Faith and Work – One Engineer's Perspective

by Barbara Yarusso
Department of Manufacturing Systems and Engineering

My aim in this paper is to bring to these discussions the perspective of an engineer, to show what we share with the scientist and how we may differ, and what relevance the topic of Science and Theology has to the education of our engineering students at the University of St. Thomas. I hope to show that it is appropriate to consider the interrelation of faith and work in engineering, and that our undergraduate program is particularly well equipped to address this in our curriculum.

Common Ground

The most obvious common ground with the scientist lies in faith in reason. As Jeff McLean[1] has explained, the process of deductive reasoning has as its basis simple faith in its validity. There is no way to prove that if a = b and b = c then we must have a = c. The foundations of logic rest on the fundamental faith that this is the way the world works. Thus the starting point for all of science and engineering rests on our belief that the world is rational.

There is another necessary article of faith in the foundations of science. That is that the truths behind our observations of the universe are unchanging (in contrast to our attempts to formulate theories to describe them). It would be impossible to do any engineering at all if this were not so, since engineering is fundamentally predictive in nature. On what can we base this faith? It is impossible to prove that something which has not changed in the past, say something as fundamental as the phenomenon of gravity, will not change tomorrow. It doesn't matter if it has gone unchanged for a lifetime of a person or through the entire existence of the universe (whatever that means). Yet we firmly believe that it is so. There are perhaps many views of the world consistent with this belief, but I can think of two at the moment. One is a kind of fatalism — the alternative would be too awful to contemplate, so we might as well believe it. The other is some kind of theology, whether Christian or something as diffuse as a vaguely benevolent universe — what Einstein refers to as cosmic religious feeling[2].

Just as adherents of many religions have acknowledged the truths about the universe that are revealed by science[3], scientists must acknowledge their dependence on their foundational beliefs. These are in the spheres of philosophy, theology, and religion. A scientist may view science as purely rational, separate from one's beliefs, but this is futile, since science must begin with the basic assumptions of the validity of observation (empiricism), logic, and the rationality of the universe. Since we generally recognize (most) science as an attempt to draw conclusions and make predictions about (i.e., model) the physical universe[4] we actually occupy (with cosmology perhaps a notable exception), it is not enough to postulate our assumptions as though they are merely hypothetical. To believe that the rational conclusions that follow have predictive value, we must hold these assumptions to be actually true.

Einstein puts it rather strongly:

[S]cience can only be created by those who are thoroughly imbued with the aspiration toward truth and understanding. This source of feeling, however, springs from the sphere of religion. To this there also belongs the faith in the possibility that the regulations valid for the world of existence are rational, that is comprehensible to reason. I cannot conceive of a genuine scientist without that profound faith. The situation may be expressed by an image: science without religion is lame, religion without science is blind.[5]

These foundations, then, are shared by scientists and engineers. Modern engineering is also dependent on the work of scientists and mathematicians. Algebra, geometry, calculus, physics, chemistry, and, increasingly, biology

The Engineer's Outlook

In spite of this, scientists and engineers have fundamentally different outlooks in some respects. While science is about explaining the way things work, engineering is about making things that work. Thus, while the scientist marvels at the intricate design of the universe, for the engineer the marvel is that this design gives us our other building blocks — forces, motion, metal, stone, polymers, liquids. This is like being supplied with a box of cosmic Legos or Tinker-Toys — with these we can design bridges, buildings, machines, reactors, appliances, airplanes, pumps, and so on. Thus, I think, the engineer appreciates the goodness of creation in a somewhat different sense than the pure scientist. The engineer's calling is to put the resources provided by nature to work in the service of humanity.

The engineer must develop an appreciation for what has been provided for us in Nature. The civil engineer must know the properties of soil and rock. For the chemical engineer, a raw material like petroleum with its hydrocarbons is much more useful than a supply of the elements carbon and hydrogen would be. Nature provides energy and cooling capacity. God's creation is good, and the engineer knows some of what it is good for.

