Electronics/Industrial Robotics Technology

8547 36 weeks / 140 hours

Table of Contents

Acknowledgments ................................................................................................................................................................... 1
Course Description .................................................................................................................................................................. 2
Task Essentials List ................................................................................................................................................................. 2
Curriculum Framework ........................................................................................................................................................... 4
Applying Basic Construction Safety Standards (Core Safety) ............................................................................................... 4
Understanding Physics ............................................................................................................................................................ 9
Exploring Electronics/Robotics Technology Careers ........................................................................................................... 10
Explaining Robotics Applications ........................................................................................................................................ 11
Introducing Robotics ............................................................................................................................................................. 12
Applying Electronics Fundamentals ..................................................................................................................................... 13
Working with DC Circuits .................................................................................................................................................... 19
SOL Correlation by Task ...................................................................................................................................................... 24
Entrepreneurship Infusion Units ........................................................................................................................................... 26
Appendix: Credentials, Course Sequences, and Career Cluster Information ........................................................................... 27

Acknowledgments

The components of this instructional framework were developed by the following curriculum development panelists:

MJ Ghahrai, Instructor, Hanover High School, Hanover County Public Schools
Vukica Jovanovic, Associate Professor, Old Dominion University, Norfolk
Paul E. Lathrop, Instructor, Chesterfield Technical Center at Hull Street, Chesterfield County Public Schools
Chung-Chee Tai, Vice President of Engineering, BluePrint Automation, South Chesterfield

Correlations to the Virginia Standards of Learning were reviewed and updated by:

Leslie R. Bowers, English Teacher (ret.), Newport News Public Schools
Vickie L. Inge, Mathematics Committee Member, Virginia Mathematics and Science Coalition
Course Description

Suggested Grade Level: 10 or 11

Our ability to function and progress in the modern age is dependent on electronics and robotics technologies. This course provides a depth and breadth of the basic skills required in today’s automated manufacturing environment. Students will explore careers, build circuits, and use principles of physics to analyze basic electronic and robotic components. Students will also earn the general industry Occupational Safety and Health Administration (OSHA) 10 card.

Task Essentials List

- 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.

<table>
<thead>
<tr>
<th>Task Number</th>
<th>8547</th>
<th>Tasks/Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applying Basic Construction Safety Standards (Core Safety)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>☑</td>
<td>Comply with federal, state, and local safety requirements.</td>
</tr>
<tr>
<td>40</td>
<td>☑</td>
<td>Maintain a safe working environment.</td>
</tr>
<tr>
<td>41</td>
<td>☑</td>
<td>Explain safe working practices around electrical hazards.</td>
</tr>
<tr>
<td>42</td>
<td>☑</td>
<td>Identify emergency first-aid procedures.</td>
</tr>
<tr>
<td>Task Number</td>
<td>8547</td>
<td>Tasks/Competencies</td>
</tr>
<tr>
<td>-------------</td>
<td>------</td>
<td>--------------------</td>
</tr>
<tr>
<td>43</td>
<td>☑️</td>
<td>Identify the types of fires and the methods used to extinguish them.</td>
</tr>
<tr>
<td>44</td>
<td>☑️</td>
<td>Identify personal protective equipment (PPE) requirements.</td>
</tr>
<tr>
<td>45</td>
<td>☑️</td>
<td>Inspect course-specific hand and power tools to visually identify defects.</td>
</tr>
<tr>
<td>46</td>
<td>☑️</td>
<td>Demonstrate lifting and carrying techniques.</td>
</tr>
<tr>
<td>47</td>
<td>☑️</td>
<td>Demonstrate safe laddering techniques.</td>
</tr>
<tr>
<td>48</td>
<td>☑️</td>
<td>Report personal injuries and environmental and equipment safety violations.</td>
</tr>
<tr>
<td>49</td>
<td>☑️</td>
<td>Pass safety exam.</td>
</tr>
<tr>
<td>50</td>
<td>☑️</td>
<td>Earn the general industry OSHA 10 card.</td>
</tr>
</tbody>
</table>

Understanding Physics

<table>
<thead>
<tr>
<th>Task Number</th>
<th>8547</th>
<th>Tasks/Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>☑️</td>
<td>Perform measurements.</td>
</tr>
<tr>
<td>52</td>
<td>☑️</td>
<td>Apply principles of the mechanics of robotics.</td>
</tr>
</tbody>
</table>

Exploring Electronics/Robotics Technology Careers

<table>
<thead>
<tr>
<th>Task Number</th>
<th>8547</th>
<th>Tasks/Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>53</td>
<td>☑️</td>
<td>Describe the skills and characteristics of a good technician.</td>
</tr>
<tr>
<td>54</td>
<td>☑️</td>
<td>Investigate community industrial and technical resources.</td>
</tr>
<tr>
<td>55</td>
<td>☑️</td>
<td>Explore occupations related to electronics and robotics technology.</td>
</tr>
</tbody>
</table>

