International Association Of Certified Practicing Engineers	www.iacpe.com Knowledge, Certification, Networking	Rev 01 – Oct 2015
IACPE No 19, Jalan Bilal Mahmood 80100 Johor Bahru Malaysia	ENGINEERING ETHICS 2 CPE LEVEL III TRAINING MODULE	

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This would help your career by

1. Providing a standard of professional competence in the practicing engineering and management field
2. Identify and recognize those individuals who, by studying and passing an examination, meets the standards of the organization
3. Encourage practicing engineers and management professionals to participate in a continuing program of personal and professional development

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INTRODUCTION

Scope

This training module covers aspects of engineering ethics to improve engineering professionalism. The module about engineering ethics at CPE level I discusses the origin of ethics, the background and purpose of ethics, and how to managing the ethics for every stakeholder. This module discusses the general principles of ethics, statements of ethical principles, rules of practice, engineering ethics, and engineering profession.

The Primary elements in these skills are the abilities to identify the different, and sometimes competing ethical concerns, to analyze the issues that might underlie those concerns and, to respond effectively to those concerns. These are key elements of good professional judgment, which complement other technical skills that from an engineer's professional competency.

At the end of the training module, there are cases for consideration to consider, stimulate thinking and discuss about the possiblitiy of common actions which might improve moral conduct.

General Design Consideration

General Principles

Codes of engineering ethics identify the engineer's consideration for the public, clients, employers, and the profession.

Many engineering professional societies have prepared codes of ethics. Some date to the early decades of the twentieth century. These have been incorporated to a greater or lesser degree into the regulatory law of several jurisdictions. While these statements of general principles served as a guide, engineers still require sound judgment to interpret how the code would apply to specific circumstances.

For example, "a practitioner shall, regard the practitioner's duty to public welfare as paramount." (Professional Engineers Ontario)

The general principles of the codes of ethics are largely similar across the various engineering societies and chartering authorities of the world, which further extend the code and publish specific guidance. The following is an example:

1. Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.

2. Engineers shall perform services only in areas of their competence.

3. Engineers shall issue public statements only in an objective and truthful manner.

4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflict of interest.

5. Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.

6. Engineers shall act in such a manner as to uphold and enhance the honor, integrity, and dignity of the engineering profession and shall act with zero tolerance for bribery, fraud, and corruption.

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

What is Engineering Ethics?

Engineering ethics concerns one's conduct of behavior and practice when carrying out engineering duties / work. Such duties / work may include consulting, researching, teaching, manufacturing, servicing and writing. The institutionalization of codes of conduct and codes of practice is common with many professional bodies for their members to observe.

Issues: Code of ethics are concerned with a range of issues, including:

- Academic Honesty
- Adherence to confidentiality agreements
- Data privacy
- Handling of human subjects
- Impartiality in data analysis and professional consulting
- Professional accountability
- Resolution of conflicts of interest
- Software piracy, etc.

Aim of Engineering code of ethics:

A code of ethics enables us to:

- Set out ideals and responsibilities of the profession
- Exert a de facto regulatory effect, protecting both clients and professionals
- Improve the profile of the profession
- Motivate and inspire practitioners, by attempting to define their raison d'etre (reason that accounts for)
- Provide guidance on acceptable conduct
- Raise awareness and consciousness of issues
- Improve quality and consistency

On the other hand, we must also consider:

- Whether the so-called standards are obligatory, or are merely an aspiration
- Whether such a code is desirable or feasible
- Whether ethical values are universal guidance given the heterogeneous nature of the profession
- What the point is of specifying responsibilities, given the limited regulatory function of a code

“Ethics” and “Morals”

We hear a lot about “morals” and “ethics”. So what is the difference?

a. Morals are standards of right and wrong in society. These are typically “self-evident” standards of goodness (or evil) that are not debatable (“do not kill”, “do not steal”, “help those in need”), but they still depend on the society (some ancient civilizations believed in human sacrifice, and some societies today believe in severe punishments for behavior that is considered acceptable in other societies).

b. Ethics: Generally, guidelines for moral behavior (ethics in general is also the name of the study of moral codes and behavior), when we discuss “ethical codes”, we generally mean a set of guidelines for behavior based on society on societal morals.

DEFINITIONS

Accidents – Effects of an action which crossed safety rules.

Act Utilitarianism – A kind of utilitarianism which focuses on individual actions rather than rules.

Characteristics – Element of trust which derived from membership of community.

Code of Ethics – Formal obligations that persons accept when they join organizations or when they allowed to enter a profession.

Duty – A term that conveys a sense of moral commitment or obligation to someone or something.

Ethics – The branch of philosophy that involves systematizing, defending, and recommending concepts of right and wrong conduct.

Ethical Code – Are adopted by organization to assist members in understanding the difference between 'right' and 'wrong' and in applying that understanding to their decisions.

Ethical Dilemmas – The problem which provide 'no perfect solution' that will lead to the condition.

Engineering – The strategy for causing the best change in a poorly understood or certain situation within available resources.

Environment – A place outside the system.

Equilibrium – The condition of a system in which all competing influences are balanced, in a wide variety of contexts.

Equity – The value of an ownership interest in property, including shareholder's equity in a business.

IACPE – International Association of Certified Practicing Engineers.

Integrity – Is the quality of being honest and having strong moral principle, moral uprightness.

Impartiality – is a principle of justice holding that decisions should be based on objective criteria, rather than on the basis of bias, prejudice, or preferring the benefit to one person over another for improper reasons.

Leadership – both a research area and a practical skill, regarding the ability of an individual or organization to “lead” or guide other individuals, teams, or entire organizations.

Moral – a message conveyed or a lesson to be learned from a story or event. The moral may be left to the hearer, reader or viewer to determine for themselves, or many be explicitly encapsulated in a maxim.

Morality – The differentiation of intentions, decisions, and actions between those that are distinguished as proper and those that are improper.

Moral Theory – A theory which defines terms of ethical principles in uniform and consistent ways.

Obligation – A course of action that someone is required to take, whether legal or moral.

Problem – factual target which could not reach set point.

Process – Element of trust which derived from the developing relationship between people.

Professional Autonomy – Condition that achieved when engineering codes of ethics emphasize the importance of objective judgment.

Professional Ethics – The moral disposition professional brings to the structure in which engineer operates.

Punishment – The authoritative imposition of an undesirable or unpleasant outcome upon a group or individual, in response to a particular action or behavior that is deemed unacceptable or threatening some norm.

Religion – One of the sources or rooted for ethical principles.

Risk – Potential of losing something of value.

Safety – The state of being “safe”, the condition of being protected against physical, social, spiritual, financial, political, emotional, occupational, psychological, educational, or other types or consequences of failure, damage, error, accidents, harm, or any other event that could be considered non desirable.

Self-evident proposition – is one that is known to be true by understanding it is meaning without proof.

Standards – One of the principal mechanisms for managing complexity of any sort, including technological complexity.

Utilitarianism – A balances between good and bad consequences.

THEORY

Why Ethics for Engineers

Practicing engineers often think that ethical problems are not really their concern. Many ethical decisions are not made by any individual. After all, legal and company rules determine much of what an engineer may or may not do, and committees or executives far removed from the average engineer decide many of the ethical questions that do arise.

Modules such as this one are essential because, for several reasons, engineers must have a clear grasp of engineering ethics. First, many of the ethical decisions that individual engineers must make are not settled by rules. After all, rules do not encompass every situation: often the rules only set limits within which decisions must be made, and some situations are not covered at all. Only ethically aware engineers can correctly apply ethical rules to complex situations, keeping to the spirit as well as the letter of ethical rules.

Second, organizations function best when the values implicit in rules and executive decisions are widely understood and discussed within the organization. The best employment situation, both for the employer and for the employees, is a community atmosphere where everyone works together for a common goal in which everyone believes. Without communication between all levels of an organization, ethical problems may slip between the cracks. Such synergistic effects arise when employees are insensitive to complex ethical dimensions of company operations. It becomes more difficult to overlook ethical problems when each engineer is aware of and sensitive to ethical concerns and potential problems.

Third, engineers should be sensitive to ethical questions because engineers who understand the ethical dimension of engineering are better and happier engineers. Engineers will be happier in a company in which every engineer understands the value of community, since a community atmosphere requires everyone's participation and it is more pleasant and rewarding to work in a place with a community atmosphere.

From the employer's standpoint, employing ethically sensitive engineers has several benefits. First, ethics is good for business. Ethical sensitivity often avoids costly situations. Although acting ethically often costs more in the short run, acting unethically usually costs more in the long run. Engineer and businesspersons are sometimes tempted to act unethically because the benefits of unethical conduct are immediate and highly visible, while the benefits of ethical conduct are often long term and hard to calculate.

Moral Theory

The approach for ethical problem solving could be similar to problem-solving strategies in other engineering classes which required some knowledge of ethical theory to provide a framework for understanding and reaching solutions.

The moral and ethical theories that will be apply in engineering ethics are derived from a cultural tradition. In other words, the ideas itself originated from all over the world. Moral thought has not come down to people from just a single source.

Ethical ideas were continually redefined during the course of history. Many thinkers have turned their attention to ethics and morals and have tried to provide insight into the issues. Locke, Kant, and Mill are the example of philosophers who wrote about moral and ethical issues.

Regarding to develop workable ethical problem-solving techniques, engineers should look at several theories of ethics first in order to have a framework for decision making. Thus, the ethical problem solving is not as cut and dried as problem solving in engineering classes. The relatively large number of theories do not indicate a weakness in theoretical understanding of ethics or a ‘fuzziness’ of ethical thinking. Rather, it reflects the complexity of ethical problems and the diversity of approaches to ethical problem solving that have been developed over the centuries.

