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Development of Standards, Objectives, and Curriculum Guide to Teach Basic Electronics for Utah Science Credit in Secondary School Education

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Development of Standards, Objectives, and Curriculum Guide to Teach
Basic Electronics for Utah Science Credit
in Secondary School Education

By

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A Plan B project submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Technology and Engineering Education

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2013

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Chapter 1

Introduction

Recently, the Utah State Office of Education (USOE) has accepted Basic Electronics, Classification of Instructional Programs (CIP) code 47.0105, as an elective to fill the required third science credit for secondary education (grades 10-12) students. The current Utah state core standards and objectives used for curriculum development in the Basic Electronics classes are now inadequate, as they are more than 15 years old, and designed specifically for students pursuing a technical career path. A formatting change to the document was implemented in 2008, but the standards and objectives were not changed.

Students are subsequently being taught the fundamentals of technology which were relevant nearly a generation ago. Much of that technology has since been replaced with greatly improved methods, equipment, and rapidly expanding applications (e.g., digital electronics). A new set of standards and objectives are needed which will be relevant and authentic to Basic Electronics as both an introductory electronics class, and a science elective.

Statement of the Problem

There is need for a new set of standards and objectives which are relevant to students who enroll in Utah's Basic Electronics class, and subsequently a curriculum guide developed from those standards and objectives.

Purpose

Traditionally, Basic Electronics was offered as the first in a series of two classes designed to give students training to become technicians. These two classes were previously offered only as electives. This approach to career training worked well when three elective credits were needed for students to graduate. Now only one elective credit is required for graduation, so students must choose carefully the electives they feel will best meet their needs.

Over the past decade, changes on several occasions have resulted in a reduction of elective credits which Utah students need to graduate. Therefore, the educational process must also change to insure proper alignment with the intended outcomes, which is to produce highly educated students who are prepared to live and work in the 21st century. By developing a revised set of standards and objectives for the Basic Electronics course, new curricula can be developed which will be relevant to student learning. This will also meet the expectations of the USOE for Basic Electronics as an elective science class.

The purpose of this project was to develop and validate new standards and objectives that would be relevant for Utah's Basic Electronics course. After the revised standards and objectives had been developed and validated, a basic electronics curriculum guide was created. This project provides a framework that will allow the Electronics class to shift its focus from producing technicians, to that of producing the next generation of technology literate students. If students are to compete with, and succeed in the evolving global market of high technology, a relevant curriculum will ensure what is being taught in the classroom aligns with these evolving needs.

The revised standards and objectives could then be used to develop a new Criterion Referenced Test (CRT) for the Basic Electronics course. Since major funding for education is driven by test scores, development of a new test would be the next logical step in the process of revising Utah's Basic Electronics course.

Need

A need exists to revise the outdated standards and objectives of Utah’s Basic Electronics course. A need exists to develop a new Basic Electronics curriculum guide based on the revised standards and objectives. A need also exists to develop a new CRT for Utah’s revised Basic Electronics course. This project addresses the first two needs discussed above.

As an incentive to help students choose electronics over other science electives, the new curriculum was developed so that it holds student interest on a fundamental level. This new curriculum supplements a shift from the old Basic Electronics class that was intended as entry-level training for technicians. The new curriculum instead, explores electronics from a scientific approach, emphasizing the connections between Science, Technology, Engineering, and Math (STEM). This idea was the initial impetus for the project with its revised standards, objectives, and accompanying curriculum guide.

These new curriculum materials shift the focus of the electronics core from that of producing technicians to an emphasis of electronics as a technological exploration with its inherent hands-on inquiry based learning.

Definition of Terms

CIP Codes — Classification of Instructional Programs. These were developed by the United States Department of Education-National Center for Education Statistics to help states identify the content of a wide range of academic, and career and technical instructional programs offered at the secondary and post-secondary levels.

CRT — Criterion Referenced Test. Tests that provide for translating test scores into a statement about the behavior to be expected of a person with that score or their relationship to a specified subject matter.

IEEE — Institute of Electrical and Electronics Engineers. The world's largest professional association for the advancement of technology.

ITEEA — International Technology and Engineering Educators Association.

LLC — Limited License Company.

NCE — National Coalition of Electronics Education. An alliance of electronics professionals and organizations in a coordinated effort to promote, support and expand electronics training opportunities to increase the number of qualified electronics professionals, providing standards through guidance, competencies, and marketing tools to industries and educational communities.

PLTW — Project Lead The Way. A non-profit organization which offers rigorous and innovative STEM education curricular programs used in middle and high schools across the U.S.

SAGE — Student Assessment of Growth and Excellence. A computer adaptive assessment system currently being phased into Utah's public education.

STEM — Science, Technology, Engineering, and Math. An education coalition representing all sectors of the technology workforce from knowledge workers, to educators, to scientists, engineers and technicians.

USOE — Utah State Office of Education.

UTIPS — Utah Test Item Pool Service. A collaborative online assessment tool for educators to use and share tests as instructional materials.

Chapter 2

Review of Literature

There appeared to be only one set of standards and objectives available at the national level for content specific material in electronics at the secondary education level. These standards and objectives are available from the National Coalition of Electronics Education (NCEE). Other popular and well known coalitions such as the Institute of Electrical and Electronics Engineers (IEEE) provide very concise standards regarding industry related needs for conformity of individual components. Those standards specify critical requirements for electrical components and how they are to be used in manufacturing and building environments, but the standards do not relate to any educational learning objectives. The research for this project was a collection of information obtained from states which have available standards and objectives used for teaching electronics at the secondary education level.

In researching what standards and objectives are available in all 50 states at the secondary education level, only nine states had available standards and objectives that related directly to electronics classes, or indirectly through other pathways such as Manufacturing Education. Five states had standards and objectives used for programs of study which provide a two-year certificate of training for technicians.

Four states had standards and objectives similar to Utah's, but do not map them to existing CIP codes as Utah does. Other standards and objectives are specific to post-secondary education technical training centers. The scope of this project focuses on material that was available at the secondary education level.

While developing the new standards, a few objectives related to becoming technologically literate were also considered. These standards and objectives were obtained from the International Technology and Engineering Educators Association (ITEEA) and its *Standards for Technological Literacy: Content for the Study of Technology* (ITEEA, 2000/2002/2007). These standards and objectives could help guide the teacher's lesson development to incorporate STEM thinking into their teaching methods.

Seven states currently use electronics standards and objectives which have a very broad scope indicative of content which might typically be delivered in a two-year program of study. California and Virginia had standards and objectives which appeared to be appropriate for the intensive training setting of a post-secondary education institute. Kentucky offered a Digital Electronics course derived from the *Project Lead The Way* (PLTW) program. Twenty six states used PLTW as a resource, but it is not known how many individual school districts incorporated PLTW Digital Electronics coursework into their respective curricula.

It did not appear advantageous to merely adopt a set of standards and objectives that were developed by other states for training technicians. This also includes PLTW standards and objectives for the Digital Electronics coursework. Upon examination of PLTW standards, it appeared the scope and sequence was too rigorous for a one-year basic electronics class which would be taught as a science elective. Those programs are typically delivered as a two-year program of study. The curriculum guide developed from the revised Utah standards and objectives would provide the necessary fundamental background knowledge of electronic theory, while maintaining the integrity of, and student interest in the subject as it relates to a science and technology class.

Chapter 3

Methodology

This project was comprised of two phases. The first phase consisted of revising Utah's Basic Electronics course standards and objectives that were outdated. These revisions were made during collaboration with Utah electronics teachers, and Dave Milliken, Utah State Skilled and Technical Sciences Specialist. A survey of related standards and objectives from nine other states were researched for further insight. The finished revised standards and objectives were submitted to Dave for review and acceptance and review. It will be published by the USOE for distribution to electronics teachers throughout the state of Utah, after it is ratified by committee members who are involved in the final decision.

The second phase, and major focus of this project, was the development of a new Basic Electronics curriculum guide that was based on the revised standards and objectives. This new curriculum guide is relevant and suitable for teaching the course as an electronics class, or a science elective, to students at the secondary education level. For this project, five sample lesson plans were developed and field tested.

Procedures

The following outline lists the procedures used in developing this project:

1. Met with Dave Milliken to discuss the feasibility of the first component of this project.
(January, 2013)
2. Initiated research for standards and objectives from states with similar Basic Electronics coursework. (February, 2013)
3. Contacted eight Utah electronics teachers to initiate collaboration for revision of standards and objectives. (February, 2013)

4. Continued revision of standards and objectives based on teacher collaboration and Dave Milliken's feedback. (May, 2013)
5. Finished revision of the standards and objectives. (June, 2013)
6. Submitted revised standards and objectives to Dave Milliken for USOE approval. (June, 2013)
7. Began writing curriculum guide that would align with revised standards and objectives. (June, 2013)
8. Developed five sample lesson plans for curriculum guide utilizing the Understanding by Design format. (September, 2013)
9. Finished writing curriculum guide for inclusion into the project. (November, 2013)

Phase I

Standards and objectives. Through state conferences and other activities, the investigator in this project has formed close ties with others who were involved in teaching electronics in the State of Utah. During collaboration with these other teachers, it became apparent they shared many of the same concerns about the inadequacies of the current Utah standards and objectives for the basic electronics course. Feedback from these teachers regarding their specific classroom teaching environments ensured realistic and authentic concerns were considered.

The state specialist (i.e., Dave Milliken) was contacted regarding the need of this project, and he continually offered his input and support. Input from Dave and the other teachers ensured congruency regarding revisions they wanted to see implemented. These revisions encompassed various exclusions and inclusions of the document which addresses adaptation for the course as either an electronics class or science class. Working with Dave also ensured proper integrity of documentation as required by the USOE.

The original standards and objectives as adopted by the state of Utah from NCEE were entitled *Electronics Technicians Basic Electronics*. When asked about the process of developing Utah's current standards and objectives, Dave Milliken said “A committee makes the recommendation to the USOE staff and move forward from there. The main purpose of the Basic Electronics class was to introduce students to the electronics industry and to teach them basic analog principles, formulas and show an application of the concepts.” It was this idea of “...introduce students to the electronics industry...” which led to the inclusion of standards and objectives which are now related to outdated technologies. The standards that relate to these older technologies were specifically addressed while developing the new and relevant revisions.

From NCEE's comprehensive “master” list, the Utah committee had chosen standards and objectives that it felt would meet the needs of electronics education nearly 15 years ago. The NCEE standards and objectives had been updated in 2012, which makes them more relevant for researching today. Upon examination of the updated materials, no discernible difference from the old standards and objectives was noticed, except for some minor formatting changes to the document.

Revisions. The proposed revision of standards and objectives were compiled from the existing Utah standards and objectives. Input from the other eight Utah electronics teachers was gathered via email, telephone, and collaboration during attendance at various CTE conferences, which are typically held twice a year.

The majority of revisions were the deletion of objectives and standards that were specifically related to items relevant to technicians. These included such references as knowing the proper names of, and being able to identify hand tools that would be used to assemble cabinets and chassis. Other exclusions were items such as those that require a thorough knowledge of analog meters, and the proper handling and use of this old technology.

Formatting changes were necessary to create better congruence throughout the document. There are single item objectives associated with standards that could logically be combined with other standards.

Data collection. The data collected for this project were the standards and objectives obtained from all the other states which had available documentation as it relates to the teaching of electronics at the secondary education level. Appendix C lists the web addresses from which the National, and state standards and objectives are obtained.

Phase II

Curriculum guide development. The project's second phase was the development of a new curriculum guide that met the needs of practicing electronics teachers in Utah. The scope of the guide is a simple to follow framework used in presenting the Utah State core standards for the Basic Electronics class. The guide is a companion for the included teaching materials and resources. This will enable any competent instructor to present the material with a minimum amount of preparation time while insuring adequate coverage of the required subject matter.

Components of the new curriculum guide include:

- Philosophy
- Course Description
- Standards and Objectives
- Course Outline (Scope and Sequence)
- Teacher Resources
- Sample Lesson Plans:
 - Batteries
 - Electromagnetism
 - Ohm's Law
 - Series Circuits
 - Parallel Circuits
- Assessments
- Resources CD

A list of basic tools, equipment and materials needed to properly teach the electronics class is included in the curriculum guide. Software resources are included which can be purchased as a single use or a site license. Low cost, and non-copyrighted resources are included. Instructional materials include sample lesson plans, with accompanying assessments.

Existing lesson plans were converted into the backward design format developed by Wiggins and McTighe (2005). This three stage design places emphasis of lesson development using a reverse procedure for the desired learning outcomes. The first stage of planning is to define the end results. Stage two focuses on assessments and performance evaluations. Stage three then incorporates the actual activities that will lead to the desired results as defined in stage one. The original lesson plans were developed using various resources including the textbooks written by Floyd (2007), and Roberts, Gerrish, and Dugger (2009). These textbooks utilize a scope and sequence similar to Grob (1997).

The scope of the material is described in the objectives. Along with the standards, these objectives define the breadth of the coursework. The course outline offers a typical sequence for instructional delivery. For this project, greater emphasis will be placed on depth over breadth.

The teacher resources provide a list of available text, media, software, and internet websites which have proven valuable in developing lesson activities. Purchasing tools, equipment, and consumable supplies from the list of reliable vendors should prove to be simple and straight forward for the beginning electronics teacher.

Assessments. Precision Exams LLC, a nationwide exam administration system, has online CRT's mapped to National Career Clusters. The company is located in Orem Utah, and used the original Utah standards and objectives for developing the Electronics 550 test references. This test is available nationally for secondary education level students enrolled in electronics classes. A test bank of questions and answers similar to those used on test 550 are included. These questions and answers reflect the scope and sequence relevant to the new curriculum guide.

The Utah Test Item Pool Service (UTIPS) is a free source for public school use. It must be initialized at each specific district site. Unit tests were installed on UTIPS for secondary and post-secondary education student use. These tests are easily modified by the instructor as individual need may arise. Since beginning this project it was learned that the USOE will be phasing out UTIPS in favor of an adaptive test platform called Student Assessment of Growth and Excellence (SAGE). It is proposed the UTIPS system will be available for only a few years after the implementation of the new system. Content from UTIPS will be exportable into SAGE. A preliminary FAQ sheet and other information about the progress of SAGE, which was recently released for public awareness, is available at <http://www.schools.utah.gov/assessment/Adaptive-Assessment-System.aspx>.

Chapter 4

Conclusions and Recommendations

Conclusion

This project consisted of two phases. The first phase of the project consisted of revising Utah's Basic Electronics outdated core standards and objectives. The newly revised Utah core standards and objectives for Basic Electronics are shown in Appendix B.

The second phase of this project was the development of a new Basic Electronics Curriculum Guide based on the newly revised standards and objectives. Contained in Appendix D is the new curriculum guide.

Recommendations

It is recommended that this new curriculum guide is used to teach Basic Electronics as a science class in Utah's secondary education. Use of this curriculum guide is also recommended for instructors who are new to teaching electronics at the secondary education level.

References

Floyd, T. L. (2007). *Electronics fundamentals: circuits, devices, and applications, 7th Edition*. Library of Congress Cataloging-in-Publication Data. Pearson/Prentice Hall.

Grob, B. (1997). *Basic Electronics 8th Edition*. McGraw Hill.

Roberts, R.M., Gerrish, H.H., and Dugger Jr., W.E. (2009). *Electricity and Electronics, 9th Edition*. Goodheart Wilcox.

Wiggins, G. and McTighe, J. (2005). *Understanding by design. Expanded 2nd Edition*. Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Appendix A

Proposed Revisions

ELECTRONICS TECHNICIAN

Basic Electronics

A course that prepares individuals to apply technical knowledge and skills to assemble, install, operate, maintain, and repair electrical/electronic equipment used in business, industry, and manufacturing. Includes instruction in installing, maintaining, and testing various types of electronic equipment. These courses are based on the state electronics task list.

