FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

OFFICE OF CURRICULUM AND INSTRUCTION

SCIENCE AND ENGINEERING

SCIENCE AND ENGINEERING ELECTRONICS

Grade Level: 11

Credits: 5

BOARD OF EDUCATION ADOPTION DATE:

AUGUST 25, 2014

SUPPORTING RESOURCES AVAILABLE IN DISTRICT RESOURCE SHARING
APPENDIX A: ACCOMMODATIONS AND MODIFICATIONS
APPENDIX B: ASSESSMENT EVIDENCE
APPENDIX C: INTERDISCIPLINARY CONNECTIONS

FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

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172440: SCIENCE AND ENGINEERING ELECTRONICS
COURSE PHILOSOPHY
Science and Engineering Electronics is a junior level course in the Science and Engineering Learning Center. It provides an accelerated, in depth, hands-on experience within the field of electronics. The course emphasizes exploration, observation, and documentation through structured laboratory experiences designed to bring about an awareness of the importance of electronics in the student's life, and as a possible career path. Students will be challenged as they are transported from the theoretical world of advanced mathematics and science into the practical realm of electronics.
COURSE DESCRIPTION
Science and Engineering Electronics is designed for students to explore theories of electronics using practical, hands-on methods. Students will be grounded in the safe use of tools and measurement devices, as well as basic electrical theory, components and circuits. Students are expected to apply knowledge they have gained toward building, troubleshooting, analyzing, and explaining the operation of various electronic circuits and devices. By the end of the course, students will be able to read schematics, use basic tools, measure devices, construct circuits, design and program microcontroller-based electronic systems, and apply their knowledge toward designing solutions for increasingly difficult problems. Students will have an opportunity to combine their knowledge of computer programming and electronics in an original design project in which they will build, test, troubleshoot, present and defend a solution.

COURSE SUMMARY	
COURSE GOALS	
CG1: Students will be able to effectively and safely design, construct, and troubleshoot electronic systems and devices. CG2: Students will be able to safely design microprocessor-based electronic systems capable of solving problems.	
COURSE ENDURING UNDERSTANDINGS	COURSE ESSENTIAL QUESTIONS
CEU1: Complex electronic systems are constructed and designed by combining smaller electronic systems.	CEQ1: How do engineers construct operational circuits?
CEU2: Designing and troubleshooting electronic systems requires an understanding of electronic components, semiconductors, timers, oscillators, amplifiers, and microcontrollers.	CEQ2a: What steps are involved in troubleshooting a circuit? CEQ2b: When designing circuits, what is a "good" design?

UNIT GOALS & PACING		
UNIT TITLE	**UNIT GOALS**	**RECOMMENDED DURATION**
Unit 1: Safety	Students will be able to transfer their learning of safety and lab procedures to make safer and more informed decisions when selecting and using equipment or tools.	1-2 weeks
Unit 2: Components And Devices	Students will be able to transfer their learning of components and devices to construct operational circuits containing resistors, capacitors, diodes, relays, motors, switches and other components and devices.	6 weeks
Unit 3: Theory of Basic Electronic Circuits	Students will be able to transfer their learning of Ohm's Law, Watt's Law, Thevenin's Theorem and Kirchhoff's Law to construct, analyze, and troubleshoot electronic circuits and devices containing series, parallel, and combination circuits.	6 weeks
Unit 4: Semiconductors	Students will be able to transfer their learning of semiconductor devices to construct and troubleshoot electronic circuits incorporating transistors, diodes, and other semiconductors.	6 weeks
Unit 5: Oscillators, Timers, and Amplifiers	Students will be able to transfer their learning of oscillators, timers and amplifiers to construct and troubleshoot circuits containing timers, audio amplifiers, op-amps, comparators, and other integrated circuits.	6 weeks
Unit 6: Motors and Controls	Students will be able to transfer their learning of various motors and methods for controlling motors to construct and control devices containing DC motors, stepper motors, and servo motors.	6 weeks
Unit 7: Microcontrollers	Students will be able to transfer their learning of microcontrollers to create electronic systems capable of measuring, sensing, and recording their environment by interfacing inputs and outputs with various microcontrollers.	6 weeks