Moral theory defines terms in uniform ways and links ideas and problems together in consistent ways. This definition is also apply for scientific theories usage in other engineering classes function. So, in moral theory, the engineers will organize ideas, define terms, and facilitate problem solving.

Three Types of Ethics or Morality

1. Common Morality

   Common morality is the set of moral beliefs shared by almost everyone. It is the basis, or at least the reference point, for the other two types of morality that we shall discuss. When we think of ethics or morality, we usually think of such precepts as that it is wrong to murder, lie, cheat or steal, break promises, harm others physically, and so forth. It would be very difficult for us question seriously any of these precepts.

   Three characteristics of common morality must be mentioned here. First, many of the precepts of common morality are negative. According to some moralists, common morality is designed primarily to protect individuals from various types of violations or invasions of their personhood by others

   Second, although common morality on what we might call the "ground floor" is primarily negative, it does contain a positive or aspirational component in such precept as "Prevent Killing", "Prevent deceit", "prevent cheating", and so forth.

   Third, common morality makes a distinction between an evaluation of a person's actions and an evaluation of his intention. An evaluation of action is based on applications of the types of moral precepts we have been considering, but an evaluation of the person himself is based on intention.

2. Personal Morality

   Personal ethics or personal morality is the set of moral beliefs that a person holds. For most of us, our personal moral beliefs closely parallel the precepts of common morality. We believe that murder, lying, cheating, and stealing are wrong. However, our personal moral beliefs may differ from common morality in some areas, especially where common morality seems to be unclear or in a state of change. Thus, we may oppose some research, even though morality may not be clear on the issue.

3. Professional Ethics

   Professional ethics is the set of standards adopted by professionals in so far as they view themselves acting as professionals. Every profession has its professional ethics: medicine, law, architecture, pharmacy, and so forth. Engineering ethics is that set of ethical standards that applies to the profession of engineering. There are several important characteristic of professional ethics.

There are at least four ethical theories that will be considered. Each differs according to what is held to be most important moral concept including:

1. Utilitarianism.
   Utilitarianism is looking to produce the most utility, defined as a balance between good and bad consequences of an action, taking into account the consequences for everyone affected.

2. Duty ethics.
   Duty ethics contends that there are duties that must be performed regardless of whether these acts lead to the best. Treat others fairly is one of the examples of duty ethics.

3. Right ethics.
   Meanwhile, right ethics emphasizes that all of the people have moral rights, and any action that violates these right is ethically unacceptable. The ultimate overall good of the actions is not taken into account.

4. Virtue ethics.
   Virtue ethics regards actions as bad that display bad character traits. The theory is focuses on the type of person we should strive to be.

Utilitarianism

Utilitarianism description could be whatever the action will lead to its consequences, such as good actions serve to maximize human welfare. But, the emphasis in utilitarianism is not on maximizing the well-being of the individual, but rather on maximizing the well-being of society as a whole and as such it is somewhat of a collectivist approach.

Utilitarianism is fundamental to many types of engineering analysis, including risk-benefit analysis and cost-benefit analysis. However, as good as the utilitarian principle sounds, there are also some problems.

An objection to utilitarianism is that its implementation depends on knowing what will lead to the best. Frequently, it is impossible to know exactly what the consequences of an action. It is often impossible to do a complete set of experiments to determine all of the potential outcomes. Then maximizing the benefit to society involves guesswork and the risk that the best guess might be wrong. Despite the objections, utilitarianism is a valuable tool for ethical problem solving.

It should be noted that there are many flavors of the basic tenets of utilitarianism, as follows:

- Act utilitarianism.

  Act utilitarianism focuses on individual actions rather than rules.

- Rule utilitarianism.

  Rule utilitarianism differs from act utilitarianism in holding that moral rules are most important. The rules include ‘do not harm others’ and ‘do not steal’. Rule utilitarian’s hold that although adhering to these rules might not always maximize good in a particular situation. Overall, adhering to moral rules will ultimately lead to the best.

Utilitarianism focuses on the consequences that occur from the actions. The principles of utilitarianism can be applied to engineering situations where ethical problems arise. Although these two different types of utilitarianism can lead to slightly different results when applied in specific situations.

Cost-Benefit Analysis

Cost-Benefit Analysis one of the tools that is frequently used in engineering analysis, especially when trying to determine whether a project makes sense. Fundamentally, this type of analysis is just an application of utilitarianism. By this theory, the costs of a project are assessed, as are the benefits. Only those projects with the highest ratio of benefits to costs will be implemented. This principle is similar to the utilitarian goal of maximizing the overall good.

Similar to utilitarianism, there are pitfalls by using cost-benefit analysis method. While it is often easy to predict the costs for most projects, the benefits that are derived from them are often harder to predict and to assign a dollar value to. Once dollar amounts for the costs and the benefits are determined, calculating a mathematical ratio could look very objective and therefore may appear to be the best way to make a decision.

It should be noted that although cost-benefit analysis shares many similarities with utilitarianism, cost-benefit analysis is not really an ethical analysis tool. The goal of an ethical analysis is to determine what is the ethical path. The goal of a cost-benefit analysis is to determine the feasibility of a project based on costs. Whenever the engineer facing an ethical problem, first step must be to determine what the right course of action and then factor in the financial costs in choosing between ethical alternatives.

Duty Ethics and Rights Ethics

There are the two other ethical theories which are similar to each other and frequently occurred together. These theories hold that those actions are good that respect the rights of the individual. Here, good consequences for society as a whole are not the only moral consideration.

Duty ethics and rights ethics are really just two different sides of the same coin. Both of these theories achieve the same end: Individual persons must be respected, and actions are ethical that maintain this respect for the individual. In duty ethics, people have duties, an important one of which is to protect the rights of others. While in right ethics, people have fundamental rights that others have duties to protect.

There is also problem between the duty and rights ethics theories that must be considered as follows:

- First the basic rights of one person (or group) could be conflicted with the basic rights of another group.

- Second, the problem with duty and rights ethics is that these theories don't always account for the overall good of society very well. Since the emphasis is on the individual, the good of a single individual can be paramount compared to what is good for society as a whole.

Already it is clear why the engineer should be considering more than one ethical theory in engineering cases. Thus, any complete analysis of ethical problem must incorporate multiple theories if valid conclusions are to be drawn.

Virtue Ethics

Virtue ethics is usually described as positive moral distinction and goodness. Virtue ethics is interested in determining the kind of person you should become. In virtue ethics, actions are considered right if they support good character traits (virtues) and wrong if they support bad character traits (vices).

Virtue ethics focuses on words such as responsibility, honesty, competence, fairness, respect, trustworthiness and loyalty which are virtues. Incompetence, disloyalty, and irresponsibility are vices.

The theory is not only about personal ethics but could also applicable to engineering or professional ethics. Therefore, virtue ethics could be applied to business and engineering situations by answering several questions such as:

- Is this action honest?
- Will this action demonstrate loyalty to my community and/or my employer?
- Have I acted in a responsible fashion?

To use virtue ethics in an analysis of an ethical problem, the engineer should first identify the virtues or vices that are applicable to the situation. Then, determine what course of action each of these suggests. As with any ethical theory, it is important to be careful in applying virtue ethics. Problems can arise with words that on the face seem to be virtues, but can actually lead to vices.

Non-Western Ethical Thinking

As explained before, since the rest of the world has different foundations for ethical systems. Hence, ethics is not geographic or cultural. Indeed, ethical consideration and standards which have been developed similarly around the world, and it is not dependent on a Western cultural or religious tradition.

A detailed understanding of ethical considerations from cultures around the world is well beyond the scope of the module. Despite the diversity of origins of ethical philosophy, the engineer must see the ethical concepts governing engineering practice are similar regardless of where engineers practice. Nonetheless, personal ethics are not determined by geography. Personal and business behavior must be the same regardless of where an engineer happens to be on a given day. Several examples non-western ethical consideration are further explain following:

- Chinese Ethics.

  Confucian ethics emphasizes the importance of balancing individual rights with the needs of the larger community. In trying to balance individual and group rights, Confucianism emphasizes the fact that this is not a neither/or proposition: neither individual rights are paramount or the rights of society as a whole paramount.

  By acknowledging the interdependence, Confucianism mirrors the tension inherent in trying to balance the Western concepts of utilitarianism and rights or duty ethics. Confucian ethics could have informed the engineer at decision-making moment by emphasize on virtues and the importance of leading a virtuous life speaks very directly to the engineering profession especially in terms of honesty, integrity, and other core values of engineers.

- Indian Ethics.

  Indian philosophy and ethics was focused less on the theoretical and intellectual aspects of philosophy, and more on the practical and the spritiual. Nothing could be more practical than the ethical concerns about human social behavior.

  Indian ethical philosophy has much in commmon with virtue ethics discussed in Western ethical traditions. Nevertheless, the Indian philosophical and ethical traditions speaks to modern engineering practice by emphasis on the practical everyday nature of philosophy directly speaking to modern engineers and engineering practice. In addition, the emphasis on reinforcing virtues and avoiding vices directly mirrors the language used in modern engineering codes of ethics.

- Muslim Ethics.

  Muslim ethics could be considered as a cousin to many Western ethical traditions. Broadly speaking, the Muslims ethics have much in common with what Western philosophers refer to virtue ethics. For muslim philosophers, ethics is derived from principles set forth in the Qur'an.

  Specific virtues mentioned in the Qur'an are humility, honesty, kindness, giving the poor, and trustworthiness. It is clear that honesty and trustworthiness are an essential virtues for those practicing a profession such as engineering. In many areas Islamic world is different compared to the Western world, but the way Islam impacts engineering professional practice is similar as Western ethics.

