APS DISTRICT HIGH SCHOOL SCIENCE CURRICULUM FRAMEWORK

Course Title: Digital Circuitry **Course Number:** 44118

Department: Science **ADS Number:** 17814944

Prerequisites: Pre-Engineering Electronics

Length of Course: One Year **Credit/PRI Area:** .50 per Sem/Elective **Grade Level(s):** 11-12

Important Notes:

It is strongly recommended that Algebra II has been completed or is being taken concurrently.

COURSE DESCRIPTION: This laboratory course* is designed to teach the student to analyze and design combinational logic circuits using Boolean algebra, Karnaugh maps, logic diagrams, and lab view. He/She studies number systems, binary codes, and code conversions as well as methods of fault analysis and trouble shooting techniques and begins to learn about J-K flip flops. Laboratory experiments emphasize practical application of concepts taught in the theory portion of the course, requiring the student to wire, design, troubleshoot, and demonstrate combinational logic circuits (e.g., adders, counters, multiplexers, simple memory). Literacy strategies are integrated throughout the curriculum.

*Lab Courses: A minimum of 250 minutes per week of directed class activity for 36 weeks, 40% of which must be lab oriented, for a total of 150 clock hours (90 hours of class plus 60 hours of lab) shall be required for one (1) unit of credit, excluding passing period. [APS Procedural Directives, Section I – Instruction, Basis for offering credit].

References in parentheses following each performance standard refer to and are aligned with the New Mexico Science Standards (NM) and the Albuquerque Public Schools Language Arts Standards (APS-LA).

STRATEGIES:
The "Illustrations" column provides exemplars of the performance standards, strategies, and the best practices suggested by the high school science teachers in the Albuquerque Public Schools. Some illustrations are introductory and others are culminating activities for concepts. Illustrations may be modified for individualized instruction, accessibility of equipment and materials, etc.

ASSESSMENTS:
Assessments include the following: authentic and performance-based assessments, cooperative learning, teacher observations, role playing, checklists, rubrics, tests and exams, formal and informal writing, oral presentations, group discussions, multimedia presentations, projects and demonstrations. The "Illustrations" column also incorporates a variety of assessments.

SUGGESTED TEXTBOOKS AND INSTRUCTIONAL MATERIALS:
- State adopted textbooks and ancillary materials
- Supplementary materials
- Films/videos
- Internet

SUGGESTED TITLES/AUTHORS WEB SITES:
- *Practical Digital Electronics* - Cook, Nigel - Prentice Hall - 2003
- *Foundations of Electronics: Circuits and Devices* – Meade - Delmar Publishers, Inc. - 1994
- *Simulations for Digital Electronics Using EWB* – Antonakos - Prentice Hall
- *Digital Fundamentals* - Floyd, T. - Prentice Hall International, Inc. - 1997
- *Digital Electronics (A Practical Approach)* - Kleitz, William - Prentice Hall - 1997
- *Introductory Electronic Devices and Circuits* - Paynter, Robert - Prentice Hall - 1997
- *Microelectronic Circuits* - Rashid, Muhammad H. - PWS Publishing Company, Boston - 1999

• http://www.aps.edu/aps/wmhs/atca/academies.html	West Mesa High School's Academy home page
• http://www.aps.edu/aps/whmh/atca/acad_advtech_links.html	West Mesa High School's Advanced Manufacturing Academy links page
• http://www.discovercircuits.com/resources/tutorials.html	Discover circuits electronic resources
• http://dmoz.org/Science/Technology/Electronics/Tutorials/	Electronics tutorial page
• http://parallax.com	Digital circuit board kits, online activity manuals, software
• www.dmu.ac.uk	Dr. Andrei Dinu

Approved by HSCA: 12/04

STRAND I: SCIENCTIFIC THINKING AND PRACTICE
CONTENT STANDARD: The student understands the processes of scientific investigations and uses inquiry and scientific ways of observing, experimenting, predicting, and validating to think critically.

BENCHMARKS:
A. The student uses accepted scientific methods to collect, analyze, and interpret data and observations and to design and conduct scientific investigations and communicate results.
B. The student understands that scientific processes produce scientific knowledge that is continually evaluated, validated, revised, or rejected.
C. The student uses mathematical concepts, principles, and expressions to analyze data, develop models, understand patterns and relationships, evaluate findings, and draw conclusions.