A course which introduces students to the fundamentals of electricity with emphasis placed on safety, electrical concepts, and required math skills.

USOE

7/23/2008

BASIC ELECTRONICS

Levels: Grades 10-12

Units of Credit: Minimum 0.5

CIP Code: 47.0105

Prerequisite: None

CORE STANDARDS, OBJECTIVES, AND INDICATORS

STANDARD 47010501

Students will be able to understand and demonstrate safe practices.

Objectives

470105-0101 Use safe work practices. (A1)

- Describe the purposes of legislation concerning safety in the workplace.
- Describe safety precautions and procedures pertaining to and working with electricity.
- Describe correct safety procedures for hand and power tools.
- Locate and describe shop safety equipment.
- Use safe work practices.

STANDARD 47010502

Students will be able to understand and demonstrate the use of shop tools, materials, and techniques.

Objectives

470105-0201 Select and use hand and common power tools. (B1)

- Identify hand tools used by electronics technicians.

- Describe the procedures to be used to care for hand tools.
 - Identify the proper use and care of power tools and their accessories
 - Select and use hand tools.
 - Select and use common power tools and their accessories.
- ~~470105-0202 Select and use hardware associated with electricity. (B2, B5)~~
- ~~• Identify nuts, bolts, screws, and washers.~~
 - ~~• Identify cable and wire support hardware.~~
 - ~~• Select and use hardware used by electronics technician.~~
- 470105-0203 Solder and desolder. (B3, B5)
- Explain the principles of soldering and desoldering.
 - Describe appropriate soldering techniques such as tinning, physical connections, temperature selection, and cleaning.
 - Describe the precautions to prevent electrostatic discharge (ESD) during soldering.
 - On a P.C. board solder and desolder ICs, wire and discrete components.
 - ~~• Show appropriate use of heat sinks on solid state components.~~

STANDARD 47010503

Students will be able to understand and demonstrate the use of test equipment.

Objectives

- 470105-0301 Use *digital* multimeters ~~—digital and analog.~~ (C1)
- Describe the proper handling, storage and use of digital meters.
 - ~~• Describe the proper handling, storage and use of analog meters.~~
 - Use multimeters.
- + *Describe the proper use of leads with multimeters.*
- 470105-0302 Use bench power supplies. (C2)
- Describe the operation of a bench power supply and its controls.
 - Use power supplies *safely*.

STANDARD 47010504

Students will be able to understand and demonstrate how to test and select passive electronics components.

Objectives

- 470105-0401 Identify electronic components. (D1)
- Identify electronic passive components i.e. resistors, *and* capacitors, ~~and inductors.~~
 - Using standard electronic multiplication prefixes, determine the

values for electronic components from their markings and physical characteristics.

- Identify electronic components.

470105-0402 Use, test and select batteries. (D2)

- Describe the construction, operation, testing and maintenance of batteries.

- Use, test, and select batteries.

470105-0403 Use, test and select resistive devices. (D3)

- Describe the principles of resistance.
- Identify resistive devices and draw their schematic symbols.
- Describe the function of resistive devices.
- Describe the procedures for testing resistive devices.
- Use, test and select resistive devices.

470105-0404 Use, test, and select switches and relays. (D4)

- Describe switch types, schematic symbols and operation.
- ~~• Describe relay types, their major parts, schematic symbols and operation.~~
- Describe procedures for selecting, connecting and testing switches and relays.
- Connect, test and select switches.
- ~~• Test, select and connect relays.~~

STANDARD 47010505

Students will be able to understand and demonstrate induction.

Objectives

470105-0501 Describe principles of magnetism and electromagnetism learning. (F7)

- Explain the principles of magnetic fields.
- Explain the principles of electromagnetic fields.
- Describe the operation and application of magnetic devices.
- Describe the principles of electromagnetic induction.

STANDARD 47010506

~~**Students will be able to understand and demonstrate capacitors & their application.**~~

Objectives

470105-0601 Use, test, and select capacitors. (D8)

- ~~• Describe the principles of operation of capacitors.~~
- ~~• Describe the common types of capacitors, their schematic symbols,~~

major parts and uses.

- Describe the operation of capacitors in DC and AC circuits.
- Describe the procedures for selecting, testing and connecting capacitors in series and parallel circuits.
- Use, test, and select capacitors.

STANDARD 47010507

Students will be able to understand and demonstrate how to use transformers.

Objectives

470105-0701 Troubleshoot transformer circuits. (G3)

- Describe the procedure for constructing, *and* testing *transformers*. ~~and troubleshooting transformer circuits.~~
- + Describe how transformers step up voltage, and step down voltage as a factor of turns ratios, and Ohm's and Watt's laws.
- + Describe the function of alternating current in transformers.
- + Describe difference between AC and DC

STANDARD 47010508

Students will be able to understand and deomstrate basic electronic theroy.

Objectives

470105-0801 Describe basic principles of electrical theory. (F1)

- Describe the atomic structure of matter.
- Describe the units of electrical charge, voltage and current.
- Describe the factors that affect the movement of electrical charges.

470105-0802 Verify ohm's law and power equations. (F2)

- State Ohms Law and graph the relationships between voltage, current and resistance in circuits.
- Use formulas and basic mathematics to solve Ohms Law problems.
- Use formulas to calculate electric power requirements.
- Describe the effect on power requirements of changing voltage, current or resistance on power.
- Describe power dissipation in resistive devices.
- From schematic diagrams, predict the voltage, current, and resistance in all parts of a circuit.
- Determine proper power ratings for resistors.

470105-0803 Construct, measure and analyze simple series resistive circuits. (F3)

- Describe the principles of series circuits.
- Calculate the voltage across, current through, equivalent resistance of

and power dissipation for any component or group of components in a series resistive circuit.

- State and use Kirchoff's voltage law and the voltage divider formula.
- 470105-0804 Construct, measure and analyze simple parallel resistive circuits. (F4)
- Describe parallel circuit principles.
 - Calculate the theoretical values of voltage, current, resistance and power in all parts of the circuit.
 - State and use Kirchoff's current law and the current divider formula to solve parallel circuit problems.

PROFESSIONAL DEVELOPMENT

STANDARD 47010514

Students will understand the need for professional development.

Objectives

- 470105-1401 Complete a personal inventory.
 - 470105-1402 Set and meet goals.
 - 470105-1403 Be self-motivated.
 - 470105-1404 Know how to make decisions.
 - 470105-1405 Know how to manage time.
 - 470105-1406 Organize personal belongings and equipment.
 - 470105-1407 Learn to communicate verbally.
 - 470105-1408 Write effective communications.
 - 470105-1409 Establish a personal reading program.
 - 470105-1410 Develop effective work skills and attitudes.
 - 470105-1411* Master a working knowledge of SkillsUSA.
- State the SkillsUSA motto.
 - State the SkillsUSA creed.
 - Learn the SkillsUSA colors.
 - Describe the official SkillsUSA dress.
 - Describe the procedure for becoming a SkillsUSA officer.

STANDARD 47010515

Students will understand the need for leadership skills.

Objectives

- 470105-1501 Serve on a committee.
 - 470105-1502 Prepare an agenda.
 - 470105-1503 Assist in planning a meeting.
 - 470105-1504 Review basic parliamentary procedure.
- Make a main motion.
- 470105-1505 Participate in a school project.
 - 470105-1506 Attend a community meeting.
 - 470105-1507 Practice effective speaking.

470105-1508 Present a three- to five-minute talk.

470105-1509 Implement a leadership project.

470105-1510* Master a working knowledge of SkillsUSA.

- Describe the meaning of the SkillsUSA emblem.
- State the SkillsUSA pledge.
- Describe the duties of a SkillsUSA officer.

STANDARD 47010516

Students will understand the need for career planning.

Objectives

470105-1601 Define your future occupation.

470105-1602 Survey employment opportunities.

470105-1603 Report on a trade journal article.

470105-1604 Explore opportunities for advanced training.

470105-1605 Conduct a worker interview.

470105-1606 Contact a professional association.

470105-1607 Explore entrepreneurship opportunities.

470105-1608 Give a talk about your career.

470105-1609 Review career goals.

STANDARD 47010517

Students will understand the importance of employability and work habits.

Objectives

470105-1701 Develop a list of work standards to follow at school and on the job.

470105-1702 Evaluate your personal ethics.

- Evaluate your personal ethics against acceptable workplace ethics.

470105-1703 Build a job search network.

470105-1704 Find job leads.

470105-1705 Write a resume.

470105-1706 Create a job portfolio.

470105-1707 Complete a job application.

470105-1708 Write a business letter and memo.

470105-1709 Participate in an actual or simulated job interview.

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* SkillsUSA PDP requirements - recommended.

The following standard is from ENGR-STEM-2

STANDARD 47010518

Students will identify the impact of technology within global, economic, environmental, and social contexts.

Objectives

470105-1801 Describe the social, economic, and environmental impacts of a technological product, process, or system.

470105-1802 Demonstrate ethical and professional behavior in the development and use of technology.

470105-1803 Explain the influence of technology on history and the shaping of contemporary issues.

Appendix B

Revised Standards and Objectives

ELECTRONICS

A course which introduces students to the fundamentals of electricity with emphasis placed on safety, electrical concepts, and required math skills.

USOE

8/1/13

BASIC ELECTRONICS

Levels: Grades 10-12

Units of Credit: Minimum 0.5

CIP Code: 47.0105

Prerequisite: None

CORE STANDARDS, OBJECTIVES, AND INDICATORS

STANDARD 1

Students will be able to understand and demonstrate safe practices.

Objective 1: Use safe work practices. (A1)

- a. Describe the purposes of legislation concerning safety in the workplace.
- b. Describe safety precautions and procedures pertaining to and working with electricity.
- c. Describe correct safety procedures for hand and power tools.
- d. Locate and describe shop safety equipment.
- e. Use safe work practices.

Objective 2: Understand electrical hazards. (A1)

- a. Describe the effects of electric current on a human body.
- b. Describe typical electric shock hazards in industry.
- c. List general safety precautions to observe when working with electricity.
- d. Identify potential dangers to people and the environment.
- e. Identify various types of safety devices used with electricity.

STANDARD 2

Students will be able to understand and demonstrate the use of shop tools, materials, and techniques.

Objective 1: Select and use hand and common power tools. (B1)

- a. Identify hand tools used by electronics technicians.
- b. Describe the procedures to be used to care for hand tools.
- c. Identify the proper use and care of power tools and their accessories
- d. Select and use hand tools.
- e. Select and use common power tools and their accessories.

Objective 2: Solder and desolder. (B3, B5)

- a. Explain the principles of soldering and desoldering.
- b. Describe appropriate soldering techniques such as tinning, physical connections, temperature selection, and cleaning.
- c. Describe the precautions to prevent electrostatic discharge (ESD) during soldering.
- d. On a P.C. board solder and desolder ICs, wire and discrete components.

STANDARD 3

Students will be able to understand and demonstrate the use of test equipment.

Objective 1: Use digital multimeters (C1)

- a. Describe the proper handling, storage and use of digital meters.
- b. Use multimeters.
- c. Describe the proper use of leads with multimeters.

Objective 2: Use bench power supplies. (C2)

- a. Describe the operation of a bench power supply and its controls.
- b. Use power supplies safely.

STANDARD 4

Students will be able to understand and demonstrate how to test and select passive electronic components.

Objective 1: Identify electronic components. (D1)

- a. Identify electronic passive components i.e. resistors, and capacitors.
- b. Using standard electronic multiplication prefixes, determine the values for electronic components from their markings and physical characteristics.
- c. Identify electronic components.

Objective 2: Use, test and select batteries. (D2)

- a. Describe the construction, operation, testing and maintenance of batteries.
- b. Use, test, and select batteries.

Objective 3: Use, test and select resistive devices. (D3)

- a. Describe the principles of resistance.
- b. Identify resistive devices and draw their schematic symbols.
- c. Describe the function of resistive devices.
- d. Describe the procedures for testing resistive devices.
- e. Use, test and select resistive devices.
- f. Describe switch types, schematic symbols and operation.
- g. Describe procedures for selecting, connecting and testing switches
- h. Connect, test and select switches.

STANDARD 5**Students will be able to understand and demonstrate induction.****Objective 1:** Describe principles of magnetism and electromagnetism. (F7)

- a. Explain the principles of magnetic fields.
- b. Explain the principles of electromagnetic fields.
- c. Describe the operation and application of magnetic devices.
- d. Describe the principles of electromagnetic induction.

Objective 2: Students will be able to understand and demonstrate how to use transformers. (G3)

- a. Describe the procedure for constructing, and testing transformers.
- b. Describe how transformers step up voltage, and step down voltage as a factor of turns-ratios, and Ohm's and Watt's laws.
- c. Describe the function of alternating current in transformers.
- d. Describe the difference between AC and DC.

STANDARD 6**Students will be able to understand and demonstrate basic electronic theory.****Objective 1:** Describe basic principles of electrical theory. (F1)

- a. Describe the atomic structure of matter.
- b. Describe the units of electrical charge, voltage and current.
- c. Describe the factors that affect the movement of electrical charges.

Objective 2: Verify ohm's law and power equations. (F2)

- a. State Ohms Law and graph the relationships between voltage, current and resistance in circuits.
- b. Use formulas and basic mathematics to solve Ohms Law problems.
- c. Use formulas to calculate electric power requirements.
- d. Describe the effect on power requirements of changing voltage, current or resistance on power.
- e. Describe power dissipation in resistive devices.
- f. From schematic diagrams, predict the voltage, current, and resistance in all parts of a circuit.
- g. Determine proper power ratings for resistors.

Objective 3: Construct, measure, and analyze simple series resistive circuits. (F3)

- a. Describe the principles of series circuits.
- b. Calculate the voltage across, current through, equivalent resistance of and power dissipation for any component or group of components in a series resistive circuit.
- c. State and use Kirchoff's voltage law and the voltage divider formula.

Objective 4: Construct measure and analyze simple parallel resistive circuits. (F4)

- a. Describe parallel circuit principles.
- b. Calculate the theoretical values of voltage, current, resistance and power in all parts of the circuit.
- c. State and use Kirchoff's current law and the current divider formula to solve parallel circuit problems.

PROFESSIONAL DEVELOPMENT

STANDARD 7

Students will gain an understanding of Design Technology as a profession and will develop professional skills for the workplace.

Objective 1: As a participating member of the SkillsUSA student organization complete the SkillsUSA Level 1 Professional Development Program.

- a. Complete a self-assessment inventory and identify individual learning styles.
- b. Discover self-motivation techniques and establish short-term goals.
- c. Determine individual time-management skills.
- d. Define future occupations.
- e. Define awareness of cultural diversity and equity issues.
- f. Recognize the benefits of conducting a community service project.
- g. Demonstrate effective communication skills with others.
- h. Participate in a shadowing activity.
- i. Identify components of an employment portfolio.
- j. Explore what is ethical in the workplace or school.
- k. Demonstrate proficiency in program competencies.
- l. Explore what is ethical in the workplace or school.
 - State the SkillsUSA motto.
 - State the SkillsUSA creed.
 - Learn the SkillsUSA colors.
 - Describe the official SkillsUSA dress.
 - Describe the procedure for becoming a SkillsUSA officer.

Objective 2: Understand the use of drawings in architectural design and how those drawings relate to career opportunities.

Objective 3: Display a professional attitude toward the instructor and peers.

