Design gudielines

Lecture 6

Schedule

Week nr.	Date	Lecture (Wednesday)			Lab (Wednesday)		Comment
1	09.04.	1	General information		1	Lab	
2	09.11.	2	Development methods		2	Lab	Online
3	09.18.	3	Design goals and requirements		3	Lab	
4	09.25.	4	Conceptualization I		4	Lab	
5	10.02.	5	Design guidelines		5	Lab	
6	10.09.	6	Testing strategies in the automotive industry		6	Lab	
7	10.16.	T1	Midterm exam I.				
8	10.23.	B	National holiday				
9	10.30.	7	System level testing		T1 R	Exam 1 - Retake	Online
10	11.06.	8	Performance and reliability testing		7	Lab	
11	11.13.	9	Troubleshooting and error calculation		8	Lab	
12	11.20.	10	Project management		9	Lab	Online
13	11.27.	T2	Midterm exam II.				
14	12.04.	T2R	Exam 2 - Retake				

- Detailed design phase
- Key design principles
- Industry standards and regulations
- Top-down, and Bottom-up Design
- Specific design guidelines
- Design for X
- Lessons learned
- Q & A

Detailed design phase

- Reviewing, Expanding, and Developing Design Requirements:
  - This involves critically evaluating the existing design criteria, identifying any additional requirements, and refining them to ensure a comprehensive foundation for the design process.
- Establishing Constraints and Boundary Conditions Influencing the Design:
  - This step focuses on defining the key constraints or boundary conditions (such as technical, regulatory, or physical limitations) that shape or limit the design process.
- Identifying and Structuring the Primary Functional Carriers:
  - In this phase, we will focus on determining the main components or subsystems that carry out essential vehicle functions and outline their preliminary design.
- Reviewing, Critiquing, and Improving Preliminary Designs:
  - This stage includes evaluating early-stage designs, providing constructive feedback, and making improvements to refine the concept before moving to more detailed development.

Detailed design phase

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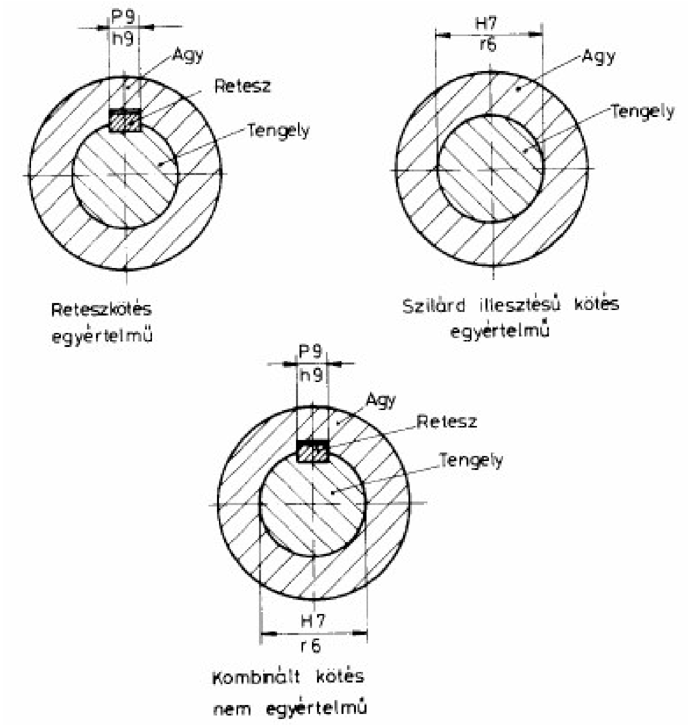
- Preliminary Design of All Major Functional Carriers:
  - This step involves the rough, conceptual design of the primary components or subsystems responsible for major vehicle functions.
- Identifying Necessary Auxiliary Functions and Their Carriers:
  - Students will determine the supporting functions required for the vehicle and identify the components or subsystems responsible for carrying out these auxiliary functions.
- Detailed Design of Major and Auxiliary Functional Carriers:
  - This phase requires a more detailed design of both primary and secondary systems, ensuring that all components meet functional and technical requirements.
- Review, Technical-Economic Evaluation, and Weakness Analysis of Major Design Variants:
  - Here, we will critically review different design alternatives, evaluate their technical and economic feasibility, and identify potential weak points through failure analysis.
- Selection and Detailed Development of the Optimal Design Variant:
  - After evaluating alternatives, the optimal design solution is selected, and students will work on its detailed development.
- Detailed Design and Optimization of Functional Carriers and Structural Elements:
  - In this final step, students focus on the detailed design and optimization of specific components and structural elements to ensure performance, reliability, and efficiency.

