INTRODUCTION
This lesson provides a detailed understanding of Laws used in electricity; such as: Ohm’s & Kirchhoff’s Laws. Series, Parallel, & Series-Parallel Circuits. This contextual curriculum material will use a Criterion Referenced Instruction (CRI), which is instruction driven by specific performance objectives. Criterion is defined as a standard of judgment or criticism; a rule or principle for evaluating something.

CRI INSTRUCTIONAL STRATEGIES

- **Task Analysis** – Tasks identified by NATEF and author as what needs to be learned.

- **Performance Objectives** – exact specification of outcomes to be accomplished and how they are to be evaluated (criterion), which identifies what needs to be learned. NATEF tasks & Academic standards, along with the Maryland Academic Skills in Mathematics, Science, and Language Arts standards will be connected to these objectives.

- **Contextual Teaching/Learning Media** – Demonstrate completion of the performance objectives; such as: A6 Worksheets, Experiment Tasksheets, Academic Learning Projects, NATEF Job Sheets, Academic Sheets, Glencoe (optional) Academic Sheets, video snippets, group discussions, and e-learning modules, if available.

- **Criterion Referenced Testing** – evaluation of learning in terms of the knowledge/skills specified in the tasks.

- Laboratory experiences will be through Discovery and Problem-Solving connected to the appropriate Mathematics, Science, & English Language Arts.

- Completion of **A6 Electrical and Electronic Systems** comprising will prepare the student to take the ASE A6 Electrical & Electronic Systems Student Certification. http://www.asestudentcertification.com/.

Margin lists hyperlinks to support documents & materials along with NOTES & ICON definitions and instructions.

1. Student Presentation Notes
2. Student Binder Guidelines
3. PowerPoint – U1L4 Ohm’s Law & Circuits
4. Worksheet 1: – WS1 Ch03 Ohm’s Law
5. Job Sheet 1– JS1 MLR A6A2 Ohm’s Law Applied
6. VIDEO: – Ohm’s Law
7. Academic Sheet – AS1 MATH Electrical Circuits
8. Academic Sheet –AS1 MATH Series Circuit Problems
9. Academic Sheet – AS1 MATH Parallel Circuit Problems
10. Academic Sheet – AS1 MATH Series-Parallel Circuit Problems
11. Academic Sheet – AS2 MATH Circuits, P.137 (Glencoe Optional)
12. Experiment Task Sheet 1 Academic Sheet – ETS1 Ohm’s Law & Circuits
15. Job Sheet 2 – JS1 Vocabulary Scavenger Hunt and ID.
16. Student Presentation Notes
17. Reflection Lesson 4 – What Did I Learn?
LEARNING (PERFORMANCE) OBJECTIVES

- Demonstrate the ability to measure and analyze voltage drops across a load in a circuit in a classroom, using a S.E.T Project Board or trainer as measured by correctly building the circuit answering the fill-in-the-blank questions and solving the Ohm’s Law equations.

- Demonstrate the ability to build series, parallel, and series-parallel circuits and apply the principles of Ohms and Kirchhoff Laws to perform circuit analysis and diagnosis in a classroom, using a S.E.T Project Board or trainer as measured by correctly building the circuits answering the fill-in-the-blank questions and solving the Ohm’s Law equations.

- Apply combinations of algebra and statistics techniques to use in formulas to solve for simple and complex equations to solve for the unknown quantity in series, parallel, and series-parallel circuits on a S.E.T Project Board or trainer.

- **S.E.T. PROJECT BOARDS WILL BE used in this Lesson**

TIME

**15 – 45 MINUTE CLASS/LAB OR 11 HOURS**

NATEF TASK

- **NATEF MLR Task A6A2** Diagnose electrical/electronic integrity for series, parallel and series-parallel circuits using principles of electricity (Ohm’s Law), P-1

PERFORMANCE OBJECTIVES

Performance objectives or occupational competencies contain three elements: the action or behavior the student must be capable of performing, the conditions under which to perform them, and the performance standards to reach (Biehler and Snowman, 2006, p. 247-249).

**NOTE on Time Check:** Depending on time, You may want to move next section to following day or continue on with instruction.

