Ethics for U.S. Engineers

Protecting the Public Welfare

by

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Ethics for U.S. Engineers
A SunCam online continuing education course

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Introduction

From the day we enter the engineering profession, we begin the unending process of perfecting the skills and increasing the knowledge that we acquired in our training. This lifelong improvement process is important because every engineer becomes heir to the onerous responsibility to <u>protect the public health, safety, and welfare</u>. We hear these words so often that they tend to lose meaning which is why it is useful to refresh our memories periodically by reviewing the ethical expectations of professional engineers.

This course will address a few of the ethical considerations that confront engineers in the normal conduct of their professional life. When you have completed the course, we welcome your review comments and course rating. Whether you find agreement or disagreement with the principles advanced in this course, the review comments are the best place to share your views with other engineers. And, you may make your comments anonymously if you prefer.

An Opening Comment from SunCam

Teaching a course on ethics is awkward because it is so closely akin to teaching morality, which most would agree would best be left to parents and clergy. Lawmakers and engineering boards have the duty to write the more important "Rules of Professional Conduct," and those rules carry the force of law. By contrast, the "Codes of Ethics" of our various engineering societies are guidelines for behavior, merely opinions, which have no penalty for noncompliance other than sanctions or loss of membership. Common to both society codes and the law is the central premise that all engineers must <u>protect the public health, safety, and welfare</u>. The laws and rules do an excellent job of protecting the public health and safety, but the public welfare is more nebulous and harder to define in law. This course will embark upon that ill-defined issue of protecting the public welfare and, because it is an indefinable topic, we acknowledge that not all may share our opinions. Please feel free to voice your own opinion about our approach to this topic.

Have I Optimized?

Engineers are optimizers. Our job is not simply to find "a" solution to a problem but to find "the optimal" solution to a problem. As designers, we may be tempted to accept the first answer that works for any given design element, but that's not really protecting the public welfare. We squander resources if we accept a design that is a size larger than necessary just to economize on design effort. The first iteration of design is almost never optimal, and the difference between the first and the fifth iteration will be a smaller beam, motor, pipe or wire that is easier to install, consumes smaller amounts of material, is less expensive, provides greater utility and lasts longer. Lean Manufacturing, Sustainable Construction, and Green Building are all concepts aimed at

improving utility to humans while consuming less. Involving yourself in these practices will make you a better engineer and a better custodian of the earth's precious and limited resources.

While we are talking about conserving precious resources, let's not forget about ourselves. One of earth's most precious resources is our own time and money. Project management techniques were first utilized on a large scale during the development the US Navy's first nuclear submarine "USS Nautilus" in the early 1950's. The manufacturing and construction industries have since adopted these PM techniques to optimize the delivery schedule and costs for projects large and small. These tools include:

- CPM (critical path method diagramming)
- PERT (Program Evaluation Review Technique)
- Gantt charts
- EVM (Earned Value Management)

These tools and techniques have been responsible for saving time and money on product development and construction, but we seldom use them in our engineering design efforts. This puts the engineer at a disadvantage when it comes to knowing which tasks are critical to on-time completion and getting the earliest possible warning of cost overruns and resource shortages. We tend to manage our tasks by "seat-of-the-pants" methods and sometimes suffer mightily as a result. It may seem like a stretch to relate these issues to engineering ethics, but if you are not using Project Management techniques to manage your projects, then your service to the public health safety and welfare is less than optimal.

Honest Service

"Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest." This is one of the ASCE "Canons of Ethics," but it is common to the code of ethics of all engineering societies. It speaks of the ethical obligation that an engineer has, to:

- Avoid or disclose any conflict of interest that could influence their judgment or the quality of their service.
- Serve only one master by accepting compensation or gratuities from only one party for services on the same project unless there is full disclosure and agreement of all parties.
- Honestly report the bad news along with the good about the results of their engineering studies.

- Abstain from profiting personally, at the expense of the client, employer or the public, from any confidential insider information that comes to them in the course of their assignments.
- Disclose or forego outside employment.

All of the various engineering codes of ethics do a good job of guiding employees on an ethical path in their relationship with employers and clients but none addresses specifically, the obligations of engineers who *are* employers or clients. Honest service is a two-way street so the concomitant ethical obligation to employees would include:

- Be aware of the limitations of your employee/consultant's training and experience when making assignments and pay heed to any disclosure that they are not technically suited for the work. Recognize that forcing or coercing acceptance of such an assignment could result in a loss of license for the employee/consultant as well as a danger to the public.
- Do not ask your employee/consultant to offer gifts, gratuities or financial remuneration to any public official. Recognize that such acts could result in criminal charges and a loss of license for the employee/consultant.
- Disclose fully, the presence of any physical or professional risks associated with any assignment.
- Facilitate the continuing professional development of employees so they may deliver the most informed professional service to you and to the public.

