Electronics Systems III

8413 36 weeks

Table of Contents

Acknowledgments 1
Course Description 2
Task Essentials Table 3
Curriculum Framework 6
Analyzing Microprocessors 6
Using Sensors 12
Examining Magnetism and Coils 14
Investigating Motors 18
Introducing Motor Controllers 22
Introducing Power Supplies 24
Analyzing Digital Logic Circuits 30
Exploring Robotic Programming 45
SOL Correlation by Task 51
Cyber Security and Cyber Forensics Infusion Units 54
Entrepreneurship Infusion Units 54
Appendix: Credentials, Course Sequences, and Career Cluster Information 55

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Course Description

Suggested Grade Level: 11 or 12
Prerequisites: 8412

In this capstone course, students perform hands-on activities to apply advanced electronics concepts in state-of-the-art digital electronics and robotic programming, including concentrated work with microprocessors, magnetism, diodes, motors, transistors, amplifiers, power supplies, and automation.

Note: Electronics Systems III may be offered as a complement to an existing concentration sequence in any Career Cluster. In some instances, where noted, it may be combined with specific courses to create concentration sequences.

Task Essentials Table

- Tasks/competencies designated by plus icons (⊕) in the left-hand column(s) are essential
- Tasks/competencies designated by empty-circle icons (○) are optional
- Tasks/competencies designated by minus icons (⊖) are omitted
- Tasks marked with an asterisk (*) are sensitive.

Task Number	8413	Tasks/Competencies
Analyzing Microprocessors		
39	⊕	Demonstrate adherence to safety procedures and guidelines for using lab tools and equipment.
40	○	Analyze digital and microprocessor circuit characteristics, using circuit simulation software.
41	○	Describe the primary functions of the components of a microprocessor.
42	○	Correlate electricity principles to circuitry and microprocessors.
43	⊕	Describe the atomic structure and construction methods of semiconductors.
44	⊕	Describe complex direct current (DC) circuits.
45	⊕	Design a simple microprocessor circuit, including user input and feedback to the user.
Using Sensors		
46	⊕	Identify Sensors.
47	⊕	Describe types of conversions.
48	⊕	Use sensors in circuit design.
Examining Magnetism and Coils		

49	⊕	Describe the principles of magnetism as applied to electronics and robotics.	
50	⊕	Describe the characteristics of magnetism.	
51	⊕	Identify coil technology.	
52	⊕	Design a coil.	
Investigating Motors			
53	⊕	Describe the components of electric motors.	
54	⊕	Describe the design principles and concepts related to electric motors and generators.	
55	⊕	Describe the process of selecting a motor for application.	
56	⊕	Design gear ratios for a specified application.	
57	⊕	Design an electric motor.	
Introducing Motor Controllers			
58	⊕	Identify motor controllers.	
59	⊕	Identify the purpose of servo motors.	
60	⊕	Examine quadcopters.	
Introducing Power Supplies			
61	⊕	Identify types of power supply circuits.	
62	⊕	Compare types of rectifier circuits and their functions.	
63	⊕	Describe the function of voltage regulators.	
64	⊕	Describe the function of oscillators.	
65	⊕	Describe types of oscillators.	
66	⊕	Describe the function of pulse for control circuits.	
67	⊕	Describe modulation.	
68	⊕	Connect a power supply, using a rectifier circuit.	

Analyzing Digital Logic Circuits			
69	○	Describe digital characteristics, techniques, numbering systems, and binary arithmetic.	
70	⊕	Analyze digital and microprocessor circuit characteristics, using circuit simulation software.	
71	⊕	Construct analog-to-digital (ADC) and digital-to-analog (DAC) circuits.	
72	○	Convert between the binary and decimal number systems.	
73	⊕	Describe data representation.	
74	⊕	Compare the function of digital logic circuits.	
75	⊕	Compare practical logic circuits.	
76	⊕	Use Boolean algebra to express logic operations and minimize logic circuits in design.	
77	⊕	Describe the methods used to calculate values in logical expressions.	
78	⊕	Design a logic circuit, using Boolean algebra and methods.	
79	⊕	Compare the functions of flip-flops and registers.	
80	⊕	Describe the operation of memory circuits.	
81	⊕	Describe the characteristics of the most commonly used sequential and combinational logic circuits.	
82	⊕	Describe the operation and application of binary and binary coded decimal (BCD) counters, shift registers, and other sequential logic circuits.	
83	⊕	Develop combinational and sequential logic circuits for an application.	
84	⊕	Test digital integrated circuits.	
85	⊕	Troubleshoot digital circuits.	
Exploring Robotic Programming			
86	⊕	Compare automated system programming options.	

87	⊕	Troubleshoot a malfunctioning robot.	
88	⊕	Troubleshoot robot programming and control problems.	
89	⊕	Describe emerging technologies in robotics.	
90	⊕	Implement basic programming procedures.	
91	⊕	Program an automated system.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

Analyzing Microprocessors

Task Number 39

Demonstrate adherence to safety procedures and guidelines for using lab tools and equipment.

