Engineering, Technology, and Applications of Science
Grade Band End Point by the end of Grade 12

Core Ideas			SE, INV, TG, Ancillary (section, sheet, or investigation number and page number)	Notes
ETS1		**ENGINEERING DESIGN** ***How do engineers solve problems?***		
ETS1.A		**Defining and Delimiting an Engineering Problem** ***What is a design for? What are the criteria and constraints of a successful solution?***		
		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.	SE: p 55, 123, 225, 268 ANC: Biography 12.3, biography 21.1	SE: Students are asked to design a backpack, a new shoe, a complex machine for doing a task, and a window with a high R-value ANC: Narcis Monturiol (submarine pioneer), George Westinghouse (train safety)
		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.	SE: p 73, 308-9, 434 (#5) TG: p 119, 439	SE: Risks in clinical trials for drugs, complexities associated with flying an airplane (air pressure), the role of health physicists TG: Hydroplaning in cars, risks -- static electricity at gas pumps
		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.	SE: p 377-8, 521, 522-3	SE: Whole-tire recycling, recycling cell phones, energy conservation and light bulb design
		These global challenges also may have manifestations in local communities.	SE: p 200-1 p 264-5 p 430-1	SE: Reducing environmental impact with human-powered transportation Environmental responsibility and green buildings Reducing carbon footprints
		But whatever the scale, the first things that engineers do is define the problem and specify the criteria and constraints for potential solutions.	SE: p 50 and 70, 522-3 INV: 12B, 12C TG: p 49 and 72, 601 ANC: Ch6 activity	SE: Engineering design cycle, designing energy-efficient light bulbs INV: Clay boat design TG: Design project and science reporting, definition of prototype ANC: Making a spool car
ETS1.B		**Developing Possible Solutions** ***What is the process for developing potential design solutions?***		
		Complicated problems may need to be broken down into simpler components in order to develop and test solutions.	SE: p 48-51, 70-1 INV: p 130 of 23A TG: p 48-9	SE: Solving problems, engineering design cycle INV: Design a clock TG: Solving problems
		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.	SE: p 72-73 p 156-7 p 182-3	SE: Ethics in medical research/drug development Car safety design, reducing the impact during a collision Using solar power to reduce the load that soldiers carry
		Testing should lead to improvements in the design through an iterative procedure.	SE: p 50 and 70, 51 TG: p 49	SE: Engineering design cycle, solving a design problem TG: A design project

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		Both physical models and computers can be used in various ways to aid in the engineering design process.	SE: p 46 p 220-1 p 626-7	SE: Scientists use mathematical models Prosthetic design Using computers/the importance of the Internet in astronomy
		Physical models, or prototypes, are helpful in testing product ideas or the properties of different materials.	SE: p 70-1, 404, 536 TG: 601	SE: Definition of a prototype, prototypes of hydrogen-powered cars, prototype of a maglev train TG: Definition of prototype
		Computers are useful for a variety of purposes, such as in representing a design in 3-D through CAD software; in troubleshooting to identify and describe a design problem; in 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.	SE: p 50 & 70, 221, 264 TG: p 206	SE: Engineering design cycle, computer modeling and prosthetics, designing efficient buildings TG: Motivate activity -- meeting a surgeon to learn about technologies involved in treating people
ETS1.C		**Optimizing the Design Solution** ***How can the various proposed design solutions be compared and improved?***		
		The aim of engineering is not simply to find a solution to a problem but to design the best solution under the given constraints and criteria.	SE: p 50, 51, 55 TG: p 49	SE: Design problems, students solve a design problem, design a backpack TG: Problem solving and design problems
		Optimization can be complex, however, for a design problem with numerous desired qualities or outcomes.	SE: p 69, 52-3, 156-7 TG: 73 ANC: Biography 18.3	SE: Scientists and engineers, science tools to study the ocean, forensic engineering and tools to understand a complex system TG: Models ANC: Rosalyn Sussman Yalow (engineer and medical scientist)
		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.	SE: p 72-73 p 156-7 p 182-3	SE: Ethics in medical research/drug development Car safety design, reducing the impact during a collision Using solar power to reduce the load that soldiers carry
		The comparison of multiple designs can be aided by a trade-off matrix.	SE: p 46 p 220-1 p 626-7	SE: Scientists use mathematical models Prosthetic design Using computers/the importance of the Internet in astronomy
		Sometimes a numerical weighting system can help evaluate a design against multiple criteria.	SE: p 50, 51, 55 TG: p 49	SE: Design problems, students solve a design problem, design a backpack TG: Problem solving and design problems

