



Engineering Ethics – A Review

- Engineers are professional practitioners (in the same way that lawyers and physicians are professionals).
- Although engineers may work for companies, non-profit organizations, or governmental units, many engineers, like MD's or attorneys, are independent business people and work for clients.
- All professions have guidelines for interacting with clients.
- We as (electrical) engineers, have ethical guidelines as well, and we often refer to them as engineering ethics.

Interaction Rules

- Society has rules of conduct that govern personal and organizational interactions.
- There are various levels of these rules or behavioral guidelines. For example:
 - Etiquette – Rules governing personal interaction; in general, the only penalty for breaking such rules is embarrassment.
 - Laws – Societal mandates of behavior, with consequent penalties for breaking those rules.
 - Morals – Principles or standards of behavior. In general, apply to the more serious behavioral issues in a society.





Examples

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



“Ethics” and “Morals”

- We hear a lot about “morals” and “ethics.” So what is the difference?
 - **Morals are standards of right and wrong in a society. These are typically “self-evident” standards of goodness (or evil) that are not debatable (“do not kill,” “do not steal,” “help those in need”), but they still depend on the society (some ancient civilizations believed in human sacrifice, and some societies today believe in severe punishments for behavior that is considered acceptable in other societies).**
 - **Ethics – Generally, guidelines for moral behavior (ethics in general is also the name of the study of moral codes and behavior). When we discuss “ethical codes,” we generally mean a set of guidelines for behavior based on societal morals.**



Engineering Ethics

- **Accepting that “ethics” are guidelines or rules for proper behavior, we electrical engineers have guidelines that apply specifically to our profession.**
- **The next slide shows the IEEE code of ethics (many of you may have seen this when you joined the IEEE this semester).**
- **Most of these guidelines are of the form “don’t do this;” “be sure to do that,” etc.**
- **However, note in particular guidelines five and six (and number seven, to an extent).**



IEEE CODE OF ETHICS

WE, THE MEMBERS OF THE IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world and in accepting a personal obligation to our profession, its members and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree:

- 1.** to accept responsibility in making decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;
- 2.** to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;
- 3.** to be honest and realistic in stating claims or estimates based on available data;
- 4.** to reject bribery in all its forms;
- 5.** to improve the understanding of technology, its appropriate application, and potential consequences;
- 6.** to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
- 7.** to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
- 8.** to treat fairly all persons regardless of such factors as race, religion, gender, disability, age, or national origin;
- 9.** to avoid injuring others, their property, reputation, or employment by false or malicious action;
- 10.** to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.



Competence Guidelines

- **“To improve the understanding of technology, its appropriate application, and potential consequences.”**
- **“To maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training and experience, or after full disclosure of pertinent limitations.”**
- **“To seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others.”**

Incompetence as Ethical Failure

- Clearly, those who formulated the ethical code of the IEEE considered that ethical lapses include not only “doing wrong” or “failing to do right,” but **“failing to perform competently in the engineering profession.”**
- We will explore in this lecture (and in the teams that we will assign shortly) how inability to achieve competence (via failure to update skills after graduation or lack of preparation during the university experience) is a **very real ethical failure.**





Ethical “Do’s” for the EE...

- **Make the most of your university training – the surest road to technical competence (at least initially).**
- **Once you are a part of the engineering work force, increase your expertise via graduate school or special training as required to keep skills sharp.**
- **Be sure to join IEEE and one or more of its societies. There is no better way to keep technically current than to read publications and attend symposia sponsored by your technical society.**
- **Always be willing to help fellow engineers when they have technical problems or need advice.**



And Some Ethical “Don’ts” as Well...