172440: SCIENCE AND ENGINEERING ELECTRONICS
UNIT 1: SAFETY **SUGGESTED DURATION: 1-2 WEEKS**

<table>
<tr><th colspan="2">UNIT OVERVIEW</th></tr>
<tr><td colspan="2">UNIT LEARNING GOALS</td></tr>
<tr><td colspan="2">Students will be able to transfer their learning of safety and lab procedures to make safer and more informed decisions when selecting and using equipment or tools.</td></tr>
<tr><td colspan="2">UNIT LEARNING SCALE</td></tr>
<tr><td>4</td><td>In addition to a level 3 performance, the student can correct a peer that is not following appropriate safety protocol.</td></tr>
<tr><td>3</td><td>Given a task, the student can:
• select the appropriate equipment or tool;
• use the appropriate equipment or tool;
• follow all appropriate safety procedures;
• respond appropriately in an emergency situation.</td></tr>
<tr><td>2</td><td>The student sometimes needs assistance from a teacher, makes minor mistakes, and/or can do the majority of level 3 performances.</td></tr>
<tr><td>1</td><td>The student needs assistance or makes larger errors in attempting to reach level 3.</td></tr>
<tr><td>0</td><td>Even with help, the student does not exhibit understanding of performances listed in level 3.</td></tr>
</table>

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: A comprehensive safety plan limits the potential for injuries in a laboratory classroom or workplace setting.	EQ1: There is a saying: “Never let your guard down.” How does this apply to the lab?
EU2: Safety is important no matter what process or operation is being performed in the lab.	EQ2: Can any procedure be completely safe?

NJCCCS & COMMON CORE STANDARDS
8.2.12.B.3 Analyze the full costs, benefits, trade-offs and risks related to the use of technologies in a potential career path 8.2.12.C.3 Evaluate the positive and negative impacts in a design by providing a digital overview of a chosen product and address the negative impacts. 8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system. 8.2.12.F.2 Explain how material science impacts the quality of products. 8.2.12.F.3 Select and utilize resources that have been modified by digital tools in the creation of a technological product or system (CNC equipment, CAD software). 9.1.12.B.3 Assist in the development of innovative solutions to an onsite problem by incorporating multiple perspectives and applying effective problem-solving strategies during structured learning experiences, service learning, or volunteering. 9.1.12.F.2 Demonstrate a positive work ethic in various settings, including the classroom and during structured learning experiences. RST.11-12.3 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. RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.

NJCCCS & COMMON CORE STANDARDS
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. RST.11-12.9 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.

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG1 EU1, EQ1, EU2, EQ2 8.2.12.C.3, 8.2.12.F.1, 8.2.12.F.2, 8.2.12.F.3, 9.1.12.B.3, 9.1.12.F.2 RST.11-12.4, RST.11-12.7, RST.11-12.9 DOK 3	Lab Recommendations: In conjunction with their peers, the students will analyze the lab including all tools and procedures and make recommendations based on their analysis. The students will conduct research on building codes, OSHA requirements, tool manufacturers, etc. They will make a presentation or create a video showcasing their findings and recommendations.

SUGGESTED STRATEGIES		
ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Given the appropriate materials, tools, and equipment, students will demonstrate proficiency in their safe and effective use. The students will engage in an equipment scavenger hunt in which they need to identify the equipment and the location of each piece of equipment in the laboratory (including lab safety equipment). Use teacher demonstrations to show safe and proper use upon completion of the scavenger hunt.	• Parts of the tools • Guidelines regarding proper use of tools • Location and use of all safety equipment with the classroom DOK 1	• Follow proper techniques for tool usage • Identify hazardous materials • Read and evaluate HSFS and MSDS data sheets DOK 2
Given a set of safety standards and guidelines, the students will demonstrate compliance through practical demonstration in a laboratory setting.	• Dangerous characteristics of electricity and laboratory equipment • Guidelines for working around electrical devices in a laboratory setting DOK 1	Follow strategies for working with electricity in a safe manner DOK 2

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students will demonstrate safe and effective soldering techniques.	Parts of the soldering iron DOK 1	• Demonstrate proper setup and technique for soldering and de-soldering circuits and electrical equipment • Follow rules regarding proper use and ventilation requirements for soldering DOK 2

172440: SCIENCE AND ENGINEERING ELECTRONICS
UNIT 2: COMPONENTS AND DEVICES **SUGGESTED DURATION: 6 WEEKS**

UNIT OVERVIEW	
UNIT LEARNING GOALS	
Students will be able to transfer their learning of components and devices to construct operational circuits containing resistors, capacitors, diodes, relays, motors, switches and other components and devices.	
UNIT LEARNING SCALE	
4	In addition to a level 3 performance, the student can utilize three or more components and/or devices to construct a single operational circuit.
3	The student is able to construct operational circuits containing: • resistors; • capacitors; • diodes; • relays; • motors; • switches.
2	The student can distinguish between several types of resistors, capacitors, diodes, relays, motors, and switches.
1	With help, the student can distinguish between several types of resistors, capacitors, diodes, relays, motors, and switches.
0	Even with help, the student does not exhibit understanding of components and devices.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: The most complex electronic systems consist of simpler devices.	EQ1: How do components of an operational circuit interact and affect one another?
EU2: Electronic components impact the flow of electrons in different ways based on scientific laws and principles.	EQ2: How does electrical current "know" where to go?