Appendix C

List of Web Addresses for Standards and Objectives

National standards and objectives retrieved from:

<http://www.ncee-edu.org>

State standards and objectives retrieved from:

<http://fldoe.org/workforce/dwdframe/1112/stem/rtf/8600900.rtf>

<https://www.georgiastandards.org/standards/georgia%20performance%20standards%20ctae/foundations-of-electronics.pdf>

<http://education.ky.gov/cte/documents/engineeringandtechnologypos.pdf>, Pages 43-44

http://education.nh.gov/career/career/program_manu.htm

<http://ed.sc.gov/agency/programs-services/148/documents/electronicstechnology.pdf>

<http://doe.sd.gov/octe/documents/electrni.pdf>

<https://www.google.com/url?q=http://careertech.k12.wv.us/cte-draft-csos/ET>

<http://cte.dpi.wi.gov/files/cte/doc/electronics.doc>

http://pte.idaho.gov/pdf/skilled_technical_sciences/sts/curriculum/idaho_electronics_curriculum

Appendix D
Curriculum Guide

Curriculum Guide
For
Basic Electronics
Utah 10-12 Science Elective



Rick Peirce

Utah State University

2013

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I. Philosophy

The curriculum guide for Basic Electronics is intended to describe the scope and sequence of instructional delivery in Utah high schools as either an electronics class, or a science class. It has been designed so that whenever possible, the core concepts have a natural and logical sequence with each other. The core focuses on providing experiences with concepts that students can explore and understand within a framework suitable to the maturity level of a typical high school student.

It is further intended to facilitate a simple delivery method for teachers wishing to enhance their skill set in electronics knowledge.

The guide includes desired objectives mapped to Utah core standards for Basic Electronics. These will enable the instructor to provide evidence of assessment through performance tasks, and relevant learning activities. Teachers should provide a variety of classroom assessment approaches in conjunction with standard practices to properly evaluate student mastery of the core concepts. Sample tests and laboratory assessments are found in appendix F. Simple observation of students engaged in laboratory activities also provides a timely assessment of their performance and abilities. The nature of questions posed by students also gives excellent insight and evidence of their learning.

Not all electronics topics are specified in this guide. By emphasizing depth over breadth, this guide seeks to empower students rather than intimidate them with volumes of data and isolated forgettable facts. It is intended for teachers to help students understand fundamental electronics concepts while developing sound scientific habits through experiencing the process of scientific investigation. Students should enjoy discovering electronics while applying the scientific method to its exploration. Classroom activities should help students:

- Identify a problem
- Formulate a research question and hypothesis
- Identify variables and describe relationships between them
- Collect data on the dependent variables
- Plan procedures to control independent variables
- Select appropriate format to summarize data obtained
- Analyze data, check for accuracy, and construct reasonable conclusions
- Prepare written and oral reports of investigations

II. Course description

Basic Electronics 470105

This is an introductory level course with a few simple applications of electronics concepts and principles. The primary purpose of this course is to provide a basic understanding of DC electronics, and sound laboratory procedures. Students will be taught basic analog principles and formulas related to electronics, while being exposed to applications of the concepts.

Students should have completed, or be currently enrolled in Algebra I prior to enrolling in the course. The course will reinforce skill development in applied mathematics through theory and laboratory assignments based on industry procedures.

Students will be provided instruction on safety, tool and equipment use, soldering techniques, and employability skills and habits. Students will be involved in activities which reinforce Problem Solving, Teaming, Language Arts, Science, and Mathematics skills through real-life industry examples and procedures. These activities will also help promote an environment of STEM thinking.

The course will give students the opportunity to study devices and passive components that are used in DC series and DC parallel circuits. An introduction to AC concepts may also be included as time permits.

This course may be offered in one or two semester blocks of instruction depending on the desired depth of instruction. If two semesters are chosen, students will have ample time to explore kinesthetic activities which greatly enhance their overall classroom experience. A hands-on approach to education is a natural conduit for learning electronics.

III. Standards and Objectives

The following seven standards and related performance objectives chosen from the Utah State Core reflect a typical scope for delivering the basic concepts of electronics at the secondary level. The objectives are typical for a program of study as suggested by Grob (1997), Floyd (2001), and Roberts (2009). These specific objectives are assessed by the Utah Criterion Referenced Test (CRT) 550 Electronics 1. The code appearing after the objective maps that specific objective directly to its competency in the test bank which is included as appendix D. The complete standards and objectives recommended for a comprehensive education are included in appendix A, and are available at the following website:

www.schools.utah.gov/cte/documents/sts/standards/ElectronicsBasic.pdf

Appendix D is a list of websites from states which have access to standards and objectives for teaching electronics. Of all 50 states, these were the only ones available. They are included to give the teacher greater insight to the scope of electronics literacy throughout the nation, and possible ideas for his/her instructional development.

STANDARD **470105-01 Students will be able to understand and demonstrate safe practices.**

Objectives

470105-0101 Use safe work practices. (A1)

STANDARD **470105-02 Students will be able to understand and demonstrate the use of shop tools, materials, and techniques.**

Objectives

470105-0201 Select and use hand and common power tools. (B1)

470105-0203 Solder and desolder. (B3, B5)

STANDARD **470105-03 Students will be able to understand and demonstrate the use of test equipment.**

Objectives

470105-0301 Use digital multimeters (C1)

470105-0302 Use bench power supplies. (C2)

STANDARD **470105-04 Students will be able to understand and demonstrate how to test and select passive electronic components.**

Objectives

- 470105-0401 Identify electronic components. (D1)
- 470105-0402 Use, test and select batteries. (D2)
- 470105-0403 Use, test and select resistive devices. (D3)

STANDARD **470105-05 Students will be able to understand and demonstrate induction.**

Objectives

- 470105-0501 Describe principles of magnetism and electromagnetism learning. (F7)

STANDARD **470105-07 Students will be able to understand and demonstrate how to use transformers.**

Objectives

- 470105-0701 Understand transformer circuits. (G3)

STANDARD **470105-08 Students will be able to understand and demonstrate basic electronic theory.**

Objectives

- 470105-0801 Describe basic principles of electrical theory. (F1)
- 470105-0802 Verify ohm's law and power equations. (F2)
- 470105-0803 Construct, measure, and analyze simple series resistive circuits. (F3)
- 470105-0804 Construct measure and analyze simple parallel resistive circuits. (F4)

IV. Scope and Sequence

While the sequence defined in the following course outline is typical, the teacher is free to explore concepts in any order which provides the greatest instructional value.

A few sample lesson plans are included in appendix B. Each lesson should be presented in a minimum of two units of instructional time. A typical unit of instruction is described as 50 minutes of classroom time. In CTE classes, two units or double class periods may be allowed to facilitate a more efficient exploration of lab activities. In most lesson delivery, one unit should be sufficient for instruction while one or two units might be needed to accommodate the associated lab activities, depending on student proficiency. The following lesson plans are mapped to specific objectives as indicated by (SLP) after that objective:

- 470105-0402 Batteries
- 470105-0501 Electromagnetism
- 470105-0802 Ohm's Law
- 470105-0803 Series Circuits
- 470105-0804 Parallel circuits

470105-0101 Use safe work practices. (A1)

001 Work safely with electrical equipment.

002 Identify the correct procedures for safety techniques.

003 Take necessary steps to eliminate hazards.

004 Work safely with tools.

005 Read, understand and comply with material safety data sheets (MSDS).

470105-0201 Select and use hand and common power tools. (B1)

470105-0203 Solder and desolder. (B3, B5)

001 Work safely with soldering and de-soldering equipment.

002 Explain the principles of soldering and desoldering.

003 Describe appropriate soldering techniques such as tinning, physical connections, temperature selection, and cleaning.

004 On a P.C. board, solder and de-solder ICs, wire and discrete components.

005 Practice good electrostatic discharge (ESD) and damage prevention.

470105-0301 Use digital multimeters (C1)

001 Describe the proper handling, storage and use of digital meters.

002 Use multimeters.

003 Describe the proper use of leads with multimeters.

470105-0302 Use bench power supplies. (C2)

001 Describe the operation of a bench power supply and its controls.

002 Use power supplies safely.

470105-0401 Identify electronic components. (D1)

001 Identify passive electronic components i.e. resistors and capacitors.

002 Using metric prefixes, determine the values for electronic components from their markings and physical characteristics.

003 Identify switch types, schematic symbols and operation.

004 Describe procedures for selecting, connecting and testing switches

005 Connect, test and select switches.

470105-0402 Use, test and select batteries. (D2)(SLP)

001 Describe the construction, operation, testing and maintenance of batteries.

002 Use, test, and select batteries.

470105-0403 Use, test and select resistive devices. (D3)

001 Describe the principles of resistance.

002 Identify resistive devices and draw their schematic symbols.

003 Describe the function of resistive devices.

004 Describe the procedures for testing resistive devices.

005 Use, test and select resistive devices.

470105-0501 Describe principles of magnetism and electromagnetism learning. (F7)(SLP)

001 Explain the principles of magnetic fields.

002 Explain the principles of electromagnetic fields.

003 Describe the operation and application of magnetic devices.

004 Describe the principles of electromagnetic induction.

470105-0701 Understand transformer circuits. (G3)

001 Describe the procedure for constructing, and testing transformers.

002 Describe how transformers step up voltage, and step down voltage as a factor of turns-ratios.

003 Describe the relationship of and Ohm's law and Watt's law in determining transformer input and output voltages.

004 Describe the function of alternating current in transformers.

005 Describe the difference between AC and DC.

470105-0801 Describe basic principles of electrical theory. (F1)

001 Describe the atomic structure of matter.

002 Describe the units of electrical charge, voltage and current.

003 Describe the factors that affect the movement of electrical charges.

470105-0802 Verify Ohm's law and power equations. (F2)(SLP)

001 State Ohm's Law and graph the relationships between voltage, current and resistance in circuits.

002 Use formulas and basic mathematics to solve Ohm's Law problems.

003 Use formulas to calculate electric power requirements.

004 Describe the effect on power requirements of changing voltage, current or resistance on power.

005 Describe power dissipation in resistive devices.

006 From schematic diagrams, predict the voltage, current, and resistance in all parts of a circuit.

007 Determine proper power ratings for resistors.

470105-0803 Construct, measure, and analyze simple series resistive circuits. (F3)(SLP)

001 Describe the principles of series circuits.

002 Calculate the voltage across, current through, equivalent resistance of and power dissipation for any component or group of components in a series resistive circuit.

470105-0804 Construct measure and analyze simple parallel resistive circuits. (F4)(SLP)

001 Describe parallel circuit principles.

002 Calculate the theoretical values of voltage, current, resistance and power in all parts of the circuit.

003 State and use Kirchoff's current law and the current divider formula to solve parallel circuit problems.

V. Teacher Resources

TEXT

The following textbook is recommended for this course. Floyd, Thomas L. (2007) *Principles of electric circuits: electron flow version*. There are other excellent books written by Grob, B. (1997). *Basic Electronics 8th Edition*, and Roberts, R.M., Gerrish, H.H., and Dugger Jr., W.E. (2009). *Electricity and Electronics, 9th Edition*.

MEDIA

Documentaries and movies are informative, stimulating and engaging. Quizzes for the following media presentations are included in appendix E:

- *Electric Current* by Bill Nye (2005) 26 minutes. <http://www.dep-store.com/ProductDetails.asp?ProductCode=77A10VL00>.
- *Silicon Run Lite* (2004) 30 minutes. www.siliconrun.com
- *Magnets* by Modern Marvels (2002) 50 minutes. Cat. No. AAE-76191.
- *Mad Electricity* by Modern Marvels (2007) 50 minutes. Cat. No. AAE-131230.
- *Understanding Electricity* by Discovery Communications (2001) 53 minutes. 11937.
- *Frequency* (2000) rated PG-13, 119 minutes. ISBN 0-7806-3156-0.
- *Contact* (1997) rated PG, 150 minutes. ISBN 0-7907-3322-6.

INTERNET

The internet website <http://www.howstuffworks.com> is an excellent investigative tool for many topics relating to electronics. It is a better alternative to Wiki research.

The website <http://www.brainpop.com> contains many animated videos which are just a few minutes long. They give a very elementary introduction to a wide variety of subjects. Some of them are good conceptually for electrical fundamentals. The material is geared more towards the average layperson, but they are still good for high school students as an introduction or quick review. The site has quizzes and activities for each topic covered.

INTERACTIVE SOFTWARE

Included on the CD are in-depth evaluation versions of training software which students can use at an individual pace. The software could also be used as an enhancement for motivated students who want a greater challenge. ETCAI www.etcai.com contains a large selection of modules that range from basic electronic theory to more complex AC instruction. The program needs to be installed on a PC to run, and it is a full version which allows 10 trials. After the trials have expired, the program can be re-installed to run another 10 trials. This is a good program to use as a final review with the students.

OrchEd is a complete training package developed by Dr. Robert Summers and Dr. Gill Bearnson of Weber State University. They sell a compact digital trainer with all necessary components to explore their curriculum. An evaluation version of the software is available on the CD, which includes self-paced instruction, labs, and assessments. Some of the modules are referenced in the sample lesson plans included in appendix B. Their website www.orched.com offers a fun selection of free experiments and a large selection of other website resources.

GW Publisher offers Computer Aided Instruction (CAI) which aligns with the units in their textbook. Matt, Stephen R. (2013). *Electricity and basic electronics* (8th ed.). Goodheart-Wilcox Company, Inc. ISBN 978-1-60525-953-6. It is included with the purchased textbook. The information covered is fairly rudimentary and somewhat spartan, but the assessments are good for practice and review of concepts previously covered.

PDF RESOURCES

The Navy Electricity and Electronics Training Series (NEETS) is a comprehensive compilation of material developed by and for the U.S. Navy for training their technicians. It consists of 24 modules which are beyond the scope of a secondary basic electronics class. Modules one and two however, contain many topics related to the fundamental concepts in this curriculum guide. These may be used to provide the instructor with a deeper understanding of topics before presenting the material in the classroom.

Flinn Scientific offers some material for instructors which include fun activities such as how to build a simple electric motor. The complete instructions have illustrations, and are easy to follow. flinnsci.com/media/396304/ps10405.pdf.

All the materials in this curriculum guide are available on the CD, which is included as appendix G, as a word document, or PDF to facilitate lesson development. Videos of classroom lectures and demonstrations of safety requirements, and soldering techniques are also available on the CD. Tests for these videos are included with the resource materials.

Recommended tools, materials, and equipment

The following tools, materials, and equipment are recommended for the course, and should be sufficient for most basic classroom/lab instruction. This is not a comprehensive list of everything one might need, but is offered as a guideline to get started teaching in the lab as quickly as possible.

These materials may be obtained anywhere, but the listed vendors have excellent prices for bulk purchases. The Fluke 87 multimeter listed below is an industry standard piece of equipment, which would be a solid investment if funds are available. If budget is a concern, less expensive meters will suffice as long as they have true RMS capabilities. The other parts and equipment were chosen for entry level use and should give adequate performance in a typical high school setting.

Electronix Express <http://www.elp.com> 1-800-972-2225

	<u>Part no.</u>	<u>Price</u>
Breadboard	03MB102	4.75
Capacitor collection	32CAPKIT	13.95
Diagonal cutter	0602MS549J	18.60
Function generator	016FG8250	250.00
Function generator leads	05SPAT2	3.25
Helping hands	060836	3.95
Magnet wire 24 gauge	2701MG24	4.75
Meter leads	05DBA	3.25
Miscellaneous jumper leads	2700WK30	3.50
Multimeter Fluke 87	01DMFL87-5	360.00
Needle nose pliers	0602NNPI	1.95
Oscilloscope	01GDS1052U	299.00
Oscilloscope leads	05SPAK510	17.95
Power supply	01PHSY3005	118.00
Resistor collection	13RK2501	6.95
Solder	060710	69.90
Solder iron	0603WLC100	44.99
Solder sucker	060820	2.25
Solder wick	060800	0.95
Wire cutter, mini	060200	1.95
Wire stripper 16-26 ga	0602HT1042	5.50
Wire stripper 22-30 ga	0602HT1043	5.95

The following vendors have given excellent value and reliable performance over the years:

mouser.com 1-800-346-6873

Every imaginable component.

digikey.com 1-800-344-4539

Another excellent source for components and materials.

kjmagnetics.com 1-888-SHOP-KJM

Neodymium magnets

chaneyelectronics.com 1-800-227-7312

Excellent selection of inexpensive electronic kits ready to solder. Prices start at about 4 dollars each.

allelectronics.com 1-888-826-5432

Miscellaneous parts, equipment and supplies.

goldmine-elec.com 1-800-445-0697

Great selection of surplus goodies like LEDs, transformers, speakers, and fun gadgets.