- Buddhists Ethics.

  Like other formulations of ethical consideration in non-Western societies, Buddhist ethics could appeared to be similar to the Western concept of virtue ethics. Buddhist's speak of five major vices: Destruction of life, taking what is not given, licentiousness, lying, and consuming intoxicants. Buddhism speaks of virtues such as spiritual development, mastery of skills, friendship, diligence, patience and a sense of proportions of limits.

The engineer must examine the role that the Buddhist virtues of learning, mastery of skills, and diligence have in relation to engineering practice. The engineering codes of ethics often discuss the importance of continous development of an engineer's skills, and supporting others in developing their skills.Thus, the ideas regarding protecting the environment and sustainable development that appear in the most recent versions of the codes of ethics of professional engineering societies are similar to ideas found in Buddhist teachings.

Although ethical consideration throughout the world has originated in various ways and has diverse language and terminlogy, the results are similar across cultures.

Moral judgments

Ethics is the study of morals and moral judgments. What are moral judgments? The words moral and ethical have similar meanings:

Right = Moral = Ethical
Wrong = Immoral = Unethical

Descriptive ethical statements are those statements that take a neutral attitude toward morals. For example, a descriptive ethical statement may be "She bribed the official". The normative ethical statement would be "It was wrong for her to bribe the official".

Normative ethical statements take a judgment attitude towards morals in order to guide actions. For example, "The right (ethical, moral) thing to do is to return stolen money, in the example a judgment is being stated concerning the action of returning stolen money in order to convince the listener to return the money.

We need to consider two related concepts in addition to moral and immoral: amoral and non-moral. Amorality describes those people who truly do not know right from wrong. A small child or mental psychopath could be classified as amoral. Non-moral is not a moral statement. Non-moral does not equate to immoral.

Consider these two examples of non-moral statements:

a. It is right (correct) to say the earth is round.
b. It is wrong (incorrect) to say the earth is flat.

Moral Frameworks

The engineers do not share a single set of moral principles by which to make ethical decisions, it is fully expected that different readers will make different decisions. In a complex condition what is the proper decision to take under a short period of time. The goal is not to unify all decisions by all engineers, but give some autonomy to each engineer to make the right decision. By this context, the 'right' decision can be identified by the use of a heuristic method.

As for the right decision is one that following a'consistency of values' such as :

- General codes of engineering conduct.
- Moral principles for Engineers.
- Any obligations that previously accepted.
- Laws.

Nonetheless, the right decision is the one that the engineer can live with. Thus, there is always a chance of possiblity for people to make an unacceptable decision.

Moral autonomy is the ability to make one's own ethical decisions. In order of that term, moral autonomy does not require that you able to look back and alwas be confident that the choice made was the best of all possible choices. This is a 'moving-target', since it is very dynamic. In conclusion, whenever the decision choice based on a reasonable analysis of the potential consequences consistent with moral values, legal, faith, ethical beliefs, duties, right, laws, and also obligations, it was actually exercising the moral autonomy of engineers.

On the other hand, if there are no understanding of moral principles, strategy to go along with for ethically analyzing a situation properly, and defer the engineers resonsibility to others, it will lead to to the lowering competency of engineer.

The idea of normal design might be related to 'business-as-usual' technology development there is no need for engineers to reflect ethically. There are some situations which an engineer must ethically reflect the development of technology.

There is a normative framework that exists which governs all ethically relevant decisions in technology development. The engineers should obey the rules from the normative framework without further ethical reflection.

The normative framework must meet one of the following requirements:

- Pragmatics.

  This requirement has to comprehend properly the decision to be made and must leave out no important aspects from consideration.

- Unambiguous.

  Beyond the normative framework, there has to be a sufficient common understanding among the actors in the decision under discussion.

- Consistent at local stage.

  This term has to be also ‘sufficient’ degree of freedom from contradiction among the various elements of the normative framework.

- Observation.

  The normative framework has to be in fact observed.

- Acceptation.

  The normative framework has to be accepted as the basis for the decision by the decision maker and also those who concerned about engineering ethics.

Regarding to the acceptance of the normative framework, it cited that the acceptance requires neither to be universal nor should it be restricted to the very narrow sphere of engineering. Thus, the normative framework could be composed from all obligations given by political regulation and all obligations resulting from other societal regulation like technical codes and standards and codes of ethics. In conclusion, the normative framework comprises the same elements as the regulative framework.

Reflection of Action

After an engineering event has achieved in which ethical decisions were made, one party or a group of people should sit down and reviews the case, analyzing the facts, the missing information, the constraints, the unnecessary perceived constraints, the options considered, the options not considered, and the strategy used to arrive at the decision. Frequent postmortem analysis is one of the key characteristics of successful professionals in a variety of fields. Reflection in action at any cost will be focus on two things:

- The force for the one that must be analyze the strengths and weaknesses of their strategy.
- Provides continual opportunities and encouragement for rehearsal.

There are several step that should follow consider of doing a reflection of action including:

- Definition of the problem.
- Exploration of an alternative ways.
- Planning the details of action.
- Do the action with eagerness to accomplish it well.
- Review all of the action from beginning to the end.

At the end of any reflection, person or party in-charge must develop a list of heuristics to use in future ethical problem solving. The following heuristics could be identified as:

- Traditional problem – solving strategy usage for solving ethical problems.
- Consider the possibility that inexperienced people can be right.
- Debrief people fully before assuming facts about their decisions.
- Consideration of the consequences.
- Honesty.
- Concern about the welfare of the company.
- Be aware about the welfare from the employees.
- Independency.

As the technology grows, so does for the additional ethics heuristics approachment. Many heuristics for the solution of ethical problems have been explained. Thus, some great heuristics methods are always try to develop new heuristics. Such as in example points below:

- Obtain all of information about the exact situation. The problem may be more serious than it first appears, or it could be lead to the opposite matter, in which no real problem exists.
- Always open minded and honest.
- Acknowledge the concerns of others frequently.

Engineering Ethics

Engineering ethics is the field of applied ethics and system of moral principles that apply to the practice of engineering. The field examines and sets the obligation by engineers to society, to their clients, and to the profession. As a scholarly discipline, it is closely related to subjects such as the philosophy of science, the philosophy of engineering, and the ethics of technology.

Engineering ethics is the field of study focuses on the ethical aspects of the actions and decisions of engineers, both individually and collectively. A rather broad range of (ethical) issues are discussed in engineering ethics: professional codes of conduct, whistle-blowing, dealing with safety and risks, liability issues, conflicts of interests, multinational corporations, privacy etc.

- Professional maturity
- Learning to be comfortable with ambiguity
- More than one answer to the same question
- Sometimes one answer is not entirely correct
- Professional Maturity
- Learning to be comfortable with ambiguity
- More than one answer to the same question
- Sometimes one answer is not entirely correct
- Emotional intelligence
    - Self-awareness (e.g., handling stress)
    - Self-regulation (e.g., the words you use)
    - Empathy (e.g., feeling other's pain)
    - Social skills (verbal, non-verbal skills)
- Data
- Information
- Facts
- Knowledge
- Expertise
- Wisdom

"Novice" – Complies with strict rules based on context free features of the task environment.

"Advanced Beginner" – Recognizes the situational aspect of the task environment and follows maxims to adjust his or her actions accordingly.

"Competent Performer" – Does not try to account for all discrete elements of the task environment; instead, he or she selects a plan, goal or perspective to establish which elements are relevant and which may be safely ignore;

"Proficient Performer" – No longer reflects on the task environment as a detached observer; without having to evaluate multiple options, he or she simply sees what needs to be done and then chooses how to go about doing it.

"Expert" – Intuitively perceives both what needs to be done and how to do it, making extremely subtle and refined discriminations in a variety of task environments that are sufficiently similar to those previously encountered.

Moral History

- Hinduism… “one should not behave towards others in a way which is unpleasant for oneself: that is the essence of morality…”
- Buddhism… “a state which is not pleasant or enjoyable for me, will also not be so for him, and how I can impose on another a state which is not pleasant or enjoyable to me…”
- Confucianism… “what you yourself do not want, do not do to another person…”
- Jainism… “human beings should be indifferent to worldly things and treat all creatures in the world as they would want to be treated themselves…”
- Judaism… “do not do to others what you would not want them to do to you…”
- Islam… “none of you is a believer as long as he does not wish his brother what he wishes himself…”
- Christianity… “whatever you want people to do to you, do also to them…”

Moral Discussion

- Utilitarianism – what is ethical is that which produces the greatest good for the greatest number

- Duty Ethics – what is ethical is to perform duties regardless of whether they lead to “good” outcomes.

- Right Ethics – mirrors of duty ethics; people have rights that cannot be violated.

- Virtue Ethics – actions reflecting good character traits are good, vices are bad; outcome of action is not relevant.

Engineers should adhere to professional codes of conduct that state, for example that engineers shall hold the safety and welfare of the public paramount. Based on descriptions of the Challenger disaster, Davis emphasizes that there is a difference between engineers and managers. Engineers should adhere to their professional norms and hold safety paramount and managers do not do this.

- Engineers are professional practitioners (in the same way that lawyers and physicians are professionals).
- Although engineers may work for companies, nonprofit organizations, or governmental units, many engineers, like MD’s or attorneys, are independent business people and work for clients.
- All professions have guidelines for interacting with clients.

Engineering ethics is applied ethics, i.e. ethics to specific practical problems. Ethics is about what one should do, how one should live. Engineering ethics is about what engineers should do as engineers. It is both different and the same. Different because engineers face unique problems and the same because the solution to these problems may be similar to the solution to other problem. It is because of this uniqueness that engineering ethics can exist as an independent field and it is because of this similarity that it can draw from the work philosophers on the other aspects of ethics.

