ENGINEERING ETHICS

CHAPTER ONE

Introduction

Objectives:

After reading this chapter, you will be able to:-

- Know why it is important to study engineering ethics
- Understand the distinction between professional and personal ethics
- See how ethical problem solving and engineering design are similar.

On August 10, 1978, a Ford Pinto was hit from behind on a highway in Indiana.

The impact of the collision caused the Pinto's fuel tank to rupture and burst into flames, leading to the deaths of three teenage girls riding in the car. This was not the first time that a Pinto had caught on fi re as a result of a rear-end collision. In the seven years following the introduction of the Pinto, there had been some 50 lawsuits related to rear-end collisions. However, this time Ford was charged in a criminal court for the deaths of the passengers.

The case against Ford hinged on charges that it was known that the gas-tank design was fl awed and was not in line with accepted engineering standards, even tough it did meet applicable federal safety standards at the time. During the trial, it was determined that Ford engineers were aware of the dangers of this design, but management, concerned with getting the Pinto to market rapidly at a price competitive with subcompact cars already introduced or planned by other manufacturers, had constrained the engineers to use this design.

The dilemma faced by the design engineers who worked on the Pinto was to balance the safety of the people who would be riding in the car against the need to produce the Pinto at a price that would be competitive in the market. They had to attempt to balance their duty to the public against their duty to their employer.

Ultimately, the attempt by Ford to save a few dollars in manufacturing costs led to the expenditure of millions of dollars in defending lawsuits and payments to victims.

Of course, there were also uncountable costs in lost sales due to bad publicity and a public perception that Ford did not engineer its products to be safe.

1.1 BACKGROUND IDEAS:

The Pinto case is just one example of the ethical problems faced by engineers in the course of their professional practice. Ethical cases can go far beyond issues of public safety and may involve bribery, fraud, environmental protection, fairness, honesty in research and testing, and confl icts of interest. During their undergraduate education, engineers receive training in basic and engineering sciences, problem solving methodology, and engineering design, but generally receive little training in business practices, safety, and ethics.

A good place to start a discussion of ethics in engineering is with definitions of ethics and engineering ethics. Ethics is the study of the characteristics of morals.

Ethics also deals with the moral choices that are made by each person in his or her relationship with other persons. As engineers, we are concerned with ethics because these defi nitions apply to all of the choices an individual makes in life, including those made while practicing engineering.

For our purposes, the defi nition of ethics can be narrowed a little. Engineering ethics is the rules and standards governing the conduct of engineers in their role as professionals.

1.2 WHY STUDY ENGINEERING ETHICS?

Why is it important for engineering students to study engineering ethics? Several notorious cases that have received a great deal of media attention in the past few years have led engineers to gain an increased sense of their professional responsibilities.
These cases have led to an awareness of the importance of ethics within the engineering profession as engineers realize how their technical work has far-reaching impacts on society. The work of engineers can affect public health and safety and can influence business practices and even politics.

The goal of this book and courses in engineering ethics is to sensitize you to important ethical issues before you have to confront them. You will study important cases from the past so that you will know what situations other engineers have faced and will know what to do when similar situations arise in your professional career.

Finally, you will learn techniques for analyzing and resolving ethical problems when they arise.

Our goal is frequently summed up using the term “moral autonomy.” Moral autonomy is the ability to think critically and independently about moral issues and to apply this moral thinking to situations that arise in the course of professional engineering practice.

Good people already know the right thing to do, and bad people aren’t going to do the right thing no matter how much ethical training they receive. The answer to this question lies in the nature of the ethical problems that are often encountered by an engineer. In most situations, the correct response to an ethical problem is very obvious. For example, it is clear that to knowingly equip the Pinto with wheel lugs made from substandard, weak steel that is susceptible to breaking is unethical and wrong. This action could lead to the loss of a wheel while driving and could cause numerous accidents and put many lives at risk. Of course, such a design decision would also be a commercial disaster for Ford.

One of these trade-offs involved the placement of the gas tank, which led to the accident in Indiana. So, for the Ford engineers and managers, the question became the following: Where does an engineering team strike the balance between safety and affordability and, simultaneously, between the ability of the company to sell the car and make a profi t?
These are the types of situations that we will discuss in this book. The goal, then, is not to train you to do the right thing when the ethical choice is obvious and you already know the right thing to do. Rather, the goal is to train you to analyze complex problems and learn to resolve these problems in the most ethical manner.

