Experiment in technical practice
1. Application of the experiment in product development

Classic (historical) process (last century)

- **EXPERIMENT**
  - material properties determining
  - verification of functionality, safety and the required criteria meeting

- **Each experiment is**
  - expensive
  - time-consuming

- **product development**
  - design
drawing documentation
  - prototype
  - serial production

Experimental methods – lecture 1
The new idea of the process (about in the 2000 year)

- CAD FEM
- 3D model
- virtual prototype
- database of materials
- virtual tests
- serial production

NO EXPERIMENT
- only a powerful computer and SW
- cheap, fast solution
This idea can be very dangerous !!!!

The space shuttle Columbia tragedy - February 2, 2003
A small piece of insulating foam was released from the tank and hit the left wing of the shuttle during the start.

It had no effect during the start, the shuttle normally flew into orbit.
the space shuttle Columbia tragedy

Engineers in the Flight Center drew attention to this problem, the impact was recorded on the video.

The management decided only to simulate the impact by the computer !!!

The simulation result?  NO PROBLEM, the foam is too soft, it could not damage the wing. But engineers still warned that the result might not be good and they wanted an experiment.

The management decided - no experiment, we believe in the simulation result!!!!

AND REALITY?
the space shuttle Columbia tragedy

One thermal ceramic protection plate was destroyed by the foam impact!

The shuttle was disintegrated during the landing.
All seven astronauts died!!!
the space shuttle Columbia tragedy

A real impact test was conducted during the accident investigation. The ceramic plate was destroyed by the impact of the foam!!

… but this finding came too late for the shuttle crew.
The current approach

**product development**

- **CAD FEM 3D model**
- **virtual prototype**
- **real prototype**
- **serial production**

**database of materials**

**EXPERIMENT**

- determining of
  - non-traditional material properties
  - material properties under extreme conditions

**virtual tests**

verification of functionality, safety and the required criteria meeting
2. Methodology of the experiment

real experiment

- **Exciter**
  - generates a load signal
  - corrects load parameters by the feedback

- **Measurement unit**
  - measures the loading signal
  - measures the response of the specimen to the load
  - displays measured signals in real time
  - performs time recording of the signals
3. Classification of experiments

- Short-term and one-off experiments
  - excitation by various signals – periodic, non-periodic, random, real
  - adherence to the exact shape, amplitude and speed of the excitation signals
    - precision exciter and its control system to maintain the exact shape, amplitude and speed of excitation signals
  - monitoring and measuring many physical quantities
    - precision measurement device for monitoring, measurement and recording a lot of signals

- Long-term experiments
  - excitation by various signals – periodic, random, real
  - often millions of cycles, it is usually not necessary to follow the exact shape of the signal
    - long-life exciter and its control system, long-term stability
  - usually simple monitoring, often the only criterion is to achieve a specified number of cycles without destroying the object
    - no measurement device
  - periodically repeated measurement and recording (e.g., every 1000th cycle)
  - automatic measurement and recording only when a criterion is met
    - long-term stability of the measurement device
    - possibility to set criteria for automatic recording
Single-purpose experiments
- periodically repeated experiment (quality control of serial production)
- usually simple excitation and simple monitoring
- often evaluating results in real time and sending a "good, bad" signal
- often automatic experiment implementation in an unattended production line
  - long-term stability of the exciter and the measurement device
  - possibility of programming for automatic operation
  - resistance to the operating environment
Experiment examples

measurement of the tow hitch beam stiffness during riding
Experiment examples

long-term test of the tow hitch with a bike carrier
Experiment examples

- crash test of the tow hitch - simulation of the crash to a wall when reversing

**Impact speed 1.2 ms⁻¹**

- hydraulic engine
- set of weights
- trolley
- rail
- barrier
- tested tow hitch

Diagram:
- tested tow hitch
- trolley
- hydraulic engine
- barrier
- rails
Experiment examples

crash test of the flood barriers - simulation of the wood log crash into a flood barrier

4m long and 400kg heavy wood log
impact speed 2ms⁻¹
Experiment examples

measurement of the mining machine cabin vibrations
**Experiment examples**

crash test of the student racing car impact attenuator

\[
v = \sqrt{2 \times g \times h} = \sqrt{2 \times 9.81 \times 2.5} \approx 7 \text{[ms}^{-1}\text{]}\]

\[
m = \frac{2 \times E}{v^2} = \frac{2 \times 7350}{7^2} \approx 300 \text{[kg]}\]
Experiment examples

measurement of forces and torques during carving skiing
4. Experiment realization procedure

Planning
- experiment methodology
- necessary testing machines
- necessary sensors and measurement unit
- necessary accessories
- data processing methodology
- result interpretation

Preparation
- design and manufacture of accessories
- testing device assembling
- sensors connection
- sensors calibration
- measurement unit setting
- exciter setting and programming

Realization
- experiment implementation
- data acquisition
- photo documentation
- video recording

Processing
- data processing
- test report
- result interpretation

Time distribution
Exam questions

- Application of the experiment in product development
  - historical and current state, block diagrams (pages 2 and 9)
- Methodology of the experiment
  - block diagram (page 10)
- Classification of experiments
  - types of experiments and their brief characteristics (page 11, 12)
- Experiment realization procedure
  - 4 steps of the experiment realization and their brief characteristics (page 20)