APS DISTRICT HIGH SCHOOL SCIENCE CURRICULUM FRAMEWORK

Course Title: Photonics **Course Number:** 44117

Department: Science **ADS Number:** 17344944

Prerequisites: Chemistry I and Pre-Engineering/Electronics

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

Important Notes:

It is highly recommended that the student has completed or is concurrently enrolled in Algebra II.

There is a lab fee, part of which pays dues to the SPIE, the student chapter of the International Society for Optical Engineers, the balance to pay for supplies needed for holography, laser engraving, and transportation.

COURSE DESCRIPTION:

This laboratory course* is designed to introduce the student to fiber optics and optical transducer theory including the basics of laser safety and operation. He/She learns the elements of laser theory, the safety procedures concerning lasers and related equipment; fiber optics, including the theory and operation of fiber optics, handling of fiber optics, integrated optics, wave-guided transmission, optical circuitry, fiber optic components, and holography.

* 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 APS 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 authentic and performance-based assessment, 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:
- STEP I and II *Scientific and Technological Education in Photonics.* Hull, D., Seber, F., Guenther, A., Roychoudhuri, C. (CORD 2004)
- *Mathematics for Photonics Education* (CORD 2003)
- *Basics of Photonics.* Vasan, Srini 2004. Trafford Publishing. Victoria, British Columbia, Canada
- *Shoebox Holography* DeFreitas, F., Rhody, A., Michael, S. (Ross Books, Berkeley, CA)
- *Practical Holography Third Edition* Saxby, G. (IOP 2003)

- http://www.aps.edu/aps/wmhs/atca/academies.html West Mesa High Schools Academy home page
- http://www.aps.edu/aps/wmhs/atca/acad_photo_links.html West Mesa High Schools Photonics Academy website links (well worth the visit)
- http::://cord.org/STEPII/ Center for Occupational Research and Development Optics page; includes Applets
- http://www.spie.org/ The International Society for Optical Engineering
- http://www.osa.org/ The Optical Society of America
- http://www.lightandmatter.com/area1book5.html *Optics***,** an online physics book
- http://home.planetinternet.be/~poolly/eng/part4.html Applets related to optics
- http://www.opticsforkids.org/biomed/bio-optic.cfm Welcome to World of Optics in Biomedical/health
- http://info.phys.uvic.ca/dbr/resman/optics.html List of demonstrations of optics
- http://planet.tvi.edu/srini/ TVI's Srini Vasan/s home page. Valuable links and information
- http://www.tvi.cc Albuquerque TVI home page
- http://www.designerinlight.com/holo/books.htm Links to holography texts and websites

Approved by HSCA: 12/04

STRAND I: SCIENTIFIC 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 observation 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 the following: • 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 (NM-I.I.I.2). 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 the following: • 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

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	• reasoned arguments (NM-I.I.I.4). 5. Understands how scientific theories are used to explain and predict natural phenomena (e.g., plate tectonics, ocean currents, structure of atom) (NM-I.I.I.5). 6. Understands how scientific processes produce valid, reliable results, including the following: • 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 (NM-I.I.II.1). 7. Uses scientific reasoning and valid logic to recognize the following: • faulty logic, • cause and effect, • the difference between observation and unsubstantiated inferences and conclusions, and • potential bias (NM-I.I.II.2). 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).	-FOR EXAMPLE- After completing laser safety training, the student performs a lab on laser power reading that includes the following: • set up of all electronics that control laser and sensors by the following: • mounting optics, • aligning laser, optics, and meter, and • using safety check list √ classification of lasers with associated hazard √ identification of tissues affected by various laser radiation √ documentation of all safety videos and presentations √ recognition of safety risks and appropriate actions taken to minimize or eliminate risks √ calculation and map of the region of maximum permissible exposure √ accurate power meter set up √ accurate power reading graph -ALSO- As part of a pair, the student sets up an optics light show. The show includes the following elements: • set up of all electronics that control motors and drivers, • mounting optics, • aligning optics, and • display. The student demonstrates lissajous patterns that can be created based on his/her setup. √ quality of display √ quality of setup √ proper wiring of digital driver √ interface with input device √ accurate explanation of how patterns are created

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: 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 transformation and transmission of energy and how energy and matter interact.
C. The student understands the motion of objects and waves and the forces that cause them.