Explaining Robotics Applications

<table>
<thead>
<tr>
<th>Task Number</th>
<th>8547</th>
<th>Tasks/Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>☑️</td>
<td>Explain the use of robotics for industrial applications.</td>
</tr>
<tr>
<td>57</td>
<td>☑️</td>
<td>Explain the use of robotics in the inspection and quality-assurance process.</td>
</tr>
</tbody>
</table>

Introducing Robotics

<table>
<thead>
<tr>
<th>Task Number</th>
<th>8547</th>
<th>Tasks/Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>58</td>
<td>☑️</td>
<td>Identify types of robot geometry, manipulators, and end effectors.</td>
</tr>
<tr>
<td>59</td>
<td>☑️</td>
<td>Identify types of robot control and drive systems.</td>
</tr>
</tbody>
</table>

Applying Electronics Fundamentals

<table>
<thead>
<tr>
<th>Task Number</th>
<th>8547</th>
<th>Tasks/Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>☑️</td>
<td>Explain the nature of electricity.</td>
</tr>
<tr>
<td>61</td>
<td>☑️</td>
<td>List ways to produce electrical energy.</td>
</tr>
<tr>
<td>62</td>
<td>☑️</td>
<td>Determine characteristics of capacitance.</td>
</tr>
<tr>
<td>63</td>
<td>☑️</td>
<td>Identify electric and electronic components and symbols.</td>
</tr>
<tr>
<td>64</td>
<td>☑️</td>
<td>Apply soldering and desoldering techniques.</td>
</tr>
<tr>
<td>65</td>
<td>☑️</td>
<td>Identify properties of conductors and insulators.</td>
</tr>
<tr>
<td>66</td>
<td>☑️</td>
<td>Determine the properties of resistance.</td>
</tr>
<tr>
<td>67</td>
<td>☑️</td>
<td>Explore the theory of electromotive force (voltage).</td>
</tr>
<tr>
<td>68</td>
<td>☑️</td>
<td>Outline the path of electron flow.</td>
</tr>
<tr>
<td>69</td>
<td>☑️</td>
<td>Determine the properties of power.</td>
</tr>
<tr>
<td>70</td>
<td>☑️</td>
<td>Explain circuit-protection devices.</td>
</tr>
<tr>
<td>71</td>
<td>☑️</td>
<td>Describe circuit-control devices.</td>
</tr>
<tr>
<td>72</td>
<td>☑️</td>
<td>Identify schematics, technical drawings, and flowcharts.</td>
</tr>
</tbody>
</table>

Working with DC Circuits

<table>
<thead>
<tr>
<th>Task Number</th>
<th>8547</th>
<th>Tasks/Competencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>73</td>
<td>☑️</td>
<td>Construct series circuits.</td>
</tr>
<tr>
<td>74</td>
<td>☑️</td>
<td>Construct parallel circuits.</td>
</tr>
<tr>
<td>75</td>
<td>☑️</td>
<td>Construct series-parallel circuits.</td>
</tr>
<tr>
<td>76</td>
<td>☑️</td>
<td>Evaluate the difference in voltage between loaded and unloaded voltage-divider circuits.</td>
</tr>
<tr>
<td>77</td>
<td>☑️</td>
<td>Examine magnetic properties of a circuit or component.</td>
</tr>
<tr>
<td>78</td>
<td>☑️</td>
<td>Construct circuits with electromagnetic properties.</td>
</tr>
<tr>
<td>79</td>
<td>☑️</td>
<td>Examine meter movement, using analog and digital multimeters.</td>
</tr>
<tr>
<td>80</td>
<td>☑️</td>
<td>Determine characteristics of inductance.</td>
</tr>
</tbody>
</table>

Legend: ☑️ Essential  ☐ Non-essential  ☞ Omitted
Curriculum Framework

Applying Basic Construction Safety Standards (Core Safety)

Task Number 39

Comply with federal, state, and local safety requirements.

Definition

Compliance should include the Occupational Safety and Health Administration (OSHA), Virginia Occupational Safety and Health (VOSH) program, and the U.S. Environmental Protection Agency (EPA) and identifying

- Hazard Communication Standard (HCS)
- the information included on safety data sheets (SDS)
- responsibilities of employers and employees under HCS
- good manufacturing practices (GMP).

Process/Skill Questions

- Where should hazardous materials be stored?
- What information can be found on an SDS?
- What does SDS stand for?

Task Number 40

Maintain a safe working environment.

Definition

Maintenance should be ongoing and should result in identifying potential hazards on a jobsite or in the lab, such as

- electrical hazards
- jobsite debris
- improperly stored materials
- air quality hazards.

When present, these must be remedied in compliance with school and instructor's guidelines.
Process/Skill Questions

- What are some examples of jobsite hazards?
- Why is it important to adhere to safety standards on a jobsite?
- Why is it important to store materials and tools properly?
- Why is important to protect humans when working with industrial robots?
- Why is it important to avoid contact with hydraulic fluid?

