UNIT 3

ENGINEERING AS SOCIAL EXPERIMENTATION

3.1. ENGINEERING AS EXPERIMENTATION

Before manufacturing a product or providing a project, we make several assumptions, trials, desing and redesign and redesign and test several times till the product is observed to be functioning satisfactorily. We try different materials and experiments. From the test data obtained we make detailed design and rests. Thus, design as well as engineering is iterative process as shown in figure 3.1.

Several redesigns are made based on the feedback information on the performance or failure in the field or in the factory. Besides testing, each engineering project is modified during execution, based on periodical feedback on the progress and the lessons from other sources. Hence the development of a product as a whole may be considered as an experiment.

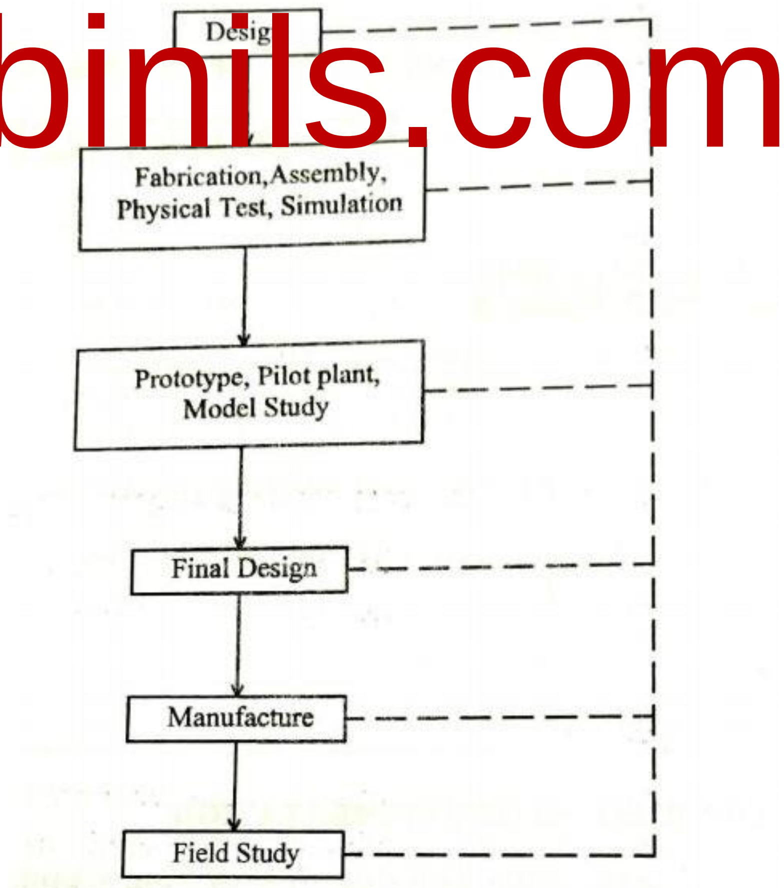

Figure 3.1 Design as an iterative process

3.2. ENGINEER AS AN EXPERIMENTER

The function of the engineer is to develop new products and processes. Since each stage of the design or development, is experienced for the first time, there are uncertainties at every stage and the engineer is bound to make presumptions either from desing data books or from his experience. These uncertainties can be in the from of

- Models used for the desing calculations.
- Performance characteristics of the materials.
- In consistencies in the material purchased.
- Nature of the pressure the finished product will encounter.

His success lies in his capacity to accomplish his task with this partial knowledge. This brings forth the need to develop prototype or simulation models at every stage and conduct experiments to test them. Rough designs are, thus, developed from simulation tests conducted from time to time, which form the basis for developing more detailed designs, till the final product or the process emerges.

Thus, it is obvious that every engineering activity is based on experimental processes. These experiments shall be done not only in laboratory but also in the field, from the point of view of public safety and performance.

3.3. ENGINEERING EXPERIMENTS VS STANDARD EXPERIMENTS

There are many similarities and differences between engineering experiments and other standard experiments.

(i) Similarities

1. Partial ignorance

The engineering experiments is usually executed in partial ignorance. Uncertainties exist in the model assumed. The behavior of materials purchased is uncertain and not constant. They may vary with the suppliers, processed lot, time, and the process used in shaping the materials. There may be variations in the variations in the grain structure and its resulting failure stress. It is not possible to collect data on all variations. In some cases, extrapolation, interpolations, assumptions of linear behaviour over the range of parameters, accelerated testing, simulations and virtual testing are resorted.

