Lezione 1

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MDLB2425 → Password for slides.
10-12 → Monday
13-17 → Friday } 6 hours/week

Classes end around the of March. → then final project.

Homework by 8/5 is the report on the experimental lab.

Experimental lab is joined between A and B, it has something to do with the worm gear

Part A → CAD and drawings
Part B → Calculations.

Part B is a short report on the appropriate calculations.

"open book" mechanical design written test, consists of 7/8 of the course. 18/30 needed.

R. D. Cook
"Finite Element modelling for Stress Analysis"

Books are not needed to pass the course.

What the course will teach?

General topics on what is mechanical & machine design.

↳ Technical Design

↳ Every part has been thought of and calculated.

↳ We learn also how to choose and where to place parts, to then design it.

Every parts of a machine needs to be designed well and chosen appropriately.

Mechanical (Machine) Design

↳ Design, Sizing and Checking some of the main machine elements.

We need to review CdM → since it will not be reviewed.

Shaft, Bearing, Gears, connections and threaded connections.

What is a machine?

Machine

↳ Anything that transforms and use power and energy, for a job.

Mechanical Design is the activity that responds to the need to realise the mechanical functions with minimum costs. There are many solutions, but we need to minimise the cost so there is one best solution.

Creativity delivers the many solutions to the problem.

Reducing cost with maximal service safety and functional efficiency.

Come up with solutions, complying with constraints, and choosing the best such solution.

optimal

The cost of failure is much greater than the cost of designs.

Prevention is usually cheaper than bad designs.

Damage to third parties can lead to prison time.

most common part failure

Classification of mechanical failures

- Welds
- Shafts
- Bolts
- Pulleys
- ...

90% from stress concentration, due to geometric shape.

not all

Most failures (~80%) come from fatigue.

78% of failures are due to inappropriate design.

Most design failures come from design errors on notched elements subject to fatigue.

With the hypothesis (and objective) of not wanting failures?

Steps:

- → Concept (Thinking)
- → { Design (Developing) → calculations, shapes and materials.
- → Drawing (communication) } → Focus of part A.
- → Manufacturing (Realising)
- → Service (using)

What we look at in lab B

In reality it's not linear, at every step we get feedback which we can use. → pg. 13

Main Principle of Machine Design

$$\boxed{\phi_{max} \leq \frac{\phi_{lim}}{\eta}}$$

ϕ → quantity of interest (stress generally)

physical or not for our design.

→ We want to fulfill this condition

→ The real skill is applying this to every design, while also applying it to the monetary design.

ϕ_{max} → worst condition.

ϕ_{lim} → limit condition

η → safety factor.

$\frac{\phi_{lim}}{\eta}$ → the permissible condition.

If the condition is not satisfied during the design, we can do two things: working on the shape and size of the design, or working on the material. Or both.
(geometry)

→ This can be seen as both a good thing or a bad thing.

Usually we cannot work on the external load, maybe we will not even be able to know the loads.

Specifications → limitations on design and money.
- → the least of the relationships that we need to satisfy.
- → size, money, material are some common specifications.
  - → all common are:
    - → stress and strength (stress concentration
    - → deflections of the machine, or stiffness of the design
      - → in some case we make the piece so stiff (by adding material) that the stresses are not a problem.
    - → ergonomics
    - → technological processes.
    - → assembly and dissassembly: the possibility of assembly and therefore disassembly must be guaranteed.
    - → Inspection, maintainance and assistance ability.
    - → Recycling / Sustainability / ability to reuse at the end of life cycle.

↳ aesthetics and design.
↳ misuse → what the user does with a product that you have not though about
↳ we can use a user-manual to avoid culpability in case a person misuses the product.

Lack of uniqueness in solutions in machine design
↳ In machine design, the uniquess of solutions does not exist. There can be ∞ acceptable solutions, in the end, all acceptable design specifications are met.

A lack of specifications means that you have to justify the choice.

Uniquess means singularity, there are many solutions, there never is only one.

The onus of the choice is on the designer.

Materials: → These are the distribution for mechanical engineering
↳ Steel: ~70% of uses
↳ Cast Iron: ~15%
↳ Non-ferrous metals and alloys: ~10%
↳ Polymers:
↳ Ceramic materials → concrete and glass and others
↳ Composites (mix of two or more of the above)

Aeronautical → more use of alloys and polymers for less weight

Civil Engineering → more ceramics like concrete and glass.

Pre-sizing and checking.

Two scenario

look at similar projects

↓

accurate calculations for this use.

↓

Few changes to design.

There is no outline or similar product.

↓

Pre-sizing, build product based on simplified specifications.

↓

Multiple checks on accurate calculations and corrections are applied

More interest and what we will be looking at generally

Safety Factor (η)

↳ There are a lot of things we don't know that influence on the real result. To protect us from the variability we add the safety factor.

$$\eta = \frac{\text{limit condition}}{\text{in-service condition}}$$

→ it is basically a measure on how ignorant I believe I am on the problem, the low the more confident.

We choose the safety factor but also the size are based on η, every cost is dependent on it.

Then in the final check we find the η and based on what we get, we determine if we are okay with it or not.

η → Below minimum: risk of failure too high

↳ Unnecessarily high: oversized component, i.e. too expensive.

Oversized is as wrong as oversized.

Also tells us if the design is acceptable.

Standards and norms

↳ Almost all macchine elements are fully standardised, we must not develop new things every time. We do the calculations on what is on the catalogue a choose. Shafts on the other hand are not standardized (except some parts) so we have to design that.

Anytime we have a standard we should use it.

Why we use them:
- ↳ technical → they tell you how to use it
- ↳ We use a standard so we are less culpable.

Again, eventhough we typically say that the cycle is linear, in reality it's more like a V, at every step we get feedback.

We devide the system into subsystems, every part is designed accordingly. Then as we reintegrate each part into every subsystem we need to recheck that what we designed does what they intend to do.