Task Number 41

Explain safe working practices around electrical hazards.

Definition

Explanation should include

- identifying equipment used to test electrical circuits
- identifying potential arc flash hazards
- describing safe working conditions
- demonstrating safe work habits according to industry standards and instructor's guidelines.

Process/Skill Questions

- What is the definition of proximity work?
- What are safe working clearances, according to the National Electric Code (NEC)?
- What are considered safe working conditions and safe working habits?

Task Number 42

Identify emergency first-aid procedures.

Definition

Identification should include first-aid procedures for accidents involving

- bodily fluids
- electrical injuries
- eye injuries
- falls
- burns
- cuts

according to standard first-aid and school policies.

Process/Skill Questions

- What are the steps that should be followed in the event of an accident?
• Why is knowing cardiopulmonary resuscitation (CPR) an important skill within the electrical trades?
• Why is it important to be certified to administer first aid?
• What are the different classifications (degrees) of electrical burns?
• What is the procedure if someone gets cut and is in contact with hydraulic fluid?

Task Number 43

Identify the types of fires and the methods used to extinguish them.

Definition

Identification should include

• the classifications of fires (A, B, C, and D)
• causes of fires
• prevention of fires
• types of extinguishers
• the use (when possible) of a fire extinguisher, in accordance with government regulations and instructor's guidelines.

Process/Skill Questions

• What are the three things necessary to start a fire?
• Why is it important to know the classification of fire when trying to extinguish it?
• Why should extinguishers be inspected, and how often should they be inspected?
• What are the classifications of extinguishers?

Task Number 44

Identify personal protective equipment (PPE) requirements.

Definition

Identification should include procedures for inspecting, putting on, wearing, and removing PPE. Appropriate PPE may include

• eye protection
• gloves
• hearing protection
• safety shoes.

Process/Skill Questions

• Why should side shields be worn with prescription glasses?
• How is foam hearing protection used?
• Why is it important to wear safety glasses when in the lab?
Task Number 45

Inspect course-specific hand and power tools to visually identify defects.

Definition

Inspection should include

- identifying components of machinery (e.g., guards, blades, moving parts, start/stop switches)
- identifying standard safety procedures (i.e., lab practices and manufacturer recommendations)
- observing the safe operation of each piece of machinery in the lab
- identifying defects in hand tools.

Process/Skill Questions

- What are some of the basic power tools used in electronics and robotics?
- What action should be taken before using a drill press?
- Why should a power tool always be grounded?

Task Number 46

Demonstrate lifting and carrying techniques.

Definition

Demonstration should include lifting and carrying materials and equipment while

- lifting with the legs
- keeping the back straight
- holding the load close to the body
- getting help, if necessary

Demonstration should include adherence to government regulations and instructor's guidelines.

Process/Skill Questions

- What are common injuries associated with improper lifting techniques?
- What can one do to prevent injury?
- How does proper positioning affect proper technique?

Task Number 47
Demonstrate safe laddering techniques.

Definition

Demonstration should involve using appropriate conduct and safety procedures while using aluminum ladders (e.g., three-point contact), while carrying ladders (e.g., two people at all times), and while erecting and setting ladders. Identification of additional ladder types may include

- wall (straight) ladder
- extension ladder
- roof ladder
- attic ladder
- special-purpose ladders (e.g., "A" ladder, folding ladder, pompier ladder)
- solid beam ladder
- truss beam wood ladder
- aluminum ladder
- wood and aluminum truss ladder
- fiberglass ladder and the parts and safety features of each.

Process/Skill Questions

- Why are ladders rated for certain weights?
- Why is the apex (highest point) of a step ladder not considered a step?
- Why are aluminum ladders considered unsafe for electrical work?

Task Number 48

Report personal injuries and environmental and equipment safety violations.

Definition

Report should include an oral or written statement identifying the violation and the date it was observed and should be given to the instructor, supervisor, or the local OSHA inspectors.

Process/Skill Questions

- What ethical considerations might be involved when reporting coworkers?
- Why is it important to follow reporting procedures?
- What is legal liability?

Task Number 49

Pass safety exam.
Definition

Passing should include an assessment that must measure participation in safety training programs, including attending safety meetings and periodically demonstrating knowledge and skills gained from program topics (e.g., interpretation of SDS).

Process/Skill Questions

- How often should one participate in safety training programs? Why?
- How does insurance affect the requirement of continuous retraining for safety?
- What is worker's compensation?

Task Number 50

Earn the general industry OSHA 10 card.

Definition

Earning an OSHA 10 card will

- recognize the completion of 10 hours of safety instruction
- help teach national standards for personal safety within a lab environment
- validate safety skills to the industry
- promote safety consciousness and responsibility.

