Course Instructions

NOTE: The following pages contain a preview of the final exam. This final exam is identical to the final exam that you will take online after you purchase the course.

After you purchase the course online, you will be taken to a receipt page online which will have the following link: **Click Here to Take Online Exam**. **You will then click on this link to take the final exam.**

3 Easy Steps to Complete the Course:

1.) **Read the Course PDF Below.**

2.) **Purchase the Course Online & Take the Final Exam – see note above**

3.) **Print Out Your Certificate**

Ethics in the World of Engineering

A Professional Development Course for Engineers

By: Professor Nael Barakat, Ph.D. P.Eng. FASME

Contents

1. Objectives of the course

By the end of this course, the student should be able to:

1. Realize the nature of engineering and its interaction with human life and society.
2. Explain the need for Engineering Ethics by society, the profession, and the professionals.
3. Define Engineering Ethics in relation to personal and religious ethics.
4. Recognize the existence of professional codes of ethics, or professional value systems, to protect humans and the profession.
5. Understand professional responsibility, related limitations, and proactive responsible actions.
6. Realize the ethical basis and need for life-long learning as a critical part of the profession of engineering.
7. Understand the concept of sustainable development and the relationship between engineering and the environment.
8. Understand the source, and effect, of public concerns on technology advancement.

2. Introduction

What is it that engineers do? This question is usually posed to senior high school students who are trying to decide their prospective field of study in college. This question is often used as a conversation starter to promote engineering as a possible career option. If you recall the days of senior high school, what type of answers do you think students are likely to give? What level of detail do you think students can provide about the work that engineers do? What you've most likely surmised is that engineering is usually the career about which high school students have the least amount of knowledge. So the question then becomes: does this group of high school students represent society as a whole?

In fact, the experience of this course author shows that the majority of people across the board, not just high school students, are unable to articulate what engineers really do and what role they play in society. These same people usually rely on numerous engineering products in their day to day life which are taken for granted. Imagine waking up one day only to find out that you cannot use a cell phone, a microwave, a vehicle, a water heater, or an air conditioner, just to name a few. This short exercise is an effective method for any member of society to help realize the depth of the influence that engineering has in their life.

Look at figure 1 where a cell phone tower is shown as an example of an engineering product that is faceless. This facelessness is due to the fact that the cell phone tower was developed by engineers behind the scenes. Consequently, the public does not directly associate the engineers with the cell phone tower. As a matter of fact, one of the distinct differences between the profession of engineering and other professions, such as medical professions, is that the link made between the public and the engineers who make products like a cell phone tower is usually missing. Engineers apply science in order to create innovative products and services that improve daily life. Examples of these are: gasoline, hot water, communication devices, and even the paved road. Yet, the general public sees these products of engineering as faceless. The public rarely relates these products to engineers and the profession of engineering. On the other hand, every person must have seen their medical doctor at least once, and can directly tie their health care to the person providing it, unlike in the field of engineering.

From a different angle, the nature of work in the engineering field does not provide enough drama for media makers to be able to sell it to the public through the different media outlets. It is easy to notice how little time engineering occupies on television compared to medical dramas or Crime Scene Investigators (CSI) episodes. Engineering reality is not something that would be as exciting or as attractive as media focused on other professions if it were publicized.

Furthermore, there are usually very few instances when an engineering disaster occurs that brings media attention to the profession. Examples of instances that do bring media attention to engineers might be a plane crash, or a building falling and causing casualties, or a nuclear reactor exploding. These occurrences will carry enough drama for the media to bring the event out to the front pages. Examples where this has occurred include: the Challenger space shuttle case, the Fukushima nuclear reactor case, and the BP deep water horizon spell case, to name a few.

It should be noted that the calculated risk of these disasters and the likelihood that they will occur is extremely low. Yet, when they do happen they provide a significant impact on society that lasts for a long time. Public disasters, combined with society's lack of understanding of the role of engineers (which is to improve and advance society with utmost care to protect the health and welfare of the public), can lead to significant confusion and distortion of the reality of engineering, engineering products, and the engineering profession. In addition, engineers do not usually act alone but rather as part of an organization with a decision-making hierarchy that gives management the last word in any decision. The result is that engineers are not making decisions related to projects in isolation. This hierarchy causes even more confusion among the public in regards to who really authorized a failing product to move forward into the market.

As an example, after the Japanese nuclear reactor in Fukushima went out of order in the year 2011, causing a major disaster, public opinion based on the impact of this incident resulted in the complete elimination of all nuclear power plants in Germany. Germany made this decision despite nuclear power plants' very low risk, environmental friendly output, and excellent historical performance.

The collective result of 1. Society's lack of knowledge about the profession of engineering, 2. Vagueness surrounding engineers' role in projects and in society, and 3. Misunderstandings surrounding disasters, makes engineering ethics a critical part of the profession. Furthermore, as such a crucial element to the profession, engineering ethics should be thoroughly understood and well-articulated. This course will delve into the topic of engineering ethics, and will explain that engineering ethics does not stop at doing the right thing when the right thing is obvious; engineering ethics covers multiple aspects of the engineering profession, particularly those related to interaction with society and humanity.

3. Nature of Engineering

A clear understanding of the role of engineering in society will quickly lead to the established fact that: engineering is a vitally needed profession for society.

Engineering is a profession that requires significant formal education and extensive training. Engineers possess specialized skills and knowledge which they use autonomously to solve problems and develop technical solutions. Engineering practice is dynamic and innovative, requiring intellectual judgement and extrapolation of knowledge into unchartered territories. In essence, the nature of engineering involves managing the unknown for the betterment of human life. Therefore, most engineering projects become social experiments with some risk factors.

These risk factors stem mainly from two elements:

1. The complexity and interactions of all the unknowns associated with the different parts in an engineering endeavor, and;
2. The novel nature of engineering products, particularly new and innovative ones, which have not been tested before.

Figure 2 shows these relations and how a case involving their combination could lead to liability issues. However, blind legal regulation of the profession of engineering alone would not be adequate because of the specialized knowledge and autonomy needed to practice the profession and the fact that most regulatory rules are reactive in nature.

In fact, like many other professions, as engineering interacts with society an implicit contract between society and engineers is established. This contract allows engineering to self-regulate in exchange for ethical and responsible practice of the profession that protects and holds paramount the health and welfare of the public. Similar provisions are found within other professions, like the medical profession. Figure 3 shows the societal and human dimensions and interactions of engineering. Consequently, engineering as a profession self-regulates and self-governs utilizing tools such as the professional licensing process and formal education on engineering ethics.