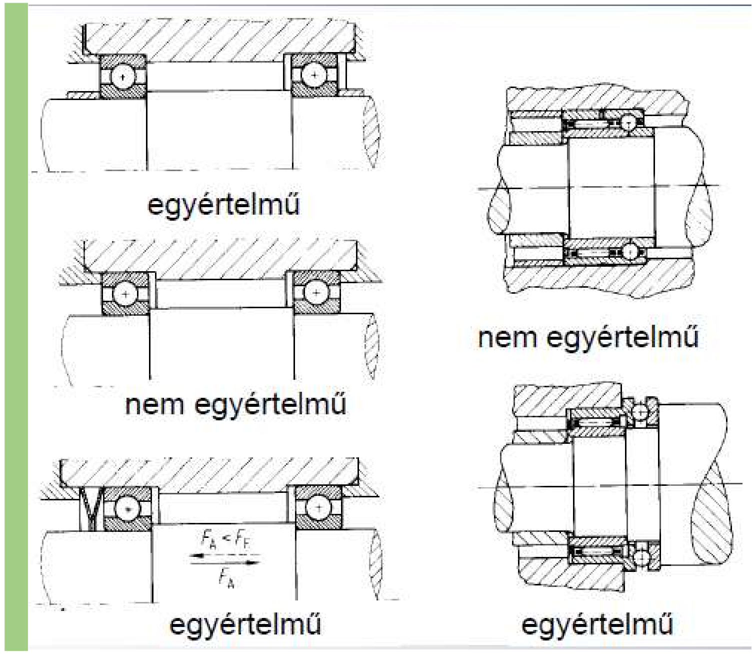
Design principles

- Key design principles
  - Clarity
  - Simplicity
  - Safety
- Complex design principles
  - Ergonomics
  - Reliability and durability
  - Sustainability

Key design principles

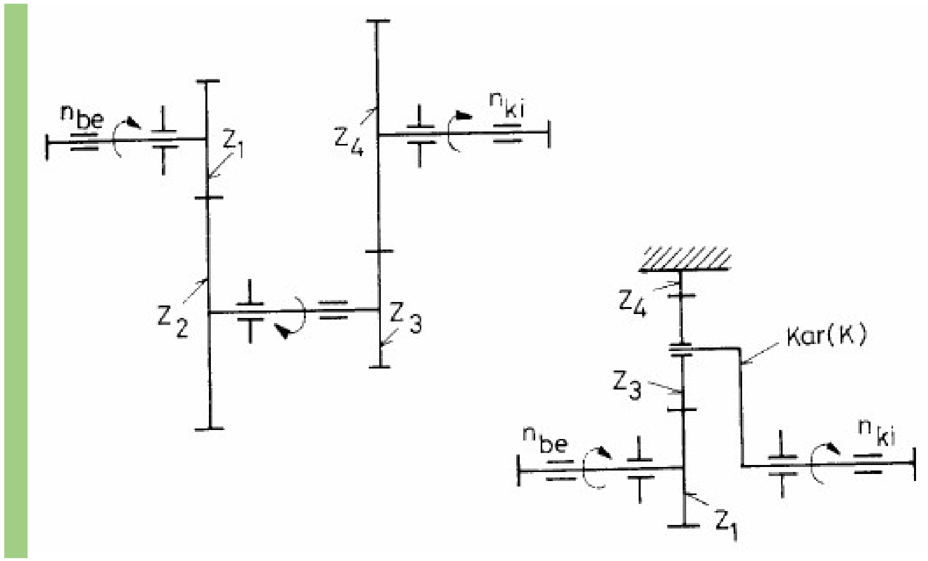
- Clarity
  - Adhering to clarity ensures the fulfillment of the technical function, the unambiguous relationship between input and output, and the reliable determination of effects and behavior.





Key design principles

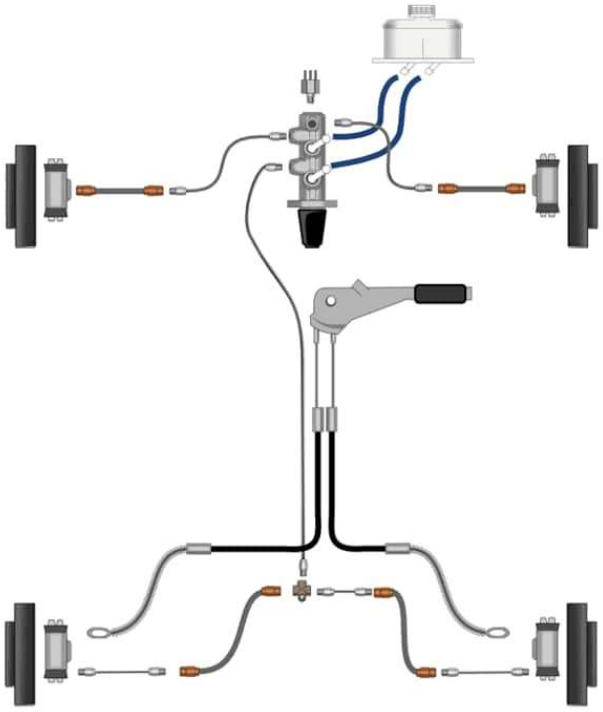
- Simplicity
  - A simple design with fewer parts generally leads to an economical solution.



