PBL Challenge: Blinded by the Light
International Laser Display Association

In this PBL challenge, you will investigate an incident of a laser targeting an aircraft.

Photonics Principles Reinforced:

Laser divergence	Irradiance
Maximum permissible exposure	Laser safety

Science, Technology, and Mathematics content standards and benchmarks for grades 9 – 12 addressed by this *Photon PBL Challenge: Blinded by the Light* are included in the following document.

National Science Education Standards: Fundamental Concepts and Principles

This Photon PBL Challenge, *Blinded by the Light* is aligned with the following science content standards from *Science as Inquiry and Content Standards* for Grade 9-12. Refer to *National Science Education Standards* issued by the National Committee on Science Education for the complete standards. ***(http://www.nap.edu/openbook.php?record_id=4962)***

Content Standard: Science as Inquiry

Fundamental abilities and concepts that underlie this standard include: Understandings About Scientific Inquiry

- Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.
- Scientists conduct investigations for a wide variety of reasons. For example, they may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories.
- Scientists rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used.
- Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results.

- Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge.
- Results of scientific inquiry—new knowledge and methods—emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation.

Content Standard: Physical Science

Fundamental underlying concepts and principles include: Interactions of Energy and Matter

- Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.
- Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.
- Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.

Content Standard: Science and Technology

Fundamental concepts and principles that underlie this standard include: Understandings About Science and Technology

- Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations. Many scientific investigations require the contributions of individuals from different disciplines, including engineering. New disciplines of science, such as geophysics and biochemistry often emerge at the interface of two older disciplines.
- Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.
- Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.
- Science and technology are pursued for different purposes. Scientific inquiry is driven by the desire to understand the natural world, and technological design is driven by the need to meet human needs and solve human problems. Technology, by its nature, has a more direct effect on society than science because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations. Technological solutions may create new problems. Science, by its nature, answers questions that may or may not directly influence humans. Sometimes scientific advances challenge people's beliefs and practical explanations concerning various aspects of the world.

Content Standard: Science in Personal and Social Perspectives

Fundamental concepts and principles that underlie this standard include: Science and Technology in Local, National, and Global Challenges

- Progress in science and technology can be affected by social issues and challenges. Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology.
- Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them. Students should understand the appropriateness and value of basic questions—"What can happen?"—"What are the odds?"—and "How do scientists and engineers know what will happen?"

Content Standard: History and Nature of Science

Fundamental underlying concepts and principles include: Science as a Human Endeavor

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.
- Scientists have ethical traditions. Scientist's value peer review, truthful reporting about the methods and outcomes of investigations, and making public the results of work. Violations of such norms do occur, but scientists responsible for such violations are censured by their peers.

Nature of Scientific Knowledge

- Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.
- Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science such as the conservation of energy or the laws of motion have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested. In areas where data or understanding are incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest.

Standards for Technological Literacy/STL: Content for the Study of Technology

This PBL Challenge, *Blinded by the Light* is aligned with the technology content standards from *Standards for Technological Literacy/STL 3rd edition* for Grades 9-12. The following standards with accompanying benchmarks detail the particular knowledge required to meet the standard. Refer to the *Standards for Technological Literacy* published by the International Technology Education Association for the complete standards and benchmarks. ***(http://www.iteaconnect.org/TAA/Publications/TAA_Publications.html)***

Content Standard: An understanding of the characteristics and scope of technology

Conceptual understandings and abilities required for this standard:

- The nature and development of technological knowledge and processes are functions of the setting.
- Inventions and innovations are the results of specific, goal-directed research.
- Most development of technologies these days is driven by the profit motive and market.

Content Standard: An understanding of the core concepts of technology

Conceptual understandings and abilities required for this standard:

- Selecting resources involves tradeoffs between competing values, such as availability, cost, desirability, and waste.
- Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.
- Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.
- Quality control is a planned process to ensure that a product, service, or system meets established criteria.
- Management is the process of planning, organizing, and controlling work.

Content Standard: An understanding of the relationships among technologies and the connections between technology and other fields of study

Conceptual understandings and abilities required for this standard:

- Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.
- Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across fields.
- Technological ideas are sometimes protected through the process of patenting.
- Technological progress promotes the advancement of science and mathematics.

National Mathematics Standards: Principles and Standards for School Mathematics

This Photon PBL Challenge, *Blinded by the Light* is aligned with the mathematics content standards from the *National Mathematics Standards: Principles and Standards for School Mathematics* for Grades 9-12. The following content standards with specific expectations for each standard specify the particular knowledge required to meet the standard. Refer to the *National Mathematics Standards: Principles and Standards for School Mathematics* issued by the National Council of Teachers of Mathematics for the complete standards. ***(http://standards.nctm.org/document/chapter7/index.htm)***

Content Standard: Numbers and operations for grades 9-12

Content goal: Understand numbers, ways of representing numbers, relationships among numbers, and number systems

Expectations to meet the standard include:

- Develop a deeper understanding of very large and very small numbers and of various representations of them.
- Develop fluency in operations with real numbers, vectors, and matrices, using mental computation or paper-and-pencil calculations for simple cases and technology for more-complicated cases.
- Judge the reasonableness of numerical computations and their results.

Content Standard: Algebra for grades 9-12

Content goal: Represent and analyze mathematical situations and structures using algebraic symbols

Expectations to meet the standard include:

- Understand the meaning of equivalent forms of expressions, equations, inequalities, and relations
- Use symbolic algebra to represent and explain mathematical relationships
- Judge the meaning, utility and reasonableness of the results of symbol manipulations, including those carried out by technology.

Content Standard: Geometry standard for grades 9-12

Content goal: Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships

Expectations to meet the standard include:

- Establish the validity of geometric conjectures using deduction, prove theorems, and critique arguments made by others;
- Use trigonometric relationships to determine lengths and angle measures.

Content goal: Use visualization, spatial reasoning, and geometric modeling to solve problems

Expectations to meet the standard include:

- Use geometric models to gain insights into, and answer questions in other areas of mathematics
- Use geometric ideas to solve problems in and gain insights into other disciplines and other areas of interests such as art and architecture.

Content Standard: Measurement standard for grades 9-12

Content goal: Understand measurable attributes of objects and the units, systems, and processes of measurement

Expectations to meet the standard include:

- Make decisions about units and scales that are appropriate for problem situations involving measurement.

Content goal: Apply appropriate techniques, tools, and formulas to determine measurements

Expectations to meet the standard include:

- Analyze precision, accuracy, and approximate error in measurement situations.
- Understand and use formulas for the area, surface area, and volume of geometric figures, including cones, spheres and cylinders.

Content Standard: Connections standard for grades 9-12

Expectations to meet the standard include:

- Recognize and use connections among mathematical ideas.
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole.
- Recognize and apply mathematics in contexts outside of mathematics.