The emphasis on the practical application is of course one way in which scientists and engineers differ. Many scientists are employed in finding practical applications for chemistry, biology, or other areas. It is part of the mentality of the engineer, though, to constantly ask the question: What is it good for? The practicing engineer is not as interested in the results of pure science as in how they can be applied to some practical end. The scientist's work may be judged on the basis of how it adds to our knowledge about how the universe works. The engineer's work is usually judged by more mundane criteria: Does the design do the job it is supposed to do? Is it safe? Is it cost effective?

Knowledge itself is judged by different standards in engineering and in pure science. The engineer's reliance on empirical correlations to predict the behavior of disordered phenomena like turbulent flow of liquids depends on faith in the rationality of the universe. In problems such as this, we cannot apply the axiomatic method to set up equations that can be used to calculate exact results. Yet we believe that there is an underlying order, even if we cannot discern it. I doubt that most engineers consider their reliance on rules of thumb and empirical correlations to be an expression of faith. However, it is founded on one’s fundamental understanding of the way the universe works to the same extent that philosophy and theology are. That we can rely on this order to design things (bridges, machines, etc.) that then actually work the way they are predicted to confirms this faith. (I don’t think there is a chicken and egg type of problem here; you must have this faith first before you’d build a bridge and let people drive over it.)

If a correlation is shown to be true under certain circumstances, it may be considered useful even without a proof from first principles showing how this comes to be (although researchers in engineering science[6] strive to do so). It is considered sufficient that careful, repeatable experiments give consistent results. The reliance on experimentation and the need to deal with circumstances that are far from ideal adds an element of uncertainty to engineering design that the engineer must acknowledge and take into account.

Uncertainty

The engineer’s job is to create new things. Sometimes the work is completely novel — a new invention, a chemical process never done before. Many times, the novelty is in the extension of previous work — a longer bridge, lighter bicycle, more efficient process. The challenge is to predict the behavior of an object or system that does not yet exist. This is where the results of science have been so helpful. Newtonian physics has given us the laws of mechanics, which predict the behavior of structures like bridges. Thermodynamics allows us to design power plants. Chemistry and material science guide choices of raw materials. Engineering science helps us design distillation towers, heat exchangers, and pumps to be used under conditions that have never been tried before.

Yet while scientists frequently make use of idealized cases, the engineer must deal with the world as it exists. We cannot build a bridge on an idealized river bed. We cannot make polymers from pure ethylene. We cannot build parts with no bolts, welds, or defects. We cannot ignore turbulence because it is too difficult to describe its behavior in detail.

Engineers have always had to deal with the kind of uncertainty that some branches of science and mathematics are beginning to confront. Mechanical engineers know that the laws of mechanics will only take them part way through the design process. We cannot calculate the effects of the actual defects that will exist in a steel shaft when it is made, though we know they will occur. We are only beginning to be able to calculate the effects of holes and joints, through advances in numerical computation. We employ rules of thumb — the accumulated experience of others — to overcome these difficulties.

There has not been the kind of crisis of faith in the foundations of engineering that there seems to have been for some scientists confronted with the new challenges of quantum mechanics and theories of chaos. In fact, engineers look forward to these new developments going far enough to help them with the challenge that has always been there — how to predict the behavior of a system when you cannot possibly have enough detailed data to know how all of its components will behave.

Most scientific theories can be tested through experimentation. If a scientist's hypothesis holds up when tested, it is deemed to be true — to the extent that the data are reliable, the experiment was properly designed, and so on. By contrast, the engineer receives more definite confirmation of the validity of a design — the bridge stands up, a chemical process works, an assembly line actually puts the pieces together properly. However, just as the scientist's theory may later be disproved in the light of new data, unforeseen circumstances may cause a structure or process to fail.