Process/Skill Questions

- What are the benefits of earning the OSHA 10 card?
- What is OSHA, and how are its standards validated?
- Why was OSHA established, and how has it evolved?

Understanding Physics

Task Number 51

Perform measurements.

Definition

Performance should include measuring and scaling using both U.S. customary and metric devices and systems. These may include an engineer's scale, metric scale, decimal measurement, and fractional measurement.

Process/Skill Questions

- What are the gradations found on an engineer's scale?
• How do U.S. customary units and metric units differ in relationship to distance, mass, force, and temperature?
• How do you convert U.S. customary units into metric units and vice versa?

---

**Task Number 52**

**Apply principles of the mechanics of robotics.**

**Definition**

Application should include explaining the concepts of

- velocity, acceleration, and force
- work, power, and energy
- simple machines.

Application also should include

- solving problems, using the concepts of mechanics
- measuring the robot's velocity, acceleration, and force
- applying various simple machines.

**Process/Skill Questions**

- What is the velocity of a robot that travels 10 feet in five seconds?
- What is the formula for calculating gear ratios?
- How much force is required to accelerate a mass of 10 kg at two m/s/s?

---

**Exploring Electronics/Robotics Technology Careers**

**Task Number 53**

**Describe the skills and characteristics of a good technician.**

**Definition**

Description should include

- mathematics background and other educational requirements
- physical skills/abilities
- workplace readiness skills.

**Process/Skill Questions**


• What role do work habits play in the success of an electronics technician's career?
• What are the consequences of neglecting to continue education after employment?
• What aspects of the electronics technician's job require physical skills?

**Task Number 54**

**Investigate community industrial and technical resources.**

**Definition**

Investigation includes

- using the Internet to locate local industrial and/or robotic resources
- referencing professional journals
- contacting local chapters of professional engineering and technical organizations, local colleges, universities, and workforce development offices.

**Process/Skill Questions**

- What are the names of industry suppliers involved in robotics?
- What are two colleges/universities that have a robotics program?
- What are examples of certifications offered by companies that manufacture robots?

**Task Number 55**

**Explore occupations related to electronics and robotics technology.**

**Definition**

Exploration should include

- researching career opportunities
- identifying education, training, and other requirements needed for a career in robotics.

**Process/Skill Questions**

- What are some resources that could be used to find career information in robotics?
- What is the entry-level salary range for jobs in the robotics' field in your area?
- What is the latest projection for the employment in the field of robotics in the next 10 years?
- What jobs in other career areas are related to the robotics field?

**Explaining Robotics Applications**

**Task Number 56**
Explain the use of robotics for industrial applications.

Definition

Explanation should include

- coating
- machining
- welding
- assembling
- handling materials.

Process/Skill Questions

- What welds can a robot perform?
- What are some advantages and disadvantages of industrial robots?
- What are the economic advantages of using industrial robots?

Task Number 57

Explain the use of robotics in the inspection and quality-assurance process.

Definition

Explanation should include

- reducing the possibility of human error
- avoiding putting humans in dangerous situations.

Process/Skill Questions

- What is the main advantage of using robots in the inspection and quality-assurance process?
- How are lasers and robots used in the quality-assurance process?

Introducing Robotics

Task Number 58

Identify types of robot geometry, manipulators, and end effectors.

Definition

Identification includes
• spherical/polar
• Cartesian
• cylindrical
• revolute/articulated.

Process/Skill Questions

• Which robot geometries best operate in an automobile manufacturing environment? With spray painting?
• What type of end effector would be best suited for palletizing?
• Which robot geometry is suitable for computer numerical controlled (CNC) machining?

Task Number 59

Identify types of robot control and drive systems.

Definition

Identification should include servo and non-servo robot control. Drive systems include

• pneumatic
• fluid power
• electrical.

Process/Skill Questions

• What are the differences between servo and non-servo control functions?
• What is a closed-loop control system?
• What is an open-loop control system?
• What is the function of a feedback potentiometer?

Applying Electronics Fundamentals

Task Number 60

Explain the nature of electricity.

Definition

Explanation includes

• defining electronics and electricity
• defining matter and listing its forms
• identifying relationships among
  o matter
  o elements
Process/Skill Questions

- What is the relationship between electrons and protons?
- What theory describes electron flow?
- What is the major difference between electronics and electricity?

Task Number 61

List ways to produce electrical energy.

Definition

List includes an explanation of how electricity is produced using

- friction
- heat
- light
- pressure
- chemical action
- magnetism.

Process/Skill Questions

- Which electrical energy production occurs naturally?
- What is the most widely used method of producing electricity?
- What are examples of using magnetism to produce electrical energy?

Task Number 62

Determine characteristics of capacitance.