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	Structure of Matter 1. Understands that matter is made of atoms and that atoms are made of subatomic particles (NM-II.I.I.5). 2. Understands atomic structure, including the following: • most space occupied by electrons, • nucleus made of protons and neutrons, • isotopes of an element, • masses of proton and neutron 2000 times greater than mass of electron, and • atom held together by proton-electron electrical forces (NM-II.I.I.6). 3. Explains how electrons determine the properties of substances by the following: • interactions between atoms through transferring or sharing valence electrons, • ionic and covalent bonds, and • the ability of carbon to form a diverse array of organic structures (NM-II.I.I.7). 4. Knows that some atomic nuclei can change, including the following: • spontaneous decay, • half-life of isotopes, • fission, • fusion (e.g., the sun), and • alpha, beta, and gamma radiation (NM-II.I.I.11).	1, 2, 11, 12. The student diagrams an atom to show structure and different energy levels of the electrons and the emission of photons. √ spectrum analysis of various gases √ accurate diagram √ identification of gas by spectrum √ calculation of the electron volt potential of energy levels and the associated wavelengths and frequencies 3. After listening to a guest speaker from the Starfire Optical Range, the student composes an essay on the information he/she gathered. √ clear communication √ accurate information √ writing conventions √ thoroughness 4, 9, 13. The student uses visuals to explain how the excitation of one type of gas causes another gas to give off a single wave length of spectrum. This is called the lasing process. √ clear communication √ distinction between spontaneous and stimulated radiation √ accuracy √ supportive visuals √ calculation of energy transfer

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	Energy Transformation and Transfer 5. Identifies different forms of energy, including kinetic, gravitational (i.e., potential), chemical, thermal, nuclear, and electromagnetic (NM-II.I.II.1).	5. The student converts wavelength and frequency in various units to make size comparisons between various types of electronegative energy. √ accurate calculations √ sequencing √ classification
	6. 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).	6 – 8. The student draws the components of lasers, identifies the different components, and describes the function of each component. He/She analyzes three different types of lasers, comparing and contrasting how they work together and writes an analysis of findings. √ accurate diagrams √ correct identification of component and its function √ thorough, accurate analysis of how components work together √ laser cavity configuration and losses in a laser cavity √ TEM modes and their significance √ laser beam properties
	7. 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).	
	8. Understands that the ability of energy to do something useful (i.e., work) tends to decrease and never increases as energy is converted from one form to another (NM-II.I.II.6).	
	Interactions of Energy and Matter 9. Understands that electromagnetic waves carry energy that can be transferred when they interact with matter (NM-II.I.II.7).	9. See Strand II (Content of Physical Science) Illustration #1, 2, 11, 12 and Illustration #4, 9, 13, and Illustration #5.
	10. 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), including the following: • origin and potential hazards of various forms of electromagnetic radiation, and • energy of electromagnetic waves carried in discrete energy packets (i.e., photons) whose energy is inversely proportional to wavelength (NM-II.I.II.8).	10, 16 – 19. The student researches the safety risks that different electromagnetic waves have on his/her body [e.g., different lasers affect different structures (e.g., cornea, optic nerve retina) of the eye]. Following the research, the student prepares a report containing visuals and presents it to the class. √ accurate information √ thoroughness √ citation of sources √ clear communication √ identification of relationship between laser type and area affected
	11. Knows that each kind of atom or molecule can gain or lose energy only in discrete amounts (NM-II.I.II.9).	11, 12. See Strand II (Content of Physical Science) Illustration #1, 2, 11, 12 and Illustration #5.
	12. Explains how wavelengths of electromagnetic radiation can be used to identify atoms, molecules, and the composition of stars (NM-II.I.II.10).	