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	1. Describes the essential components of an investigation, including appropriate methodologies, proper equipment, and safety precautions (NM-I.I.I.1). 2. Designs and conducts scientific investigations that include (NM-I.I.I.2): • testable hypotheses, • controls and variables, • methods to collect, analyze, and interpret data, • results that address hypotheses being investigated, • predictions based on results, • re-evaluation of hypotheses and additional experimentation as necessary, and • error analysis. 3. Uses appropriate technologies (e.g., computers, calculators, balances, microscopes) to collect, analyze, and communicate scientific data (NM-I.I.I.3). 4. Conveys results of investigations using scientific concepts, methodologies, and expressions, including (NM-I.I.I.4): • scientific language and symbols, • diagrams, charts, and other data displays, • mathematical expressions and processes (e.g., mean, median, slope, proportionality), • clear, logical, and concise communication, and	**NOTE: Illustrations include suggested activities for attaining each performance standard. A check (√) refers to a key feature to look for while assessing student performance.** 1 – 16. The student properly designs and performs a controlled experiment using scientific methods, gathers and analyzes data, and reports results in both an oral and written format. ✓ proper safety technique ✓ correct use of appropriate equipment ✓ evidence of current scientific knowledge ✓ organization of data ✓ appropriate analysis of data ✓ reasonable and testable problem ✓ defensible conclusion based on data ✓ quantitative/qualitative data ✓ trials to verify data ✓ theory supported by data ✓ critical thinking and insights ✓ use of technology ✓ effective communication skills ✓ writing conventions -FOR EXAMPLE- The student troubleshoots a digital circuit using a reproducible procedure, data chart/logic tables, and Boolean logic. He/She then produces a diagram for a digital design. This design includes the following: • flow chart (i.e., logic gates), • code converter,

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	• reasoned arguments. 5. Understands how scientific theories are used to explain and predict natural phenomena (e.g., plate tectonics, ocean currents, structure of atoms) (NM-I.I.I.5). 6. Understands how scientific processes produce valid, reliable results, including (NM-I.I.II.1): • consistency of explanations with data and observations, • openness to peer review, • full disclosure and examination of assumptions, • testability of hypotheses, and • repeatability of experiments and reproducibility of results. 7. Uses scientific reasoning and valid logic to recognize (NM-I.I.II.2): • faulty logic, • cause and effect, • the difference between observation and unsubstantiated inferences and conclusions, and • potential bias. 8. Understands how new data and observations can result in new scientific knowledge (NM-I.I.II.3). 9. Critically analyzes an accepted explanation by reviewing current scientific knowledge (NM-I.I.II.4). 10. Examines investigations of current interest in science (e.g., superconductivity, molecular machines, age of the universe) (NM-I.I.II.5). 11. Examines the scientific processes and logic used in investigations of past events (e.g., using data from crime scenes, fossils), investigations that can be planned in advance but are only done once (e.g., expensive or time-consuming experiments such as medical clinical trials), and investigations of phenomena that can be repeated easily and frequently (NM-I.I.II.6). 12. Creates multiple displays of data to analyze and explain the relationships in scientific investigations (NM-I.I.III.1).	• choice of logic family based on characteristics, • switch debouncing, • delay times, • pull up resistors, • automatic reset, and • fan-in and fan-out. The student analyzes the logic circuits for various malfunctions (e.g., no output, incorrect wiring, faulty components). ✓ thorough diagram ✓ working circuit ✓ proper output ✓ truth tables ✓ accurate analysis ✓ corrective action -ALSO- The student researches and reports on the history and development of a modern technology (e.g., Micro Electrical Mechanical devices, traffic signals, CD players, robots, semiconductors, computers). The research includes the following: • global/local impact, • historical timeline, • scientific principles, • economic impact, • hazards, and • electrical design. The student uses technology (e.g., Lab View, PowerPoint, slide show, working model) to present findings. ✓ clear communication ✓ accurate information ✓ writing conventions ✓ thoroughness ✓ adherence to rubric

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	13. Uses mathematical models to describe, explain, and predict natural phenomena (NM-I.I.III.2). 14. Uses technologies (e.g., calculators, computer spreadsheets and databases, graphing software, simulations, modeling) to quantify relationships in scientific hypotheses (NM-I.I.III.3). 15. Identifies and applies measurement techniques and considers possible effects of measurement errors (NM-I.I.III.4). 16. Uses mathematics to express and establish scientific relationships (e.g., scientific notation, vectors, dimensional analysis) (NM-I.I.III.5).	

STRAND II: THE CONTENT OF PHYSICAL SCIENCE
CONTENT STANDARD: The student understands the structure and properties of matter, the characteristics of energy, and the interactions between matter and energy.