**NATEF Tasks Student Competency Record**
NATEF ACADEMIC STANDARDS

Communication
- NATEF AC-3– Abbreviations/Acronyms
- NATEF AC-14 – Directions and Tasks
- NATEF AC-15 – Listening/Reading/Speaking/Writing
- NATEF AC-20 – Summaries

Mathematics
- NATEF AM-14 – Mentally
- NATEF AM-39 – Equal/Not Equal
- NATEF AM-44 – Formulas
- NATEF AM-46 – Equivalent Form
- NATEF AM-47 – Specified Symbols
- NATEF AM-48- Algebraic Expressions

Science
- NATEF AS-61 – Parallel/ Series Circuits
- NATEF AS-66 – Electricity—Measurement
- NATEF AS-67 – Ammeter/Voltmeter
- NATEF AS-70 – Ohm’s Law
- NATEF AS-71 – Resistance

SKILLS USA TASKS
- Working effectively on a team and demonstrating effective team work skills
- Gathering, analyzing, and arranging information in a logical sequence to convey written communication clearly and concisely
- Adapting successfully to changing situations and environments with flexibility
- Setting objectives, managing time, and able to plan activities and carry them through effectively
SAFETY

- Comply with NATEF safety TASKS found in MLR Supplemental Task Course UNIT 1 LESSON 1 associated with clothing, eye protection; hand tools; power equipment; proper ventilation; and the handling, storage, and disposal of chemicals and materials in accordance with local, state, and federal safety and environmental regulations.
  - Follow safe tool use.
  - Customer service concerns of electrical & electronic service
  - Importance and use of fender covers and wiping cloths for care of paint finishes with regards to corrosive BATTERY acid.
  - Wearing safety glasses and personal protective equipment when working in shop environment
  - Warnings and cautions used during electrical and electronic service to prevent electrical shock and the corrosive nature of battery electrolyte.

- All students will receive instruction in storage, handling, and use of Hazardous Materials as required in Hazard Communication Title 29, Code of Federal Regulation Part 1910.1200, ‘Right to Know Law’, and state and local requirements; HAZ-MAT will be handled, removed, and recycled or disposed of according to federal, state, and local regulations. All students will be given proper instruction on safety & use of automotive vehicle lift procedures.
CRI INSTRUCTIONAL DOCUMENTS
The Job Sheets, A6 Worksheets, Academic Sheets, Academic Learning Projects, Experiment Task Sheets, and are criterion referenced instructional (CRI) Documents used for a hands-on contextual discovery of what the student should be able to learn based on the Learning (Performance) Objectives and NATEF Tasks. The NATEF Academic Standards, National Science Education standards, and Maryland Required Mathematics and Language-Arts Common Core Standards are contained within the Lesson and its Assets. PowerPoint Presentations (based on learning [Performance] objectives) are used to explain the basic concepts in the classroom and support the CRI documents used in the automotive lab.

INSTRUCTIONAL DOCUMENT RECAP
The job sheets, A6 worksheets and academic sheets will be used in this lesson:

JOB SHEETS
- Job Sheet 1 – A6A2 Ohm’s Law applied
- Job Sheet 2 – Vocabulary Scavenger Hunt and ID.

A6 WORKSHEETS
- A6 WS1 Ch03 Ohm’s Law
- Student Presentation Notes
- Reflection Lesson 1– What Did I Learn?

ACADEMIC WORKSHEETS
- AS1 MATH – Electrical Circuits
- AS1 MATH – Series Circuit Problems
- AS1 MATH – Parallel Circuit Problems
- AS1 MATH – Series-Parallel Circuit Problems

ACADEMIC LEARNING PROJECTS
- Academic Learning Project ALP_M1 – Illumination
- Academic Learning Project ALP_M2 – Kirchhoff’s Law

EXPERIMENT TASK SHEETS
- Experiment Task Sheet 1 Ohm’s Law & Circuits

ACADEMIC SHEETS (OPTIONAL)
The following may or may not be necessary for use, but are provided to give students extra practice with the related academic area:
- AS2 MATH Circuits, P.137 (Glencoe Optional)

ACADEMIC SKILLS EMBEDDED IN LESSON

JOB SHEETS
NATEF Tasks Student Competency Record ICON driven worksheets based on the A6 NATEF Task list that will document that the student completed the NATEF task. They are RUBRIC scored.

A6 WORKSHEETS
These worksheets are CRI documents that are either based on the student text A6 Auto Electricity and Electronics 5th Edition by James E. Duffy or other text supplied by the Curriculum Author.

