

# AALBORG UNIVERSITY

JAN PLISKA



AALBORG UNIVERSITY  
DENMARK

# AALBORG UNIVERSITY

- Založeno 1974
- V souč. přes 18,500 studentů
- Problem-based and project-oriented teaching method (PBL)
- Mezinárodní porovnání univerzit:
  - US News World Ranking:  
AAU 260. Celosvětově (VUT 399. )
  - V oblasti **engineering**:  
AAU 4. Na světě (VUT 472.)  
AAU 1. V Evropě
  - Potvrzeno v 2018 MIT „The global state of the art in engineering education“ report



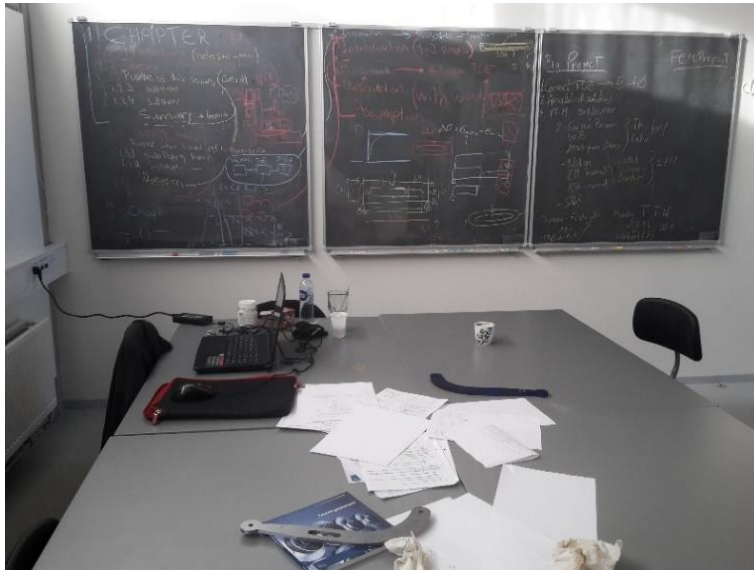
[<https://www.en.aau.dk/research/ranking/>]