Engineering ethics can be defined as the activity of solving moral problems by understanding, developing, and justifying moral judgments related to engineering issues and the development of and compliance with currently accepted ethical codes of conduct. It is important to understand the components of this definition before you can fully comprehend the concept of engineering ethics. In first part of the definition start by elaborating on the individual terms, moral, judgments and ethics.

Code of Ethics (Standards of Engineering)

Codes of ethics are formal obligations that persons accept when they join organizations or when they are allowed to enter a profession. Especially for engineers, there were at least three main types of codes of ethics: Employer, Technical Societies / Associations and also Government (National Bureaucracy). The employer-based codes of ethics are usually incorporated into the codes of business conduct that one agrees to upon employment with a particular firm.

For engineering associations like IACPE, the code will identify to whom the code applies and purpose of the code (such as upholding and advancing the honor, integrity, and dignity of the engineering profession).

Generally, the purposes are based on the concept that each member of a group who has a high responsibility to maintain the good image of all other members of the group through professional behaviors that tend to increase the trust that society has in the profession.

This concept is a strong one due to high-impact of acknowledging the unethical behavior of any member of the group that could cause the trust issues between internal members of the group and externally relationships. Therefore, all members should have share the same interest level of the ethical behavior of all members.

The second part of codes for engineering societies the list which identify the duties that engineers must have (being honest, impartial, loyal), to whom (employers, clients, the public, the profession), and why (enhancing of human welfare). Also, it represents that practicing engineering ethically involves improving the profession (striving to upgrade their competency). This section provides two important purposes:

- The engineers should acknowledge the core responsibility to the society that may not be apparent in day-to-day work. The decision that their made could save many lives by productizing fertilizer / pesticide to grow much needed food, it might be turned to the other way and kill scores of people by catastrophic event. (for example Bhopal, India)

- Second purpose as the list of goals points out quite clearly that not all goals can be met simultaneously all of the time. As a matter of fact, one frequently encounters ethical dilemmas, in which no choice is a perfect choice, completely satisfying all of our moral, legal, and ethical responsibilities.

The third part of the code of ethics will be focused on specific responsibilities that engineers have. During reiterating and clarifying the responsibilities of engineers for safety and health of the society at large, the engineers speak to the responsibilities to clients, employees, and the profession itself.

An engineering code of ethics generally insist that engineers conform to standards of competence. Regulatory standards and standards of competence are intended to provide some assurance of quality, safety, and efficiency in engineering.

It is also important that engineers have a responsibility to use their specialized knowledge and skills in ways that will give benefit to the clients and also to the public (environment) with no violation of trust placed for them.

An early code is called the 'Engineer's Creed' which illustrated as a pledge:

"As a professional engineer, I dedicate my professional knowledge and skill to the advancement and betterment of human welfare. I pledge to give the utmost of performance, to participate in none but honest enterprise, to live and work according to the laws of man and the highest standards of professional conduct, to place service before profit, honor and standing of the profession before personal advantage, and the public welfare above all other considerations. In humility and with need for divine guidance. I make this pledge."

Some code of Ethics of Professional Engineering Societies:

As engineers we are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Hence engineers must perform their duties that requires adherence to highest principles of ethical conduct. Engineers in the fulfillment of their professional duties shall.

- Hold paramount the safety, health and welfare of the people
- Perform service only in areas of their competence
- Issue public statement only in an objective and truthful manner
- Act for each employer or client as faithful agents or trustees
- Avoid deceptive acts – To receive bribes to show favor
- Conduct themselves honorably, responsibly, ethically and lawfully so as to enhance the honor, reputation and usefulness of the profession.

What is A Profession

We can begin by looking at the dictionary definition of professionalism. An early meaning of the term *profession* referred to a free act of commitment to a way of life. When associated with the monastic vows of a religious order, it referred to a monk's public promise to enter a distinct way of life with allegiance it high moral ideals. One "professes" to be a certain type of person and to occupy a special social role that carries with it stringent moral requirements. By the late 17^{th} century, the term had been secularized to refer to anyone who professed to be duly qualified.

- **A sociological analysis of professionalism**

  Although probably no profession has all of these characteristics to the highest degree possible, the more characteristics an occupation has, the more secure it is in its professional status.

  1. Extensive training: entrance into a profession typically an extensive period of training, and this training is of an intellectual character. Many occupations require extensive apprenticeship and training, and they often require practical skills, but the training typically required of professionals focuses more on intellectual content than practical skills.

2. Vital knowledge and skills: Professionals knowledge and skills are vital to the well-being of the larger society. A society that has a sophisticated scientific and technological base is especially dependent on its professional elite.

The Engineering Profession

Engineering practice can be defined as a “profession”, as opposed to an “occupation” or “job”. A profession has the following attributes:

- Work requires sophisticated skills, judgment, and exercise of discretion (work is not routine)
- Membership in the profession requires formal education
- Special societies (controlled by members of the profession) establish standard for admission into the profession and conduct of its members
- Significant positive public service results from the practice of the profession

Engineering is a profession, but differs from law and medicine in the following ways:

- Most engineers are not self-employed, but work for large companies (the exceptions include civil engineers and consulting engineers)
- Education is different: only a BS degree is required to practice engineering
- Engineering societies are not as powerful as the AMA or ABA, since BS degree holders can practice engineering without a professional license

Ethics and the professions

Why is ethics an integral part of professional life, and in particular the life of an engineering professional? The importance of ethics in the professions can be understood through thinking about what a profession such as medicine, law, accountancy and engineering. However broadly speaking there is agreement on common characteristics shared by all professions. Thus a professional:

- Has specialized skills and knowledge
- Has acquired such knowledge and skills through a long period of training and study, and continues to maintain and update them through professional life
- Has, as result of this specialized expertise, significant power to affect individual clients and wider society
- Belongs to professional body which regulates their practice
- And as part of that self-regulation adheres to ethical principles which the professional body oversees

The expertise of professionals, and the domains over which they exercise that expertise, given them power to improve people’s wellbeing, or to cause significant harm.

This is perhaps most obvious in the case of doctors, whose actions can save lives or cause death, and affect quality of life in many subtlest ways. A patient needs to know that a medical professional is not just technically competent, but will exercise ethically informed judgment in treating them, acting only with consent, maintaining confidentiality, pursuing their best interests, and so on.

Characteristics of Ethical Statements

- Provide standards for action
- Blind to discrimination
- Important above all other interests (hopefully!)
- Not changed by opinion or laws
- Can’t be proven as truths based only on tradition or customs

Most people make ethical decisions based on one or more of several moral philosophies:

Table 1. Moral Philosophies

PHILOSOPHY	DEFINITION
Egoism	Advocates that a person to put his/her self-interests above those of others. With egoism, a person should choose the solution the best promotes or least harms his/her self-interests.
Natural Law	Advocates that a person's actions be in accord with human nature. Natural law favors four basic values: life, procreation, knowledge, and sociability. A person may not violate anyone else's needs unless his/her own needs have been violated. To be a moral decision, the act itself must be good. If there is a bad effect associated with the good deed, the bad effect must be absolutely unavoidable. The good effect cannot be brought about by the bad effect, but the bad effect may only be side effect. Also, the undesirable degree of the bad effect must be outweighed by the desirable degree of the good deed.
Utilitarianism	Advocates a person to put overall human welfare as a priority above courses of action. In utilitarianism, one asks, "will this action produce the greater overall human well-being?" Out of any two courses of action, a person is obligated to choose the action that produces the greatest amount of utility. If the actions are equal in their amount of utility, they are equally morally acceptable.
Ethics of Respect for Persons	Advocates a person to respect the equal dignity of all human beings. An action is right if one can apply that action to all people in all situations without undermining one's own ability to act in accordance with it, and without defeating the purpose of the original action. Action cannot override the freedom or wellbeing of one's self or others. A person loses the right to be treated in such a way if he/she does not treat others with that same respect. This theory follows the general principle of doing unto others as you would have done unto yourself (the "Golden Rule").

Statement of Ethical Principles

There are four fundamental principles that should guide engineers and technicians in achieving the high ideals of professional life. These express the beliefs and values of the profession and are amplified below.