Core Ideas			SE, INV, TG, Ancillary (section, sheet, or investigation number and page number)	Notes
		When evaluating solutions, all relevant considerations, including cost, safety, reliability, and aesthetic, social, cultural, and environmental impacts, should be included.	SE: p 72-73 p 156-7 p 182-3	SE: Ethics in medical research/drug development Car safety design, reducing the impact during a collision Using solar power to reduce the load that soldiers carry
		Testing should lead to design improvements through an iterative process, and computer simulations are one useful way of running such tests.	SE: p 50 & 70, 221, 264 TG: p 206 ANC: skill and practice sheets 8.2	SE: Engineering design cycle, computer modeling and prosthetics, designing efficient buildings TG: Motivate activity -- meeting a surgeon to learn about technologies involved in treating people ANC: Solving efficiency and efficiency and energy problems
ETS2		**LINKS AMONG ENGINEERING, TECHNOLOGY, SCIENCE, AND SOCIETY** ***How are engineering, technology, science, and society interconnected?***		
ETS2.A		**Interdependence of Science, Engineering, and Technology** ***What are the relationships among science, engineering, and technology?***		
		Science and engineering complement each other in the cycle known as research and development (R&D).	SE: p 69, 52-3, 156-7 TG: 73 ANC: Biography 18.3	SE: Scientists and engineers, science tools to study the ocean, forensic engineering and tools to understand a complex system TG: Models ANC: Rosalyn Sussman Yalow (engineer and medical scientist)
		Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.	SE: p 72-73, 182-3, 220-1 TG: p 168	SE: Experts work as a team to develop drugs, to improve technology for soldiers, to design prosthetics TG: Students practice team work while designing experiments
		For example, developing a means for safely and securely disposing of nuclear waste will require the participation of engineers with specialties in nuclear engineering, transportation, construction, and safety; it is likely to require as well the contributions of scientists and other professionals from such diverse fields as physics, geology, economics, psychology, and sociology.		SE: Use of nuclear energy in various countries TG: Students discuss the pros and cons of nuclear technology
ETS2.B		**Influence of Engineering, Technology and Science on Society and the Natural World** ***How do science, engineering, and the technologies that result from them affect the ways in which people live? How do they affect the natural world?***		
		Modern civilization depends on major technological systems, including those related to agriculture, health, water, energy, transportation, manufacturing, construction, and communications.	SE: p 66, 71, 572-3, 264-5, 404-5 ANC: Biography 21.1	SE: Faraday's work and Maglev trains, cell phone technology, climate control systems, how hydrogen-powered cars could work ANC: Thomas Edison (pioneer in invention of modern technology)

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		Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	SE: p 66, 71, 572-3, 264-5, 404-5 ANC: Biography 21.1	SE: Faraday's work and Maglev trains, cell phone technology, climate control systems, how hydrogen-powered cars could work ANC: Thomas Edison (pioneer in invention of modern technology)
		Widespread adoption of technological innovations often depends on market forces or other societal demands, but it may also be subject to evaluation by scientists and engineers and to eventual government regulation.	SE: p 69, 70, 627 TG: p 73-2 ANC: Biography 21.1	SE: Innovation/invention, engineering cycle, an invention (a UV light detector) TG: Nature of science and technology ANC: George Westinghouse (inventor)
		New technologies can have deep impacts on society and the environment, including some that were not anticipated or that may build up over time to a level that requires attention or mitigation.	SE: p 24-5 TG: p 118-9 ANC: Biography 21.1	SE: Nanotechnology TG: Inventions and innovations related to friction forces ANC: Thomas Edison (pioneer of modern technology)
		Analysis of costs, environmental impacts, and risks, as well as of expected benefits, is a critical aspect of decisions about technology use.	SE: p 73, 100-1, 200-1, 264-5	SE: Risks in clinical trials for drugs, computers used to track and map seal migrations and reduce environmental impact of fisheries. reducing environmental impact with human-powered transportation, environmental responsibility and green buildings