Definition

Demonstration should include

- locating safety data sheets (SDSs), labeling, and Occupational Safety and Health Administration (OSHA) and manufacturer specifications
- wearing personal protective equipment (PPE) when necessary
- identifying school and lab safety policies and emergency procedures
- identifying lab or work area layout and safety areas
- locating potential hazards with tools, machines, equipment, and supplies.

Process/Skill Questions

- What are some consequences of failing to follow safety precautions in the lab and the workplace?
- What are the safety precautions to follow when using hand tools, machines, equipment, and chemicals in a lab?

Common Career Technical Core

ST3
Describe and follow safety, health and environmental standards related to science, technology, engineering and mathematics (STEM) workplaces.

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

TSA Competitive Events

Animatronics

Computer Integrated Manufacturing (CIM)

System Control Technology

Task Number 40

Analyze digital and microprocessor circuit characteristics, using circuit simulation software.

Definition

Analysis should include using computer-aided instruction equipment to reinforce theoretical knowledge of electronic circuitry.

Process/Skill Questions

- What are the advantages and disadvantages of circuit simulation?
- How can circuit simulation software be used to enhance the design process?
- How is simulation used to evaluate circuitry?
- What are the new trends in circuit simulation software?

Common Career Technical Core

ST-ET3
Apply processes and concepts for the use of technological tools in STEM.

ST-ET4
Apply the elements of the design process.
ST2
Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

16. Energy and Power Technologies

TSA Competitive Events

Animatronics

System Control Technology

Task Number 41

Describe the primary functions of the components of a microprocessor.

Definition

Description should include the characteristics of internal and external components.

Process/Skill Questions

- How do the internal and external parts of a computer work?
- How do microcomputers operate?
- What circuits/elements make up a microprocessor?
- What is the difference between a microprocessor and a microcomputer?

Common Career Technical Core

ST-ET2
Display and communicate STEM information.

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

16. Energy and Power Technologies

TSA Competitive Events

Animatronics

System Control Technology

Task Number 42

Correlate electricity principles to circuitry and microprocessors.

Definition

Correlation should include

- atomic structure
- conductors and insulators
- sources of electricity
- positive and negative poles (i.e., directional reference)
- voltage, current, and resistance
- closed circuitry
- power and Watt's law.

Process/Skill Questions

- How does atomic structure compare to circuitry and microprocessors?
- How does directional reference compare to circuitry and microprocessors?
- Which electrical principles enable the functions of microcomputer processing?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Animatronics

System Control Technology

Task Number 43

Describe the atomic structure and construction methods of semiconductors.

Definition

Description should include the

- atomic structure
  - identifying the number of protons and neutrons in the nucleus
  - creating a diagram of the number of electrons in each orbital
- definition of *covalent bonding*
- materials used
  - identifying pentavalent, trivalent, and pure semiconductor materials
  - providing an explanation of the doping process for creating N- and P-type semiconductor materials
- effects of temperature on semi conductive materials
- construction methods
  - identifying deposition, removal, patterning, and modification of electrical properties
- explanation of current flow and hole flow in semiconductor material.

Process/Skill Questions

- What is the atomic structure of semiconductor material?
- What are some terms related to semiconductor construction?
- How are the electrical properties of semiconductor devices modified?
- How are semiconductor devices manufactured?
- What are the strengths and weaknesses of donor and acceptor impurities?
- What would happen if a negative temperature coefficient had no effect on semiconductor materials?

- What are the strengths and weaknesses of germanium and silicon semiconductors?
- What is the relationship between intrinsic and extrinsic material, with respect to donor impurities?
- What are the strengths and weaknesses of N-type and P-type semiconductor materials?
- How do pentavalent and trivalent materials compare, with respect to covalent bonding and majority/minority carriers?
- What is the purpose of doping? How do electron-hole pairs work?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 44

Describe complex direct current (DC) circuits.

Definition

Description should include

- Kirchhoff's laws
- network theorems
- voltage dividers
- current dividers
- nodes, meshes, and branches methods.

Process/Skill Questions

- How do you control voltage and current values in a complex DC circuit?
- What are the steps to redrawing a complex schematic?
- What are the pros and cons of simplifying a complex circuit?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Animatronics

System Control Technology

Task Number 45

Design a simple microprocessor circuit, including user input and feedback to the user.

Definition

Design should include

- selecting a breadboard design
- selecting a programming language
- designing a microprocessor that will control a motor
- selecting a commercial off-the-shelf microprocessor board
- selecting a programming language
- interfacing using inputs and outputs to that microprocessor board that will provide feedback to the user
- programming the microprocessor.

Process/Skill Questions

- What are some common functions of a microprocessor circuit?
- What factors should be considered when choosing a programming language for a microprocessor?
- Why should the language be chosen before assembling components?

ITEEA National Standards

16. Energy and Power Technologies

Using Sensors

Task Number 46

Identify Sensors.