1. Accuracy and Rigor

   Professional engineers and technicians have a duty to ensure that they acquire and use wisely and faithfully the knowledge that is relevant to the engineering skills needed in their work in the service of others. They should:

   - Always act with care and competence
   - Perform services only in areas of current competence
   - Keep their knowledge and skills up to date and assist the development of engineering knowledge and skills in others
   - Not knowingly mislead or allow others to be misled about engineering matters
   - Present and review engineering evidence, theory and interpretation honestly, accurately and without bias
   - Identify and evaluate and, where possible, quantify risks

2. Honesty and Integrity

   Professional engineers and technicians should adopt the highest standards of professional conduct, openness, fairness and honesty. They should:

   - Be alert to the ways in which their work might affect others and duly respect the rights and reputations of their parties
   - Avoid deceptive acts, take steps to prevent corrupt practices or professional misconduct, and declare conflict of interest
   - Reject bribery or improper influence
   - Act for each employer or client in a reliable and trustworthy manner

3. Respect for life, law and the public good

   Professional engineers and technicians should give due weight to all relevant law, facts and published guidance, and the wider public interest. They should:

   - Ensure that all work is lawful and justified
   - Minimize and justify any adverse effect on society or on the natural environment for their own and succeeding generations
   - Take due account of the limited availability of natural and human resources
   - Hold paramount the health and safety of others
   - Act honorably, responsibly and lawfully and uphold the reputation, standing and dignity of the profession

4. Responsible leadership: listening and informing

   Professional engineers and technician should aspire to high standards of leadership in the exploitation and management of technology. They hold a privileged and trusted position in society, and are expected to demonstrate that they are seeking to serve wider society and to be sensitive to public concerns. They should:

   - Be aware of the issues that engineering and technology raise for society, and listen to the aspirations and concerns of others
   - Actively promote public awareness and understanding of the impact and benefits of engineering achievements
   - Be objective and truthful in any statement made in their professional capacity

Ethical dilemmas:

- Taking office supplies for home use (paper, pencil, pen, etc.)
- Using phone for personal use on company time
- Putting personal expenses as business expenses

Ethical Dilemmas' in the Profession:

- Question your motivates
- Practice what you preach
- Be your own investigative reporter
- Keep your commitments
- Learn to say "No" to things for which you have no time, talent, or sincere interest
- Build and maintain your integrity (not to copy in examination)

Ethical use of Power:

Basis of Power – Guidelines for use

- Treat subordinates fairly
- Maintain credibility
- Be cordial and polite
- Make feasible and reasonable request
- Inform subordinates of rules and penalties
- Warn before punishing
- Punish in private

Florman on Ethics and Failures

Florman shows that more than half of all celebrated engineering failures can be attributed some from of human un-reliability (again, not necessarily a "failure of the engineers" to do the best they can). Many of them could have been caught with even "one inspection". Florman's point: the great ethical need of engineers is competence. "The greatest threats to moral engineering are carelessness, sloppiness, laziness and lack of concentration". The greatest likelihood of danger to the public from engineers comes not from evil intent, but from miscalculation.

Here are some conflicts faced by the individual engineer:

- Make the product safer vs. make it more economical
- Protect the environment vs. use the available resources
- Promote the military vs. disarmament
- Make food safer via pesticides vs. protect all levels of the food chain
- Drill for oil offshore vs. protect beaches
- Work for other people (or nations) who don't share your views but need your services

These conflicts can be broken down to "how the engineer feels" about the military, the environment, product safety, etc. which are according to Florman, needs to be a political concern, best decided by society as a whole. And how the engineer feels isn't any different than how anyone else feels, right?

Rules of Practicing Engineers

1. Engineer shall hold paramount the safety, health and welfare of the public, and welfare of the public.

   a. If engineer's judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate.
   b. Engineers shall approve only those engineering documents that are in conformity with applicable standards.
   c. Engineers shall not reveal facts, data, or information without the prior consent of the client or employer except as authorized or required by law or code.
   d. Engineer shall not permit the use of their name or association in business ventures with any person or firm that they believe is engaged in fraudulent or dishonest enterprise.

e. Engineers shall not aid or abet the unlawful practice of engineering by a person or firm.
f. Engineers having knowledge of any alleged violation of codes shall report thereon to appropriate professional bodies and, when relevant, also to public authorities in furnishing such information or assistance as may be required.

2. Engineers shall perform services only in the areas of their competence

a. Engineer shall undertake assignment only when qualified by education or experience in the specific technical fields involved.
b. Engineers shall not affix their signatures to any plans or documents dealing with subject matter in which they lack competence, nor to any plan or document not prepared under their direction and control.
c. Engineers may accept assignments and assume responsibility for coordination of an entire project and sign and seal the engineering documents for the entire project, provide that each technical segment is signed and sealed only by the qualified engineers who prepared the segment.

3. Engineers shall issue public statement only in an objective and truthful manner.

a. Engineers shall be objective and truthful in professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony, which should bear the date indicating when it was current.
b. Engineers may express publicity technical opinions that are founded upon knowledge of the facts and competence in the subject matter.
c. Engineer shall issue no statements, criticism, or arguments on technical matters that are inspired or paid for by interested parties, unless they have prefaced their comments by explicitly identifying the interested parties on whose behalf they are speaking, and by revealing the existence of any interest the engineers may have in the matters.

4. Engineers shall act for each employer or client as faithful agents or trustees

a. Engineers shall disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or the quality of their services.
b. Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.

c. Engineers shall not solicit or accept financial or the valuable consideration, directly or indirectly, from outside agents in connection with the work for which they are responsible.
d. Engineers in public service as members, advisors, or employees of a governmental or quasi-governmental body or department shall not participate in decisions with respect to services solicited or provided by them or their organizations in private or public engineering practice.
e. Engineer shall not solicit or accept a contract from a governmental body on which a principal or officer of their organization serves as a member.

5. Engineers shall avoid deceptive acts.

a. Engineers shall not falsify their qualifications or permit misrepresentation of their qualifications. They shall not misrepresent or exaggerate their responsibility in or for the subject matter of prior assignments. Brochures or other presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associated, joint ventures, or past accomplishments.

b. Engineers shall not offer, give, solicit, or receive, either directly or indirectly, any contribution to influence the award of a contract by public authority, or which may reasonably construed by the public as having the effect or intent of influencing the awarding of a contract. They shall not offer any gift or other valuable consideration in order to secure work. They shall not pay a commission, percentage, or brokerage fee in order to secure work. Except to a bona fide employee or bona fide established commercial or marketing agencies retained by them.

Interaction Rules

Society has rules of conduct that govern personal and organizational interactions. There are various levels of these rules or behavioral guidelines. For example

a. Etiquette: Rules governing personal interaction; in general, the only penalty for breaking such rules is embarrassment.
b. Laws: Societal mandates of behavior, with consequent penalties for breaking those rules.
c. Morals: Principles or standards of behavior. In general, apply to the more serious behavioral issues in a society.

Examples

- Etiquette: Proper etiquette generally involves “proper” public behavior (which can vary with the society to which the etiquette applies): Dressing professionally, speaking well (face to face and over the telephone), and using proper table manners.
- Laws: Rules that allow people in societies to successfully coexist (these are generally “don’t do’s”): Prohibition of speeding (can cause car accidents), prohibition of overuse of alcohol or use of drugs (user can hurt self or others), prohibition of theft. Penalties for law breakers can be (will be) imposed (prison, fines, etc.).
- Morals: Societal and personal standards (can be “don’ts” or “do’s”): Do not murder, do not take another’s possessions, help those in need, work in the community in which you live to promote the common good.

Table 2. Law vs. Ethics

Law	Ethics
Creates rules to guide conduct	Offers guidance on conduct
Balances competing values	Address situations in which competing values clash
Punishes conduct that is "illegal" through formal structures	Incentives and disincentives may be created by "group" (formal or informal)

Table 3. Is "legal" the same as "ethical"?

Yes	No
Law defines duties, rights, "allowable conduct".	law does not address all ethical dilemmas
Compliance approach to business ethics: fulfill legally recognized duties, and don't go further.	Legal duties may not meet standard of ethical conduct
	"Beyond Compliance" approach: fulfill legally recognized duties, but don't stop there.

Engineering Ethics and Legal Issues

- Contract law

  Mutual agreement between two or more parties to engage in transaction which provides benefits to each of them

  1. Mutual consent
  2. Offer and acceptance
  3. Consideration

- Other contract issues

  Legally enforceable agreement requires a definite promise by each party to do something specific
  Some benefit received that each did not have before
  Does not have to be in writing to be valid

- Breach of contract

  An actual violation of the terms in the contract
  must occur

  1. Items not supplied, supplied but of substandard quality, or not supplied until long after a deadline
  2. Party required to provide an equivalent value previously offered
  3. Inability to fulfill contract is under ethical and legal imperative to do everything possible to provide equivalent value to other party

- The letter vs. spirit of the law

  "Read between the lines" in terms of the intent of those documents as understood by those who formulated them"

Engineers and Environment

Engineers have a complex relationship to the environment. On the one hand, they have helped to produce some of the environmental problems that plague human society. Project designed by engineers produce toxic chemicals that pollute the land, air, and rivers. Engineer also design project that flood farmlands, drain wetlands, and destroy the forests.

On the other hand, engineers can design projects, products, and processes that reduce or eliminate these same threats to environmental integrity. If engineers have contributed to our environmental problems (as have most of the rest of us), then they are also an essential part of their solution.

- **Criteria for A "Clean" Environment**

  Most environmental laws focus on making the environment "clean" – that is, free from various pollutants. The project of making the environment clean naturally raises the question of what criteria for "clean" underlies these regulations. **Table 1.** Lists various criteria for a clean environment that can be found in the discussions of this topic.

Table 4. Inadequate Definitions of "Clean"

No	Criteria	Objections	Application
1	Comparative criterion: The environment is clean if it imposes no greater threat to human life or health than to other risks.	The levels of pollution currently accepted may be too high	Workers should not expect working conditions to be safer than the drive to and from work
2	Normalcy criterion: the environment is clean if the pollutants present in it are normally present in nature to the same degree.	The levels of pollution in nature vary and may sometimes be accepted only because they are unavoidable.	Radiation as high as the level of ultraviolet radiation in Denver is acceptable.
3	Optimal-pollution reduction criterion:	Cost and benefits may be unfairly distributed.	The funds required to reduce a pollutant further would save more lives if used elsewhere.
4	Maximum protection criterion: The environment is clean only if any identifiable risk from pollution that poses a possible threat to human health has been	This criterion would require the elimination of many substances whose toxicity is doubtful or extremely limited.	A new chemical is assumed to be harmful unless shown to be harmless.

	eliminated, up to the capacity of available technology and legal enforcement to do so.		
5	Demonstrable harm criterion: The environment is clean if every pollutant that is demonstrably harmful to human health has been eliminated.	It is often difficult to prove a substance is harmful, even when it is. Also, eliminating a pollutant completely may be too costly, as well as unnecessary if the pollutant is harmless at low levels.	Eliminate anything that can be proven to be a pollutant leave everything else as it is.

