

# M. Sc. Program Computational Mechanics

TUM Master's Days

Munich, 23 March 2026



# Agenda

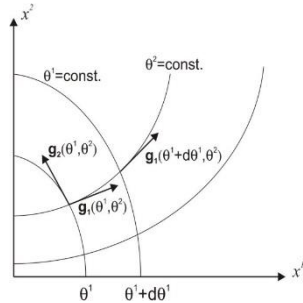
- Key Facts
- Structure and Layout
- Numbers
- Requirements, Application & What to Expect
- Your Questions
- Contacts

# Key Facts

## Key Facts

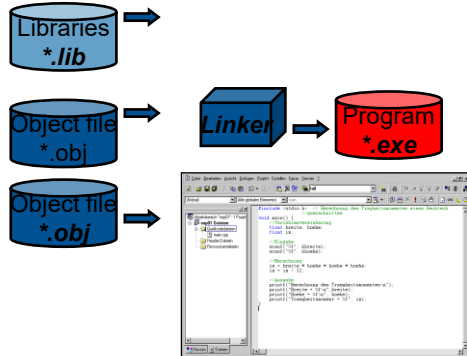
- Founded in 2000, international degree program
- Target group: Bachelor graduates with a focus on mechanical engineering, civil engineering, computer science and applied mathematics
- Interdepartmental consecutive Master of the TUM School of Engineering and Design
- Full time program - 4 semesters with 120 credits in total
- Intake only in the winter semester
- All lectures in English
- Degree: Master of Science (M.Sc.)

# Study Content



$$\mu u^i |^j + (\lambda + \mu) u^j |^i - \rho \ddot{u}^i = 0$$

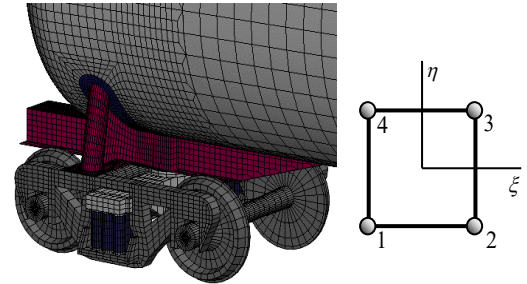
Derivation of differential equations for the description of mechanical systems



Implementation in software

Solution of technical problems using numerical methods

$$\mathbf{K} = \int_{-1}^1 \int_{-1}^1 \mathbf{t} \mathbf{B}^T \cdot \mathbf{C} \cdot \mathbf{B} |J| d\xi d\eta$$



Numerical solution methods

## New Chances

- Teaching the necessary skills in the field of simulation of mechanical problems and development of numerical methods
- Interface between classical mechanical or civil engineer, and software development
- Career opportunities in a dynamically developing branch of industry
- Leading position in one of the established engineering professions

## Fields of Activity

- Simulation and numerical analysis in classical engineering disciplines
- Software development for the solution of problems in fluid and structural analysis
- Development of new analysis tools
- Relevant in all engineering disciplines