Key design principles

- Safety
  - It refers to the reliable fulfillment of the technical function, as well as the protection of people and the environment.
  - Direct Safety
    - Choose a solution that is inherently not dangerous.
    - Principles:
      - Guaranteed compliance
      - Limited failure
      - Redundant arrangement
  - Indirect Safety
    - Use of protective systems and devices.
  - Indicative Safety
    - Only provides a warning of the danger.

Key design principles



Industry standards and regulations

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Importance of Industry Standards

- **Definition:** Industry standards are established guidelines that ensure safety, quality, and efficiency in automotive design and production.
- **Role in Automotive Sector:**
  - Promote safety for drivers, passengers, and pedestrians.
  - Enhance product quality and reliability.
  - Ensure environmental sustainability and compliance.
- **Impact on Consumers:** Boosts consumer confidence through certifications and safety ratings.

Industry standards and regulations

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SAE (Society of Automotive Engineers)

- **Overview of SAE:**
  - A professional organization that develops standards for engineering professionals in the automotive sector.
- **Key Standards:**
  - **SAE J3016:** Defines levels of driving automation.
  - **SAE J1349:** Standard for measuring engine power.
- **Benefits of SAE Standards:**
  - Provides a framework for design and testing.
  - Facilitates communication between manufacturers and regulators.
  - Encourages innovation while maintaining safety standards.

SAE INTERNATIONAL®

https://en.wikipedia.org/wiki/SAE_International; ;

Industry standards and regulations

ISO (International Organization for Standardization)

- **Overview of ISO:**
  - A globally recognized organization that sets international standards across various industries, including automotive.
- **Key Standards:**
  - **ISO 9001:** Focuses on quality management systems, ensuring consistent product quality.
  - **ISO 26262:** Addresses functional safety in automotive systems, particularly for electronic and electrical systems.
- **Significance of ISO Certification:**
  - Enhances operational efficiency and customer satisfaction.
  - Provides a competitive edge in the global market.
  - Ensures compliance with international safety and quality benchmarks.

https://www.rewo.io/what-are-iso-compliant-work-instructions-and-how-to-write-them/ ;

Industry standards and regulations

NHTSA (National Highway Traffic Safety Administration)

- **Overview of NHTSA:**
  - A U.S. government agency responsible for promoting vehicle safety and regulating the automotive industry.
- **Key Responsibilities:**
  - Establishes and enforces safety standards for motor vehicles.
  - Conducts vehicle crash tests and publishes safety ratings.
- **Impact of NHTSA Regulations:**
  - Protects consumers through mandatory recalls and safety campaigns.
  - Promotes the adoption of advanced safety technologies (e.g., airbags, electronic stability control).

https://www.nhtsa.gov/files/edit-nhtsa-brandpng ;

Industry standards and regulations

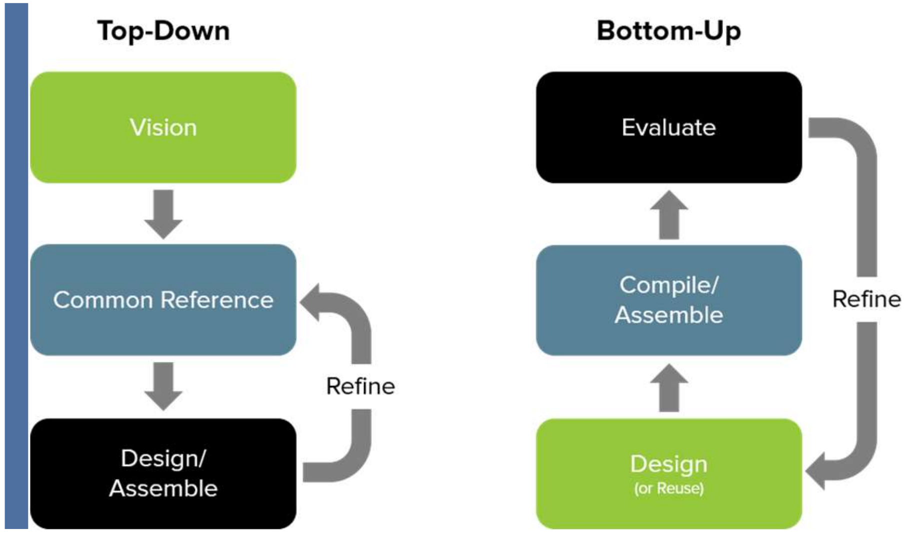
EPA (Environmental Protection Agency)

- **Overview of EPA:**
  - The U.S. agency responsible for regulating environmental standards, including those related to vehicle emissions.
- **Key Regulations:**
  - **Clean Air Act:** Sets emissions standards for vehicles to reduce air pollution.
  - **Corporate Average Fuel Economy (CAFE) Standards:** Mandates improvements in fuel efficiency across manufacturers' fleets.
- **Importance of EPA Compliance:**
  - Encourages manufacturers to innovate in clean technologies.
  - Protects public health and the environment.
  - Aligns with global efforts to combat climate change.

https://hu.m.wikipedia.org/wiki/F%C3%A1jl:Seal_of_the_United_States_Environmental_Protection_Agency.svg ;

Top-down, and Bottom-up Design

- Top-down
  - Starts with a high-level concept and breaks it down into smaller, detailed components. This method ensures that the overall structure and functionality are defined early in the design process.
- Bottom-up
  - begins with creating detailed components and then integrates them to form the complete system. This approach allows for flexibility and innovation at the component level before assembling the final product.
- Middle-out
  - combines elements of both top-down and bottom-up approaches, starting with a central component and expanding outwards. This method balances the need for a strong core structure with the flexibility to adapt and refine individual parts.