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# PROSTŘEDÍ

- Grouprooms/třídy

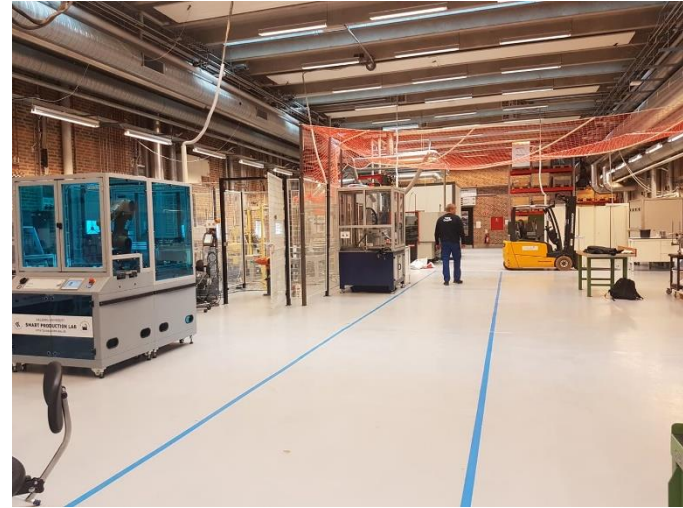


- Laboratoře



# PROSTŘEDÍ

- Dílny
  - Klasická
  - Těžké stroje
  - Roboty



# ORGANIZACE VÝUKY

Semester	Module	ECTS	Grading	Exam
1.	Stress and Deformation Analyses of Load Carrying Structural Element	15 <sup>1</sup>	7-point scale	Internal
	Stress and Deformation Analyses of Load Carrying Structural Element (INTRO semester)*	10	7-point scale	Internal
	Solid Mechanics with Microstructure	5	7-point scale	Internal
	Fracture Mechanics and Fatigue	5	7-point scale	Internal
	Finite Element Methods	5	7-point scale	Internal
	INTRO Course: Problem-based Learning, Theory of Elasticity and the Finite Element Method, MATLAB.*	5	Pass/Fail	Internal
2.	Engineering Design of Mechanical Systems	15	7-point scale	External
	Engineering Optimization – Concepts, Methods and Applications	5	7-point scale	Internal
	Mechanics of Composite Materials and Structures	5	7-point scale	Internal
	Energy and Variational Methods with Applications	5	7-point scale	Internal
3.	Industrial Development	20, 25, 30	7-point scale	Internal
	Internship <sup>2</sup>	20, 25, 30	7-point scale	Internal
	Elective courses**			
	Computational Fluid Dynamics (CFD) and Multiphase Flow	5	7-point scale	Internal
	Test and Validation	5	Pass/Fail	Internal
4.	Design of Mechanical Systems	30, 50, 60	7-point scale	External



# ORGANIZACE VÝUKY

- Výuka formou 2-4 hodinových přednášek
- Prezentace výsledků v hodinách (+feedback)
- 7.-12. týden semestru bez výuky – v případě potřeby konzultace přímo s vyučujícími
- Zkouška (ústní, 15 min)
- Obhajoba projektu

Week 40

Monday	Tuesday	Wednesday	Thursday	Friday
02/10/2017	03/10/2017	04/10/2017	05/10/2017	06/10/2017
[E17] Finite Element Methods (DMS1, EMSD1, VT1) [C-A-M] <i>Erik Lund</i> Time: 08:15 - 12:00 Location: Pon 111/1.177 Note:	[E17] Fracture Mechanics and Fatigue (DMS7, BAKK9) [C-A-M1] <i>Jens H. Andreasen</i> Time: 08:15 - 12:00 Location: Fib 16, 1.108 Note:	[E17] Solid Mechanics with Microstructure <i>Jan Schjodt-Thomsen</i> Time: 08:15 - 12:00 Location: Fib 16, 1.111 Note:	[E17] Finite Element Methods (DMS1, EMSD1, VT1) [C-A-M] <i>Erik Lund</i> Time: 08:15 - 12:00 Location: Pon 111/1.177 Note:	[E17] Fracture Mechanics and Fatigue (DMS7, BAKK9) [C-A-M1] <i>Esben Lindgaard</i> Time: 08:15 - 16:00 Location: Fib 16 1.108 Note: from 12.30 room 1.101

- 2 hodiny přednáška
- 2 hodiny pro vypracování zadaných příkladů

- 4 hodiny přednáška
- 4/8 hodin pro vypracování zadaných příkladů



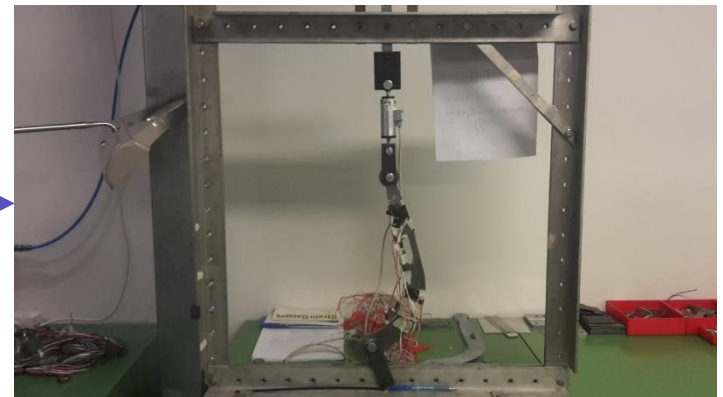
# 1. SEMESTR

- INTRO course: PBL, Theory of Elasticity, FEM, Matlab
- Solid Mechanics with Microstructure
- Fracture Mechanics and Fatigue
- Finite Element Methods
  - Miniproject
- **Project: Stress and Deformation Analysis of a Load Carrying Structural Element**