Definition

Identification should include

- encoders (e.g., incremental and absolute position)
- position sensors (e.g., potentiometers, magnetic absolute position)
- position sensors (pots)
- speed sensors
- hall effect sensors
- distance, range sensors
- color sensor
- pressure sensor
- light sensor
- gyros and compass sensors.

Process/Skill Questions

- Why are so many sensors necessary?
- How does a position sensor work?
- How is a gyro sensor different from a pot sensor?
- What are the functions of gyro and compass sensors?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 47

Describe types of conversions.

Definition

Description should include

- converting signals, voice, to digital
- converting analog to digital

- converting digital to analog.

Process/Skill Questions

- How do you convert analog to digital?
- How do you convert digital to analog?
- Why are such conversions necessary?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 48

Use sensors in circuit design.

Definition

Usage should include various types of sensors to accomplish desired output.

Process/Skill Questions

- What type of sensor would follow a line that is drawn?
- What action might a pressure sensor on a robot cause?

ITEEA National Standards

16. Energy and Power Technologies

Examining Magnetism and Coils

Task Number 49

Describe the principles of magnetism as applied to electronics and robotics.

Definition

Description should include

- magnetic fields
- flux and flux density
- induction
- types of magnets (ferrites)
- the Hall effect.

Process/Skill Questions

- How do flux and flux density affect magnetism?
- What effects do different types of magnets have on magnetic fields?
- How are the principles of magnetism, as applied to electronics and robotics, incorporated into robotic design?

ITEEA National Standards

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Animatronics

Task Number 50

Describe the characteristics of magnetism.

Definition

Description should include

- units of magnetic measurement
- field intensity

- permeability
- hysteresis
- Ohm’s law for magnets
- comparison of magnetic and electric fields
- electromagnetism
- Lenz’s law
- Faraday’s law.

Process/Skill Questions

- What are some everyday devices that use magnetism and electromagnetism?
- How are the characteristics of magnetism demonstrated through the left-hand rule and the right-hand rule?
- How does Faraday’s law apply to magnetic characteristics?

ITEEA National Standards

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Animatronics

Task Number 51

Identify coil technology.

Definition

Identification should include

- inductors
- electromagnets
- transformers
- sensor coils.

Process/Skill Questions

- What changes can be made to coils to control a transformer’s characteristics?

- What can interfere with a coil's effectiveness?
- How do sensor coils compare to other sensors?

ITEEA National Standards

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Animatronics

Task Number 52

Design a coil.

Definition

Design should include

- core
- winding
- turn
- coupling.

Process/Skill Questions

- How does changing the characteristics of a coil affect radio frequencies?
- What characteristics are important when designing coils for alternating current-direct current (AC-DC) circuits?
- What are cores usually made from?

Common Career Technical Core

ST-ET4
Apply the elements of the design process.

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Engineering Design

Investigating Motors

Task Number 53

Describe the components of electric motors.

Definition

Description should include

- magnetic coil
- electrical energy
- mechanical energy
- motor (e.g., AC brushless, DC motors, servo motors, stepper motors)
- generator.

Process/Skill Questions

- How does an electromagnet work?
- What can prevent a coil from working?
- What is the difference between a motor and a generator?

ITEEA National Standards

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Animatronics

Task Number 54

Describe the design principles and concepts related to electric motors and generators.

Definition

Description should include

- induction
- inductive reactance
- L/R circuits
- capacitance
- capacitive reactance
- RC circuits
- LRC circuits
- resonance
- damping.

Process/Skill Questions

- What is the difference between an L/R circuit and an LRC circuit?
- What are ways to use LRC circuits to control frequency?
- What characteristics of LRC circuits make good filters?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Engineering Design

Task Number 55

Describe the process of selecting a motor for application.

Definition

Description should include

- motor power curves
- torque
- motor performance
- speed.

Process/Skill Questions

- What is *torque*? Why is it important in the process of selecting a motor?
- What is *motor power curves*?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 56

Design gear ratios for a specified application.

Definition

Design may include

- gear ratios
- motor selection
- torque
- planetary gearboxes
- worm gearboxes.

Process/Skill Questions

- How do gear ratios work?
- What is the function of a planetary gear box?
- Why are worm gear boxes necessary with motors?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 57

Design an electric motor.

Definition

Design should include

- rotor
- stator
- air gap
- windings
- induction
- force
- torque.

Selection should be made from a variety of motor types, including

- brushed DC motor
- brushless DC motor
- synchronous motors
- servo motor
- stepper motor

Process/Skill Questions

- How does the number of windings affect a motor?
- Why is the material of the core important in designing a motor?
- How can the efficiency of a motor be improved?

Common Career Technical Core

ST-ET4
Apply the elements of the design process.

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Engineering Design

Introducing Motor Controllers

Task Number 58

Identify motor controllers.

Definition

Identification should include

- passive motor controllers (control the motor)
- smart controllers (sensor inputs)
- mechanical controllers (screen door closer)
- basic damping effects.

Process/Skill Questions

- Why is it necessary to understand the role of motor controllers?
- How do smart controllers work?
- What are basic damping effects?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 59

Identify the purpose of servo motors.

