High School Physical Science

Instructional Focus:		
• Describe the Scientific Method in solving a problem or question. • Demonstrate the scientific method by identifying the relationship between a manipulated/independent variable and a responding/dependent variable. • Given a data set, develop an appropriate, correctly labeled data table and graph. • Using graphs and data tables; identify trends and analyze these trends to support conclusions. • Write conclusions that are logical and supported by evidence. • Solve a problem or question, of your own design, applying the various steps of the scientific method.		
Matter and its Interactions		
Cross Cutting: • HS.PS1-1. Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. • HS.PS1-4. Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. • HS.PS1-7. The total amount of energy and matter in closed systems is conserved. • Scientific Knowledge Assumes an Order and Consistency in Natural Systems-Science assumes the universe is a vast single system in which basic laws are consistent. • HS.PS1-8. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.		
Standard	**Objective**	**Examples**
HS.PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. **HS.PS1.A** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. **[9] MSBSD.SB1.1** Describing atoms and their base components (i.e., protons, neutrons, electrons). **[10] MSBSD.SB1.1** Using the periodic table to describe atoms in terms of their base components (i.e., protons, neutrons, electrons). **[10] MSBSD.SB3.1** Describing the behavior of electrons in chemical bonding.	***Investigate our current understanding of the atom.*** Students will: • Examine the structure of the atom in terms of proton, electron, and neutron locations, atomic mass and atomic number, as well as atoms with different numbers of neutrons (isotopes). • Explain the relationship of the proton number to the element's identity. • Compare and contrast ionic and covalent bonds in terms of electron movement.	• Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.

HS.PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.	***Explore the nature of matter, its classifications, and its system for naming types of matter.*** Students will: • Calculate density when given a means to determine a substance's mass and volume. • Predict formulas for stable binary ionic compounds based on balance of charges. • Demonstrate the Law of Conservation of Matter in a chemical reaction. • Apply the Law of Conservation of Matter by balancing the following types of chemical equations: Synthesis, Decomposition, Single Replacement, and Double Replacement.	
HS.PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level atoms.	***Investigate the arrangement of the periodic table.*** Students will: • Investigate and understand the organization and use of the periodic table of elements to obtain information.	• Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.
HS.PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. **HS.PS1-7.** Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. **HS.PS1.B** The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. **[9] MSBSD.SB3.1** Recognizing that a chemical reaction has taken place. **SB3.2** Explaining that in chemical and nuclear reactions, energy (e.g., heat, light, mechanical, and electrical) is transferred into and out of a system. **[10] MSBSD.SB1.1** Using the periodic table to describe atoms in terms of their base components (i.e., protons, neutrons, electrons). **SB3.2** Recognizing that radioactivity is a result of the decay of unstable nuclei.	Students will: • Investigate and understand changes in matter and the relationship of these changes to the Law of Conservation of Matter an Energy. • Recognize indicators of chemical reactions e.g. color change, gas production precipitate formation, etc.	• Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen. • Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. • Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.
HS.PS1-4. Develop a model to illustrate that the release or absorption of energy from a	***Describe how energy is produced and absorbed in chemical reactions.*** Students will:	• Emphasis is on the idea that a chemical reaction is a system that affects the energy change.

chemical reaction system depends upon the changes in total bond energy. **HS.PS1.A** A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. **HS.PS1.B** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	• Compare and contrast endothermic and exothermic reactions. • Investigate changes in matter and the relationship of these changes to the Law of Conservation of Matte and Energy. Key concepts include: physical changes, chemical changes, and nuclear reactions.	• Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.
HS.PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. **[9] MSBSD.SB3.1** Recognizing that a chemical reaction has taken place. **SB3.2** Explaining that in chemical and nuclear reactions, energy (e.g., heat, light, mechanical, and electrical) is transferred into and out of a system.	Students will: • Describe properties of solutions in terms of solute/solvent, conductivity, concentration. • Observe factors affecting the rate a solute dissolves in a specific solvent. • Demonstrate that solubility is related to temperature by constructing a solubility curve. • Compare and contrast the components and properties of acids and bases. • Determine whether common household substances are acidic, basic, or neutral.	• Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.
HS.PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. **HS.PS1.C** Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. **[9] MSBSD.SB3.2,** Explaining that in chemical and nuclear reactions, energy (e.g., heat, light, mechanical, and electrical) is transferred into and out of a system. **[10] MSBSD.SB3.2** Recognizing	***Distinguish the characteristics and components of radioactivity.*** Students will: • Differentiate among alpha and beta particles and gamma radiation. • Differentiate between fission and fusion. • Explain the process half-life as related to radioactive decay. • Describe nuclear energy source, and its practical application as an alternative energy source, and its potential problems.	• Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.

that radioactivity is a result of the decay of unstable nuclei.		