2. Uncertainty

The final outcomes of engineering projects, like those of experiments, are generally uncertain. Sometimes unintended results, side effects, and unsafe operation have also occurred. Unexpected risks such as undue seepage in a storage dam, leakage of nuclear radiation from an atomic power plant, presence of pesticides in food or soft drink bottle, an new irrigation canal spreading water borne diseases, and an unsuspecting hair dryer causing lung cancer on the user from the asbestos gasket used in the product have be reported.

3. Continuous monitoring

Effective engineering relies upon knowledge gained about products both before and after they leave the factory-knowledge needed for improving current products and crating better ones. That is, on going success in engineering depends upon gaining new knowledge, just as does ongoing success in experimentation. Monitoring is thus as essential to engineering. As it is to experimentation in general. To monitor is to make periodic observations and test in order to check for both successful performance and unintended side effects. But since the ultimate test of a product's efficiency, safety, cost-effectiveness environmental impact, and a esthetic value lies in how well that product functions within society, monitoring cannot be restricted to the in-house development or testing phases of an engineering venture. The product performance is to be monitored even during use by the end customer.

4. Learning from the past

Engineers normally learn from their own prior designs and infer from the analysis of operation ands results, and sometimes from the reports of other engineers. Unfortunately that is frequently not the case. Lack of established channels of communication, misplaced pride in not asking for information, guilty upon the failure, fear of legal actions, and mere negligence lead to many repetitions of past mistakes. A few examples are listed below.

The titanic lacked sufficient number of life boats- it had only 825 boats for the actual passengers of 2227, the capacity of the ship being 3547. In the emergency situation, all the existing life boats could not be launched. Forty years back, another steamship Arctic met with same tragedy due to the same problem in the same region. But the lesson was learned. In most of the hydraulic systems, valves had been the critical components that are least reliable. The confusion of knowing whether the value was opened or closed, was the cause of the three-mile island accident in 1979. Similarly malfunctioning of valves and mis-reading of gauges have been reported to have caused the accidents elsewhere in some power plants.

(ii) Contrasts

1. Experimental control

In standard experiments, members for study are selected into two groups namely A and B at random. Group A is given special treatment. The group B is given no treatment and is called the controlled group. But they are placed in the same environment as the other group A. This practice is called the experimental control. This practice is followed in the field of medicine. In engineering, this does not happen, except when the project is confined to laboratory experiments. This is because it is the clients or consumers who choose the product, exercise the control. It is not possible to make a random selection of participants for various groups. In engineering, through random sampling, the survey is made from among the users, to assess the results on the product.

2. Humane touch

Engineering experiments involve human souls, their needs. Views, expectations, and creative use as in case of social experimentation. This point of view is not agreed by many of the engineers. But now the quality engineers and managers have fully realized this human aspect.

3. Informed consent

Engineering experimentation is viewed as social experiment since the subject and the beneficiary are human beings. In this respect, it is similar to medical experimentation on human beings. In medical practice, moral and legal rights have been recognized while planning for experimentation. Informed consent is adopted in medical experimentation such a practice is not there in scientific laboratory experiments.

Informed consent has two basic elements:

- **Knowledge**: The subject should be given all relevant information needed to make the decision to participate.
- **Voluntariness:** Subject should take part without force fraud or deception. Respect for rights of minorities to dissent and compensation for harmful effect are assumed here.

The following conditions are essential for a valid consent:

- Consent must be voluntary.
- All relevant information shall be presented in a clearly understandable form.
- Consenter should be capable of processing the information and make rational decisions.
- The subject's consent may be offered in proxy by a group that represent many subjects of like interests.

4. Generating new knowledge

One of the prime objectives of scientific experiments is to generate new knowledge for a better understanding of the universe we live. Engineering projects are undertaken to develop products and services, and focus on technological excellence in attaining the same.

The creation of new knowledge is not the main objective of the project. Many of the engineering projects undertaken of the warfare of the society have the simple objective of realizing a conceived engineered product or service. From this point of view, engineering differs from other scientific experiments.