In fact, the engineer often fails. Bridges fall down, plants blow up. Trying to extend old results to new things is inherently risky. Any but a very foolish engineer knows that human perfection has never been and never will be possible. We must be more aware of our uncertainties than those things that are well known, since it is the unknown that will cause a calamity. Thus the safety factor (the extent to which a system is made stronger or safer than appears to be necessary) used is one of the most important decisions an engineer makes. These ideas have been hard won. Roszak says that this is the great paradox of the technological mystique — its remarkable ability to grow strong by virtue of chronic failure.[7]

Engineering Ethics

Of course, a good engineering design does more than avoid disaster. There are many objectives in any project. Actually, the question of whether a particular design is good becomes quite complicated. What is good? The common, simplistic criterion for the best design is what will make the most profit for the employer. However, any engineering project has a broad impact on society and the world. Raw materials, labor, and capital are used, public and worker safety must be safeguarded, and environmental impacts minimized, while a quality product (be it a bridge or soap) that does what it is supposed to do is turned out. An engineer's decisions must be based on the relative value placed on these. It is not only possible but in fact the usual case that a design which is the best under one criterion is not under another.

Who decides what these values are? In a democracy, the local culture determines much of the relative value placed on things such as environmental safety vs. jobs, through laws and regulations written by elected officials and their appointees, and through the climate in the press and the courts (as influenced by juries and elected or appointed judges). Thus, in a broad sense, the religion and ethics of the society as a whole will influence the outcome of engineering decisions.

For example, a theology which emphasizes stewardship will have a different effect on society's attitudes toward the environment, human welfare, and animal rights than one which emphasizes mankind's mastery over creation. We have witnessed this in the last century in the United States, as communities have begun to demand higher standards in pollution control and public safety. This has many far-reaching effects on engineering design. For example, at one time it was considered acceptable to discharge industrial wastes and municipal sewage directly into rivers. Today this is no longer permitted. Instead, industry must discharge wastewater to municipal treatment, and sometimes must pretreat its own wastewater. Provisions for this must be made in plant design, and alternative processes may be chosen to minimize costs for wastewater treatment. Similarly, cooling towers have become common to generate cold water for plant use, where once river water may have been used. In response to the increasing regulation of emissions of volatile organic compounds and other pollutants, at many companies the basic technology used to make their products has been changed. For example, many products that formerly used solvent-based adhesives now use water-based adhesive or hot melt adhesive.

In many cases, changes in industry are made in direct response to regulation or the threat (actual or perceived) of litigation. However, some companies have made more liberal changes than would be required. These companies are not necessarily behaving altruistically (though some owners may), since they may see a benefit in avoiding future regulatory cost, or in maintaining good public relations. Individual employees have some control as well. The individual engineer may decide which alternatives to consider seriously, which suppliers are preferred, which recommendation to make to management. In these decisions the values of the individual may play a part, since they influence the relative weight given to environmental hazards vs. plant safety vs. product quality and so on.

Samuel Florman has argued that engineers do not have the responsibility, much less the right, to establish goals for society. Although they have an obligation to lead, like most professionals, they have an even greater obligation to serve.[8] Florman interprets this as freeing the individual engineer to work on projects that are perhaps at odds with personally held values, much as a lawyer may defend a guilty client. Thus Florman doesn't believe the individual engineer should be overly concerned about whether or not to work on projects for the military, or to develop plans for casinos, and so on, and that decisions regarding environmental and safety standards, as well as the acceptability of risk, should be left to the public through governmental laws and regulations[9].

Florman's basic arguments[10] are along the lines that:
Ethics defies concretization and universal agreement (therefore Codes of Ethics are unhelpful).
Setting of ethical priorities for public works should rest with the public.
Most disasters are the result of technical incompetence or carelessness.

Florman concludes, then, that the best way to ensure that engineers work for the public good is to encourage the development of competent, hardworking, dependable engineers.

Yet the individual engineer must also bear responsibility for design decisions along with what the law requires. I wouldn’t expect many engineers to believe that the majority of the general public and members of legislative bodies have the education and training to understand complex technical issues. Is it right to ignore a certain pollutant because no one has gotten around to regulating it yet? Is it right for US engineers to design plants for offshore locations without meeting the same safety and environmental standards their company would have to adhere to here? Is it right to ignore a regulation because insufficient funds have been appropriated to enforce it? (We must also recognize that in our increasingly litigious society there is also a question as to whether any of these actions would be prudent.)