Miscellaneous materials

22 gauge wires can be recycled from old CAT 5 (network) cables. These can typically be obtained free from housing contractors, security system installers, home entertainment installers, etc. They make great jumper wires for the breadboards, or any other electrical connection.

Purchase specialty LEDs, such as RGB with pre-programmed patterns, from Chinese vendors on the internet through eBay. All of them are reliable to do business with, and the prices are about 80% less expensive than domestic purchases when bought in bulk of 100 or more. This works great for inexpensively putting lots of flash into student projects, which greatly enhances their motivation.

VI. Evaluation and Assessments

Precision Exams at www.precisionexams.com/usoe is Utah's delivery system for the Electronics CRT. The test is on-line for portability, ease of use, and instant feedback of student results. The test provides 80 questions randomly chosen for each participant from a test bank. A copy of the test bank questions for all competencies is included in appendix E. Each school district should already be using Precision Exams for other Career and Technical Education (CTE) certification assessment. Students achieving 80% or greater on the test receive a certificate of competency as an Electronic Technician. Test 550 Electronics 1 covers the following standards with the total number of questions per standard:

- 470105-01 Safe work practices, 4 questions
- 470105-02 Shop tools and soldering, 12 questions
- 470105-03 Test equipment, 8 questions
- 470105-04 Passive electronic components, 12 questions
- 470105-05 Induction, 2 questions
- 470105-06 Capacitors, 2 questions
- 470105-07 Transformers, 2 questions
- 470105-08 Electronic theory, 38 questions

Unit tests which use questions from the included test bank are found in appendix D. These are similar in structure to the questions students will see on the CRT. These unit tests are also available on the Utah Test Item Pool Service (UTIPS). The system needs to be initialized by IT personnel for the school district you are teaching in. This allows the student's test results to be sent directly to the teacher's email for evaluation. Sample assessments for related topics are included in appendix F. Utah is currently phasing in an adaptive testing system called Student Assessment and Growth (SAGE). Beta tests are planned for the end of the school year 2014. The UTIPS is proposed to still be active for the next few years while accommodating this changeover.

Students are encouraged to track their progress with the learning objectives and competencies by using the Student Performance Evaluation form which is available on the CTE website <http://schools.utah.gov/cte/>. A copy of the form is provided in appendix F.

[Quizlet.com](https://www.quizlet.com) provides many tests submitted by individuals for enhanced review of electronics principles. The submissions include flash cards, games, and practice tests to help students review the material. Of particular note are the submissions directly related to the Armed Services Vocational Aptitude Battery (ASVAB). This test attempts to measure the developed abilities of people and helps predict future academic and occupational success in the military. The assessment items align to questions that a student would likely encounter when taking the electronics portion of the ASVAB.

VII. References

Grob, B. (1997), *Basic Electronics 8th Edition*. McGraw Hill

Floyd, T. L. (2007). *Electronics fundamentals: circuits, devices, and applications, 7th Edition*. Library of Congress Cataloging-in-Publication Data. Pearson/Prentice Hall.

Roberts, R.M., Gerrish, H.H., and Dugger Jr., W.E. (2009). *Electricity and Electronics, 9th Edition*. Goodheart Wilcox etc.

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Appendix A

Utah State core Standards and Objectives

ELECTRONICS

A course which introduces students to the fundamentals of electricity with emphasis placed on safety, electrical concepts, and required math skills.

USOE

8/1/13

BASIC ELECTRONICS

Levels: Grades 10-12

Units of Credit: Minimum 0.5

CIP Code: 47.0105

Prerequisite: None

CORE STANDARDS, OBJECTIVES, AND INDICATORS

STANDARD 1

Students will be able to understand and demonstrate safe practices.

Objective 1: Use safe work practices. (A1)

- f. Describe the purposes of legislation concerning safety in the workplace.
- g. Describe safety precautions and procedures pertaining to and working with electricity.
- h. Describe correct safety procedures for hand and power tools.
- i. Locate and describe shop safety equipment.
- j. Use safe work practices.

Objective 2: Understand electrical hazards. (A1)

- a. Describe the effects of electric current on a human body.
- b. Describe typical electric shock hazards in industry.
- c. List general safety precautions to observe when working with electricity.
- d. Identify potential dangers to people and the environment.
- e. Identify various types of safety devices used with electricity.

STANDARD 2

Students will be able to understand and demonstrate the use of shop tools, materials, and techniques.

Objective 1: Select and use hand and common power tools. (B1)

- f. Identify hand tools used by electronics technicians.
- g. Describe the procedures to be used to care for hand tools.
- h. Identify the proper use and care of power tools and their accessories
- i. Select and use hand tools.
- j. Select and use common power tools and their accessories.

Objective 2: Solder and desolder. (B3, B5)

- e. Explain the principles of soldering and desoldering.
- f. Describe appropriate soldering techniques such as tinning, physical connections, temperature selection, and cleaning.
- g. Describe the precautions to prevent electrostatic discharge (ESD) during soldering.
- h. On a P.C. board solder and desolder ICs, wire and discrete components.

STANDARD 3

Students will be able to understand and demonstrate the use of test equipment.

Objective 1: Use digital multimeters (C1)

- d. Describe the proper handling, storage and use of digital meters.
- e. Use multimeters.
- f. Describe the proper use of leads with multimeters.

Objective 2: Use bench power supplies. (C2)

- d. Describe the operation of a bench power supply and its controls.
- e. Use power supplies safely.

STANDARD 4

Students will be able to understand and demonstrate how to test and select passive electronic components.

Objective 1: Identify electronic components. (D1)

- a. Identify electronic passive components i.e. resistors, and capacitors.
- b. Using standard electronic multiplication prefixes, determine the values for electronic components from their markings and physical characteristics.
- f. Identify electronic components.

Objective 2: Use, test and select batteries. (D2)

- c. Describe the construction, operation, testing and maintenance of batteries.
- d. Use, test, and select batteries.

Objective 3: Use, test and select resistive devices. (D3)

- i. Describe the principles of resistance.
- j. Identify resistive devices and draw their schematic symbols.
- k. Describe the function of resistive devices.
- l. Describe the procedures for testing resistive devices.
- m. Use, test and select resistive devices.
- n. Describe switch types, schematic symbols and operation.
- o. Describe procedures for selecting, connecting and testing switches
- p. Connect, test and select switches.

STANDARD 5

Students will be able to understand and demonstrate induction.

Objective 1: Describe principles of magnetism and electromagnetism. (F7)

- e. Explain the principles of magnetic fields.
- f. Explain the principles of electromagnetic fields.
- g. Describe the operation and application of magnetic devices.
- h. Describe the principles of electromagnetic induction.

Objective 2: Students will be able to understand and demonstrate how to use transformers. (G3)

- e. Describe the procedure for constructing, and testing transformers.
- f. Describe how transformers step up voltage, and step down voltage as a factor of turns-ratios, and Ohm's and Watt's laws.
- g. Describe the function of alternating current in transformers.
- h. Describe the difference between AC and DC.

STANDARD 6

Students will be able to understand and demonstrate basic electronic theory.

Objective 1: Describe basic principles of electrical theory. (F1)

- d. Describe the atomic structure of matter.
- e. Describe the units of electrical charge, voltage and current.
- f. Describe the factors that affect the movement of electrical charges.

Objective 2: Verify ohm's law and power equations. (F2)

- h. State Ohms Law and graph the relationships between voltage, current and resistance in circuits.
- i. Use formulas and basic mathematics to solve Ohms Law problems.
- j. Use formulas to calculate electric power requirements.
- k. Describe the effect on power requirements of changing voltage, current or resistance on power.
- l. Describe power dissipation in resistive devices.
- m. From schematic diagrams, predict the voltage, current, and resistance in all parts of a circuit.
- n. Determine proper power ratings for resistors.

Objective 3: Construct, measure, and analyze simple series resistive circuits. (F3)

- d. Describe the principles of series circuits.
- e. Calculate the voltage across, current through, equivalent resistance of and power dissipation for any component or group of components in a series resistive circuit.
- f. State and use Kirchoff's voltage law and the voltage divider formula.

Objective 4: Construct measure and analyze simple parallel resistive circuits. (F4)

- d. Describe parallel circuit principles.
- e. Calculate the theoretical values of voltage, current, resistance and power in all parts of the circuit.
- f. State and use Kirchoff's current law and the current divider formula to solve parallel circuit problems.

PROFESSIONAL DEVELOPMENT

STANDARD 7

Students will gain an understanding of Design Technology as a profession and will develop professional skills for the workplace.

Objective 1: As a participating member of the SkillsUSA student organization complete the SkillsUSA Level 1 Professional Development Program.

- m. Complete a self-assessment inventory and identify individual learning styles.
- n. Discover self-motivation techniques and establish short-term goals.
- o. Determine individual time-management skills.
- p. Define future occupations.
- q. Define awareness of cultural diversity and equity issues.
- r. Recognize the benefits of conducting a community service project.
- s. Demonstrate effective communication skills with others.
- t. Participate in a shadowing activity.
- u. Identify components of an employment portfolio.
- v. Explore what is ethical in the workplace or school.
- w. Demonstrate proficiency in program competencies.
- x. Explore what is ethical in the workplace or school.
 - State the SkillsUSA motto.
 - State the SkillsUSA creed.
 - Learn the SkillsUSA colors.
 - Describe the official SkillsUSA dress.
 - Describe the procedure for becoming a SkillsUSA officer.

Objective 2: Understand the use of drawings in architectural design and how those drawings relate to career opportunities.

Objective 3: Display a professional attitude toward the instructor and peers.

Appendix B

Sample lesson plans

Batteries

Stage 1 - Desired Outcome

Established Goals:

Meet standard 470105-0402 Use, test and select batteries.
Students will be able to describe the construction, operation, testing, and maintenance of batteries.

Understandings:

Students will understand that... batteries are relatively simple electrochemical devices with many uses requiring special care.

Essential Questions:

1. How are batteries manufactured?
2. How do we properly care for batteries?
3. How do we properly use batteries?

Student Objectives:

Students will know . . .

1. how batteries are manufactured.
2. how to safely handle batteries.
3. how to properly charge, and discharge batteries.
4. how to properly dispose of dead batteries.
5. the difference between primary and secondary batteries.
6. how to properly test the functionality of batteries.
7. the increased safety hazards of certain types of batteries.

Students will be able to. . .

1. use multimeters to measure the voltage of a battery.
2. build a simple battery from common materials.
3. interpret the MSDS for battery electrolyte.
4. calculate amp/hour requirements for a given application.

Stage 2 - Assessment Evidence

Performance Tasks:

1. Perform the following tasks under instructor supervision.
2. Configure the multimeter correctly to measure voltage.
3. Connect the meter leads to the battery, observing correct polarity.
4. Determine the general condition of the battery.
5. Perform a load test on the battery.
6. Determine if the battery is useable.
7. If the battery is not useable, determine if it is disposable or rechargeable.
8. Properly charge if it is a rechargeable battery, or properly dispose the dead battery.

Other Evidence:

1. Repeat the performance tasks on another battery of unknown condition, under instructor's supervision.
2. Repeat the performance tasks on a third battery, without instructor's supervision, but only inform the instructor if any unsafe condition is determined.

Stage 3 - Learning Plan

Learning Activities:

Hook the students by exploring the lab entitled "Fruit Salad Batteries."

Have students log onto <http://home.how.stuff.works.com/battery.htm>. Students will read the short article, and write a one page summary in their own words (no copy paste). Students will address in their summary, the voltaic pile.

They will then construct a voltaic pile using coins, and compete with one another for the greatest achievable voltage.

Explain the MSDS for the acids, particularly sulfuric, and alkalis used in batteries.

Have students log onto "How stuff works." Have students research lithium ion batteries, and lead acid batteries. Have them watch some you-tube videos of batteries exploding, warning them to learn from other people's stupidity. Students will then prepare a report on the proper charging and discharging of these two types of batteries. Include in the report all significant safety hazards.

Explain the concept of amp/hours, and how it relates to the proper use and life of the battery.

Students take the unit test on batteries.

Fruit Salad Batteries

OBJECTIVE:

To explore the electrochemical properties of some relatively common materials.

CONCEPTS:

Chemical reactions, Voltage, Current, Series and Parallel circuits.

SCOPE:

Students will use various combinations of fruits and vegetables as the electrolyte for making simple batteries. The electrodes can be any two dissimilar metals. This lab will use galvanized nails and pieces of copper-clad epoxy circuit board.

MATERIALS:

Fruit and vegetables

Copper pieces

Galvanized nails (16d)

Hook up wire

Digital multi-meter

PROCEDURE:

1. Choose a piece of fruit and stick the nail halfway into it. Stick the copper halfway into the fruit. The spacing between the electrodes is arbitrary and should not affect the results.
2. Select the VOLTAGE range on the multimeter, and plug the leads into the correct location. Place one lead on the nail and the other lead on the copper. Observe the polarity and record the

value to two decimals. What direction is the current flowing?

3. Select the CURRENT range on the multimeter and change the leads to the correct location. Record the value in milliamps or microamps.

4. Push the nail all the way into the fruit and record the new value for current. Push the copper all the way into the fruit and record the new value for current.

5. Select the VOLTAGE range and record the value.

6. Make another battery with a different piece of fruit and repeat steps 1 through 5.

7. Connect the two batteries in a series configuration. Measure and record the voltage and current.

8. Connect the two batteries in a parallel configuration. Measure and record the voltage and current.

9. Experiment with different combinations of metals and observe the values for voltage, current, and polarity.

Electromagnetism

Stage 1 - Desired Outcome

Established Goals:

Meet standard 470105-0501 Describe principles of magnetism and electromagnetism. Students will be able to describe the principles of magnetic and electromagnetic fields.

Understandings:

Students will understand that... magnets can create an electric field, and electric current can create a magnetic field.

Essential Questions:

1. How are magnets manufactured?
2. How can a magnet generate an electric field?
3. How can electricity make a magnet?
4. What useful devices can be made with electromagnets?

Student Objectives:

Students will know . . .

1. how permanent magnets are manufactured.
2. that electromagnetic fields emanate from conductors when a current is flowing.
3. that electromagnetic fields have polarity.
4. the strength of an electromagnetic field is proportional to the current flowing in the conductor.
5. the strength of an electromagnetic field is proportional to the number of windings.
6. to induce a current in a wire, it must be moving in relation to an outside magnetic field.
7. how speakers and electric motors work.

Students will be able to. . .

1. build a simple electromagnet.
2. explain the principles of electromagnetic induction.
3. describe the application of electromagnetic devices.
4. explain the "left hand rule."

Stage 2 - Assessment Evidence

Performance Tasks:

1. Correctly explain the "left hand rule".
2. Explain how to make an electromagnet.
3. Explain two methods to make an electromagnet stronger.
4. Explain how an electric motor works.
5. Explain how a speaker works.

Other Evidence:

1. Students will demonstrate their functioning motors.
2. Students will prepare a list of all the electromagnetic devices they can.
3. Show a simple electromagnet and have students determine which polarity it will exhibit by observ-

ing the polarity of the battery.