NJCCCS & COMMON CORE STANDARDS
8.2.12.B.3 Analyze the full costs, benefits, trade-offs and risks related to the use of technologies in a potential career path 8.2.12.C.2 Evaluate the ethical considerations regarding resources used for the design, creation, maintenance and sustainability of a chosen product. 8.2.12.C.3 Evaluate the positive and negative impacts in a design by providing a digital overview of a chosen product and address the negative impacts. 8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system. 8.2.12.F.2 Explain how material science impacts the quality of products. 8.2.12.F.3 Select and utilize resources that have been modified by digital tools in the creation of a technological product or system (CNC equipment, CAD software). 9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences. 9.1.12.F.2 Demonstrate a positive work ethic in various settings, including the classroom and during structured learning experiences. RST.11-12.3 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.

NJCCCS & COMMON CORE STANDARDS
RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. RST.11-12.9 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.

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
CG1,CG2, LG1 CEU1, CEQ1, CEU2, CEQ2a, CEQ2b, EU1, EQ1, EU2, EQ2 8.2.12.C.2, 8.2.12.C.3, 8.2.12.F.1, 8.2.12.F.2, 8.2.12.F.3, 9.1.12.A.1, 9.1.12.F.2 DOK 4	Line Following Robot: The students will research, design, construct, troubleshoot and document the entire process of building a line following robot using resistors, capacitors, diodes, relays, switches and DC motors. Each student will document the process in an engineer's notebook, which can be an electronic notebook.

SUGGESTED STRATEGIES		
ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students construct simple circuits using resistors, LEDs, switches, variable power supplies, photo resistors, potentiometers, and capacitors. The level of expectation for individual student's circuits will be based on their ability.	• Characteristics of components • Concepts of voltage dividers • Schematic symbols and diagrams DOK 1	• Build circuits using solder-less breadboards • Demonstrate proper safe usage of tools and electronic testing devices • Troubleshoot simple circuits using multimeters and oscilloscopes • Interpret a schematic diagram DOK 4

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students measure voltage, current, and resistance using a multimeter and report their findings.	• Concepts of voltage, current, resistance • Relationship between current and voltage • Relationship between current and resistance • Concept of voltage drop DOK 1	• Proper usage of a multimeter • Measure voltage of a power source • Measure resistance of resistors, potentiometer, light dependent resistors • Measure current flow in a simple circuit • Plot the relationship between current and voltage • Plot the relationship between current and resistance • Check components for continuity DOK 3
Students watch a digital overview of a component and discuss their learning with a partner. A larger class discussion should follow.	• Physical characteristics of a component • Schematic symbols • Materials used in manufacturing • Manufacturing processes DOK 1	• Analyze a component in a circuit or device • Interpret a schematic diagram DOK 3

172440: SCIENCE AND ENGINEERING ELECTRONICS
UNIT 3: THEORY OF BASIC ELECTRONIC CIRCUITS **SUGGESTED DURATION: 6 WEEKS**

UNIT OVERVIEW	
UNIT LEARNING GOALS	
Students will be able to transfer their learning of Ohm's Law, Watt's Law, Thevenin's Theorem and Kirchhoff's Law to construct, analyze, and troubleshoot electronic circuits and devices containing series, parallel, and combination circuits.	
UNIT LEARNING SCALE	
4	In addition to a level 3 performance, the student can create authentic operational circuits with an expressed purpose.
3	The student can: • apply knowledge of Ohm's Law, Watt's Law, Thevenin's Theorem and Kirchhoff's Law, • construct electronic circuits and devices containing series, parallel, and combination circuits; • analyze electronic circuits and devices containing series, parallel, and combination circuits; • troubleshoot electronic circuits and devices containing series, parallel, and combination circuits.
2	The student can: • construct and troubleshoot circuits by applying their knowledge of some of the laws; • calculate values for some components using Ohm's Law and Watt's Law.
1	The student can: • identify series, parallel and combination circuits; • discuss the flow of current in basic circuits.
0	Even with help, the student does not exhibit understanding of the theory of basic electronic circuits.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: The operation of all circuits and devices can be explained by using one or more laws.	EQ1: There is a saying, "laws are meant to be broken." How does this apply to electronics?
EU2: All complex circuits are comprised of series, parallel, or combination circuits.	EQ2: My circuit doesn't work. What do I do now?