3.4. THE ENGINEER AS A RESPONSIBLE EXPERIMENTER

As per Murphy's law, if anything is to go wrong, it will go wrong, sooner or later. It means that all products of technology present potential hazards to some extent due to failure, making engineering a risky activity. Thus, each engineering project, whether development of processes or setting up a new plant or building a new railway track or even preparing for launching a luxury cruiser like titanic with a full load of passengers, should be viewed as an experimental process. Before introducing to the public, every engineering product must undergo various experiments, not only in the laboratory but also from the point of view of safety to the public, specially wherever the lives of several people are involved. That is the reason why the engineer is called not only an experimenter, but a responsible experimenter in view of his concern for public safety as he is experimenting with his design with the society in stake.

The engineer being a responsible experimenter, should bear in mind and appreciate fully the fact that the experiments are to be done for the society and from a safety point of view.

- His major duty is to protect the safety of human beings and respect the rights of consent.
- Have a clear awareness of the experimental nature of the project, forecasting its possible side effects.
- Monitor these effects or side effects meticulously and record any significant issues that arise.
- Ensure full personal involvement in all the steps of the project.

- He should be fairly well developed moral autonomy, i.e. his moral beliefs and attitudes must be held only on basis of critical reflection rather than merely through the passive adoption of the conventions of the society.
- Be accountable for the results of the project.
- Exhibit technical competence and other characteristics of professionalism.

3.4.1. Conscientiousness

It means (a) Being sensitive to full range of moral values and responsibilities relevant to the prevailing situation and (b) the willingness to develop the balance possible among those considerations. In nutshell, engineers must possess open eyes, open ears, and an open mind.

This makes the engineers s social experimenters, respect foremost the safety and health of the public, while they seek to enrich their, or care for only the beneficiary. The human rights of the participant should be protected through voluntary and informed consent.

3.4.2. Comprehensive perspective

The engineer should grasp the context of his work and ensure that the work involved results in only moral ends. One should not ignore his conscience, if the product or project that he is involved will result in damaging the nervous system of the people or even the enemy, incase of weapon development.

A product has a built-in obsolete or redundant component to boost sales with a false claim. In possessing of the perspective of factual information, the engineer should exhibit a moral concern and not agree for this design. Sometimes, the guilt is transferred to the government or the competitors. Some organizations think that they will let the government find the fault or let the fraudulent competitors be caught first. Finally, a full-scale environment or social impact study of the product or project by individual engineers is useful but not possible, in practice.

3.4.3. Moral autonomy

The morally responsible engineers are the one who are personally motivated to have a dedicated involvement in all aspects of a project.

3.4.4. Accountability

The term accountability means

- The capacity to understand and act on moral reasons.

- Willingness to submit one's actions to moral scrutiny and be responsive to the assessment of others. It includes being answerable for meeting specific obligations i.e., liable to justify the decisions, actions or means, and out comes.
- In short, responsible people accept moral responsibility for their actions.

3.5. CODE OF ETHICS

They provide guidelines for professionals, as to how to conduct their routine professional tasks with relation to the public well being and with ethical thinking.

The Oxford dictionary gives the following two definitions for codes

(a) A set of moral principles accepted by the society or a group of people.

(b) A set of rules arranged in a system.

3.5.1. Purposes Served by Code of Ethics

1. Inspiration and guidance

The codes express the collective commitment of the profession to ethical conduct and public good and thus inspire the individuals. They identify primary responsibilities and provide statements and guidelines on interpretations for the professionals and the professional societies.

2. Support to engineers

The codes give positive support to professionals for taking stands on moral issues. Further they serve as potential legal support to discharge professional obligations.

3. Deterrence and discipline

The codes serve as the basis for investigating unethical actions. Where such an investigation is possible, it also acts as a deterrent for the moral acts contemplated.

4. Education and mutual understanding

Codes are used to prompt discussion and reflection on moral issues. They develop a shared understanding by the professionals, public and the government on the moral responsibilities of the engineers. The Board of Review of the professional societies encourages moral discussion for educations purposes.

5. Create good public image

The codes present positive image of the committed profession, help the engineers to serve the public effectively.

6. Self regulation

It helps the engineers maintain self regulation and self control in ethical aspects of their profession.

7. Protect the status quo

They create minimum level of ethical conduct and promotes agreement within the profession. Primary obligation namely the safety, health and welfare of the public, declared by the codes serves and protects the public.