4. Concepts and Definitions

Engineering ethics can be defined as the set of common standards of conduct and professional dimensions shared by engineering professionals, with promoting responsible practice as one of its goals. Other goals include providing a framework for critical analysis and understanding the evolution of non-technical issues and contemporary topics affecting engineers and their profession. In addition, engineering ethics allows the integration between the technical side of engineering and the societal and human dimensions of the profession. This promotes the development of professional aspects like: societal impact assessment, technical and public education improvement, public informing and responsibility, citizenship, and stewardship.

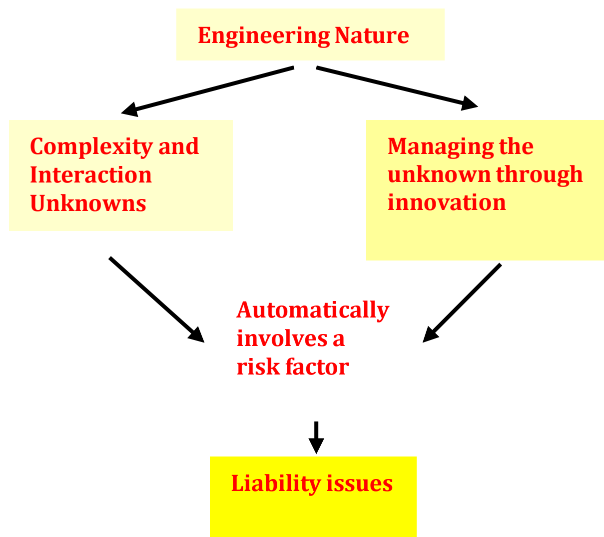

Figure 2: Risk factors resulting from the nature of Engineering.

Engineering ethics are professional ethics, which are different than personal or religious ethics, in spite of many overlaps between these sets. Actually, it is very hard to clearly define a distinct boundary between engineering ethics and personal ethics without sufficient reflection and analysis. However, for the time being, a set of working definitions can be used as follows:

1. Personal ethics can be defined as the set of a person's ethical commitments, acquired during upbringing and later modified. These usually formulate the base upon which certain choices were made at an individual level.
2. Interchangeably, morality is used in this context of discussing ethics where morality can be defined as the set of ideals, values, and beliefs, presumably guiding personal behavior.
3. As a result, common morality is defined as the set of moral ideals shared by most members of a culture or society.
4. Accordingly, ethical philosophies can also be defined in general as culture norms filtered through (mainly) religious traditions and ideal values.

It is to be noted that - in general: morality is usually more descriptive of individualized ideals while ethics are usually more descriptive of the ideals and values of a group or organization. Nevertheless, an example of the overlap between personal and professional ethics is always present when looking at the concept of integrity, which is significantly emphasized by ethical theories and codes of ethics, as will be discussed later. Integrity is an individual trait that by definition indicates a healthy moral character. This also implies loyal obedience to moral principles, especially when tested, like when no one is looking or when under pressure.
Although

integrity is an individualized concept, it has been emphasized throughout the fundamentals of professional ethics. This is a clear example of how blurry the line can be between personal and professional ethics because of the simple fact that professionals are still human individuals.

A. Code of Ethics

Engineering ethics are usually documented in a written form known as the "Code of Ethics." Codes of ethics are provided by professional organizations as an agreed upon guide for its members, in matters related to their professional practice. However, a code of ethics is more than just a guide. It is actually an agreement between the public and the professionals to promote and protect public health and welfare which helps solidify public trust in the profession. A code of ethics also aims at advancing the profession by requiring continuous improvement and update of skills and knowledge by its members to stay competent in the profession. From a bigger picture, a code of ethics provides a medium for professionals to discuss and understand the evolution of the profession and its ethics as well as the reasoning for a professional to adhere to professional standards. These standards include both the technical and ethical sets.

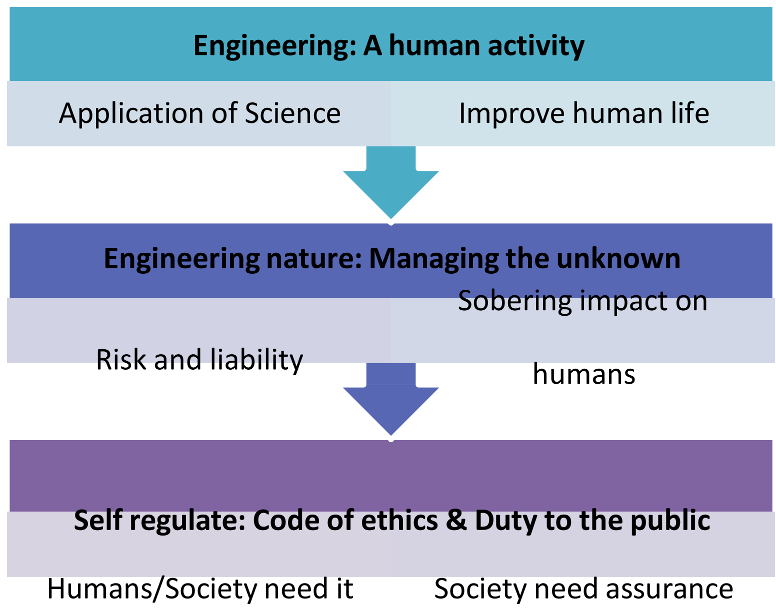

Figure 3: Societal and human dimensions of engineering.

Codes of ethics for engineers are available from most of the engineering professional organizations like: the American

Society of Mechanical Engineers (ASME) [1], the Institute for Electrical and Electronic Engineers (IEEE) [2], the American Institute of Chemical Engineers (AIChE) [3], and the National Society of Professional Engineers (NSPE) [4]. Some of these professional organizations, like the ASME and IEEE, have made their codes of ethics part of the professional society policies. Nevertheless, the one code of those which can be used by any engineer is provided by the NSPE [4].

A closer examination of these codes shows that all of them share similar fundamentals including the following:

1. A clear commitment to hold paramount the health and welfare of humans.
2. An obligation to protect the dignity and right of consent of human subjects.
3. An understanding of engineering endeavors as managing the unknown within a societal context resulting in risks and liability.
4. A profound acceptance of accountability for the results of engineering projects.
5. An obligation to protect and advance the engineering profession.