- **Never undertake a job which requires technical skills that you do not possess.**
- **Never withhold information or required technical knowledge from a colleague or co-worker for any reason – but especially to better your own position.**
- **Do not fail to ask for advice if you feel that you lack some technical knowledge or skill that your project requires.**
- **Never fail to communicate with your supervision about project status, even if (especially if) the news is bad.**



Case Studies

- **Many of the engineering disasters that have been witnessed in the last few decades in the US were due primarily to the fact that engineers or engineering managers made unethical choices in their work.**
- **In some cases, these choices were not simply “doing something dishonest,” but making a technical choice that was NOT based on the best technical information, but for some other, expedient reason (political, monetary, or simply the “easier choice”).**
- **We will review a few of these and then some case analyses will be assigned to teams.**

Challenger Space Shuttle Disaster

- Like all space shuttles, *Challenger* had two solid-fuel booster rockets that used rubberized propellant, made by Thiokol.
- The booster rocket tubes were made in pieces, assembled close to the site.
- Tubes were connected using rubber O-rings and putty between the sections.
- The day of the launch (January 28, 1986) was cold and windy (~ 18 ° earlier, ~28-29° F at launch). Engineers warned that seals were fragile in cold weather.
- Thiokol management initially supported engineers' recommendation to postpone the launch.
- NASA staff opposed a delay, arguing that if the primary O-ring failed the secondary O-ring would still seal.
- This assertion was unproven, and was in any case an illegitimate argument for a Criticality 1 component. (it was forbidden to rely on a backup for a Criticality 1 part).





Challenger (2)

- **NASA did not know that Thiokol had earlier recorded concerns about the effects of the cold on the O-rings.**
- **Because of NASA opposition, Thiokol management reversed itself and recommended that the launch proceed as scheduled. In the aftermath of the accident opinions were expressed that NASA managers frequently evaded safety regulations to assure that launches were on schedule.**
- **Thiokol engineers argued that low overnight temperatures of 18 °F (−8 °C) the evening prior to launch would almost certainly result in booster temperatures below their redline of 40 °F (4 °C). Ice had accumulated all over the launch pad, raising concerns that ice could damage the shuttle upon lift-off.**
- **The temperature on the day of the launch was far lower than had been the case with previous launches: 28 or 29 °F (some sources put the temperature as high as 35 °F). Previously, the coldest launch had been at 53 °F (12 °C).**