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Grade Level	Standard		ITEA Benchmark/Standard	SE, INV, TG, Ancillary (section, sheet, or investigation number and page number)	Notes
	1		**Students will develop an understanding of the characteristics and scope of technology.**		
9to12	1	J	The nature and development of technological knowledge and processes are functions of the setting.	SE: p 100-1, 182-3, 200-1	SE: Satellites tags for seals, solar powered energy sources for soldiers, human-powered transportation
9to12	1	K	The rate of technological development and diffusion is increasing rapidly.	SE: p 60, 75, 157, 220 TG: p 312	SE: History of heat understanding/ challenge sidebar box, timeline of car development, advances in automobile safety, development of prosthetics TG: Students create a timeline of contributions to understanding the atom
9to12	1	L	Inventions and innovations are the results of specific, goal-directed research.	SE: p 69, 70, 627 ANC: Biography 21.1	SE: Innovation/invention, engineering cycle, an invention by an astrophysicist ANC: George Westinghouse (inventor and innovator)
9to12	1	M	Most development of technologies these days is driven by the profit motive and the market.	SE: p 73, 572-3 TG: p 571	SE: Drug research findings can be at odds with the market, cell phone technology TG: Use of color in marketing and business
	2		**Students will develop an understanding of the core concepts of technology.**		
9to12	2	W	Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.	SE: p 219 (sidebar) INV: 7A, 21A TG: p 160	SE: Biological systems thinking (biomechanics) INV: Energy in a system, electrical circuits TG: Energy transformations and roller coaster design
9to12	2	X	Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.	SE: p 207, 489, 511, 546 INV: 9B	SE: Simple machines are building blocks for complex machines, electrical systems and superconductivity, electrical systems in homes, systems in an underwater robot INV: Mechanical systems (simple machines) in complex machines (the human body as an example)

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9to12	2	Y	The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.	SE: p 494-5, 547-8 ANC: Ch20 activity	SE: Feedback loops in the human body (bio-electrical systems), working and maintaining an underwater robot ANC: Electric circuits game
9to12	2	Z	Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.	SE: p 141, 179, 182-3	SE: Tradeoffs in car/airplane manufacture, energy resources and alternatives, developing solar cell technology for soldiers
9to12	2	AA	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.	SE: p 50 and 70, 522-3 TG: p 601	SE: Engineering design cycle, designing energy-efficient light bulbs TG: Definition of prototype
9to12	2	BB	Optimization is an ongoing process or methodology of designing or making a product ands dependent on criteria and constraints.	SE: p 522-3, 182-3 ANC: Biography 21.1	SE: Designing energy-efficient light bulbs, solar cells make soldiers' lives better ANC: Thomas Edison (inventor and innovator)
9to12	2	CC	New technologies create new processes.	SE: p 405, 522-3 ANC: Biography 21.1	SE: Need for new technology for hydrogen-powered cars, compact fluorescent technology and new products ANC: Thomas Edison (inventor and innovator; his work led to General Electric)
9to12	2	DD	Quality control is a planned process to ensure that a product, service, or system meets established criteria.	SE: p 20, 588 TG: p 20, 48	SE: High definition TV, design of concert halls (sound quality) TG: Photographic quality (pixel count), students work together in team-based, problem solving to make a quality project
9to12	2	EE	Management is the process of planning, organizing, and controlling work.	SE: p 42, 264-5 TG: p 168	SE: Graphs as a way to organize, Leadership in Energy and Environmental Design or LEED (this organization evaluates green construction) TG: Students organize a energy-focused research project