Definition

Determination should include
- defining
  - capacitor
  - dielectric
  - dielectric constant
  - microfarad
  - nanofarad
  - picofarad
  - working voltage
- describing the construction of capacitors
- drawing the schematic symbols for
  - fixed capacitors
  - variable capacitors
  - polarized electrolytic capacitors
- explaining the significance of voltage rating and capacitance rating of capacitors
- calculating parallel capacitance, using the formula $CT = C_1 + C_2 + C_3 \ldots C_n$
- calculating series capacitance, using the formula $\frac{1}{CT} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots \frac{1}{C_n}$
- listing and explaining the safety factors involved in handling capacitors.

**Process/Skill Questions**

- What are the characteristics of a good dielectric?
- What are two ways to increase capacitance?
- Why are most capacitors measured in microfarads and picofarads?

**Task Number 63**

**Identify electric and electronic components and symbols.**

**Definition**

Identification should include components, their properties, graphic symbols, and functions, including

- resistors
- capacitors
- switches
- circuit breakers
- transistors
- diodes.

**Process/Skill Questions**

- What are the consequences of not being able to read a schematic when repairing a component?
- What are some diagramming methods that help the electronics technician identify components in a drawing?
- Why is it necessary to know components' names and symbols?
Task Number 64

Apply soldering and desoldering techniques.

Definition

Application includes

- stating primary reasons why soldering is performed in the electronics industry
- identifying soldering tools and materials
- identifying methods of soldering/desoldering
- distinguishing between good and bad soldering connections
- demonstrating soldering/desoldering techniques for various connections
- preparing a printed circuit board with soldered components
- defining hazards of working with lead and materials containing lead.

Process/Skill Questions

- What effects can improper soldering techniques have on one's repair success rate?
- What is a common cause of bad solder connections?
- What is the most important safety device to use when soldering?

Task Number 65

Identify properties of conductors and insulators.

Definition

Identification includes stating from a cross-sectional area the length and material for conductors and the type of material for insulators.

Process/Skill Questions

- Why should a conductor be flexible?
- What is the most popular insulator, and why?
- Why are thick conductors more effective than thin ones?

Task Number 66

Determine the properties of resistance.

Definition

Determination should include identifying the

- ohmic value, using an ohmmeter and reading the color code
- power rating, considering physical size, markings, and manufacturer recommendations
- tolerance range (percentage), using color code.

**Process/Skill Questions**

- How does the size of a resistor relate to its power-handling capability?
- What are the two most common ways of determining resistance?
- What is the ohmic (resistance) value on an ohmmeter of a resistor with the following color bands: orange, yellow, red, gold?

**Task Number 67**

**Explore the theory of electromotive force (voltage).**

**Definition**

Exploration should include

- the definition of *voltage*
- the measurement of voltage, using a voltmeter
- measurement of potential difference (electromotive force), using a voltmeter for direct current (DC) power sources
- the calculation of voltage, using Ohm's law.

**Process/Skill Questions**

- How is measurement of potential difference determined?
- What formula is used to calculate voltage if current and resistance are known?
- How is a voltmeter used to measure voltage across a resistor in a series circuit?

**Task Number 68**

**Outline the path of electron flow.**

**Definition**

Outline should include

- defining the term *current*
- measuring current, using an ammeter
- calculating current, using Ohm's law.

**Process/Skill Questions**

- What are the consequences of not observing polarity when measuring current?
- How fast does current flow? If current is increased, does it flow faster?
- What is Ohm's law?
· How does one measure current with an ammeter in a series circuit?

**Task Number 69**

**Determine the properties of power.**

**Definition**

Determination includes

· defining power and work
· calculating power, using Watt's law
· describing the principles of the maximum power transfer theorem.

**Process/Skill Questions**

· What formula is used to compute power when current and resistance are known?
· What is the purpose of dynamic braking? What is regenerative braking?
· What is the difference between power and work?

**Task Number 70**

**Explain circuit-protection devices.**

**Definition**

Explanation should include

· defining
  · shorted circuit
  · open circuit
  · integrated circuit protection (ICP)
  · circuit breaker
  · fuse
  · fusible resistor
  · thermistor
· describing the construction and operation of circuit-protection devices
· demonstrating the use of a testing device to determine the condition of a circuit-protection device.

**Process/Skill Questions**

· What is the difference between a fuse and a circuit breaker?
· When should a fuse or interlock be defeated?
· What is the difference between an open circuit and a short circuit?

**Task Number 71**
Describe circuit-control devices.

Definition

Description includes

- construction, number, and location of terminal connections on switches and relays
- operation of switches and relays
- significance of voltage and current ratings
- explanation of abbreviations
  - SPST (single pole, single throw)
  - SPDT (single pole, double throw)
  - DPST (double pole, single throw)
  - DPDT (double pole, double throw)
  - NO (normally open)
  - NC (normally closed)
- illustration of how to hook up three-way switches for two points of control.

Process/Skill Questions

- What common circuit-control device is used in most heating, ventilation, and air-conditioning (HVAC) systems?
- What is the significance of voltage and current ratings when replacing control devices?
- How is a DPDT switch identified?

