Core Ideas			SE, INV, TG, Ancillary (section, sheet, or investigation number or 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 41 and 45-6, 113 INV: p 155 TG: p 43, 46	SE: Experimental techniques and the engineering cycle, students design a new shoe INV: Students design a clock TG: Problem-solving techniques, models and designing paper airplanes
		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.	TG: p 111 ANC: Ch2 connection, ch15 connection	TG: Hydroplaning in cars ANC: Risks in clinical trials for drugs, obstacles to developing and using wind power
		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 260 and 364, 368, 569 ANC: Ch4 connection, ch13 connection	SE: Importance of soil, importance of water on Earth, water quality monitoring ANC: Conservation organizations and marine environments, using scrap tires to decontaminate water and soil
		These global challenges also may have manifestations in local communities.	ANC: Ch9 connection, ch15 connection	ANC: Climate control systems in efficient buildings, developing and using wind power using available resources
		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 41 and 45-6, 113 INV: p 155	SE: Experimental techniques and the engineering cycle, students design a new shoe INV: Students design a clock
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 41 and 45-6, 113 TG: p 43, 46	SE: Experimental techniques and the engineering cycle, students design a new shoe TG: Problem-solving techniques, models and designing paper airplanes

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		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.	ANC: Ch7 connection, biography 10.4, biography 16.4	ANC: Solar power technology designed for soldiers, Narcis Monturiol (submarine pioneer), George Westinghouse (train safety)
		Testing should lead to improvements in the design through an iterative procedure.	INV: p 155 TG: p 43, 46	INV: Students design a clock TG: Problem-solving techniques, models and designing paper airplanes
		Both physical models and computers can be used in various ways to aid in the engineering design process.	SE: p 245, 503, 719 TG: p 46	SE: Computer models and storm prediction, seismic data is collected and studied using computers, astronomers and computer-based modeling TG: Scientists use mathematical models/students design a paper airplane
		Physical models, or prototypes, are helpful in testing product ideas or the properties of different materials.	SE: p 113 INV: p 155, 10B TG: p 46	SE: Students design a new shoe INV: Students design a clock, students design a clay boat TG: Models and designing paper airplanes
		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 419, 734 TG: p 88 ANC: Skill and practice sheet 2.2	SE: MRI technology, students create a computer presentation (AYK#4) TG: Students create a PowerPoint presentation ANC: Using a computer spreadsheet
ETS1.C		**Optimizing the Design Solution** ***How can the various proposed design solutions be compared and improved?***		

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		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 41 and 45-6, 113 INV: p 155 TG: p 43, 46	SE: Experimental techniques and the engineering cycle, students design a new shoe INV: Students design a clock TG: Problem-solving techniques, models and designing paper airplanes
		Optimization can be complex, however, for a design problem with numerous desired qualities or outcomes.	SE: p 46 ANC: Ch9 connection, ch28 connection	SE: Engineering cycle ANC: Building energy-efficient buildings, invention of a UV light detector and other astronomy instruments
		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 45-6, 129, 131, 150 ANC: Skill and practice sheet 7.1, ch9 connection	SE: Engineering design cycle, trade-off between mass and strength of materials, trade-off between acceleration and energy, mechanical advantage ANC: Bicycle gears project, resources and energy-efficient buildings
		The comparison of multiple designs can be aided by a trade-off matrix.	SE: p 45-6 ANC: Ch7 connection, ch9 connection, ch15 connection	SE: Engineering design cycle ANC: Designing solar cells for soldiers, building energy-efficient buildings, constraints and criteria regarding wind turbines NOTE: The text does not present trade-off matrices.
		Sometimes a numerical weighting system can help evaluate a design against multiple criteria.	SE: p 45-6 ANC: Ch7 connection, ch9 connection, ch15 connection	SE: Engineering design cycle ANC: Designing solar cells for soldiers, building energy-efficient buildings, constraints and criteria regarding wind turbines NOTE: The text does not present numerical weighting systems.
		When evaluating solutions, all relevant considerations, including cost, safety, reliability, and aesthetic, social, cultural, and environmental impacts, should be included.	SE: p 45-6 ANC: Ch7 connection, ch9 connection, ch15 connection	SE: Engineering design cycle ANC: Designing solar cells for soldiers, building energy-efficient buildings, constraints and criteria regarding wind turbines

Core Ideas			SE, INV, TG, Ancillary (section, sheet, or investigation number or page number)	Notes
		Testing should lead to design improvements through an iterative process, and computer simulations are one useful way of running such tests.	SE: p 245, 503, 719 TG: p 46	SE: Computer models and storm prediction, seismic data is collected and studied using computers, astronomers and computer-based modeling TG: Scientists use mathematical models/students design a paper airplane
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).	ANC: Ch2 connection, ch6 connection, ch7 connection	ANC: Ethics in medical research/drug development, car safety design and reducing impacts during collisions, using solar power to reduce the load that soldiers carry
		Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.	INV: 24A TG: p 580-7 ANC: Ch2 connection, ch7 connection	INV: Students work in teams to investigate harmonic motion TG: Teaching INV 24A ANC: Experts work as a team to develop drugs, to improve technology for soldiers
		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.	ANC: Ch2 connection, ch20 connection TG: p 332	ANC: Developing medicines to benefit people in other countries, tsunami warning systems in the U.S. and the Indian Ocean 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?***		

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		Modern civilization depends on major technological systems, including those related to agriculture, health, water, energy, transportation, manufacturing, construction, and communications.	SE: p 47, 381, 440 ANC: Biography 16.4	SE: Michael Faraday and maglev trains, new technology to vacuum CO2 from air (student research), new technology and growing crops as biomass energy sources ANC: Thomas Edison (work led to General Electric)
		Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	SE: p 426 ANC: Ch1 connection, ch13 connection, Biography 14.4	SE: Applications of electromagnets ANC: Developing applications of nanotechnology, scrap tires used in new ways, Rosalyn Sussman Yalow (radioimmunoassay and diabetes research)
		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.	ANC: Ch2 connection, ch4 connection TG: p 45	ANC: Ethics in medical research, high tech animal trackers TG: Ethics in science and technology
		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 47, 381, 440 ANC: Biography 16.4	SE: Michael Faraday and maglev trains, new technology to vacuum CO2 from air (student research), new technology and growing crops as biomass energy sources ANC: Thomas Edison (work led to General Electric)
		Analysis of costs, environmental impacts, and risks, as well as of expected benefits, is a critical aspect of decisions about technology use.	ANC: Ch1 connection, ch4 connection, ch15 connection	ANC: Nanotechnology applications, computers are used to track seals and reduce environmental impact of fisheries, environmental effects of wind turbines