Predicting Results

The greatest advantage that an experienced engineer has over a neophyte is the ability to be a better guesser. Most engineering design problems are not design problems at all but analysis. The engineer makes an informed guess and then analyzes the guess to see if it works. If the engineer is a good guesser, then the design process is quicker because less time is wasted zeroing in on the optimum answer.

Even when the design process does not require an initial guess, it is a good discipline to make a first guess and write it down. If you employ engineering interns, it is useful to formalize the process when you make an assignment by asking that they submit their guesses before they begin the design process. Not only will this improve their guessing skill, it will also often save them the embarrassment of submitting a laughable design that should have aroused their suspicions even before submittal.

Preliminary guessing is a particularly valuable tool if you are an engineer who works alone or in an office with only engineers of other disciplines. With no one to review your work, the simplest human error can result in a costly, disastrous failure and a threat to the public health, safety, and welfare. To help overcome this deadly disadvantage you should employ every "rule of thumb" and redundant computer software solutions to approach every engineering problem from different directions. Even if you take every such precaution, you will be best served if you find a colleague in a similar circumstance who can exchange project review services with you. Remember that when a medical doctor makes a mistake, it jeopardizes a life. When an engineer makes a mistake, it jeopardizes *all* lives.

Am I Qualified?

One of the most common causes for disciplinary action against engineers is for performing an engineering assignment when not qualified by training or experience. Engineering boards generally do not restrict engineers to practicing within a single discipline. If you are a civil engineer with extensive experience or training in electrical engineering, then you are usually permitted to practice electrical engineering. Likewise, if you are unqualified in some aspect of your primary engineering discipline, you are not permitted to perform an assignment in that area. As a professional engineer, State Engineering Boards expect you to make the judgment about your qualifications, but if your work product reveals a lack of understanding, you will be subject to costly, embarrassing and humbling disciplinary action.

If your business card suggests that you are qualified to practice engineering in "Civil, Mechanical, Structural and Electrical Engineering" then there is a good chance that you will someday have to answer to your engineering board for "performing an engineering assignment when not qualified by training or experience." Although most engineers would consider that such a disciplinary action would be dire, there are worse potential consequences because people could come to harm as a result of your unqualified work.

Remember that confidence is not synonymous with competence. Don't let arrogance or bravado ruin your professional career or cause harm to others.

Software - Trust but Verify!

When President Ronald Reagan was engaged in arms limitations talks with The Soviet Union, he famously said, "Trust but Verify" to characterize the central theme of the negotiations. Engineers should have the same attitude about software.

Computers and software have been a boon to engineering over the past few decades. With today's software, it is possible to perform engineering calculations that would have been impossible 50-years ago. The speed of computer calculations makes it possible to test endless variations in the input data to find the optimum outcome and to repeat the calculations reliably and without variation. The benefits are so enormous that it is sometimes difficult to accept the fact that imperfect human beings write software. Therefore, any software may contain imperfections. That does not alter the usefulness or utility of software, but it does mean that you will want to verify the final results before you sign and seal them.

A professional engineer should have a healthy skepticism about all software outputs, even the software that you write yourself. All state engineering boards have adopted rules that make the engineer responsible for the results generated by the computer software and hardware that he or she uses in providing engineering services.

We recommend the following best practices:

- Test new software with known sets of data.
- Always guess the outcome before you do the calculations (recommended for all calculations, not just software).
- Ask yourself if the answer "looks right." (Also recommended for all calculations.)
- When any of these cast doubt on the software output, use hand calculations or alternative software to crosscheck and verify results.

How Should I use my Influence?

As an engineer, you know things that will baffle and confound non-engineers. If you are the only engineer in your workplace, you will probably find that others will come to you to solve any problem that mystifies everyone else. Others will perceive you as having advanced skills in matters that they do not understand. This makes you an influential person simply because people who do not have your knowledge training and experience will take your word in matters that they don't understand. This power can be a force for good by following this simple guide for ethical behavior:

1. Express your engineering opinion only on topics that you know and understand
2. If someone is paying you to express an opinion, disclose that fact and identify who is paying you.
3. Be objective, truthful and complete in your engineering statements and reports. Leaving out pertinent facts is as unethical as lying.

4. Don't dishonor your profession by boasting or exaggerating your ability or accomplishments.

Standardization

Metrification may seem ill-suited to a course on ethics but it addresses the public welfare very directly, and it is not just the US public but also the population of the entire world. The world's manufacturers are forced to produce products in one unit of measure for domestic sales and then retool if they want to participate in export. When the US accedes to metrification these manufacturers, both US and foreign, will benefit from the efficiencies of standardization.