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9to12	2	FF	Complex systems have many layers of controls and feedback loops to provide information.	SE: p 404-5, 494-5 ANC: Ch20 activity	SE: Feedback loops in the human body (bio-electrical systems), feedback loops in hydrogen-powered car technology ANC: Electric circuits game
	3		**Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.**		
9to12	3	G	Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.	SE: p 376-7	SE: Scrap tires used in new ways
9to12	3	H	Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.	SE: p 348-9 ANC: Biography 21.2	SE: Computer chip technology ANC: Lewis Latimer (inventor, improved the light bulb filament)
9to12	3	I	Technological ideas are sometimes protected through the process of patenting.	SE: p 221, 512, 529 ANC: Biography 18.3	SE: Biomechanics patents, Lewis Latimer helped others get patents, patents using magnets ANC: Rosalyn Sussman Yalow (chose not to get a patent for her invention of radioimmunoassay in order to make it available to people)
9to12	3	J	Technological progress promotes the advancement of science and mathematics.	SE: p 219 (sidebar), 463 (sidebar) ANC: Biography 1.4	SE: Biomechanics combines science and math, chemistry and math ANC: Katherine Johnson (NASA mathematician)
	4		**Students will develop an understanding of the cultural, social, economic, and political effects of technology.**		
9to12	4	H	Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.	SE: p 233, 401, 404-5	SE: Development of shatter-proof glass, automobile manufacturing innovations related to new fuels, hydrogen-powered cars
9to12		I	Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.	SE: p 72-3, 182-3, 156-7	SE: Ethics in medical research/drug development, using solar power to reduce the load that soldiers carry, car safety design and reducing the impact during a collision

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9to12	4	J	Ethical considerations are important in the development, selection, and use of technologies.	SE: p 72-3, 100-1	SE: Ethics in medical research/drug development, high tech animal trackers
9to12	4	K	The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.	SE: p 73, 426 TG: p 403	SE: Developing medicines to benefit people in other countries, use of nuclear energy in various countries TG: Students discuss the pros and cons of nuclear technology
	5		**Students will develop an understanding of the effects of technology on the environment.**		
9to12	5	G	Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.	SE: p 377-8, 521, 522-3	SE: Whole-tire recycling, recycling cell phones, energy conservation and light bulb design
9to12		H	When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.	SE: p 141, 404-5, 522-3	SE: Tradeoffs in car and airplane design, hydrogen-powered cars, energy conservation and light bulb design
9to12		I	With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making.	SE: p 100-1, 264-5	SE: High tech animal trackers, energy efficient building construction
9to12		J	The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment.	SE: p 100-1, 264-5, 404-5	SE: High tech animal trackers, energy efficient building construction, hydrogen-powered cars
9to12	5	K	Humans devise technologies to reduce the negative consequences of other technologies.	SE: p 377-8, 521, 522-3	SE: Whole-tire recycling, recycling cell phones, energy conservation and light bulb design
9to12	5	L	Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.	SE: p 404-5, 426 TG: p 403	SE: Hydrogen-powered car technology, use of nuclear energy in various countries TG: Students discuss the pros and cons of nuclear technology
	6		**Students will develop an understanding of the role of society in the development and use of technology.**		

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9to12	6	H	Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values.	TG: p 279, 572 ANC: Skill and practice sheet 1.3, biography 12.3	TG: American culture and the gas station (book recommendation), color design schemes in different cultures ANC: Importance of languages, Narcis Monturiol (Spanish submarine pioneer inspired to help local coral fishermen)
9to12	6	I	The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures.	SE: p 52-3, 404-5	SE: Importance of raising funding for research, hydrogen-powered cars (infrastructure needed)
9to12	6	J	A number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.	SE: p 246-7, 264-5 TG: p 571	SE: Television technology, the need for energy efficient buildings (to conserve energy and address climate change) TG: Color and advertising
	7		**Students will develop an understanding of the influence of technology on history.**		
9to12	7	G	Most technological development has been evolutionary, the result of a series of refinements to a basic invention.	SE: p 75, 199, 200-1 TG: 449, 563	SE: Development of the automobile over time, developing energy efficient technologies, development of human-powered transportation over time TG: Students are asked to make a timeline of developments in electricity, history of film technology (book recommendation)
9to12		H	The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials.	SE: p 205, 207 ANC: Biography 12.3	SE: Building the Great Pyramids, simple machines relate to more complex machines ANC: Archimedes (Archimedes' screw)