8. Promotes business interests

The codes offer inspiration to the entrepreneurs, establish shared standards, healthy competition, and maximize profit to investors, employees and consumers.

Limitations:

1. General and vague wordings: Many statements are general in nature and hence and hence unable to solve all problems.
2. Not applicable to all situations: It is not possible to analyse fully and predict the full range of moral problems that arise in complex situations. In these cases, codes form guidelines but not solutions.
3. Often codes create internal conflicts. At the same time these conflicts help development or modification of codes by debates and discussions.
4. They cannot be treated as final moral authority for professional conduct. Codes have flaws by commission and omission. They are still some grey are as undefined by codes. They cannot be equated to laws. After all, even laws have loopholes and they invoke creativity in the legal practitioners.
5. Only a few enroll as members in professional society and non-members cannot be compelled.
6. Even as members of the professional society, many are unaware of the codes.
7. Different societies have different codes: The codes cannot be uniform or same. Unifying the codes may not necessarily solve the problems prevailing various professions, but attempts are still made towards this unified codes.
8. Codes are said to be coercive: They are sometimes claimed to be threatening and forceful.

3.5.2. Reputed Engineering Societies that have Published Code of Ethics

1. American Society of Mechanical Engineers (ASME)
2. American Society of Civil Engineers (ASCE)
3. Institute of Electrical and Electronics Engineers (IEEE)
4. The Institution of Engineers (India)
5. National Society of Professional Engineers (NSPE)
6. American Institute of Chemical Engineers (AICHE)

3.6. INDUSTRIAL STANDARDS

A standard is defined as a set of technical definitions and guidelines that function as instructions for designers, manufacturers, operators or users of equipment. It may run from a few pages to hundreds, and is written by committee of professionals in a particular technical field.

Standards consists of explicit specifications that, when followed with care, ensure that stated criteria for interchange ability and quality will be attained standards are imported for an industry. Standardization reduces the production costs and at the same time, the quality is achieved easily. It helps the manufacturers, client and the public they preserve some competitiveness in industry by reducing overemphasis on name brands and giving the smaller manufacturer a chance to complete. They ensure a measure of quality and thus facilitate more realistic trade off decisions trade off decisions.

Industrial standards are established by the Bureau of Indian standards, in our country in consultation with leading industries and services. International standards are becoming a necessity with the development of the world trade. The International Standards Organization has now detailed specifications for generic products/ services with procedures that the manufacturers or service provides should follow to assure the quality of their products or service. Tables 3.1 lists some types of standards with a few examples.

In short standards facilitate the following

(i) Interchangeability

(ii) Accuracy in measurement

(iii)Ease of handling

(iv) Prevention of harms

(v)Reduce the production cost

(vi) Quality products

Table 3:1 Types of Standards

Criterion	**Purpose**	**Examples**
Uniformity of physical properties and functions	Accuracy in measurement interchangeability, ease of handling	Standards of weights screw thread dimensions, standard time, film size.
Safety and reliability	Prevention of injury, death, and loss of income or property	National Electric code, boiler code, methods of handling toxic wastes
Quality of product	Fair value for price	Plywood grades, lamp life
Quality of personnel and service	Competence in carrying out tasks	Accreditation of schools, professional licenses
Use of accepted procedures	Sound design, ease of communications	Drawing symbols, test procedures
Separability	Freedom from interference	Highway lane markings, radio frequency bands

3.7. A BALANCED OUTLOOK ON LAW

Law is that which is laid down, obtained or established. It is a body of rules of action prescribed by a controlling legal authority and having binding legal force. It is more often than not a written code of rules that must be obeyed by people under a given jurisdiction or those people will be subject to sanctions or legal consequences. Law is a solemn expression of the will of a supreme power, an authority.

The 'balanced outlook on law' in engineering practice stresses the necessity of laws and regulations and also their limitations in directing and controlling the engineering practice. Laws are necessary because people are not fully responsible by themselves and because of the competitive nature of the free enterprise, which does not encourage moral initiatives. Laws are needed to provide a minimum level of compliance.

Good laws when enforced effectively produce benefits. They establish minimal standards of professional conduct and provide a motivation to people. Further they act as moral support and protection for the people who are willing to act ethically.