1.3 ENGINEERING IS MANAGING THE UNKNOWN

One source of the ethical issues encountered in the course of engineering practice is a lack of knowledge. This is by no means an unusual situation in engineering.

Engineers often encounter situations in which they don’t have all of the information that is needed.

So, to a large extent, an engineer’s job is to manage the unknown. How does an engineer accomplish this? Really, as an engineer you can never be absolutely certain that your design will never harm anyone or cause detrimental changes to society.
But you must test your design as thoroughly as time and resources permit to ensure that it operates safely and as planned. Also, you must use your creativity to attempt to foresee the possible consequences of your work.

1.4 PERSONAL VS. PROFESSIONAL ETHICS

In discussing engineering ethics, it is important to make a distinction between personal ethics and professional, or business, ethics, although there isn't always a clear boundary between the two. Personal ethics deals with how we treat others in our day-to-day lives. Many of these principles are applicable to ethical situations that occur in business and engineering. However, professional ethics often involves choices on an organizational level rather than a personal level. Many of the problems will seem different because they involve relationships between two corporations, between a corporation and the government, or between corporations and groups of individuals. Frequently, these types of relationships pose problems that are not encountered in personal ethics.

1.5 THE ORIGINS OF ETHICAL THOUGHT

Before proceeding, it is important to acknowledge in a general way the origins of the ethical philosophies that we will be discussing in this book. The Western ethical thought that is discussed here originated in the philosophy of the ancient Greeks and their predecessors. It has been developed through subsequent centuries by many thinkers in the Judeo–Christian tradition. Interestingly, non-Western cultures have independently developed similar ethical principles.

Although for many individuals, personal ethics are rooted in religious beliefs, this is not true for everyone. Certainly, there are many ethical people who are not religious, and there are numerous examples of people who appear to be religious but who are not ethical.

1.6 ETHICS AND THE LAW

We should also mention the role of law in engineering ethics. The practice of engineering is governed by many laws on the international, federal, state, and local levels.

Many of these laws are based on ethical principles, although many are purely of a practical, rather than a philosophical, nature.

There is also a distinction between what is legal and what is ethical. Many things that are legal could be considered unethical. For example, designing a process that releases a known toxic, but unregulated, substance into the environment is probably unethical, although it is legal.

1.7 ETHICS PROBLEMS ARE LIKE DESIGN PROBLEMS

At first, many engineering students fi nd the types of problems and discussions that take place in an engineering ethics class a little alien. The problems are more open ended and are not as susceptible to formulaic answers as are problems typically assigned in other engineering classes. Ethics problems rarely have a correct answer that will be arrived at by everyone in the class. Surprisingly, however, the types of problem-solving techniques that we will use in this book and the nature of the answers that result bear a striking resemblance to the most fundamental engineering activity: engineering design.

The essence of engineering practice is the design of products, structures, and processes. The design problem is stated in terms of specifi cations: A device must be designed that meets criteria for performance, aesthetics, and price.

1.8 CASE STUDIES

Before starting to learn the theoretical ideas regarding engineering ethics and before looking at some interesting real-life cases that will illustrate these ideas, let's begin by looking at a very well-known engineering ethics case: the space shuttle Challenger accident. This case is presented in depth at the end of this chapter, but at this point we will look at a brief synopsis of the case to further illustrate the types of ethical issues and questions that arise in the course of engineering practice.

A word of warning is necessary: The cliché “Hind-sight is 20/20” will seem very true in engineering ethics case studies. When studying a case several years after the fact and knowing the ultimate outcome, it is easy to see what the right decision should have been. Obviously, had the National Aeronautics and Space Administration (NASA) owned a crystal ball and been able to predict the future, the Challenger would never have been launched. Had Ford known the number of people who would be killed as a result of gas-tank failures in the Pinto and the subsequent financial losses in lawsuits and criminal cases, it would have found a better solution to the problem of gas-tank placement. However, we rarely have such clear predictive abilities and must base decisions on our best guess of what the outcome will be. It will be important in studying the cases presented here to try to look at them from the point of view of the individuals who were involved at the time, using their best judgment about how to proceed, and not to judge the cases solely based on the outcome.