NJCCCS & COMMON CORE STANDARDS
8.2.12.C.2 Evaluate the ethical considerations regarding resources used for the design, creation, maintenance and sustainability of a chosen product. 8.2.12.C.3 Evaluate the positive and negative impacts in a design by providing a digital overview of a chosen product and address the negative impacts. 8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system. 8.2.12.F.2 Explain how material science impacts the quality of products. 8.2.12.F.3 Select and utilize resources that have been modified by digital tools in the creation of a technological product or system (CNC equipment, CAD software). 9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences. 9.1.12.F.2 Demonstrate a positive work ethic in various settings, including the classroom and during structured learning experiences.

NJCCCS & COMMON CORE STANDARDS
RST.11-12.3 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. RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. RST.11-12.9 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.

COMMON ASSESSMENT

ALIGNMENT	DESCRIPTION
LG1 EU1, EQ1, EU2, EQ2 8.2.12.C.3, 8.2.12.F.1, 8.2.12.F.2, 9.1.12.A.1, 9.1.12.F.2 RST.11-12.3, RST.11-12.4, RST.11-12.7, RST.11-12.9 DOK 4	<u>Troubleshooting Project</u>: The students will receive a circuit or device that does not function correctly. They will research the device including components, manufacturing processes, and schematic diagrams. The students will use a multimedia presentation to present their research and make suggestions for improvement or redesign. Emphasis will be placed on applying knowledge of the basic theory of electronic circuits.

SUGGESTED STRATEGIES

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students will construct simple circuits using resistors, LEDs, switches, variable power supplies, photo resistors, potentiometers. The level of expectation for individual student's circuits will be based on their ability.	Characteristics of components DOK 1	Building circuits using solder-less breadboards DOK 4

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students will measure voltage, current, and resistance using a multimeter.	Concepts of voltage, current, resistance DOK 1	• Proper usage of a multimeter • Measure voltage of a power source • Measure resistance of resistors, potentiometer, and light dependent resistors • Measure current flow in a simple circuit • Check components for continuity DOK 2
Students will analyze series circuits, parallel circuits, and combination circuits and communicate their analysis.	• Ohm's Law • Watt's Law • Kirchhoff's Law • Thevenin's Law DOK 1	Calculate missing values for current, voltage, resistance and power DOK 2
Students will be assigned one of the laws. They will create presentations in which they explain the law and its application to different situations. Students can determine how they will present their law to the class (i.e. digital presentations, demonstrations, and posters).	• Ohm's Law • Watt's Law • Kirchhoff's Law • Thevenin's Law DOK 1	Explain how the law applies to different situations DOK 2

172440: SCIENCE AND ENGINEERING ELECTRONICS	
UNIT 4: SEMICONDUCTORS	SUGGESTED DURATION: 6 WEEKS

UNIT OVERVIEW

UNIT LEARNING GOALS

Students will be able to transfer their learning of semiconductor devices to construct and troubleshoot electronic circuits incorporating transistors, diodes, and other semiconductors.

UNIT LEARNING SCALE

4	In addition to a level 3 performance, the student can create an operational circuit with semiconductors, motors, capacitors, and/or resistors for an expressed purpose.
3	The student can: • construct electronic circuits incorporating transistors, diodes, and other semiconductors; • troubleshoot electronic circuits incorporating transistors, diodes, and other semiconductors.
2	The student can: • explain properties of semiconductor materials; • construct simple operational circuits using various semiconductors.
1	The student can: • identify different semiconductors; • describe the operation of various semiconductors.
0	Even with help, the student does not exhibit understanding of semiconductors.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: The invention of the semiconductor gave rise to the information age and modern computing as we know it.	EQ1: Which semiconductor device is the most important? Why?
EU2: Semiconductors behave differently depending on changes in voltage, current and resistance.	EQ2: What makes a semiconductor, a semiconductor?

NJCCCS & COMMON CORE STANDARDS

8.2.12.C.2 Evaluate the ethical considerations regarding resources used for the design, creation, maintenance and sustainability of a chosen product.
8.2.12.C.3 Evaluate the positive and negative impacts in a design by providing a digital overview of a chosen product and address the negative impacts.
8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system.
8.2.12.F.2 Explain how material science impacts the quality of products.
8.2.12.F.3 Select and utilize resources that have been modified by digital tools in the creation of a technological product or system (CNC equipment, CAD software).
9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences.
9.1.12.F.2 Demonstrate a positive work ethic in various settings, including the classroom and during structured learning experiences.