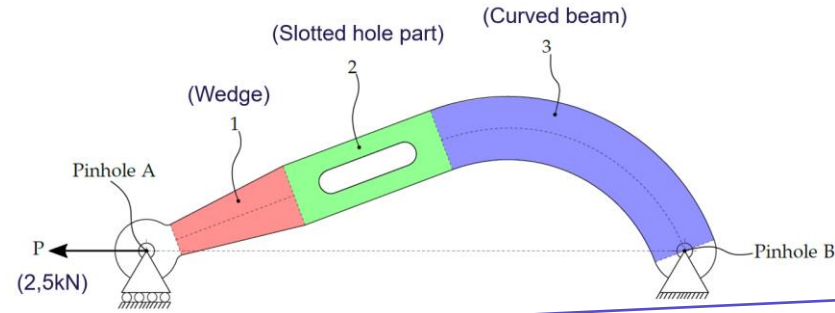
1. Static stress analysis
2. Element technology
3. Substructuring
4. Validation of the FE model (mesh convergence study, check of reaction forces, etc.)
5. Error estimation and adaptive mesh generation
6. Free vibration analysis (eigenfrequency problem)
7. Structural dynamic problems (using mode superposition)
8. Structural dynamic problems (using direct time integration)

9. Multi-physics problems (e.g. thermo-elastic)
10. Static geometrically nonlinear analysis
11. Behaviour of nonlinear systems (special equilibrium points and effects)
12. Nonlinear solution methods
13. Linearized buckling analysis
14. Pre-stressed free vibration analysis (static stress + eigenfrequency problem)
15. Contact analysis
16. Constraint equations (Multi-Point Constraints - MPC's)
17. Nonlinear material modelling and analysis
18. Symmetry considerations

Témata FEM miniprojektů



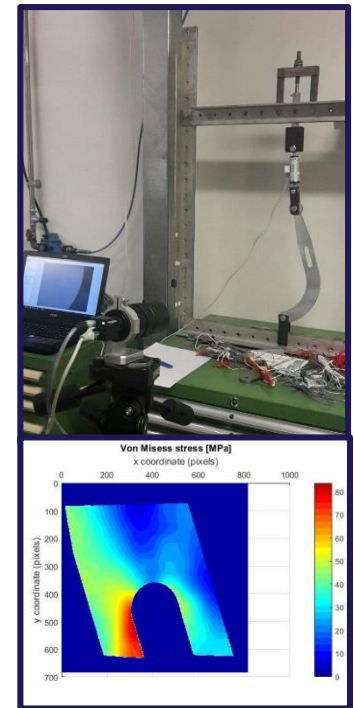
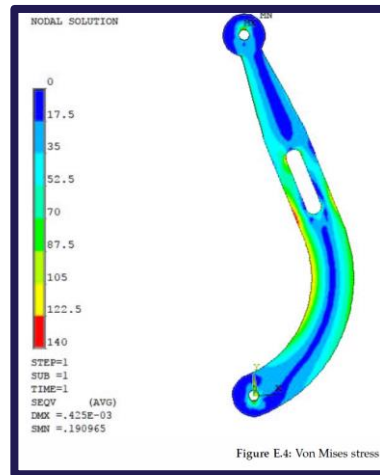
# Stress and Deformation Analysis of a Load Carrying Structural Element