Others who write about engineering ethics take issue with Florman’s point of view. In a discussion of whether employees should have uncritical loyalty to their employer (i. e. working faithfully for the employer without questioning the ethical implications of projects themselves) or critical loyalty (in which an employee reserves the right to critical judgment), Harris, Pritchard, and Rabins argue:

There are serious problems with Florman’s argument as a justification of uncritical loyalty. First, Florman’s position can involve a serious abridgment of the autonomy and moral integrity of individuals. ... A second argument against Florman is based upon the value to the company of independent employees — and especially independent professional employees. ... Third, ethically aware professionals who are willing and able to protest, and in some cases refuse to participate in, morally questionable activities are a great resource for the public. It is not possible for the law to control all abuses in business. Laws are usually enacted only after serious abuses, many of which might have been avoided by ethically responsible employees. Further-more, the law tends to be clumsy and inept at regulating activities that are potential sources of abuse. There is no substitute for the ethically responsible professional.[11]

Similarly, the World Wide Web page for the Engineering Ethics Module developed by the Murdough Center for Engineering Professionalism (Texas Tech University, Lubbock, Texas) states:

The days when an engineer’s only ethical commitment was loyalty to his or her employer have long passed. The expansiveness of technology is such that now, more than ever, society is holding engineering professions accountable for decisions that affect a full range of daily life activities. Engineers now are responsible for saying: Can we do it, should we do it, if we do it, can we control it, and are we willing to be accountable for it? ... Since engineers have been accorded professional status and the privileges that go with it, since they have literally created our way of life, and since their designs require experimentation with subjects — sometimes many subjects and without their knowledge or permission — it is no wonder that engineers are being held accountable for their actions. And for engineers, the implications are inescapable. Handling ethical dilemmas and making ethical decisions are very important elements of being a professional.[12]

In addition, the general public must delegate some of its responsibility for decisions when dealing with areas requiring specialized knowledge. Harris, Pritchard, and Rabins note that William F. May warns that experts (including engineers) had better be virtuous, since few are in a position directly to observe and understand what they do. ... We expect engineers to exercise independent judgment about matters within their range of expertise in carrying out their responsibilities.[13]

Even the State recognizes this responsibility of the individual. In many states, a statement of engineering ethics is one of the many pieces of paperwork that must be signed as one becomes registered as a Professional Engineer (a license to provide engineering services to the public). Rebecca Morton has summarized the prevailing situation:

Many different sets of codes and canons of ethics have been produced by various engineering societies and state registration boards. ... Fundamental to such ethical codes is the requirement for consulting engineers to render faithful professional service and to honestly represent the interests of their clients while, at the same time, protecting public health, safety, and welfare.[14]

It turns out, though, that there are ethical problems with the ethics codes themselves, as well as practical difficulties in their implementation. A few of these have been noted in the report of the AAAS Professional Ethics Project:

A number of societies ... have adopted rules of conduct derived from some undefined set of general principles. This may reflect a common experience among the societies that it is easier to agree upon the rules themselves than the underlying reasons supporting each rule.[15]

When a code of ethics is drawn up as a set of rules to be followed (sometimes with the threat of consequences for infractions) it ceases to really be about ethics.[16]

Some of the objectives of codes devised by professional societies are less about ethics and more about protection of the image of the profession and regulation of competition.[17]

Some of these concerns are echoed by Harris, Pritchard, and Rabins, who also note that many of the provisions of the codes seem to conflict with each other, for example, concern for public safety and loyalty to an employer. They cite Heinz Luegenbiehl, saying that he agrees that engineering students should be introduced to ethics. He advocates assisting them in becoming morally autonomous engineers. This requires respecting the basis of their own ethical beliefs, a basis that presumably comes from something other than the acceptance of a professional code of ethics.[18]

Attempting to balance sometimes conflicting goals and values is one of the main jobs of an engineer. A consideration of ethics complements the more material aspects of engineering — the engineer is accustomed to dealing with balances of forces and rates. A difficulty arises, though, if the values of the employer or society and those of the engineer are in conflict. Just as the scientist must find some support to pay for research, the engineer undertakes projects for an employer. The employer is often a corporation or other public body, which is inherently irreligious.