APPLICATION

THE SPACE SHUTTLE CHALLENGER AND COLUMBIA ACCIDENTS

The NASA Space Shuttle Disasters:

The space shuttle is one of the most complex engineered systems ever built. The challenge of lifting a space vehicle from earth into orbit and have it safely return to earth presents many engineering problems. Not surprisingly, there have been several accidents in the U.S. space program since its inception, including two failures of the space shuttle.

The Space Shuttle Challenger Disaster

The explosion of the space shuttle Challenger is perhaps the most widely written about case in engineering ethics because of the extensive media coverage at the time of the accident and also because of the many available government reports and transcripts of congressional hearings regarding the explosion.

Background

The space shuttle was designed to be a reusable launch vehicle. The vehicle consists of an orbiter, which looks much like a medium-sized airliner (minus the engines!), two solid-propellant boosters, and a single liquid-propellant booster. At takeoff, all of the boosters are ignited and lift the orbiter out of the earth’s atmosphere.

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The accident on January 28, 1986, was blamed on a failure of one of the solid rocket boosters. Solid rocket boosters have the advantage that they deliver far more thrust per pound of fuel than do their liquid-fueled counterparts, but have the disadvantage that once the fuel is lit, there is no way to turn the booster off or even to control the amount of thrust produced.

Early Problems with the Solid Rocket Boosters

Problems with the fi eld-joint design had been recognized long before the launch of the Challenger. When the rocket is ignited, the internal pressure causes the booster wall to expand outward, putting pressure on the fi eld joint. This pressure causes the joint to open slightly, a process called “joint rotation,”

O-rings were being eroded by hot gases during the launch. Although there was no failure of the joint, there was some concern about this situation, and Thiokol looked into the use of different types of putty and alternative methods for applying it to

solve the problem. Despite these efforts, approximately half of the shuttle flights before the Challenger accident had experienced some degree of O-ring erosion.

The Political Climate

To fully understand and analyze the decision making that took place leading to the fatal launch, it is important also to discuss the political environment under which NASA was operating at that time. NASA's budget was determined by Congress, which was becoming increasingly unhappy with delays in the shuttle project and shuttle performance. NASA had billed the shuttle as a reliable, inexpensive launch vehicle for a variety of scientifi c and commercial purposes, including the launching of commercial and military satellites. It had been promised that the shuttle would be capable of frequent fl ights (several per year) and quick turnarounds and would be competitively priced with more traditional nonreusable launch vehicles. NASA was feeling some urgency in the program because the European Space Agency was developing what seemed to be a cheaper alternative to the shuttle, which could potentially put the shuttle out of business.

These pressures led NASA to schedule a record number of missions for 1986 to prove to Congress that the program was on track. Launching a mission was especially important in January 1986, since the previous mission had been delayed numerous times by both weather and mechanical failures.

The Days Before the Launch

Even before the accident, the Challenger launch didn’t go off without a hitch, as NASA had hoped. The fi rst launch date had to be abandoned due to a cold front expected to move through the area. The front stalled, and the launch could have taken place on schedule. But the launch had already been postponed in deference to Vice President George Bush, who was to attend. NASA didn’t want to antagonize Bush, a strong NASA supporter, by postponing the launch due to inclement weather after he had arrived. The launch of the shuttle was further delayed by a defective micro switch in the hatch-locking mechanism. When this problem was resolved, the front had changed course and was now moving through the area. The front was expected to bring extremely cold weather to the launch site, with temperatures predicted to be in the low 20’s (°F) by the new launch time.

The engineers' point was that the lowest temperature at which the shuttle had previously been launched was 53°F, on January 24, 1985, when there was blow-by of the O-rings. The O-ring temperature at Challenger's expected launch time the following morning was predicted to be 29°F, far below the temperature at which NASA had previous experience. After the engineers' presentation, Bob Lund, the vice president for engineering at Morton Thiokol, presented his recommendations.