Task Number 72

Identify schematics, technical drawings, and flowcharts.

Definition

Identification should include

- reading and verifying the symbols and legends used in schematics, technical drawings, and flowcharts
- converting a schematic into a printed circuit board (PCB) layout
- applying the interpretation of a flowchart to write a computer program
- applying the interpretation of technical drawings to build or assemble a product or circuit
- following electrical schematics to create a circuit on a breadboard.

Process/Skill Questions

- What does the term schematic mean?
- When might technicians need to read flowcharts, technical drawings, or schematics?

Working with DC Circuits
Task Number 73

Construct series circuits.

Definition

Construction should include

- defining the characteristics of a series circuit
- calculating current, voltage, resistance, and power in a series circuit, using Ohm's law, Watt's law, and Kirchoff's law
- measuring resistance, voltage, and current in a series circuit
- identifying series circuits at home and in industry
- designing a series circuit for a practical application
- troubleshooting series circuits.

Process/Skill Questions

- What is the relationship of resistors to total resistance in a series circuit?
- What characterizes a series circuit?
- What is the simplest series circuit used in the home?

Task Number 74

Construct parallel circuits.

Definition

Construction should include

- defining the characteristics of a parallel circuit
- calculating current, voltage, resistance, and power in a parallel circuit, using Ohm's law, Watt's law, and Kirchoff's law
- measuring resistance, voltage, and current in a parallel circuit
- identifying parallel circuits at home and in industry
- troubleshooting parallel circuits.

Process/Skill Questions

- What are identifying characteristics that distinguish a parallel circuit from a series circuit?
- How is Kirchoff’s current law applied in the study of parallel circuits?
- What is the formula used to find total circuit resistance (RT) in a parallel circuit?

Task Number 75

Construct series-parallel circuits.
Definition

Construction should include

- defining the characteristics of a series-parallel circuit
- calculating current, voltage, resistance, and power in a series-parallel circuit, using Ohm's law, Watt's law, and Kirchoff's law
- measuring resistance, voltage, and current in a series-parallel circuit
- identifying series-parallel circuits at home and in industry
- troubleshooting series-parallel circuits.

Process/Skill Questions

- What characteristic identifies a main-line component in a series-parallel circuit?
- Why is it important to learn to analyze series-parallel circuits?
- Which type of circuit is characterized by a current that stays the same?

Task Number 76

Evaluate the difference in voltage between loaded and unloaded voltage-divider circuits.

Definition

Evaluation includes

- defining
  - unloaded voltage divider
  - loaded voltage divider
  - loads
  - reference points
- explaining the purposes of a voltage divider
- listing examples of voltage divider uses
- calculating the voltages, resistances, currents, and power in a voltage-divider network.

Process/Skill Questions

- What causes voltage shifts during loaded voltage-divider circuits?
- How does one compensate for voltage shifts between loaded and unloaded voltage-divider circuits?
- How does one calculate voltage in an unloaded voltage-divider circuit?

Task Number 77

Examine magnetic properties of a circuit or component.

Definition
Examination should include

- defining
  - magnetic field
  - induced current polarity
  - lines of flux
  - left-hand rule
  - oersted, gilbert, maxwell, gauss, and Lenz units of magnetism
- using the left-hand rule to determine the direction of induced current for generators
- explaining principles of electromagnetism
- explaining principles and operation of the d'Arsonval meter movement
- using the right-hand rule to determine the direction of induced current for motors
- explaining magnetic operation of relay.

**Process/Skill Questions**

- What effects would magnetic field reversal have on your life?
- What makes electromagnetic interference (EMI) a concern for technicians?
- Why is it important to understand the left-hand rule of current?

**Task Number 78**

**Construct circuits with electromagnetic properties.**

**Definition**

Construction should include

- using the left-hand rule to determine the direction of induced current for generators
- using the right-hand rule to determine the direction of induced current for motors
- assembling circuits with electromagnetic relay or components.

**Process/Skill Questions**

- What effects can magnetic fields have on a body?
- What makes EMI a concern for technicians?
- Why is it important to understand the left-hand rule of current?
- What are the internal components of a relay?

**Task Number 79**

**Examine meter movement, using analog and digital multimeters.**

**Definition**
Examination includes

- defining
  - meter sensitivity
  - shunts
  - multipliers
  - internal resistance
  - loading
  - Wheatstone bridge
- explaining the operation of a Wheatstone bridge
- explaining the internal resistance and loading effect.

Process/Skill Questions

- What are the consequences of neglecting to zero a meter?
- What are the advantages of digital multimeters?
- How does the internal resistance affect a meter's reading?
- What is the function of the Wheatstone bridge?

Task Number 80

Determine characteristics of inductance.