ACADEMIC SHEETS
These worksheets are based on completing work that conforms to the NATEF Academic Standards

ACADEMIC LEARNING PROJECTS
These are hands-on demonstrations of knowledge, skills, and attitudes (KSA) that require students to organize activities, conduct research, solve problems, develop information, and create products or performances. Every scenario addresses some relevant, authentic problem that automotive technicians experience. Students are challenged to use high-level skills and knowledge from at least one academic discipline. Solutions require information technology and problems are solved by teams as problems are solved on the job. They are RUBRIC scored.

EXPERIMENT TASK SHEETS
These are detailed CRI task sheets designed around the S.E.T. (Specialized Electronics Training) Project Boards, where students are required to build a circuit.
NATIONAL SCIENCE STANDARDS

TABLE 6.1: SCIENCE AS INQUIRY STANDARDS
Abilities necessary to do scientific inquiry
Understanding scientific inquiry

TABLE 6.2: PHYSICAL SCIENCE STANDARDS
Transfer of Energy
Interactions of Energy & Matter

TABLE 6.5: SCIENCE AND TECHNOLOGY STANDARDS
Abilities of technological design
Understanding about science and technology

MATHEMATICS SKILLS
Follows required format for listing Mathematics Common Core standards as required by state of Maryland.

Maryland Algebra Common Core Standards:
Mathematical Practice: Graphs, Distance, Word Problems
Quantities-NQ: Reason quantitatively and use units to solve problems.
Complex Number System N –CN Perform arithmetic operations with complex numbers.
Algebra–APR (Arithmetic with Polynomials and Rational Expressions)
1. Understand that polynomials form a system analogous to the integers,
4. Prove polynomial identities and use them to describe numerical relationships.
Algebra–CED (Creating Equations): 1. Create equations and inequalities in one variable and use them to solve problems. 4. Rearrange formulas to highlight a quantity of interest
Algebra–REI (Reasoning with Equations & Inequalities):
• 1. Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from assumption that original equation has a solution.

ENGLISH LANGUAGE ARTS SKILLS
Follows required format for listing English Language Arts Common Core standards as required by state of Maryland.

• Reading – Science and Technical Subjects: 3. Key Ideas and Details (9-11)
• College and Career Readiness for Writing: 2. Text Types and Purposes (6-12)
• College and Career Readiness for Writing: 4. Production and Distribution of Writing (6-12)

• Speaking and Listening: 4. Presentation of Knowledge and Ideas (9-12)
ASSESSMENTS BEYOND PERFORMANCE – CRITICAL THINKING

Explanation

- Students will be better able to understand the characteristics of electricity when they see it in action using ETS 1 to actually build series, parallel, and series-parallel circuits and measure voltage, current, and resistance with digital multimeter (DMM) to prove Ohm’s Law.

Application

- Completion of the Experiment Task Sheet 1 on series, parallel, and series-parallel circuits will show how this valuable to complete NATEF Task A6A5, which is used to service and diagnose electrical and electronics systems in cars and trucks.

Perspective

- Students when building series, parallel, and series-parallel circuits, measuring the values using the DMM used in ETS 1 and then solving the Algebraic equations to prove the value that were measured.

VOCABULARY

Vocabulary ← Terms are in Main Glossary PDF
Students will match Series, Parallel, Series-Parallel terms using Job Sheet 2 – Vocabulary Scavenger Hunt and ID.
DEMONSTRATIONS

- **Demonstration 1**: Using an inductive ammeter or AVR, CSB tester to show that amount of current leaving the battery on the positive side is returned on the negative side.

- **Demonstration 2**: Remind students how to construct circuits on the S.E.T. Project Board through a DEMO using U1L4 EXPERIMENT 1: COMPASS CURRENT DETECTOR on Page 3 of U1L4 ETS1.

- **Demonstration 3**: Construct a circuit like the one shown in the below Figure on the S.E.T. Project Board. Use bulbs of different resistance. Show your students how to check the voltage drop at each bulb. Ask them to add-up the voltage drops and compare them to the source voltage.

SCOPE & SEQUENCE OF INSTRUCTION & LEARNING

**NOTE**: Prior to instruction, you should review day-to-day notes in order to prepare the lab with tools and vehicles to teach and ready the environment for students to complete the expectations of the lesson, such as tools, test equipment, vehicles, NATEF task sheets, job sheets, and worksheets.

**DAY 1 (45 MINUTES): LESSON OPENING**

- Give an explanation of the NATEF Task A6A5 that will be covered on applying Ohm’s Law regarding series, parallel, and series-parallel circuits.

