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 134-5, 271 (sidebar), 582-3 INV: 23.2	SE: Design of structures, constraints in machine design, designing a deep-water submarine INV: Electromagnets and the electric motors (optimizing motor design through experimentation)
		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 135, 160-1, 414-5, 494 ANC: Biography 23.3	SE: Engineering design cycle, robot navigation, hybrid gas/electric car technology, maglev trains ANC: Michael Faraday (electromagnetic induction and electrical power plants)
		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 4-5, 414-5, 632	SE: Energy resources and public concern, automobile technology and reliance on oil, nuclear energy
		These global challenges also may have manifestations in local communities.	SE: p 218-9, 632	SE: Hydroelectric power, storing nuclear waste
		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 24 and 72, 134-5	SE: Problem-solving techniques, the design of structures and the engineering design cycle
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 24 and 72, 134-5	SE: Problem-solving techniques, the design of structures and the engineering design cycle
		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 134-5, 239, 428, 595	SE: Science-technology-engineering, tidal power research challenges, solving circuit problems, countries are working together in fusion research

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		Testing should lead to improvements in the design through an iterative procedure.	INV: 13.2, 23.2 TG: p 230-2	INV: Why things oscillate, electromagnets and the electric motors (optimizing motor design through experimentation) TG: Teaching INV 13.2 (iterating the design cycle)
		Both physical models and computers can be used in various ways to aid in the engineering design process.	SE: p 23, 51, 114, 134-5	SE: Models, graphical models, force platforms are used in many fields of science and engineering, science/engineering and the design cycle
		Physical models, or prototypes, are helpful in testing product ideas or the properties of different materials.	SE: p 126, 135	SE: Prototypes of maglev trains, prototypes and the engineering design cycle
		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 159, 256, 512	SE: Computers control space missions, space shuttle on-board computers, how computers work
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 27-8, 53	SE: Finding engineering solutions in biology, nanotechnology
		Optimization can be complex, however, for a design problem with numerous desired qualities or outcomes.	SE: p 134-5, 271 (sidebar), 582-3 INV: 23.2	SE: Design of structures, constraints in machine design, designing a deep-water submarine INV: Electromagnets and the electric motors (optimizing motor design through experimentation)
		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 189, 474, 621, 632	SE: Rollovers and car design, MRIs are engineered to be painless and virtually risk-free to patients, risks and medical X-rays, risks with using nuclear technology

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		The comparison of multiple designs can be aided by a trade-off matrix.	SE: p 189, 456-7	SE: Rollovers and car design, rival projector technologies NOTE: The text does not present trade-off matrices.
		Sometimes a numerical weighting system can help evaluate a design against multiple criteria.	SE: p 189, 456-7	SE: Rollovers and car design, rival projector technologies 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 134-5, 239, 428, 595	SE: Science-technology-engineering, tidal power research challenges, solving circuit problems, countries are working together in fusion research
		Testing should lead to design improvements through an iterative process, and computer simulations are one useful way of running such tests.	SE: p 256 INV: 13.2 TG: p 230-2	SE: On-board computers monitor the flight of the space shuttle INV: Why things oscillate (students build a mechanical oscillator) TG: Teaching INV 13.2
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 135 ANC: Biography 23.3, 30.1B	SE: Engineering design cycle ANC: Michael Faraday (electromagnetic induction and electrical power plants), Marie and Pierre Curie
		Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.	SE: p 134-5, 238-9	SE: The science and engineering behind designing structures, science and engineering involved in harnessing energy from ocean tides

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		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: p 631-2 ANC: Biography 30.1B	SE: Nuclear power and nuclear waste ANC: Radioactivity work by Marie and Pierre Curie
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 499-515 INV: 24.1 TG: p 442-5	SE: Electronics systems INV: Semiconductors (and diodes) TG: Teaching about semiconductors and use of these in control systems
		Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	SE: p 134-5, 271 (sidebar), 582-3 INV: 23.2	SE: Design of structures, constraints in machine design, designing a deep-water submarine INV: Electromagnets and the electric motors (optimizing motor design through experimentation)
		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 73-4, 94-5, 333, 370, 414-5	SE: Slow-motion photography (innovation), anti-lock braking (innovation), invention of the light bulb, invention of the camera, hybrid gas/electric cars (invention/innovation)
		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 189, 474, 621, 632	SE: Rollovers and car design, MRIs are engineered to be painless and virtually risk-free to patients, risks and medical X-rays, risks with using nuclear 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 4-5, 414-5, 632	SE: Energy resources and public concern, automobile technology and reliance on oil, nuclear energy