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9to12		I	Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.	SE: p 75, 199, 200-1 TG: 449, 563	SE: Development of the automobile over time, developing energy efficient technologies, development of human-powered transportation over time TG: Students are asked to make a timeline of developments in electricity, history of film technology (book recommendation)
9to12		J	Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how.	SE: p 205, 207 ANC: Biography 12.3	SE: Building the Great Pyramids, simple machines relate to more complex machines ANC: Archimedes (Archimedes' screw)
9to12		K	The Iron Age was defined by the use of iron and steel as the primary materials for tools.	SE: p 24, 30, 442, 528 INV: 22A and 22B	SE: Why steel is so strong, steel is a component of cars and bicycles, description of alloys, steel and magnets INV: How to magnets, compasses, and electromagnets work
9to12		L	The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society.	INV: 14B TG: p 309	ANC: How atoms change from one element to the next compared to thinking in Middle Ages TG: Middle ages and alchemy
9to12		M	The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology.	SE: p 219 ANC: Biography 6.1	SE: Biomechanics work of Borelli (17th century Italian physicist and mathematician) ANC: Isaac Newton
9to12		N	The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation and communication systems, advanced construction practices, and improved education and leisure time.	SE: p 430, 475 and 535 ANC: Biography 21.1	SE: Industrial Revolution and increased CO2 in atmosphere, developments in understanding electricity ANC: Work of George Westinghouse (19th century)
9to12	7	O	The Information Age places emphasis on the processing and exchange of information.	SE: p 348-9, 572-3	SE: Silicon and the Information Age, cell phone technology

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	8		**Students will develop an understanding of the attributes of design.**		
9to12	8	H	The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results.	SE: p 50 and 70, 522-3 INV: 12B, 12C TG: p 49 and 72, 601 ANC: Ch6 activity	SE: Engineering design cycle, designing energy-efficient light bulbs INV: Clay boat design TG: Design project and science reporting, definition of prototype ANC: Making a spool car
9to12	8	I	Design problems are seldom presented in a clearly defined form.	SE: p 50, 51, 55 TG: p 49	SE: Design problems, students solve a design problem, design a backpack TG: Problem solving and design problems
9to12	8	J	The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.	SE: p 50 and 70 TG: p 49	SE: Engineering design cycle TG: A design project
9to12	8	K	Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.	SE: p 522-3, 182-3 ANC: Biography 21.1	SE: Designing energy-efficient light bulbs, solar cells make soldiers' lives better ANC: Thomas Edison (inventor and innovator)
	9		**Students will develop an understanding of engineering design.**		
9to12	9	I	Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.	SE: p 50 and 70 INV: p 130 TG: p 49	SE: Engineering design cycle INV: Design a clock TG: A design project
9to12	9	J	Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.	SE: p 50 and 70, 51, 626-7 TG: p 49	SE: Engineering design cycle, solving a design problem, Dr. Hakeem Oluseyi (astrophysicist and inventor) TG: A design project
9to12	9	K	A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.	SE: p 70-1, 404, 536 TG: 601	SE: Definition of a prototype, prototypes of hydrogen-powered cars, prototype of a maglev train TG: Definition of prototype
9to12	9	L	The process of engineering design takes into account a number of factors.	SE: p 50 and 70, 51, 626-7 TG: p 49	SE: Engineering design cycle, solving a design problem, Dr. Hakeem Oluseyi (astrophysicist and inventor) TG: A design project