Frequently the values of the individual and those of the employer will be in conflict. In the worst case, the engineer may be asked to do something which is illegal or clearly harmful. More often, though, the question is much more subtle. The engineer may realize that the most cost effective solution is not the best in terms of pollution prevention, or that it poses a slightly higher safety risk. It is never possible to create a perfect solution. Even in cases where it is easy to clarify what criteria should be considered, it is often not possible to put the best solution into practice. For example, in bridge design, public safety is paramount- the bridge shouldn't fall down when it is full of people. However, it is not practical to insist on the safest possible bridge — it would cost more than the community is willing to spend, or disrupt river traffic. The engineer must frequently decide when a design is good enough for the purpose intended.

There seems to be a consensus that a consideration of ethics is important to engineering practice. This is reminiscent of Nancey Murphy's comments with respect to economics: theory may be independent of ethics, but only insofar as it is not applied. Application requires judgment about what is good for humankind, what is necessary for human dignity, and such judgments are the province of ethics.[19]

There is less agreement about how ethics should be taught in the undergraduate engineering curriculum. Since ethics is concerned with individual values and decisions, the easy way out is to say that we can't teach students ethics. However (as I am sure those in Philosophy and Theology would agree), we can give students the tools to recognize and analyze ethical problems, and to clarify their own beliefs and values. Robert Baum has recognized some of the particular difficulties of teaching engineering ethics. Most engineering curricula leave little room for additional electives, and the typical engineering student favors quantitative, objective subjects over subjective subjects such as philosophy. Thus, most engineering students have not studied philosophy or ethics. As a result, Baum believes that a great deal of time in any [engineering] ethics course must be spent in dealing with peripheral issues that could or should be dealt with in more depth in other courses, such as psychology, political science, history, sociology, and communications.[20] In addition, Baum stresses the need for courses in ethics to be taught by instructors with adequate training- ideally to be team taught by instructors with complementary backgrounds in ethics and engineering.

Ethics, Theology, Philosophy, and the University of St. Thomas Engineering Student

I believe that the general education curriculum for undergraduates at the University of St. Thomas addresses Baum's chief concerns regarding student preparation. By the time students at the University of St. Thomas reach their senior year, they will have had exposure to the rudiments of philosophy and theology, and so will have some experience with the skills needed to analyze ethical dilemmas. We should also be able to design lectures, seminars, or courses that take advantage of the sort of interdisciplinary cooperation shown in this Science and Theology conference. We should not underestimate the importance of these characteristics of the University of St. Thomas: some of the chief barriers to including significant training in engineering ethics in the undergraduate engineering curriculum do not exist here. In addition, it would seem that a consideration of engineering ethics is necessary to the mission of producing graduates who will practice their professions in a socially responsible way.

Beyond ethics, an even subtler dilemma exists for many students and for many practicing engineers. Is the work to be done somehow good for society? In order to feel satisfaction in one's work, the work must somehow be good in itself. For some it is enough that they profit by it, whether by direct compensation or by career advancement. Others need to feel that the work they do benefits society, or at the least is not harmful.

The analogy of the title of this paper with the religious connotation of faith and works is deliberate. In some traditions, good works are seen as coming out of one's faith in the grace of God.[21] These works include one's labor at one's occupation. Samuel Florman has had much to say about this in his several books dealing with the philosophical side of engineering. He points out that the Old Testament seems supportive of engineering, with several detailed descriptions of design projects. For example, the specifications are given in detail for Noah's Ark. The engineering impulse comes to man as a gift from God. ... [T]echnological effort directed toward prosperity for society is also considered worthy, if the prosperous society is to be devoted to virtuous purposes.[22] However, he sees the New Testament as less supportive, for...The Christian Church, from its earliest days, was ambivalent in its attitude toward technology. The Gospels warned against giving too much thought to worldly goods. Yet honest labor was praised ....[23]

Historically, our society was quite supportive of the kind of work engineers do. It fit in well with the Protestant work ethic. Florman quotes Arnold Jacob Wolf: Our task is to find a way to work that is really working and not also self-destructive- really doing the hard things that the world needs and the self needs.[24] As was also evident in Flormans discussion of engineering ethics, he sees the process of engineering itself as rewarding, and does not direct much attention toward the end product. But many engineers want to work on projects that satisfy an urge to be useful to humanity.[25] Making better widgets cheaper and faster does not always answer this need.