BENCHMARKS: A. The student understands the properties, underlying structure, and reactions of matter.
B. The student understands the motion of objects and waves and the forces that cause them.

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	1. Identifies, measures and uses a variety of physical and chemical properties (e.g., electrical conductivity, density, viscosity, chemical reactivity, pH, melting point) (NM-II.I.I.2).	1, 2. The student analyzes the physical makeup of various semiconductor devices. He/She diagrams the makeup to show all components, to identify the different types of materials used, and to discover how the components interact with each other to produce an electrical current. ✓ accurate diagram showing electrical flow ✓ accurate labels ✓ accurate classification ✓ metallic/nonmetallic properties
	2. Describes trends (e.g., ionization energy or reactivity as a function of location on the periodic table, boiling point of organic liquids as a function of molecular weight) in properties (NM-II.I.I.4). 3. Understands that matter is made of atoms and that atoms are made of subatomic particles (NM-II.I.I.5). 4. Understands atomic structure including (NM-II.I.I.6): • most space occupied by electrons, • nucleus made of protons and neutrons, • isotopes of an element, • masses of proton and neutron 2000 greater than mass of electron, and • atom held together by proton-electron electrical forces. 5. Explains how electrons determine the properties of substances by (NM-II.I.I.7): • interactions between atoms through transferring or sharing valence electrons, • ionic and covalent bonds, and • ability of carbon to form a diverse array of organic structures.	2 – 7. The student investigates the electrical conductivity/resistivity of several materials (e.g., aluminum, copper, gold, carbon, glass, ceramic, plastic, paper) and relates it to the atomic crystalline, molecular, and macroscopic structures. He/She predicts elements' conductivity based on placement on the periodic chart. ✓ proper use and safety of equipment ✓ atomic structure ✓ mobility of electrons ✓ ionic/covalent bonding ✓ accurate measurement of conductivity/resistivity ✓ accurate prediction of conductivity of elements ✓ clearly written description of observed properties with chemical ✓ structure and placement on periodic chart

	6. Understands how the type and arrangement of atoms and their bonds determine macroscopic properties (e.g., boiling point, electrical conductivity, hardness of minerals) (NM-II.I.I.9).	6, 7. See Strand II (Content of Physical Science) Illustration #2 – 7.
	7. Knows that materials containing equal amounts of positive and negative charges are electrically neutral, but that a small excess or deficit of negative charges produces significant electrical forces (NM-II.I.III.3).	7 – 10. See Strand I (Scientific Thinking and Practice) Illustration #1 – 16.
	8. Explains how electric currents cause magnetism and how changing magnetic fields produce electricity (e.g., electric motors, generators) (NM-II.I.III.5). 9. Represents the magnitude and direction by vector diagrams (NM-II.I.III.6). 10. Knows that when one object exerts force on a second object, the second object exerts a force of equal magnitude and in the opposite direction on the first object (i.e., Newton's Third Law) (NM-II.I.III.7).	8, 9. The student researches and describes the process involved in etching a semiconductor or MEMs chip, including an overview of the chemical reactions that take place and methods of manufacturing. He/She discusses hazardous byproducts and their disposal. ✓ accurate description of steps ✓ correct identification of reactions, reaction types (e.g., endo or exothermic) ✓ clear explanation of factors that might change rate of reactions ✓ description of byproduct, hazards, and proper disposal methods ✓ disposal of manufacturing process 8 – 10. The student properly debounces a switch. ✓ use of vectors to diagram phenomena ✓ corrective solution wired in ✓ output measured to demonstrate debounce
	11. Identifies different forms of energy, including kinetic, gravitational (i.e., potential), chemical, thermal, nuclear, and electromagnetic (NM-II.I.II.1). 12. Explains how thermal energy (i.e., heat) consists of the random motion and vibrations of atoms and molecules and is measured by temperature (NM-II.I.II.2). 13. Understands that energy can change from one form to another (e.g., changes in kinetic and potential energy in a gravitational field, heats of reaction, hydroelectric dams) and knows that energy is conserved in these changes (NM-II.I.II.3). 14. Understands that the ability of energy to do something useful (i.e., work) tends to decrease (and never increase) as energy is converted from one form to another (NM-II.I.II.5).	11 – 14. The student researches, then diagrams, and describes the energy changes and transfers from an electrical energy source (e.g., solar, battery) to mechanical (e.g., flywheel, spring) to electrical (e.g., magnets, coils), and then through a circuit (e.g., electrical to mechanical for a switch, motor, electrical to thermal in a resistor). The student explains that the temperature is a measure of thermal energy and describes how energy is conserved; yet, available energy decreases. ✓ accurate energy flow chart showing various forms of energy ✓ accurate identification of energy transformations ✓ clear communication of relationship between temperature and thermal energy ✓ recognition of entropy in these energy transfers