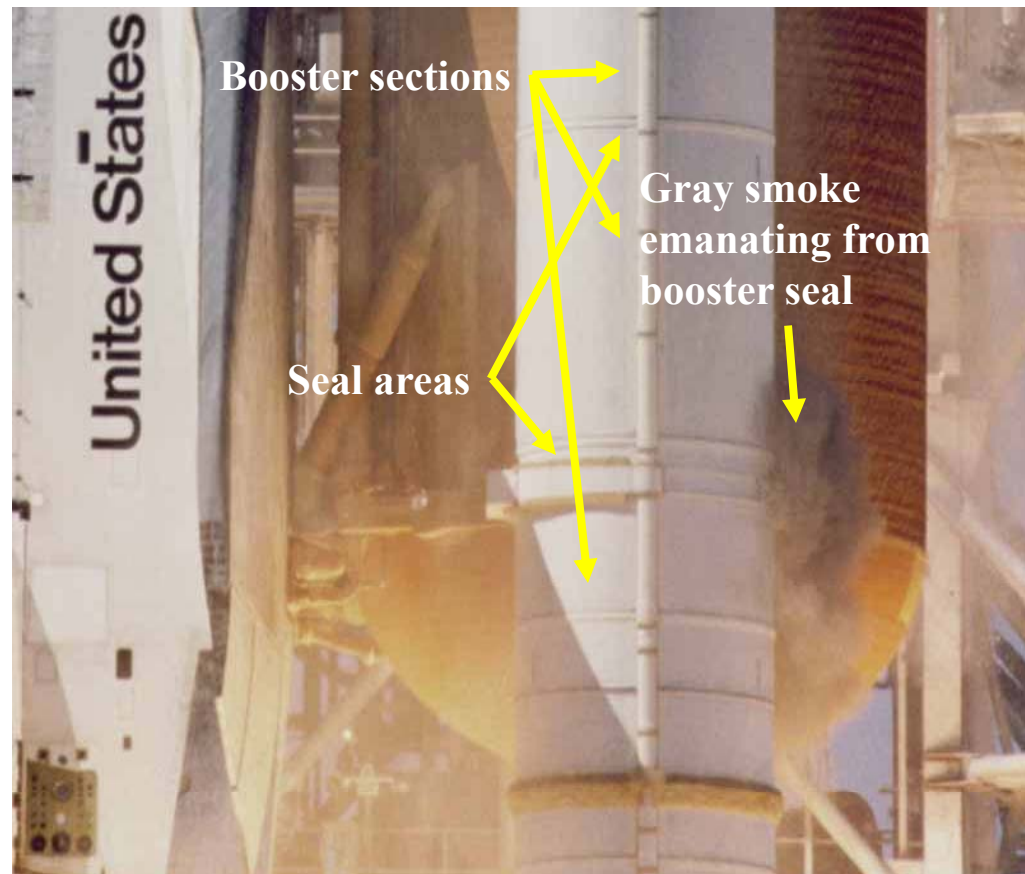


Challenger (3)

- **Although removal of ice had progressed through the night, Rockwell engineers were horrified when they saw the amount of ice. They feared that during launch, ice might be shaken loose and strike the shuttle's thermal protection tiles (something that happened, due to a different reason, years later to cause the *Columbia* shuttle disaster).**
- **However, Rockwell's managers at the Cape voiced their concerns in a manner that led mission control to go ahead with the launch. (This has been referred to as “Go Fever.”)**
- **A decision was made to postpone the shuttle launch one hour to give the Ice Team time to perform another inspection. After that last inspection, during which ice appeared to be melting, *Challenger* was finally cleared to launch at 11:38 am EST.**

Challenger (4)

- **Almost from liftoff, smoke could be seen spewing from one seal area on a booster.**
- **Clearly, the seal was breached in one or more places,**
- **Very shortly, exhaust gases were directed against the fuel tank for the main engines.**
- **Moments later, the fuel tank exploded.**



Challenger (5): Questions

- **Should Thiokol engineers have “blown the whistle,” refusing to be cowed by management and insisting on a postponement?**
- **Space travel is dangerous – is such an accident just “an acceptable risk?”**
- **Were Thiokol engineers at fault for an inferior design?**
- **Should NASA engineers (and management) insisted that an expensive escape system be developed?**
- **Were NASA directors unethical in agreeing to a launch when the Thiokol consensus was that a launch was dangerous?**



Note on the Following Example

- **Note: Much of the text following comes from a story on the National Society of Professional Engineers (NSPE) website and is © NSPE, 1997.**
- **From the NSPE website: “This opinion is for educational purposes only and should not be construed as expressing any opinion on the ethics of specific individuals.”**
- **Some material has also been taken from a Texas A&M ethics study website, which also presents an analysis of the Missouri City antenna mast disaster.**

Missouri City TV Antenna Collapse (1982)

- A Houston TV station decided to erect a 1,000 ft. antenna in Missouri City, TX (a suburb of Houston).
- An engineering company designed the antenna in 50-ft sections to be stacked onto one another, the top two of which had microwave antenna “baskets” on them.
- A construction company was hired by the TV station to assemble the tower. They used a “crawling jib” crane to lift the sections into place, one atop the other.
- The crane crawled up the tower, placing each section.
- Each 50-ft segment of the tower had a lifting lug in the middle of the section, used to lift it.
- The construction company decided to use this lug to lift sections of the tower into place. They would lift it by the center and rotate it using additional wires so that it would be vertically oriented.



Final (doomed) antenna (“basket”) section of Missouri City antenna.



Missouri City (2)

- **This method worked for all but the last two sections, which had the microwave antennas along their length, as the wire would hit these baskets when the section was rotated around the lifting lug.**
- **The construction company asked the engineering firm if the baskets could be taken off during the lifting phase and then reattached once the section was in place. However, the engineering firm had let this happen once before, completely destroying the baskets in the process. It said “No!”**
- **When construction company employees asked how they were supposed to lift the section intact, they were told that assembly was their problem.**
- **The construction company devised a solution by using channel steel parts attached to the antenna section at a right angle. They would attach the cable to the end of the channel steel and rotate about that point, leaving the baskets untouched.**



Missouri City (3)

