

Ethics, Technology, and Engineering, An Introduction

Chapter 1 – The Responsibilities of Engineers

Learning goals

- Describe passive vs active responsibility
- Describe the four conditions of blameworthiness and apply to concrete cases
- Challenger case
- Whistle blowing

1.1 Challenger case

- 25th launch of a space shuttle, first time with human on board. During launch it was -4 degrees Celsius, the shuttle was launched and exploded 11 km above the ocean due to the failure of a rubber sealing ring. This ring was not tested at such low temperatures, due to the failure of the ring, fuel leaked out of the booster and caught fire. After repeated announcements that launch below 11 degrees Celsius would be unsafe (rings weren't tested in these conditions) NASA still decided to launch and put the burden of proof at the ring designers, to prove that launch was actually unsafe instead of not knowing if it was safe because rings were not tested.

1.2 Responsibility

- **Role responsibility:** the responsibility that is based on the role one has or plays in a certain situation
- **Moral responsibility:** based on moral obligations, moral norms or moral duties. Often not linked to a role, yet can extend and limit role responsibilities.
- **Professional responsibility:** based on one's role as professional in as far it stays within the limits of what is morally allowed. Can be both passive and active.

1.3 Passive responsibility

- **Passive responsibility:** Backward-looking responsibility, relevant after something undesirable occurred; specific forms are accountability, blameworthiness, and liability.
- **Accountability:** backward-looking responsibility in the sense of being held to account for, or justify one's actions towards others.
- **Blameworthiness:** backward-looking responsibility in the sense of being a proper target of blame for one's actions or the consequences of one's actions. In order for someone to be blameworthy the following four conditions need to apply:
 - **Wrong-doing:** An individual or institution has violated a norm or did something wrong. This norm can be: laid down in the law, common in the organization, or be a moral one.
 - **Causal contribution:** A casual contribution to the consequences have to be more before being able to be held responsible. Firstly, not only an action, as well a failure to act may be considered a casual contribution. Secondly, a casual contribution is not usually not a sufficient condition for the consequence. Often, a range of casual contributions have to be made. A casual contribution will often be a necessary ingredient for the consequence (without it, it would not occur)
 - **Foreseeability:** To be held responsible for something, you must have been able to know the consequence of your actions. Yet you should do everything that is reasonably possible to know the consequences.
 - **Freedom:** Someone must not have acted under compulsion. Individuals are either not responsible or responsible to a lesser degree when he is coerced to take certain decisions. Acting out of own interest does not count as being coerced (lose promotion chances when

not cooperating), but the responsibility is still somewhat smaller than when you freely chose to cooperate.

1.4 Active responsibility

- **Active responsibility:** Responsibility before something happened referring to a duty or task to care for certain state-of-affairs or persons. He/she is expected to act in such a way that undesired consequences are avoided.
- **Taylorism:** scientific management. Make the whole production process as efficient as possible based on calculations and data.

1.5 Engineers versus Managers

- **Technocracy:** government by engineers (dictaat HS 4)
- **Paternalism:** the making of moral decisions for others on the assumption that one knows better what is good for them than those others.
- **Whistle-blowing:** the disclosure of certain abuses in a company by an employee in which he or she is employed, without the consent of his/her superiors, and in order to remedy these abuses and to warn the public about these abuses.
 - These can be endangerment of the public, health, safety, environmental, offences, violations of the law and legislation, deception of public or the government, corruption, fraud, destroying or manipulation information, abuse of power including sexual harassment and discrimination.
 - Whistle blowers often pay a huge price, losing their job and future job chances, even loss of friends and family.
 - **Edward Snowden!!!**
- **Guidelines** for when whistle-blowing is **morally required**
 1. The organization to which the would-be whistle-blower belongs will, through its product or policy, do **serious** and considerable **harm** to the public.
 2. The would-be whistle-blower has identified the threat, **reported** it to superiors and concluded that superiors won't do anything **effective**.
 3. The would-be whistle-blower has **exhausted** other internal procedures within organization as far as the danger to safety make reasonable.
 4. The would-be whistle-blower has **evidence** that would convince a reasonable objective observer that it's view of the **threat is correct**.
 5. The would-be whistle-blower has good reason to believe that **revealing** the threat will **prevent** the harm at reasonable cost

Chapter 2 – Codes of Conduct

Learning goals

- Describe professional codes and corporate codes
- Differentiate between three types of codes of conduct; aspirational, advisory and disciplinary
- Understand codes of conduct with respect to responsibility of engineers
- Identify strengths and weaknesses of codes of conduct

