# 18

# LEGAL AND ETHICAL ISSUES IN ENGINEERING DESIGN

## 18.1 INTRODUCTION

Engineering is not only applying scientific laws and principles to technical problems. It is focused on improving the lot of society, and as such, it brings engineers into the mainstream of business and industry. Almost all entry-level engineers become involved, at least tangentially, with situations that call for some understanding of the law and situations that call for ethical judgments. Therefore, this chapter presents a brief overview of some legal and ethical issues in engineering. With topics as broad as law and ethics we can only scratch the surface, so we have chosen to focus on those issues that are most pertinent to engineering design.

The following are examples of where a design engineer might be concerned with legal and ethical issues:

- Preparing a contract to secure the services of a product data management firm.
- Reviewing a contract to determine whether a contractor who built an automated production facility has satisfactorily fullfilled the terms of a contract.
- Deciding whether it is legal and ethical to reverse engineer a product.
- Managing a design project to avoid the possibility of a product liability suit.
- Protecting the intellectual property created as part of a new product development activity.
- Deciding whether to take a job with a direct competitor that is bidding on a contract in the area where you are now working.

The law is a formalized code of conduct describing what society feels is the proper way to behave. In other words, laws reflect what society values. As society evolves, its attitude toward behavior changes, and the laws change as well. Also, the advances in technology create new ethical issues. Ethics is the study of human conduct that lays out the moral ground rules. It is intimately related to the values of society. Thus,

laws and ethics, while distinct, are not independent. *Ethical conduct is the behavior desired by society that is separate from the minimum standards of the law.* For example, making a defective product despite taking all due care may subject you to product liability law, but it is not generally considered unethical.

This chapter comes with a warning label. *A little knowledge can be a dangerous thing.* Just as we would not expect a lawyer to practice engineering, so an engineer should not practice law. One objective of this chapter is to give you enough knowledge about the legal aspects of engineering practice to recognize when you need to take certain actions or to know when to seek legal counsel. A second objective is to help you realize that the engineering profession has expectations for your conduct and that a true professional recognizes responsibilities to the employer, the profession, and society, not just those to himself or herself.

## 18.2
## THE ORIGIN OF LAWS

The code of American law has its origin in English *common law.* These laws derived from agreed-upon tradition and custom and were given the authority of law by decisions in the courts. Since each court decision is based on the study of previous court cases, it is often called *case law.*

*Statutory law* is law that is created by a legislative body, either state or federal. These laws, known as *statutes,* are often codified, as opposed to common law, and prescribe particular actions that apply to specific situations. Statutes may modify, reverse, or abolish common law doctrines. Statutes are subject to both change and extinction by legislative action.

While the two basic types of law are common law and statutory law, many political entities contribute to the body of law. *Constitutional law,* which is based on the Constitution of the United States, defines governmental powers, especially with respect to the states, and secures the rights of the individual citizen. The Congress of the United States and the legislatures of the states provide their own body of statutory law. Municipal law is a subdivision of statutory law that is produced by towns and cities. *Municipal ordinances* deal with issues like traffic laws, zoning, and building codes. A large body of *administrative law* has been created by rulings and regulations of federal and state agencies other than the courts. Examples are OSHA and the EPA. Although cases involving administrative law are usually handled within the agency, disputes are finally resolved through the regular court system.

The purpose of the legal system is to protect and make life easier for each member of society. The rule of law is important not only in criminal matters, but as it affects other aspects of society like politics and the economy. The legal system is divided into criminal law and civil law. Criminal law deals with crimes against society such as murder, arson, larceny, bribery, perjury, and embezzlement. Civil law cases are concerned with the law of property, the law of contracts, and the law of torts. In this brief chapter on the law we discuss only the latter two categories. Most of us who watch television are familiar with criminal law, but the majority of cases are concerned with civil law. There are several important distinctions between the two forms of legal

practice. In criminal law, emphasis is placed on whether the defendant is innocent or guilty. The defendant is assumed innocent until proven guilty. The defendant must be found guilty beyond a reasonable doubt by a unanimous verdict of a jury of his peers. The penalty for being found guilty is imprisonment or in extreme cases, death.

The issue of guilt or innocence is not at question in a civil case. Here the question is which of the parties failed to live up to an agreement or acted improperly in a way that caused someone damage. In a civil trial the jury is not required to be unanimous in its verdict, and it is only necessary to reach the verdict based on the preponderance of the evidence, as opposed to the higher standard in a criminal case. The winner in a civil case is usually awarded monetary damages or custody of the disputed property.

## 18.3 CONTRACTS

A contract is a promise by one person to another to do or not to do something. The only promises that the law will enforce are contracts. The three elements of a contract are:

$$\text{Contract} = \text{offer} + \text{acceptance} + \text{consideration}$$

An *offer* is an expression made by one person (the promisor) that leads another person to reasonably expect that the promisor wishes to create an agreement. The offer must be clear, definite, and specific, with no room for serious misunderstanding. An *acceptance* of the offer is necessary to make a contract legally binding. Both the offer and the acceptance must be voluntary acts. A contract cannot be forced on anyone. A contract is not enforceable by law unless it contains an agreement to exchange promises with value, the *consideration.* For example, if A and B enter into a contract in which A promises to pay B $1000 for modifying a CAD software package, both the money and the service are considerations.

### 18.3.1 Types of Contracts

Contracts can take many forms. They may be classified as express or implied, bilateral or unilateral. Also, a contract may be either written or verbal. Examples of contracts are purchase contracts, leases, a contract to perform a service, or an employment contract.

- An *express contract* is a contract in which all of the terms are agreed upon and expressed in words, either written or oral. An oral contract, once made, can be just as legal as a written contract, but it is much more difficult to prove and enforce. Moreover, many states have statutes of fraud that require written documentation for certain contracts to be enforceable.
- An *implied contract* is a contract in which the agreement between parties is inferred by the legal system wholly or in part by their actions. For example, Jim goes to the local convenience store, where he has an account. He picks up a Sunday *New York Times* and holds it up so the clerk sees him take it and the clerk nods in return as he leaves the store with the paper. Jim has made an implied contract to pay for the newspaper.

**TABLE 18.1**
**Types of Contracts when There Is More than One Promisor or Promisee**

| Type of Contract | Number of Parties | Liability |
|---|---|---|
| Joint | Two or more persons promise the same performance as a single party | All promisors are liable for the complete fulfillment of the contract |
| Several | Separate promises made by more than one promisor | Each promisor is liable for his or her individual promise |
| Joint and several | Two or more parties make a joint contract but also state that they are individually liable for completion of contract | All promisors face cumulative liability |

- A *bilateral contract* is a contract in which two parties have both made a promise to each other. A promise is made in return for a promise. Each party is both a promisor and a promisee.
- A *unilateral contract* is one in which the promisor does not receive a promise as consideration for her promise but instead agrees to pay if she receives an act or service. For example, Mrs. Jones says to Johnny Smith, "I promise to pay you $100 tomorrow if you will clean out my basement and garage today." Johnny immediately goes to work. This constitutes acceptance of the offer and creates a unilateral contract.

If more than one promisor or promisee is involved, the contract can take different forms (Table 18.1). The chief implication is with respect to the liabilities incurred by the different parties.

An engineer will have to deal with contracts in a number of different situations. Contracts for the purchase or sale of property are common. On taking a job you may be asked to sign a contract stating that all technical ideas that you develop belong to the company, even those conceived while not on the job. These contracts are often negotiable at the time of employment and are something to consider when you are looking for employment. In technical dealings between companies, one of the parties may be asked to sign a *confidentiality agreement.* This is a contract in which one of the parties agrees to not disclose, make use of, or copy a design or product that the other party is about to disclose.

### 18.3.2 General Form of a Contract

In general, every business contract should contain the following information:

1. Introduction to the agreement. Include title and date.
2. Name and address of all parties. If one of the parties is a corporation, it should be so stated.
3. Complete details of the agreement. State all promises to be performed. Include such details as specifications and expected outcomes. Give details on promises of payments, including amounts, timing of payments, and interest.

