1. Engineering design is an iterative process involving modeling and optimization used to develop technological solutions to problems within given constraints.

Students engage in the following steps in a design process:
• initiate and carry out a thorough investigation of an unfamiliar situation and identify needs and opportunities for technological invention or innovation.
• identify, locate, and use a wide range of information resources including subject experts, library references, magazines, videotapes, films, electronic data bases and on-line services, and discuss and document through notes and sketches how findings relate to the problem.
• generate creative solution ideas, break ideas into the significant functional elements, and explore possible refinements; predict possible outcomes using mathematical and functional modeling techniques; choose the optimal solution to the problem, clearly documenting ideas against design criteria and constraints; and explain how human values, economics, ergonomics, and environmental considerations have influenced the solution.
• develop work schedules and plans which include optimal use and cost of materials, processes, time, and expertise; construct a model of the solution, incorporating developmental modifications while working to a high degree of quality (craftsmanship).
• in a group setting, devise a test of the solution relative to the design criteria and perform the test; record, portray, and logically evaluate performance test results through quantitative, graphic, and verbal means; and use a variety of creative verbal and graphic techniques effectively and persuasively to present conclusions, predict impacts and new problems, and suggest and pursue modifications.

This is evident, for example, when students:
▲ search the Internet for world wide web sites dealing with renewable energy and sustainable living and research the development and design of an energy efficient home.
▲ develop plans, diagrams, and working drawings for the construction of a computer-controlled marble sorting system that simulates how parts on an assembly line are sorted by color.
▲ design and model a portable emergency shelter for a homeless person that could be carried by one person and be heated by the body heat of that person to a life-sustaining temperature when the outside temperature is 20°F.

2. Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.

Students:
• test, use, and describe the attributes of a range of material (including synthetic and composite materials), information, and energy resources.
• select appropriate tools, instruments, and equipment and use them correctly to process materials, energy, and information.
• explain tradeoffs made in selecting alternative resources in terms of safety, cost, properties, availability, ease of processing, and disposability.
• describe and model methods (including computer-based methods) to control system processes and monitor system outputs.

This is evident, for example, when students:
▲ use a range of high-tech composite or synthetic materials to make a model of a product, (e.g., ski, an airplane, earthquake-resistant building) and explain their choice of material.
▲ design a procedure to test the properties of synthetic and composite materials.
▲ select appropriate tools, materials, and processes to manufacture a product (chosen on the basis of market research) that appeals to high school students.
▲ select the appropriate instrument and use it to test voltage and continuity when repairing a household appliance.
▲ construct two forms of packaging (one from biodegradable materials, the other from any other materials), for a child’s toy and explain the tradeoffs made when choosing one or the other.
▲ describe and model a method to design and evaluate a system that dispenses candy and counts the number dispensed using, for example, Fischertecnik, Capsela, or Lego.
▲ describe how the flow, processing, and monitoring of materials is controlled in a manufacturing plant and how information processing systems provide inventory, tracking, and quality control data.
Students will apply technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.

## Computer Technology

3. Computers, as tools for design, modeling, information processing, communication, and system control, have greatly increased human productivity and knowledge.

Students:
- understand basic computer architecture and describe the function of computer subsystems and peripheral devices.
- select a computer system that meets personal needs.
- attach a modem to a computer system and telephone line, set up and use communications software, connect to various on-line networks, including the Internet, and access needed information using e-mail, telnet, gopher, ftp, and web searches.
- use computer-aided drawing and design (CADD) software to model realistic solutions to design problems.
- develop an understanding of computer programming and attain some facility in writing computer programs.

This is evident, for example, when students:
- choose a state-of-the-art computer system from computer magazines, price the system, and justify the choice of CPU, CD-ROM and floppy drives, amount of RAM, video and sound cards, modem, printer, and monitor; explain the cost-benefit tradeoffs they have made.
- model, explain, and analyze the performance of a feedback control system.
- develop an understanding of computer programming and attain some facility in writing computer programs.