2.2 Codes of conduct

- **Codes of conduct:** A code in which organizations (like companies or professional associations) lay down guidelines for responsible behavior of their members.
- **Aspirational code:** a code that expresses the moral values of a profession or company. The objective is to express to the outside world the kind of values the profession or company is committed to.
- **Advisory code:** A code of conduct that has the objective to help individual professionals or employees to exercise moral judgements in concrete situations on the basis of the more general values and norms of the profession or company.
- **Disciplinary code:** Code so that the behavior of all professionals or employees meets certain values and norms. (Big companies)
- **Professional codes:** Code conduct that is formulated by a professional associations and are guidelines for exercising a certain profession. [IEEE / NSPE (American) / FEANI (European)]
 - **Integrity:** Living by one's own moral values, norms and commitments
 - **Honesty**
 - **Conflict of interest:** The situation in which one has an interest (personal or professional) that, when pursued, can conflict with meeting one's professional obligations to an employer or to clients.
- **Corporate codes:** codes formulated by companies in which engineers are employed
- Definition of **profession**
 1. Use of specialized knowledge and skill (often with long study)
 2. A monopoly of the carrying out of the occupation (not everyone can do it)
 3. Assessment whether the work is carried out in a competent is only possible by peers. They have the right knowledge and skills for a legitimate judgement
 4. Provides society with products, services or values that are useful and serve the society.
 5. Ethical standards, derived from or relating to the society-serving ideal.
- Companies have a **Corporate Social Responsibility:** The responsibility of companies towards stakeholders and to society at large that extends beyond meeting the law and serving shareholders' interest.
 - Opposition of Friedman = Companies only have responsibilities towards their stakeholders, and not to other stakeholders, society, or the environment:
 - Money spend by the corporation on social responsibility is ultimately the money of the shareholders, this expenditure conflicts with their goal to maximize profits.
 - Corporations are not democratically elected. They can create ideas about what is morally desirable or allowable, they are enforcing their own particular view upon others without democratic legitimization. If any limits for corporations are desirable, they should be laid down in the law.
 - Corporate codes contain:
 - Mission statement: Concisely formulates the strategic objectives of the company and where it stands for
 - Core values: Qualities that a company considers desirable and which ground business conduct and outcomes. (Like teamwork/creativity/flexibility)
 - Responsibility to stakeholders
 - Norms and rules

2.3 Possibilities and Limitations of Codes of Conduct

- **Window-dressing:** Presenting a favorable impression that is not based on the actual facts.
- **Google in China:** they launched google.com in China, Chinese government blocked the website until google launched a version that censored the data in favour of the Chinese government. Google received much criticism because it wasn't according to Google's slogan and mission (code of conduct (aspirational code)). Google presented the outside world a favourable impression (slogan: "don't be evil", vision: "organize world's information and make it universally accessible and usefull") but this was not based on the actual facts (actions in China).
- **Uncritical loyalty:** Placing the interest of the employer, as the employer defines those interests, above any other considerations
- **Critical loyalty:** Giving due regard to the interest of the employer, insofar as this is possible within the constraints of the employee's personal and professional ethics.
- Apart from **vagueness**, codes of conduct may be plagued by inconsistencies, both within codes and between codes. This may cause contradictions:
 - Engineers shall ... observe proper duties of confidentiality
 - Engineers shall be prepared to contribute to public debate on matters of technical understandings in fields in which they are competent to comment
 - "contributing to public debate" can be interpreted as informing the public about possible hazards, though this conflicts with the confidentiality rule.
 - This is different from code to code, e.g. NSPE has attempted to avoid vagueness and contradictions.
- **Protection of Whistle-Blowers:** Several countries try to protect Whistle-blowers, mainly in the USA and UK.
 - USA: The Sarbanes-Oxley Act (SOX) came in force in 2002. Companies were required to adopt policies for internal whistle blowing with respect to accounting and auditing. Though they may also apply such procedures to other kinds of violations. Prior to SOX, federal whistleblowers statutes covered the public sector and specific areas like safety and the environment.
 - UK: The Public Interest Disclosure Act of 1998 protects both internal and external whistle blowing from retaliation, but does not cover the whistle blowing of policies of companies. The Combined Code on Corporate Governance of 2003, by the Financial Services Authority, encourages the institutionalization of whistle blowing policies of companies. Corporations should follow this code or explain why they did not.

Chapter 3 – Normative Ethics

Learning goals:

- Describe and distinguish normative versus descriptive judgments.
- Describe norms, values and virtues.
- Describe the four ethical theories; utilitarianism, Kantian theory, virtue and care ethics.
- Identify their criticism and apply them in engineering practice.
- Reflect on how ethical theories may impact on moral decision making.

3.2 Ethics and Morality & 3.3 Descriptive and Normative Judgments

Morality	opinions, decisions and action with which people, individually or collectively, consider what is good or bad.
Ethics	a process of searching for the right kind of morality, systematic reflection on what is moral.
Descriptive ethics	the branch of ethics that describes existing morality: customs, habits, opinions and action, either good or evil.
Normative ethics	the branch of ethics that takes it one step further; it also judges morality and formulates norms on how to live or act
Descriptive judgments	value-free judgments that describe what is/will be/was the case, they are either true or false. Describes how the world is.
Normative Judgements	Judgments that involve value, they judge whether something is good or bad, desirable or undesirable, right or wrong. Prescribes how the world should be.