DIC

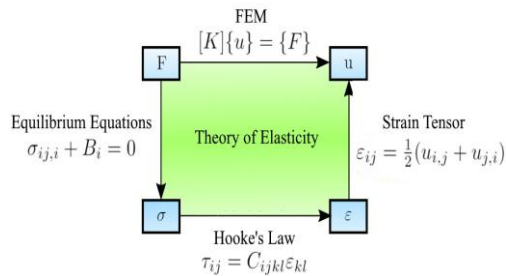
Tenzometry

MKP



## Rešerše

- Teorie elasticity



- Analytické metody
- MKP
- Experimentální metody
- Nejistoty měření





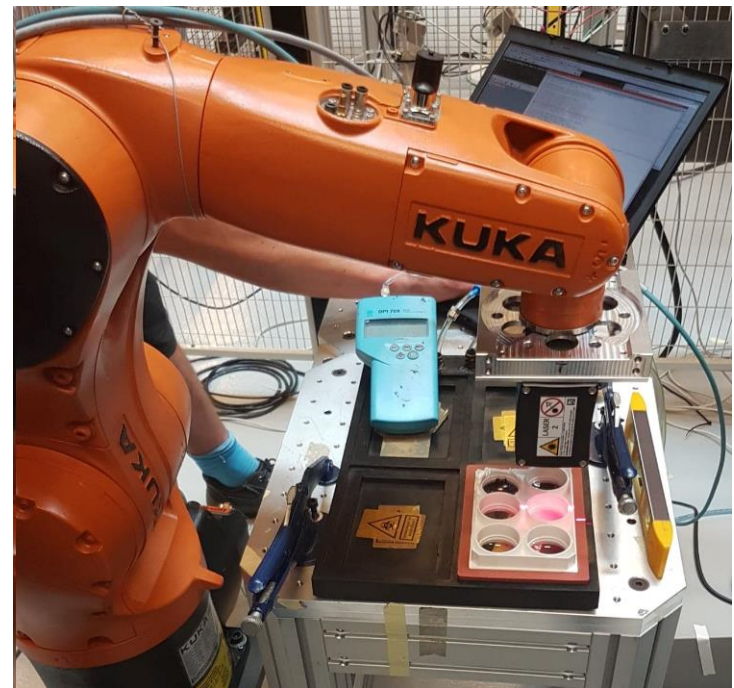
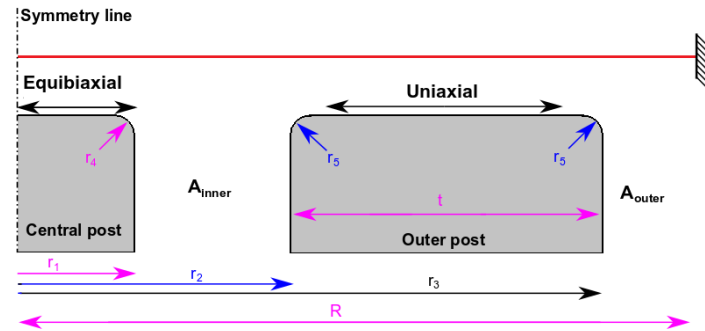
## 2. SEMESTR

- Engineering Optimization – Concepts, methods and Applications
- Mechanics of Composite Materials and Structures
- Energy and Variational Methods with Applications
- Project: Engineering Design of Mechanical Systems
  - **Optimization of a Loading System for Tissue Engineering**
    - Projektová zpráva
    - Vědecký článek
    - Plakát pro vědecké symposium



## 2. SEMESTR - Projekt

- Cíl: Navrhnout a zoptimalizovat podstavec, který by při natažení membrány přes podstavec způsobil v různých částech membrány přesně definované dvouosé i jednoosé přetvoření zároveň
  - Vytvoření návrhu podstavce
  - Vytvoření nelineárního MKP modelu
  - Vyvinutí metody pro experimentální ověření
  - Optimalizace návrhu



# SYMPOSIUM A OBHAJOBA PROJEKTU

## Symposium

- *Mechman symposium*
- Ústní prezentace, vědecký článek, plakát
- Pro studenty výrobních technologií a materiálových věd, konstruktérů a elektrotechniky

## Obhajoba projektu

- Účast: Vedoucí projektu, oponent
- Doba trvání: 4 hodiny:
  - Prezentace projektu – 1 hodina
  - Odborná diskuze – 3 hodiny

6<sup>th</sup> Student Symposium on Mechanical and Manufacturing Engineering, 2018

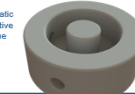
### Optimization of a Loading System for Tissue Engineering

C. Gunderson, J. Søholm, J. Pliska, L. Christensen, M. Christensen, Ø. Aune  
Department of Materials and Production, Aalborg University, DK

#### 1. Introduction

Mechanical stimulation of cells during growth is proven to alter their cellular response, effectively altering the mechanical properties of the cells. This is utilized in the field of tissue engineering to maintain or grow new tissue, enabling replacement of damaged tissue: e.g. cartilage.