- **The construction company called the design firm asked if design firm engineers could come to the site and look at the solution they had devised, since the construction company had no engineers on staff.**
- **The engineering firm said that it could not look at the solution since then it would be liable if anything went wrong. In fact, the president of the design company told his engineers to stay as far away from the site as possible, so they would not be linked to anything the riggers were doing.**
- **The construction company solution had some problems that even a freshman ME student could identify, but as it had no mechanical design engineers, so they were unable to perform a stress analysis.**
- **The second to last section was installed smoothly (more due to dumb luck than anything else).**
- **It looked as though the installation would be successful.**

Missouri City (4)

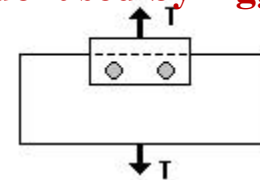


- **As the last section rose, physics caught up with the riggers. Near the top of the tower, their solution failed.**
- **The bolts holding the channel steel failed and the section fell.**
- **The falling section hit one of the tower's guy wires and the entire tower collapsed. All of the riggers on the tower and on the section were killed in the collapse (seven men total).**

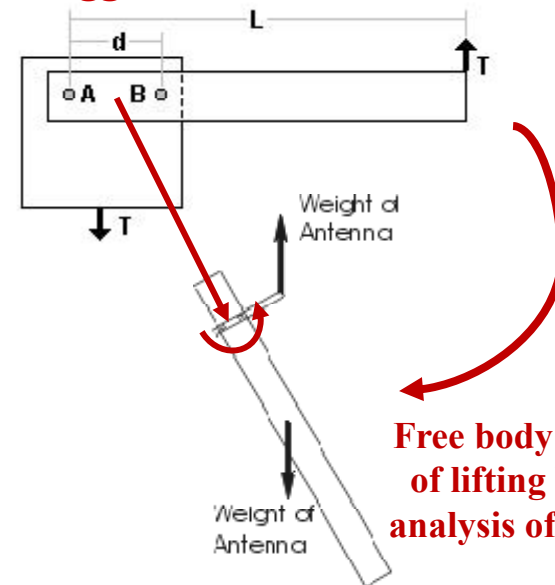
Missouri City (5) – Analysis

- The bolts for the extension were based on weight, not the torque due to extension projection.
- As the diagram shows, the force on the bolts was not a simple direct stress, but a multiplied stress due to the length of the bar that was connected (~ six feet).
- In fact, the torque due to the rotational force on the bolts caused a stress 12 times the force the construction company calculated.

Model used by riggers



Model riggers should have used



Free body diagram of lifting bar and analysis of solution.



Missouri City Antenna Disaster (6)

- **Questions:**
 - **Was the original design faulty?**
 - **Was the construction company at fault for “engineering” a solution?**
 - **Should the engineering company have consulted and approved the design?**
 - **Was there a greater fault? A lesser? Were any parties “innocent?”**
 - **Classify the ethical lapses involved here.**

Kansas City Hyatt Walkway Collapse (1981)

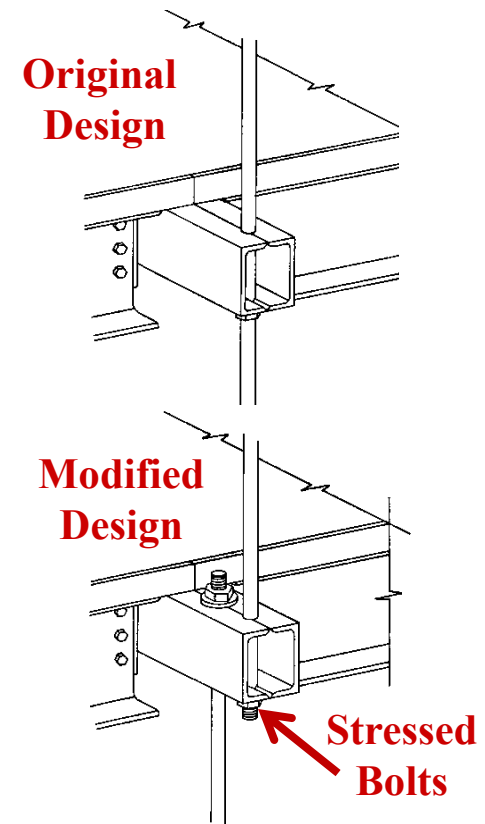
**Aftermath of
Hyatt walkway
collapse.**