- Present the Learning Objectives and Concepts, Safety Procedures, **Vocabulary**, and Instructional Documents, in order to provide a lesson overview.

- Pass out copies of **Student Presentation Notes** for use with this Lesson.

- **Using Power Point U1L4 Ohm’s Law & Circuits WALK through SLIDES 1-32 & EXPLAIN basics of Ohm’s Law**

- **DEMONSTRATION 1**: Using an inductive ammeter or AVR, CSB tester to show that amount of current leaving battery on
**Positive side is returned on negative side**

**12 feet potential energy**

**Water Flow is amps does Work**

**Pressure (Voltage) Drops to Zero**

**Water Wheel**

Positive battery terminal was cleaned due to starter cranking slowly. Why only clean positive post? Response: negative terminal is ground.” Current, in amperes, is constant throughout series circuits (cranking motor circuit). If 200 amperes leave positive battery post, then 200 amperes must return to battery through negative post. Same amount of current, in amperes returns as left battery. Current is constant in circuit, voltage (pressure) drops to 0 in circuit. This is like the waterwheel to the left. As water drops from a higher level to lower level, high potential energy (voltage) is used to turn waterwheel & results in low potential energy (lower voltage). Same amount of water (amperes) reaches pond under waterwheel as started fall above waterwheel. As current (amperes) flows through conductor, it performs work in circuit (turns waterwheel) while its voltage (potential) drops.
TIME CHECK

NOTES:____________________________

HOMEWORK: Ask the students to write a description of the effects of higher resistance on current flow. Using the RUBRIC grade the students on their understanding of Ohm’s Law

DAY 2 (45 MINUTES): OHM’S LAW VIDEO
- Do report out on the Homework assignment
- Show Optional VIDEO Part 2 on Ohm’s Law @ SLIDE 33: 28 Minutes

DAY 3 (45 MINUTES): U1L4 WS1 OHM’S LAW
Complete A6 U1L4 Worksheet 1
WS1 Ch03 Ohm’s Law @ SLIDE 34
Complete A6 U1L4 Academic Sheet 1 Electrical Circuits @ SLIDE 34
Ohm’s Law Animations in box below:

Ohm’s Law, Current
Ohm’s Law, Resistance
Ohm’s Law, Volt

DAY 4 (45 MINUTES): U1L4 CIRCUITS
Using Power Point U1L4 Ohm’s Law & Circuits
WALK through SLIDES 35-45 on Series, Parallel, & Series-Parallel Circuits

INSTRUCTOR NOTE:

Series Circuit, Open Circuit ANIMATION

Time Check: Depending on time, you may want to move the next section to the following day or move on with more material

Homework

Video

Power Point Embedded Video in U1L4 SLIDE #40: 28 Minutes

Task

Hands-On Task: WS1 Ohm’s Law

Task

Academic Task: AS1 Electrical Circuits

Power Point

A6U1L4 SLIDES 35-45:

Circuit wire size will be covered in ALP_M1 Illumination, coming up after the completion of ETS1 (Experiment Tasksheet 1): Ohm’s Law: Series, Parallel, & Series-Parallel Circuits
Parallel Circuit
Parallel Circuit, Open
Parallel Circuits, Volts

DAY 5 (45 MINUTES): U1L4 DEMO 2

**DEMONSTRATION 2:** Remind students how to construct circuits on S.E.T. Project Board through a DEMO, using U1L4 EXPERIMENT 1: COMPASS CURRENT DETECTOR on P3 of U1L4 ETS1

DAY 6 (45 MINUTES): U1L4 BEGIN ETS1 SLIDE 46

BEGIN Experiment Task Sheet ETS1 Ohm’s Law: Series, Parallel, & Series-Parallel Circuits

Begin ETS1 (Experiment Tasksheet 1): Ohm’s Law: Series, Parallel, & Series-Parallel Circuits. This is a large Task Sheet with 31 pages of text and 13 experiments using S.E.T. Project Boards

**TIME CHECK**

**NOTES:**

DAY 7 (45 MINUTES): U1L4 ETS1 CONTINUED

- **Continue ETS1:** SLIDES 47-54 Cover Experiments over Days 5-8

Using Power Point U1L4 Ohm’s Law & Circuits WALK through SLIDES 55-60 on MEASURING VOLTAGE DROPS