In attempting to construct a more adequate criterion, we must begin with the assumption that we are trying to balance the goals of increasing job opportunities and income, on the one hand, with protecting the health of individuals, on the other hand. Here, we have a classic conflict between utilitarian and respect for person's ethical considerations. From the utilitarian standpoint, we want to increase income, job opportunities, and even overall public health.

Design

The conception of design processes.

Design process

According to Cross, the design process can be seen as process in which products or tools are created to suit human purposes. The starting point of a design process is usually some stated of perceived customer's need. A material structure that meets these functional requirements is designed. The design process is usually constrained be economic and time restrictions. A design should be finished by certain date and the costs of the whole design process should not exceed a certain amount of money.

Cross presents a model of the design that consists of three phases: generation, evaluation and communication. A concept is generated in the first phase of the design process. A designer needs to understand the design problem and to find possible solutions for it; this usually happens simultaneously. Possible solutions help the designer to get a better understanding of the design problem. The concept is adapted in an iterative process.

Often, more than one iterative step is necessary because adaptation of a part of the design can lead to problems in other parts of the design. The design is communicated to the people who are responsible for production in the third phase. Drawings, computer drawings and descriptions of the design are used in this communication.

Another more detailed model is proposed by French. French divides the design processes into four activities:

- Analysis of the problem
- Conceptual design
- Embodiment of schemes
- Detailing

Design Problems

If design problems are problems in which the requirements alone determine the solution the engineers can say that they are not possible for ethical issues because the requirements determine everything and the customers define the requirements. Some authors maintain that engineers are not, and should not be, involved the formulation of design requirements, criteria of goals. The formulation of requirements and goals is ethically relevant, but this should not be done by engineers.

In this line of thinking, the task of engineers is to discover what is technologically the best solution given certain requirements. This task is seen as ethically neutral. Ethical questions may arise in the user phase when technologies are used for certain purpose and produce certain (social) effects. In this model, the sole responsibility of engineers is to carry out a task formulated by others in a competent way.

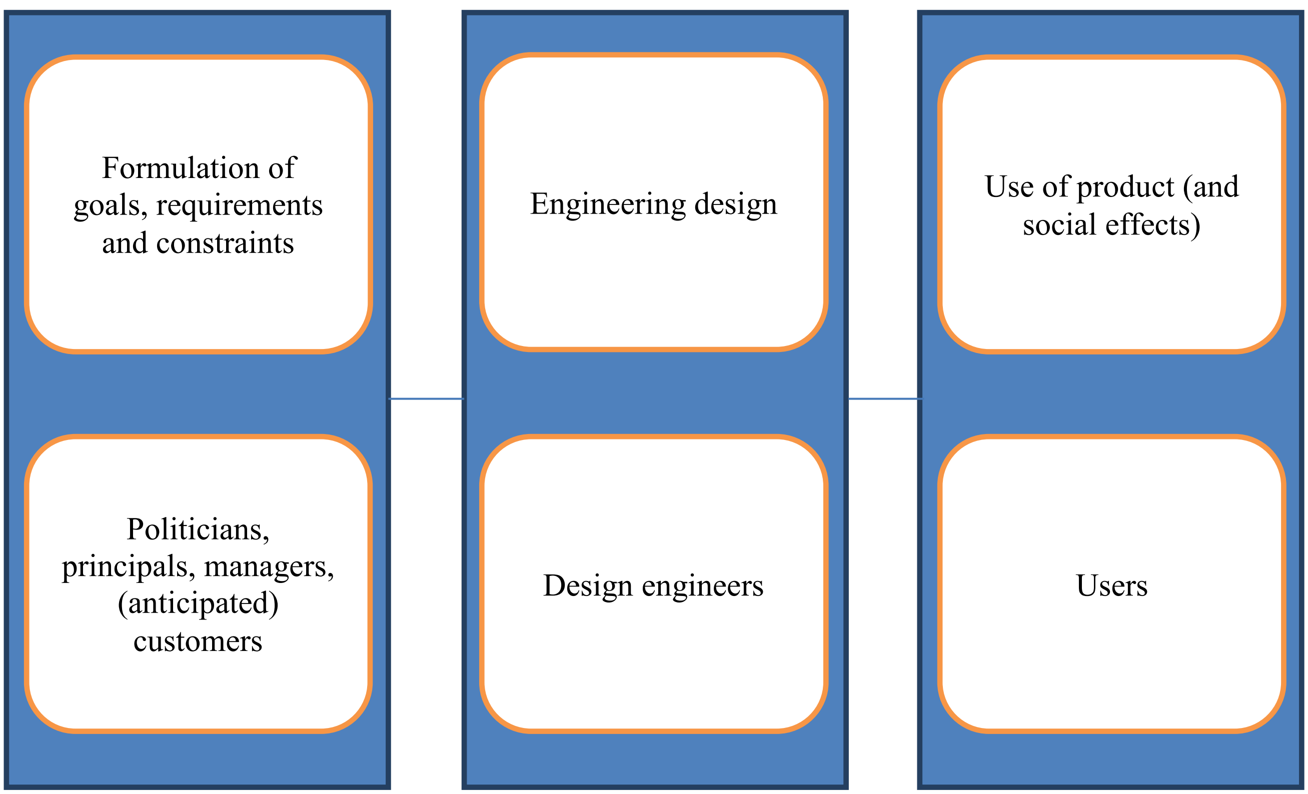

Figure 1. Division of labor with respect to engineering design if design problems were well-structured problems in which the requirements fully determine the solution after.

"There is initially no definite criterion to test a proposed solution, much less a mechanizeable process to apply the criterion. The problem space is not defined in any meaningful ways."

Design problems are, however, usually not problems where a clear set of requirements is available that completely determines the solution. Design problems are more or less ill structured problems. Some design methods require that engineers formulated the requirements and solutions separately, but this is impossible if design problems are ill structured.

An example of an ill-structured problem is the following. In the mid nineteen nineties substitutes were sought for replacing CFCs as coolants in refrigerators, because CFCs damage the ozone layer. Two alternatives were considered: HFC_{134a} and hydrocarbons, both have their advantages and their disadvantages. Hydrocarbons are for example flammable and existing refrigerator design needed to be changed if hydrocarbons were used. HFC_{134a} has a long atmospheric lifetime and if released would therefore still damage the environment, although to a lesser extent than CFCs.

There were different operationalization's available for the environmental, health and safety criteria. Both proposed solutions scored differently under different operationalization of the criteria. There was no solution that was best under all operationalization. No definite criterion was available to say which solution was the better one. This example shows that even for the seemingly simple case of looking for a substitute coolant in existing refrigerator design, there are features of the problem that make it ill-structured.

In cases where a design problem is an ill-structured problem, there may be more than one solution; each of these solutions can be valid. Engineers, in this case, have to make a choice: it is not the case that the requirements will lead to just one solution. At the start of a design process, there may not even be a clear and unambiguous set of requirements.

During the design process it may be proved that there is no solution to the ill-structured problem. In some cases, it might prove to be necessary to adjust or drop some requirements because no solution meeting all the requirements can be found. So a design problem can bounder, or over, determined by the requirements. Either way, engineers need to make choices during the design process for example regarding which requirements can be dropped or which of the possible solutions to the design problem is the best.

Safety and Engineering Design

Safety and Risk

The main duty of engineers is to protect the safety and well-being of the public. Indeed, the codes of ethics of the professional engineering societies make it clear that safety is paramount importance to the engineer. The engineering codes of ethics will show that engineers should have a responsibility to society to produce products, structures, and processes that are safe. There is an implied warranty that products are safe to use. Engineers are required to make their designs as safe as reasonably possible. Thus, safety must be an integral part of any engineering design.

What is safety? As in general, safety is a vague term, safety is a value judgment. Some literature cited that safety as a freedom condition from damage, severe, injury, or risk. Hence, it is impossible to discuss safety without including a discussion about risk.

Risk could be described as a danger, the possibility of suffering harm or loss. There is a strong relationship on both of the terms. Risk could be engaged by doing something that is unsafe, meanwhile something is unsafe if it involves substantial risk.

Although these definitions are on point. Essentially, safety and risk are subjective and they are depending on many factors as follow:

- Background of Risk.

  Risk could be achieved either from intentional action or unintentional action. Many engineers believe something will safer if they knowingly take on the risk, but would find it unsafe if forced to do so. Such an example, if the property values are low, some people will be tempted to buy house near a plant that emits low levels of a toxic waste into the air. However, if a person already living near a plant finds that toxic fumes are emitted by the plant and he wasn't informed, the risk could gained to be larger, since it was not voluntarily assumed.

- Time period of consequences.

  From humanity perspective, something that might cause a temporarily illness or disability looks safer than something that will result permanent destruction. On this term, the engineers should consider how to manage the safety, risk, and time period of consequences for not only the people who run the action, but also a larger unit such as community and environment.

- Probability.

  There is always a chance to cause a severe injury and also fairly minor injury. It might be about 50:50 or another ratio. It is depending on how to the risk occurred, is it merely from the substance? In addition, any unsafe action could also lead to the higher chance of severe injury consequences.

- Reversible effects.

  Something will seem less risky if the bad effects are could be reversible. At this point, the concept reversibility has a similar base of time period term.

- Degrees / Levels of Risk.

  The probability of being an automobile accident is the same regardless of how often people drive, on the other hand, studies shown that low levels of nuclear radiation is actually have beneficial effects on human health, whilst only at higher levels of exposure are there severe health problems or death. This kind of example prove that something is risky for only at fairly high exposures, and it will seem safer than something with a uniform exposure (such as habit) to risk.