Motion and Stability: Forces and Interactions

Cross Cutting:

- HS.PS2-1. Cause and Effect–Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- HS.PS2-2. Systems and System Models–When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.
- HS.PS2-4. Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Standard	Objective	Examples
HS.PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. **[9]** **MSBSD.SB4.1** Explaining the relationship of motion to an object's mass and the applied force. **HS.PS2.A** Newton's second law accurately predicts changes in the motion of macroscopic objects.	***Determine relationships among force, mass and motion.*** Students will: • Create and demonstrate the physical relationships in Newton's Second Law of Motion F=ma. • Demonstrate the mathematical relationships in Newton's Second Law of Motion F=ma. • Calculate velocity and acceleration. • Apply Newton's three laws to everyday situations by explaining the following: inertia, relationship between force, mass and acceleration, equal and opposite forces, relate falling objects to gravitational force explain the difference in mass and weight. • Investigate and understand the scientific principles of work, force, and motion. Key concepts include: speed, velocity, and acceleration, Newton's laws of motion, work, force, mechanical advantage, efficiency and power; and technological applications of work, force and motion.	• Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.
HS.PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. **HS.PS2.** A momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.	Students will: • Describe that momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. • Describe the law of conservation of momentum. • Calculate momentum.	• Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.

HS.PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. **HS.PS2.B** Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.	Students will: • Describe that the gravitational attraction between two objects is proportional to their masses and decreasing with their distances. • Recognize that the gravitational attraction between objects is proportional to their masses and decreasing with their distance. • Determine the effect of the gravitational force of the sun and moon on tides.	• Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.
HS.PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. **HS.PS2.B** Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. **HS.PS3.A** "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents.	***Investigate the properties of electricity and magnetism.*** Students will: • Investigate static electricity in terms of friction induction conduction. • Explain the flow of electrons in terms of alternating and direct current. • Explain the relationship among voltage, resistance and current. • Describe simple series and parallel circuits. • Investigate applications of magnetism and/or its relationship to the movement of electrical charge as it relates to electromagnets, simple motors and permanent magnets. • Understand basic principles of conductors, semiconductors, and insulators.	

Energy

Cross Cutting:

- HS.PS3-1. Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems–Science assumes the universe is a vast single system in which basic laws are consistent.
- Energy and Matter–Energy cannot be created or destroyed–only moves between one place and another place, between objects and/or fields, or between systems.
- HS.PS3-3. Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.
- Influence of Science, Engineering and Technology on Society and the Natural World–Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.
- HS.PS3-5. Cause and Effect–Relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.

Standard	Objective	Examples
HS.PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). **HS.PS3-1.** Create a computational model to calculator the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. **HS.PS3.A** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	***Relate transformations and flow of energy within a system.*** Students will: • Distinguish between forms of energy and how energy is transferred and transformed include, potential and kinetic energy; and mechanical, chemical, electrical, thermal, radiant, and nuclear energy. • Identify energy transformations within a system (e.g. lighting of a match). • Investigate molecular motion as it relates to thermal energy changes in terms of conduction, convection, and radiation.	• Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. • Examples of models could include diagrams, drawings, descriptions, and computer simulations.

HS.PS4-1. Waves and their Applications in Technologies for Information Transfer

Cross Cutting:

- HS.PS4-1. Cause and Effect–Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.
- Stability and Change–Systems can be designed for greater or lesser stability.
- Influence of Engineering, Technology, and Science on Society and the Natural World–Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.
- Systems and System Models–Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions-including energy, matter, and information flows-within and between systems at different scales.
- HS.PS4-4. Cause and Effect–Relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.
- HS.PS4-5. Cause and Effect–Systems can be designed to cause a desired effect.
- Interdependence of Science, Engineering, and Technology–Science and engineering complement each other in the cycle known as research and development (R&D).