# Structure and Layout

# Main Chairs in Program Design

## Chair of Structural Mechanics

Prof. Dr.-Ing. Gerhard Müller



## Chair of Computational Modeling and Simulation

vacant

## Professorship for Computational Solid Mechanics

Prof. Dr.-Ing. habil. Fabian Duddeck



## Chair of Hydromechanics

Prof. Dr.-Ing. habil. Michael Manhart



## Chair of Structural Analysis and Dynamics

Prof. Dr.-Ing. Roland Wüchner

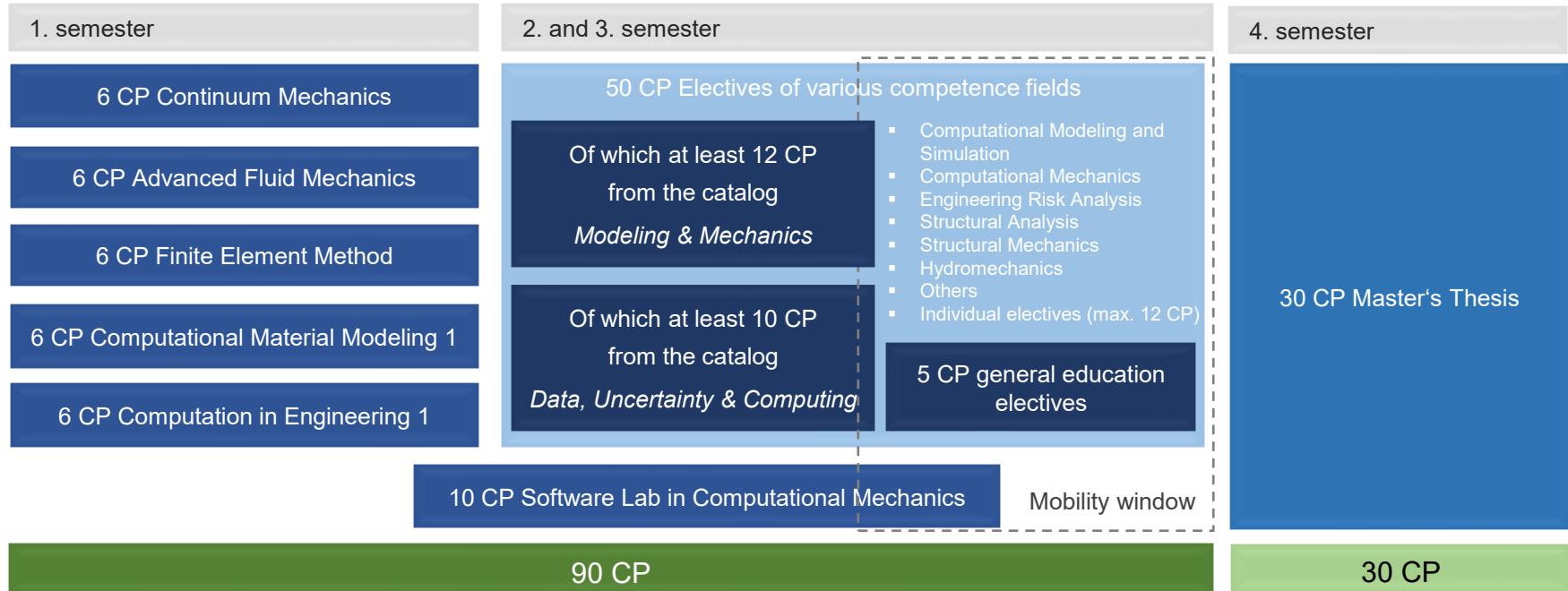


## Engineering Risk Analysis Group

Prof. Dr.-Ing. Daniel Straub

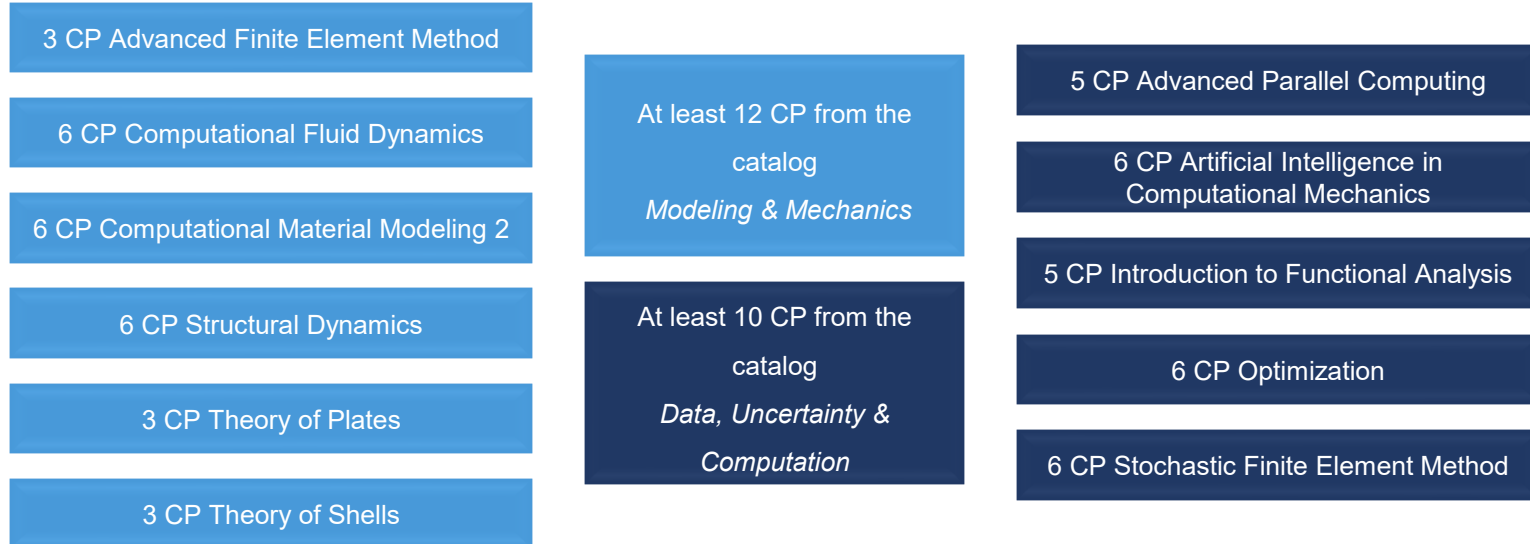


# Curriculum



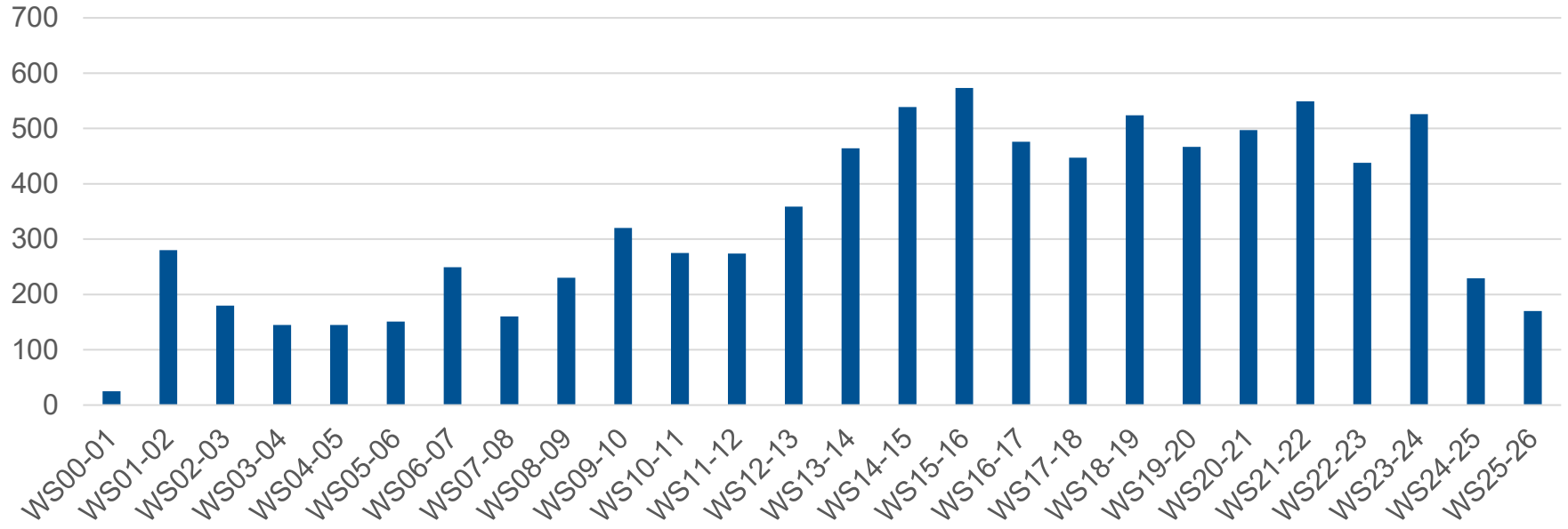
→ [Further info and details on homepage](#)