Recommended: https://help.autodesk.com/view/INVNTOR/2025/ENU/?guid=GUID-63FA128E-63E2-4176-8653-327BD80D8A43

https://www.m3design.com/guide-to-top-down-design/ ;

Specific design guidelines

- Principles of power transmission
  - Short and direct
  - Coordinated deformation
  - Force equilibrium
- Self-Help
- Design correctness from the perspective of …

Specific design guidelines

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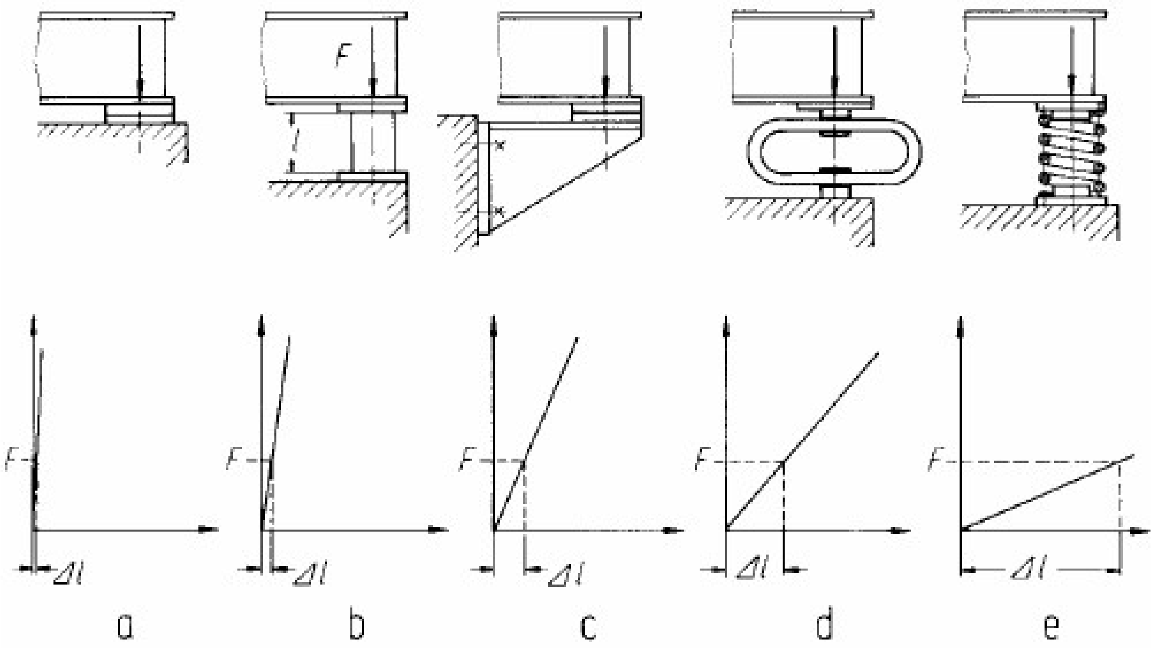

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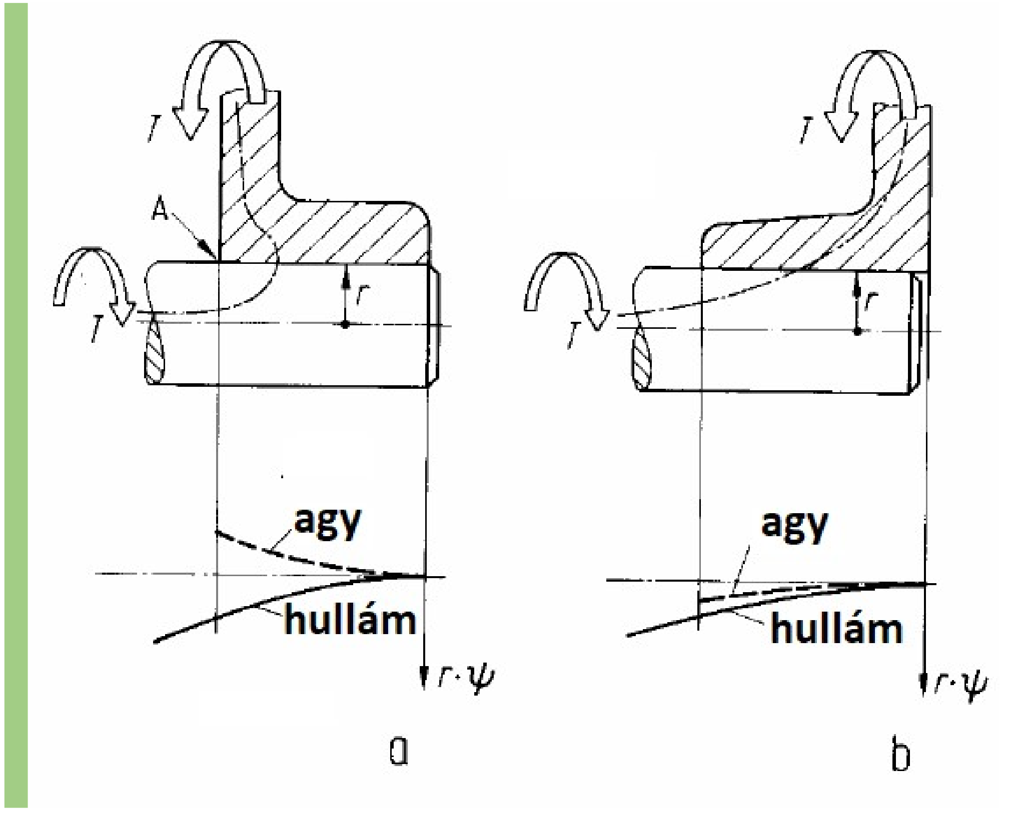