	15. Understands that electromagnetic waves carry energy that can be transferred when they interact with matter (NM-II.I.II.7). 16. Describes the characteristics of electromagnetic waves (e.g., visible light radio, microwave, X-ray, ultraviolet, gamma) and other waves (e.g., sound seismic waves, water waves) (NM-II.I.II.8). 17. Knows that each kind of atom or molecule can gain or lose energy only in discrete amounts (NM-II.I.II.9).	15 – 17. The student creates a diagram and explains how a photo detector works, including electron transitions at the atomic level. ✓ accurate diagram ✓ clear communication ✓ light output related to electron energy level transitions
	18. Knows that materials containing equal amounts of positive and negative charges are electrically neutral, but a small excess or deficit of negative charges produces significant electrical forces (NM-II.I.III.3).	18. The student describes the process of how he/she gets a static shock when touching a doorknob, relating this to static buildup in any circuit. He/She explains ways to prevent a static charge buildup. ✓ clear, accurate description of process ✓ identification of regions of excess electrons ✓ accurate description of how to ground out a circuit
	19. Explains how electric currents cause magnetism and how changing magnetic fields produce electricity (e.g., electric motors, generators) (NM-II.I.III.5).	19. The student investigates electromechanical relays and solid state switches, combining them with various amplifiers to control output displays. ✓ proper description of relay operation ✓ motors that turn on/off and operate at stepped speeds ✓ proper LED and LCD displays
	20. Represents the magnitude and direction of forces by vector diagrams (NM-II.I.III.6).	20. The student creates force diagrams of the interaction between like and unlike charges [i.e., protons and electrons; e.g., (+)→ ←(-)]. ✓ accurate diagram
	21. Identifies, measures, and tests electric circuit components (e.g., resistors capacitors, inductors, transistors, LEDs, amplifiers, oscillators, integrated circuits, regulated power supplies).	21. Given a schematic circuit diagram, the student identifies the components, verifies them by measurements (e.g., finds the actual resistance of a resistor with a meter), constructs a circuit, and tests its operation. ✓ correct identification of components ✓ accurate measurements ✓ selection of proper equipment and appropriate lab safety ✓ working circuit verified with appropriate tests
	22. Understands circuit schematic diagrams including the following: • proper symbols, • current flow, and • component values.	22. Given a circuit diagram, the student identifies each component (e.g., resistors, capacitors, op amps, logic gates) and their properties or values (e.g., resistance values, power ratings) when appropriate and determines the function of the circuit. ✓ correct identification of components ✓ accurate properties/values

		✓ determination of circuit function
	23. Applies circuit principals (e.g., de Morgan's Theory, Ohm's Law, Kirchoff's Law, power formulas) for schematic diagrams and calculations.	23. The student analyzes a combinational circuit diagram and determines total input and output through each leg, voltages at various points with respect to ground or between two points, and the power requirements for the components. ✓ appropriate application of Ohm's and Kirchhoff"s Laws ✓ appropriate application of de Morgan's theory ✓ accurate calculations ✓ correct choice of power requirements
	24. Explains how electronic components function in AC and/or DC circuits.	24. The student describes the voltage biases necessary and current flows through transistors and explains their operation on the atomic level (i.e., p-type and n-type materials) in a DC circuit. ✓ accurate description of necessary voltage biases ✓ correct identification of current flow directions ✓ clear description of transistor properties and operation on the atomic level
	25. Analyzes a circuit diagram and its input/output signals (e.g., power, voltage, current, resistance).	25. Given a digital logic circuit diagram (e.g., counter, R latch, J-K flip-flop), the student predicts the output signal(s) (e.g., high or low) based on the input signal(s). ✓ correct signal progression at each point in the circuit ✓ correct output signal(s)
	26. Understands logic symbols and truth tables for digital logic circuits.	26. Given a diagram with a string of logic gates, the student constructs a truth table for the input/output signals. ✓ accurate truth table
	27. Understands the usefulness of sensors (e.g., motion, light, temperature, carbon monoxide, pH, radiation, noise).	27. The student, as part of a small group, constructs a circuit and simple counter that detects motion and moves a digital display up one number. Variations can include a digital thermometer, traffic switching, and light levels. ✓ efficient and neatly laid-out circuit ✓ efficient use of detectors and display
	28. Employs scientific trouble-shooting methods in circuits.	28. The student uses efficient trouble-shooting techniques to find a fault in a circuit. ✓ portions of circuit divided/isolated ✓ repetition of process to demonstrate an understanding that faults cause voltage/resistance changes

STRAND III: SCIENCE AND SOCIETY
CONTENT STANDARD: The student understands how scientific discoveries, inventions, practices, and knowledge influence and are influenced by individuals and societies.