Definition

Determination requires

- defining
  - henry
  - inductor
  - inductance
  - Lenz's law
  - phase relationships
- explaining physical properties of an inductor
- explaining electrical characteristics of an inductor
- constructing a simple inductive circuit, and observing results of changing frequency or inductance
- demonstrating the use of a
  - voltmeter
  - oscilloscope
  - signal generator
- drawing the schematic symbol for an inductor.

Process/Skill Questions

- What is a practical application of inductance?
- What is the phase relationship in a purely inductive circuit?
- What are the physical properties of an inductor?
<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>English</th>
<th>History and Social Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>39</td>
<td>Comply with federal, state, and local safety requirements.</td>
<td>10.5, 11.5</td>
<td>GOVT.7, GOVT.8, GOVT.9, GOVT.14, GOVT.15</td>
</tr>
<tr>
<td>40</td>
<td>Maintain a safe working environment.</td>
<td>10.5, 11.5</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Explain safe working practices around electrical hazards.</td>
<td>10.5, 11.5</td>
<td>WHII.8</td>
</tr>
<tr>
<td>42</td>
<td>Identify emergency first-aid procedures.</td>
<td>10.5, 11.5</td>
<td>WHII.8</td>
</tr>
<tr>
<td>43</td>
<td>Identify the types of fires and the methods used to extinguish them.</td>
<td>10.5, 11.5</td>
<td>WHII.8</td>
</tr>
<tr>
<td>44</td>
<td>Identify personal protective equipment (PPE) requirements.</td>
<td>10.5, 11.5</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Inspect course-specific hand and power tools to visually identify defects.</td>
<td>10.1, 10.6, 10.7, 11.1, 11.6, 11.7</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Demonstrate lifting and carrying techniques.</td>
<td>10.5, 11.5</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Demonstrate safe laddering techniques.</td>
<td>10.5, 11.5</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Report personal injuries and environmental and equipment safety violations.</td>
<td>10.1, 10.6, 10.7, 11.1, 11.6, 11.7</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Pass safety exam.</td>
<td>10.5, 11.5</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Earn the general industry OSHA 10 card.</td>
<td>10.5, 11.5</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Perform measurements.</td>
<td>10.5, 11.5</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Apply principles of the mechanics of robotics.</td>
<td>10.5, 11.5</td>
<td>A.1, A.4, AII.3</td>
</tr>
<tr>
<td>53</td>
<td>Describe the skills and characteristics of a good technician.</td>
<td>10.1, 11.1</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Investigate community industrial and technical resources.</td>
<td>10.2, 10.5, 10.8, 11.2, 11.5, 11.8</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>Explore occupations related to electronics and robotics technology.</td>
<td>10.5, 10.8, 11.5, 11.8</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>Explain the use of robotics for industrial applications.</td>
<td>10.5, 11.5</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>Explain the use of robotics in the inspection and quality-assurance process.</td>
<td>10.5, 11.5</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>Identify types of robot geometry, manipulators, and end effectors.</td>
<td>10.5, 11.5</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>Identify types of robot control and drive systems.</td>
<td>10.5, 11.5</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>Explain the nature of electricity.</td>
<td>10.5, 11.5</td>
<td>CH.2, PH.11</td>
</tr>
<tr>
<td></td>
<td>Task</td>
<td>Subject(s)</td>
<td>Language(s)</td>
</tr>
<tr>
<td>---</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>61</td>
<td>List ways to produce electrical energy.</td>
<td></td>
<td>English: 10.6, 11.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science: PH.11</td>
</tr>
<tr>
<td>62</td>
<td>Determine characteristics of capacitance.</td>
<td></td>
<td>English: 10.3, 10.5, 11.3, 11.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mathematics: A.1, A.4, AII.3</td>
</tr>
<tr>
<td>63</td>
<td>Identify electric and electronic components and symbols.</td>
<td></td>
<td>English: 10.5, 11.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science: PH.11</td>
</tr>
<tr>
<td>64</td>
<td>Apply soldering and desoldering techniques.</td>
<td></td>
<td>English: 10.5, 11.5</td>
</tr>
<tr>
<td>65</td>
<td>Identify properties of conductors and insulators.</td>
<td></td>
<td>English: 10.5, 11.5</td>
</tr>
<tr>
<td>66</td>
<td>Determine the properties of resistance.</td>
<td></td>
<td>English: 10.5, 11.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science: PH.11</td>
</tr>
<tr>
<td>67</td>
<td>Explore the theory of electromotive force (voltage).</td>
<td></td>
<td>English: 10.5, 10.8, 11.5, 11.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mathematics: A.1, AII.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science: PH.11</td>
</tr>
<tr>
<td>68</td>
<td>Outline the path of electron flow.</td>
<td></td>
<td>English: 10.3, 10.6, 11.3, 11.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mathematics: A.1, AII.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science: PH.11</td>
</tr>
<tr>
<td>69</td>
<td>Determine the properties of power.</td>
<td></td>
<td>English: 10.3, 10.5, 11.3, 11.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mathematics: A.1, AII.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science: PH.5</td>
</tr>
<tr>
<td>70</td>
<td>Explain circuit-protection devices.</td>
<td></td>
<td>English: 10.3, 10.5, 11.3, 11.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science: PH.11</td>
</tr>
<tr>
<td>71</td>
<td>Describe circuit-control devices.</td>
<td></td>
<td>English: 10.5, 11.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science: PH.11</td>
</tr>
<tr>
<td>72</td>
<td>Identify schematics, technical drawings, and flowcharts.</td>
<td></td>
<td>English: 10.5, 11.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science: PH.11</td>
</tr>
<tr>
<td>73</td>
<td>Construct series circuits.</td>
<td></td>
<td>English: 10.3, 10.5, 11.3, 11.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mathematics: A.1, A.4, AII.3, AII.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science: PH.11</td>
</tr>
<tr>
<td>74</td>
<td>Construct parallel circuits.</td>
<td></td>
<td>English: 10.3, 10.5, 11.3, 11.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mathematics: A.1, A.4, AII.3, AII.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Science: PH.11</td>
</tr>
<tr>
<td>75</td>
<td>Construct series-parallel circuits.</td>
<td></td>
<td>English: 10.3, 10.5, 11.3, 11.5</td>
</tr>
<tr>
<td></td>
<td>Mathematics: A.1, A.4, AII.3, AII.5</td>
<td>Science: PH.11</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>76</td>
<td>Evaluate the difference in voltage between loaded and unloaded voltage-divider circuits.</td>
<td>English: 10.3, 10.5, 11.3, 11.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mathematics: A.1, A.4, AII.3, AII.5</td>
<td>Science: PH.11</td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>Examine magnetic properties of a circuit or component.</td>
<td>English: 10.3, 10.5, 11.3, 11.5</td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>Construct circuits with electromagnetic properties.</td>
<td>Science: PH.7</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>Examine meter movement, using analog and digital multimeters.</td>
<td>English: 10.3, 10.5, 11.3, 11.5</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>Determine characteristics of inductance.</td>
<td>English: 10.3, 10.5, 11.3, 11.5</td>
<td></td>
</tr>
</tbody>
</table>