Definition

Identification should include

- bringing together motors and sensor control
- recognizing the benefit of position control.

Process/Skill Questions

- How are the motor and sensor control brought together?
- What is the purpose of a servo motor?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 60

Examine quadcopters.

Definition

Examination should include

- microcontroller
- blade motors
- gyro sensor.

Process/Skill Questions

- How do blade motors work?
- What is a gyro sensor?
- Why were quadcopters invented?

ITEEA National Standards

16. Energy and Power Technologies

Introducing Power Supplies

Task Number 61

Identify types of power supply circuits.

Definition

Identification should include a variety of power supplies, the circuit diagrams for each, and their associated applications.

Process/Skill Questions

- What are the types of power supplies?
- How does one formulate the relationship between the rate of energy loss and the time passed?
- How can one use an energy-vs.-time chart to formulate the curve of power loss for a robot?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Engineering Design

Task Number 62

Compare types of rectifier circuits and their functions.

Definition

Comparison should include

- half-wave
- full-wave
- bridge.

Process/Skill Questions

- What is the purpose of a rectifier circuit?
- Why might one want to convert from a full-wave to a half-wave form?
- Why would a circuit designer not want to completely smooth out an AC signal?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Engineering Design

Task Number 63

Describe the function of voltage regulators.

Definition

Description should include

- load, Zener, voltage, feedback
- typical circuits, such as
    - shunt
    - protective
    - integrated circuits (IC)
    - series.

Process/Skill Questions

- What is the function of voltage regulators?
- What purpose does a Zener diode serve in voltage regulator circuits?
- How does feedback work to improve voltage regulation?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

Task Number 64

Describe the function of oscillators.

Definition

Description should include

- sine wave
- square wave
- frequency
- inverter.

Process/Skill Questions

- What is the purpose of an oscillator?
- What conditions are necessary to allow an amplifier to act as an oscillator?
- What is the purpose of a relaxation oscillator circuit?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

Task Number 65

Describe types of oscillators.

Definition

Description should include

- characteristics of oscillators (e.g., main requirement, output)
- operation of oscillators (e.g., tank circuit, LC, crystal, RC sinusoidal, feedback circuits)
- applications of oscillator circuits.

Process/Skill Questions

- Which components can be used as oscillators?
- What are the basic characteristics of oscillators?
- How are oscillators classified?
- What are the different types of oscillators?
- How are oscillators used in frequency circuits?
- How are sinusoidal, rectangular, and saw-tooth waveforms similar to/different from one another?
- How does positive feedback work?
- What would happen if an oscillator did not have a feedback circuit?
- What would happen if an oscillator had a degenerative feedback circuit?
- What are the strengths and weaknesses of the three basic types of LC oscillators (i.e., Hartley, Colpitts, Clapp)?
- What are the strengths and weaknesses of the three basic types of sinusoidal oscillators (i.e., LC, crystal, RC)?
- What is the difference between non-sinusoidal and sinusoidal oscillators?

Task Number 66

Describe the function of pulse for control circuits.

Definition

Description should include

- pulse-width modulation
- motor speed control
- noise
- debounce.

Process/Skill Questions

- Why would pulse be used for control circuits?
- What is the purpose of pulse-width modulation?
- How is a sawtooth waveform produced?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

Task Number 67

Describe modulation.

Definition

Description should include

- modulator
- demodulator
- modulation: amplitude, frequency, phase
- Silicon Controlled Rectifiers (SCRs)
- Silicon Controlled Switches (SCSs)
- triode alternating current (TRIAC)
- diode alternating current (DIAC).

Process/Skill Questions

- How can pulse-width modulation be tested without an oscilloscope?
- How can servomotors be controlled through modulation?
- What is the difference between amplitude modulation and frequency modulation?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

Task Number 68

Connect a power supply, using a rectifier circuit.

Definition

Connection should include

- ripple
- regulation
- filter
- rectification
- reference point
- forward and reverse motor control (example, using an H-bridge)
- motor speed control.

A microcontroller should be connected to a motor using a semiconductor circuit, which controls the delivery of power to control the motion of the motor.

Note: In the case of stepper motors and solenoids, ripple controls motion and position.

Process/Skill Questions

- What creates ripple effect?
- What is *rectification*?
- What is a common need for filter circuits?

Common Career Technical Core

ST-ET3
Apply processes and concepts for the use of technological tools in STEM.
ST6

Demonstrate technical skills needed in a chosen STEM field.

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

TSA Competitive Events

Animatronics

Engineering Design

Analyzing Digital Logic Circuits

Task Number 69

Describe digital characteristics, techniques, numbering systems, and binary arithmetic.

Definition

Description should include

- comparing digital and analog signals
- identifying the functions of digital circuits
- comparing digital numbering systems (e.g., decimal, binary, octal, hexadecimal)
- converting between numbering systems
- applying binary arithmetic, including negative numbers and two's complement.