Thus, it is concluded that

1. The rules which govern engineering practice should be construct as of responsible experimentation rather than rules of a game. This make the engineer responsible for the safe conduct of the experiment.
2. Precise rules and sanctions are suitable in case of ethical misconduct that involves the violation of established engineering procedures, which are aimed at the safety and the walfare of the public.
3. In situations where the experimentation is large and time consuming, the rules must not try to cover all possible outcomes, and they should not compel the engineers to follow rigid courses of action.
4. The regulations should be broad, but make engineers accountable for their decisions.
5. Through their professional societies, the engineers can facilitate framing the rules, amend them wherever necessary, and enforce them, but without giving in conflicts of interest.

3.8. THE PROPER ROLE OF LAW IN ENGINEERING

As we look at engineering as social experimentation, we find that the field of engineering develops products and services for the public good. In an experiment fails, causing damage to society in many forms, one thinks of regulating the field of engineering and its applications so that such damages do not recur. Here, we look at how such regulations work and the need for such regulatory criteria.

An engineer is bound by many rules and regulations. The country's civil and criminal laws are applicable to him/her if any of his/her actions are not legally justifiable. An engineer is also governed by the code of ethics of the professional society of which he/she is a member. In addition he/she is bound by the service rules and regulations as per the contract of the employment, either in the private sector or in the government sector. These, in general, do not put any restrictions on his/her professional activities.

Engineering projects are undertaken for the good of the society. However even projects are carried out with the best of intentions can have downsides. For example, a medicine taking for curing an illness can have side effects. A roadway constructed for easing traffic problems is for the good of the public. On the downside, it displaces many people living is the area of construction. A big dam has the potential to benefit people by irrigating their lands and generating power. However, it will have many long-term ill effects by damaging the ecosystem in the neighbor hood. Many engineering products emit radiations and can have long-term damaging effects on people. An Mp4 player used with head phone for a long time can damage your hearing organs. Likewise the list in endless. It is a delicate balancing act to execute engineering projects so that the least harm comes to the public. Regulation in engineering activities has to been in this light.

As technology develops and technological innovations come up, for the public good, one has to look at the side effects. The government steps in with many regulatory bodies, which frames rules and regulations to control the damage. The food and drugs control administration and environmental regulation are examples of agencies that have a say and control over what products and projects can be undertaken. Even though they do not have any executive or judicial powers, they have regulations that are similar to the laws of the country.

Industries complain of the retarding effect of such regulations. If you have to taken sanctions from various legal agencies before taking up a project, the gestation period of the project increases, resulting in enormous cost. The project thus becomes uneconomical and unviable.

Engineering products have gone global today. To be competitive in a global market, standardization is essential. Industries appreciate the need for such standards as these only add to their competitiveness. The standardization of products have thus become a matter of mutual consent and is not considered restrictive by industries.

Development in engineering and technology is a double-edged sword. Nuclear research is necessary as it can solve the energy needs of the exponential growth of world population. It has also created an arsenal of nuclear weapons, which can create catastrophic conditions. Research in biology is necessary, but biological welfare warfare is a threat. Research in genetics can be a boon but can also result in unknown hazarded. Regulation and the role of law is needed for a regulated development of the world society.

3.9. CASE STUDY -THE CHALLENGER DISASTER

The space shuttle challenger disaster of 1986 is a typical case of safety ethics. The fact that prior knowledge of a possible catastrophe existed and warnings (just before the accident) were ignored.

What happened?

After many delays, the space shuttle challenger was launched on 28 January 1986. The shuttle broke into pieces just 73 seconds into flight. All seven crew members died in the accident. The space craft disintegrated and fell into the Atlantic ocean off the coast of Florida. The accident was mainly attributed to a sealing ring, which did not perform well in the cold weather. There was structural failure after the leakage of the gas and this resulted in the disintegration of the shuttle.

Prior to challenger, the space shuttle used was titan missile and in 1974 NASA decided to build a large shuttle and awarded the contract to a company called Marton Thiokol, who developed a scaled up version of titan with additional booster cylinders. This design was approved by NASA in 1976.

A key aspect of the booster is the field joint where the individual cylinders containing the fuel are fastened together by tang and clevis joints as shown in figure.3.2 (a). Each joint is sealed by to O- rings, made of synthetic rubber to prevent leakage of hot gases. Since these O-rings are not optimally heat resistant, additional layer of putty is applied in the joint.