Gary Smith is a district salesman for Zip-R Engineering Corp., manufacturers of automation equipment. He submitted a proposal to ABC Mfg. Co. for 20 specialized robots, in response to ABC Mfg.'s request for bids. The next day, Gary was talking with Joe Clark, purchasing agent for ABC. During the conversation Joe told Gary, "Congratulations, you are a lucky guy." Gary took this as a signal that he had won the contract, and that a written agreement would be entered into later. Because it was close to the end of the quarter, and he needed this job to make his sales quota, Gary booked the job. Zip-R started work on the order immediately.

One week later, ABC's VP of Manufacturing decided to buy the robots from another company because of their reputation for requiring low maintenance. Can Zip-R recover damages for breach of contract?

The words "you are a lucky guy" spoken over the phone are too vague to constitute acceptance of an agreement. Without acceptance there is no legal contract. Gary had no justification for interpreting Joe's vague statement as an acceptance.

4. Include supporting documents such as technical information, drawings, specifications, and statements of any conditions on which the agreement depends.
5. Time and date of the start of the work and of the expected completion.
6. Terms of payment.
7. Damages to be assessed in case of nonperformance. Statement of how disputes are to be arbitrated.
8. Other general provisions of the agreement.
9. Final legal wording. Signatures of parties, witnesses, and notary public.

### 18.3.3 Discharge and Breach of Contract

A contract is said to be *discharged* when the agreement has been performed to the satisfaction of both parties. The contracting parties can agree at any time that the contract has been discharged. It can be discharged if it becomes impossible to perform due to circumstances beyond the control of the contracting parties, for example, *force majeure*. A *force majeure* (greater force) clause in a commercial contract excuses a party from performing its obligations due to causes beyond their control, such as war or natural disasters. However, extreme difficulty in executing the contract does not discharge it even if it becomes more costly to carry out than originally anticipated.

A *breach of contract* occurs when one party fails to perform his or her part of the contract. A legal injury is said to have occurred, and the injured party can sue in court for damages.[1]

1. Another way to settle legal disputes is through arbitration. The United States has become a highly litigious society. In 1995 Americans filed more than 14.8 million civil lawsuits and paid $121.7B in legal fees (National Center for State Courts, Research Department). The number of civil cases filed with federal courts increased fivefold between 1962 and 2005. However, only 1.7 percent of the cases went to trial.

## 18.4 LIABILITY

Any party to a contract must be clear on the potential liability he or she is incurring. *Liability* means being bound or obligated to pay damages or restitution. Two ways to incur liability are (1) breaking a contract or (2) committing a tort, such as fraud or negligence.

A *breach* of contract refers to violating a contract's promise. Failure to deliver detail drawings of a new machine by the date specified in the contract is a breach of contract. It makes no difference whether this was done intentionally or not.

*Fraud* is intentional deceitful action aimed at depriving another party of his or her rights or causing injury in some respect. Examples would be double billing a client or falsely certifying that a component had passed the ASME pressure vessel code.

*Negligence* is failure to exercise proper care and provide expertise in accordance with the standards of the profession that results in damage to property or injury to persons. This is the most common way for an engineer to incur liability to the public. For example, an engineer fails to include a major source of loading in design calculations for a public project so that the design fails. Note that being honest and well-intentioned does not absolve the engineer from a legal charge of negligence.

To be liable for negligence it must be proved that the defendant did not take reasonable and prudent action. This is determined by a jury. One way to demonstrate reasonable care is to show that you acted at the current level of technological development, that is, the *state of the art*. A defense allowed in some states is to prove *contributory negligence,* that the plaintiff was also negligent or could have prevented the accident had due care been taken.

The degree of risk concerning negligence depends on the way the business is organized. In a *sole proprietorship* the owner and the business are one and the same. No distinction is made between the property of the business and that of the owner. Thus, if the business is sued for negligence, the owner is at risk of losing her own savings if the business does not have enough funds to pay the judgment of the court. A *partnership* is similar to a proprietorship but has many co-owners. All general partners are responsible for the acts and financial dealings of each other. A *corporation* is a legal entity that possesses many of the legal powers of individuals, but the corporation exists independently of the people who own and manage it. A corporation can buy and sell property, enter into legal agreements, and sue and be sued. The personal finances of the owners of a corporation are separate from those of the corporation.

The corporation will be held liable for the acts of an employee who commits a civil wrong while engaged in corporate business. For example, the corporation can be fined by the EPA for the act of an employee who discharges liquid waste into a stream. Generally speaking, the corporation will incur the penalties of its employees, and the employee, in turn, may face the wrath of the corporation. Thus, working in a corporate structure provides some degree of protection from liability, but it is not absolute protection. Employees of corporations have been sued in the courts for negligence. Moreover, the trend in the courts is toward greater accountability of corporate employees. A corporate form cannot protect a professional from professional negligence.

Bill Garrison was hired by ABC Mfg. Co. as a consultant in plastic processing. Bill has a chemical engineering degree and 10 years of experience. He was asked to recommend the equipment needed to convert a certain product line from metal to plastic parts. In particular, it was required that the production rate be at least equal to that at which the line made metal parts. When over $10M of new equipment was installed, it was found that because of longer cycle time due to curing the plastic, the plastic line produced only 70 percent of the number of parts as made by the metal line in a given time. Can ABC hold Garrison personally responsible for this development?

Garrison can be held personally responsible to ABC for damages. As a consultant he acted as ABC's agent in designing the production line. By failing to take proper account of the plastic curing time he showed that he had not acted with due care and skill. He could be liable to ABC for negligence in tort, or for breach of contract. In addition, it was found that his 10 years of experience was in the area of polymer formulation, not plastics molding and manufacturing. If it could be shown that he misrepresented his background in order to secure the consulting contract, he could also be liable for fraud.

## 18.5
## TORT LAW

A *tort* is a *civil wrong* that involves damage committed against a person or his or her property, business, or reputation. It is a breach of the rights of an individual to be secure in his or her person and property and be free from harassment.[1] Tort law is chiefly case law of the state courts, rather than statutory law. A decision in a case based on tort law hinges on three questions:

- Have a person's rights been infringed upon?
- Did the act occur as a result of negligence or actual intent on the part of the defendant?
- Did the plaintiff suffer damages as a result of the act?

Tort law deals with civil cases for which the penalty usually is monetary compensation rather than confinement. The difference between a tort and a *crime* is that a tort is a civil wrong while a crime is a wrong against society that threatens the peace and safety of the community. The victim of a crime may also bring a tort suit against the defendant to recover damages.

Tort suits involving engineers usually are concerned with one of four types of actions: (1) misrepresentation, (2) nuisance, (3) negligence, and (4) product liability. *Misrepresentation* is a false statement by a person of a fact that is known to be false, with the intent to deceive another person. When done under oath, it is called *perjury.* Misrepresentation is often claimed in a breach of contract suit. *Nuisance* concerns the annoyance or disturbance of a person such that the use of property becomes physically

1. *Engineering Law, Design Liability, and Professional Ethics,* Professional Publications, Belmont, CA, 1983.

uncomfortable. Nuisances that affect the community, such as a blaring sound system at an open window, become a public nuisance. *Negligence* was defined in Sec. 18.4. *Product liability* is the action whereby an injured party seeks to recover damages for injury to person or property from a manufacturer or seller when the plaintiff alleges that a defective product or design caused the injury. This rapidly growing type of tort suit is discussed in Sec. 18.6.

## 18.6 PRODUCT LIABILITY

Product liability refers to the legal actions by which an injured party seeks to recover damages for personal injury or property loss from the producer or seller of a product. Product liability suits are pursued under the laws of tort. In no area of U.S. law has activity increased as dramatically as in personal injury product-liability civil lawsuits. These span the gamut from individual suits by a single plaintiff against a single company to industry-wide *class action suits* with tens of thousands of plaintiffs against all asbestos manufacturers. The costs associated with tort-based litigation, of which product liability and medical malpractice cases are the predominate share, are estimated to be over $300 billion per year.[1] This is based on annual damage awards and plaintiff and defense legal fees. The authors estimate the real costs of tort-based cases to be at least twice this amount as companies shift product development funding to R&D (so-called defensive R&D) aimed at defending product liability cases. In extreme cases product liability costs have resulted in the near demise of once-profitable industries. In the 1970s the annual production of piston-engine powered light planes was from 10,000 to 15,000 per year and accounted for more than 100,000 jobs. In the early 1990s production was barely 500 planes per year. This decrease has been attributed to the high cost of product liability litigation in the industry.[2]

### 18.6.1 Evolution of Product Liability Law

Before the Industrial Revolution, product liability laws did not exist. The purchaser had the responsibility to buy carefully and to use the product prudently. If the product broke or caused damage, the manufacturer was not required by law to stand behind it, although the better manufacturers gave warranties with their products. Around the mid-1800s the concept of *privity* came into use. Privity means that liability could occur only between those who entered into a contract or a direct transaction. The courts held that the injured party could sue only the party in privity. Thus, if a consumer was blinded by a broken hammer, he or she could sue only the retailer who sold him the tool; the retailer, in turn, could sue only the wholesaler, who in turn could sue the manufacturer.