3.4 Values, Norms and Virtues

- **Values:** global convictions, ends or matters that people feel should be strived for in general, to be able to lead a good life or realize a good society. (e.g. freedom, equality, justice, health, happiness)
 - Intrinsic value: a value in itself (the higher end value)
 - Instrumental value: a value that contributes to an intrinsic value
 - Example: if a person has much satisfaction of his work than having a job is an intrinsic value, but if a person values having a job because it supports the value of being rich than having a job is an instrumental value and being rich is an intrinsic value.
- **Norms:** the means to realize values, specific rules that prescribe what actions are required, permitted or forbidden to realize the values. You need norms to realize values but a norm is ineffective without a clear underlying value that makes sense.
- **Virtues:** human characteristic that have the following five features:
 1. They are desired characteristics that express a value worth striving for
 2. They are expressed in action
 3. They are lasting and permanent, the form a foundation for action
 4. They are always present but only used when necessary
 5. They can be influenced by the individual (learned, shaped)
- Virtues can be **moral** (justice, honesty, courage, loyalty, creativity, humor) or **intellectual** (knowledge and skills), moral virtues look like moral values but moral virtues mainly focusses on the character development of the individual.
- Examples:
 - In the traffic system, “safety” would be a main value. Just having the value isn’t enough, therefor we implement laws and traffic rules (norms) to achieve the value.
 - A company can formulate nice values like responsibility and respect, but without the moral virtues being present in the employees little will be accomplished.

3.5 Relativism and Absolutism & 3.6 Ethical Theories

- **Normative Relativism:** Argues that all values, norms and virtues are relative, so what is good for one person is not necessarily good for another. It is impossible to state that certain values or norms are better than others. There are no guidelines about behavior independent of culture, time and place. Three main **problems**:
 - Theory states that there are no universal norms but at the same time states everybody has to respect each others opinions → **contradiction**
 - It creates an **unworkable** and intolerable situation as regulations and laws don't have to be followed as an individual might have another opinion which has to be respected.
 - It also makes any meaningful **discussion totally impossible** as someone's opinion is not better nor worse than any other and someone can always appeal to the freedom of opinion and argumentation might not be valid.
- **Universalism:** states that there is a system of values and norms that is universally applicable, independent of time, place or culture.
- **Absolutism:** form of universalism in which no exceptions to rules are possible. (universalism states "thou shalt not kill", but when killing a person is the most morally responsible thing to do it is excepted, absolutism doesn't make this exception). Three main problems:
 - We cannot work with notion that a universal norm prescribes the best action in all situation
 - It offers no room for an **independent** judgment
 - It gives no answer to **conflicting** norms

Approach	Actor	Action	Consequences
Theory	Virtue ethics → Aristotle	Deontology (duty) → Kantian theory → Immanuel Kant	Consequentialism → Utilitarianism → Bentham, Mill
Point of Departure	Virtues	Norms	Values

3.7 Utilitarianism

In **consequentialism** the consequences of the action are central to the moral judgment of the action. **Utilitarianism** is a form of consequentialism where the consequences of the actions are measured as values: pleasure, happiness, welfare, but also pain or harm. The action that brings the **greatest happiness for the greatest number** should be chosen. It is a **monistic** type of consequentialism, as it only measures one value and doesn't weigh different values against each other (pluralistic type).

➤ Jeremy Bentham (1748-1832)

- Founder of utilitarianism (utility)
- Purpose is an **intrinsic** value (mainly provide pleasure and avoid pain)
- Connects to **hedonism**: the idea that pleasure is good in itself and to which all other things are instrumental
- Places experience at heart of his ethics
- **Utility principle**: one should choose the action that results in the greatest happiness for the greatest number (happiness etc. can be quantified)
- **Moral balance sheet**: balance sheet in which the **costs** and **benefits** of a single actions are weighed against each other, to determine the utility of actions. (cost-benefit analysis)
- **Criticized** because it is hard to measure pleasure or happiness as it is subjective and hard to compare.

➤ John Stuart Mill (1806-1873)

- Extended and revised Bentham's thinking through two main adaptations:
 - Qualities should be taken into account when following the utility principle, a more valuable, quantitatively smaller pleasure might be preferred over a less valuable, quantitatively larger pleasure.

- If the pleasure of the majority outweighs the unhappiness of a minority, this minority could be exploited or abused, as Bentham's utilitarianism doesn't say anything about the division of pleasure.
- Introduced the **freedom principle**: everyone is free to strive for his own pleasure as long as they do not deny or hinder the pleasure of others. (aka **no harm principle**)
- **Criticism**
 - Happiness cannot be measured and utilitarianism can lead to exploitation
 - 1. Consequences are hard to foresee objectively, they are unpredictable, unknown or uncertain. → started working with expectations and gave rise to statistics
 - 2. Problem with **distributive justice** (value of having a just distribution of goods like income, happiness and career). In utilitarianism, an equal distribution of happiness is not relevant. Some argue equal distribution should be strived to, while others say utilitarianism itself automatically balances common goods because of **marginal utility** (the additional utility that is generated by an increase in a good or service) and the fact that inequality leads to **jealousy** and thus pain which is to be avoided.
 - 3. It ignores the **personal relationships** between people. Saving your child makes you more happy than saving a famous surgeon while utilitarianism states to do the reverse.
 - 4. Actions might maximize pleasure even though they are morally unacceptable and vice versa. (e.g. lying or falsifying measurements) **Act utilitarianism** is the traditional approach in which the action is judged by its consequences. **Rule utilitarianism** is the approach in which the action is judged by the consequences of the rules it is based on (closer to duty ethics). "Measurements should be presented correctly" would be the rule that brings the greatest happiness to society.