When the rocket is ignited the internal pressure causes the booster wall to expand outward pushing the joints to open slightly as shown in figure 3.2(b). The purpose of the putty is to take up this pressure and push O-rings into the gap for effective sealing.

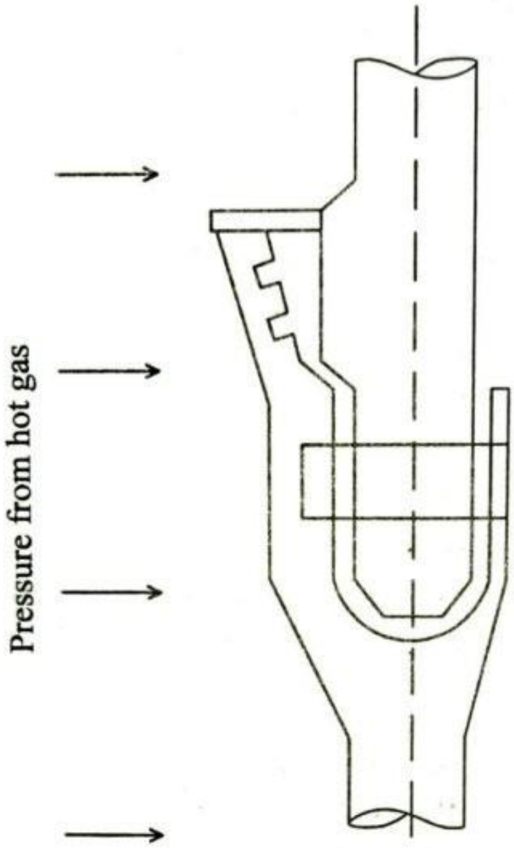

Figure 3.2 (b) Field joint after ignition

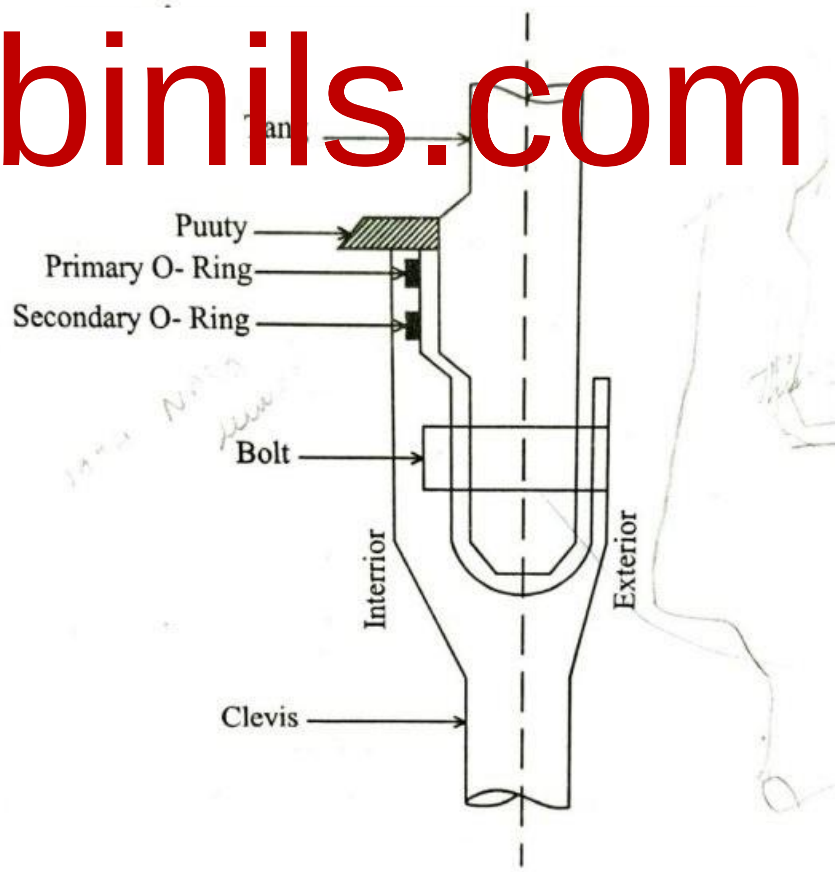

Figure 3.2(a) Field joint before ignition

Prelaunch scenario

The launch of challenger was originally scheduled for 22 January 1986. This was delayed due to many problems and scheduled for 23 January, and then for 25 January. There were further delays due to bad weather and the launch was rescheduled for 27 January. A technical problem arose with a microswitch and the launch was further delayed by one day and scheduled for 28 January.