RST.11-12.3 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.

NJCCCS & COMMON CORE STANDARDS
RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. RST.11-12.9 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.

COMMON ASSESSMENT

ALIGNMENT	DESCRIPTION
LG1 EU1, EQ1, EU2, EQ2 8.2.12.C.3, 8.2.12.F.1, 8.2.12.F.2, 8.2.12.F.3, 9.1.12.A.1, 9.1.12.F.2 RST.11-12.3, RST.11-12.4, RST.11-12.7, RST.11-12.9 DOK 4	Dark Detector: The students will design a circuit that incorporates one or more semiconductor devices (e.g., a device that detects darkness). They will research existing solutions to the same problem for ideas. The students will construct the circuit on a solder-less breadboard. They will be required to document the design process in a daily log or engineer's notebook and present the project to the class.

SUGGESTED STRATEGIES

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students construct circuits using p-n junction diodes, Schottky diodes, Zener diodes, light emitting diodes, and photodiodes. The level of expectation for individual student's circuits will be based on their ability.	• Semiconductors • Zener voltage • Flyback diode DOK 1	• Build circuits using solder-less breadboards • Research data sheets to determine current and voltage limits and characteristics DOK 4

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students build a circuit that can detect when light levels fall using transistors and LEDs. The level of expectation for individual student's circuits will be based on their ability.	• Voltage dividers • Bipolar transistors • NPN • PNP DOK 1	• Explain the forward biasing of the base emitter junction • Build a circuit by following a schematic diagram • Troubleshoot a circuit using a multimeter and a schematic diagram DOK 4
With a partner, students will explore the relationship between current and voltage and communicate their analysis.	• Forward bias • Reverse bias DOK 1	• Measure voltage and current • Graph the relationship between voltage and current DOK 2
Students will test a transistor to determine functionality.	• Relationship between voltage drop, diodes and transistors • Relationship between resistance and forward and reverse bias DOK 1	• Use a multimeter • Perform a diode check on a transistor • Use a ohmmeter • Determine if a transistor is NPN or PNP DOK 3
With a partner, students will investigate the gain of transistors. Students must compare their analysis with other groups in the class.	• Gain • Load resistor • Common emitter • Amplifier collector current DOK 1	Measure voltage drop and collector current DOK 2

172440: SCIENCE AND ENGINEERING ELECTRONICS	
UNIT 5: TIMERS, OSCILLATORS, AND AMPLIFIERS	**SUGGESTED DURATION: 6 WEEKS**

UNIT OVERVIEW	
UNIT LEARNING GOALS	
Students will be able to transfer their learning of oscillators, timers and amplifiers to construct and troubleshoot circuits containing timers, audio amplifiers, op-amps, comparators, and other integrated circuits.	
UNIT LEARNING SCALE	
4	In addition to a level 3 performance, the student can: • apply learning of timers, oscillators, and IC OP amps to increasingly difficult practical design problems; • utilize knowledge and skills from previous units to design operational circuits with an expressed purpose.
3	The student can: • construct circuits containing timers, audio amplifiers, op-amps, comparators, and other integrated circuits; • troubleshoot circuits containing timers, audio amplifiers, op-amps, comparators, and other integrated circuits.
2	The student can: • construct timers, oscillators and amplifiers by following schematic diagrams; • troubleshoot timers, oscillators and amplifiers as needed; • identify patterns such as sine waves, square waves, sawtooth waves, and triangle waves.
1	The student can: • distinguish between timers, oscillators, and amplifiers; • recall domain specific terminology such as monostable, astable, comparator, duty cycle, pulse width modulation, frequency, and amplitude.
0	Even with help, the student does not exhibit understanding of timers, oscillators and amplifiers.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: Timers, oscillators and amplifiers form the basic architecture for all digital devices.	EQ1: How would you design a device that will time an event, flash an LED, or make a small sound larger?
EU2: Digital devices are made increasingly smaller due to advancements in manufacturing of timers, oscillators and amplifiers.	EQ2: Do you think Moore's Law will continue to be proven true? Why or why not?