A significant change occurred in 1916, when a court allowed an automobile owner to sue the manufacturer for negligence. This established the precedent that

1. L.J. McQuillan and H. Abramyan, *The Wall Street Journal,* March 27, 2007, p. A18.
2. B.E. Peterman, *Product Liability and Innovation,* National Academy Press, Washington, DC, 1994, pp. 62–67.

manufacturers are directly liable to consumers. Clearly, from the viewpoint of recovering monetary damages it is advantageous to directly sue the manufacturer, whose resources are likely to be much greater than those of a local retailer. When the Uniform Commercial Code was made law in the 1960s, it stated that there is an *implied warranty* of the fitness of products for their purposes and intended uses.

Also in the early 1960s the case law evolved to what is now called *strict product liability.* Previously, manufacturers or sellers were liable only when they could be proved negligent or unreasonably careless in what they made or how they made it. It had to be proved that a reasonable manufacturer using prudence would have exercised a higher standard of care. However, today in most states a standard of strict liability is applied. Under this theory of law the plaintiff must prove that: (1) the product was defective and unreasonably dangerous, (2) the defect existed at the time the product left the defendant's control, (3) the defect caused the harm, and (4) the harm is appropriately assignable to the identified defect. Thus, the emphasis on responsibility for product safety has shifted from the consumer to the manufacturer of products.

A related issue is the use for which the product is intended. A product intended to be used by children will be held to a stricter standard than one intended to be operated by a trained professional. Under strict liability a manufacturer may be held liable even if a well-designed and well-manufactured product injured a consumer who misused or outright abused it.

### 18.6.2 Goals of Product Liability Law

Only 100 years ago it was the practice in American and British law to not respond to accidental losses. It was generally held that the accident victim, not the manufacturer, should bear the economic burdens of injury. Starting in the mid-20th century, the law began to assume a more active role. Product liability law evolved to serve four basic societal goals: loss spreading, punishment, deterrence, and symbolic affirmation of social values.[1] Loss spreading seeks to shift the accidental loss from the victim to other parties better able to absorb or distribute it. In a product liability suit the loss is typically shifted to the manufacturer, who theoretically passes this cost on to the consumer in the form of higher prices. Often the manufacturer has liability insurance, so the cost is spread further, but at the price of greatly increased insurance rates.

Another goal of product liability law is to punish persons or organizations responsible for causing needless loss. It is important to recognize that under liability law the designer, not just the company, may be held responsible for a design defect. In extreme cases, the punishment may take the form of criminal penalties, although this is rare. More common is the assessment of punitive damages for malicious or willful acts. A third function is to prevent similar accidents from happening in the future, that is, deterrence. Substantial damage awards against manufacturers constitute strong incentives to produce safer products. Finally, product liability laws act as a kind of symbolic reaffirmation that society values human safety and quality in products.

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1. D. G. Owen, *The Bridge,* Summer, 1987, pp. 8–12.

### 18.6.3 Negligence

A high percentage of product litigation alleges engineering negligence. Negligence is the failure to do something that a reasonable person, guided by the considerations that ordinarily regulate human affairs, would do. In product liability law, the seller is liable for negligence in the manufacture or sale of any product that may *reasonably be expected* to be capable of inflicting substantial harm if it is defective. Negligence in design is usually based on one of three factors:

1. That the manufacturer's design has created a concealed danger.
2. That the manufacturer has failed to provide needed safety devices as part of the design of the product.
3. That the design called for materials of inadequate strength or failed to comply with accepted standards.

Another common area of negligence is failure to warn the user of the product concerning possible dangers involved in the product use. This should take the form of warning labels firmly affixed to the product and more detailed warnings of restrictions of use and maintenance procedures in the brochure that comes with the product.

### 18.6.4 Strict Liability

Under the theory of strict liability, it is not necessary to prove negligence on the part of the manufacturer of the product, nor is it necessary to prove breach of warranty or privity of contract. The defect itself, regardless of how it got there, is sufficient to create liability under the tort laws. The fact that the injured party acted carelessly or in bad faith is not a defense under strict liability standards. The courts have acted so as to require the manufacturer to design its products in a way as to anticipate foreseeable use and abuse by the user.

Under most court decisions, defects divide into manufacturing defects and design defects.[1] Failure to conform with stated specifications is an obvious manufacturing defect. A manufacturing defect also exists when the product does not satisfy user requirements. Finally, a manufacturing defect exists when a product leaves the assembly line in a substandard condition, differs from the manufacturer's intended result, or differs from other, ostensibly identical units of the same product line.

A design defect exists if the product fails to perform as safely as an ordinary consumer would expect. The criteria by which a defective and unreasonably dangerous product[2] may be tested in litigation are:

1. The usefulness and desirability of the product
2. The availability of other and safer products to meet the same need
3. The likelihood of injury and its probable seriousness

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1. C. O. Smith, "Product Liability and Design," *ASM Handbook,* Vol. 20, pp. 146–51.
2. H. R. Piehler, A. D. Twerski, A. S. Weinstein, and W. A. Donaher, *Science,* vol. 186, p. 1093, 1974.

4. The obviousness of the danger
5. Common knowledge and normal public expectation of the danger
6. The avoidability of injury by care in use of the warnings
7. The ability to eliminate the danger without seriously impairing the usefulness of the product or making the product unduly expensive

### 18.6.5 Design Aspects of Product Liability

Court decisions on product liability coupled with consumer safety legislation have placed greater responsibility for product safety on the designer. The following aspects of the design process should be emphasized to minimize potential problems from product liability.

1. Take every precaution to assure that there is strict adherence to industry and government standards. Conformance to standards does not relieve or protect the manufacturer from liability, but it certainly lessens the possibility of product defects.
2. All products should be thoroughly tested before being released for sale. An attempt should be made to identify the possible ways a product can become unsafe (see Sec. 14.5), and tests should be devised to evaluate those aspects of the design. When failure modes are discovered, the design should be modified to remove the potential cause of failure.
3. The finest quality-control techniques available will not absolve the manufacturer of a product liability if, in fact, the product being marketed is defective. However, the strong emphasis on product liability has placed renewed emphasis on quality engineering as a way to limit the incidence of product liability.
4. Make a careful study of the relationships between your product and upstream and downstream components. You are required to know how malfunctions upstream and downstream of your product may cause failure to your product. You should warn users of any hazards of foreseeable misuses based on these system relationships.
5. Documentation of the design, testing, and quality activities can be very important. If there is a product recall, it is necessary to be able to pinpoint products by serial or lot number. If there is a product liability suit, the existence of good, complete records will help establish an atmosphere of competent behavior. Documentation is the single most important factor in winning or losing a product liability lawsuit.
6. The design of warning labels and user instruction manuals should be an integral part of the design process. The appropriate symbols, color, and size and the precise wording of the label must be developed after joint meetings of the engineering, legal, marketing, and manufacturing staffs. Use international warning symbols.
7. Create a means of incorporating legal developments in product liability into the design decision process. It is particularly important to get legal advice from the product liability angle on innovative and unfamiliar designs.
8. There should be a formal design review before the product is released for production. (See Sec. 9.4.)

### 18.6.6 Business Procedures to Minimize Risk of Product Liability

In addition to careful consideration of the preceding design factors, a number of business procedures can minimize product liability risk.