The weather forecasts predicted that the morning of 28 January would be cold, with the temperature in the subzero range. There was snow all over the place and significant ice build up on the service structure. A team worked overnight to remove all the ice on the structure.

Before the launch, NASA at Alabama had a teleconference with Thiokol at Utah and Kennedy space centre. During this Thiokol engineers pointed out the existence of a cold front at the launch site, which is as low as 20°F (minus 8°c) supposedly lower than any previous launch period and expressed that the O-rings may not function properly at such low temperatures. The Morton Thiokol managers overruled the warnings given by engineers and recommended NASA to proceed with the launch. Another pressure on NASA was by the American vice president George Bush who was already unhappy at the temporary deferment of the first launch schedule, to arrange for this teleconference. Consequently NASA pressurized the senior manager of Morton Thiokol to overcome the resistance from their engineers and to get the project completed on schedule. The judgment of the engineers was not given weightage.

Launch

The launch took place on 28 January 1986 at 11.38 A.M. Several cameras were fitted on to the launch vehicle to monitor the critical are as and these are seen from the monitor TV screens at the ground station. Initially one of the cameras focusing on to the right booster recorded puffs of smoke coming from field joints. Due to extremely low temperatures, the O-rings became less elastic and did not seal properly. The putty, supposed to ne head resistant, also opened up the gap and due to the extremely low temperature did not regain its position. And, hot gases burned past the o-rings soon there was a flame that hit the external tank. Just 73 seconds into the launch, the shuttle broke apart and ended up in a large ball of fire and over the ocean. All the crew members died as there was no escape available to them.

REVIEW QUESTIONS

1. Why do uncertainties occur during the design process?
2. List some of the forms of the uncertainties that arise during the design process.
3. What do you understand by informed consent?
4. What are the similarities between engineering experiments and standard experiments?
5. The final outcomes of engineering projects, like those of experiments, are generally uncertain. Discuss.
6. What is meant by conscientiousness?
7. What are the general responsibilities of engineers to society?
8. Illustrate why it is not sufficient for engineers to rely on handbooks alone.
9. What are the aspects of engineering that make it appropriate to view engineering projects as experiments ?
10. What is social experimentation?
11. Discuss the moral issues that engineer faces at the design stage of the product.
12. List the responsibilities of engineering to society.
13. Discuss the responsibilities of engineers as experimenter.
14. What are codes of ethics?
15. What are the different roles and functions of codes of ethics?
16. What is the need for codes of ethics?
17. Explain the several purposes served by the codes of ethics?
18. What are the limitations of codes of ethics?
19. What are industrial standards?
20. What are the benefits of industrial standards?
21. What is law?
22. Enumerate the proper role of law in engineering.
23. What do you understand by balanced outlook on law?

24. How do the functions of standards, regulations, and laws differ from one another in their effects on engineering products and practice?

25. What are the moral and ethical lessons we can learn from the space shuttle challenger tragedy?

Two Marks and Answers

1. What reasons lead to many repetitions of past mistakes? [Apr / May 2021]

The absence of interest and channels of communication, ego in not seeking information, guilty upon the failure, fear of legal actions, and mere negligence have caused many a failure.

2. What are the general features of morally responsible engineers? [Apr / May 2021]

- A conscientious commitment to live by moral values
- A comprehensive perspective on relevant information
- Unrestricted free-personal involvement in all steps of the project development
- Be accountable for the results of the project

3. What are the uncertainties that occur in Model Design? [Apr / May 2019, Apr / May 2017]

The uncertainties may include uncertainties in the

(i) Design calculations

(ii) Exact properties of raw materials used

(iii) Constancies of materials processing and fabrication

(iv) Nature of working of final product

4. What is the Code of Ethics? [Apr / May 2019]

- The primary aspect of codes of ethics is to provide the basic framework for ethical judgment for a professional
- The codes of ethics, also referred as codes of conduct, express the commitment to ethical conduct shared by members of a profession. In other words, these codes furnish common. Agreed-upon standards for professional conduct.