However, while sharing the same concepts, these codes from the different engineering organizations have different flavors and minor differences related to the engineering type they represent. For example: while both codes of ethics for civil engineers [5] and computer engineers [2 and 6] focus on health and welfare of the public as to be held paramount, the code for civil engineers would add a focus on sustainable development of resources, while the code of ethics for computer engineers would add a focus on data security and privacy issues. These codes can become very handy in the process of analyzing and understanding ethical dilemmas related to the profession. However, engineering codes of ethics should not be mistakenly used as a recipe substituting for sound judgment, or as a legal document constituting law.

To help understand the levels of complexity an ethical dilemma might bring, the following concept and example are presented for clarification. The concept states that: ethical does not necessarily constitute legal and vice versa. The example is presented through the following hypothetical scenario: If the Environmental Protection Agency (EPA) laws state that no contaminant should be disposed of in a natural lake with a concentration of more than 10 Parts Per Million (PPM), then disposing of the same contaminant at a concentration of 6 PPM might be legal, but is it completely ethical to do so? A clear cut answer to this question is not easy to find. In fact, to answer this question it might be necessary to find more facts and gather more information to understand the context of the problem. Once the facts have been streamlined, codes of ethics can be brought in to the discussion for reflection and testing of the findings, to help formulate the most ethical solution. Yet, this solution would most probably be a compromise, or a middle ground solution, that would use some ethical theory or concept in addition to the professional codes of ethics. As was mentioned before, engineering ethics do not stop at just doing the right thing when the right thing is obvious, but they go deeper and further in helping to resolve very complex ethical problems related to the professional practice of engineering in the context of society and humanity. Moreover, engineering ethics is not an ad hoc topic; the ethical context of an engineering project should be discussed from the beginning. In the following sections some fundamental ethical theories will be presented in a summarized format to help understand the basis for codes of ethics and ethics related decisions.

B. Philosophical Background

Ethics is a topic that is deeply rooted in philosophy. Ethics includes the conceptualization, analysis, and understanding of right and wrong in human behavior.

Understanding the philosophical background of ethics and the concepts behind ethical decisions helps professionals, particularly engineers, to understand the depth and meaning of their professional responsibility as well as the basis for ethically related decisions. This depth also helps them grasp the bigger picture provided by codes of ethics of professional organizations. Therefore, a quick review of the basic ethical theories is provided here to help in understanding decisions related to ethical dilemmas and in solving ethical problems. This will ultimately help engineers in building ethical-judgement autonomy when practicing engineering. As shown in figure 4, ethical theories provide a framework for: common morality check, analyzing and resolving ethical conflicts, and identifying relevant ethical considerations. Nevertheless, this will

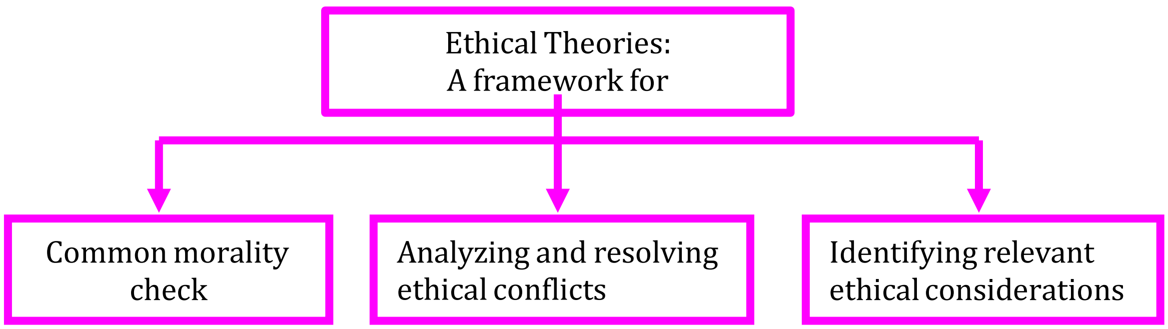

Figure 4: Applications of ethical theories

only be a summary of some common ethical theories to maintain focus on the applicability of these theories in engineering practice where different ethical situations and decisions occur.

C. Ethical Theories

Fundamental ethical theories can be categorized as follows:

1. Western Ethical Theories: These are the theories that were developed throughout history and had more contributions from, and influence on, the western hemisphere of the globe. Decisions made to organize societies and most current constitutions in the west are based majorly on combinations of these theories. Some main stream theories in this category include:
   a. *Utilitarianism:* This is an ancient theory that was further developed and attributed to John Stuart Mill (1806-1873) as being the main developer of the theory [7]. This theory considers a balance between good and bad consequences of actions and decisions, in relation to everyone affected, or the entire society. Good actions are considered to be those that serve to promote the wellbeing of the human majority. An application that is acceptable within the boundaries of this theory is the risk-benefit or cost-benefit analysis. This technique is based on quantifying actions and decisions to produce a final number representing cost or benefit of the action or decision at hand. According to this theory, consideration of most benefit to the most people outweighs the needs of few individuals. This theory is also known as "Consequentialism." Some of the disadvantages of this theory include the lack of consideration for the distribution of benefit, or cost, when it is for the majority; and the override of all considerations when quantification is taking place, including some items which might be invaluable like human life.
   b. *Rights Ethics:* This theory is mainly attributed to John Locke (1632-1704) [7]. The theory states that people have fundamental rights (like life, liberty, & property) that others have a duty to respect. This theory is related to deontology and Justice Ethics.
   c. *Duty Ethics:* This theory is attributed mainly to Immanuel Kant (1724-1804) [7]. The essence of the theory is that there are duties which should be performed (e.g. Duty to treat others fairly, duty not to injure others, etc.), regardless of whether these acts do the most good or not. This theory is also related to deontology ethics or Rule philosophy. Duty ethics and Rights ethics are usually considered together as they both relate to each other very closely. The theory of rights-ethics has its applications, advantages, and disadvantages as well. On the one hand, the main advantage of this theory is to treat all humans equally. On the other hand, the main disadvantage of this theory is the disregard of the public good when very few individuals object to such good based on harm inflected upon them, even if this harm was not significant and subject to compensation by other means.

In Summary: The previous are two non-mutually exclusive western ethical theories based on what is held as the most important moral or ethical concept:

1. *Utilitarianism:* Seeks the most utility and overall good result for the majority.
2. *Respect for Persons:* Accord equal respect to each person as a moral agent within two theories - Duty ethics and Rights ethics.