NJCCCS & COMMON CORE STANDARDS
8.2.12.B.3 Analyze the full costs, benefits, trade-offs and risks related to the use of technologies in a potential career path 8.2.12.C.2 Evaluate the ethical considerations regarding resources used for the design, creation, maintenance and sustainability of a chosen product. 8.2.12.C.3 Evaluate the positive and negative impacts in a design by providing a digital overview of a chosen product and address the negative impacts. 8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system. 8.2.12.F.2 Explain how material science impacts the quality of products. 8.2.12.F.3 Select and utilize resources that have been modified by digital tools in the creation of a technological product or system (CNC equipment, CAD software). 9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences.

NJCCCS & COMMON CORE STANDARDS
9.1.12.B.3 Assist in the development of innovative solutions to an onsite problem by incorporating multiple perspectives and applying effective problem-solving strategies during structured learning experiences, service learning, or volunteering. 9.1.12.F.2 Demonstrate a positive work ethic in various settings, including the classroom and during structured learning experiences. RST.11-12.3 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. RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. RST.11-12.9 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.

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG1 EU1, EQ1, EU2, EQ2 8.2.12.C.2, 8.2.12.C.3, 8.2.12.F.1, 8.2.12.F.2, 8.2.12.F.3, 9.1.12.A.1, 9.1.12.B.3, 9.1.12.F.2 RST.11-12.3, RST.11-12.4, RST.11-12.7, RST.11-12.9 DOK 4	<u>Timer, Oscillator, Amplifier Design Challenge</u>: The students will design a sound-activated timer that will output an audible signal as well as a visual signal. The expectation is that the students will research multiple sources, synthesize information and document the entire design process. They will: build their circuit; test and troubleshoot their circuit; analyze their circuit; and be asked to defend their solution in a presentation to their peers. The students will be asked to maintain an engineer's notebook documenting their design process.

SUGGESTED STRATEGIES		
ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students construct 555 timers in monostable and astable modes. The level of expectation for individual student's timers will be based on their ability.	• Characteristics of 555 timers • Characteristics of square waves DOK 1	• Build monostable and astable timers by following a schematic diagram • Troubleshoot monostable and astable timers by following a schematic diagram DOK 4

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students build a two-transistor oscillator. The level of expectation for individual student's two-transistor oscillators will be based on their ability.	Characteristics of RC time circuits DOK 1	• Proper usage of a multimeter • Measure voltage of a power source • Measure resistance of resistors, potentiometer, and light dependent resistors • Measure current flow in a simple circuit • Check components for continuity DOK 3
Students construct an audio amplifier using the LM386 or equivalent. The level of expectation for individual student's audio amplifiers will be based on their ability.	• Characteristics of sound waves (frequency, intensity, timbre) • Impedance • Gain • Filter • Preamplifier DOK 1	• Build an audio amplifier circuit by following a schematic diagram • Troubleshoot an audio amplifier circuit by following a schematic diagram • Modify the operation of the circuit by substituting different values for components DOK 4
Students construct an analog-to-digital converter using a 555 timer. The level of expectation for individual student's converters will be based on their ability.	• Analog • Digital • Comparator • Voltage divider DOK 1	• Build an analog to digital converter by following a schematic diagram • Troubleshoot an analog to digital converter by following a schematic diagram • Create a circuit by synthesizing information from previous units DOK 4