Larry Mulloy, the Solid Rocket Booster Project manager at Marshall and a NASA employee, correctly pointed out that the data were inconclusive and disagreed with the Thiokol engineers. After some discussion, Mulloy asked Joe Kilminster, an engineering manager working on the project, for his opinion. Kilminster backed up the recommendation of his fellow engineers. Others from Marshall expressed their disagreement with the Thiokol engineers' recommendation, which prompted Kilminster to ask to take the discussion off line for a few minutes. Boisjoly and other engineers reiterated to their management that the original decision not to launch was the correct one.

The Launch

Contrary to the weather predictions, the overnight temperature was 8°F, colder than the shuttle had ever experienced before. In fact, there was a signifi cant accumulation of ice on the launchpad from safety showers and fi re hoses that had been left on to prevent the pipes from freezing. It has been estimated that the aft field joint of the right-hand booster was at 28°F.

NASA routinely documents as many aspects of launches as possible. One part of this monitoring is the extensive use of cameras focused on critical areas of the launch vehicle. One of these cameras, looking at the right booster, recorded puffs of smoke coming from the aft field joint immediately after the boosters were ignited.

The Aftermath

As a result of the explosion, the shuttle program was grounded as a thorough review of shuttle safety was conducted. Thiokol formed a failure-investigation team on January 31, 1986, which included Roger Boisjoly. There were also many investigations into the cause of the accident, both by the contractors involved (including Thiokol) and by various government bodies. As part of the governmental investigation, President Reagan appointed a blue-ribbon commission, known as the Rogers Commission, after its chair. The commission consisted of distinguished scientists and engineers who were asked to look into the cause of the accident and to recommend changes in the shuttle program.

Eventually, the atmosphere became intolerable for Boisjoly, and he took extended sick leave from his position at Thiokol. The joint was redesigned, and the shuttle has since fl own numerous successful missions. However, the ambitious launch schedule originally intended by NASA was never met. It was reported in 2001 that NASA has spent $5 million to study the possibility of installing some type of escape system to protect the shuttle crew in the event of an accident. Possibilities include ejection seats or an escape capsule that would work during the first three minutes of fl ight. These features were incorporated into earlier manned space vehicles and in fact were in place on the shuttle until 1982. Whether such a system would have saved the astronauts aboard the Challenger is unknown, and ultimately an escape system was never incorporated into the space shuttle.

The Space Shuttle Columbia Failure

During the early morning hours of February 1, 2003, many people across the Southwestern United States awoke to a loud noise, sounding like the boom associated with supersonic aircraft.

This was the 28th mission flown by the Columbia, a 16-day mission involving many tasks. The first indication of trouble during reentry came when temperature sensors near the left wheel well indicated a rise in temperature. Soon, hydraulic lines on the left side of the craft began to fail, making it difficult to keep control of the vehicle. Finally, it was impossible for the pilots to maintain the proper positioning of the shuttle during reentry the Columbia went out of control and broke up.

This was not the first time that foam had detached from the fuel tank during launch, and it was not the first time that foam had struck the shuttle. Apparently numerous small pieces of foam hit the shuttle during every launch, and on at least seven occasions previous to the Columbia launch large pieces of foam had detached and hit the shuttle. Solutions to the problem had been proposed over the years, but none had been implemented.

After the Columbia accident, the space shuttle was once again grounded until safety concerns related to foam strikes could be addressed. By 2005 NASA was confident that steps had been taken to make the launch of the shuttle safe and once again restarted the launch program. In July of 2005 Discovery was launched. During this launch, another foam strike occurred. This time, NASA was prepared and had planned for means to photographically assess the potential damage to the heat shield, and also planned to allow astronauts to make a space walk to assess the damage to the tiles and to make repairs as necessary.

SUMMARY

Engineering ethics is the study of moral decisions that must be made by engineers in the course of engineering practice. It is important for engineering students to study ethics so that they will be prepared to respond appropriately to ethical challenges during their careers. Often, the correct answer to an ethical problem will not be obvious and will require some analysis using ethical theories. The types of problems that we will encounter in studying engineering ethics are very similar to the design problems that engineers work on every day. As in design, there will not be a single correct answer. Rather, engineering ethics problems will have multiple correct solutions, with some solutions being better than others.