Our system of measure in the US will most certainly not survive in this modern and evolving world, and we may well be the last generation to use it. This world, shrunk by high-speed communication and travel, is demanding the efficiency of universal standards for everything and although we in the USA are accustomed to winning the race to set world standards, we will lose *this* race because metric is simply more logical. We can complain about being forced to adapt, but remember that English will probably win the contest for a universal world language and it will be the British and Irish that will have to adapt to driving on the right-hand side of the road. (Interestingly, the Swedes made this left to right switch nationwide on a single Sunday in 1967.)

We won't have to adapt to metric on a single Sunday, but the switch to metric is inevitable. Our children and grandchildren are already learning metric in school, and aside from Myanmar and Liberia, the US is the only nation in the world that has not officially adopted the metric system.

We can make a gentle transition to metric while continuing to operate in our comfortable US Standard Units by producing our designs in dual units such as this:

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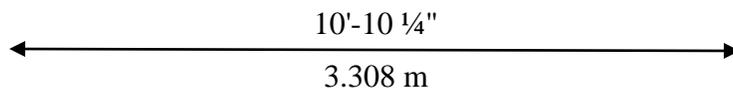
This will help us become more comfortable with the new system. We can protect against confusion and conflicts by declaring that metric dimensions are for information purposes only.

Automation

Never in history have the opportunities and benefits of automation and standardization been greater. Computer-aided design and drafting (CADD) gives us a perfect example. If you were an early adopter, then you know the tremendous advantage of CADD over pencil on vellum or ink on mylar. Your first efforts at adopting CADD were probably time-consuming and costly as you relearned and retrained on this new tool. In the early phases of adoption, it was commonplace for engineers to doubt that there were any benefits at all but by now, design professionals are

reaping the unending benefits. This is the nature of all investments in automation. If you have avoided adopting CADD in your workplace, you have missed out on the benefits of this innovation. Make the investment. Reap the benefits.

The first machine for the production of the common nail must have seemed an absurd expense when compared to the simple one-by-one methods used by blacksmiths for 1600 years but, that initial expense was quickly recovered. Automation meant the profits from nail manufacture increased while the cost per nail dropped precipitously. A nail has gone from being a precious object, more valuable than the wood that it joined, to an expendable, hardly worth picking-up when dropped. It is easy to see the public welfare benefit of this kind of automation and automation in your workplace will have the same indirect benefit to the public and a very direct benefit to you.

Learn/Teach/Mentor

Engineering is an accumulation of knowledge dating back 1.8 million years to *Homo habilis*, the first tool makers. (Or, perhaps to the ancient Egyptians if you hold the belief that humans were created 6,000 years ago.) Today, we benefit from the vast body of knowledge of engineering and mathematics that exists because teachers have been willing to teach, and students have been willing to learn in an unbroken chain of mentoring, the beginning of which predates civilization, language, and religion. As engineers, each of us is ethically bound to add our own link in that chain, always learning, always teaching and always mentoring our successors.

Advance your professional knowledge and the knowledge of colleagues and subordinates by engaging in:

1. "Over-the-shoulder" training of subordinates
2. Reading/authoring books and journal articles
3. Conducting/attending seminars or webinars
4. Attending/teaching college courses
5. Enrolling in/teaching continuing professional education

Research shows that teaching a subject or concept and fielding questions from your students is the ideal way to perfect your knowledge of a topic.

Errors

No engineer is infallible. We may take extreme precautions to deliver only the most accurate and error free work product, but mistakes are inevitable, and the consequences may be enormous.

Mitigation for errors must begin immediately upon discovery with an acknowledgment and a clear, undistorted, unaltered statement of the nature of the error. Perhaps more than any other act, the way that you comport yourself in such circumstances will determine how others will view you and your profession. Attempts to conceal the error or shift the blame will cause delays in making the appropriate corrections and add to the expense. Anything less than full disclosure will foster mistrust in you and in the profession of engineering that you represent.

Respect

Engineering is a noble and respected profession but simply earning a university degree in engineering, passing the professional licensing examination or joining an engineering society will not automatically convey respect to any member of the profession. Respect is earned or lost based on our behavior. A few guidelines for earning the respect of others:

- Be respectful of others even when your opinions differ.
- Compose your thoughts before you speak.
- Listen more, speak less.
- Never, ever gossip. Always speak about someone who is not present as though they were standing next to you.
- Always keep your promises and commitments.
- Don't waste other people's time. Arrive on time for meetings and stick to the meeting agenda. Don't take advantage of a captive audience to tell jokes, war stories or attempt to entertain.
- Don't sanction injustice. Speak up when you witness injustice and be a champion for removing it.
- Respond, don't react. When you feel anger or resentment surfacing, your emotional self will respond defiantly and make matters worse. Pause long enough to allow your intellect to fashion a response, and you will set a path toward resolution rather than escalation.

Share your thoughts about this course with the author and others by completing a course review.

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