Process/Skill Questions

- What are the characteristics of binary numbering?
- What are some characteristics of digital circuits?
- How does binary numbering apply to digital circuits?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Engineering Design

Task Number 70

Analyze digital and microprocessor circuit characteristics, using circuit simulation software.

Definition

Analysis should reinforce theoretical knowledge of electronic circuitry and include

- conductor paths
- digital components
- integrated circuit design, front and back.

Process/Skill Questions

- What are the advantages and disadvantages of circuit simulation?
- How can circuit simulation software be used to enhance the design process?
- How is simulation used to evaluate circuitry?
- What are the new trends in circuit simulation software?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 71

Construct analog-to-digital (ADC) and digital-to-analog (DAC) circuits.

Definition

Construction should include

- drawing the schematic and artwork of the circuit
- using state-of-the-art drawing techniques
- making the printed circuit board
- printing the IC board on the back side
- populating the printed circuit board
- assembling components on the front side
- testing the circuit.

Process/Skill Questions

- What are the characteristics and applications of digital-to-analog conversion circuits?
- How do circuits operate?
- What are the advantages and disadvantages of the conversion methods?
- What components make up conversion circuits?
- What are the design parameters for conversion circuits?

ITEEA National Standards

16. Energy and Power Technologies

Task Number 72

Convert between the binary and decimal number systems.

Definition

Conversion should include

- identifying the most commonly used numbering systems and the mathematical relationships between them
- describing the reasons for converting between numbering systems
- applying equations to ensure successful conversion
- explaining the conversion between the binary and decimal number systems, as well as the use of Gray Coding for position sensing and control.

Process/Skill Questions

- What is a *numerical system*?
- What are the common codes used in advanced electronics, and where are they found?

- What are the advantages and disadvantages of parallel and serial data?
- How are conversions made from one code system to another?
- How do different code systems affect the transmission of data?

Common Career Technical Core

ST-ET3
Apply processes and concepts for the use of technological tools in STEM.

ITEEA National Standards

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

9. Engineering Design

TSA Competitive Events

Animatronics

System Control Technology

Task Number 73

Describe data representation.

Definition

Description should include

- data representation using electromagnetic devices and transistors
- logic levels
- positive and negative logic
- serial vs. parallel data.

Process/Skill Questions

- What does bit width mean in relation to digital design?
- What types of signals are logic gates designed for?
- How are true and false represented in logic?

- What is a truth table used for?

Common Career Technical Core

ST2
Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

System Control Technology

Task Number 74

Compare the function of digital logic circuits.

Definition

Comparison should include

- inverter
- AND gate
- OR gate
- dual gates
- NAND gate
- NOR gate.

Process/Skill Questions

- How does an AND gate function?
- How does a NAND gate function?

- How does an inverter affect logic gates?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Engineering Design

Task Number 75

Compare practical logic circuits.

Definition

Comparison should include

- relays and switches
- discrete component logic circuits
- integrated circuits
- logic equivalents.

Process/Skill Questions

- How are switches and relays used in logic circuits?
- How can components represent logic?
- How do discrete component logic circuits function?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Engineering Design

Task Number 76

Use Boolean algebra to express logic operations and minimize logic circuits in design.

Definition

Use should include mathematical and graphical methods to simplify and reduce logic circuits.

Process/Skill Questions

- What are the mathematical Boolean rules for logic circuits?
- What is the hierarchy of operations to apply these rules?
- What is a Karnaugh map, and how is it used to reduce circuitry?

Common Career Technical Core

ST-ET1
Use STEM concepts and processes to solve problems involving design and/or production.

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

9. Engineering Design

TSA Competitive Events

System Control Technology

Task Number 77

Describe the methods used to calculate values in logical expressions.

Definition

Description should include

- truth tables
- Boolean rules
- DeMorgan's theorem
- minimizing circuits
- NAND/NOR gates
- NAND and NOR logic equivalent circuits
- Karnaugh mapping:
    - two input
    - three input
    - four input
    - "don't care" states.

Process/Skill Questions

- How do Boolean rules apply to the calculation of values in a logic circuit?
- How and when is De Morgan's theorem used?
- How are logic equivalent circuits developed?

ITEEA National Standards

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Engineering Design

Task Number 78

Design a logic circuit, using Boolean algebra and methods.

Definition

Design should include the following Boolean equations and methods:

- Logic circuits and Boolean equations
- Basic function
- Boolean formats
- Sum of products
- Product of sums
- Circuit equations

Process/Skill Questions

- What are the values available in Boolean algebra?
- Why are Boolean numbers distinct/different from binary numbers?
- How does Boolean addition relate to the logical function of an OR gate?

ITEEA National Standards

11. Apply the Design Processes

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Engineering Design

Task Number 79

Compare the functions of flip-flops and registers.

Definition

Comparison should include

- sequential logic circuits
- combinational circuits.

Process/Skill Questions

- What is the difference between flip-flops and registers?
- What are sequential logic circuits, and how are they used to transmit and store coded information?

- What makes a circuit combinational?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Engineering Design

Task Number 80

Describe the operation of memory circuits.