3.8 Kantian Theory

- **Duty ethics** (deontology) states that an action is morally correct if it is in agreement with a moral rule that is applicable in itself, independent of the consequences of that action.
 - Monistic vs. pluralistic, relying on one main principle which all moral norms are derived from or not.
 - Foundation of **origin**:
 - A God, through the Bible or Koran
 - Appeal to a social contract that the involved parties agreed to (working code)
 - Based on reasonable arguments
- Best known duty ethics theory → **Immanuel Kant (1724-1804)**, moral laws and normative ethics cannot be based on happiness or welfare as it used to be, because it is an individual matter and differs per person and during a lifetime.
- **Kantian theory**:
 - **autonomy**; man himself should determine what is morally correct through reasoning
 - based on the **Categorical imperative**; a universal principle that everyone should obey and that forms the foundation of all moral judgments (do X). Rather than a **hypothetical norm**: a conditional norm, it only applies under certain circumstances (if you want Y, do X)
 - We act with **good will** only if our actions are led by the categorical imperative, the good will is the only thing that is unconditionally good.
- Kant's first categorical imperative: the **universality principle**: "*Act only on that maxim which you can at the same time will that should become a universal law*". A **maxim** is a prescribed rule. When you want something was to become a universal law, but then a **contradiction** exists, the action is not ethically correct.
- From the above, Kant's **Equality postulate** follows: the prescription to treat persons as equal, with equal concern and respect.
- Second categorical imperative of Kant: the **reciprocity principle**; "*Act as to treat humanity, whether in your own person or in that any other, in every case as an end, never as means only.*"

Or you must not merely misuse humans, and respect the free, intelligent, self-directing human ratio.

- Two main **criticisms**:
 - All moral laws can be derived from the categorical imperative but this can lead to **contradictory** norms (example: you can only save a friend by lying, but one should always help someone and one must not lie).
 - Kant does not allow for any exceptions. This can be solved with the pluralistic theory of **Ross**: good is situated on two levels: what seems to be good at first (**prima facie norms**) and that which is good once we take everything into consideration (**self-evident norms**).

3.9 Virtue Ethics

- **Virtue ethics**: focusses on the nature of the actor, indicates which good or desirable characteristics people should have or develop to be moral
- Already present in ancient Greece; Socrates, Plato and **Aristotle**
 - According to Aristotle, the final goal of human action is to strive for “**the good life**” or *eudaimonia*, being a good person.
 - Each moral virtue holds an equilibrium position between two extremes of evil
 - Cowardice < courage < recklessness
 - Stinginess < generosity < spendthrift
 - Subservience < pride < arrogance
 - Moral virtues are not given at birth nor supernatural, they can be **developed** by deeds.
 - People know what they want by instinct but not what they should do. The good can be ambiguous, what is good in one case is not necessarily good in another. An intellectual virtue, **practical wisdom**, is a virtue that enables one to make the right choice for action, the ability to choose the right middle course.
- **Criticisms**: being a virtuous person doesn’t necessarily justify your actions. Virtue ethics doesn’t give concrete clues about how to act while solving a case. Last, we can wonder whether we can simply declare a moral virtue to be good in itself.
- **Virtues for a morally responsible engineer**:
 - Expertise/professionalism
 - Clear and informative communication
 - Cooperation
 - Willingness to make compromises
 - Objectivity
 - Being open to criticism
 - Stamina (doorzettingsvermogen)
 - Creativity
 - Striving for quality
 - Having an eye for detail
 - Being in the habit of reporting on your work carefully

3.10 Care Ethics

- An ethical theory that emphasizes the importance of **relationships**, development of morals doesn’t come about by learning general moral principles. Instead, it holds that cultivating mutual responsibility and **care** within relationships is the basis of moral development.

3.11 The Ford Pinto Case

- Ford wanted to design a cheap car to compete with European companies (Ford Pinto at a price of \$2000 maximum). This resulted in placing the petrol tank behind the rear axis. After doing tests, Ford knew the tank could easily explode after a collision. They could place the tank above the rear axis or include extra protection for \$11 per unit. After they had been sued for homicide they explained their choice through a cost-benefit analysis. Costs of the safer model

were $\$11 \times 12.5 \text{ million units} = \137.5 million . Benefits were $180 \text{ deaths} \times \$200,000 + 180 \text{ injured} \times \$67,000 + 2100 \text{ burned vehicles} \times \$700 = \$49.53 \text{ million}$.