172440: SCIENCE AND ENGINEERING ELECTRONICS
UNIT 6: MOTORS AND CONTROLS **SUGGESTED DURATION: 6 WEEKS**

<table>
<tr><th colspan="3">UNIT OVERVIEW</th></tr>
<tr><td colspan="3">UNIT LEARNING GOALS</td></tr>
<tr><td colspan="3">Students will be able to transfer their learning of various motors and methods for controlling motors to construct and control devices containing DC motors, stepper motors, and servo motors.</td></tr>
<tr><td colspan="3">UNIT LEARNING SCALE</td></tr>
<tr><td>4</td><td colspan="2">In addition to level 3 performances, the student can:
apply knowledge of motors and controls to increasingly difficult design problems with minimum instructor intervention;
sufficiently control motors within an authentic design project.</td></tr>
<tr><td>3</td><td colspan="2">The student can:
construct and control devices containing DC motors, stepper motors, and servo motors;
construct circuits to control the speed, position, or direction of various motors (DC, steppers, servos);
defend their design choices.</td></tr>
<tr><td>2</td><td colspan="2">The student can:
select motors and controls to accomplish given tasks;
defend design choices.</td></tr>
<tr><td>1</td><td colspan="2">The student can:
identify and describe the operation of motors (DC, steppers, servos);
distinguish between methods of control (H-Bridges, IC motor drivers, pulse width modulation, transistors).</td></tr>
<tr><td>0</td><td colspan="2">Even with help, the student does not exhibit understanding of motors and controls.</td></tr>
<tr><td colspan="2">ENDURING UNDERSTANDINGS</td><td>ESSENTIAL QUESTIONS</td></tr>
<tr><td colspan="2">EU1: Speed, direction, and position are important aspects of motor control.</td><td>EQ1: What are the best means to control an electric motor?</td></tr>
<tr><td colspan="2">EU2: The application of motor control is important for automating manufacturing processes.</td><td>EQ2: How does an electric motor operate and what are the advantages of using electrical motors?</td></tr>
<tr><td colspan="3">NJCCCS & COMMON CORE STANDARDS</td></tr>
<tr><td colspan="3">8.2.12.B.3 Analyze the full costs, benefits, trade-offs and risks related to the use of technologies in a potential career path
8.2.12.C.2 Evaluate the ethical considerations regarding resources used for the design, creation, maintenance and sustainability of a chosen product.
8.2.12.C.3 Evaluate the positive and negative impacts in a design by providing a digital overview of a chosen product and address the negative impacts.
8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system.
8.2.12.F.2 Explain how material science impacts the quality of products.
8.2.12.F.3 Select and utilize resources that have been modified by digital tools in the creation of a technological product or system (CNC equipment, CAD software).
9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences.</td></tr>
</table>

NJCCCS & COMMON CORE STANDARDS
9.1.12.B.3 Assist in the development of innovative solutions to an onsite problem by incorporating multiple perspectives and applying effective problem-solving strategies during structured learning experiences, service learning, or volunteering. 9.1.12.F.2 Demonstrate a positive work ethic in various settings, including the classroom and during structured learning experiences. RST.11-12.3 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. RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. RST.11-12.9 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.

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG1 EU1, EQ1, EU2, EQ2 8.2.12.C.2, 8.2.12.C.3, 8.2.12.F.1, 8.2.12.F.2, 8.2.12.F.3, 9.1.12.A.1, 9.1.12.B.3, 9.1.12.F.2 RST.11-12.3, RST.11-12.4, RST.11-12.7, RST.11-12.9 DOK 4	<u>Motor Control Design Challenge</u>: The students will be issued a design challenge in which they specify a particular motor and method for controlling the motor. They will: build their circuits; test and troubleshoot their circuits; analyze their circuits; and be asked to defend their solutions in a presentation to their peers. The students will be asked to maintain an engineer's notebook documenting their design process.

SUGGESTED STRATEGIES		
ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students will compare and contrast DC motors, stepper motors and servo motors.	• Parts of DC motors, stepper motors and servo motors • Operations of DC motors, stepper motors and servo motors DOK 1	Build an operational circuit by following a schematic diagram DOK 4

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students control a DC motor by using a transistor switch, half bridge, and H bridge.	• Four states of DC motor operation DOK 1	• Build an operational circuit by following a schematic diagram • Use a fly back diode to prevent transistor damage DOK 4
Students build a 555-controlled servo motor circuit. The level of expectation for individual student's circuits will be based on their ability.	• Parts of a servo motor • Differences between servo and continuous rotation servo DOK 1	Build an operational circuit by following a schematic diagram DOK 4
Students build a stepper motor controller using transistors and a microcontroller. The level of expectation for individual student's controllers will be based on their ability.	• Unipolar • Bipolar stepper motors DOK 1	• Build a circuit by following a schematic diagram • Troubleshoot a circuit by following a schematic diagram DOK 4
Students analyze a DC motor to determine operating current and stall current.	• Operating current • Stall current DOK 1	• Measure current in a DC motor circuit • Specify an appropriate transistor for a motor control circuit DOK 3
Students construct a pulse width modulated DC motor speed controller using a 555 timer. The level of expectation for individual student's controllers will be based on their ability.	• Pulse width modulation • Duty cycle DOK 1	• Build a circuit by following a schematic diagram • Troubleshoot a circuit by following a schematic diagram • Interpret the duty cycle of a 555 DC motor controller by using an oscilloscope DOK 4