Stage 3 - Learning Plan

Learning Activities:

Show the 50 minute Modern Marvels video “Magnets.” Give students the video quiz.

Have students build a simple electromagnet with one meter of 28 gauge magnet wire wrapped around a nail. Strip the ends of the wire with sand paper. Use a AA battery as the voltage source. The wires will get quite warm within a few seconds. Hold the head of the nail next to a compass and observe what pole is attracted. Reverse the battery polarity and observe the pole change direction. Explain the “left hand rule” to the students. Challenge students to compete for the most paper clips picked up with their magnet.

Give students the Flinn Scientific lab for simple electric motors. Have them determine which direction the armature will spin for a given input polarity of the battery.

Have students build the plastic cup speaker from the OrchEd resource guide. Dixie cups work well also. Cut the ends off an old pair of head phones and attach alligator clips to the wires where the speakers used to be. Use these to attach two student speakers. Plug the other end into their music playing device (iPod) and have them hold the two speakers against their ears. It won't be loud, but amazingly clear. This is also a good lab to introduce the concept of alternating current.

Students review the concepts in the text.

Students will write a summary of all key concepts explored. The concepts will then be think-pair-shared as a preparation for the test.

Students take the unit test on magnets and electromagnetism.

Ohm's Law

Stage 1 - Desired Outcome

Established Goals:

Meet Standard 470105-0802 Verify Ohm's Law and power equations.

Students will be able to demonstrate a working knowledge of Ohm's Law as a relationship between voltage, current, and resistance.

Understandings:

Students will understand that... changing the resistance value in a circuit directly affects the other values of voltage and current in the circuit.

Essential Questions:

1. What is current?
2. What is voltage?
3. What is resistance?
4. How do these values interact with one another?

Student Objectives:

Students will know . . .

1. that *current* is the movement of charge through a conductor.
2. that *voltage* is the force that moves a charge through a conductor.
3. that *resistance* is opposition to the flow of charge in a conductor.
4. the unit of current is the *ampere*.
5. the unit of voltage is the *volt*.
6. the unit of resistance is the *ohm*.
7. the concept of direct proportionality.
8. the concept of indirect proportionality.

Students will be able to . . .

1. graph the relationships between voltage, current, and resistance in a simple circuit.
2. use linear algebra to solve Ohm's Law problems.
3. correctly identify standard schematic symbols for a voltage source, and a resistor.
4. determine the correct value of voltage, current, and resistance for a simple circuit.

Stage 2 - Assessment Evidence

Performance Tasks:

1. Correctly identify the value of a resistor from a schematic.
2. Correctly determine the voltage from a schematic.
3. Correctly determine how to manipulate Ohm's Law to solve for the missing variable.
4. Insert the values from the circuit into the equation, and perform the math required to achieve a correct answer for the missing variable.
5. Use the proper units for determined values.

Other Evidence:

1. Prepare a graph which plots current as a function of changing voltage and constant resistance.
2. Prepare a graph which plots current as a function of constant voltage and changing resistance.
3. Pass the unit test on Ohm's Law.

Stage 3 - Learning Plan

Learning Activities:

Show the 20 minute video *Electrical Current* by Bill Nye.

Discuss the concept of current as a movement of charge, or electrons through an electrically conductive material. Ask students for ideas of any materials they can think of which conduct current.

Restate the analogy of a water system as it relates to an electrical system. Explain that a person standing on the water hose reduces the flow of water much the same as a resistor reduces the flow of electrical current. The heavier the person, the greater the reduction in water flow. The greater the value of the resistor, the greater the reduction in current.

Explain the concept of indirect proportionality by showing that as resistance increases in a circuit, the current decreases by a proportional amount. Show the concept with a graphical example.

Explain the concept of direct proportionality by showing that as voltage increases in a circuit, with resistance remaining constant, the current increases by a proportional amount. Show the concept with a graphical example.

Explain how to manipulate Ohm's Law correctly to solve for the missing variable. Show the magic triangle as a tool for those who want it.

Give students the worksheet of simple circuits, and have them fill in the missing values, showing all their work.

Pass out graph paper and have students plot the current for the given examples.

Students take the unit test on Ohm's Law.

Series Circuits

Stage 1 - Desired Outcome

Established Goals:

Meet standard 470105-0803 Construct, measure, and analyze simple series resistive circuits. Students will be able to describe the principles of series circuits. Students will be able to calculate the voltage across, current through, equivalent resistance of and power dissipation for any component or group of components in a series resistive circuit. Students will be able to state and use Kirchoff's voltage law and the voltage divider formula.

Understandings:

Students will understand that... Kirchoff's laws are tools which allow simple analysis of complex series circuits.

Essential Questions:

1. How are complex circuits simplified?
2. How do we analyze circuit values?

Student Objectives:

Students will know . . .

1. how to simplify complex series circuits.
2. how to determine total current in a series circuit.
3. how to determine total voltage in a series circuit.
4. how to determine total resistance in a series circuit.
5. how to determine total power dissipated by a series circuit.

Students will be able to . . .

1. use a multimeter to measure the voltage across a resistor, or group of resistors.
2. use a multimeter to measure the current through a resistor, or group of resistors.
3. calculate the total values of resistance, voltage, current, and power for any series circuit.
4. state Kirchoff's Laws for a series circuit.

Stage 2 - Assessment Evidence

Performance Tasks:

1. Calculate the total resistance for the group of resistors in the series circuit.
2. Configure the multimeter correctly to measure resistance.
3. Connect the meter leads to each resistor individually.
4. Connect the meter leads to the total group of resistors.
5. Determine if the calculations are within acceptable tolerance.
6. Calculate the voltage drops for each resistor in the series circuit.
7. Configure the multimeter correctly to measure voltage.
8. Measure the voltage drops for each resistor in the series circuit.
9. Calculate the total current for the group of resistors in the series circuit.
10. Configure the multimeter correctly to measure current.
11. Calculate total power dissipated by the series circuit.

Other Evidence:

1. Correctly calculate and then measure the desired parameters for an unknown series circuit.

Stage 3 - Learning Plan

Learning Activities:

Explain Kirchoff's Law for total resistance; $R_T = R_1 + R_2 + R_3...$

Give examples on board, and then let students practice from problems in the text.

Explain Kirchoff's Law for total voltage; $V_T = V_{R1} + V_{R2} + V_{R3}...$

Give examples on board, and then let students practice from problems in the text.

Explain Kirchoff's Law for total current; $I_T = I_{R1} = I_{R2} = I_{R3}...$

Give examples on board, and then let students practice from problems in the text.

Explain Kirchoff's Law for total power; $P_T = P_{R1} + P_{R2} + P_{R3}...$

Give examples on board, and then let students practice from problems in the text.

Show students how to simplify a complex circuit by using Kirchoff's law of total resistance. All the resistors are calculated to give one single resistance. A circuit with just one voltage source and one resistor value can now be evaluated with Ohm's Law. Once current is known, it can be applied to the original circuit to calculate the individual voltages.

Show students how to breadboard three resistors into a series configuration. Show students how to configure the meter to measure resistance.

Show students how to measure resistance of each resistor, and then measure the whole group of resistors. Be sure to emphasize that no voltage should ever be applied when making resistance measurements.

Allow students to breadboard their own resistors. Have students calculate the total resistance for the series configuration. Have students measure and record their results. Did the results fall within the expected values? Was the resistor tolerance accounted for?

Show students how to hook up a 9volt battery to their circuit. Show students how to configure the meter to measure voltage. Show students how to measure voltage dropped across each resistor.

Have students calculate the total voltage, and individual voltage across each resistor in the series configuration. Have students measure and record their results. Did the results fall within the expected values? Was the resistor tolerance accounted for?

Show students how to configure the meter to measure current. Show students how to measure current through each resistor. Have students calculate the total current. Have students measure and record their results. Did the results fall within the expected values? Was the resistor tolerance accounted for?

Have students calculate the individual, and the total power dissipated by the resistors. Explain that watts are the unit of power expressed as the amount of *heat* energy given off by the resistor. Watts are also the unit used to express the rate at which *electrical* energy is consumed.

Using a power supply, have students breadboard the series circuits lab. Have them calculate the required values before attempting to explore the lab. They will apply 5volts, and 10volts for the lab.

On the computers, have students open ETCAI and the basic circuits trial for series circuits. Have them practice until they are proficient.

Ask if they have ever fixed Christmas lights that were wired in series configuration? What happens to the current in the circuit if one resistor were to burn up (opened), or taken out of the circuit?

Give the series circuits quiz.

Parallel Circuits

Stage 1 - Desired Outcome

Established Goals:

Meet standard 470105-0804 Construct, measure, and analyze simple parallel resistive circuits. Students will be able to describe parallel circuit principles.
 Students will be able to state and use Kirchoff's current law and the current divider formula.
 Students will be able to calculate the theoretical values of voltage, current, resistance, and power in all parts of the circuit.

Understandings:

Students will understand that... Kirchoff's laws are tools which allow simple analysis of complex parallel circuits.

Essential Questions:

1. What is a parallel circuit?
2. How does a parallel circuit differ from a series circuit?
2. How are complex circuits simplified?
3. How do we analyze electrical values for components in a parallel circuit?

Student Objectives:

Students will know . . .

Students will be able to . . .

1. how to simplify complex parallel circuits for further analysis.
2. how to determine total current in a parallel circuit.
3. how to determine total voltage in a parallel circuit.
4. how to determine total resistance in a parallel circuit.
5. how to determine total power dissipated by a parallel circuit.
6. when to use Ohm's Law, and when to use Kirchoff's Law in a circuit analysis.
7. that a parallel circuit has more than one current path.

1. use a multimeter to measure the voltage across a resistor, or group of resistors.
2. use a multimeter to measure the current through each resistor, and/or current path in the circuit.
3. calculate the total values of resistance, voltage, current, and power for any parallel circuit.
4. state Kirchoff's Laws for a parallel circuit.

Stage 2 - Assessment Evidence

Performance Tasks:

1. Calculate the total resistance for the group of resistors in the parallel circuit.
2. Configure the multimeter correctly to measure resistance.
3. Connect the meter leads to each resistor individually.
4. Determine if the calculations are within acceptable tolerance.
5. Calculate the voltage drops for each resistor in the parallel circuit.
6. Configure the multimeter correctly to measure voltage.
7. Measure the voltage drops for each resistor in the parallel circuit.
8. Calculate the total current for the group of resistors in the parallel circuit.
9. Configure the multimeter correctly to measure current.
10. Measure the current through each resistor, and the total current for the parallel circuit.
11. Calculate the individual resistor, and total power dissipated by the parallel circuit. Record the values.

Other Evidence:

1. Correctly calculate all required values from a schematic of an unknown parallel circuit, with only key values given.
2. Breadboard the circuit and correctly measure all the required values.

Stage 3 - Learning Plan

Learning Activities:

Explain Kirchoff's Law for total resistance in a parallel circuit; $R_T = 1 / (1/R_1 + 1/R_2 + 1/R_3...)$

Mathematically this is; the reciprocal of the sum of the reciprocals.

Give examples on board, and then let students practice from problems in the text. It might be less traumatic for the students struggling with their math skills if this law is shown and practiced after the other laws.

Explain Kirchoff's Law for total voltage in a parallel circuit; $V_T = V_{R1} = V_{R2} = V_{R3}...$

Give examples on board, and then let students practice from problems in the text. Explain that in a parallel circuit, the voltage is the same across all resistors. This differs from series circuits where the current is the same through all the resistors.

Explain Kirchoff's Law for total current in a parallel circuit; $I_T = I_{R1} + I_{R2} + I_{R3}...$

Give examples on board, and then let students practice from problems in the text. Explain that in a parallel circuit, the currents through all the resistors add up. This differs from series circuits where the resistor values add up.

Explain Kirchoff's Law for total power in parallel circuit; $P_T = P_{R1} + P_{R2} + P_{R3}...$
Give examples on board, and then let students practice from problems in the text.

Show students how to simplify a complex parallel circuit by using Kirchoff's law of total resistance. All the resistors are calculated to give one single resistance. A circuit with just one voltage source and one resistor value can now be evaluated with Ohm's Law to determine the total current in the parallel circuit. Knowing that the same voltage exists across all resistors, Ohm's Law can be used to calculate the current through each resistor path, or branch of the circuit.

Use Ohm's law to calculate the current through each resistor. Use Kirchoff's current law to merely add the values to determine the total current in the circuit.

Show students how to breadboard three resistors into a parallel configuration. Show students how to configure the meter to measure resistance.

Show students how to measure resistance of each resistor, and then measure the whole group of resistors. Be sure to emphasize that no voltage should ever be applied when making resistance measurements.

Allow students to breadboard their own resistors. Have students calculate the total resistance for the parallel configuration. Have students measure and record their results. Did the results fall within the expected values? Was the resistor tolerance accounted for?

Show students how to hook up a 9volt battery to their circuit. Show students how to configure the meter to measure voltage. Show students how to measure voltage dropped across each resistor.

Have students calculate the total current, and individual currents through each resistor in the series configuration. Have students measure and record their results. Did the results fall within the expected values? Was the resistor tolerance accounted for?

Show students how to configure the meter to measure voltage. Show students how to measure voltage across each resistor. Have students calculate the total voltage. Have students measure and record their results. Did the results fall within the expected values? Was the resistor tolerance accounted for?

Have students calculate the individual, and the total power dissipated by the resistors. Explain that watts are the unit of power expressed as the amount of *heat* energy given off by the resistor. Watts are also the unit used to express the rate at which *electrical* energy is used.

Using a power supply, have students breadboard the parallel circuits lab. Have them calculate the required values before attempting to explore the lab. They will apply 5volts and 10volts respectively, for the lab.

On the computers, have students open ETCAI and the basic circuits trial for parallel circuits. Have them practice until they are proficient.

Ask students if they would prefer Christmas lights that were wired in series or parallel configuration? What happens to the total current in the circuit if one resistor were to burn up (opened), or taken out of the circuit?

Give the parallel circuits quiz.