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	10		**Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.**		
9to12	10	I	Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	SE: p 182-3, 404-5, 522-3 ANC: Biography 21.1	SE: Solar cells make soldiers' lives better, hydrogen-powered cars, designing energy-efficient light bulbs ANC: Thomas Edison (inventor and innovator)
9to12	10	J	Technological problems must be researched before they can be solved.	SE: p 182-3, 404-5, 522-3 ANC: Biography 21.1	SE: Solar cells make soldiers' lives better, hydrogen-powered cars, designing energy-efficient light bulbs ANC: Thomas Edison (inventor and innovator)
9to12	10	K	Not all problems are technological, and not every problem can be solved using technology.	SE: p 264-5, 290-1, 430-1 TG: 49	SE: Building energy efficiency depends on human efforts as well as design elements and technology, boat hull design determines how a boat floats and its capabilities, human and community solutions to reduce carbon footprints TG: Variation in problem solving
9to12	10	L	Many technological problems require a multidisciplinary approach.	SE: p 72-3, 182-3, 546-7	SE: Many scientists, government agencies, and teams of people are involved in getting a drug safely to market; a team of scientists developed a solar cell to be used by soldiers; the Jason underwater robot is used by scientists and engineers all over the world to study the ocean floor
	11		**Students will develop the abilities to apply the design process.**		
9to12	11	M	Identify the design problem to solve and decide whether or not to address it.	SE: p 50 and 70, 51 TG: p 49	SE: Engineering design cycle, solving a design problem TG: A design project and the design and problem solving process

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9to12	11	N	Identify criteria and constraints and determine how these will affect the design process.	SE: p 50 and 70, 51 TG: p 49, 73	SE: Engineering design cycle, solving a design problem TG: A design project, design paper airplanes
9to12	11	O	Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.	SE: p 51 INV: 12B and 12C TG: p 49, 73 ANC: Ch6 activity	SE: Solving a design problem INV: Design a clay boat TG: A design project, design paper airplanes ANC: Making a spool car
9to12	11	P	Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.	SE: p 51 INV: 12B and 12C TG: p 49, 73 ANC: Ch6 activity	SE: Solving a design problem INV: Design a clay boat TG: A design project, design paper airplanes ANC: Making a spool car
9to12	11	Q	Develop and produce a product or system using a design process.	SE: p 55, 123, 225, 268 INV: p 130	SE: Students are asked to design a backpack, students are asked to invent and design a new shoe, design a complex machine to do a task, design a window with a high R-value INV: Design a clock
9to12	11	R	Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.	INV: 12B and 12C TG: p 49, 73, 267-71	INV: Designing a clay boat TG: A design project, various models to design a paper airplane and communicating findings, teaching the design process for designing a clay boat
	12		**Students will develop the abilities to use and maintain technological products and systems.**		
9to12	12	L	Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.	SE: p 65, 309 INV: p 247-50 TG: p 449-50 ANC: Lab skill sheet 3.2	SE: Communicating results, students prepare an oral or written report on an aviation pioneer INV: Recording observations TG: Electricity project presentation ANC: Writing a lab report

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9to12	12	M	Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.	SE: p 547 INV: p 224, 251-68 TG: p 590-1	SE: Maintaining a robot INV: Safety skills, equipment setup instructions TG: Safety instructions for maintaining the science classroom and lab
9to12	12	N	Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.	SE: p 547 INV: p 224, 251-68 TG: p 590-1	SE: Maintaining an robot INV: Safety skills, equipment setup instructions TG: Safety instructions for maintaining the science classroom and lab
9to12	12	O	Operate systems so that they function in the way they were designed.	SE: p 547 INV: p 224, 251-68 TG: p 590-1	SE: Maintaining an robot INV: Safety skills, equipment setup instructions TG: Safety instructions for maintaining the science classroom and lab
9to12	12	P	Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.	SE: p 458, 531 TG: p 96 ANC: Skill and practice sheet 3.2, Ch1 activity	SE: Use a calculator to determine pH, use an online calculator to determine a carbon footprint TG: Students create a PowerPoint presentation ANC: Using computer spreadsheets, using a scientific calculator
	13		**Students will develop the abilities to assess the impact of products and systems.**		
9to12	13	J	Collect information and evaluate its quality.	SE: p 48 INV: 2A, 247-50 TG: p 30-3	SE: Collecting information is part of problem solving INV: Gathering information to solve a problem, recording observations TG: Quantitative and qualitative observations
9to12	13	K	Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment.	SE: p 42 and 47, 156-7, 179 INV: 2B TG: p 36, 38 and 39	SE: Trends and graphing, forensic engineering (data trends related to car crashes), energy resources and society INV: Looking for patterns in data TG: Extrapolating, Inv 2B and looking for trends