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	13. Understands the concept of equilibrium (i.e., thermal, mechanical, and chemical) (NM-II.I.II.11).	13. See Strand II (Content of Physical Science) Illustration #4, 9, 13.
	Forces 14. Knows that materials containing equal amounts of positive and negative charges are electrically neutral but that a small excess of deficit of negative charges produces significant electrical forces (NM-II.I.III.3).	14, 15. The student successfully sets up a telecommunications lab that demonstrates how energy changes from mechanical to electricity to optical and then reverses the process back to mechanical. √ working model √ proper wiring √ alignment of laser, optics or fiber, and photo diode √ simulation of relay station √ documentation in lab book includes analysis, procedure, diagram
	15. Explains how electric currents cause magnetism and how changing magnetic fields produce electricity (e.g., electric motors, generators) (NM-II.I.III.5).	
	16. Represents the magnitude and direction of forces by vector diagrams (NM-II.I.III.6).	16 – 20. As part of a holographic study, the student creates a model or uses a model created by an art class. After mounting the model, the student sets up a holographic camera, tests for exposure time (i.e., power of expanded beam), shoots a holographic image of the model, and develops the film. He/She uses a rubric to assess quality of product and analyzes how the product might be improved. √ all steps completed √ quality hologram √ accurate assessment √ accurate analysis
	Motion 17. Describes relative motion using frames of reference (NM-II.I.III.10).	
	18. Describes wave propagation using amplitude, wavelength, frequency, and speed (NM-II.I.III.11).	
	19. Explains how the interactions of waves can result in interference, reflection, and refraction (NM-II.I.III.12).	
	20. Describes how waves are used for practical purposes (e.g., seismic data, acoustic effect, Doppler effect) (NM-II.I.III.13).	

STRAND III: EARTH AND SPACE SCIENCE
CONTENT STANDARD: The student understands the structure of Earth, the solar system and the universe, the interconnections among them, and the processes and interactions of Earth's systems.

BENCHMARK: The student examines the scientific theories of the origin, structure, contents, and evolution of the solar system and the universe and their interconnections.

GRADE 11 - 12	PERFORMANCE STANDARDS	ILLUSTRATIONS
	1. Understands the scale and contents of the universe including the range of structures from atoms through astronomical objects to the universe (NM-II.III.I.1).	1. The student maps out various EM waves and associates them with the range structures in the universe. √ accurate maps √ accurate associations
	2. Understands how knowledge about the universe comes from evidence collected from advanced technology (e.g., telescopes, satellites, images, computer models) (NM-II.III.I.3). 3. Explains how objects in the universe emit different electromagnetic radiation and how this information is used (NM-II.III.I.5).	2, 3. Using data collected from telescopes and satellites, the student explains how spectrum analysis Doppler shift tells us about the universe. √ accurate explanation
	4. Examines the role that New Mexico research facilities (e.g., Very Large Array, Goddard Space Center) play in current space exploration (NM-II.III.I.7).	4. See Strand II (Content of Physical Science) Illustration #3.

STRAND IV: SCIENCE AND SOCIETY
CONTENT STANDARD: The student understands how scientific discoveries, iinventions, 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, plow, printing press, 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). 6. Describes uses of radioactivity (e.g., nuclear power, nuclear medicine, radiometric dating) (NM-III.I.I.8).	1 – 12. The student researches a topic in photonics (e.g., how a CD works, medical imaging, telescope), using a variety of sources. He/She writes a technical paper that includes the following: all of the facts on how the equipment works, a diagram and several other visuals related to the topic, and information regarding careers in the field. The student presents the paper to the class using technology (e.g., PowerPoint), using a rubric as a guide. √ research sources cited √ proper format √ all components of a technical paper included √ effective presentation √ clear communication √ adherence to rubric -ALSO- The student visits area cluster feeder schools and gives 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 Society 7. Describes how scientific knowledge helps decision makers with local, national, and global challenges (e.g., Waste Isolation Pilot Project [WIPP], mining, drought, population growth, alternative energy, climate change) (NM-III.I.I.9). 8. Describes how environmental, economic, and political interests impact resource management and use in New Mexico (NM-III.I.I.13). **Science and the Individual** 9. Identifies how science has produced knowledge that is relevant to individual health and material prosperity (NM-III.I.I.15). 10. Identifies important questions that science cannot answer (e.g., questions that are beyond today's science, decisions that science can only help to make, questions that are inherently outside of the realm of science) (NM-III.I.I.17). 11. 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). 12. 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).	10 – 12. See Strand IV (Science and Society) Illustration #1 – 12.

STRAND V: 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 II (Content of Physical Science) Illustration #3 and Illustration #4, 9, 13. Also see student lab notebook. -AND- See Strand IV (Science and Society) Illustration #1 - 12.