Standard	Objective	Examples
HS.PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. **HS.PS4.A** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	***Investigate the properties of waves.*** Students will: • Recognize that all waves transfer energy. • Relate frequency and wavelength to the energy of different types of electromagnetic waves and mechanical waves. • Compare and contrast the characteristics of electromagnetic and mechanical (sound) waves. • Investigate the phenomena of reflection, refraction, interference, and diffraction. • Relate the speed of sound to different mediums. • Explain the Doppler Effect in terms of everyday interactions. • Investigate and understand the characteristics of transverse waves include wavelength, frequency, speed, amplitude, crest, and trough. • Describe the wave behavior of light. • Research how humans use waves in technology. • Investigate images formed by lenses and mirrors the electromagnetic spectrum.	• Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.
The following standards can be used as extensions.		
Standard	**Objective**	**Examples**
HS.PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. **HS.PS3.A** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **HS.PS3.D** Although energy cannot be destroyed, it can be converted to less useful forms-for example, to thermal energy in the surrounding environment. **ETS1.A** Criteria and constraints to satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	Students will: • Understand at the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • Use criteria and constraints to satisfy any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	• Emphasis is on both qualitative and quantitative evaluations of devices. • Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. • Examples of constraints could include use of renewable energy forms and efficiency.
HS.PS3-5. Develop and use a model of two objects interacting through electric or	Students will:	• Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two

magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. **HS.PS3.C** When two objects interacting through a field change relative position, the energy stored in the field is changed.	• Demonstrate when two objects interacting through a field change relative position, the energy stored in the field is changed.	charges of opposite polarity are near each other.
HS.PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information.	Students will: • Know the information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	• Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. • Disadvantages could include issues of easy deletion, security, and theft.
HS.PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. **HS.PS4.B** Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.	Students will: • Evaluate that waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) • Identify that electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.	• Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. • Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.
HS.PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. **HS.PS4.B** When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.	Students will: • Know when light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.	• Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. • Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.

HS.PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. **HS.PS3.D** Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. **HS.PS4.A** Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. **HS.PS4.B** Photoelectric materials emit electrons when they absorb light of a high-enough frequency. **HS.PS4.C** Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	Students will: • Communicate that solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. • Understand the information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. • Demonstrate photoelectric materials emit electrons when they absorb light of a high-enough frequency. • Use multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, and scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	• Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.
HS.ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. **HS.ETS1.A** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. Humanity faces major global challenges today, such as the need for supplies of clean water and	Students will: • Analyze criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • Understand that humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	

food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.		
HS.ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. **HS.ETS1.C** Criteria may need to be broken down into simpler ones that can be approached systemically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	Students will: • Analyze criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	
HS.ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. **HS.ETS1.B** Complicated problems may need to be broken down into simpler components in order to develop and test solutions. When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. Testing should lead to improvements in the design through an iterative procedure.	Students will: • Know that when evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	

HS.ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. **HS.ETS1.B** Complicated problems may need to be broken down into simpler components in order to develop and test solutions. When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. Testing should lead to improvements in the design through an iterative procedure.	Students will: • Develop both physical models and know that computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	
HS.PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. **HS.PS2.A** Newton's second law accurately predicts changes in the motion of macroscopic objects, but it requires revision for subatomic scales or for speeds close to the speed of light. (Boundary: No details of quantum physics or relativity are included at this grade level.) **HS.ETS1.A** Design criteria and constraints, which typically reflect the needs of the end-user of a technology or process, address such things as the product's or system's function (what job it will perform and how), its durability, and limits on its size and cost. Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. **HS.ETS1.C** The aim of	Students will: • Understand that if a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. • Analyze the criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • Know the criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	• Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. • Examples of a device could include a football helmet or a parachute.

engineering is not simply to find a solution to a problem but to design the best solution under the given constraints and criteria. Optimization can be complex, however, for a design problem with numerous desired qualities or outcomes. Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. The comparison of multiple designs can be aided by a trade-off matrix. Sometimes a numerical weighting system can help evaluate a design against multiple criteria. When evaluating solutions, all relevant considerations, including cost, safety, reliability, and aesthetic, social, cultural, and environmental impacts, should be included. Testing should lead to design improvements through an iterative process, and computer simulations are one useful way of running such tests.		