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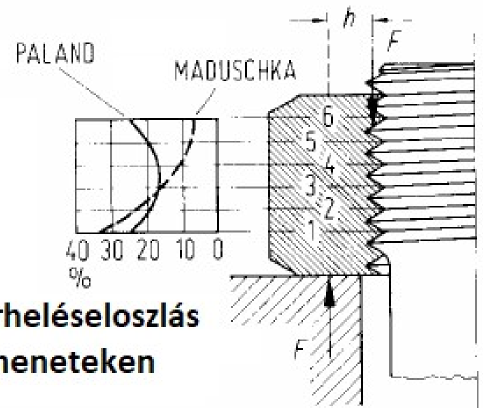
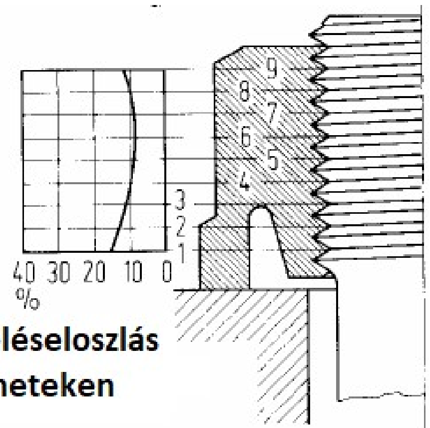