Tissue can be grown on elastic membranes loaded by pressure. To regulate tissue growth, the control over the deformation of the membrane is necessary. Therefore, an initial premise is to understand the membrane where tissue is placed during development. Different but well-defined strain states on the same membrane are desirable to enable the study of cells subjected to different conditions. This paper investigates strain states of a silicone elastomer membrane draped over a loading post by a pneumatic hydrostatic pressure. The objective is to optimize the geometry of the loading post to achieve an equibiaxial and unidirectional strain state on a single membrane.

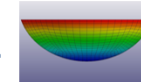


#### 2. Experimental Work and Prestress

**Experimental work:**  
The displacement field of the membrane subjected to a constant pressure was acquired by a 3D laser scanner mounted on a robotic arm.

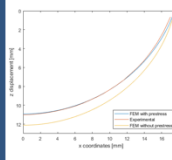
##### Finite Element model:

The asymmetric membrane was established as a quarter model utilizing shell elements. The FE model is solved with an implicit solver to address the contact problem.



##### Prestress:

To optimize the model by applying the prestress, the nonlinear Least Square method is utilized. This method utilizes displacements acquired from the experimental tests as target values for the FE model.



#### 3. Geometry Optimization

The optimization of the loading post is performed by utilizing the Global Weighted Sum method. The purpose of the loading post is to simultaneously induce an equibiaxial and a uniaxial strain state at two different locations on the membrane. The strain formulation is utilized in the objective function.

Equibiaxial strain state:  $\epsilon_1 = \epsilon_2 \rightarrow \frac{\epsilon_1}{\epsilon_2} - 1$   
Uniaxial strain state:  $\epsilon_1 \neq 0 \quad \epsilon_2 = 0 \rightarrow -\frac{\epsilon_1}{\epsilon_2}$

Objective function:

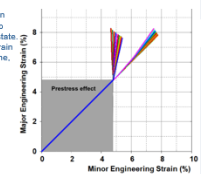
$$f_{obj}(\vec{x}) = \left[ \frac{1}{n_0} \sum_{i=1}^{n_0} \left( \frac{\epsilon_1(\vec{x}_i)}{\epsilon_2(\vec{x}_i)} - 1 \right)^2 \right]^{\frac{1}{2}} + \left[ \frac{1}{n_0} \sum_{i=1}^{n_0} \left( \frac{\epsilon_1(\vec{x}_i)}{\epsilon_2(\vec{x}_i)} \right)^2 \right]^{\frac{1}{2}}$$

The design variables of the optimization problem are the radii of the central and the outer posts and their edges supporting the membrane.



#### 4. Conclusion

The lines in the figure represent a strain state of selected elements in contact with the loading post. The new optimized loading post introduced a new central section, increasing the area of equibiaxial strain. The geometry optimization of the outer post resulted in a strain state close to pure uniaxial strain state. To investigate the strain state in the membrane, the major and minor strain are evaluated. The objective was thereby fulfilled.



#### Acknowledgement

The authors of this work gratefully acknowledge Grundfos for sponsoring the 6<sup>th</sup> MechMen Symposium



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# ZHODNOCENÍ

- **Způsob výuky:**
  - Náročný ale efektivní
  - Velmi dobré podklady pro výuku + literatura
  - Výborně připravené a propracované lekce
  - Osobní přístup
- **Projekty:**
  - 1. semestr:
    - Výhoda stálého zadání
    - Komplexní – různé oblasti a způsoby analýz na jediné součásti
    - Navzdory opakujícímu se zadání vysoká obtížnost
  - 2. semestr:
    - Výběr z velkého množství praktických projektů (průmysl/výzkum)
    - Problém – analýza – model – validace – optimalizace - experimentální ověření > vše v rámci teamu studentů pod vedením koordinátora



**DĚKUJI ZA POZORNOST**

**JAN PLISKA**



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