**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.” Teachers can find the infusion/unit in the course listing.
Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- Associate Certified Electronics Technician (CETa) Examination
- Certified Satellite Installer (CSI) Examination
- College and Work Readiness Assessment (CWRA+)
- Computer Service Technician (CST) Examination
- Customer Service Examination
- Customer Service Specialist (CSS) Examination
- Electronics Assessment
- Electronics Module: AC (EM2) Examination
- Electronics Module: Analog (EM3) Examination
- Electronics Module: Comprehensive Basic (EM5) Examination
- Electronics Module: DC Basics (EM1) Examination
- Electronics Module: Digital Basics (EM4) Examination
- Electronics Technology Assessment
- Engineering Technology Examination
- Industrial Electricity Assessment
- Industrial Electronics Assessment
- Manufacturing Specialist Certification Examination
- Manufacturing Technician Level I Certification Examination
- Mechatronic Systems Certification Examinations
- Mechatronics Level 1 Assessment
- Mobile Electronics Certified Professional (MECP) Basic Installation Technician Examination
- National Career Readiness Certificate Assessment
- Pre-Manufacturing Technician I (PreMT1) Examination
- Professional Communications Certification Examination
- Robotics and Automation Examination
- Student Electronics Technician (SET) Examination
- Telecommunications Electronics Technician (TCM) 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 Technology (8537/36 weeks, 280 hours)
- Industrial Robotics Technology (8558/36 weeks, 280 hours)
<table>
<thead>
<tr>
<th>Career Cluster: Arts, Audio/Video Technology and Communications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pathway</strong></td>
<td><strong>Occupations</strong></td>
</tr>
</tbody>
</table>
| Audio and Video Technology and Film | Audio and Video Equipment Technician  
Audio-Video Designer, Engineer  
Sound Engineering Technician |

<table>
<thead>
<tr>
<th>Career Cluster: Manufacturing</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pathway</strong></td>
<td><strong>Occupations</strong></td>
</tr>
</tbody>
</table>
| Manufacturing Production Process Development | Electro-Mechanical Technician  
Industrial Engineer  
Industrial Engineering Technician  
Manufacturing Systems Engineer  
Network Designer  
Precision Inspector, Tester, or Grader  
Production Manager  
Programmer |
| Production | Assembler  
Automated Manufacturing Technician |

<table>
<thead>
<tr>
<th>Career Cluster: Science, Technology, Engineering and Mathematics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pathway</strong></td>
<td><strong>Occupations</strong></td>
</tr>
</tbody>
</table>
| Engineering and Technology | Electrical Engineer  
Electrical Engineering Technician  
Electronics Engineering Technician |