2. Non-western Ethical Theories: The rest of the world has different foundations for their ethical systems.
   However, Ethical standards are similar worldwide although cultural practices are

significantly different. For example, being deceptive is wrong everywhere, not just in the western world. Moreover, some of these ethical norms have been developed a long time before the western theories developed.

Differences in western and non-western theories leads to new practical aspects which engineers are not always aware of as they practice their profession globally. It is critically important that engineers avoid the extremes of moral relativism and moral absolutism, or superiority, when practicing engineering on a global level. Moral relativism means that an engineer would behave similar to others within the environment of operation, from a moral point of view, even if the behavior is not in agreement with their professional ethics. In other words, when in Rome, do like Romans do. Meanwhile, moral superiority or absolutism implies an embedded notion of moral superiority which results in the engineer trying to replace local ethical systems with their own, assuming these local systems are inadequate. The bottom line concept is that engineers should understand that their professional ethics are expected to apply in any geographical location, with extra effort to understand and respect local cultures and institutions, while not compromising one's own. Nevertheless, when the legal aspects are involved, it is critical that engineers from the USA realize that their actions are governed by American laws even if they are practicing outside the USA. For example: bribery is as prosecutable outside the USA as it is inside the USA, without any differentiation.

Ethical theories can converge offering stronger arguments or diverge leading to different solutions of an ethical situation. When ethical theories diverge, more analysis and richer views can result in helping to better understand the situation. Generally, respect for the person's ethics take precedence over utilitarian considerations if rights are violated. This is because based on the rights of the person ethics are the foundation for the majority of western constitutions. Otherwise, a balance of theories must be met or a middle creative solution must be found, to solve the ethical dilemma at hand.

5. Applications

A. Concepts

A moral dilemma results from a situation where two or more ethical rulings or moral options are applicable but point in opposing directions. Complexity in these situations stems usually from three main sources:

1. Lack of facts: where information is scarce and details are missing to point at a particular ethical principle that could be applied to the situation.
2. Interpretation differences: where different persons disagree regarding the applicability and interpretation of ethical principles, especially in authority structured relationships.
3. Conflicting logic: where two or more ethical principles are applicable to the situation but point in opposing directions.

Therefore, when analyzing ethical problems to find a solution, a deep understanding of the issues and a great deal of investigation to find the facts is required. To arrive at this understanding, facts have to be collected aiming at finding the whole truth, or at least get as close as possible to the truth. Of course, not everyone will agree on the "truth," but further research helps clarify the situation. Following this step an attempt should be made to reach an agreement regarding the applicable ethical concepts and the meaning or interpretation of these concepts. An agreement is not always possible, but further analysis helps to bring it closer. The final solution would probably never be the most ideal ethical solution, but rather a compromised position by all parties that is the closest possible to the best ethical solution. Therefore, being one of many correct solutions, the ethical problem under consideration can be considered an open ended problem. Engineering design problems are usually open ended problems, making ethical dilemmas analogous to engineering design. Consequently, these types of problems have the following properties:

1. They have more than one correct solution.
2. They require applying a large body of knowledge to formulate a solution.
3. They require significant utilization of analytical skills.
4. They require multiple iterations at every step to arrive at a solution satisfactory to the initiation criteria.

B. Legal vs. Professional Responsibility

Conforming to professional standards helps protect the public and the engineer from possible accidents and safety concerns, as well as legal ramifications. However, engineers should be aware of the boundaries and limitations of their legal and professional responsibility. This is particularly important when problems occur resulting in grave legal and liability questions. To fulfill this professional responsibility engineers can follow a model known as ***reasonable care.*** Proper understanding of this model is necessary to avoid actions which can be taken advantage of in case of disasters and problems. Since the very nature of engineering will always involve occurrences which have never been accounted for previously, and to properly identify and understand reasonable care, an analysis of the legal precedence and views in this regard might be helpful. For this purpose, a part of the law known as "Tort Law" is examined. Tort Law is the part of the legal system that addresses legal injuries or wrongs in the course of practicing a profession. It is also known as the malpractice law. This law defines & accepts a ***professional standard of care***, or reasonable care, as that which: relies on, but not restricted to, the standard operating procedures of a profession, and ordinary job responsibility. Accordingly, this definition is also open to some interpretation and subjectivity depending on the circumstances and evidence in the case at hand. Therefore, most codes of ethics support a broader principle of care that goes as far as recommending that one should avoid even contributing to producing harm by action or inaction. Codes of ethics emphasize that engineers are privileged to be able to see the potential for harm and to be able to prevent it.

Moral responsibility usually parallels legal liability. This brings in another term that needs definition which is ***liability***. The simplest definition of liability is: deserving punishment for causing harm. The severity of the punishment is usually decided through a legal process that considers the degree of harm and gives weight to the cause for inflecting harm, which can be one of three levels: intentional harm, reckless harm, and negligent harm. In liability cases against professionals, rarely any professional is proven to have caused intentional harm, and very few cases result in proving that harm was caused recklessly. In fact most of the professional liability cases would reveal that the cause of harm was negligence.

Since engineering ethics provide a higher calling than legal regulations, in terms of protecting the health and welfare of the public, codes of ethics strongly emphasize a responsibility fulfilment model known as ***Good Works***. Good works is the model that calls for going above and beyond the call of duty to insure staying multiple steps away from unexpected disasters. In comparison to reasonable care, which is the basis for obligation responsibility, good works would be an extension of reasonable care. Good works encourages finding and exploiting opportunities for going beyond minimum responsibility requirements, which is a desirable character of engineers that lies in the abstract commendable area.

However, no one can blame an engineer for not doing good works since it is not part of their duty. Nevertheless, if done, good works are admirable. One precaution associated with good works is that an engineer performing it must accept the extra responsibility associated with it since professional performance is now expected.

C. Proactive and Responsible Actions

Engineers are educated as professionals to perform their duties with ethics in mind. However, maintaining this attitude and understanding in action is not an easy task, especially considering the facts that engineers are human. Humans' actions are directed by their frames of mind and their attitude, which might not help realize the long term gains or losses behind a certain action, compared to the quick recognition of short term gains or losses associated with a contradicting action. There are many influential elements that stem from a human frame of mind and attitude, which sometimes results in a diversion from performing a responsible action. Awareness of these elements can help a great deal in correcting the actions of a professional.

