UNIT - IV

SAFETY AND RISK

- The American Heritage Dictionary defines risk as the possibility of suffering harm or loss. Risk is sometimes used synonymously with danger.
- The same dictionary defines safety as freedom from damage, injury, or risk. There is some circularity to these definitions: We engage in risky behavior when we do something that is unsafe, and something is unsafe if it involves substantial risk.
- Although these definitions are precise, safety and risk are essentially subjective and depend on many factors:

1. **Voluntary vs. involuntary risk:**
    - Many consider something safer if they knowingly take on the risk, but would find it unsafe if forced to do so.

      Ex: If the property values are low enough, some people will be tempted to buy a house near a plant that emits low levels of a toxic waste into the air. They are willing to assume the risk for the benefit of cheap housing. However, if a person already living near a plant finds that toxic fumes are emitted by the plant and he wasn't informed, the risk will appear to be larger, since it was not voluntarily assumed. This principle is true even if the level of emission is identical to that in the example of a person choosing to move near the plant.
2. **Short-term vs. long-term consequences:**
    - Something that might cause a short-lived illness or disability seems safer than something that will result in permanent disability.

      Ex: An activity for which there is a risk of getting a fractured leg will appear much less risky than an activity with a risk of a spinal fracture, since a broken leg will be painful and disabling for a few months, but generally full recovery is the norm. Spinal fractures, however, can lead to permanent disability.
3. **Expected probability:**
    - Many might find a one-in-a-million chance of a severe injury to be an acceptable risk, whereas a 50:50 chance of a fairly minor injury might be unacceptable.

Ex: Swimming at a beach where there is known to be a large concentration of jellyfish would be unacceptable to many, since there would be a high probability of a painful, though rarely fatal, sting. Yet, at the same beach, the risk of a shark attack is low enough that it doesn't deter anyone from swimming, even though such an attack would very likely lead to death or dismemberment. It is important to remember here that the expected probability is only an educated guess.

4. **Reversible effects:**
   - Something will seem less risky if the bad effects are ultimately reversible. This concept is similar to the short-term vs. long-term risk question discussed previously.
5. **Threshold levels for risk:**
   - Something that is risky only at fairly high exposures will seem safer than something with a uniform exposure to risk.

     Ex: The probability of being in an automobile accident is the same regardless of how often you drive. (Of course, you can reduce the likelihood of being in an accident by driving less often.) In contrast, studies have shown that low levels of nuclear radiation actually have beneficial effects on human health, while only at higher levels of exposure are there severe health problems or death. If there is a threshold for the effects, generally there will be a greater tolerance for risk.
6. **Delayed vs. immediate risk:**
   - An activity whose harm is delayed for many years will seem much less risky than something with an immediate effect.

     Ex: For several years now, Americans have been warned about the adverse long-term health effects of a high-fat diet. This type of diet can lead to chronic heart problems or stroke later in life. Yet, many ignore these warnings and are unconcerned about a risk that is so far in the future. These same people might find an activity such as skydiving unacceptably risky, since an accident will cause immediate injury or death.

Engineers and Safety:

- Since safety is an essential aspect of our duties as engineers, how can we be sure that our designs are safe? There are four criteria that must be met to help ensure a safe design.
- **First, the minimum requirement is that a design must comply with the applicable laws**. This requirement should be easy to meet, since legal standards for product safety are generally well known, are published, and are easily accessible.
- **Second, a design must meet the standard of "accepted engineering practice."** You can't create a design that is less safe than what everyone else in the profession understands to be acceptable.
- For example, federal safety laws might not require that the power supply in a home computer be made inaccessible to the consumer who opens up her computer. However, if most manufacturers have designed their supplies so that no potentially lethal voltages are accessible, then that standard should be followed by all designers, even if doing so increases the cost of the product.
- **Third, alternative designs that are potentially safer must be explored.** This requirement is also difficult to meet, since it requires a fair amount of creativity in seeking alternative solutions. This creativity can involve discussing design strategies with others in your field and brainstorming new alternatives with them. The best way to know if your design is the safest available is to compare it to other potential designs.
- **Fourth, the engineer must attempt to foresee potential misuses of the product by the consumer and must design to avoid these problems.** Again, this requires a fair amount of creativity and research. It is always tempting to think that if someone is stupid enough to misuse your product and is injured, then it's his own fault and the misuse and its consequences shouldn't bother you too much.

Designing for Safety:

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

In step 1, it is appropriate to include issues of safety in the product definition and specification. During steps 2 through 5, engineers typically consider issues of how well the solution meets the specifications, how easy it will be to build, and how costly it will be. Safety and risk should also be criteria considered during each of these steps. Safety is especially important in step 5, where the engineer attempts to assess all of the trade-offs required to obtain a successful final design. In assessing these trade-offs, it is important to remember that safety considerations should be paramount and should have relatively higher weight than other issues. Minimizing risk is often easier said than done. There are many things that make this a difficult task for the engineer. For example, the design engineer often must deal in uncertainties. Many of the risks can only be expressed as probabilities and often are no more than educated guesses. Sometimes, there are synergistic effects between probabilities, especially in a new and innovative design for which the interaction of risks will be unknown. Risk is also increased by the rapid pace at which engineering designs must be carried out. The prudent approach to minimizing risk in a design is a “go slow” approach, in which care is taken to ensure that all possibilities have been adequately explored and that testing has been sufficiently thorough.

However, this approach isn’t always possible in the real world.

ACCIDENTS:

Accidents are of three types. They are;

1. Procedural
2. Engineered
3. Systemic

Procedural accidents:

- Procedural accidents are perhaps the most common and are the result of someone making a bad choice or not following established procedures.
- For example, in the airline industry, procedural accidents are frequently labeled as“pilot error.” These are accidents caused by the misreading of an important gauge, flying when the weather should have dictated otherwise, or failure to follow regulationsand procedures.
- In the airline industry, this type of error is not restricted to the pilot; it can also be committed by air-traffic controllers and maintenance personnel.
- Procedural accidents are fairly well understood and are amenable to solution through increased training, more supervision, new laws or regulations, or closer scrutiny by regulators.

Engineered accidents:

- Engineered accidents are caused by flaws in the design. These are failures of materials, devices that don’t perform as expected, or devices that don’t perform well under all circumstances encountered.
- For example, micro-cracks sometimes develop in turbine blades in aircraft engines. When these cracks become severe enough, the blade can fail and break apart. Sometimes, this has resulted in the penetration of the cabin by metal fragments, causing injury to passengers.
- Engineered failures should be anticipated in the design stage and should be caught and corrected during testing.
- However, it isn’t always possible to anticipate every condition that will be encountered, and sometimes testing doesn’t occur over the entire range of possible operating conditions. These types of accidents can be understood and alleviated as more knowledge is gained through testing and actual experience in the field.

Systemic accidents:

- Systemic accidents are harder to understand and harder to control. They are characteristic of very complex technologies and the complex organizations that are required to operate them.
- A perfect example of this phenomenon is the airline industry. Modern aircraft are very complicated systems. Running them properly requires the work of many individuals, including baggage handlers, mechanics, flight attendants, pilots, government regulators and inspectors, and air-traffic controllers.