Engineering

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Most simply, the art of directing the great sources of power in nature for the use and the convenience of humans. In its modern form engineering involves people, money, materials, machines, and energy. It is differentiated from science because it is primarily concerned with how to direct to useful and economical ends the natural phenomena which scientists discover and formulate into acceptable theories. Engineering therefore requires above all the creative imagination to innovate useful applications of natural phenomena. It is always dissatisfied with present methods and equipment. It seeks newer, cheaper, better means of using natural sources of energy and materials to improve the standard of living and to diminish toil.

Types of engineering

Traditionally there were two divisions or disciplines, military engineering and civil engineering. As knowledge of natural phenomena grew and the potential civil applications became more complex, the civil engineering discipline tended to become more and more specialized. The practicing engineer began to restrict operations to narrower channels. For instance, civil engineering came to be concerned primarily with static structures, such as dams, bridges, and buildings, whereas mechanical engineering split off to concentrate on dynamic structures, such as machinery and engines. Similarly, mining engineering became concerned with the discovery of, and removal from, geological structures of metalliferous ore bodies, whereas metallurgical engineering involved extraction and refinement of the metals from the ores. From the practical applications of electricity and chemistry, electrical and chemical engineering arose.

This splintering process continued as narrower specialization became more prevalent. Civil engineers had more specialized training as structural engineers, dam engineers, water-power engineers, bridge engineers; mechanical engineers as machine-design engineers, industrial engineers, motive-power engineers; electrical engineers as power and communication engineers (and the latter divided eventually into telegraph, telephone, radio, television, and radar engineers, whereas the power engineers divided into fossil-fuel and nuclear engineers); mining engineers as metallic-ore mining engineers and fossil-fuel mining engineers (the latter divided into coal and petroleum engineers).

As a result of this ever-increasing utilization of technology, people and their environments have been affected in various ways—some good, some bad. Sanitary engineering has been expanded from treating the waste products of humans to also treating the effluents from technological processes. The increasing complexity of specialized machines and their integrated utilization in automated processes has resulted in physical and mental problems for

the operating personnel. This has led to the development of bioengineering, concerned with the physical effects upon humans, and management engineering, concerned with the mental effects.

Integrating influences

While the specialization was taking place, there were also integrating influences in the engineering field. The growing complexity of modern technology called for many specialists to cooperate in the design of industrial processes and even in the design of individual machines. Interdisciplinary activity then developed to coordinate the specialists. For instance, the design of a modern structure involves not only the static structural members but a vast complex including moving parts (elevators, for example); electrical machinery and power distribution; communication systems; heating, ventilating, and air conditioning; and fire protection. Even the structural members must be designed not only for static loading but for dynamic loading, such as for wind pressures and earthquakes. Because people and money are as much involved in engineering as materials, machines, and energy sources, the management engineer arose as another integrating factor.

Typical modern engineers go through several phases of activity during their careers. Formal education must be broad and deep in the sciences and humanities underlying the particular field. Then comes an increasing degree of specialization in the intricacies of the discipline, also involving continued postscholastic education. Normal promotion thus brings interdisciplinary activity as the engineer supervises various specialists. Finally, the engineer enters into the management function by interweaving workers, money, materials, machines, and energy sources into completed processes for the use of humankind.

For specific articles on various engineering disciplines *See also:* CHEMICAL ENGINEERING; CIVIL ENGINEERING; ELECTRICAL ENGINEERING; INDUSTRIAL ENGINEERING; MANUFACTURING ENGINEERING; MARINE ENGINEERING; MECHANICAL ENGINEERING; METHODS ENGINEERING; MINING; NUCLEAR ENGINEERING; SCIENCE; TECHNOLOGY.

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Additional Readings

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G. O. Langford, *Engineering Systems Integration*, CRC Press, Boca Raton, FL, 2012