These elements include:

1. Internal element: self-centering, self-interest, and self-deception.
2. Surrounding element: Peer pressure, desire for acceptance, and groupthink.
3. Intellectual element: Ignorance and poor educational updates, as well as the lack of appreciation of the different perspectives and the big picture.

These barriers do not just work against an individual professional engineer when trying to act responsibly, but also exert the same effect on an entire organization. Recall that the majority of professional engineers work within bigger organizations which have their own authority structures. Management style within an organization could provide an environment that encourages or discourages these barriers to grow and affect performance. Successful organizations usually encourage and grow a culture of dissent, to empower professionals towards ownership of their actions and their consequences. Ultimately, this would enable the organization to find out its mistakes and errors quickly and efficiently, and consequently correct these errors in the way of continuous improvement. Moreover, most organizations now have their own codes of ethics and guidelines for employees to decide if an action is acceptable or not. In engineering organizations, most of those codes agree with the professional engineers' codes of ethics from professional organizations, with some added flavor related to the locality. In case there are none, an engineer can be one of the initiators of this culture by introducing awareness classes and seminars that will allow this organization and colleagues to learn and gain awareness about ethics and societal dimensions of engineering.

D. Integrity and Honesty

As mentioned previously, integrity is emphasized by ethical theories and engineering codes of ethics as an expected base for professional action and judgment. In application, integrity implies honesty and reliability, which are required by engineering ethics as essential bases for professional actions and judgment. The definitions of these words can be traced through their linguistic roots where the dictionary defines them as follows:

- **Honesty:** Sincerity, fairness, and freedom from deceit or fraud.
- **Integrity:** Adherence to moral principles, wholeness, and soundness of moral character.
- **Reliability:** Trustworthiness, predictability, and dependability.

The term reliability has a technical definition, not to be confused with the linguistic definition, which is the ratio of the number of correct runs to the number of attempted runs.

In the context of practicing professional engineering, many regulations and professional expectations rely on, and deal directly with, the concept of integrity and honesty. Examples of these situations include the following:

A. Full disclosure: Engineering codes of ethics stipulate that information needed for informed consent of an individual should be provided in full. The order of priority is always to protect the public and society, then the client, and finally the engineer's interests. Failure to inform those whose decisions are impaired by the absence of the information would invoke the honesty part of an engineer's code of ethics and might lead to undesirable legal consequences. However, the way to produce this information, particularly if a client's interest or the interests of an engineer would become in jeopardy, is a typical ethical dilemma. Resolving such a dilemma usually requires significant effort to arrive at a compromising solution that is mutually acceptable by all parties.

B. Confidentiality: Confidential information will reach the engineer either directly from the client or by accidental discovery during the course of performing work for the client. This information can be subject to abuse in two forms: the first form is when confidentiality is broken while the action is not warranted, and the second form is when confidentiality is not broken although the higher obligation to the public requires it. The limits for these two forms are highly controversial but engineers should be aware of them.

C. Conflict of interest: This situation exists when a professional judgment is subject to influences, loyalties, or other interests. Conflict of interest also tends to make the judgment less likely to benefit the client than the client is justified in expecting. The professional context is important for this concept to apply as conflict between interests in two different sports does not really pertain to this concept. Moreover, protected interests in case of invoking this concept should be morally and legally legitimate. There are three types of conflict of interest: 1) actual: which exists in a real situation, 2) potential: which seems anticipated based on the current events and where they are leading, and; 3) apparent: which might seem like a conflict of interest exists, but in reality there is none. Regardless of which type is occurring, engineers should avoid all three types. If avoidance is not possible, then an engineer should reveal the conflict to the client as soon as it is realized. In general, if faced with a situation that seems to bring about a conflict of interest, policies within the company or organization should be followed. If no policy is available in the workplace, the situation should be discussed with a manager. If this solution is not practical or attainable, then a professional engineer should examine their motivations and try to take documented precautions in every step along the way until the situation is resolved.

A scenario that encapsulated all of the above situations occurred when an engineer with relevant expertise was hired by his previous father in law to inspect and certify an apartment building owned by the ex-father in law. As the engineer was performing the inspection he realized that one of the structural elements (a beam) carrying the building at the basement level was cracked. After informing the owner of the building, the owner did not want to do something about the situation in the near future and asked the engineer to closely observe client confidentiality. This situation had multiple complexities leading to an ethical dilemma. In particular, the client confidentiality concept was directly contradicting the concept of full disclosure, which formulates the basics of an ethical dilemma. In addition, the previous relationship between the engineer and the owner of the building provided grounds for an apparent conflict of interest, when actually the relationship was in the past and had nothing to do with the job at hand. Had the situation continued without action, then legal ramifications, as well as professional penalties would not have been the worst that could happen. Someone could have been killed by a falling building which is the worst result possible. The engineer had to do a lot of diplomacy negotiation with the building owner, including bringing in help from colleagues in the profession who offered reasonable charges to help repair the building and correct the entire situation. As for the apparent conflict of interest part, the engineer should have not accepted the job in the first place.

Another common form of dishonesty is lying, which is issuing a false or misleading statement with the intention to deceive. Lying can take different forms including deliberate deception. Withholding information with the intent to deceive and failure to disclose information that the audience would reasonably expect to know are also forms of dishonesty. Failure to seek the truth can also be considered a form of dishonesty. Honest engineers are committed to finding the truth, not just avoiding dishonesty.

As was mentioned, ethical theories include honesty as an essential part. According to the theory of "respect for the person," dishonesty violates the moral agency of individuals. This leads to problems like decisions being made without knowledge of all of the possible consequences. The utilitarian theory also stipulates that dishonesty undermines the relations of trust, which is necessary for the public good. Moreover, dishonesty impedes the development of technology, particularly when scientific findings are not completely disseminated, which results in depriving the public from an expected benefit.

E. Professional Academics and Scholars

Numerous engineers are involved in academia between teaching and research to advance fundamental science and its applications. Academic and scholarly work is prone to many forms of dishonesty, with the majority of it being unintended. An example demonstrating this issue is the simple elimination of an irregular data point in order to match predictions without the proper scientific proof that the irregular point was an outlier. Similarly, eliminating results which do not match expectations, or adding missing points to complete data sets per expectations without reasonable scientific basis is a form of dishonesty. Also common in academic and scholarly work is the act of plagiarism which is the use of intellectual products of others without their permission or claiming credit in joint work that is not proportional to the contribution in that work. In general, academic honesty and integrity is not only obedience to an arbitrary set of rules while learning creativity and discovery, but rather learning and applying the standard of evaluating and crediting contributions made in the discipline. The criteria for fair use of resources depends on many factors including the field of discipline and the context of the work. However, the bottom line is that plagiarism is never acceptable, and proper citation and credit of reference and sources is extremely important in the context of scholarly work.