- **Utilitarianism approach:** act utilitarianism justified Fords choice because of the cost-benefit analysis though you might question the reasons behind the amount of deaths and injured and the value of a human life. It is also against the **freedom principle** of Mill. **Rule utilitarianism** states might state that rules like “companies should produce save cars” maximize overall happiness.
- **Kant approach:** Kant states that Fords choice is justified if the maxim “marketing unsafe cars without informing the consumer is allowable” can be a **universal** law. If this would be universalized no rational person will buy this car because he cannot trust whether it is safe. You should also have respect for people’s **moral autonomy** in making their own choices and this cannot be done when Ford doesn’t inform the consumers about safety issues.

Chapter 5 - The Ethical Cycle

Learning goals

- Understand that moral problems are ill-structured;
- Explain the analysis steps of the ethical cycle;
- Explain the role of the ethical cycle in moral decision-making;
- Apply the ethical cycle to concrete moral problems in engineering;
- Analyze and evaluate the complex consequences and motives that typically attend moral issues in engineering practice;
- Describe wide reflective equilibrium and its relation with the analysis step reflection;

5.2 Ill-structured problems

Design analogy (Caroline Whitbeck): Mainstream ethics is dominated by rational foundalist approaches building on unrealistic decision-making.

Moral philosophers say that moral problems are well-structures while Whitbeck says they are ill-structured.

Ill-structures problems: A problem that has no definitive formulation of the problem, may embody inconsistent problem formulations, and can only be defined during the process of solving the problem.

Well-structured problems: A problem such as a basic arithmetical calculation that usually has a clear goal, fixed alternatives to choose from, usually maximally one correct answer and rules or methods that will generate more or less a straightforward answer.

Synthetic reasoning: finding new solutions to a problem when you already have one.

5.3 The ethical cycle

Ethical cycle: A tool in structuring and improving moral decisions by making a systematic and thorough analysis of the moral problem, which helps to come to a moral judgment and to justify the final decision in moral terms.

Moral problem: Problem in which two or more positive moral values or norms cannot be fully realized at the same time.

Moral dilemmas: A moral problem with the crucial feature that the agent has only two (or a limited number of) options for action and that whatever he chooses he will commit a moral wrong.

Cycle:

1. Moral problem statement
2. Problem analysis
3. Options for action
4. Ethical evaluation
5. Reflection

Problem statement:

1. it must clearly state what the problem is;
2. it must state who has to act (not always relevant)
3. the moral nature of the problem needs to be articulated.

Problem analysis:

Three important elements can be distinguished: the stakeholders and their interests, the moral values that are relevant in the situation, and the relevant facts.

(**Stakeholders:** Actors that have an interest (“a stake”) in the development of a technology.)

Options for action:

Multiple strategies:

- Black-and-white-strategy
 - A strategy for action in which only two options for actions are considered: doing the action or not.
- Strategy of cooperation
 - The action strategy that is directed at finding alternatives that can help to solve a moral problem by consulting other stakeholders.
- Whistle-blowing(last resort strategy)
 - speaking to the media or the public on an undesirable situation against the desire of the employer, see Section 1.5.3

Ethical evaluation:

2 frameworks:

- Intuitivist framework
 - Indicate which option for action in your view is intuitively most acceptable and formulate arguments for this statement.
- Common sense method
 - Weigh the available options for actions in the light of the relevant values

Reflection:

The approach to reflection we want to advocate here is known as the method of **Wide reflective equilibrium**.

Wide reflective equilibrium:

Approach that aims at making coherent three types of moral beliefs:

1. considered moral judgments
2. moral principles
3. background theories

5.5 Collective Moral Deliberation and Social Arrangements

Moral deliberation: An extensive and careful consideration or discussion of moral arguments and reasons for and against certain actions.

Overlapping consensus: An agreement on the level of moral judgments, while there may be disagreement on the level of moral principles and background theories. Each of the participants should be able to justify the overlapping consensus in terms of his or her own wide reflective equilibrium.

Learning.

A distinction can be made between first-order learning, in which the people involved learn better to achieve given goals, and second-order learning, in which learning takes place with respect to what goals to strive for and what moral values to take into account.

Inclusiveness and openness.

Inclusiveness means that all relevant perspectives are included in the debate, for example by engaging a diversity of relevant stake-holders. Since inclusiveness is usually relative – what is relevant may change in the course of time or maybe subject to disagreement – also openness is important. Openness means that new considerations and parties can enter the debate.

Chapter 6 - Ethical Questions in the Design of Technology

Learning goals

- Identify ethical issues at the different stages of the design process;
- Understand how conflicts between design requirements in design may amount to value conflicts;
- Describe the various methods for dealing with value trade-offs in design and their pros and cons;
- Apply these methods to engineering design problems;
- Describe the difference between normal and radical design and the moral relevance of this distinction;

6.2 Ethical Issues During the Design Process

Engineering design: The activity in which certain functions are translated into a blueprint for an artifact, system, or service that can fulfill these functions with the help of engineering knowledge.

Design process: An iterative process in which certain functions are translated into a blueprint for an artifact, system, or service. Often the following six stages are distinguished: problem analysis and formulation; conceptual design; simulation; decision; detail design; and prototype development and testing.