1. There should be an active product liability and safety committee responsible for an effective product liability loss control and product safety program. This committee should have representatives from the advertising, engineering, insurance, legal, manufacturing, marketing, materials, purchasing, and quality-control departments of the corporation.
2. Insurance protection for product liability suits and product recall expenses should be obtained.
3. Develop a product usage and incident-reporting system just as soon as a new product moves into the marketplace. It will enable the manufacturer to establish whether the product has good customer acceptance and to detect early signs of previously unsuspected product hazards or other quality deficiencies.

### 18.6.7 Problems with Product Liability Law

Product liability has grown so rapidly that certain problems have developed in the implementation of the law.[1] There has been a dramatic shift in the doctrine of product liability law from negligence to strict liability, but the law has proved incapable of defining the meaning of strict liability in a useful fashion. The rules of law are vague, which gives juries little guidance, and as a result verdicts appear capricious and without any definitive pattern. Another problem concerns the computation of damages once liability is established. There is great uncertainty and diversity in awarding damages for pain and suffering. Our adversarial legal system and juries' unfamiliarity with even the rudiments of technical knowledge lead to high legal costs and exorbitant awards.

The great increases in the number of product liability claims and the dollars awarded by the courts have brought pressure on the U.S. Congress to bring some restraint to the situation before we become a no-fault economy. Advocates of reform point to product liability insurance costs and damage awards as a significant factor in reducing American competitiveness. National product liability legislation has been introduced in Congress to ease the situation. It aims at making tort law on product liability uniform in all the states and on speeding up product liability disputes. It proposes a limit on joint and several liability, a doctrine by which a defendant responsible for only a small portion of harm may be liable for an entire judgment award. It also calls for a limit on a product seller's liability to cases in which the harm was proximately caused by the buyer's own lack of reasonable care or a breach of the seller's warranty.

1. D. G. Owen, op. cit.

A small child threw an aerosol can into a blazing fireplace. The can exploded, injuring the child, and the child's father sued the manufacturer of the cleaner in the spray can. The manufacturer defended itself by stating that the can contained a label warning the user not to incinerate. The child's father argued that the manufacturer should have anticipated that some cans would accidentally be incinerated and that some sort of fail-safe design should have been provided to prevent explosion.

The manufacturer of the spray can won the case by arguing that the presence of a warning label against incineration should excuse liability for the injury. This is a situation where the present state of technology does not provide for a safe means of preventing an explosion upon rapid rise in temperature. The manufacturer should not be held in liability so long as the users of the product have been clearly warned of potential dangers. In fact, the parents of the child were really negligent for allowing their child to play with an aerosol can near an open fire.

## 18.7 PROTECTING INTELLECTUAL PROPERTY

The protection of intellectual property by legal means has become a topic of general interest and international diplomatic negotiations. There are two conflicting motivations for this: (1) creations of the mind are becoming more valuable in the Information Age, and (2) modern information technology makes it easy to transfer and copy such information. We saw in Sec. 5.9 that intellectual property is protected by patents, copyrights, trademarks, and trade secrets. These entities fall within the area of property law, and as such they can be sold or leased just like other forms of property.[1]

The functional features of a design can be protected with *utility patents.* A utility patent protects not only the specific embodiments of the idea shown in the patent application but functional equivalents as well. A well-written patent is the best protection for a valuable idea. For the criteria of patentability refer to Sec. 5.9. If an idea is worth patenting, it is worth hiring an experienced patent attorney to do the job well.

A different type of patent, the *design patent,* covers the *ornamental* aspects of a product such as its shape, configuration, or surface decoration.[2] Design patents are easier to obtain than utility patents, and they are easier to enforce in court. If a competitive design has essentially the same overall appearance, then it is in violation of your patent. A design patent can have only one claim, which is a serious disadvantage, because it means that every unique aspect of a product's design requires a separate patent. This can be expensive.

A copyright has only limited usefulness in protecting product designs. This form of intellectual property is primarily intended to protect writing and creative works like plays and movies.

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1. H. B. Rockman, *Intellectual Property Law for Engineers and Scientists,* John Wiley & Sons, Hoboken, NJ, 2004.
2. The name of this type of patent can be confusing. Design patents do not cover function.

Trademarks are used to protect the names or symbols (logo) of products. A related form of protection is known as *trade dress.* This consists of distinctive features of a product like its color, texture, size, or configuration. Trademark and trade dress are intended to protect the public about the source of a product—that is, to protect against cheap "knock-offs." Trademark protection is achieved by registration with the U.S. Patent and Trademark Office, or by actual use of the trademark in the marketplace such that it achieves market recognition. Obviously, it is easier to defend against a competing trademark if it is registered. A registered trademark is issued for 20 years and can be renewed every 20 years as long as the product remains in the marketplace.

An innovation becomes a trade secret when a company prefers to forgo legal protection for the intellectual property. The reason for doing this is often a feeling that patents are difficult or costly to defend in the particular area of technology, or an unwillingness to let the public know what the company is doing. If the company takes active steps to protect the trade secret, then the courts will protect it as a form of intellectual property. Process innovations are more often protected by trade secrets than product innovations. Companies sometimes require nondisclosure agreements from their employees and may attempt to legally prevent an employee who leaves their employ with sensitive trade knowledge from working for a competitor in order to protect a trade secret.

## 18.8
## THE LEGAL AND ETHICAL DOMAINS

We move now from considerations of the law to a discussion of ethics, and how ethical issues affect the practice of engineering design. Ethics is the study of the principles of conduct that govern the behavior of an individual or a profession. It provides the framework of the rules of behavior that are moral, fair, and proper for a true professional. Ethical conduct is behavior desired by society and is above and beyond the minimum standards of the law.

Former U.S. Supreme Court Justice Potter Stewart said "Ethics is knowing the difference between what you have the right to do, and what is the right thing to do". The connection between legal and ethical action is illustrated by Fig. 18.1. In this model[1] the solid vertical line presents a clear distinction between what is legal and illegal, as set forth by statute and case law. The location of the dashed horizontal line between ethical and unethical behavior is much less well defined. The actions considered ethical depend on values, some of which are important to society, some to the profession, some to the employer, and some to the individual. The task of the ethical professional is to balance these value responsibilities. These values are clarified for the professional and business world by various codes of ethics (see Sec. 18.9). While you would find

1. S. G. Walesh, *Engineering Your Future,* Chap. 11, Prentice Hall, Englewood Cliffs, NJ, 1995; R. H. McCuen and J. M. Wallace, eds., *Social Responsibility in Engineering and Science,* Prentice Hall, Englewood Cliffs, NJ, 1987.

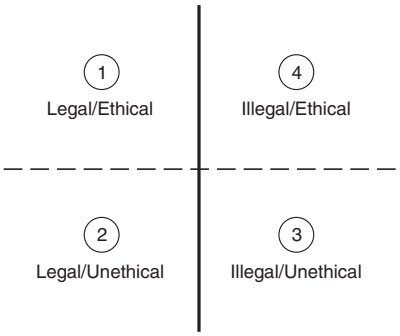


**FIGURE 18.1**
Legal and ethical domains.

close agreement among engineers as to whether an action is legal or illegal, you would find much greater disagreement as to whether some act is ethical or unethical.

Quadrant 1, legal and ethical behavior, is where you should strive to operate at all times. Most design and manufacturing activities fall within this quadrant. Indeed, a good case can be made that quality is dependent on ethical behavior. "Doing what is right in the first place and doing what is best for all involved, when done at every level of the organization and in every work process, has proven to be the most efficient way of conducting a business."[1]

Quadrant 2, legal and unethical, is the concern of the rest of this chapter. The goal is to explain how to identify unethical behavior and to learn what to do about it when it occurs. There is a feeling that unethical behavior in the workplace is increasing because of increasing workplace pressures and changing societal standards. Most corporations have adopted codes of ethics.[2] Many have established an ethics office and are offering ethics training to their personnel. It is interesting that the prevailing view about ethics instruction has changed substantially. Throughout most of the 20th century the common view about ethics was that you either learned ethics in the home when you were growing up, or it was too late. This is changing today to a view that ethics is a teachable subject that can be learned by just about everyone.

Quadrant 3, illegal and unethical, is the sector where "go-to-jail" cards are distributed. In general, most illegal acts also are unethical.