- **DEMONSTRATION 3:** Construct a circuit like the one on page 20 on S.E.T. Project Board. Use bulbs of different resistance. Show your students how to check **voltage drop** at each bulb. Ask them to add-up the voltage drops and compare them to source voltage.
DAY 8 (45 MINUTES) COMPLETE ETS1:
**Complete ETS1**
- Complete ETS1 Pages 25-31, finishing ETS1

**DISCUSSION:** Host a Discussion on MATH used in U1L4 ETS1 Host a Discussion on Kirchhoff’s Second Voltage Law and how does it relate to Ohm’s Law

DAY 9 (45 MINUTES): U1L4 WS1 WATT’S LAW
Using Power Point U1L4 Ohm’s Law & Circuits WALK through SLIDES 61-70 on Watt’s Law and Power

**DISCUSSION:** Host a DISCUSSION on WATT’S LAW

**DISCUSSION:** Ask students to DISCUSS Watt’s Law. How can Watt’s Law be applied to automotive lighting circuits when calculating fuse size needed to protect circuit

TIME CHECK
**NOTES:**__________________________________________

DAY 10 (45 MINUTES): ALP_M1 ILLUMINATION
**Begin Academic Learning Project U1L4 ALP_M1 Illumination @SLIDE 71**

DAY 11 (45 MINUTES): ALP_M1 ILLUMINATION
- Continue Academic Learning Project U1L4 ALP_M1 Illumination

TIME CHECK
**NOTES:**__________________________________________
DAY 12 (45 MINUTES): ALP_M1 ILLUMINATION
FINISH Academic Learning Project U1L4
ALP_M1 Illumination @SLIDE 71

DAY 13 (45 MINUTES): U1L4 ALP_M2
Do Academic Learning Project U1L4
ALP_M2 Kirchhoff’s Law @SLIDE 71

TIME CHECK
NOTES:____________________________

DAY 14 (45 MINUTES): NATEF JS1 A6A2
Have students’ complete JS1 NATEF
MLR Task JS1 A6A2 Ohm’s Law
Applied (P-1) @SLIDE 72

DISCUSSION: Host Discussion: How
Ohm’s Law is used in diagnosis of Circuit
Faults?

DAY 15 (45 MINUTES): LESSON COMPLETION
• Complete Job Sheet 2 – Vocabulary
Scavenger Hunt and ID
• Students will place the Job Sheets 1 & 2 (after receiving
a grade) with notes of corrections or
misunderstandings in their Student A6 Binder.
• Complete Reflection Lesson 3 Worksheet What Did I
Learn Regarding the use and importance of a DMM as
a viable tool for Electrical & Electronics service. Do
these connect in your opinion with any academic skills;
such as: Math, Language-Arts, or Science?
RESOURCES
The following is a listing of all documents needed to use during lesson, most are in Word or Power Point format for ease of printing or copying. It also includes a listing of relevant resources beyond those used as support materials, but may be used as enhancements or related background information.

NATEF TASKS STUDENT COMPETENCY RECORD

NATEF ACADEMIC STANDARDS CORRELATION
- English – Communication
- Mathematics
- Science

POWERPOINTS
- U1L4 Ohm’s Law & Circuits

VOCABULARY
- Unit 1 – Glossary Listing in PDF
- A6 Course Glossary

VIDEOS
- GM Ohm’s Law

JOB SHEETS
- Job Sheet 1 A6A2 Ohm’s Law applied
- Job Sheet 2 – Vocabulary Scavenger Hunt and ID.

A6 WORKSHEETS
- A6 WS1 Ch03 Ohm’s Law
- Student Presentation Notes
- Reflection Lesson 1– What Did I Learn?

ACADEMIC WORKSHEETS:
- AS1 MATH – Electrical Circuits
- AS1 MATH – Series Circuit Problems
- AS1 MATH – Parallel Circuit Problems
- AS1 MATH – Series-Parallel Circuit Problems

ACADEMIC LEARNING PROJECTS
- Academic Leaning Project ALP_M1 – Illumination
- Academic Leaning Project ALP_M2 – Kirchhoff’s Law

EXPERIMENT TASK SHEETS
- Experiment Task Sheet 1 Ohm’s Law & Circuits

ACADEMIC SHEETS (OPTIONAL)
The following may or may not be necessary for use, but are provided to give
students extra practice with the related academic area:

- AS2 MATH Circuits, P.137 (Glencoe Optional)

GOODHEART-WILLCOX RESOURCES


WEBSITE AND OTHER RESOURCES