The **design process** is an iterative process that can be divided in different stages, like:

- **Problem analysis and formulation**, including the formulation of design requirements;
- **Conceptual design**, including the creation of alternative conceptual solutions to the design problem and possible reformulation of the problem;
- **Simulation** of one or more concept design to test how well they meet the design requirements;
- **Decision**: choice of one conceptual solution from a set of possible solutions;
- **Detail design**: the design is further detailed;
- **Prototype development and testing**, in which a prototype is developed and tested. This testing may lead to adaptations in the design.

6.2.1 Problem analysis and formulation

During the problem analysis stage, the designer or the design team conceptualizes the design problem. This stage results in a certain formulation of the design problem and of certain design requirements that a good or acceptable solution has to meet. Findings in later stages can sometimes result in the revision of the problem formulation or the design requirements.

Problem analysis stage: The stage of the design process in which the designer or the design team analyses and formulates the design problem, including the design requirements.

Design requirements: Requirements that a good or acceptable design has to meet.

Technical codes and standards: Technical codes are legal requirements that are enforced by a governmental body to protect safety, health, and other relevant values. Technical standards are usually recommendations rather than legal requirements that are written by engineering experts in standardization committees.

Certification: The process in which it is judged whether a certain technology meets the applicable technical codes and standards.

6.2.2 Conceptual design

In the conceptual design stage the aim is to generate concept designs. The focus is on an integral approach to the design problem. The designer does not try to realize each design requirement independently, but works on a combination of design requirements and searches for a total concept that can bring about this combination.

Conceptual design stage: The stage in which the designer or the design team generates concept designs. The focus is on an integral approach to the design problem.

Creativity: The virtue of being able to think out or invent new, often unexpected, options or ideas. Creativity is an important professional virtue for designers.

6.2.3 Simulation

The concept designs are checked in the simulation stage to see whether they meet the design requirements. This takes place in a number of ways, for example, through calculations, carrying out computer simulations, and doing tests with prototypes. Moral considerations play a partial role in how much reliability in predictions is desirable or acceptable. The answer to this question depends in part on what is morally at stake.

Simulation stage: The stage of the design process in which the designer or the design team checks through calculations, tests, and simulations whether the concept designs meet the design requirements.

6.2.4 Decision

In the decision stage, various concept designs are compared with each other and a choice is made for a design that has to be detailed. The results from the simulation stage are used for this comparison.

Decision stage: The stage of the design process in which various concept designs are compared with each other and a choice is made for a design that has to be detailed.

Design criteria: A kind of design requirements which are formulated in such a way that products meet them to a greater or lesser extent. Design criteria are often used to compare and choose between different concept designs.

Trade off: Compromise between design criteria. For example, you trade off a certain level of safety for a certain level of sustainability.

Organizational deviance: Norms that are seen as deviant or unethical outside the organization are seen within the organization as normal and legitimate.

One important lesson is that adequately organizing decision-making during the design process is essential to good design. David Collingridge has suggested four criteria for such decision-making:

1. corrigibility of decisions;
2. choose systems that are easy to control;
3. flexibility of the decision; and
4. insensitivity of the decision to error.

6.2.5 Detail design

Detail design stage: The stage in which a chosen design is elaborated on and detailed.

6.2.6 Prototype development and testing

After the design is detailed, often a prototype of the design is constructed and tested. A test is the execution of a technology in circumstances set and controlled by the experimenter, and in which data are systematically gathered about how the technology functions in practice.

Test: The execution of a technology in circumstances set and controlled by the experimenter, and in which data are gathered systematically about how the technology functions in practice.

6.3 Trade-offs and Value Conflicts

Value conflict: A value conflict arises if (1) a choice has to be made between at least two options for which at least two values are relevant as choice criteria, (2) at least two different values select at least two different options as best, and (3) the values do not trump each other.

We will define a value conflict as the situation in which all of the following conditions apply:

1. A choice has to be made between at least two options for which at least two values are relevant as choice criteria.
2. At least two different values select at least two different options as best. The reason for this condition is that if all values select the same option as the best one, we do not really face a value conflict.
3. The values do not trump each other. If one value trumps another any (small) amount of the first value is worth more than any (large) amount of the second value. If values trump each other, we can simply order the options with respect to the most important value and if two options score the same on this value we will examine the scores with respect to the second, less important, value. So if values trump each other, there is not a real value conflict.

Trumping (of values): If one value trumps another any (small) amount of the first value is worth more than any (large) amount of the second value.

Cost-benefit analysis: A method for comparing alternatives in which all the relevant advantages (benefits) and disadvantages (costs) of the options are expressed in monetary units and the overall monetary cost or benefit of each alternative is calculated.

Discount rate: The rate that is used in cost-benefit analysis to discount future benefits (or costs). This is done because 1 dollar now is worth more than 1 dollar in 10 years time.

Contingent validation: An approach to express values like safety or sustainability in monetary units by asking people how much they are willing to pay for a certain level of safety or sustainability (for example, the preservation of a piece of beautiful nature).

