x		x	x	x			x
STL-9		x	x	x	x	x	x	x	x	x	x	x	x	x
STL-10			x	x	x	x	x	x	x	x	x		x	x
STL-11				x	x	x	x	x	x	x	x	x		
STL-12		x					x		x	x	x		x	x
STL-13		x			x		x		x				x	x
STL-14		x						x	x					
STL-15			x						x				x	
STL-16		x	x					x	x		x	x	x	
STL-17									x	x	x			x
STL-18							x		x					
STL-19						x	x		x					
STL-20						x	x		x	x				

International Technology and Engineering Education Association (ITEEA)-Standards for Technological Literacy

STL1 Students will develop an understanding of the characteristics and scope of technology.
STL2 Students will develop an understanding of the core concepts of technology.
STL3 Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
STL4 Students will develop an understanding of the cultural, social, economic, and political effects of technology.
STL5 Students will develop an understanding of the effects of technology on the environment.
STL6 Students will develop an understanding of the role of society in the development of and use of technology.
STL7 Students will develop an understanding of the influence of technology on history.
STL8 Students will develop an understanding of the attributes of design.
STL9 Students will develop an understanding of engineering design.
STL10 Students will develop an understanding of the role of troubleshooting, research and development, inventions and innovation, and experimentation in problem solving.

STL11 Students will develop the abilities to apply the design process.
STL12 Students will develop the abilities to use and maintain technological products and systems.
STL13 Students will develop the abilities to assess the impact of products and systems.
STL14 Students will develop an understanding of and be able to select and use medical technologies.
STL15 Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.
STL16 Students will develop an understanding of and be able to select and use energy and power technologies.
STL17 Students will develop an understanding of and be able to select and use information and communication technologies.
STL18 Students will develop an understanding of and be able to select and use transportation technologies.
STL19 Students will develop an understanding of and be able to select and use manufacturing technologies.
STL20 Students will develop an understanding of and be able to select and use construction technologies.

Appendix B: MS-CCR Physical Science Standards

	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13
Standard														
PHS.1.1														
PHS.1.2														
PHS.1.3														
PHS.1.4					x	x	x		x	x	x	x	x	x
PHS.1.5									x					
PHS.1.6										x				
PHS.2.1														
PHS.3.1														
PHS.3.2														
PHS.3.3														
PHS.3.4														
PHS.3.5														
PHS.4.1														x
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			x		x		x			
PHS.5.7							x		x		x			
PHS.5.8							x		x		x			
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	x				
PHS.7.3							x		x	x				
PHS.7.4							x		x	x				
PHS.8.1														x

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

* Indicates enrichment

2018 Mississippi College and Career Readiness Standards – Physical Science

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 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 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 - CO_2, sodium chloride - NaCl, iron III oxide- Fe_2O_3, and calcium bromide - $CaBr_2$).
PHS.3.4 Use naming conventions to name common acids and common compounds used in classroom labs (e.g., sodium bicarbonate (baking soda), $NaHCO_3$; hydrochloric acid, HCl; sulfuric acid, H_2SO_4 ; acetic acid (vinegar), $HC_2H_3O_2$; and nitric acid, HNO_3).
PHS.3.5 Use mathematical and computational analysis to determine the atomic mass of binary compounds.

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	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	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	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 mv2.
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	Students will demonstrate an understanding of temperature scales, heat, and thermal energy transfer.
PHS.8.1	Compare and contrast temperature scales by converting between Celsius, 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 masses/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 of energy generated by burning food products. Communicate conclusions based on evidence from the simulation. *
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.*