Definition

Description should include the operation of flip-flop registers in memory circuits and other electronic memory storage circuits.

Process/Skill Questions

- How are binary numbers stored in circuits?
- What are the characteristics, operations, and applications of the various electronic memory storage circuits?
- What are the advantages and disadvantages of registers vs. other memory circuit systems?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

9. Engineering Design

TSA Competitive Events

Engineering Design

Task Number 81

Describe the characteristics of the most commonly used sequential and combinational logic circuits.

Definition

Description should include the characteristics, operation, and application of combinational logic circuits.

Process/Skill Questions

- What are the characteristics of typical sequential and combinational logical circuits?
- What are the characteristics of counters, registers, clocks, and decoder circuits? How do they operate individually and as parts of other systems?
- What is *microprogramming*?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

System Control Technology

Task Number 82

Describe the operation and application of binary and binary coded decimal (BCD) counters, shift registers, and other sequential logic circuits.

Definition

Description should include the uses of BCD counters, shift registers, and other sequential logic circuits to perform digital computation.

Process/Skill Questions

- What are the characteristics of counters, registers, and clocks?
- How are these circuits used to perform binary mathematics?
- What are the design constraints of serial and parallel data?

Common Career Technical Core

ST-ET3
Apply processes and concepts for the use of technological tools in STEM.

ITEEA National Standards

1. The Characteristics and Scope of Technology

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

11. Apply the Design Processes

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

16. Energy and Power Technologies

17. Information and Communication Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

8. The Attributes of Design

9. Engineering Design

TSA Competitive Events

Engineering Design

Task Number 83

Develop combinational and sequential logic circuits for an application.

Definition

Development should be done for an application such as ladder diagram circuits for programmable logic controllers (PLCs).

Development should also include construction of a digital solution to a practical circuit problem by

- defining the problem
- conceptualizing the solution
- selecting the integrated circuit
- acquiring the components
- assembling the circuit.

Process/Skill Questions

- How are digital design solutions defined?
- What are the constraints to design?
- How are circuit outcomes determined?
- What processes, materials, and research are required to develop a solution?
- How can mathematical and computer simulations assist in developing a solution to the problem?
- What are the ethical and societal effects of circuit development?
- How does a ladder diagram behave differently from a hard-wired control circuit?

Common Career Technical Core

ST-ET1
Use STEM concepts and processes to solve problems involving design and/or production.
ST-ET4
Apply the elements of the design process.
ST-ET5
Apply the knowledge learned in STEM to solve problems.
ST6
Demonstrate technical skills needed in a chosen STEM field.

ITEEA National Standards

11. Apply the Design Processes

13. Assess the Impact of Products and Systems

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Engineering Design

Task Number 84

Test digital integrated circuits.

Definition

Testing should include

- evaluation of the characteristics and operation,
- application of integrated circuits, using mathematical test instrumentation
- computer simulation as a means of circuit analysis.

Process/Skill Questions

- How do the characteristics of theoretical, actual, and simulated circuits differ?
- How can mathematics be used to predict circuit characteristics?
- How can test instruments and computer-assisted simulation be used to verify circuit theory?
- How can test instruments facilitate electronic equipment troubleshooting?

Common Career Technical Core

ST-ET3
Apply processes and concepts for the use of technological tools in STEM.
ST2
Use technology to acquire, manipulate, analyze and report data.
ST6
Demonstrate technical skills needed in a chosen STEM field.

ITEEA National Standards

1. The Characteristics and Scope of Technology

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

17. Information and Communication Technologies

9. Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

Task Number 85

Troubleshoot digital circuits.

Definition

Troubleshooting should include

- evaluating the characteristics, operation, and applications of integrated circuits
- using standard test equipment and special instruments (e.g., logic probes, logic and signature analyzers).

Process/Skill Questions

- How do actual and simulated circuit characteristics differ?
- How can circuit theory be verified using test instruments and computer-assisted simulation?
- How can test instruments facilitate electronic equipment troubleshooting?

Common Career Technical Core

ST-ET3
Apply processes and concepts for the use of technological tools in STEM.
ST-ET5
Apply the knowledge learned in STEM to solve problems.
ST2
Use technology to acquire, manipulate, analyze and report data.

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

16. Energy and Power Technologies

TSA Competitive Events

Animatronics

Engineering Design

System Control Technology

Exploring Robotic Programming

Task Number 86

Compare automated system programming options.

Definition

Comparison should include

- event-driven programming

- procedural programming.

Process/Skill Questions

- What is meant by *event*?
- What is the difference between event-driven and procedural programming?
- Is one type of programming better than another?

ITEEA National Standards

16. Energy and Power Technologies

9. Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

System Control Technology

Task Number 87

Troubleshoot a malfunctioning robot.

Definition

Troubleshooting should include

- applying the design process
- selecting the appropriate hardware and software for the program solution
- identifying the required tools
- modifying the robot's program.