Multiple criteria analysis: A method for comparing alternatives in which various decision criteria are distinguished on basis of which the alternatives are scored. On basis of the score of each of the alternatives on the individual criteria, usually a total score is calculated for each alternative.

Ordinal scale: A measurement scale in which only the order of the items of the scale has meaning.

Interval scale: A measurement scale in which in addition to the order of items also the distance between the items has meaning.

Ratio scale: A measurement scale in which the ratio between items on a scale has meaning.

Threshold: The minimal level of a (design) criterion or value that an alternative has to meet in order to be acceptable with respect to that criterion or value.

Value Sensitive Design: An approach that aims at integrating values of ethical importance in a systematic way in engineering design.

6.4 Regulatory Frameworks: Normal and Radical Design

Regulatory framework: The totality of (product-specific) rules that apply to the design and development of a technology.

Normal design: Design in which the normal configuration and working principle of the product remain the same.

Radical design: The opposite of normal design. Design in which either the normal configuration or the working principle (or both) of an existing product is changed.

Working principle: The (scientific) principle on which the working of a product is based.

Chapter 8 – Ethical Aspects of Technical Risks

Learning goals:

- Discuss why engineers are responsible for safety and how they can apply this
- Describe the main approaches to risk assessment
- Describe the main ethical considerations for judging the moral acceptability of risks
- Argue why risks of similar magnitude are not necessarily equally acceptable
- Identify ethical issues in risk communication and judge different ways of dealing with them
- Explain what is meant by engineering as a societal experiment and reflect on the moral acceptability of such societal experiments

8.2 – Definitions of Central Terms

Hazard	Possible damage or otherwise undesirable effect
Risk	A specification of a hazard, the product of probability of an undesirable event and the effect of that event. Hazard that can be expressed in quantitative terms
Safety	The condition in which the risks have been reduced as far as reasonably feasible and desirable
Acceptable risk	A risk that is morally acceptable. The following are relevant for deciding whether a risk is acceptable: (1) the degree of informed consent with the risk; (2) the degree to which the benefits of a risky activity weigh up against the disadvantages and risks; (3) the availability of alternatives with a lower risk; and (4) the degree to which risks and advantages are justly distributed
Complexity	Reason why it can be hard to express a hazard in a risk; relations between variables can be complex, there can be intervening variables, time delays etc.
Uncertainty	A lack of knowledge, situation in which you know the consequences but not the probabilities of these consequences
Ignorance	A lack of knowledge, situation in which we don't at all know what we don't know
Ambiguity	Fourth possible impossibility of expressing hazards in risks; the property that different interpretations or meanings can be given to a term.

8.5 – When are Risks Acceptable?

- See the four point above in short:
 1. **Informed consent:** principle that states that activities (experiments, risks) are acceptable if people have freely consented to them after being fully **informed** about risks and benefits. Is justified by Mill's **freedom** principle, also by Kant **reciprocity** principle as you should respect other's moral autonomy. Ford should have left the choice to the consumers in the **Pinto** case, they didn't fully inform the consumer.
 2. **Do advantages outweigh risks?:** risky activities can have advantages that are larger. This can be seen in a **risk-cost-benefit analysis**: the social costs for risk reduction are weighed against the social benefits offered by risk reduction, thereby achieving an optimal level of risk (mainly consequentialism→greatest happiness for greatest number). Two **objections**: pricing things is hard and ambiguous (Ford Pinto case) and little attention is paid to the other points that make a risk acceptable.
 3. **Availability of alternatives:** risks are more accepted when there are no less riskier alternatives. One has to choose the **best available technology**: the best available technology is a yardstick for what is acceptable.
 4. **Just distribution of risks and benefits:** Risks and benefits should be equally distributed in order to make a risk more acceptable, this is also according to Kant's equality postulate. Not everybody runs the same risk but the maximum permissible risk is equal for everyone. First objection is that a slight reduction in risk to meet prescribed standards might cost an immense amount of money. Second objections is that prescribing standards does not allow individuals or collectives to accept a risk. Especially **personal risks** like smoking, risks that only affect an individual and the individual can

choose whether to take the risk. A **collective risk** is a flooding for example, a risk that affects a collective of people, this risk cannot be averted by an individual.

8.6 – Risk Communication

- **Risk communicators** are specialists that inform, or advise how to inform, the public about risks and hazards. But should they also persuade?

8.7 – Dealing with Uncertainty and Ignorance

- **Precautionary principle:** principle that prescribes how to deal with threats that are uncertain and/or cannot be scientifically established. It has the following general format:
 - If there is (1) a threat, which is (2) uncertain, then (3) some kind of action (4) is mandatory.
 1. The threat dimension
 2. The uncertainty dimension
 3. The action dimension
 4. The prescription dimension
- For nanoparticles: the threat is toxicity of the nanoparticles, it is uncertain, some kind of action, doing (animal) tests, is mandatory.