Quadrant 4, illegal and ethical, is a relatively rare event. An example could be an engineer who had signed a secrecy agreement with an employer, but then found that the employer had been engaged in producing a product that was very hazardous to the general public. Unable to get attention focused on the problem within the company, the engineer goes to the press to warn the public. The engineer has breached a contract, but in what is believed to be a highly ethical cause. Such a person would be called a whistle blower; see Sec. 18.10.1.

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1. L. Bottorff, *Quality Progress,* February 1997, pp. 57–60.
2. For example, the Code of Conduct for the DuPont Corp. is given at http://www2.dupont.com/Social_Commitment/en_US/assets/downloads/code_of_conduct/DuPont_Code_of_Conduct_English.pdf.

## 18.9 CODES OF ETHICS

We start by making a distinction between *morality* and *professional ethics*. Morality refers to those standards of conduct that apply to all individuals within society rather than only to members of a special group. Moral values arise from our obligation to respect every other human. These are the standards that every rational person wants every other person to follow and include standards such as the following:

- *Respect* the rights of others.
- Show *fairness* in your dealings with others.
- Be *honest* in all actions.
- *Keep promises* and contracts.
- Consider the *welfare* of others.
- Show *compassion* to others.

Note that each of these standards of conduct is based on the italicized values. Moral values are not static. They change as the culture changes and people become better educated and worldly-wise. For example, 100 years ago there was little concern for the impact of technology on the global environment. Today, engineering designs must be concerned with their impact on the sustainability of the planet.

By professional ethics we mean those standards of conduct that every member of a profession expects every other member to follow. These ethical standards apply to members of that group simply because they are members of that professional group. Like morality, standards of ethical conduct are value-based. Some values that are pertinent to professional ethics include:[1]

- *Honesty* and *truth*
- *Honor*—showing respect, *integrity,* and *reputation* for achievement
- *Knowledge*—gained through education and experience
- *Efficiency*—producing effectively with minimum of unnecessary effort
- *Diligence*—persistent effort
- *Loyalty*—allegiance to employer's goals
- *Confidentiality*—dependable in safeguarding information
- Protecting *public safety* and *health*

Note that some of these values are directed toward the employer (e.g., confidentiality), some toward the customer (e.g., diligence), some toward the profession (e.g., honor), and some toward society (e.g., public health and safety). These values reflect the professional's value obligations.

### 18.9.1 Profession of Engineering

The members of a profession are involved in an intellectual effort that requires special training that benefits society. Collectively, a group of people form a true profession

1. R. H. McCuen, *Ethics Education Program of the Institute for Professional Practice,* Verona, NJ, 1998.

only as long as they command the respect of the public and inspire confidence in their integrity and a belief that they are serving the general welfare.

The nature of professional service varies widely. The physician, lawyer, and clergyman have direct, individual relationships with their clients, but an engineer usually is salaried in someone else's employ. About 95 percent of engineers work for either industry or government, and only a small, but important, percentage is in direct contact with the public as consulting engineers or university faculty. Thus, the service aspect of engineering is less obvious to the general public than in other professions.

The peculiarities of the engineering profession as compared with the professions of law and medicine carry over into the area of ethics. Because engineering lacks the homogeneous character of such professions as law and medicine, it is not surprising to find that there is no widely accepted code of engineering ethics. Most professional societies have adopted their own codes, and ABET and NSPE have adopted broader-based ethical codes.[1] Again, because engineers who are employees of either business or government are in the great majority, they face ethical problems that self-employed professionals avoid. These arise from the conflict between the engineer's desire to gain a maximum profit for the employer (and thus achieve recognition and promotion) and the desire to adhere to a standard of ethics that places the public welfare ahead of corporate profit. For example, what can an employed engineer[2] do to expose and correct the corrupt practices of an employer? What should an engineer do if employed in a business atmosphere in which kickbacks and bribes are an accepted practice?

### 18.9.2 Codes of Ethics

Strong parallels exist between problem solving in design and in ethical decision making.[3] In both instances, a uniquely correct solution or response is rarely possible. However, some solutions are better than others, and some solutions are clearly unacceptable.

To provide guidance on how to behave in situations with ethical implications, each engineering professional society has published a code of ethics. The Code of Ethics for the American Society of Mechanical Engineers is given in Fig. 18.2. Note that the code is rather brief and quite general in its statements and that it is heavily oriented toward values. It is not a list of do's and don'ts. The three fundamental principles identify goals for the ethical behavior of engineers. Use your knowledge as an engineer for the good of humanity. Do it in an honest and impartial way. Work to increase the competence of the profession of engineering. The 10 fundamental canons get a bit more specific, but they still emphasize value statements and leave many things unsaid. This generality is intentional in well-conceived codes of ethics.

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1. ABET is the Accreditation Board for Engineering and Technology, the professional organization that evaluates and accredits engineering and technology curricula in the United States. NSPE is the National Society of Professional Engineers.
2. T. S. Perry, *IEEE Spectrum,* pp. 56–61, September 1981.
3. C. Whitbeck, *Ethics in Engineering Practice and Research,* Cambridge University Press, New York, 1998, pp. 55–66.

**CODE OF ETHICS OF ENGINEERS**

The Fundamental Principles

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

I. using their knowledge and skill for the enhancement of human welfare;
II. being honest and impartial, and serving with fidelity their clients (including their employers) and the public; and
III. striving to increase the competence and prestige of the engineering profession.

The Fundamental Canons

1. Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.

2. Engineers shall perform services only in the areas of their competence; they shall build their professional reputation on the merit of their services and shall not compete unfairly with others.

3. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional and ethical development of those engineers under their supervision.

4. Engineers shall act in professional matters for each employer or clients as faithful agents or trustees, and shall avoid conflicts of interest or the appearance of conflicts of interest.

5. Engineers shall respect the proprietary information and intellectual property rights of others, including charitable organizations and professional societies in the engineering field.

6. Engineers shall associate only with reputable persons or organizations.

7. Engineers shall issue public statements only in an objective and truthful manner and shall avoid any conduct which brings discredit upon the profession.

8. Engineers shall consider environmental impact and sustainable development in the performance of their professional duties.

9. Engineers shall not seek ethical sanction against another engineer unless there is good reason to do so under the relevant codes, policies and procedures governing that engineer's ethical conduct.

10. Engineers who are members of the Society shall endeavor to abide by the Constitution, By-Laws and policies of the Society, and they shall disclose knowledge of any matter involving another member's alleged violation of this code of Ethics or the Society's Conflicts of interest policy in a prompt, complete and truthful manner to the chair of the Committee and Ethical Standards and Review.

**FIGURE 18.2**
The Code of Ethics of ASME International.

http://files.asme.org/ASMEORG/Governance/3675.pdf

The canons[1] present the general duties of an ethical engineer. They start by reinforcing the point that the safety, health, and welfare of the public is the first responsibility of the engineer. Next the canons charge engineers to work only in areas of their competence. The greater our competence, the better we will be able to protect public safety. Recognition of your real competencies is an important attribute. One should work to improve and expand their competence (canon 3), but also know when it is important to bring in other expertise to work on a design. After all, that is why we have design teams. While it is not specifically stated in canon 3, the wording implies that maintaining professional competency applies not just to technical competency but also to competency in knowledge of ethics and values.

Canon 4 charges engineers to act professionally with respect to the employer or client as faithful agents or trustees. This implies that the engineer places high importance on the values of loyalty, confidentiality, efficiency, and diligence. The second part of this canon talks about avoiding *conflicts of interest,* or the *appearance* of such conflict. A person is in a position of conflict of interest when he or she is in a position to personally benefit from actions under his or her influence, especially when the employer is unaware of this benefit. For example, a design engineer who owns considerable stock in a startup company would be in conflict of interest if he specified that company's product in his new design. Often a conflict of interest is impossible or impractical to avoid. In this case, the best practice is to make it known to everyone involved. For example, persons serving on study committees of the National Research Council are asked to disclose any potential conflicts of interest. You might have large stock holdings in your company, yet your expertise is vital to the study that is to be undertaken. Your conflict would be made part of the public record, and you would need to excuse yourself from deliberations if they ever came close to your area of conflict.