172440: SCIENCE AND ENGINEERING ELECTRONICS
UNIT 7: MICROCONTROLLERS **SUGGESTED DURATION: 6 WEEKS**

UNIT OVERVIEW	
UNIT LEARNING GOALS	
Students will be able to transfer their learning of microcontrollers to create electronic systems capable of measuring, sensing, and recording their environment by interfacing inputs and outputs with various microcontrollers.	
UNIT LEARNING SCALE	
4	In addition to a level 3 performance, the student can: • design solutions for instructor created problems by applying concepts of microcontrollers; • authentically design projects with microcontrollers for an expressed purpose.
3	The student can: • interface inputs and outputs with various microcontrollers; • create electronic systems capable of measuring, sensing, and recording their environment.
2	The student can: • construct or hook up a basic microcontroller system and download a simple program; • create an electronic system using knowledge of inputs and outputs; • debug programs by observing interactions between inputs and outputs.
1	The student can: • identify parts of a microcontrollers system; • discus the basic operation of a microcontroller.
0	Even with help, the student exhibits no understanding of microcontrollers.

ENDURING UNDERSTANDINGS	ESSENTIAL QUESTIONS
EU1: Microcontrollers are becoming an increasingly important part of our daily existence.	EQ1: What are the limitations of microcontrollers?
EU2: Automation requires the application of microcontrollers.	EQ2: How do microcontrollers influence your daily life?

NJCCCS & COMMON CORE STANDARDS
8.2.12.B.3 Analyze the full costs, benefits, trade-offs and risks related to the use of technologies in a potential career path 8.2.12.C.2 Evaluate the ethical considerations regarding resources used for the design, creation, maintenance and sustainability of a chosen product. 8.2.12.C.3 Evaluate the positive and negative impacts in a design by providing a digital overview of a chosen product and address the negative impacts. 8.2.12.F.1 Determine and use the appropriate application of resources in the design, development, and creation of a technological product or system. 8.2.12.F.2 Explain how material science impacts the quality of products. 8.2.12.F.3 Select and utilize resources that have been modified by digital tools in the creation of a technological product or system (CNC equipment, CAD software). 9.1.12.A.1 Apply critical thinking and problem-solving strategies during structured learning experiences.

NJCCCS & COMMON CORE STANDARDS
9.1.12.B.3 Assist in the development of innovative solutions to an onsite problem by incorporating multiple perspectives and applying effective problem-solving strategies during structured learning experiences, service learning, or volunteering. 9.1.12.F.2 Demonstrate a positive work ethic in various settings, including the classroom and during structured learning experiences. RST.11-12.3 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. RST.11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics. RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. RST.11-12.9 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.

COMMON ASSESSMENT	
ALIGNMENT	DESCRIPTION
LG1 EU1, EQ1, EU2, EQ2 8.2.12.C.2, 8.2.12.C.3, 8.2.12.F.1, 8.2.12.F.2, 8.2.12.F.3, 9.1.12.A.1, 9.1.12.B.3, 9.1.12.F.2 RST.11-12.3, RST.11-12.4, RST.11-12.7, RST.11-12.9 DOK 4	<u>Robot Design</u>: The students will design a micro-controlled robot that will accomplish an assigned task (e.g., avoid obstacles in a room, navigate a floor plan, or follow a wall). They will research possible design options and give an overview presentation of their design, build, test and troubleshooting. The students will also have to justify their design choices. <u>Extension</u>: The students can choose to enter a contest such as the Trinity College Fire Fighting Home Robot Contest.

SUGGESTED STRATEGIES		
ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students creates a “Hello World!” program. This is the first program that will activate an output.	Microcontroller system DOK 1	• Install and set up the integrated development environment • Connect the microcontroller to the computer and download code DOK 3

ACTIVITIES	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE
Students create a blinking wave using multiple outputs.	Microcontroller DOK 1	• Use variables in a program to accomplish assigned tasks • Connect various outputs to the microcontroller DOK 4
Students experiment with Pulse Width Modulation by varying the duty cycle of an output.	For loops DOK 1	Connect various outputs to the microcontroller DOK 3
Students activate an output using a digital input.	• Analog inputs • Digital inputs • Sinking current • Sourcing current DOK 1	Connect various inputs to the microcontroller DOK 3
Students create a system that reads an input and activates an output.	Switch bounce DOK 1	Interface the microcontroller with inputs and outputs DOK 3
Students create a system that reads multiple inputs and activates multiple outputs. The level of expectation for individual student's systems will be based on their ability.	• Shift register • Shift register pins DOK 1	Interface the microcontroller with inputs and outputs DOK 3
Students analyze the operation of various sensors and outputs.	• Ultrasonic sensors • Infrared sensors • Light dependent resistors • Thermistors DOK 1	• Write a program to interface a sensor with a microcontroller • Build a sensor circuit external to the microcontroller • Debug a program by observing the interaction between sensors and outputs DOK 4