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9to12	13	L	Use assessment techniques, such as trend analysis and experimentation, to make decisions about the future development of technology.	SE: p 72-3, 120, 250	SE: Ethics in medical research (the future of drugs depends on careful experimentation), maglev trains (currently expensive but may be used in the future), evaluating the use of plasma in the future
9to12	13	M	Design forecasting techniques to evaluate the results of altering natural systems.	SE: p 195, 100-1, 264-5	SE: Earth as a natural system and climate change, tracking seals to protect them and to better manage fisheries and how oceans are used, designing efficient buildings to reduce the impact on the environment (predicting energy savings)
	14		**Students will develop an understanding of and be able to select and use medical technologies.**		
9to12	14	K	Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained.	SE: p 72-3, 409 TG: p 564 ANC: Biography 18.3	SE: Ethics in medical research, Curies (medical technology) TG: Students research how lasers are used in medicine ANC: Rosalyn Sussman Yalow (immunoassay)
9to12	14	L	Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.	SE: p 25, 220-1, 225 TG: p 212	SE: Nanotechnology and medicine, prosthetics design, biomechanics and medicine TG: Biomechanics and medicine
9to12	14	M	The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures.	SE: p 24-5, 427 TG: p 563	SE: Nanotechnology and bacterial DNA and DNA repair, radiation can damage DNA TG: Book recommendation ("Decoding the Universe")
	15		**Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.**		
9to12	15	K	Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products.	SE: p 63, 296, 371, 403 TG: p 221	SE: Paper production, plant proteins and food, biochemistry, George Washington Carver (biofuel research) TG: Dr. Percy Lavon Julian (products from soy)

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9to12	15	L	Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering.	SE: p 24-5, 371	SE: Nanotechnology (antibacterial materials and medical apps), biotechnology and chemistry
9to12	15	M	Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.	SE: p 100, 255, 296, 377, 469	SE: Conservation organizations and marine environments, importance of water on Earth, importance of soil, using scrap tires to decontaminate water and soil, field study and water quality question
9to12	15	N	The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna.	SE: p 70, 297 TG: p 173	SE: Engineering design cycle, the role of photosynthesis in ecosystems TG: Warm water from nuclear plants affects ecosystems
	16		**Students will develop an understanding of and be able to select and use energy and power technologies.**		
9to12	16	J	Energy cannot be created nor destroyed; however, it can be converted from one form to another.	SE: p 177 INV: 7B TG: p 164-5	SE: Definition of law of conservation of energy INV: Conservation of energy TG: Teaching the law of conservation of energy
9to12	16	K	Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.	SE: p 164-72 INV: 11A, 20B TG: p 158-9	SE: Forms of energy INV: Temperature and heat, electrical energy TG: Teaching forms of energy
9to12		L	It is impossible to build an engine to perform work that does not exhaust thermal energy to the surroundings.	SE: p 193-4 INV: 7C ANC: Skill and practice sheet 8.2	SE: Efficiency INV: Energy and efficiency ANC: Efficiency problems
9to12	16	M	Energy resources can be renewable or nonrenewable.	SE: p 179, 186 (#2), 404-5, 430-1 TG: p 167-8	SE: Energy resources, students are asked to list various resources, hydrogen-powered cars (renewable resource), ways to reduce one's carbon footprint TG: Teaching the importance of conserving energy
9to12	16	N	Power systems must have a source of energy, a process, and loads.	SE: p 264 INV: 8C, 21B TG: p 178-81	SE: Mechanical systems in efficient buildings INV: People power, electrical energy and power TG: Defining mechanical systems