Avoiding the appearance of conflict of interest is as important as avoiding the conflict itself. Some areas that could get you in trouble are hiring relatives or close friends, accepting expensive gifts from suppliers or customers, accepting a paid trip to a conference from a supplier, or owning large blocks of stock in a competitor of your company.

In another example of conflict of interest, a law firm is forbidden by the code of ethics for lawyers to represent both parties in a dispute, even if the lawyer is asked to represent the second party in a case unrelated to the first dispute.[2] This part of the code arises from the adversarial nature of the legal system and the role that lawyers play therein. It is interesting to note that none of the engineering ethics codes would prevent a company from designing plastics plants for two directly competing companies as long as confidentiality was upheld. This points out that codes of ethics can differ significantly between professions.

The fifth canon emphasizes the importance of intellectual property in engineering practice by admonishing the engineer to respect proprietary and intellectual property. Cannon 6 is self-explanatory. Nothing is more important over the long term than your reputation for having high ethical standards. The old adage, *we are known by the company we keep* applies here.

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1. A canon is an ecclesiastical or secular rule or law.
2. C. Whitbeck, op. cit.

Canon 7 has many implications. It charges the engineer to be objective and truthful in professional reports, statements, and public testimony. Engineers may express publicly a professional opinion on technical subjects only when that opinion is founded on adequate knowledge and competence in the subject matter. When making a public statement, any payments you may have received from interested parties to make the statement must be disclosed.

Canon 8 places emphasis on consideration of environmental and sustainability issues in the engineer's work. This is a relatively new addition to the canon. Canon 9 admonishes the engineer to be careful before bringing ethical charges against another engineer. Canon 10 reminds the engineer that a member of ASME is obligated to follow the other bylaws and policies of the organization. Also, it is his or her duty to report any observed violation of the Code of Ethics by a member.

The fundamental principles and canons are very general This enables them to be applied in a wide variety of situations. To assist the engineer in using the Code of Ethics, most professional societies publish guidelines for their interpretation. For example, we give some excerpts from the ASME Criteria for Interpretation of the Canons.[1]

- Canon 2. Engineers shall not request, propose, or accept professional commissions on a contingent basis if, under the circumstances, their professional judgments may be compromised.
- Canon 4. Engineers shall not solicit or accept financial or other valuable consideration, for specifying products or material or equipment suppliers, without disclosure to their clients or employers.
- Canon 4. Engineers shall admit their own errors when proven wrong and refrain from distorting or altering the facts to justify their mistakes or decisions.
- Canon 8. Engineers shall concern themselves with the impact of their plans and designs on the environment. When the impact is a clear threat to health or safety of the public, then the guidelines for this Canon revert to those of Canon 1.

Four reasons why engineers should support their profession's Code of Ethics can be presented.[2] First, supporting the Code helps protect engineers from being harmed by what other engineers do. Second, the Code helps ensure to each engineer a work environment in which refusing to perform an unethical directive becomes easier to do. One can point to the Code in support of your position. Third, supporting the Code helps to make engineering a profession about which you need feel no morally justified embarrassment. Finally, supporting the Code is the professional thing to do.

### 18.9.3 Extremes of Ethical Behavior

Ethical theory considers two extreme types of behavior. *Altruism* is a form of moral behavior in which individuals act for the sake of other people's interests. Ethical altruism is the view that individuals ought to act with each others' interests in mind. This

1. http://files.asme.org/asmeorg/NewsPublicPolicy/Ethics/10938.doc
2. M. Davis, *Thinking Like an Engineer,* Oxford University Press, New York, 1998, pp. 59–60.

A young engineer on active duty with the Air Force discovers that a component used in three aircraft is overdesigned. A special adapter, costing several hundred dollars, is required for every component. The original purpose of the adapter was to permit the component to be used with a certain aircraft, but that aircraft now has been phased out of service. Thus, the adapter is redundant. The engineer tries to get the specification changed to eliminate the adapter, but she is told that the "system" will not permit this.

The resourceful engineer then submits the proposal through the suggestion system of the maintenance depot where she is assigned. She receives a phone call from a staff member informing her that as a military officer she cannot receive a monetary award for suggestions. The advice is given that she add a civil service engineer to the suggestion, and that they agree to split the award.

The potential for monetary reward through the suggestion system is rather great, but to do as suggested would be unethical. It would be dishonest and would not show integrity. She submits the suggestion as originally formulated, forgoing an award that could exceed $100,000. Her reward, as a military officer, was dinner for two at the officer's club, and the start of a career with a reputation for high ethical behavior.

is the viewpoint best summarized by the Golden Rule: Do unto others as you would have others do unto you. *Egoism* is a form of moral behavior in which individuals act for their own advantage. Ethical egoism is the view that individuals ought always to act to satisfy their own interests.[1] Most day-to-day practice of engineering is done in the individual's self-interest and is not in conflict with the codes of ethics. However, the codes of ethics are meant to alert the practicing professional that he or she has altruistic obligations that must be properly balanced with self-interest.

## 18.10 SOLVING ETHICAL CONFLICTS

It is probably safe to say that every engineer must resolve at least one ethical dilemma over the duration of his or her career.[2] If the engineer mishandles the situation, his or her career can be damaged even in cases where he or she is trying to do the right thing. Therefore, it is important to know how to handle ethical conflicts and to have thought about conflict resolution before being confronted by a problem. A difficult problem for engineers arises from their dual obligation to serve both their employer and society diligently and with loyalty. The vast majority of businesses aim to be

1. R. H. McCuen, *Issues in Engineering—Jnl. of Prof. Activities,* ASCE, vol. 107, no. E12, pp. 111–120, April 1981.
2. It is also safe to say that every engineering student has had to face an ethical dilemma with adhering to their university's code of academic integrity in their undergraduate career.

**TABLE 18.2**
**Procedure for Solving Ethical Conflicts**

I. Internal appeal option
  A. Individual preparation
    1. Maintain a record of the event and details
    2. Examine the company's internal appeals process
    3. Be familiar with the state and federal laws that could protect you
    4. Identify alternative courses of action
    5. Decide on the outcome that you want the appeal to accomplish
  B. Communicate with your immediate supervisor
    1. Initiate informal discussion
    2. Make a formal written appeal
    3. Indicate that you intend to begin the company's internal process of appeal
  C. Initiate appeal through the internal chain of command
    1. Maintain formal contacts as to where the appeal stands
    2. Formally inform the company that you intend to pursue an external solution
II. External appeal option
  A. Individual actions
    1. Engage legal counsel
    2. Contact your professional society
  B. Contact with your client (if applicable)
  C. Contact the media

R. H. McCuen, *Hydrologic Analysis and Design,* 2d ed., Prentice Hall, Englewood Cliffs, NJ, 1998.

honest and responsible corporate citizens, but the conflict between profit and societal good is potentially always present. What should you do when confronted by an ethical conflict where it is obvious that you have competing value responsibilities?

Ethical decision making is not easy. However, the chances for successfully resolving an ethical conflict can be greatly increased by following a systematic procedure. Table 18.2 presents one set of guidelines that will help ensure meeting one's professional responsibilities. Except under the unusual circumstances of imminent danger to the public, it is important that all internal procedures should be explored before seeking options outside of the organization. The process of seeking resolution to an ethical conflict within the organization is usually handled through an appeals process within management or by the complaint process through the office of the ombudsman or the ethics officer. Seeking resolution outside of the organization is usually called *whistleblowing*. Table 18.2 gives a step-by-step procedure for resolving an ethical conflict, or any conflict for that matter, through an internal appeals process and external to your company.

The steps that the individual should take in preparation for disclosure of unethical behavior are straightforward. Once you have studied and documented the facts and formulated a plan for appeal, you should discuss the matter with your immediate supervisor. Failure to fully communicate your concerns to your immediate supervisor

or secretly going over his or her head to higher levels is viewed as disloyalty and will be viewed negatively by all involved, even your supervisor's superior. It will also decrease the likelihood of a favorable resolution of the conflict. Often the value issue will be resolved by communicating with the immediate supervisor. However, if after fully discussing the issue with your supervisor, you feel that your supervisor is not willing or able to take appropriate action, then inform your supervisor in writing of your intention to appeal beyond that level.