- **The Hyatt Regency Hotel was built in Kansas City, Missouri in 1978.**
- **It had a 40-story hotel tower and conference facilities, connected by an open atrium that was 145 feet long, 117 feet wide and 50 feet high.**
- **Inside the atrium were three walkways that connected the hotel to the conference facilities on the second, third, and fourth floors.**
- **Construction on the hotel began in the spring of 1978. In December of 1978, a company was contracted to fabricate and erect the atrium.**

Kansas City Hyatt (2)

- **In February, the design of the connection for the second and fourth floor walkways was changed from a single to a double rod. The supervising engineer supposedly approved changes without reviewing carefully.**
- **The revised design put double stress on the upper (4th floor) bolts.**
- **During construction in October 1979, part of the atrium roof collapsed and an inspection team was brought in to investigate the collapse.**
- **The contractor vowed to review all steel connections in the atrium.**
- **In July 1980, the hotel opened for business.**



Kansas City Hyatt (3)

- On July 17, 1981, a “tea dance” in the atrium attracted many party-goers onto the walkways to watch the music and dancers below. Some began to dance on the walkways.
- The heavy weight and the extra force of the moving dancers caused top walkway to come loose and both 2nd and 4th floor walkways fell.
- **Casualties: 114 dead, 200+ injured.**



Analysis of Structural Fault

- **Due to the addition of another rod, the load on the nut connecting the fourth floor segment was increased.**
- **The original load for each hangar rod was to be 90kN, but the alteration increased the load to 181kN.**
- **The box beams were welded horizontally and therefore could not hold the weight of two walkways.**
- **During the collapse, the box beam split and the bottom rod pulled through the box beam resulting in the collapse.**



Kansas City Hyatt (2)

- **Questions:**
 - **Enumerate the ethical lapses of the contractor who built the building.**
 - **Should the engineers in this case still be permitted to practice engineering?**
 - **Should they be in jail?**
 - **What do you think of the ORIGINAL DESIGN?**



Summary

- **As engineers, we are expected to possess and continually adhere to the very highest ethical standards.**
- **However, following societal moral standards and obeying all pertinent laws is not enough!**
- **It ALSO means that the individual engineer must be technically prepared for the job and always willing to obey the ethical standards that address our technical competence.**
 - **Do: Make certain you are technologically up-to-date, that skills are continually updated, and that you respond promptly and positively to constructive criticism and technical suggestions by capable colleagues.**
 - **Don't: Undertake engineering tasks outside your area of expertise, ignore problems that effect the outcome of a technological effort, and fail to respond to a problem by trying to hide bad results or outcomes.**



Assignment

- We have now discussed and reviewed a number of technological disasters that **involve improper ethical conduct**.
- Each team must pick a major technological disaster and examine it carefully to assess the causes.
- In this case, investigate and report on the technical competence issues:
 - What technical lapses led to the disaster?
 - What specific cases of engineering incompetence can you cite?
 - How could the engineers associated with the project have prevented the disaster?
 - What technical competence examples can you find that involve (1) failure to keep technically up-to-date, (2) failure to follow competent technical advice, (3) failure to enforce proper engineering standards, (4) other?



Assignment (2)

- The result of your ethics study will be a 5-minute presentation summarizing your efforts.
- **Requirements:**
 - Five minute hard deadline, four minutes minimum (**over those limits either way = grade reduction!**).
 - At least two PowerPoint slides (**3 max.; will be turned in**). Slides NEAT and POLISHED. No hand-drawn illustrations.
 - Presentations **solid, rehearsed, coherent, professional**. Don't hem and haw around, no hands in pockets, no giggling or asides. **In short, try to sound like a professional engineer making a presentation top his/her peers.**
 - No more than two presenters.
 - **Dress well, look like a professional (only presenters).**