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	17		**Students will develop an understanding of and be able to select and use information and communication technologies.**		
9to12	17	L	Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.	SE: p 69, 572-3 ANC: Biography 21.1	SE: GPS, cell phone technology ANC: Thomas Edison (communications technology)
9to12	17	M	Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.	SE: p 100-1, 572-3	SE: High tech animal trackers, cell phone technology
9to12	17	N	Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.	SE: p 69, 246-7, 572-3 ANC: Biography 21.1	SE: GPS, television technology, cell phone technology ANC: Thomas Edison (communications technology)
9to12	17	O	Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.	SE: p 572-3	SE: Cell phone technology
9to12	17	P	There are many ways to communicate information, such as graphic and electronic means.	SE: p 42-7, 65, 591 TG: 543	SE: Graphing, lab reports, communicating information about sound TG: Electronic communication
9to12	17	Q	Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.	SE: p 246-7, 478, 572-3 TG: 543-4	SE: television technology, circuit diagrams, cell phone technology TG: Teaching about sound and communication
	18		**Students will develop an understanding of and be able to select and use transportation technologies.**		
9to12	18	J	Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.	SE: p 156-7, 200-1, 404-5	SE: Forensic engineering, human-powered transportation, hydrogen-powered cars
9to12	18	K	Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another.	SE: p 200-1, 71 and 536 TG: p 11	SE: Human-powered transportation, maglev trains TG: Time and distance and modes of transportation
9to12	18	L	Transportation services and methods have led to a population that is regularly on the move.	SE: p 200-1, 71 and 536 TG: p 11	SE: Human-powered transportation, maglev trains TG: Time and distance and modes of transportation
9to12	18	M	The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques.	SE: p 200-1, 404-5, 71 and 536 TG: p 11	SE: Human-powered transportation, hydrogen-powered cars, maglev trains TG: Time and distance and modes of transportation
	19		**Students will develop an understanding of and be able to select and use manufacturing technologies.**		

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9to12	19	L	Servicing keeps products in good operating condition.	SE: p 547 INV: p 224-9, 251-68 TG: p 590-1	SE: Maintaining a robot INV: Lab safety skills, equipment setup instructions TG: Safety instructions for maintaining the science classroom and lab
9to12	19	M	Materials have different qualities and may be classified as natural, synthetic, or mixed.	SE: p 246, 348-9, 371	SE: Materials in televisions, silicon and computer chips, natural polymers
9to12	19	N	Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time.	SE: p 37, 182, 377	SE: Ipe wood products, durable solar cells for use by soldiers, using scrap tires to make durable road surfaces
		O	Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production.	SE: p 377, 401 and 404-5, 417	SE: Processing of scrap tires (continuous production), automobile manufacturing (customized and continuous production), chemical reactions and limiting reagents (example of batch production)
		P	The interchangeability of parts increases the effectiveness of manufacturing processes.	SE: p 478 and 541, 547 ANC: Ch22 activity	SE: Basic parts of a circuit and electric motor, parts of a robot ANC: Build a simple motor
9to12	19	Q	Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products.	SE: p 348-9, 372, 401, 545	SE: Silicon and computer chips, chemical processing of food, electrochemical process and fuel cells, elements used to make semiconductors
9to12	19	R	Marketing involves establishing a product’s identity, conducting research on its potential, advertising it, distributing it, and selling it.	SE: p 157, 209, 381 TG: p 571	SE: Students create a poster to advertise the importance of seat belts, students create an advertisement for simple machines, students create an ad campaign TG: Color and advertising
	20		**Students will develop an understanding of and be able to select and use construction technologies.**		
9to12	20	J	Infrastructure is the underlying base or basic framework of a system.	SE: p 85, 405	SE: Infrastructure needed for high-speed trains, infrastructure for hydrogen-powered cars

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9to12	20	K	Structures are constructed using a variety of processes and procedures.	SE: p 70, 205, 376	SE: Building a bridge (engineering design cycle), building the great pyramids (simple machines), playground structures (using recycled tires)
9to12	20	L	The design of structures includes a number of requirements.	SE: p 50 and 70, 627	SE: Engineering design cycle, invention of a UV light detection device and other astronomy instruments
9to12	20	M	Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use.	SE: p 50, 546-7 TG: p 49	SE: Carbon nanotubes and new structural design, underwater robot workings and maintenance TG: Students are asked how to improve structural designs
9to12	20	N	Structures can include prefabricated materials.	SE: p 70, 264-5, 376	SE: Building a model bridge, constructing energy efficient buildings, playground structures (using recycled tires)