Appendix C

List of standards from other states

Florida -

<http://fldoe.org/workforce/dwdframe/1112/stem/rtf/8600900.rtf>

Georgia -

<https://www.georgiastandards.org/standards/georgia%20performance%20standards%20ctae/foundation-of-electronics.pdf>

Idaho -

http://pte.idaho.gov/pdf/skilled_technical_sciences/sts/curriculum/idaho_electronics_curriculum_revision1.pdf

Kentucky -

<http://education.ky.gov/cte/documents/engineeringandtechnologypos.pdf, Pages 43-44>

New Hampshire -

http://education.nh.gov/career/career/program_manu.htm

South Carolina -

<http://ed.sc.gov/agency/programs-services/148/documents/electronicstechnology.pdf>

South Dakota -

<http://doe.sd.gov/octe/documents/electronic.pdf>

West Virginia -

https://www.google.com/url?q=http://careertech.k12.wv.us/cte-draft-csos/ET%2520Engineering%2520and%2520Technical%2520Cluster/1763%2520Fundamentals%2520of%2520Electricity.doc&sa=U&ei=YwJTUd2NOIjDigKMvoGoCA&ved=0CAcQFjAA&client=internal-uds-cse&usg=AFQjCNEjUGiqfM025a_JyqtJXEgiZ62-QQ

Wisconsin -

<http://cte.dpi.wi.gov/files/cte/doc/electronics.doc>

Appendix D

Comprehensive test bank

Competency A1 – Use safe Work Practices (12)

1. Identify the statement that is NOT a general safety rule that should be followed in the electronics lab:
 - A. Do not work in damp areas or with wet shoes or clothing
 - B. Never tamper or try to override safety devices
 - C. Unplug all test equipment before taking measurements
 - D. Use only exact or approved replacement parts

2. When working on electrical equipment, always:
 - A. Assume that the circuit is off before beginning to work
 - B. Override safety devices
 - C. Remove the ground wire
 - D. Avoid wearing rings, watches, and similar metal items

3. An electrical fire is best extinguished by:
 - A. Applying water to the fire
 - B. Turning off the electrical equipment
 - C. Using a carbon dioxide (CO2) fire extinguisher
 - D. Allowing the circuit breaker or fuse to trip

4. To avoid an accident in the electronics lab, always:
 - A. Wear eye protection when using hand and power tools
 - B. Wear closed toe, skid resistant footwear
 - C. Avoid wearing loose fitting clothes and jewelry
 - D. All of the above answers are correct

5. When a damaged hand or power tool is discovered:
 - A. Inform the instructor so the tool may be repaired or replaced
 - B. Take extra precautions to safely use the tool
 - C. Notify the instructor when work with the tool is completed
 - D. Return the tool to the cabinet and select a different tool

6. To be prepared for an emergency in the electronics lab, you should:
 - A. Be familiar with the location of fire extinguishers and first aid supplies
 - B. Know how to contact emergency services for assistance
 - C. Be familiar with the location of room/building exits
 - D. All of the above answers are correct

7. To avoid accidents while using hand or power tools:
- A. Avoid sharp, lubricated tools
 - B. Select an appropriate tool for the task
 - C. Use damaged tools carefully
 - D. None of the above answers are correct
8. If someone is being electrocuted and cannot release themselves from the circuit, you should first:
- A. Remove the victim
 - B. Disconnect the power source
 - C. Notify the instructor
 - D. Call 911
9. You have found a power cord that has the ground prong removed, you should:
- A. Rotate the cord for proper insertion
 - B. Return the cord to the store room
 - C. Notify the instructor
 - D. There is no need for concern
10. The most common injury associated with a drill press is:
- A. Inappropriate bit speed
 - B. Using non-tempered bits
 - C. Poor lightning
 - D. Lack of center punching
 - E. Failure to clamp material
11. Which of the following in **NOT** a common cause of injury when using a drill press:
- A. Incorrect drill speed
 - B. Lack of eye/face protection
 - C. Failure to clamp material securely
 - D. Failure to center punch/drill material
 - E. Appropriate lightning
12. Which of the following is a good safety practice:
- A. Consider the safety of others
 - B. Remove jewelry and hazardous clothing
 - C. Use appropriate eye/face protection
 - D. Ensure appropriate lightning
 - E. All of the above answers are correct

Competency B1 – select, Use & Maintain Hand & Power Tools (8)

1. Identify the tool best suited for tinning a wire:
 - A. Wire strippers
 - B. Long-nose pliers
 - C. Diagonal cutters
 - D. Solder iron

2. Wire strippers/cutters should **NOT** be used to cut:
 - A. Enamel coated wire
 - B. Stranded wire
 - C. Steel wire
 - D. 22 gauge wire

3. Identify the tools that would generally be used to prepare a wire to be soldered:
 - A. Wire strippers, Long-nose Pliers, Diagonal Cutters
 - B. Phillips Screw Driver, Wire Strippers, Pliers
 - C. Pliers, Crimping Tool, Slotted Screw Driver
 - D. Diagonal Cutters, Wire Strippers, Solder Sponge

4. The immediate care of a soldering pencil after use is:
 - A. Return it to pencil holder
 - B. Cool it under a tap
 - C. Wipe it on a wet sponge
 - D. Flow solder over the tip.

5. Which of the following soldering iron wattage rating would be appropriate when soldering a ¼ Watt resistor to a printed circuit board:
 - A. ¼ Watt soldering iron
 - B. 100 Watt soldering iron
 - C. Propane pencil
 - D. 25 Watt solder pencil
 - E. 100 Watt solder gun

6. When using wire cutters it is appropriate to:
 - A. Cut over a waste basket
 - B. Point towards ceiling
 - C. Hold at arm's length and cut away from you
 - D. Point towards the floor
 - E. Use only the tip of the cutter

Competency B3 – Solder & Desolder (24)

1. The Process of penetrating solder into the metal contacts is called:
 - A. Tempering
 - B. Wetting
 - C. Stripping
 - D. Etching

2. The ingredient in solder that removes oxidation so the solder will stick to the contacts is called:
 - A. Lead
 - B. Flux
 - C. Tin
 - D. Silver

3. To ensure a good solder connection, you should:
 - A. First clean the solder iron tip on a damp sponge, then heat both surfaces to be soldered
 - B. First clip the component leads, then test for a good mechanical connection
 - C. First apply solder to the connection, then heat both surfaces to be soldered
 - D. First apply acid core solder to the solder iron tip, then heat both surfaces to be soldered

4. All of the following indicate poor soldering technique **EXCEPT**:
 - A. Cold solder joint
 - B. Solder bridge
 - C. Shiny solder joint
 - D. Excessive heat

5. Identify the item that would **NOT** be used to desolder a connection:
 - A. Spring Loaded Plunger
 - B. Desoldering Bulb
 - C. Desoldering Braid
 - D. Desoldering Flux

6. Which of the following is **NOT** appropriate when soldering/desoldering electronics:
 - A. Using acid core solder
 - B. Breathing solder fumes
 - C. Working in enclosed spaces
 - D. All of the above answers are correct

7. The purpose of soldering in electronics is to _____.
 - A. Provide a strong physical connection
 - B. Provide a low resistance electrical connection
 - C. Provide a low cost connection for prototyping circuits
 - D. Both a and b
 - E. None of the above

8. The process where solder mixes with molecules of a metal surface is called _____.
 - A. Wetting
 - B. Gluing
 - C. Flowing
 - D. Fusing
 - E. Welding

9. Solder is an alloy of ____ and _____.
 - A. Lead, iron
 - B. Iron, gold
 - C. Tin, lead
 - D. Gold, silver
 - E. None of the above

10. The indication of 60/40 on a spool of solder tells you that _____.
 - A. The solder is made up of 60% lead and 40% tin
 - B. The solder is made up of 60% tin and 40% lead
 - C. The spool is 60% solder and 40% flux
 - D. The spool is 60% flux and 40% solder

11. The melting point of solder is dependent upon _____.
 - A. The type of soldering iron used
 - B. The temperature of the soldering iron
 - C. The type of tip on the soldering iron
 - D. The ratio of tin and lead in the solder
 - E. None of the above

12. The type of flux used when soldering electronics is _____.
 - A. Rosin
 - B. Acid
 - C. Alloy
 - D. None of the above

13. Rosin core flux should be _____ before it will clean the surface.
 - A. Mixed
 - B. Applied
 - C. Heated
 - D. Cleaned
 - E. None of the above

14. Besides solder, _____ is an essential ingredient in soldering good connections.
- A. Water
 - B. Copper
 - C. Flux
 - D. Glue
15. _____ and _____ collect on air-exposed surfaces, making “wetting” impossible until surfaces are cleaned.
- A. Dirt, grease
 - B. Oil, oxide
 - C. All the above
 - D. None of the above
16. The _____ type soldering iron is the most common type of soldering iron used to solder electronics.
- A. Gun
 - B. Chisel
 - C. Pencil
 - D. Rifle
 - E. None of the above
17. The gun type soldering iron has the disadvantage of being _____,
- A. Heavy
 - B. Hot
 - C. All the above
 - D. None of the above
18. A _____ to _____ watt pencil type soldering iron is a perfect size for use on printed circuit boards.
- A. 100, 200
 - B. 200, 500
 - C. 25, 35
 - D. 1, 2
 - E. None of the above
19. The process of applying a thin layer of solder to the tip of a heated soldering iron is called _____.
- A. Tempering
 - B. Initializing
 - C. Tinning
 - D. Wetting
 - E. None of the above

20. Tinning the tip of a soldering iron will help minimize _____.

- A. Oxidation of the tip
- B. Wetting of the tip
- C. Heating of the tip
- D. Melting of the tip
- E. None of the above

21. A good solder connection should look ____ and _____.

- A. Grainy, gray
- B. Dull, grainy
- C. Shining, smooth
- D. Smooth, dull
- E. None of the above

Competency B5 – Assemble, Test & Install Cable (8)

1. Identify the largest wire gauge from the following list:

- A. 30 gauge
- B. 22 gauge
- C. 16 gauge
- D. 12 gauge

2. Identify the physical factors that affect the resistance of a conductor:

- A. Cross-sectional area, length, temperature
- B. Type of conducting material, type of insulation material, cross-sectional area
- C. Type of insulation material, length, temperature
- D. None of the above answers are correct

3. For a given gauge wire, a greater length means:

- A. Less resistance
- B. The same resistance
- C. More resistance
- D. None of the above answers are correct

4. The advantage of using stranded wire is:

- A. It is flexible, easier to handle, and less likely to develop an open
- B. It can handle twice as much current as an equivalent size solid wire
- C. It never has to be insulated
- D. There are no advantages

5. If the length of a wire is increased by a factor of 4, the resistance of the wire will:

- A. Increase by factor of 2
- B. Decrease by a factor of 4
- C. Increase by factor of 4
- D. Decrease by factor of 2
- E. None of the above answers are correct

6. Which of the following does NOT determine the resistance of a conductor:
- A. Type of material
 - B. Insulating material
 - C. Diameter
 - D. Length
 - E. Temperature
9. A transformer with a turns ratio of 1:1 would be considered a _____ transformer.
- A. Step-up
 - B. Step-down
 - C. Burned-up
 - D. Isolation
10. A transformer with a turns ratio of 1:5 would be considered a _____ transformer.
- A. Step-up
 - B. Step-down
 - C. Burned-up
 - D. Isolation

Competency I1 – Describe Basic Principles of Electrical Theory (38)

1. The unit for current is the:
- A. Farad
 - B. Ohm
 - C. Volt
 - D. Ampere
 - E. Watt
2. Which of the following materials is the best electrical conductor?
- A. Silver
 - B. Silicon
 - C. Glass
 - D. Aluminum
3. An ion is an atom that has:
- A. Lost or gained one or more protons
 - B. Lost or gained one or more neutrons
 - C. Lost or gained one or more valence electrons
 - D. No protons in its nucleus
4. Conventional current and electron current:
- A. Flow in opposite directions
 - B. Flow in the same direction
 - C. Are measured in farads
 - D. Cannot be measured

5. The resistance of a short piece of copper wire is:
 - A. Practically zero
 - B. Impossible to approximate
 - C. Extremely high
 - D. Dependent on its insulating cover

6. A potential energy difference between two points in a circuit is called:
 - A. Amperage
 - B. Voltage
 - C. Ohms
 - D. Watts
 - E. Coulombs

7. The unit of power is the:
 - A. Ampere
 - B. Volt
 - C. Ohm
 - D. Watt
 - E. Coulomb

8. The unit of resistance is the:
 - A. Ampere
 - B. Volt
 - C. Ohm
 - D. Watt
 - E. Coulomb

9. Atoms having a valence number of 1 or 2 are:
 - A. Better insulators
 - B. Better conductors
 - C. Better semiconductors
 - D. Poor conductor

10. Electron flow theory states that electrons flow from:
 - A. Positive to negative
 - B. North to South poles
 - C. Negative to positive
 - D. South to North poles
 - E. None of the above answers are correct

11. The "basic unit of charge" is:
 - A. One coulomb
 - B. Approximately 6,240,000,000,000,000 electrons
 - C. The amount of electrons delivered when one amp of current is maintained for one second
 - D. All of the above answers are correct

12. There are 6,240,000,000,000,000 electrons in:
 - A. 1 volt
 - B. 1 ampere
 - C. 1 joule
 - D. 1 coulomb
 - E. 1 farad

13. The symbol for voltage is:
 - A. V
 - B. E
 - C. Both A and B are correct
 - D. Only A is correct
 - E. Only B is correct

14. The unit of resistance is the ohm, its symbol is:
 - A. R
 - B. Ω
 - C. μ
 - D. V

15. The symbol for current is:
 - A. C
 - B. I
 - C. Ω
 - D. V
 - E. A

16. Conventional current is the flow of electrical current from:
 - A. Positive to negative
 - B. Negative to Positive
 - C. Right to left
 - D. Minus to plus

17. The resistance of a wire is dependent on the:
 - A. Type of material
 - B. Cross-sectional area
 - C. Length
 - D. Temperature
 - E. All of the above answers are correct

18. Identify which of the following statements is/are true:
 - A. Current is directly proportional to resistance
 - B. Current is directly proportional to voltage
 - C. Current is inversely proportional to resistance
 - D. Current is inversely proportional the voltage
 - E. Answers B and C are true

19. The law of electrostatic charges states that:
 - A. Like charges attract and unlike charges repel
 - B. Like and unlike charges attract
 - C. Like charges repel and unlike charges attract
 - D. Like and unlike charges repel

20. Batteries can be connected together in:
 - A. Series-aiding
 - B. Parallel
 - C. Series-opposing
 - D. Series-parallel
 - E. All of the above answers are correct

21. The ability of a battery to deliver electrical power continuously is expressed in:
 - A. Watts
 - B. Volts
 - C. Amperes
 - D. Ampere-hours

22. The two types of grounds are:
 - A. Metal and earth
 - B. Electrical and basic
 - C. Metal and semi
 - D. Relative and basic
 - E. Earth and electrical

23. Electrons have a:
 - A. Positive charge
 - B. Negative charge
 - C. Neutral charge
 - D. Charge card

24. Ground is a term used to identify:
 - A. Positive potential
 - B. Negative potential
 - C. Neutral point
 - D. The place you are standing on

Competency I2 – Verify Ohm’s law & Power Equations (40)

1. Ohm’s Law states that:
 - A. $V = IR$
 - B. $P = IV$
 - C. $I = R/V$
 - D. $P = I + V$

2. Watt's/Power Law states that:
 - A. $V = IR$
 - B. $P = IV$
 - C. $I = R/V$
 - D. $P = I + R$

3. If total resistance R_T remains constant and total voltage V_T goes up, then:
 - A. Total current I_T will go down
 - B. Total current I_T will go up
 - C. Total power P_T will go up
 - D. Total power P_T will not be effected

4. If total voltage V_T remains constant and total resistance R_T goes up, then:
 - A. Total current I_T will go down
 - B. Total current I_T will go up
 - C. Total current P_T will go up
 - D. Total power P_T will not be effected

5. The current in a circuit is proportional to:
 - A. Voltage
 - B. Resistance
 - C. All of the above answers are correct
 - D. None of the above answers are correct

6. The current in a circuit is inversely proportional to:
 - A. Voltage
 - B. Resistance
 - C. All of the above answers are correct
 - D. None of the above answers are correct

7. 15 volts is applied to a circuit resistance of 5 Ω . The total circuit current I_T is:
 - A. 0.333 A
 - B. 3 A
 - C. 10 A
 - D. 20 A

8. A 390 Ω resistor has 5 μA of current passing through it. The voltage across the resistor is:
 - A. 23.077 mA
 - B. 43.333 mA
 - C. 23.077 A
 - D. 43.333 A

9. A $4.7 \text{ k}\Omega$ resistor has $5 \text{ }\mu\text{A}$ of current passing through it. The voltage across the resistor is:
- A. $23.5 \text{ }\mu\text{V}$
 - B. 23.5 mV
 - C. 2.35 V
 - D. 23.5 V
10. 3 mA flows through a circuit resistance of $25 \text{ k}\Omega$. The applied voltage V_T for the circuit is:
- A. 8.33 V
 - B. 22 V
 - C. 25 V
 - D. 75 V
11. An electric device is rated at 90 mA and 24 volts . The resistance of the device is:
- A. $2.16 \text{ }\Omega$
 - B. $3.75 \text{ }\Omega$
 - C. $26.7 \text{ }\Omega$
 - D. $267 \text{ }\Omega$
12. 500 mA flows through an incandescent light bulb with 120 volts applied across its filament. The resistance of the filament is:
- A. $4.167 \text{ }\Omega$
 - B. $60 \text{ }\Omega$
 - C. $240 \text{ }\Omega$
 - D. $60 \text{ k}\Omega$
13. A circuit has an applied voltage of 24 V and total current of 2 A . The power consumed by the circuit is:
- A. 83.3 mW
 - B. 12 W
 - C. 24 W
 - D. 26 W
 - E. 48 W
14. 375 mA flows through a light bulb with 120 volts applied to its filament. The power consumed by the bulb is:
- A. 3.125 W
 - B. 45 W
 - C. 120 W
 - D. 320 W
 - E. 495 W