The process of appealing an ethical conflict within the company is usually similar to the process of interacting with your immediate supervisor on the issue. You should have the facts and a plan of how you would like to see the issue resolved. Formal steps should follow informal discussions, and steps within the appeal chain should not be bypassed. If the internal appeal does not resolve the ethical conflict, then you should notify the company that you intend to continue with an external review of the problem.

Before going public legal advice should be obtained. A lawyer can identify courses of action and legal pitfalls in your external appeal. While lawyers understand the legal issues, they may not have the technical background to evaluate the technical adequacy of your arguments. For this reason it might be helpful to involve an engineering professional society as an impartial judge of your arguments. Engineering societies vary widely in their willingness to become involved in these kinds of activities.

If your company worked for a client in the issue about which you are concerned, then the client should be approached before going public. The client may pressure your company to resolve the issue internally, or the client may provide the resources to obtain an unbiased review of the issue.

The last resort is public disclosure by contacting the press and news TV. This is often called whistleblowing.

### 18.10.1 Whistleblowing

*Whistleblowing* is the act of reporting on unethical conduct within an organization to someone outside of the organization in an effort to discourage the organization from continuing the activity. In the usual case the charges are made by an employee or former employee who has been unable to obtain the attention of the organization's management about the problem. Sometimes whistleblowing is confined to within the organization, where the whistleblower's supervision is bypassed in an appeal to higher management. An important issue is to determine the conditions under which engineers are justified in blowing the whistle. DeGeorge[1] suggests that it is morally permissible for engineers to engage in whistleblowing when the following conditions are met:

1. The harm that will be done by the product to the public is considerable and serious.
2. Concerns have been made known to their superiors, and getting no satisfaction from their immediate superiors, all channels have been exhausted within the corporation, including the board of directors.

1. R. T. DeGeorge, *Business and Prof. Ethics Jnl.,* vol. 1, pp. 1–14, 1981.

3. The whistleblower must have documented evidence that would convince a reasonable, impartial observer that his or her view of the situation is correct and the company position is wrong.
4. There must be strong evidence that releasing the information to the public would prevent the projected serious harm.

Clearly a person engaging in whistleblowing runs considerable risk of being labeled a malcontent or of being charged with disloyalty, and possibly being dismissed. The decision to blow the whistle requires great moral courage.[1] Federal government employees have won protection under the Civil Service Reform Act of 1978, but protection under state laws or active support from the engineering professional societies is still spotty. OSHA maintains an Office of Whistleblowers Protection for issues dealing with safety and health in the workplace. Some farsighted companies have established the office of ombudsman or an ethics review committee to head off and solve these problems internally before they reach the whistleblowing stage. Additional information can be found on the web pages of the National Whistleblower Center.[2]

### 18.10.2 Case Studies

Ethics is best taught by looking at real-life situations through case studies. From time to time major incidents occur that catch the public's attention, and these are recorded for posterity in the engineering ethics texts. Prominent examples are the space shuttle *Challenger* tragedy,[3] the Bay Area Rapid Transit (BART)[4] control system failure, and the meltdown of the Chernobyl nuclear reactor.[5] Entire areas of technology and society are the subjects of continuing ethical discussions—for example, genetic engineering. Environmental issues[6] and questions of scientific fraud and integrity in doing research[7] are also prominent areas for discussion.

While these major incidents and cutting-edge activities get most of the attention, the likelihood that the average engineer will be involved heavily in such cases is small. A more typical ethical situation would be:

- Should I authorize the release of production parts that are only marginally out of specification?
- Should I condone the use of pirated design software?

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1. For examples of actions against whistleblowers and advice on how to protect yourself, see *IEEE Spectrum,* April 2004, p. 53. Also see T. Devine and T. F. Maassarani, *The Corporate Whistleblower's Survival Guide,* Berrett-Koehler Publishers, 2011.
2. www.whistleblowers.org
3. R. L. B. Pinkus et al., *Engineering Ethics: Lessons Learned from the Space Shuttle,* Cambridge University Press, New York, 1997; C. Whitbeck, op. cit., Chap. 4.
4. S. H. Unger, *Controlling Technology: Ethics and the Responsible Engineer,* 2d ed., John Wiley & Sons, New York, 1994, pp. 20–25.
5. S. H. Unger, op. cit., pp. 77–91.
6. P. A. Vesilind and A. S. Gunn, *Engineering, Ethics, and the Environment,* Cambridge University Press, New York, 1998.
7. C. Whitbeck, op. cit., Chaps. 6, 7, 9, 10.

A consulting engineer is hired by the county to investigate a bridge collapse. In the course of his investigation he examines a bridge of similar design and finds that it is only marginally safe. He contacts the county engineer to tell him about this discovery. The county official tells him that they know about this condition and that they hope to repair it in the next budget year. However, they must keep the second bridge open because to close it would increase the response time of emergency vehicles by about 30 minutes. What should the consulting engineer do?

He goes back to the marginal bridge and makes a more thorough investigation, taking photographs and measurements. He finds the situation more dangerous than he first thought. Back at the office he makes some calculations and prepares a brief report. He asks for a meeting with the county engineer and lays out the case for closing the bridge. The county engineer is impressed, but points out the political implications of closing the bridge. He suggests a joint meeting with the county supervisor. They meet with the county supervisor, who is impressed with the severity of the situation, and the spirit of civic duty shown by the engineer. They agree to post the bridge to forbid general traffic, but to leave it open to emergency vehicles. The county supervisor schedules a press conference to which he invites the consulting engineer as an honored guest.

- What should I do about the fact that my boss has inflated my credentials on the résumé that went out with the last proposal?

The Center for Engineering Ethics of the National Academy of Engineering provides an Online Ethics Center (http://onlineethics.org) that consolidates many other ethics sites. This is an excellent source of ethics case studies. While well organized, the volume of information offered can be overwhelming at first glance, so we offer suggestions for the first-time visitor to this site.

Select **Resources,** and then click **Topics.** Under **Professional Practice** select **Cases.** The first selection, Teaching Engineering Ethics: A Case Study Approach is a good place to start because it presents cases on topics likely to be encountered by engineers early in their careers. A major feature is that each ethical quandary is answered by four or five experienced engineers. The diversity of answers shows how ethical questions do not always have a common answer. Another useful selection is Numerical Design Problems with Ethical Content.

Another path to interesting case studies is **Topics** followed by **Employment and Legal Issues.** Of particular interest are Advice from the Texas Instruments Ethics Office and Mini-Cases from Lockheed Martin Corporation. It is worth looking at both of these sites since overlapping topics have been removed. These sites include legal issues as well as ethical ones and are typical of the kind of understanding that large corporations expect from their employees.

The categories of professional practice and employment and legal issues have been discussed first because they deal with ethical issues that young engineers are likely to encounter early in their careers. Four other main categories can be found

under **Topics:** (1) **Environment, Safety, and Sustainability** deals with professional responsibility for safety and public well-being; (2) **Responsible Research,** responsible conduct in doing research (important for graduate students and their advisors); (3) **Emerging Technologies,** ethical issues for new technologies like synthetic biology, nanomaterials, and information technology; and (4) **Diversity Issues,** ethical issues surrounding members of underrepresented groups in engineering and research.

We have initially directed the reader to collections of case studies because we feel they are the best way to understand the application of moral and ethical values to engineering problems. Each of the major categories under **Topics** has a section devoted to **Essays and Articles** and **Other Resources** (websites) that should be consulted for more general information than is found in the case studies.

## 18.11 SUMMARY

Engineering is a profession that is critical to the advancement of society. How engineers do their jobs determines what kind of world future generations will enjoy. Thus, the practice of engineering without question will involve you in making ethical judgments. Most will be small in nature, involving your relationship with your management and your fellow engineers, but others could be momentous, affecting the safety of a city.

The law is a formalized code of conduct describing what society feels is the proper way to behave. Statutory law is created by a federal or state legislative body. Case law arises from the decisions of the courts. Ethics is the study of human conduct that lays out the moral ground rules based on society's values. Ethical conduct is the behavior that is desired by society and is separate from the minimum standards of the law.