BENCHMARK: The student examines and analyzes how scientific discoveries and their applications affect the world and explains how societies influence scientific investigations and applications.

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	Science and Technology 1. Knows how science enables technology but also constrains it, and recognizes the difference between real technology and science fiction (e.g., rockets vs. antigravity machines, nuclear reactors vs. perpetual-motion machines, medical X-rays vs. Star-Trek tricorders) (NM-III.I.I.1). 2. Understands how advances in technology (e.g., microscopes and cellular structure, telescopes and understanding of the universe) enable further advances in science (NM-III.I.I.2). 3. Evaluates the influences of technology on society (e.g., communications, petroleum, transportation, nuclear energy, computers, medicine, genetic engineering) including both desired and undesired effects, and including some historical examples (e.g., the wheel, the plow, the printing press, the lightning rod) (NM-III.I.I.3). 4. Understands the scientific foundations of common technologies (e.g., kitchen appliances, radio, television, aircraft, rockets, computers, medical X-rays, selective breeding, fertilizers and pesticides, agricultural equipment) (NM-III.I.I.4). 5. Analyzes the impact of digital technologies on the availability, creation, and dissemination of information (NM-III.I.I.6). **Science and Society** 6. Knows that societal factors (e.g., government funding, laws and regulations about human cloning and genetically modified organisms, gender and ethnic bias, AIDS research, alternative-energy research) can promote or constrain scientific discovery (NM-III.I.I.11).	1 – 9. The student researches semiconductor devices (e.g., biosensors, robotics, silicon wafers). The research includes the following: • manufacture, • new developments, • careers, • use, and • interviews with people in field He/ She writes a technical paper and presents findings using technology (e.g., PowerPoint, slide show), referring to a rubric for criteria. ✓ research sources cited ✓ proper format ✓ all components of a technical paper included ✓ effective presentation ✓ clear communication ✓ adherence to rubric The student visits area cluster feeder schools and makes a presentation to energize and excite elementary and middle school students about careers in science. ✓ proper dress ✓ effective presentation ✓ clear communication ✓ adherence to rubric ✓ audience response

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	Science and the Individual 7. Identifies how science has produced knowledge that is relevant to individual health and material prosperity (NM-III.I.I.15). 8. Understands that scientists have characteristics in common with other individuals (e.g., employment and career needs, curiosity, desire to perform public service, greed, preconceptions and biases, temptation to be unethical, core values including honesty and openness) (NM-III.I.I.18). 9. Knows that science plays a role in many different kinds of careers and activities (e.g., public service, volunteers, public office holders, researchers, teachers, doctors, nurses, technicians, farmers, ranchers) (NM-III.I.I.19).	7 – 9. See Strand III (Science and Society) Illustration #1 – 9.

STRAND IV: LITERACY
CONTENT STANDARD: The student communicates scientific principles through reading, writing, and speaking opportunities.

BENCHMARK: The student demonstrates proficiency in reading comprehension, specialized vocabulary, and a variety of writing and speaking requirements.

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	1. Develops and demonstrates proficiency with the following strategies to approach reading for information across content areas (APS – LA I.1): • scans reading selection to determine whether a text contains relevant information, • uses the headings and subheadings of the material to make predictions and to validate comprehension of text, • reads and rereads to decode meaning, and • reviews and summarizes essential elements of text for overview. 2. Uses textual evidence to develop and support an interpretation of a scientific process or concept (APS – LA II.2). 3. Develops increased competence in using the writing process to create a final product (APS – LA III.1). 4. Develops increased competence in using elements of effective writing (APS – LA III.2). 5. Supports an informed opinion (APS – LA III.6): • uses appropriate language, reasoning, and organizational structure for the audience and purpose, • provides relevant and convincing reasons, uses various types of evidence, and • demonstrates an awareness of possible questions, concerns, or counterarguments. 6. Responds to a variety of written, electronic, and other media (APS – LA III.7). 7. Develops increased competence with speaking and language conventions (APS – LA IV.3).	1 – 7. See Strand III (Science and Society) Illustration #1 – 9.