Process/Skill Questions

- What are some questions to ask when troubleshooting?
- How does one isolate the problem to software, firmware, or hardware?
- What systems can malfunction on a robot?
- How can test instruments facilitate electronic equipment troubleshooting?

Common Career Technical Core

ST-ET5
Apply the knowledge learned in STEM to solve problems.

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

16. Energy and Power Technologies

TSA Competitive Events

Animatronics

Engineering Design

System Control Technology

Task Number 88

Troubleshoot robot programming and control problems.

Definition

Troubleshooting should include problems related to

- navigation
- sorting
- timed tasks
- search and rescue.

Process/Skill Questions

- What process should be used to determine the changes that need to be made to the robot?
- What are some questions to ask when debugging a program?
- Are all programming issues the result of bugs?

Common Career Technical Core

ST-ET1
Use STEM concepts and processes to solve problems involving design and/or production.

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

TSA Competitive Events

Animatronics

Engineering Design

System Control Technology

Task Number 89

Describe emerging technologies in robotics.

Definition

Description should include explaining the benefits of emerging technologies.

Process/Skill Questions

- What are today's emerging technologies?
- What are the common characteristics between emerging technologies and electronics?
- How might electronics influence the development of these technologies?
- What is the developmental timeline for emerging electronics in robotics?

ITEEA National Standards

13. Assess the Impact of Products and Systems

14. Medical Technologies

16. Energy and Power Technologies

17. Information and Communication Technologies

19. Manufacturing Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

4. The Cultural, Social, Economic, and Political Effects of Technology

6. The Role of Society in the Development and Use of Technology

9. Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

System Control Technology

Task Number 90

Implement basic programming procedures.

Definition

Implementation should include

- determining the correct software to bring about the solution to the identified problem
- describing the step-by-step instructions for the programming procedures
- planning and designing a sensor-based autonomous program
- programming a sensor-based autonomous program
- planning and designing remote controller-based arcade or tank drive program
- programming an arcade or tank drive remote controller-based drive program.

Process/Skill Questions

- What are the main programs used in robotics?

- What does the term *programming procedures* mean?
- Why is it important to follow established procedure?

Common Career Technical Core

ST-ET3
Apply processes and concepts for the use of technological tools in STEM.

ITEEA National Standards

16. Energy and Power Technologies

17. Information and Communication Technologies

9. Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

System Control Technology

Task Number 91

Program an automated system.

Definition

Programming should include

- using software related to the industry associated with the robotic system application using versions of the leading industry-accepted software (e.g., RobotC, Java, C++, Python, Android Studio, or LabVIEW)
- programming some autonomous basic sensor-based software (e.g., ultrasonic, proximity, touch, gyro, accelerometers, encoders, triggers, counters)
- programming may further include use of pneumatic subsystems or vision-based autonomous routines.

Process/Skill Questions

- Which programming software is appropriate for the task that the robot has been designed to complete?
- What are some programming options?
- Can programming be done on electronic systems that are not robots?

Common Career Technical Core

ST-ET3
Apply processes and concepts for the use of technological tools in STEM.

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

17. Information and Communication Technologies

9. Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

System Control Technology

SOL Correlation by Task

39	Demonstrate adherence to safety procedures and guidelines for using lab tools and equipment.	History and Social Science: GOVT.14, GOVT.15 Science: CH.1
40	Analyze digital and microprocessor circuit characteristics, using circuit simulation software.	English: 9.5, 10.5, 11.5, 12.5
41	Describe the primary functions of the components of a microprocessor.	English: 9.5, 10.5, 11.5, 12.5 Mathematics: COM.16
42	Correlate electricity principles to circuitry and microprocessors.	Mathematics: A.4, AII.3 Science: PH.11

43	Describe the atomic structure and construction methods of semiconductors.	English: 9.5, 10.5, 11.5, 12.5 Science: CH.2
44	Describe complex direct current (DC) circuits.	English: 9.5, 10.5, 11.5, 12.5 Science: PH.11
45	Design a simple microprocessor circuit, including user input and feedback to the user.	Mathematics: COM.1, COM.2, COM.10, COM.11
46	Identify Sensors.	
47	Describe types of conversions.	English: 9.5, 10.5, 11.5, 12.5 Mathematics: T.3
48	Use sensors in circuit design.	
49	Describe the principles of magnetism as applied to electronics and robotics.	English: 9.5, 10.5, 11.5, 12.5 Science: PH.10
50	Describe the characteristics of magnetism.	English: 9.5, 10.5, 11.5, 12.5 Mathematics: A.4, AII.3 Science: PH.10
51	Identify coil technology.	English: 9.5, 10.5, 11.5, 12.5
52	Design a coil.	English: 9.5, 10.5, 11.5, 12.5
53	Describe the components of electric motors.	English: 9.5, 10.5, 11.5, 12.5 Science: PH.11
54	Describe the design principles and concepts related to electric motors and generators.	English: 9.5, 10.5, 11.5, 12.5 Science: PH.11
55	Describe the process of selecting a motor for application.	English: 9.5, 10.5, 11.5, 12.5
56	Design gear ratios for a specified application.	
57	Design an electric motor.	Science: PH.11
58	Identify motor controllers.	English: 9.5, 10.5, 11.5, 12.5
59	Identify the purpose of servo motors.	English: 9.5, 10.5, 11.5, 12.5
60	Examine quadcopters.	
61	Identify types of power supply circuits.	English: 9.5, 10.5, 11.5, 12.5
62	Compare types of rectifier circuits and their functions.	English: 9.5, 10.5, 11.5, 12.5
63	Describe the function of voltage regulators.	English: 9.5, 10.5, 11.5, 12.5 Science: PH.11
64	Describe the function of oscillators.	English: 9.5, 10.5, 11.5, 12.5 Mathematics: T.3 Science: PH.11