Dynamic Issues in Engineering Ethics

As was mentioned, engineering ethics provides the framework to discuss and understand evolving issues related to the profession of engineering from both sides: the practice and the impact. This part of the course includes a discussion of two prominent examples of these issues: Continuous Professional Development and Environmental Issues. These serve to explain the dynamic and evolving nature of the engineering practice and its interaction with society and its surroundings.

A. Continuous Professional Development (CPD)

1. Background

Continuous Professional Development (CPD), or life-long learning, is a clear example of how the dynamic and evolving nature of engineering practice dictates certain ethical aspects of the engineering profession. Fundamentally, engineering is the application of science and the utilization of new scientific discoveries into products and services that help improve human life and human endeavors. Consequently, explosive rates of engineering and technology developments are being experienced every day. The downside to this unprecedented high speed of discovery and updated knowledge is that the shelf-life of education and skillsets possessed by the professional become shorter, causing engineers to quickly become obsolete. This is particularly true if engineers do not continuously develop their skills and knowledge base. Therefore, continuous learning and update of knowledge and skills is very critical to the success and career continuation of an engineer. The national academy of engineering recommends that: "in addition to delivering content, engineering schools must teach engineering students how to learn, and must play a continuing role along with professional organizations in facilitating life-long learning, perhaps through offering (executive) technical degrees similar to executive MBAs [8]."

From a practical angle, changes in engineering used to be mostly on the technical side of the practice, or that is what was noticed more about this profession. However, non-technical changes have become as evident and influential on the practice of engineering as well. The globalization of engineering stands out as an example of these changes. One of the consequences of globalization is the increasing need for universal professional and technical standards. Having CPD as a built-in component in the practice of the profession would make engineers not only capable of accommodating these changes, but also competent. Above all, CPD encourages legally safe and correct engineering practice when professionals are practicing outside of their home countries.

2. Link to Engineering Ethics

CPD is actually a solid part of engineering ethics. Most codes of ethics from professional engineering societies state something to the effect of life-long learning being an ethical requirement of engineers. The National Society of Professional Engineers (NSPE) code of ethics, section III: professional obligations, point 9.e. includes the following statement: "Engineers shall continue their professional development throughout their careers and should keep current in their specialty fields by engaging in professional practice, participating in continuing education courses, reading in the technical literature, and attending professional meetings and seminars [4]." A closer look at the code of ethics of the NSPE reveals that four out of six cannons that make up the code directly call for the integration of continuous professional development in the engineering profession. The first fundamental cannon in that code of ethics, which is the same first cannon in most of the other engineering professional organizations codes of ethics, states that: "Engineers, in the fulfillment of their professional duties, shall hold paramount the safety, health, and welfare of the public [4]." The relevance of this particular cannon to continuous CPD can be explained by the example of safety rules and tools improvement. Safety in engineering and technology products are continuously improving, not only at the product and material level, but also in the design and build practices and procedures. However, these new technologies and methods might not have existed during the college education time of a practicing engineer. For professional engineers to fulfill their ethical duty outlined by the previously mentioned cannon, they must acquire the knowledge relevant to these new safety enhancement findings and implement them in the practice. The advantage of this step goes above and beyond fulfilling ethical duties and reaches what is known as "good works."

In the same code, the second cannon states that: "engineers, in the fulfillment of their professional duties, shall perform services only in areas of their competence [4]." Understanding this, it becomes clear that being obsolete or outdated in knowledge and skills would place an engineer outside of the limits of needed knowledge and expertise. Moreover, it might mount up to exposing the public to dangers that result from that lack of knowledge and skills. Maintaining a meaningful competence is only achieved by continuous learning of the profession from all aspects. The fourth cannon of the same code states that: "engineers, in the fulfillment of their professional duties, shall act for each employer or client as faithful agents or trustees [4]." When engineers continue learning and are up to date in knowledge of the tools and bases of the profession, they significantly help their employers. This help includes gaining competitive advantage and indirectly leading the way for others to follow in the industry.

The last cannon of the NSPE codes states that: "engineers, in the fulfillment of their professional duties, shall conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession [4]." In essence, CPD will ultimately result in a better career for the engineer, economical advantage for both the engineer and the employer, less safety issues for the public, and most of all, increased public trust and respect for the profession. These advantages even reach as far as better treatment and protection of the global environment. Therefore, professional engineering registration in most states of the USA requires proof of CPD using continuing professional development hours or PDH. This is simply because the main purpose for engineers' professional registration is to protect the public safety and welfare, which is directly linked to engineering ethics.

3. Conclusion

While demand for engineers has been steady in the market for a long time, the majority of engineers in the workforce tend to get immersed in their daily duties and delay any plans to further their education and skills. As a result, CPD activities end up being carried out by professionals on a have-to basis, and in an ad-hoc fashion. For engineers to survive against the increasing competition and to fulfill their ethical responsibilities, these activities should be performed as a way of life in the practice with appropriate planning and evaluation. Planning and managing of these activities as a core element in a career path and turning the acquired knowledge into competencies should be part of the practice of engineering. As a matter of fact, CPD effects extend to be vital for the national economy, not just the individual engineer's career.

Therefore, significant efforts are needed in the area of integrating the concept of CPD in engineering education and to provide practical and flexible models that can be merged with career management plans set by the professionals. CPD activities should not be carried out to make a big list that will satisfy requirements or show proof to employers. Moreover, when engineers require CPD as part of the practice, employers are encouraged to adopt CPD as a standard benefit for their engineers, which will slowly be removed from the list of items subject to cost cutting. In exchange, employers can enjoy a stable and continuous workforce, competitive advantage in quality and initiation, more benefits and attraction of skills, and more public trust and leadership roles in the their products and expertise.

B. Environmental Issues and Sustainable Development

1. Background

Engineering projects are considered a threat to the environment, and many environmental problems have been associated with engineering endeavors. The truth of the matter is that engineering projects have been inadvertently responsible for some environmental issues, but not to the degree presented by the media. At the same time, engineers are always sought to provide solutions to environmental problems, whether it is caused by engineers or not. Therefore, the relation between engineers and the environment is a complex one that has many dimensions.