5. What are the advantages of codes of ethics? [Nov / Dec 2018]

- Sets the right culture
- Builds a good reputation
- Attracts outstanding employees
- Helps remain in compliance with laws and regulations

6. What are the limitations of standardized experimentation? [Nov / Dec 2018]

- In standardized experiments there will be control group (used only when the project is limited to laboratory experimentation)
- "Informed consent" is not applicable in standardized experimentation

7. What are the limitations of codes of ethics? [Apr / May 2021, May / Jun 2016, Apr / May 2018]

General and vague wordings.

- Many statements are general in nature and hence unable to solve all problems

Not applicable to all situations.

- Codes are not scared, and need not be accepted without criticism. Tolerance for criticism of the codes themselves should be allowed.

8. What are the merits of standardized experimentation? [Apr / May 2018]

Standardized experiments reduces the production costs

Reduces time

Quality is achieved easily

It helps the manufacturer, customers and the public in keeping competitiveness

9. What is meant by engineering experimentation? [Apr / May 2017]

The engineering experimentation involves human beings as experimental subjects. In fact, clients and customers have more control. As they own the authority of that project. So here the experimental subjects are out of the engineering experimenter‟s control, unlike standard experiments.

10. How does the law facilitate ethics in engineering? [Apr / May 2017]

- The laws can authoritatively establish reasonable minimal standards of professional conduct
- The laws can provide a self-interested motive for most of the people and corporations to comply
- The laws act a s protector of ethical engineers. That means, they serve as a powerful support and defense to those who which to involve in ethical activities.

11. What is the need to view engineering projects as experimentation? [Nov / Dec 2016]

In engineering, each and every stage of product or process development experiments are conducted. There may be many uncertainties at each stage. But engineers cannot afford to delay projects until all the information is received. Thus the final outcome of an experiment could be uncertain. That is why, engineering projects are viewed as experimentation.

12. Enumerate the roles of codes in ethics of profession. [Nov / Dec 2016]

- Inspiration and Guidance
- Deterrence and Discipline
- Contributions to Public Image
- Education and Mutual Understanding

13. Differentiate scientific experiments and engineering projects. [**Apr / May 2021, May / Jun 2016]**

S. No.	Scientific experiments	Engineering projects
1	Scientific experiments are carried out with certainties	Engineering projects, like the standard experiments are carried out in partial uncertainties
2	The final outcomes of Scientific experiments are also generally certain	The final outcomes of engineering projects are also generally uncertain like those of other experiments

14. Why engineers are considered as responsible experimenters? [Apr / May 2015]

- Engineering projects, like the standard experiments, are carried out in partial uncertainties
- The final outcomes of engineering projects are also generally uncertain like those of other experiments.

15. Define „informed consent". [Apr / May 2015]

The experimenters whose experiments involve human subjects have moral and legal obligations to inform about all the relevant facts about the experiments to the person who participates in experiments. (**Hint: Informed consent is practiced in medical experimentation**)

Part B

1. Write short notes on the following: (i) Employee rights (ii) Professional Rights (iii) Occupational Crimes. [**Nov/ Dec 2020**]
2. Explain the characteristics of Morally Responsible Engineers. **[Apr / May 2019]**
3. Compare and contrast engineering experiments with standard experiments. **[Nov / Dec 2018, Apr / May 2018**]
4. Discuss the models of research ethics with suitable examples. **[Nov / Dec 2018]**
5. What is research ethics? Discuss the models of research ethics with suitable examples. [**Apr / May 2018**]
6. Explain the Challenger space shuttle disaster. Discuss the violation of moral ethical and professional codes of standards in it. Write a conclusion to avoid such disaster in future. **[Nov / Dec 2020, Apr / May 2015, Apr / May 2018]**
7. What is the importance of codes of ethics? Explain in detail. **[Apr / May 2021, Apr / May 2017]**

8. How can an engineer become a responsible experimenter? Explain in detail. **Apr / May 2021, May / Jun 2016, Nov / Dec 2016, Apr / May 2017]**
9. Explain in detail about balanced outlook on law. **[Nov / Dec 2016]**
10. Discuss on the roles played by the codes of ethics set by professional societies. [**May / Jun 2016]**
11. Explain how the codes of ethics guide an engineer in the professional behavior. **[Apr / May 2019, Apr / May 2015]**