15. A 12 V automobile taillight bulb draws 3 A from a battery. The “hot” resistance of the lamp is:
A. $.25 \Omega$
B. 3Ω
C. 4Ω
D. 12Ω
E. 36Ω
16. A 12 V auto lamp draws 3 A. The power dissipated by the lamp is:
A. $.25 \text{ W}$
B. 3 W
C. 4 W
D. 12 W
E. 36 W
17. The current consumed by a digital wristwatch is $10 \mu\text{A}$. If the watch is powered by a 1.2 volt battery, the equivalent resistance of the watch is:
A. 12Ω
B. 120Ω
C. $10 \text{ k}\Omega$
D. $120 \text{ k}\Omega$
18. The power dissipated by a $120 \text{ k}\Omega$ resistance connected across a 1.2 volt source is:
A. $10 \mu\text{W}$
B. $12 \mu\text{W}$
C. 120 mW
D. 1.2 W
19. The power dissipated by a computer that has an applied voltage of 120 volts and an equivalent resistance of 12 ohms is:
A. 100 W
B. 120 W
C. 1200 W
D. 1440 W
20. Efficiency is determined by:
A. Power input divided by power output
B. Power input multiplied by power output
C. Power output divided by power input
D. Power output subtracted from power input
21. The applied voltage that will cause a 20Ω resistor to dissipate 5 watts is:
A. 4 V
B. 5 V
C. 10 V
D. 25 V
E. 100 V

22. The voltage developed across a $330\ \Omega$ resistor when 100 mA of current flows through it is:
- A. 0.3 V
 - B. 3.3 V
 - C. 33 V
 - D. 3300 V
23. The power supply of a radio receiver uses 6.75 watts. If the circuit carries 0.3 A of current, the voltage across the circuit is:
- A. 2.025 V
 - B. 6.75 V
 - C. 9 V
 - D. 12.6 V
 - E. 22.5 V
24. The voltage required to operate a $5,500\ \Omega$ electric clock which draws 0.02 A of current is:
- A. 2.75 V
 - B. 12.6 V
 - C. 110 V
 - D. 275,000 V
25. A washing machine motor has a total resistance of $39\ \Omega$ and operates on 117 volts. The current drawn by the motor is:
- A. 0.333 A
 - B. 3 A
 - C. 10 A
 - D. 30 A
26. A 60 watt solder has a resistance of $240\ \Omega$. If the solder iron is connected to a 120 volt wall socket, the current drawn will be:
- A. 0.25 A
 - B. 0.5 A
 - C. 2 A
 - D. 4 A
27. An electromagnet draws 5 A from a 110 volt source. The current drawn by the electromagnet from a 220 volt source will be:
- A. 0.5 A
 - B. 2 A
 - C. 2.5 A
 - D. 5 A
 - E. 10 A

28. The full-scale reading of an ammeter is 10 A. If this current caused a voltage drop of 0.05 V, the resistance must be:
A. 0.005 Ω
B. 0.05 Ω
C. 0.5 Ω
D. 5 Ω
29. A series resistor is used to reduce the voltage to a motor by 45 V. If the motor draws 0.5 A, the resistance of the resistor must be:
A. 9 Ω
B. 22.5 Ω
C. 45 Ω
D. 90 Ω
30. A voltmeter has a resistance of 27,000 Ω . If the meter is placed across a 220 volt line, the amount of current that will pass through the meter will be:
A. 8.15 mA
B. 122 mA
C. 815 mA
D. 8.15 A
E. None of the above answers are correct
31. A series of insulators leak 0.00003 amp at 9,000 volts. The resistance of the insulator string is:
A. 0.27 Ω
B. 3 M Ω
C. 27 M Ω
D. 300 M Ω
32. If a 0.6 Ω rail connector accidentally shorted the 12 volt system of a model railroad, the amount of current that would flow would be:
A. 2 A
B. 3.6 A
C. 20 A
D. 36 A
33. A 110 volt line is protected with a 15 amp fuse. Will the fuse "carry" a continuous 5.5 Ω load?
A. The current will equal the fuse rating and may not blow
B. Yes
C. No, the current is too high
D. It depends on the type of fuse

34. The voltage measured by a voltmeter whose internal resistance is $150,000 \Omega$ when 0.001 amp flows through it is:
A. 1.5 V
B. 15 V
C. 150 V
D. 1500 V
35. The large copper leads on switchboards are called bus bars. If a bus bar carries 40 A and the voltage across its ends measures 0.06 V , the resistance of the bus bar is:
A. $1.5 \text{ m}\Omega$
B. $15 \text{ m}\Omega$
C. $150 \text{ m}\Omega$
D. 1.5Ω
36. The power dissipated in a conductor if it carries 40 A with a voltage drop of 0.06 V will be :
A. 24 mW
B. 240 mW
C. 2.4 W
D. 24 W
E. None of the above answers are correct
37. The power dissipated by a toaster that operates on 120 volts and has a resistance of 10Ω is:
A. 120 W
B. 1200 W
C. 1440 W
D. 14400 W
38. A 32 -candela (cd) lamp in a truck headlight draws 3.4 A from the 12 battery. The resistance of the lamp is:
A. 3.5Ω
B. 4.08Ω
C. 30.5Ω
D. 40.8Ω
39. The power dissipated by a siren that draws 3.4 A at 12 V is:
A. 3.5 W
B. 4.08 W
C. 30.5 W
D. 40.8 W

40. The field magnet in a relay carries 40 mA when connected to a 40 V supply. The resistance of the magnet is:
- A. 16 Ω
 - B. 1000 Ω
 - C. 1600 Ω
 - D. 10,000 Ω

Competency I3 – Construct, Measure & Analyze Simple Series Resistive Circuits (40)

1. Total voltage in a series circuit is described by the equation:
- A. $V_T = V_1 + V_2 + V_3 + \dots$
 - B. $V_T = V_1 = V_2 = V_3 = \dots$
 - C. $V_T = I_T + R_T$
 - D. $V_T = (I_2 * R_2) = (I_2 * R_2) = (I_3 * R_3) = \dots$
2. Total current in a series circuit is described by the equation:
- A. $I_T = I_1 + I_2 + I_3 + \dots$
 - B. $I_T = I_1 = I_2 = I_3 = \dots$
 - C. $I_T = V_T * R_T$
 - D. $I_T = R_T / V_T$
3. Total resistance in a series circuit is described by the equation
- A. $R_T = R_1 + R_2 + R_3 \dots$
 - B. $R_T = R_1 = R_2 = R_3 = \dots$
 - C. $R_T = I_T / V_T$
 - D. $R_T = 1 / (1/R_1 + 1/R_2 + 1/R_3 + \dots)$
4. Total power in a series circuit is described by the equation:
- A. $P_T = P_1 + P_2 + P_3 + \dots$
 - B. $P_T = P_1 = P_2 = P_3 = \dots$
 - C. $P_T = I_T / V_T$
 - D. $P_T = (I_1 * V_1) = (I_1 * V_2) = (I_3 * V_3) = \dots$
5. In a series circuit, the individual voltages:
- A. Are each equal to the total voltage
 - B. Increase when a new resistor is added in series
 - C. Remain constant when a new resistor is added in series
 - D. Add to equal the total voltage
6. Adding an additional series resistor to a series circuit causes:
- A. The total resistance R_T to decrease
 - B. The total resistance R_T to increase
 - C. The total current I_T to increase
 - D. The total voltage V_T to decrease
 - E. The total voltage V_T to increase

7. Adding an additional series resistor to a series circuit causes:
 - A. The individual circuit voltages to decrease
 - B. The individual circuit voltages to increase
 - C. The individual circuit resistances to decrease
 - D. The individual circuit resistances to increase
 - E. The total circuit current I_T to increase

8. Removing a resistor from a series circuit causes:
 - A. The total resistance R_T to increase
 - B. The total voltage V_T to decrease
 - C. The total voltage V_T to increase
 - D. The total power P_T to decrease
 - E. The total power P_T to increase

9. Removing a resistor from a series circuit causes:
 - A. The total current I_T to increase
 - B. The total voltage V_T to decrease
 - C. The total voltage V_T to increase
 - D. The total resistance R_T to decrease
 - E. No effect on total resistance R_T

10. Changing a 10 k Ω resistor to a 1 k Ω resistor in a series circuit will cause:
 - A. The total resistance R_T to decrease
 - B. The total resistance R_T to increase
 - C. the total current I_T to decrease
 - D. The total voltage V_T to change
 - E. Both A and C

Competency I4 – Construct, Measure & Analyze Simple Parallel Resistive Circuits (38)

1. Total voltage in a parallel circuit is described by the equation:
 - A. $V_T = V_1 + V_2 + V_3 + \dots$
 - B. $V_T = V_1 = V_2 = V_3 = \dots$
 - C. $V_T = I_T + R_T$
 - D. $V_T = (I_1 * R_1) + (I_2 * R_2) + (I_3 * R_3) + \dots$

2. Total current in a parallel circuit is described by the equation:
 - A. $I_T = I_1 + I_2 + I_3 + \dots$
 - B. $I_T = I_1 = I_2 = I_3 = \dots$
 - C. $I_T = V_T * R_T$
 - D. $I_T = R_T / V_T$

3. Total resistance in a parallel circuit is described by the equation:
 - A. $R_T = R_1 + R_2 + R_3 \dots$
 - B. $R_T = R_1 = R_2 = R_3 = \dots$
 - C. $R_T = I_T/V_T$
 - D. $R_T = 1/(1/R_1 + 1/R_2 + 1/R_3 + \dots)$

4. Total power in a parallel circuit is described by the equation:
 - A. $P_T = P_1 + P_2 + P_3 + \dots$
 - B. $P_T = P_1 = P_2 = P_3 = \dots$
 - C. $P_T = I_T/V_T$
 - D. $P_T = (I_1*V_1) = (I_1*V_2) = (I_3*V_3) = \dots$

5. In a parallel circuit, the individual voltages:
 - A. Are each equal to the total voltage
 - B. Increase when a new resistor is added in parallel
 - C. Decrease when a new resistor is added in parallel
 - D. Add to equal the total voltage

6. Adding an additional parallel resistor to a parallel circuit causes:
 - A. The total resistance R_T to decrease
 - B. The total resistance R_T to increase
 - C. The total current I_T to decrease
 - D. The total voltage V_T to decrease
 - E. The total voltage V_T to increase

7. Adding an additional parallel resistor to a parallel circuit causes:
 - A. The total circuit current I_T to decrease
 - B. The total circuit current I_T to increase
 - C. The individual circuit resistances to decrease
 - D. The individual circuit voltages to decrease
 - E. The individual circuit voltages to increase

8. Removing a resistor from a parallel circuit causes:
 - A. The total voltage V_T to decrease
 - B. The total voltage V_T to increase
 - C. The total current I_T to increase
 - D. The total resistance R_T to decrease
 - E. The total power P_T to decrease

9. Changing a 1 k Ω resistor to a 100 k Ω resistor in a parallel circuit will cause:
 - A. The total resistance R_T to decrease
 - B. The total resistance R_T to increase
 - C. The total current I_T to increase
 - D. The total voltage V_T to change
 - E. Both C and D

10. Changing the total voltage V_T applied to a parallel circuit from 10 volts to 12 volts will cause:
- A. The total resistance R_T to decrease
 - B. The total resistance R_T to increase
 - C. The total current I_T to decrease
 - D. The total current I_T to increase
 - E. Both B and D

Competency C1 – Use Multimeters (24)

1. To measure the voltage of a resistor in a series network, the meter must be connected:
 - A. In the path of current flow with circuit power on
 - B. In the path of current flow with circuit power off
 - C. Across the component with circuit power on
 - D. Across the component with circuit power off

2. To measure the voltage of a resistor in a series network, the meter must be connected:
 - A. In the path of current flow with circuit power on
 - B. In the path of current low with circuit power off
 - C. Across the component with circuit power on
 - D. Across the component with circuit power off

3. To prevent damaging the multimeter always:
 - A. Calibrate the meter before each use
 - B. Observe correct polarity when measuring resistance
 - C. Select the highest scale on the meter first
 - D. Turn off the circuit power while taking measurements

4. The basic function **NOT** found on a typical multimeter:
 - A. Resistance
 - B. Current
 - C. Voltage
 - D. Power
 - E. Continuity

5. When configured to measure resistance, the units displayed will be:
 - A. Volts
 - B. Amps
 - C. Mhos
 - D. Ohms
 - E. Watts

6. When configured to measure voltage, the units displayed will be:
 - A. Volts
 - B. Amps
 - C. Mhos
 - D. Ohms
 - E. Watts

7. When configured to measure current, the units displayed will be:
 - A. Volts
 - B. Amps
 - C. Mhos
 - D. Ohms
 - E. Watts

8. to measure resistance with a multi-meter, the meter must be connected:
 - A. In the path of current flow with circuit power on
 - B. In the path of current flow with circuit power off
 - C. Across the component with circuit power on
 - D. Across the component with circuit power off

9. DMM stands for:
 - A. Double modulated meter
 - B. Differential micro-meter
 - C. Digital micro-meter
 - D. Digital Multi-meter

10. To measure the voltage dropped by a resistor in a series network, the meter must be connected:
 - A. In the path of current flow with circuit power on
 - B. In the path of current flow with circuit power off
 - C. Across the component with circuit power on
 - D. Across the component with circuit power off

Appendix E
Tests and media quizzes

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Name: _____

Period:

Electronics Safety Test

1. When are safety glasses required to be worn?
2. How many students are allowed in the solder area at one time?
3. Where does the soldering iron go when you are not directly using it?
4. Approximately, how hot is the tip of the soldering iron?
5. What is the safest way to snip excess leads?
6. What should be done when you discover a broken tool?
7. What is the right tool for driving screws in or out of something?
8. When using the drill press, where should the key be?
9. When using the drill press, how should the work be held?
10. How many students are allowed in the drill press safety zone at any time?
11. When should long hair be tied up?
12. If the press is not drilling very well, is it OK to just apply more force?
13. What rating of fire extinguisher is used for an electrical fire?

14. What is a MSDS?
15. Where do tools go when you are finished with them?
16. When should you tell the instructor about a personal injury?
17. What should the solder area look like when you are finished soldering?
18. If a drill bit is dull, what should be done with it?
19. When you are done with all work, is it OK to play hackey in the classroom?
20. When the hand drill batteries run down, what should you do with them?
21. Where are the MSDS?
22. If someone is bothering you, what should you do?
23. How do you know when the soldering iron is ready?
24. Is a little "horseplay" OK in the classroom?
25. I have received safety training for the Electronics classroom and agree to follow all safety rules. Signed _____

Name

Solder Quiz

1. What does 60/40 mean?
2. What is the stuff inside the core of solder called?
3. What is that stuff made of?
4. What is the purpose of that stuff?
5. What substance do we not want in the core for electronic soldering?
6. What approximate temperature does solder melt?
7. What is it called where the copper molecules mix with the solder?
8. What do we call the process of applying a dab of solder to the hot iron tip?
9. Is a good solder joint shiny or dull?
10. Is a good solder joint convex or concave?