Engineers have an obligation towards the environment that stems from two bases. The first base is that all private citizens have an obligation to the environment and engineers are private citizens. The second base is that professionals abide by professional ethics and the majority of professional engineering codes of ethics emphasize the engineer's responsibility towards the environment. In a very detailed and elaborate fashion, the American Society for Civil Engineers (ASCE) code of ethics refers to the environment as follows:

"Cannon 1, section f: 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 [5]."

This is one of the most explicit references to the environment in an engineering code of ethics. Other professional organizations also share this reference to the environment and sustainability. The word "strive" in the first cannon of the ASCE code of ethics, described above, indicates multiple of levels of action which are required by engineers. This includes examples beyond personal compliance with sustainable development like: informing clients about the consequences of violating sustainable development and informing authorities about violators of sustainable development.

2. Sustainable Development:

Sustainable development, as shown in Figure 6, is a process of change in which human development activities meet present needs and aspirations without endangering the capacity of natural systems to absorb their effects, and without compromising future generations' ability to meet their needs and aspirations. Human development activities include things like: investment, technology, resource allocation, functioning of institutions, etc.

Engineers play a critical role in sustainable development characterized by the development of technology that conserves natural resources and protects the environment. However, engineers are not capable of doing that alone. Many factors are involved in engineering projects including political, social, and moral factors, which are beyond just environmentally-friendly technology. Knowing that engineers do not function alone, or in vacuum, it becomes obvious that there are other people and entities which need to work with engineers to achieve sustainable development. Nevertheless, the influences of an engineer continue to be significant in any engineering project.

Figure 6: Components of Sustainable Development

3. Moral Standing of the Environment:

One of the major problems faced by engineers in relation to the environment is based on the lack of consensus over the moral standing of the environment. In other words, is the value of the environment appreciated in itself, apart from human use, or is it a value based on how much the environment is useful to, and appreciated by, human beings? The answer to this question continues to differ, and that reflects on engineering applications and projects trying to incorporate sustainable development. Depending on how the value of environment is seen and considered, in relation to humans, engineering projects will face different levels of challenges in protecting and preserving the environment. In general, western ethical thinking has been anthropocentric in its views; which means that only humans have moral standing. It also means that plants, animals, the environment, and any non-human objects, have a standing depending on how useful they are to humans. However, non-western ethical thinking includes some thoughts on elements surrounding humans as having intrinsic value regardless of their usefulness to humans. Add the emergence of the environmental movement, as well as issues of global change, a new attitude towards the value of nature evolved, which views nature as not just a commodity, but a community to which humans belong. Because of this controversy, most engineering codes of ethics implicitly commit engineers to health related or public welfare elements that are directly influenced by environmental concerns. The commitment to non-health-related concerns and intrinsic value of the environment are vague and arguable. A commitment to non-health-related concerns can be extrapolated if these concerns can be related to human welfare. In fact, due to an engineer's inability to operate alone, many factors must be considered like: public attitude, politics, and businesses housing engineers. In addition, technological feasibility must be considered when taking a stand regarding controversial issues. Engineering professional organizations, through codes of ethics, are usually careful not to take sharp sides or positions on controversial political issues and disagreements to ensure that engineers and the profession continue to be viewed as a professional, nonbiased entity. Therefore, the codes of ethics are not specific regarding a strict commitment to the environment. Also, as an advantage, engineers can have their own personal views and opinions about politically and socially loaded topics without having to contradict their own professional guidelines.

To understand the controversy in such situations, the differences in business attitudes towards the environment can be examined. Businesses are divided into three categories, based on their respective attitude towards the environment:

A. Denial of need for environmental management: where very few resources are allocated to environmental matters as possible, and significantly more resources are allocated to fight against environmental regulations. Some businesses in this category would go as far as considering paying fines and lobbying for decision makers as the cheaper cost of doing business than to accept the minimum governmental regulations to preserve the environment.

B. Minimalist environmental management: where government regulations are accepted as a cost of doing business and societal goodwill, but no extra resources or commitment are provided.
C. Advanced environmental management: where the business entity provides full and unwavering support to respond to environmental concerns. These businesses would invest resources to protect the environment and build healthy relationships with surrounding communities affected by environmental concerns and governmental agencies regulating environmental issues.

Businesses belonging to the third category gain the benefits of being 'Good Neighbors' in the community, fulfilling the implied contract with the larger society, and acting as responsible citizens for being a profitable business. They also fulfill self-interest including preventing fines and legal lawsuits while generating goodwill. When it comes to engineers working within these businesses, the last thing needed from their codes of ethics and professional standards is to show them as politically biased or to place pressure on their careers.

4. Professional Engineers and the Environment

Professional engineers' obligation towards the environment is a true ethical dilemma to which a solution can take one of two opposing directions. These two directions are characterized by two arguments:

A. Engineers' obligation to the environment should be extended beyond health-related factors because people are morally responsible for their actions. In the case of engineers, they influence the environment by projects and, therefore, engineers are responsible for protecting the environment. In addition, the engineering profession can positively influence the attitude and actions with respect to the environment. By refusing projects that are destructive to the environment, modification will ultimately be enforced to protect the environment.
B. Engineers' obligation to the environment should not be assigned for non-health related factors because engineers violate professional responsibility if they do so by speaking outside their area of expertise. When judging influences on the environment, the majority of engineers are handling issues outside the engineering body of knowledge. Moreover, committing to environmental protection beyond health related issues increases divisiveness and weakness of societies and codes. Engineers still disagree on non-health related environmental issues among themselves. Consequently, management support for societies might weaken. Besides that, extending the code into controversial areas makes it sound radical and politically biased and results in ignoring the code. At the individual engineer's level, associated conscience problems might emerge because engineers have individual beliefs on environmental issues, which might require a position contrary to their employer's beliefs, which is not desirable if not needed.

Both of these arguments have merits. Therefore, it is not advisable to oblige engineers to protect the environment when human health is not at stake. However, it is advisable that the code should protect the engineer's right to engage in public efforts to protect the environment and to refuse employers' projects that are environmentally destructive. The minimum measure should always be to abide by governmental laws and regulations related to the environment.