Chapter 9 – The Distribution of Responsibility in Engineering

Learning goals:

- Describe the problem of many hands and explain how it applies to engineering
- Judge responsibility distributions by the moral fairness and by the effectiveness requirement
- Explain difference between moral responsibility and legal liability
- Distinguish different notions of liability and discuss their pros and cons
- Describe the different models for allocating responsibility in organization
- Describe how engineering design may affect the distribution of responsibility

9.2 The problem of many hands

- **Collective responsibility:** the responsibility of a collective of people. For example in the “Herald of free enterprise” case: due to leaving open the inner and outer bow doors of the ship (so the car exhaust fumes could escape the ferry) the ship caught water and capsized. Who’s responsibility is this?
 1. It is a complex situation in which the **boatswain** was responsible for closing the doors on time,
 2. it was the **first officer’s** responsibility to check this but the first officer was on the bridge to assist the captain setting sail.
 3. In the end, the **captain** also has the final responsibility of the ship
 4. and there was also a **shore captain** that has some responsibility.
 5. Finally the **company that built the ship** and the
 6. **ferry company** might also be held responsible for not installing any negative feedback system like alarms lights when the doors are not closed.
- **Problem of many hands:** the situation in which the collective can reasonably be held morally responsible for an outcome, while none of the individuals can be reasonably held responsible.
 - due to the distribution of information across different individuals
 - due to individual actions are not really wrong but when every individual of a society does it it is something wrong (car driving and greenhouse effect)
- **CitiCorp case:** LeMessurier designed a skyscraper and he designed it with welded supports. During construction the contractors decided to use bolts instead of welding due to high costs, the contractors made a man of LeMessuriers company (the approver) agree and sign for it with letting LeMessurier know. A month after the building was finished, a random student did some research and concluded that the bolts couldn’t resist a 16year storm (one that passes every 16 years) and LeMessurier took the criticism serious (**virtuous!!!**) and took a second look and concluded the same. He informed all involved parties and the problem was solved in no-time.
- **Responsibility** of LeMessurier, the contractor, the approver, an individual is morally responsible for the structural deficiency if: he did something wrong (1) that is connected to the structural deficiency of the building (2), if he then could have know that the building was structurally deficient (3) and he could act freely (4). (They could all act freely and had something to do with the deficient building, (2) and (4) apply to all)
 - LeMessurier not necessarily did something wrong because he didn’t know about the change to bolts, therefor he also couldn’t know about the deficiency in the building
 - The contractor definitely did something wrong but couldn’t know about it because he didn’t have the same expertise as LeMessurier and normally bolts or welding doesn’t make a significant difference
 - The approver did something wrong but couldn’t know that it made the building’s structure deficient. He thought it lowered comfort a little instead and also isn’t as skilled as LeMessurier.

- These three together are actually the collective and if they shared their knowledge they could have known about the deficiency and was doing something wrong, therefore the collective can be held responsible
- **Distribution of responsibility:** the ascription of (individual) responsibilities to the various actors in a collective.
 - The **moral fairness requirement** states that responsibility should be distributed justly according to the four earlier mentioned points in case of passive responsibility and in case of active responsibility one can only allocated responsibilities that one can live by (has the means and authority to fulfill the responsibilities).
 - The **effectiveness requirement** states that responsibilities should be distributed that it has the best consequences, that is most effective in preventing harm.

9.3 Responsibility and the law

- **Liability:** legal responsibility; backward-looking responsibility according to law.

Moral responsibility	Legal liability
Moral blameworthiness based on conditions of wrong-doing, causality, freedom and foreseeability	Based on conditions formulated in law
Can be established more informally	Established in well-regulated procedure in court; juridical proof required
Not necessarily connected to punishment or compensation	Usually implies the obligation to pay a fine or damages
Backward looking and forward looking	Backward looking

- **Regulation:** legal tool that can forbid the development or production of technological products but most often formulates set of the boundary conditions for the design, and use of technologies. Regulations often lag behind the technological developments.

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9.4 Responsibility in organizations

- **Hierarchical responsibility model:** the model in which only the organization's top level of personnel is held responsible for the actions of (people in) the organization. But present day, managers are often outsiders within their own organization and they are often not fully informed about what is going in within the organization.
- **Collective responsibility model:** the model in which every member of the collective is held responsible for the actions of others, there is an equal distribution of responsibility. But this often doesn't work in large organizations, only in small cooperation where members need to influence each other.
- **Individual responsibility model:** the model in which each individual is held responsible according to the 4 requirements. But this may lead to the problem of many hands

9.5 Responsibility distributions and technological design

- Design of technology also influences the way responsibility is distributed; the following two are examples of that
- **Auto-pilot:** the auto-pilot is such that pilots can always take over control so the auto-pilot designers and manufacturers cannot be held responsible.
- **V-chip:** A chip that works as follows. Parent can install it on their TV, tv broadcasters rate their own programs in terms of violence, sexualism, etc. and parents can set a boundary rating for their children. It means that broadcasters decide for parent if their children do or do not get to see a program, even though parents might want the other because they disagree with the rating. The tv broadcaster is now sort of responsible for what the children see.