Today, there is also a conflict between increasingly impersonal business concerns and the values held by many. The individual must decide how to balance career and values, money and ethics. For some, this means attempting to be as ethical as possible in the job they find themselves in. For others, it requires a rejection of career advancement in favor of working somehow for the good of society. Some must make decisions about whether or not to accept a job offer from a company with a history of environmental problems.

Many of these questions are not unique to the profession of engineering. No matter what type of work a person does, they are likely to be confronted by some of the same questions.

How can we prepare our students to deal with these questions? Here again, I think we are in a strong position at the University of St. Thomas. We should take advantage of the students' liberal education and seek connections among their engineering coursework and their courses in philosophy and theology (among others) to provide some of the groundwork for the balancing act necessary in an engineering career.

Conclusion

This is where, finally, we come to the important connection between engineering and theology. Theology and religion have to do with our relationships with God, nature, and humanity. Though the connection between God and the doing of engineering may not be obvious, the influence of engineering on nature and humanity is. Thus, we can expect that the values and teachings of a religious tradition with respect to human worth, the environment, and work itself will, for the religious person, have an important impact on the engineering they do.

In summary then, engineering and theology interact in four main ways:

Faith in the rationality of the universe is necessary to the use of science and logic to design new things and have confidence that they will work.

The usefulness of the materials provided in nature leads to an appreciation for the goodness of creation.

In engineering practice we must make ethical decisions, which depend upon our beliefs and values as they are influenced by our theology.

The engineer's job satisfaction and career decisions may be influenced in part by religious and ethical concerns.

We should include education in the application of engineering ethics in our undergraduate engineering curriculum. We should also help students discover how they can integrate their faith and values and their work. At the University of St. Thomas we have the groundwork already prepared for this through the general education requirements in philosophy and theology. We need to provide opportunities for engineering students to apply what they have learned in those fields to their chosen vocation.

References

1. Jeffery T. McLean, Validity, Truth and Faith in Mathematics, draft, 1996.

2. Albert Einstein, Ideas and Opinions, Dell (originally published by Crown Publishers, 1954), p. 47.

3. As an aside, it should be noted that engineers rarely encounter opposition to advances in their field because of the conflicts with religious beliefs that have confronted many of the sciences. Engineering advances do not usually challenge our definitions of humanity the way evolution, neurobiology, genetics, and medicine can (although many medical advances such as artificial hearts and kidneys are particularly dependent on engineering). Possible exceptions include some people's initial attitudes toward the airplane (If God had meant man to fly, he'd have given him wings!) and the Amish rejection of technological advances. There have been segments of society who view engineering as a threat — Luddites and Neoluddites, for example, as well as many individuals who are uncomfortable with mechanical or electronic devices. I doubt that this is usually on religious grounds.

4. Science is frequently described as a quest to describe why the universe behaves as it does. However, in our discussions of the similarities and differences in the goals and methods of science and theology, I became increasingly dissatisfied with identifying science with describing why things behave as they do. I think we would do better to say that science describes how things behave as they do. If we imagine a child asking Why is the sky blue?, we could replace the question with How come the sky is blue?, that is, how does it come to be blue? The usual mechanistic explanation of differential scattering of the spectrum does not even begin to address why the sky might be blue. (In fact, some children are very good at seeing through this.) I believe this leaves all of the why questions to their proper sphere, which is theology.