7. Ethics of Emerging Technologies

As scientific discovery continues to reach new frontiers, engineering and technology continue to evolve and expand at exponential rates, parallel to these scientific discoveries. Engineering generates technology in the form of products and services that help improve life. However, all new technology which has not been known to the public carry with it speculation and guesses, particularly in terms of effect on life and society. This is not unexpected as explained in sections 3 and 4, and figures 2 and 3 previously. Public opinion and support of engineers is significantly influenced by sobering experiences from previous disasters, and the human imagination. Some examples of these influences include: the discovery that Asbestos is a cause of cancer two decades after it was introduced as an improvement agent in buildings, or myths about robots taking over the world. When these combinations result in misinformation to the public, and to policy makers, detrimental results are realized. The example of cancelling the entire nuclear power generation program in Germany after the disaster of Fukushima comes back to mind. Therefore, informed public and leadership decisions (Public Policy) are keys to a sustainable, ethical, and economical technology development. In other words, public perception based on correct information is as critical as public health for engineering products, and that makes engineering ethics, particularly in the case of emerging technologies, a vital element for success.

To alleviate these issues, public education and the inclusion of ethics, human aspects, and societal impact, at the very early stages of any new technology development, have become a normally expected step in any engineering endeavor. The idea is not to stop technology or create burdens to engineers, but rather to educate stakeholders, including engineers, regarding the risks and benefits associated with an engineering project, allowing them to make informed decisions. In general, risk associated with any new technology can be categorized as follows [9]:

1. Life-basics ethics (Risk and "first do no harm" ethics): This includes concepts like autonomy. Examples of issues under this category include military applications, fear of uncontrolled actions, and health hazards.
2. Life-quality ethics (Justice and equality ethics): This includes ideas like the nano-divide associated with nanotechnology have and have-nots, where the gap between rich and poor nations will increase causing potential conflicts.
3. Life and human definition ethics (Meta-ethics): This includes the concept of integrity as a human and issues related to human change. Such changes include the enhancement of human abilities and the nature of implants in human bodies.

In summary, emerging technologies come with a huge gap of knowledge by the public leading to one of two issues: risk exaggeration or promise over-expectation. Both of these are forms of misinformation. Informing the public requires educating them about the factual benefits, risks, and limitations of the technology. It also entails clearing out the mythical and imaginary thoughts while setting realistic expectations of what this technology can achieve. Engaging the public early in the process is a prudent step that ensures increased transparency resulting in the generation of public debate and, consequently, public trust.

8. Course Summary

Engineering professional organizations provide a code of ethics, which is usually of higher calling than legal requirements to practice the profession. This code helps guide engineering decisions to protect the public first, the engineering profession, and the engineer. In general, engineering is the application of science to improve human life. The interaction between the engineering profession and society is extremely deep and intertwined which requires that engineers hold paramount the public safety and welfare as they practice their profession. Moreover, the combination of risk associated with engineering and some of the sobering examples of the impact of engineering disasters solidifies the need for engineering ethics to be understood, integrated in the practice of the profession, and publicly known. This promotes engineering self-governance as a respected profession, and supports mutual trust with the public as it helps protect both the public and the profession, while allowing engineers to move forward with their endeavors to improve human life.

9. References

1. American Society for Mechanical Engineers (ASME) code of ethics for engineers, retrieved January 15, 2017, https://www.asme.org/about-asme/advocacy-government-relations/ethics-in-engineering.
2. Institute for Electrical and Electronic Engineers (IEEE) code of Ethics, retrieved January 15, 2017, http://www.ieee.org/about/corporate/governance/p7-8.html.
3. American Institute for Chemical Engineers (AIChE) code of ethics, retrieved January 15, 2017, http://www.aiche.org/about/code-ethics.
4. National Society of Professional Engineers (NSPE) code of ethics, retrieved January 15, 2017, https://www.nspe.org/sites/default/files/resources/pdfs/Ethics/CodeofEthics/Code-2007-July.pdf.
5. American Society of Civil Engineers (ASCE) code of ethics, retrieved January 15, 2017, http://www.asce.org/code-of-ethics/.
6. Association for Computing Machinery (ACM) code of ethics, retrieved January 15, 2017, http://www.acm.org/about-acm/acm-code-of-ethics-and-professional-conduct.
7. The Stanford Encyclopedia of Philosophy (Winter 2014 Edition), Edward N. Zalta (ed.), https://plato.stanford.edu/archives/win2014/entries/
8. National Academy of Engineering, "Educating The Engineer of 2020: Adapting Engineering Education to The New Century," National Academies Press, Washington, DC, 2005.
9. Barakat N. and H. Jiao, "Proposed Strategies for Teaching ethics of Nanotechnology,"Nanoethics Journal, Springer, Netherlands, Sep. 2010. DOI 10.1007/s11569-010-0100-0.

Final Exam Questions:

1. The set of moral values of conduct developed and filtered by beliefs and education, and adopted by someone is known as:
    a. Business ethics
    b. Engineering ethics
    c. Personal ethics
    d. Moral standards
2. Engineering ethics include ideas and directives related to:
    a. Urban infrastructure
    b. Contracts
    c. Integrity
    d. Corporate business practices
3. Engineering ethics are needed for engineering practice:
    a. To prevent law suits
    b. To win contracts
    c. To increase popularity
    d. To guide the professional practice
4. Good works means:
    a. Going above and beyond the call of duty in reasonable care
    b. Doing excellent work that makes clients proud
    c. Improving engineering products above expectation
    d. All of the above
5. Dishonesty violates the moral agency of individuals. This is the view of dishonesty by:
    a. The NSPE code of ethics
    b. The Utilitarian theory
    c. The "Respect for the Persons" theory
    d. The integrity concept
6. Confidential client information includes:
    a. Information obtained by the access right
    b. Information found by the engineer while working for the client
    c. Information obtained by court order
    d. None of the above
7. Conflict of interest which should be avoided by engineers includes:
    a. Actual
    b. Perceived
    c. Apparent
    d. All of the above
8. "When in Rome do like Romans do" is a type of ___________
    a. Ethical absolutism
    b. Ethical relativism
    c. Utilitarian ethics
    d. Duty ethics

9. Professional ethics are
    a. Taught in college.
    b. Defined by the company you work for.
    c. Sets of standards of conduct adopted by professionals.
    d. Acquired during upbringing.
10. Engineering projects involve risk factors because of ___________
    a. Managing of unknown variables
    b. Managing of known variables
    c. Complex systems
    d. A and C