- Delayed and Immediate Risk.

  An activity whose harm is delayed for many years will seem much less risky than something with an immediate effect. Such an example is that since an accident will cause immediate injury or death, people might find an activity such as skydiving unacceptably risky.

Something is unsafe or risky often depends on who is asked, nonetheless. At one condition, one person could be feel safe while the rest is not. Thus, line drawing and flow charting can be used in making a decision. Therefore, the engineer and company management has to use their professional judgment to determine whether a project can be safely implemented.

Safety Design and Analysis

Safety is such an essential aspect for engineer's duties. There are at least four classifications that should be match to make sure a proper safe design, including:

1. The design should comply with the applicable laws. The requirement should be easy to meet, since legal standards for product safety are generally well known, published and easily accessible also.
2. The design should match with the standard of "accepted engineering practice."
3. Alternative designs which have future potential should be explored further. Since it requires a fair amount of creativity to seek an alternative solution, this point is kind of difficult to accomplish.
4. The engineer must attempt to foresee potential misuses of the product by the consumer and must design to avoid them. Also, this action requires a fair amount of creativity and research. In example of placing a warning label on a product is not sufficient and is not a substitute and is not a substitute for doing the extra engineering work required to produce a safe design.
5. After the product designed, it must be tested using prototypes and finished devices. The goals are to check whether the product meets the specifications that had been set.

Safety could also incorporate into engineering process by including some variation on a basic multistep procedure for effectively executing engineering design. Wilcox (1990) summarized following:

1. Describe the problem. This step includes determining the needs and requirements and often involves determining the constraints.
2. Generate several solutions. Multiple alternative designs are created.
3. Analyze each solution to determine the pros and cons of each. This step involves determining the consequences of each design solution and determining whether it solves the problem.
4. Test the solutions.
5. Choose the best solution.
6. Apply the chosen solution.

At step 1, it is appropriate to include issues of safety in the product definition and specification. During steps 2 through 5, engineers typically consider issues of how well the solution will meets the specifications, how easy it will be to build, and how much the cost should be paid off.

Safety and risk must be a criterion for consideration during every step. Especially, in step 5 which the engineer attempts to assess all of the trade-offs required to obtain a successful final design. In assessing the trade-offs, it is important to remember that safety considerations should be paramount and should have relatively higher priority than any other issues.

There are many things that make minimizing risk is a difficult task for the engineer, since the engineers almost always in touch with the uncertainties. The risks could be expressed as probabilities and often no more than educated guesses. Risk is also rise by the rapid pace at which engineering designs must be carried out.

Minimizing risks and designing for safety is not always be an expensive alternative. Looking at the possible consequences of not minimizing the risk could become such more long-term review. Thus, the prudent and ethical thing to do is to spend as much as possible to engineer the design correctly so as to minimize future risk of injury and subsequent criminal or civil cases against the engineers.

One method that engineers sometimes use to help analyzing the risk and to determine whether a project often proceed as a 'risk-benefit analysis'. The method is same to cost-benefit analysis. By risk-benefit analysis, the risks and benefits of a project are assigned dollar amounts and the most favorable ratio between risks and benefit is sought.

Meanwhile, the cost-benefit analysis is a tricky technique due to its difficulties to assign realistic dollar amounts to alternatives. Especially, in risk-benefit analysis, the method become such a difficult one since the risks are much harder to calculate and more difficult to put realistic price tag on. Nonetheless, the method could be useful technique if used as a part of broader analysis with an objectively sight view.

Accidents

There are many ways accidents could be classified and studied. Most common method is to group some accidents into three major classes, they are:

- Procedural.
  Procedural accidents become the most common and are the result of someone making bad decision by not following the proper procedures.

- Engineered.
  Engineered accidents are caused by flaws in the design. These kind of failures could come from materials, devices that are not working adequately, or do not performing as expected under all circumstances encountered. Engineered failures normally could be anticipated in the designing phase and should be caught and corrected during testing.

  However, it isn't always possible to anticipate every condition that will be encountered, and sometimes testing doesn't occur over the entire range of possible operating conditions.

- Systemic.
  This kind of types are harder to understand and harder to control. They are characteristic of very complex technologies and the complex organizations that are required to operate them. Because it is difficult to take systemic accidents into account during design, especially since there are so many small and seemingly insignificant factors that come into play, it may seem that the engineer bears no responsibility for this type of accident.

It is important for the engineer to understand the complexity of the systems that he is working on and to attempt to be creative in determining how things can be designed to avert as many mistakes by people using the technology as possible.

Responsibilities and Rights

Basic concept of responsibility is relies as a notion of accountability, it could be applied to individual engineers, a team which consists of engineers, division or units within the organization, or more over, it could be organization themselves. Respnsibility should be focus mainly on legal liabilities, jobdescription roles, and moral accountability. Engineers as a professinals are expected to commit themselves to high standards of conduct and follow them.

William F. May concludes, what is important to professional ethics is the moral disposition that the professional brings to the structure in which engineer operates. At one end of the spectrum is the minimalist approach of doing as little as one can and still stay out of trouble. On the other hand, the spectrum are attitudes and dispositions that may take one "above and beyond the call of duty". The professional's attitude could be as one dedication to an extraordinary high level of performance.

Most engineers, cited by May, typically fall somewhere in between the two ends of spectrum most of the time. We usually require some expectation of an attitude value like integrity, honesty, civic-mindedness, and willingness to make some self-sacrifice. The values involved will make an engineer as a 'highly-responsible' engineer.

Thus, the 'highly-responsible' engineer also should display the basic engineering competence including:

- Imaginative and Perseverance.
- Able to communicate clearly and informatively.
- Objective.
- Open-minded and correcting mistakes.
- Work well with the others.
- Quality oriented.
- Must be able to see the 'big-picture' as well as its details.

Duties

The engineers must have a certain duties involved by virtue of their positions, and other obligations. Joining a professional organization beyond their family is one of kind an example. To solve an ethical problem that could be achieved by this action, one needs to remind oneself of all of the duties and obligations to which one has agreed. Ones' duties and obligations form the basis for some additional important heuristics in ethical problem solving for the engineers, including :

- Always remind theirself of relevant duties and obligations that you have accepted and have not accepted.
- Make a lists, and rank the responsibilities of the relevant duties and obligation that have been accepted.
- For a decision that could cause violation of obligations, the decision must be discussed with whom was made and determine the consequences.

Impediments to Responsible Action

What attitudes and frames of mind may influence to do less than fully responsible actions, it could be intentional, reckless, or even merely negligent? There are some impediments to responsible action involving :

- Self-Interest.
  Concern for self-interest could be partially block our mind from seeing and understanding our professional responsibilities. Engineers are not simply as we think engineers they are, they are still human, just like everybody else. An extreme form of self-interest is egoism, could be defined as an exclusive concern to satisfy one's own interest, even at the possible expense of others.

- Self-Deception.
  Honestly, and always conduct a check-balance program is one of a way to resist the temptations of self-interest. We should truly aware what we are contemplating doing. Rationalizaion often gets in the way of this recognition. Self-deception is described as an intentional avoidance of truths we would find it paintful to confort self consciously. Selfdeception is naturally difficult to discover by one point of view, they always need an 'outisde view' to check them.

- Fear.
  There are a lot of kind of fear, fear of acknowledging out mistakes, or some sort of punishment or other bad consequences. Fears will make it difficult to act responsibly.

- Ignorance.
  Ignorance of vital information is an obvious barrier to responsible action. If the engineer does not realize when a design poses a safety problem, then they can not be in a position to do anything about it. Lack of awareness such as turning away from information in order to avoid having to deal with the challenges it may pose may also become a willful avoidance. It will lead to the lack of imagination from not looking in the right places for necessary information like a failure to persist, or the pressure of deadlines. Therefore, there are limitation of what engineers could be expected to know. At the end, ignorance is not always a good excuse.

- Egocentric Tendencies.
  Egocenttricity in a psychological term means as a common feature of human experience is that tends to interpret situations from very limited perspectives and it takes special effort to acquire a more objective view-point. It is not just self-interest that interferes with out ability to understand things from other perspectives. The engineers may have a good intention of others but could also failed to realize that their perspective are always different from the others.

- Microscopic Vision.
  Microscopic vision embaces a limited perspective. Microscopic vision may be strongly accurate and precise but fails due to lack of understanding of others perspective. Since microscopic vision has to take a look closer it will lead to see something that could not be seen before. It gains a detailed knowlegde but ceases to see things at the more ordinary level.

  Engineers should spend time to raise their eyes from their world of scientific and technical expertise and try to look around them in order to understand the larger implications of what they are doing. Many organizations also tend to foster microscopic thinking whereas each person has their own specialized task and are not responsible for the work of others.

- Uncritical Acceptance of Authority.
  Professional autonomy is achieved when engineering codes of ethics emphasize the importance of engineers exercising independent, objective judgement in performing their functions. The codes of ethics also insist that engineers have a duty of fidelity to their employers and clients. Therefore, there is a difference between independent consulting and the vast majority of engineers. Independent consulting engineers usually have an easier time management to professional autonomy better than the engineers who work in large and hierarical organization. Many engineers in large organization are expected to defer to authority in their organizations.

- Group Think.
  Irving Janis defines groupthink as situations where the groups come to agreement at the expense of critical thinking. Janis identifies eight symptoms in groupthink, concentrating on groups that are characterized by cohesiveness, loyalty, and solidarity as follows :

  a. An illusion of invurnability of the group to failure.
  b. Encouraging shared stereotypes of others caused by a strong feelings that bound each member of groups.
  c. Rasionalization, this value will lead agreement for shifting responsibility to others.
  d. Illusion of morality which assumes the inherent morality of group.
  e. Self-cencorship.
  f. Illusion of unanimity which construing silence of a group member as consent.
  g. Application of direct pressure.
  h. Mindguarding, means as protect the group from dissenting views.