Terheléseloszlás a meneteken



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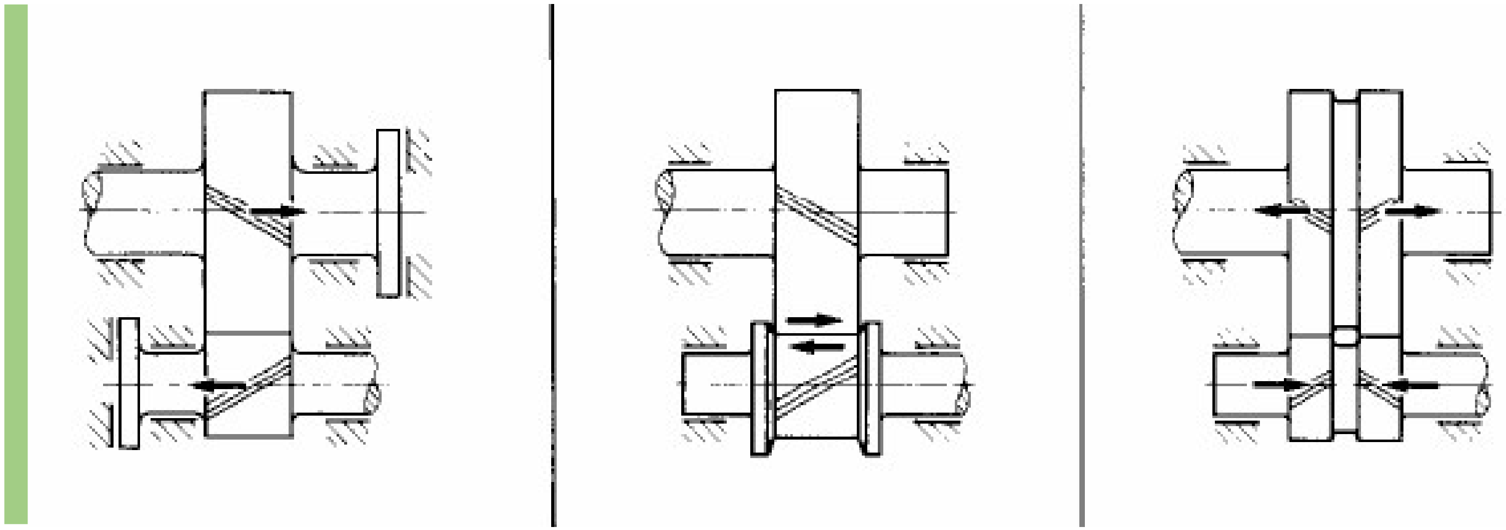
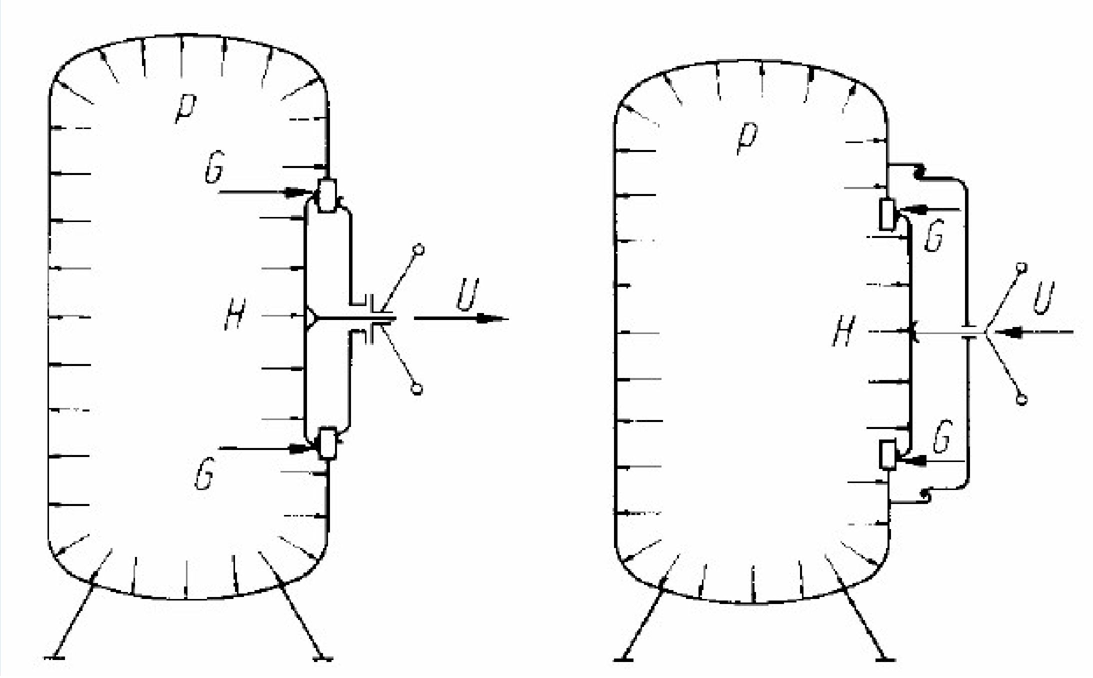


Specific design guidelines

- Self-Help



Specific design guidelines

- Design correctness from the perspective of
  - Thermal expansion
    - This refers to the appropriate design considerations that account for the expansion and contraction of materials due to temperature changes.
  - Relaxation
    - This addresses the construction methods that prevent creep (permanent deformation) under load at high temperatures.
  - Corrosion
    - This focuses on preventing corrosion through appropriate material selection and protective measures.
  - Manufacturing and assembly
    - This emphasizes designing components for ease of production and assembly, ensuring efficient manufacturing processes.
  - Standards
    - This involves adhering to established standards and regulations to ensure safety, quality, and compatibility.
  - Form and appearance
    - This considers the aesthetic aspects of the design, ensuring that the shape and appearance meet functional and consumer expectations.

Design for X (DfX)

- **Definition:** Design for X (DfX) refers to a set of design principles aimed at optimizing specific attributes or characteristics of a product. The "X" represents various aspects such as manufacturability, assembly, reliability, etc.
- **Purpose:** To improve various aspects of the product lifecycle, ensuring enhanced performance, quality, and cost efficiency.

Pro: Improved product quality, cost savings, faster time to market, enhanced customer satisfaction

Cons: Complex trade-offs, initial investment, cross-disciplinary collaboration

Meets specific customer needs and expectations by focusing on critical attributes.

https://www.youtube.com/watch?app=desktop&v=REIB2_VKPJw ;

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	DfM	DfA	DfR	DfC	DfS
Aim	Simplifying manufacturing process	Simplifying assembly process	Ensuring the product functions reliably over its intended lifecycle.	Reducing the overall cost of the product.	Minimizing the environmental impact of the product.
Key points	Reducing nr of parts, standardizing materials, minimizing complex features	Reducing the number of assembly steps, using self-locating parts, and designing for ease of part handling.	Using robust materials, incorporating redundancy, and conducting thorough testing.	Optimizing material usage, simplifying the design, and improving production efficiency.	Using eco-friendly materials, designing for energy efficiency, and facilitating recycling.