5. Ibid., pp. 54-55.

6. Researchers in engineering science (typically but not exclusively in academia) apply the scientific method of experimentation and theoretical analysis to discover underlying principles of the behavior of engineering systems. For example, in chemical engineering (my field), the relevant engineering science includes fluid mechanics, heat transfer, separations processes such as distillation, and so on. Practicing engineers engaged in engineering design apply mathematics, the sciences, engineering science, and experience to the design of products, processes, and plants, usually in an industrial setting. (Engineers hold many types of jobs, including plant operations, process engineer, project engineer, etc., and there is a lot of overlap of job functions.) In engineering science research, and in small scale (pilot plant) testing or processes or development of product prototypes, there is the usual reliance on hypothesis, experimentation, and trial and error. However, in design of full-scale manufacturing processes there is little room for error (due to safety and economic concerns). Thus the engineer must make use of safety factors or safety margins, which are themselves based on collective experience, sometimes through formal standards recommended by professional associations. Frequently the needs of design engineers outpace the state of knowledge in engineering science, forcing design engineers to rely on judgment and experience (their own and that of others).

7. Theodore Roszak, Where the Wasteland Ends, Doubleday & Company, Inc., Garden City, New York (1972), as cited by Samuel Florman, The Existential Pleasures of Engineering, op. cit., p. 84.

8. Samuel C. Florman, The Civilized Engineer, St. Martins Press, New York (1987), p. 95.

9. Ibid., Chapter 7, pp. 86-100.

10. Ibid., Chapter 6-8, pp. 78-109.

11. Charles E. Harris, Jr., Michael S. Pritchard, and Michael J. Rabins, Engineering Ethics: Concepts and Cases, Wadsworth Publishing Company (1995), pp. 289-290.

12. Jimmy H. Smith, Engineering Ethics Module, http://www.coe.ttu.edu/ethics/ethics.htm, Murdough Center for Engineering Professionalism, Texas Tech University, Lubbock, Texas (updated 5/23/96).

13. Harris, Pritchard, and Rabins, op. cit., p. 211; citation for May is listed on p. 92 of Ch. 3 (erroneously noted as Ch. 2 in the text): William F. May, Professional Virtue and Self-Regulation in Ethical Issues in Professional Life, Oxford University Press (1988), pp. 408-411.

14. Rebecca Morton, Engineering Law, Design Liability, and Professional Ethics — An Introduction for Engineers, Professional Publications, Inc., Belmont, California (1983), p. 69.

15. Rosemary Chalk, Mark S. Frankel, and Sallie B. Chafer, AAAS Professional Ethics Project: Professional Ethics Activities in the Scientific and Engineering Societies, American Association for the Advancement of Science (1981, revised 2nd printing), p. 99.

16. John Ladd, The Quest for a Code of Professional Ethics: An Intellectual and Moral Confusion, in Ibid., pp. 154-159.

17. Ibid.

18. Harris, Pritchard, and Rabins, op. cit., p. 34; citing Heinz Luegenbiehl, Codes of Ethics and the Moral Education of Engineer, in Deborah Johnson, ed., Ethical Issues in Engineering, Prentice Hall (1991), page not identified but possibly within pp. 137-151 based on more explicit citations.

19. Nancey Murphy, Theology and Ethics in the Hierarchy of the Sciences (Feb., 1996), p. 9.

20. Robert J. Baum, Ethics and Engineering Curricula, The Hastings Center (1980), p. 20.

21. See, for example, Theodore G. Tappert, translator and editor, The Augsburg Confession, Fortress Press (1980), Article XX (from the German text of 1530).

22. Samuel C. Florman, The Existential Pleasures of Engineering, St. Martin's Press, New York (1976), p. 112.

23. Samuel C. Florman, The Civilized Engineer, op. cit., 40; I am indebted to Ron Bennett for pointing these observations of Florman's out to me.

24. Arnold Jacob Wolf, Consciousness Four, Yale Alumni Magazine, Nov. 1974, p. 19, as cited by Samuel Florman, Ibid., p. 150.

25. I base this claim on personal, anecdotal evidence among my friends who are engineers, and discussions I have had with students in the past.