Professional responsibilities of Engineers:

- Confidentiality and proprietarily information
- Conflict in interest
- Environmental ethics
- Professional rights

Obligation to Society

- Broad context of responsibility

  “While performing services, the engineer’s foremost responsibility is to public welfare”

  “Engineers shall approve only those designs that safeguard the life, health, welfare, and property of the public while conforming to accepted engineering standards”

- Whistle blowing

  “if an engineer’s professional judgment is overruled resulting in danger to the life, health, welfare, or property of the public, the engineer shall notify his/her employer or client and any appropriate authority.”

- Truth in duties

  “Engineers shall be objective and truthful in professional reports, statements, or testimonies and shall provide all pertinent supporting information relating to such items”

  “Engineers shall not express a professional opinion publicly unless it is based upon knowledge of the facts and a competent evaluation of the subject matter”

- The duty of full disclosure

  “Engineers shall not express professional opinion on subject matters for which they are motivated or paid, unless they explicitly identify the parties on whose behalf they are expressing the opinion and reveal the parties’ interest in the matters”

- "Clean Hands" Rule

  "Engineers shall not enter business ventures or permit their names or their firm's names to be used by any persons or firm which is engaging in dishonest, fraudulent, or illegal business practice"

- Final obligation to society

  "Engineers who have knowledge of possible violation of any of the rules listed in this and the following two parts shall provide pertinent information and assist the state board in reaching final determination of the possible violation"

Seven Principles Impacting Each Obligation

1. Protecting the public health, safety and welfare
2. Demonstrating professional competence
3. Maintaining objectivity/truthfulness
4. Addressing conflict of interest
5. Preserving confidentiality
6. Receiving and providing valuable consideration
7. Emerging areas/emerging challenges

1. Protecting The Public Health, Safety and Welfare
   - Conformance with applicable standards
   - Approval/signing and sealing of engineering drawings
   - Responsible charge/responsible control
   - Judgment overruled
   - Awareness of safety violations
   - Awareness of illegal practice

2. Demonstrating Professional Competence
   - Education, experience, qualifications
   - Acceptance of assignment
   - Signing and sealing of work
   - Coordination of work
   - Scope of practice

3. Maintaining Objectivity/Truthfulness/Non-Deception
   - Inclusion of all relevant information
   - Issuance of public statements
   - Disclosure to interested parties
   - Expression of technical opinions
   - Reviewing work of another
   - Sales and marketing practice

4. Address Conflict of Interest
   - Faithful agent and trustee
   - Avoid vs disclosure
   - "appearances"
   - Acceptance of compensation from more than one party
   - Serving on public bodies
   - Accepting contracts from government bodies
   - Part time engineering work
   - Contingent fee arrangements
   - Representing adversary interests
   - Consent

5. Preserving Confidentiality
   - Business of technical affairs of employers/clients
   - Proprietary information/files
   - Arranging for new employment or business opportunities
   - Consent

6. Receiving and Providing Gifts and Other Valuable Consideration
   - Accepting consideration from suppliers for specifying product
   - Accepting commissions/allowances directly from contractors
   - Political contributions
   - Bribery

7. Emerging area/emerging challenges
   - Technology
     Use of internet and electronic practice
   - Sustainable design/development
     Environmental considerations
   - Alternative project delivery

Integrated project delivery
Building information modeling
Design/build

Engineer's Obligation to Employer's and Clients

- Professional competence

  "Engineers shall not undertake technical assignments for which they are not qualified"

  "Engineers shall approve or seal only those plans or designs that deal with subjects in which they are competent and which have been prepared under their direct control and supervision"

- The validity of approvals
  "Engineers may coordinate an entire project provided that each design component is signed or sealed by the engineer responsible for that design component"

- Confidentiality requirement

  "Engineers shall not reveal professional information without the employer's or client's prior consent except as authorized or required by law"

- Conflict interest

  "Engineers shall not solicit or accept direct or indirect considerations, financial or otherwise, from contractors, their agents, or other parties while performing work for employers or clients"

  "Engineers shall disclose to their employers or client's potential conflicts of interest or any other circumstances that could influence or appear to influence their professional judgment or their service quality"

- Full disclosure

"An engineer shall not accept financial or other compensation from more than one party for services rendered on one project unless the details are fully disclosed and agreed by all parties"

- Government conflict of interest

  "To avoid conflicts of interest, engineers shall not solicit or accept a professional contract from a governmental body on which a principal or officer of their firm serves as a member. An engineer who is a principal or employee of a private firm and who serves as a member of a governmental body shall not participate in decisions relating to the professional services solicited or provided by the firm to the governmental body"

Engineer's Obligation to Other Engineers

- Obligation to potential employers

  "Engineers shall not misrepresent or permit misrepresentation of their or any of their associate's academic or professional qualifications. They shall not misrepresent their level of responsibility or the complexity of prior assignments. Pertinent facts relating to employers, employees, associates, joint ventures, or past accomplishments shall not be misrepresented when soliciting employment or business"

- Conflict of interest

  "Engineers shall not directly or indirectly give, solicit, or receive any gift or commission, or other valuable consideration, in order to obtain work, and shall not make contribution to any political body with intent of influencing the award of contract by governmental body"

- Reputations of other engineers

  "Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputations, prospects, practice or employment of other engineers, nor indiscriminately criticize the work of other engineers"

  Criticize cautiously and objectively with respect to the person's professional status

Positive Values to be possessed by an Engineer

- Integrity, honesty
- Truthfulness
- Kind heartedness, humility
- Friendliness
- Faith
- Self-respect
- Open mindedness
- Creativity
- Civil sense
- Simplicity
- Forgiveness
- Poise – Equilibrium
- Detachment
- They generate positive thoughts

- Moral Values

  Pervade all aspect of technological development, and hence ethics and excellence in engineering go together

- Engineering as Social Experimentation

  That generate both new responsibilities for creating benefits preventing harm and pointing out dangers

- The Engineers Responsibility for Safety

  Safety consideration must be included in design from the start

- Ethical Dilemmas

  Problems that may occur in engineering, as elsewhere, because moral values are myriad and can conflict

- Promoting Responsible Conduct

  Promulgating and obeying the right laws and preventing wrong doing

- Technology Development

  Warrants cautious optimism-optimism with cautions

- Micro & Macro Issues

  - Micro Issues concern the decisions made by individuals and companies
  - Macro Issues concern more about global issues

  Both Micro & Macro Issues are important in Engineering ethics and often they are come together

Working Hypotheses

There are more external constraints in normal, as opposed to radical design, and in low, as opposed to high level, design. The solution space is limited in normal design processes because normal configuration and operational principle are used. Moreover, the requirements pertaining to the normal configuration and working principle have probably already been operationalized.

In radical design the solution space is less limited, and there are fewer given requirements that are operationalized to test possible solution. This may mean that engineers have to face other kinds of ethical issues in radical, as opposed to normal, design and in low, as opposed to high level, design. Based on this idea the working hypotheses 1 and 2 were formulated as follows:

1. The kinds of ethical issues faced by engineers depend on design type and design hierarchy.
2. The ways in which engineers deal with these ethical issues depend on design type and design hierarchy.

Case 1

Your company manufactures security systems. Up to now these have raised few ethical problems, since your products were confined to traditional forms of security, using armed guards, locks, reinforced alloys which are hard to cut or drill, and similar methods.

However, as a design engineer you realize that this modern technology much more comprehensive security packages could be provided to your customers. These could also include extensive video and audio surveillance equipment, along with biometric monitoring devices of employees or other personnel seeking entry to secure areas which would make use of highly personal data such as a person's fingerprints, or retinal or voice patterns.

But there is a problem to be considered. A literature search reveals that there are many ethical concerns about the collection and use of such personal data. For example, these high-tech forms of surveillance could easily become a form of spying, carried out without the knowledge of employees and violating their privacy. Or the data collected for security reasons could easily be sold or otherwise used outside legitimate workplace contexts by unscrupulous customers of your surveillance systems.

Your boss wants you to include as much of this advanced technology as possible in future systems, because customers like these new features and are willing to pay well for them.

However, you are concerned about the ethical issues involved in making these new technologies available. As an engineer, do you have any ethical responsibility to not include any such ethically questionable technologies in products which you design and sell, or to include them only in forms which are difficult to misuse? Or is the misuse of such technologies an ethical problem only for the customers who are buying your equipment, rather than it being your ethical responsibility as an engineer?

Case 2

You and an engineer colleague work closely on designing and implementing procedures for the proper disposal of various waste materials in an industrial plant. He is responsible for liquid wastes, which are discharged into local rivers.

During ongoing discussions with your colleague, you notice that he is habitually allowing levels of some toxic liquid waste chemicals, which are slightly higher than levels permitted by the law of those chemicals. You tell him that you have noticed this, but he replies that, since the levels are only slightly above the legal limits, any ethical or safety issues are trivial in this case, and not worth the trouble and expense to correct them.

Do you agree with your colleague? If not, should you attempt to get him to correct the excess levels, or is this none of your business since it is he rather than you who is responsible for liquid wastes?

If he refuses to correct the problems, should you report this to your boss or higher management? And if no one in your company will do anything about the problem, should you be prepared to go over their heads and report the problem directly to government inspectors or regulators? Or should one do that only in a case where a much more serious risk to public health and safety involved?

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