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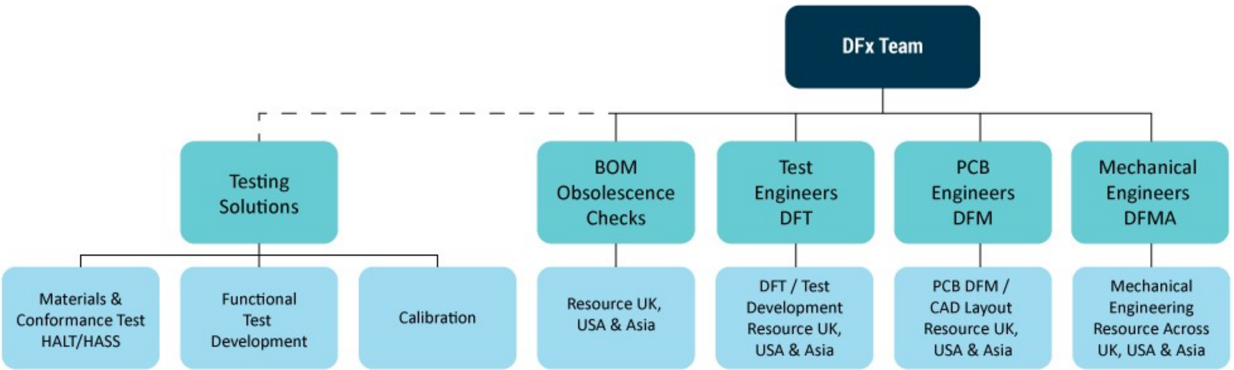


Traditional Engineering vs DFX

Traditional Engineering Design	Designing for Excellence (DFx)
Address issues after the design phase	Address issues at early design stage
Many iterations of a product	Goal is to limit iterations (get it right the first time)
Use of many tools	Select use of an efficient set of standardized tools
Considers functional requirements	Considers the product life cycle requirements
Less team based (less involvement from manufacturing, suppliers and customers)	Team based (more collaboration, supplier involvement, project management)

#work in delta

Highly recommended content:https://www.ttelectronics.com/blog/design-for-excellence/

https://www.ttelectronics.com/blog/design-for-excellence/

Design for X (DfX)

- **Tools and Techniques:**
  - Failure Modes and Effects Analysis (FMEA): Identifies potential failure modes and their impact on product performance
  - Value Engineering (VE): Analyzes the functions of a product to improve value by either improving function or reducing cost.
  - Design of Experiments (DOE): Systematically tests different design variables to optimize product performance.
  - Computer-Aided Design (CAD) and Simulation tools: Use software to model and simulate different design attributes.

https://www.ttelectronics.com/blog/design-for-excellence/

Case studies and examples

- Shutdown Circuit schematic for FS

- LV: low voltage
- MS: master switch
- BSPD: brake system plausibility device
- IMD: insulation monitoring device
- AMS: accumulator monitoring system
- AS: autonomus system
- RES: remote emergency system
- BOTS: brake over travel switch
- TS: tractive system

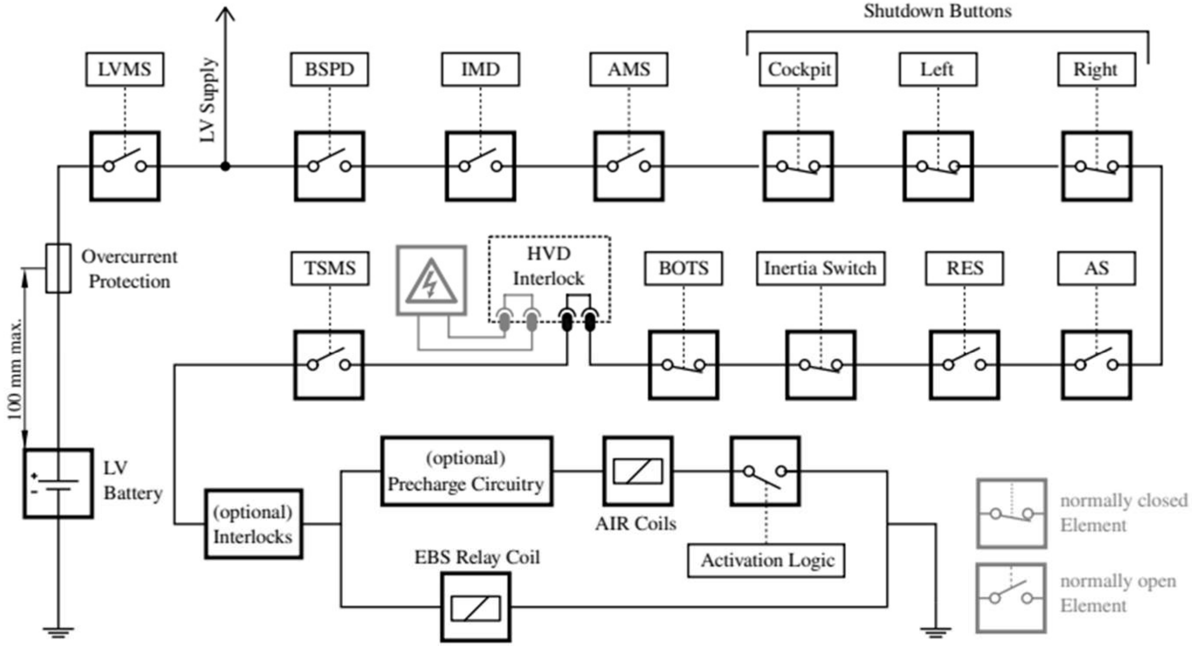


Figure 22: Explanatory example schematic of the required Shutdown Circuit (SDC)

https://www.formulastudent.de/fileadmin/user_upload/all/2024/rules/FS-Rules_2024_v1.1.pdf; ;