Engineers should be familiar with contracts and liability, especially product liability. A contract is an agreement between two parties to do or not to do something. It consists of an offer, an acceptance of the offer, and a consideration, the exchange of something of value. A contract is discharged when the agreement has been performed to the satisfaction of both parties. A breach of contract occurs when one party fails to perform its part of the contract.

Liability means being bound or obligated to pay damages or restitution. Two common ways of incurring liability are breaching a contract or committing a tort. A tort is a civil wrong committed against a person, or the business, property, or reputation that causes damage. Common examples of torts are fraud, misrepresentation, negligence, and product liability.

Product liability is the legal action by which an injured party seeks to recover damages for personal injury or property loss from the producer or seller of a product. The law under which product liability is tried has evolved to a standard of strict product liability. Under this theory of law, the plaintiff must prove that: (1) the product was defective and unreasonably dangerous, (2) the defect existed at the time the product left the defendant's control, (3) the defect caused the harm, and (4) the harm is

**TABLE 18.3**
**Typical Ethical Questions Associated with Product Design**

| Steps in Product Design | Possible Ethical Questions |
|---|---|
| Market study | Is the study unbiased, or has it been embellished to attract investors or management support? |
| Conceptual design | Will the product be useful, or will it be just a gimmick? |
| Embodiment design | Does the design team have sufficient expertise to properly judge whether computer programs are giving reliable results? Have any patents been violated? |
| Detail design | Has checking of results been done? |
| Manufacturing | Is the workplace safe and free of environmental hazards? Is enough time allowed to do quality work? |
| Product use | Is the product safe to use? Are users informed of possible hazards? |
| Retirement from service | Has the design allowed for recycling or reuse? |

appropriately assignable to the identified defect. Previously, manufacturers were liable only when they could be proved negligent or unreasonably careless.

To protect against product liability suits, the design procedures described in Secs. 13.8, 14.4 through 14.8 must be followed. In addition, documentation of these design methods and of testing and quality activities is vital. There should be an active product safety committee to see that every step is taken to ensure the design and production of safe products. Finally, it may be a wise business decision to obtain insurance protection for product liability suits and product recall expenses.

While the boundary between legal and illegal acts is generally well defined by the law, the distinction between what is ethical and what is unethical is much less well defined. Professional engineering societies provide guidance by means of codes of ethics. Different individuals respond differently, depending on their value systems. Engineering is a profession, and as such, you are bound by the ethical standards of the profession. It does not matter whether you have individually made that agreement. The profession expects you to behave in a certain ethical way. These rules of conduct are laid down in the code of ethics of each professional engineering society. The existence of a code of ethics is important to you because it gives you an authoritative standard to fall back on if you are engaged in a serious ethical conflict in the workplace.

Table 18.3 suggests typical ethical questions associated with different steps in the product design process.[1]

It is not inconceivable that you will be involved in a serious ethical conflict sometime in your career. Ethical conflict often arises from the competing value responsibilities that engineers have, such as loyalty and diligence to both their employer and the good of society. If such a conflict does arise, it is important to try to resolve the disagreement internally in your organization. Follow to the letter the prescribed

1. M. W. Martin and R. Schinzinger, *Ethics in Engineering,* 3d ed., McGraw-Hill, New York, 1996.

appeal procedure, and document everything. If you must go outside of the organization, obtain competent legal counsel.

## NEW TERMS AND CONCEPTS

| | | |
|---|---|---|
| Altruism | Implied contract | Strict liability |
| Canons of ethics | Intellectual property | Tort law |
| Code of ethics | Liability | Trade dress |
| Conflict of interest | Negligence | Utility patent |
| Express contract | Product liability | Values |
| Fraud | Statutes | Whistleblower |

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## PROBLEMS AND EXERCISES

**18.1.** John Williams, a professional engineer, agrees to testify as an expert witness for the firm of Jones & Black in a court case. In return, the firm promises to pay Williams $1500 plus expenses for his services.

(a) Is this a lawful contract? State the reasons for your decision.
(b) Suppose Williams agrees to accept $2500 if Jones wins, but only expenses if Jones loses. Is this a lawful contract? State your reasons.

**18.2.** ABC Electric agreed by fax on Monday to buy 100 fractional-horsepower motors for $3000 from Amalgamated Electric. On Wednesday the purchasing agent from ABC calls and says he is canceling the order. Amalgamated says the motors have already been shipped and they want their money.

(a) What is the legal responsibility of ABC Electric in this transaction?
(b) Would it have been any different if the motors had not already been shipped?

**18.3.** A car designer specified steel bolts of the highest quality and strength when designing a connection for the front-end steering rods. The manufacturer of the bolts used an inadequate sampling plan for inspecting the bolts, and several defective bolts caused failure of the steering mechanism. Several deaths resulted, and there was a major product recall. Discuss the liability of the designer, the auto company, and the bolt manufacturer.

**18.4.** Read the story of the failure of the General Electric refrigerator with the revolutionary rotary compressor (*Wall Street Journal,* May 7, 1990, p. A1, A5). What lessons does this teach us about product design? What implications does it have for product liability?

**18.5.** Aristotle put forth the precept that humanity should follow four virtues: (1) prudence, (2) justice, (3) fortitude, and (4) temperance. Define each virtue broadly and give examples of ethical behavior for each virtue.

**18.6.** Make a list of business practices that signal whether an organization is an ethical corporation. What role does the CEO of the corporation play in this?

**18.7.** We are in a period where the desire for steady increase in corporate earnings, driven to a large degree by the stock market, sometimes causes management to require layoffs even when profits are good. Discuss the ethics of this from the viewpoint of both corporate management and the individual engineer.

**18.8.** Imagine what it would be like if there were no codes of ethics for engineers. What would be the consequences?

**18.9.** A trend in sports equipment has been to improve the players' performance by introducing new products. Examples are the graphite-composite shaft and titanium head in golf drivers, lighter-weight composite tennis rackets with a larger "sweet" spot, and an aluminum baseball bat with built-in damping. Discuss the ethics of compensating for personal inadequacies in performance with technology in competitive sports.

**18.10.** Discuss the ethics of the following situation: You are a design engineer for the Ajax Manufacturing Co., a large multiplant producer of plastic parts. As part of your employment, you were required to sign a secrecy agreement that prohibits divulging information that the company considers proprietary.

Ajax has modified a standard piece of equipment that greatly increases the efficiency in cooling viscous plastic slurries. The company decides not to patent the development but instead to keep it as a trade secret. As part of your regular job assignment, you work with this proprietary equipment and become thoroughly familiar with its enhanced capabilities.

Five years later you leave Ajax and go to work for a candy manufacturer as chief of production. Your new employer is not in any way in competition with Ajax. You quickly realize that Ajax's trade secret can be applied with great profit to a completely different machine used for cooling fudge. You order the change to be made. Discuss the ethics.

**18.11.** Discuss the ethics in the following situation: You have been on the job for nine months as an assistant research engineer working with a world-famous authority on heat transfer. It is an ideal job, because you are learning a great deal under his sympathetic tutelage while you pursue an advanced degree part-time.

You are asked to evaluate two new flame-retardant paints A and B. Because of late delivery of some constituents of paint A, the test has been delayed and your boss has been forced to make a tentative recommendation of paint A to the design group. You are asked to make the after-the-fact tests "for the record." Much to your surprise, the tests show that your boss was wrong and that formulation B shows better flame resistance. However, a large quantity of paint A already has been purchased. Your boss asks you to "fudge the data" in favor of his original decision, and since there is reasonable possibility that your data were in error, you reluctantly change them to favor his decision. Discuss the ethics.

**18.12.** A new development in the intellectual property arena is the presence of "patent trolls." These are small organizations, usually just a clever inventor and a patent attorney, who buy up patents or hold the inventor's patents in a fast-moving area of technology, such as information technology. The trolls have no plans to make a product based on their patents. Instead they lie in wait, hoping to snare an unwitting manufacturer that infringes on one of their patents and to demand an outrageous royalty payment. Research in Motion, RIM, the producer of the hand-held wireless device called Blackberry, was sued in 2005 by a troll named NTF.

Find out more about what happened in the case of RIM versus NTF and identify the societal issues involved with patent trolls.