65	Describe types of oscillators.	English: 9.5, 10.5, 11.5, 12.5
66	Describe the function of pulse for control circuits.	English: 9.5, 10.5, 11.5, 12.5 Science: PH.11
67	Describe modulation.	English: 9.5, 10.5, 11.5, 12.5 Science: PH.11
68	Connect a power supply, using a rectifier circuit.	
69	Describe digital characteristics, techniques, numbering systems, and binary arithmetic.	English: 9.5, 10.5, 11.5, 12.5
70	Analyze digital and microprocessor circuit characteristics, using circuit simulation software.	English: 9.5, 10.5, 11.5, 12.5
71	Construct analog-to-digital (ADC) and digital-to-analog (DAC) circuits.	
72	Convert between the binary and decimal number systems.	Mathematics: A.4, COM.6
73	Describe data representation.	English: 9.5, 10.5, 11.5, 12.5 Science: PH.2
74	Compare the function of digital logic circuits.	English: 9.5, 10.5, 11.5, 12.5
75	Compare practical logic circuits.	English: 9.5, 10.5, 11.5, 12.5
76	Use Boolean algebra to express logic operations and minimize logic circuits in design.	Mathematics: G.1, COM.8, COM.15
77	Describe the methods used to calculate values in logical expressions.	English: 9.5, 10.5, 11.5, 12.5
78	Design a logic circuit, using Boolean algebra and methods.	Mathematics: G.1, COM.8, COM.15
79	Compare the functions of flip-flops and registers.	
80	Describe the operation of memory circuits.	English: 9.5, 10.5, 11.5, 12.5 Mathematics: G.1, COM.6, COM.10, DM.8, DM.9*
81	Describe the characteristics of the most commonly used sequential and combinational logic circuits.	English: 9.5, 10.5, 11.5, 12.5 Mathematics: DM.8
82	Describe the operation and application of binary and binary coded decimal (BCD) counters, shift registers, and other sequential logic circuits.	English: 9.5, 10.5, 11.5, 12.5 Mathematics: COM.6, COM.9, COM.13, COM.14, DM.8, MA.3
83	Develop combinational and sequential logic circuits for an application.	Mathematics: G.1, COM.1, COM.2, COM.6, DM.8
84	Test digital integrated circuits.	
85	Troubleshoot digital circuits.	Science: PH.3
86	Compare automated system programming options.	English: 9.5, 10.5, 11.5, 12.5

87	Troubleshoot a malfunctioning robot.	Mathematics: COM.18 Science: PH.3
88	Troubleshoot robot programming and control problems.	Mathematics: COM.18 Science: PH.3
89	Describe emerging technologies in robotics.	English: 9.5, 10.5, 11.5, 12.5 History and Social Science: VUS.13, VUS.14, WHII.13, WHII.14 Science: PH.4
90	Implement basic programming procedures.	Mathematics: COM.18
91	Program an automated system.	Mathematics: COM.2

Cyber Security and Cyber Forensics Infusion Units

Cyber Security and Cyber Forensics Infusion Units (CYBR) were designed to be infused with designated CTE courses to help students in those programs achieve additional, focused, validated tasks/competencies in personal and professional cyber security skills. These units are not mandatory, and, as such, the tasks/competencies are marked as "optional," to be taught at the instructor's discretion.

Entrepreneurship Infusion Units

Entrepreneurship Infusion Units may be used to help students achieve additional, focused competencies and enhance the validated tasks/competencies related to identifying and starting a new business venture. Because the unit is a complement to certain designated courses and is not mandatory, all tasks/competencies are marked “optional.”

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- Associate Certified Electronics Technician (CETa) Examination
- College and Work Readiness Assessment (CWRA+)
- Electronics Application/Electronics Technology Examination
- Electronics Technology Assessment
- National Career Readiness Certificate Assessment
- Student Electronics Technician (SET) Examination
- Workplace Readiness Skills for the Commonwealth Examination

Concentration sequences: *A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.*

- Electronics Systems I (8416/36 weeks)
- Electronics Systems II (8412/36 weeks)

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Computer Software Engineer** **Electrical Engineering Technician** **Electronics Engineering Technician** **Manufacturing Systems Engineer** **Network Systems and Data Communication Analyst** **Telecommunications Specialist**