Case studies and examples

- Top down design – skeleton
  - What to include to a skeleton for FS car?
    - Track, wheelbase, tyres, rims
    - Percy, cockpit template
    - Engine
    - Suspension rods
    - Chassis tubes

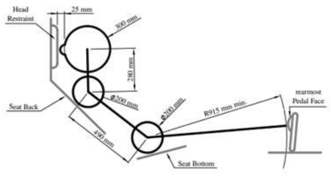


Figure 14: Percy placement

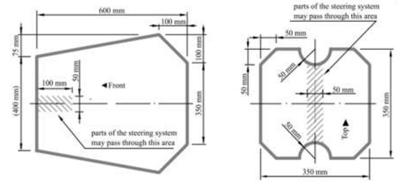


Figure 12: Cockpit opening template (left) and cockpit internal cross section template (righ

T4.3 **Percy (95th percentile male)**

T4.3.1 When seated normally and restrained by the driver's restraint system, the helmet of a 95th percentile male and all of the team's drivers must, see figure 13:

- Be a minimum of 50 mm away from the straight line drawn from the top of the main hoop to the top of the front hoop.
- Be a minimum of 50 mm away from the straight line drawn from the top of the main hoop to the lower end of the main hoop bracing if the bracing extends rearwards.
- Be no further rearwards than the rear surface of the main hoop if the main hoop bracing extends forwards.

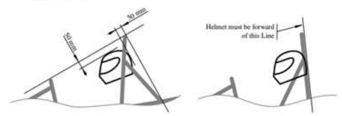
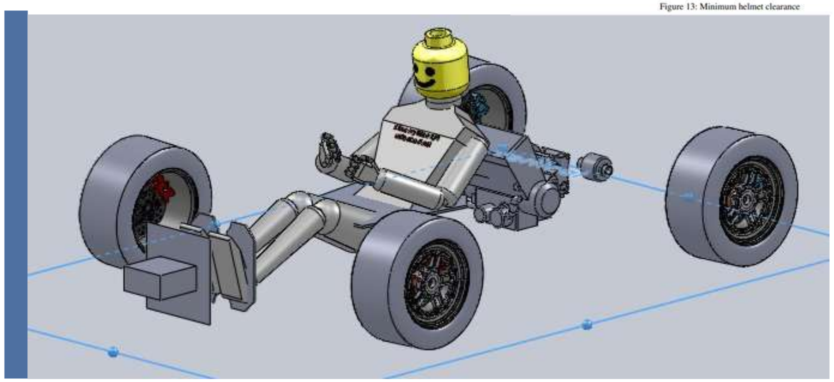


Figure 13: Minimum helmet clearance



https://www.designjudges.com/articles/starting-a-formula-sae-team-from-scratch ;

Q & A

- Main objective?
- Starting point-ending point?
- Complex parts?
- Less relevant part(s), could be omitted part(s)?
- Most useful part(s)?

Closing

- Bibliography

  - See bottom of slides
  - Tervezéselmélet és módszertan (BMEGEGE MGTM) Előadások Dr. Horák Péter BME GT3 Tanszék 2010
  - https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.nhproequip.com%2Fpro-cr3000-car-rotator&psig=AOvVaw25RMOCgAAVkurq5zlLLJ0f&ust=1601405331093000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCMi-nPLBj0wCFQAAAAAdAAAAABAO
  - https://www.google.com/url?sa=i&url=https%3A%2F%2Fgrimas.hu%2Ftermek%2Finspekt-100-kn-1500-kn-szakitogepek%2F&psig=AOvVaw3NlXWg_z4JRtOxA17FGGpT&ust=1601405395606000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCJi4tKTCj0wCFQAAAAAdAAAAABAX

- Literature

  - W. Ernst Eder: Engineering Design: Role of Theory, Models, and Methods
  - Julian Weber - The Automotive Development Process: Processes for Successful Customer Oriented Vehicle Development
  - Markus Maurer, Hermann Winner - Automotive Systems Engineering
  - Christian Grönroos - The V-Model of Service Quality: An Application in Automotive Services
  - Gerhard Pahl, Wolfgang Beitz - Engineering Design: A Systematic Approach
  - Jiju Antony - Design of Experiments for Engineers and Scientists
  - Dominic Haider - Automotive Functional Safety: A Complete Guide to ISO 26262
  - Bercsey Tibor - A terméktervezés módszertana.Jegyzet
  - Pahl-Beitz - A géptervezés elmélete és gyakorlata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