## Technological Systems

4. Technological systems are designed to achieve specific results and produce outputs, such as products, structures, services, energy, or other systems.

Students:
- explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.
- model, explain, and analyze the performance of a feedback control system.
- explain how complex technological systems involve the confluence of numerous other systems.

This is evident, for example, when students:
- model, explain, and analyze how the float mechanism of a toilet tank senses water level, compares the actual level to the desired level, and controls the flow of water into the tank.
- draw a labeled system diagram which explains the performance of a system, and include several subsystems and multiple feedback loops.
- explain how the space shuttle involves communication, transportation, biotechnical, and manufacturing systems.

## Sample Problem/Activity

Students map their local water resources and realize that they live in a watershed that is a subsystem of increasingly larger systems, all of which constitute an interrelated water cycle.

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Standard 5—Technology

History and Evolution of Technology

5. Technology has been the driving force in the evolution of society from an agricultural to an industrial to an information base.

Students:
• explain how technological inventions and innovations have caused global growth and interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete.

This is evident, for example, when students:
▲ compare qualitatively and quantitatively the performance of a contemporary manufactured product, such as a household appliance, to the comparable device or system 50-100 years ago, and present results graphically, orally, and in writing.
▲ describe the process that an inventor must follow to obtain a patent for an invention.
▲ explain through examples how some inventions are not translated into products and services with market place demand, and therefore do not become commercial successes.

6. Technology can have positive and negative impacts on individuals, society, and the environment and humans have the capability and responsibility to constrain or promote technological development.

Students:
• explain that although technological effects are complex and difficult to predict accurately, humans can control the development and implementation of technology.
• explain how computers and automation have changed the nature of work.
• explain how national security is dependent upon both military and nonmilitary applications of technology.

This is evident, for example, when students:
▲ develop and implement a technological device that might be used to assist a disabled person perform a task.
▲ identify a technology which impacts negatively on the environment and design and model a technological fix.
▲ identify new or emerging technologies and use a futuring technique (e.g., futures wheel, cross impact matrix, Delphi survey) to predict what might be the second and third order impacts.

Sample Problem/Activity

How Has The Use Of Electric Appliances Changed Over Time?

Have each student make a list of the electric appliances in her/his household, including everything from light bulbs to refrigerators. Interview students to ask a parent (or other adult of approximately the same age) to record how many of each kind of appliance was in her/his household when she was a child. Develop with the class a set of common procedures that can be used to collect the information.

What specific procedures should we follow to ensure that everyone’s data is comparable?
How will we account for missing data in our survey, due to forgetfulness of some participants or other factors?
Management of Technology

7. Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget.

Students:
- develop and use computer-based scheduling and project tracking tools, such as flow charts and graphs.
- explain how statistical process control helps to assure high quality output.
- discuss the role technology has played in the operation of successful U.S. businesses and under what circumstances they are competitive with other countries.
- explain how technological inventions and innovations stimulate economic competitiveness and how, in order for an innovation to lead to commercial success, it must be translated into products and services with marketplace demand.
- describe new management techniques (e.g., computer-aided engineering, computer-integrated manufacturing, total quality management, just-in-time manufacturing), incorporate some of these in a technological endeavor, and explain how they have reduced the length of design-to-manufacture cycles, resulted in more flexible factories, and improved quality and customer satisfaction.
- help to manage a group engaged in planning, designing, implementation, and evaluation of a project to gain understanding of the management dynamics.

This is evident, for example, when students:
- design and carry out a plan to create a computer-based information system that could be used to help manage a manufacturing system (e.g., monitoring inventory, measurement of production rate, development of a safety signal).
- identify several successful companies and explain the reasons for their commercial success.
- organize and implement an innovative project, based on market research, that involves design, production, testing, marketing, and sales of a product or a service.