Batteries – Unit Test

1. What type of battery can be re-charged? Secondary.
2. What type of battery cannot be re-charged? Primary.
3. What battery can explode violently if it is shorted? Lead/acid.
4. What dangerous condition happens if a battery is over-charged? Overheat.
5. What is the proper disposal method of a lead/acid battery? Re-cycle.
6. Name one kind of primary battery. Alkaline.
7. Name two kinds of secondary battery. NiCad, NiMH, Lithium-ion, lead acid.
8. Name two advantages of Lithium-ion over other batteries. Light weight, high energy density, charge quicker than other types.
9. Name a big disadvantage of Lithium-ion batteries. Expensive.
10. When should you make a current measurement of a battery directly with a meter? Never, it could blow the fuse, or worse.
11. If a battery is rated at 1200mAh, how long should it deliver 400mA to a load? 3 hours.
12. How much current will a 30Ah battery deliver for two hours? 15A.
13. What battery could explode if it were over charged? Lithium-ion.

Batteries – Unit Test - Key

1. Secondary.
2. Primary.
3. Lead/acid.
4. Overheat.
5. Re-cycle.
6. Alkaline.
7. NiCad, NiMH, Lithium-ion, lead acid.
8. Light weight, high energy density, charge quicker than other types.
9. Expensive.
10. Never, it could blow the fuse, or worse.
11. 3 hours.
12. 15A.
13. Lithium-ion.

Name

Period

Silicon Run

1. What percent of the earth's crust is silicon?
2. From what substance does the silicon come?
3. A transistor is like a tiny switch that _____ millions of times per second.
4. One source of contamination is the _____.
5. How many masks does a typical integrated circuit use?
6. What light sensitive substance is applied to the surface of the wafer?
7. What happens to chips on the wafer that are bad?
8. What is the wire made of that connects the pad to the pin?
9. Before soldering, what holds the tiny chips on the bottom of the board?
10. What is the machine called that does the final soldering?

Magnets Video Quiz

1. Linear synchronous motors do what to the polarity of an electromagnet?
2. How much power is used in each track of the Superman roller coaster?
3. How fast is the roller coaster?
4. Approximately, when were magnetic stripe readers developed?
5. Magnets are attracted to what metal?
6. What direction do the magnetic lines travel?
7. Where does all magnetism originate?
8. To degauss something means to do what to it?
9. Are electromagnets permanent or temporary?
10. What is a magnet's worst enemy?
11. What giant magnet are you standing on?

12. Per day, how much product is produced by the Flexmag company?
13. It is thought that birds and other animals use what to help them migrate?
14. What name is given to a natural magnet?
15. Oersted discovered he could generate what by putting current through a wire?
16. Faraday discovered magnetism induced what in a wire?
17. What were the first 2 main uses for electromagnets?
18. Would computer hard disks work without magnets?
19. How is the strength of plastic magnets controlled?
20. What critter was levitated in a powerful electromagnetic field?
21. What levitates a maglev train?
22. What specifically propels the train forward? Use the fancy name describing how the electromagnets do the job.
23. Do similar magnetic poles repel or attract?

Name

Period

Mad Electricity

1. In what year was the Tesla coil patented?
2. How many volts is the coil?
3. What happens to the current as the voltage is stepped up?
4. How many volts was the coil at Colorado Springs?
5. How far away could a light bulb be lit?
6. How tall was the tower at Wardencliffe?
7. Who invested \$150,000 in the Wardencliffe project?
8. What kind of power did Tesla envision for the world?
9. How many of Tesla's patents did Marconi use for his radio?
10. How many volts are produced by the 13M Tesla coil?
11. What does the magnetic field do in an induction motor?
12. Did Tesla receive his \$50,000 bonus from Edison?
13. Which is more efficient for long distance applications, AC or DC?
14. How much did Westinghouse pay Tesla for his patent rights?
15. What was the gruesome spectacle?
16. What did Tesla do with his royalty contract?
17. What device did Tesla show off at Madison Square Garden?
18. How many miles of range did the Death-Ray supposedly have?
19. How long does it take a Tesla roadster to go from 0-60 mph?
20. Which is more efficient, incandescent or fluorescent light?

Name

Period

Understanding Electricity

1. How many amps are in a lightning bolt?
 - a. 10,000
 - b. 50,000
 - c. 500,000
 - d. 1000

2. How many amps does it take to stop the human heart? _____

3. There are 500,000 volts running through high voltage power lines.
 - a. True
 - b. False

4. Who invented the designation of positive and negative charge?

5. What type of work did "Spider Lock-heart" do?

6. How tall is Hoover Dam? _____

7. Hoover Dam generates enough electricity to serve
 - a. 500,000 people
 - b. 750,000 people
 - c. 1,000,000 people
 - d. 2,000,000 people

8. How many generators does Hoover Dam contain?

9. Luigi Galvani did experiments with what animal?

10. How many people live without electricity?

11. What is Coney Island famous for?

Frequency Quiz

Name _____

1. What is the common name for the Aurora Borealis?
2. How do solar flares affect the Northern lights?
3. What is the name for the type of radio in the movie?
4. What weather condition stopped the radio from working?
5. What did Frank use the big soldering gun for?
6. Why did Frank pour coffee on the floor?
7. How did the radio get fixed?
8. By how many volts did the killer get shocked?
9. How far can the signal from a Ham radio travel?
10. Is a special license required for operating a ham radio?

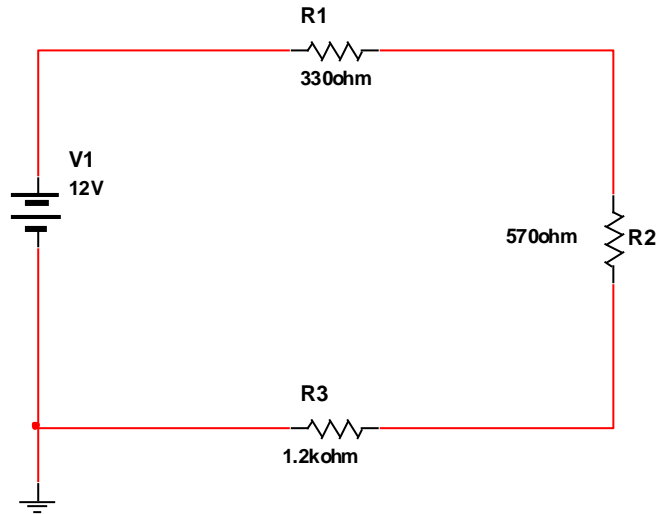
Contact Quiz

1. What does S.E.T.I. stand for?
2. What is considered the “universal language?”
3. From what star system did the signal originate?
4. Occam's Razor states that “All things being equal, the _____ explanation has to be the correct one.”
5. What did the technician/terrorist use to destroy the device?
6. From what exotic place did the rich and eccentric engineer call Ellie?
7. What final item did the scientists give Ellie for the trip?
8. Specifically, what did Ellie wear on her head?
9. Did the Vegans build the original machine?
10. If there is no other life in the universe, then it's a “ _____ _ _____.”

Series Circuit Quiz

Name _____

Using the given information, calculate the remaining values and fill in the table.

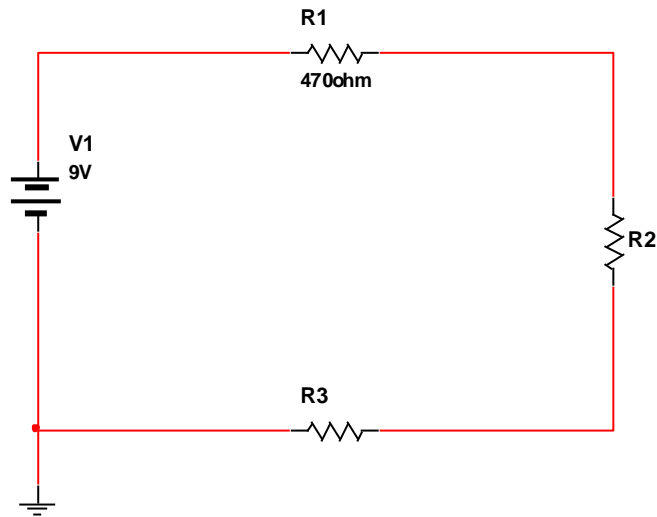


E (V) I R P

	E (V)	I	R	P
Total				
R1				
R2				
R3				

Series Circuit Quiz

Page 2



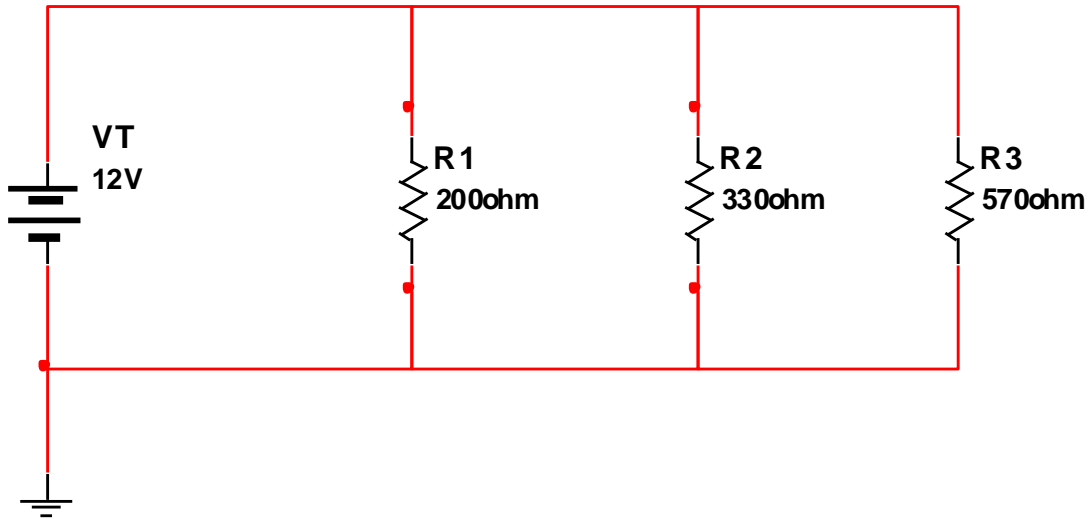
E (V) I R P

Total	9 V			27.9 mW
R1			470 Ω	
R2	.7 V			
R3				

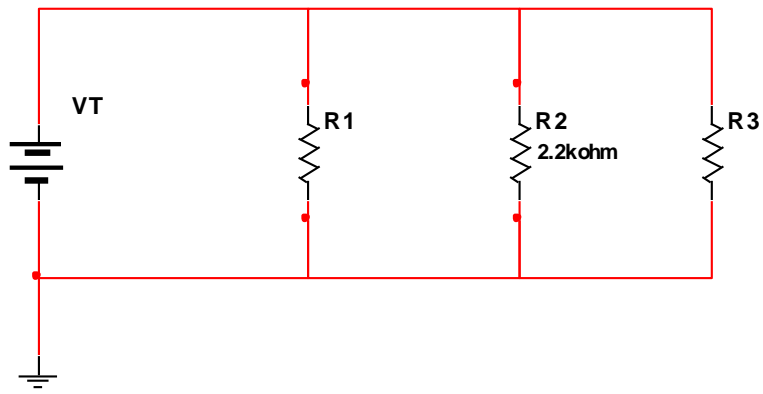
Name _____ Date _____

Parallel Circuits Quiz

Using the given information, calculate the remaining values and fill in the table.



	E (V)	I	R	P
Total				
R1				
R2				
R3				



	E (V)	I	R	P
Total		50.2 mA		
R1		14 mA		
R2		6.36 mA	2.2 kΩ	
R3				

Convert the following numbers into proper scientific notation, using metric prefixes.

1. 5,000,000 Ω _____
2. .0000006 A _____
3. 330,000 Ω _____
4. .00055 W _____
5. .003 V _____

Magnets and Electromagnetism

Unit Test

1. Similar magnetic poles attract or repel?
2. Magnetic lines of flux flow from the north to south pole or south to north pole?
3. What does heat do to a magnet?
4. Current flowing through a conductor creates _____ field around it.
5. If the current through a conductor is increased, what happens to the field?
6. If a wire is moved through a magnetic field perpendicular to the lines of flux, _____ is generated in the wire.
7. If a wire is moved through a magnetic field in the same direction as the lines of flux, _____ is generated in the wire.
8. Current flowing through a conductor can be used to create physical motion in a _____.
9. For 2 points, explain the right-hand rule.

Magnets and Electromagnetism

Answer Key

1. Repel
2. North to South
3. Reduces the magnetic strength
4. Electromagnetism
5. Increases
6. Current
7. Nothing
8. Motor, or speaker, or solenoid, etc.
9. With the right hand wrapped around a wire as an electric current is passed through it, the thumb points in the direction of the conventional current (from positive to negative), and the fingers point in the direction of the magnetic lines of [flux](#).

Appendix F

Student Performance and Evaluation form

Student Name: _____

The performance evaluation is a required component of the Skill Certification process. Each student **must be evaluated** on the required performance standards. Performance standards may be completed and **evaluated anytime during the course**.

- Students should be aware of their progress throughout the course, so that they can concentrate on the objectives that need improvement.
- Students should be encouraged to repeat the objectives until they have performed at a minimum of a number 1 or 2 on the rating scale (moderately to highly competent level).
 - 1= highly competent Successfully demonstrated without supervision
 - 2= moderately competent Successfully demonstrated with limited supervision
 - 3= limited competence Demonstrated with close supervision
 - 4= not competent Demonstration requires direct instruction and supervision
- When a standard has been achieved at a minimum of 80% (moderately to highly competent level). "Y" (Y=YES) is recorded on the last line of that standard, on the performance evaluation sheet. If a student does not achieve a 1 or a 2 (moderately to highly competent level), then "N" (N=NO) is recorded on the last line of that standard.
- All performance standards **MUST** be completed and evaluated prior to the written test.
- The **teacher** will bubble in "A" on the answer sheet for item #81 for students who have achieved "Y" on **ALL** performance standards.
- The **teacher** will bubble in "B" on the answer sheet for item #81 for students who have **ONE or more "N's"** on the performance standards.
- The signed performance evaluation sheet(s) **MUST** be kept in the teachers' file for two years.
- A copy is also kept on file with the school's ATE Skill Certification testing coordinator for two years.

Students who achieve a 1 or a 2 (moderately to highly competent) on ALL performance standards and 80% on the written test will be issued an ATE Skill Certificate.

470105-01 Students will be able to understand and demonstrate safe practices.	1	2	3	4
Use safe work practices.				

470105-02 Students will be able to understand and demonstrate the use of shop tools, materials, and techniques.	1	2	3	4
Select, use and maintain hand and power tools.				
Select and use hardware				
Solder and desolder				

470105-03 Students will be able to understand and demonstrate the use of test equipment.	1	2	3	4
Use multimeters – digital and analog.				
Use bench power supplies.				

470105-04 Students will be able to understand and demonstrate how to test and select passive electronics components.	1	2	3	4
Identify electronic components.				
Use, test and select batteries				
Use, test and select resistive devices.				
Connect, test, and select switches.				
Test, select, connect relays.				

470105-06 Students will be able to understand and demonstrate capacitors & their application.	1	2	3	4
Use, test, and select capacitors				

470105-07 Students will be able to troubleshoot transformer circuits.	1	2	3	4
Troubleshoot transformer circuits.				

470105-08 Students will be able to understand and demonstrate basic electronic theory.	1	2	3	4
Construct resistive circuits, measure voltage, current and resistance, and calculate current and power.				
Construct, measure, and analyze simple series circuits.				
Construct, measure, and analyze simple parallel circuits.				

The instructor must retain a copy of this Student Performance Evaluation for two years after the student has left the program.

Instructor Signature: _____ Date: _____

Student Signature: _____ Date : _____

School: _____

Appendix G
Resources CD