## Curriculum (core electives 2./3. semester)

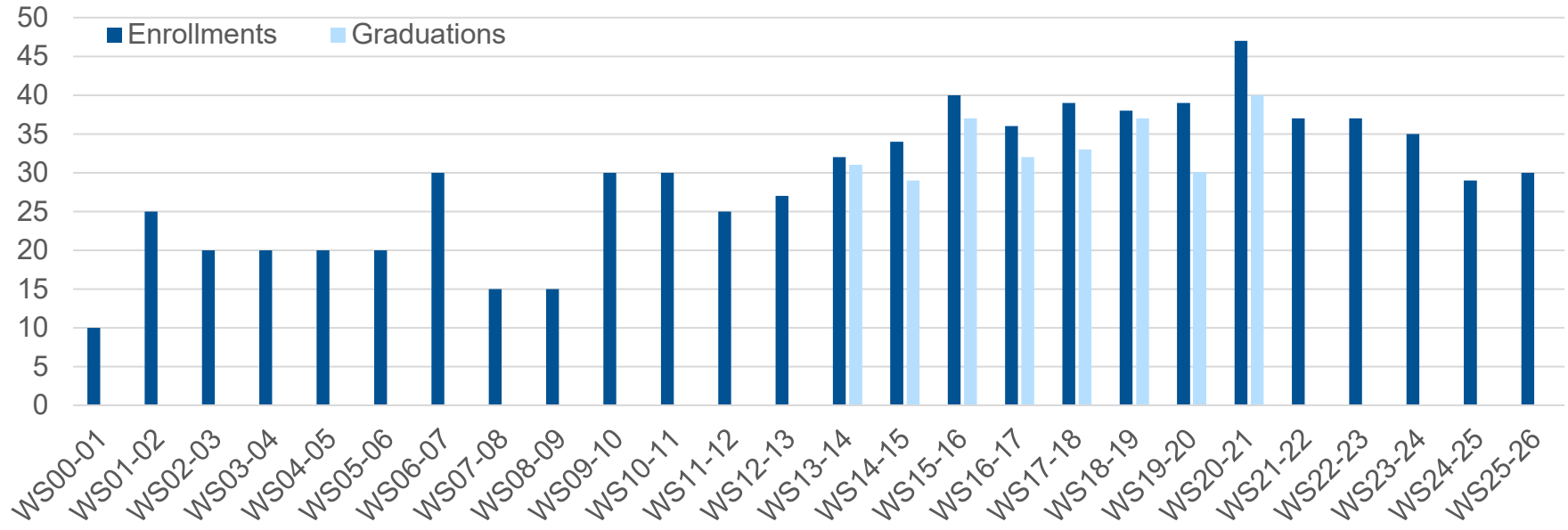


# Numbers

# Applications

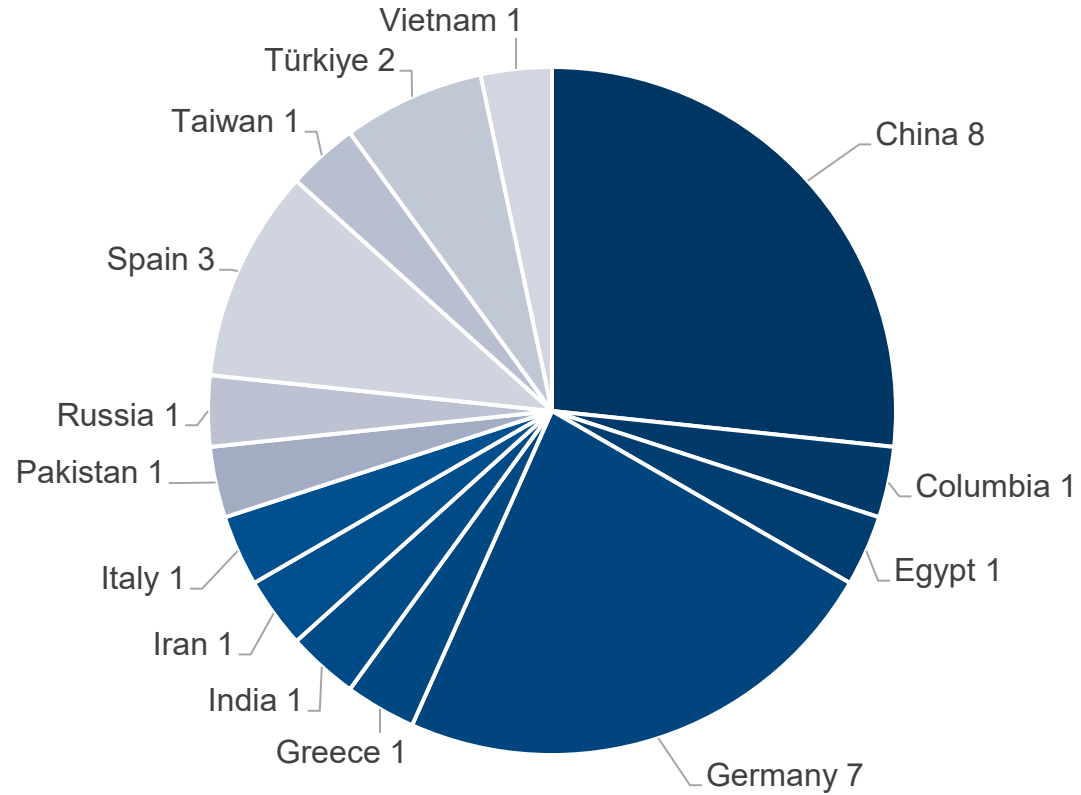


# Enrollments and Graduations



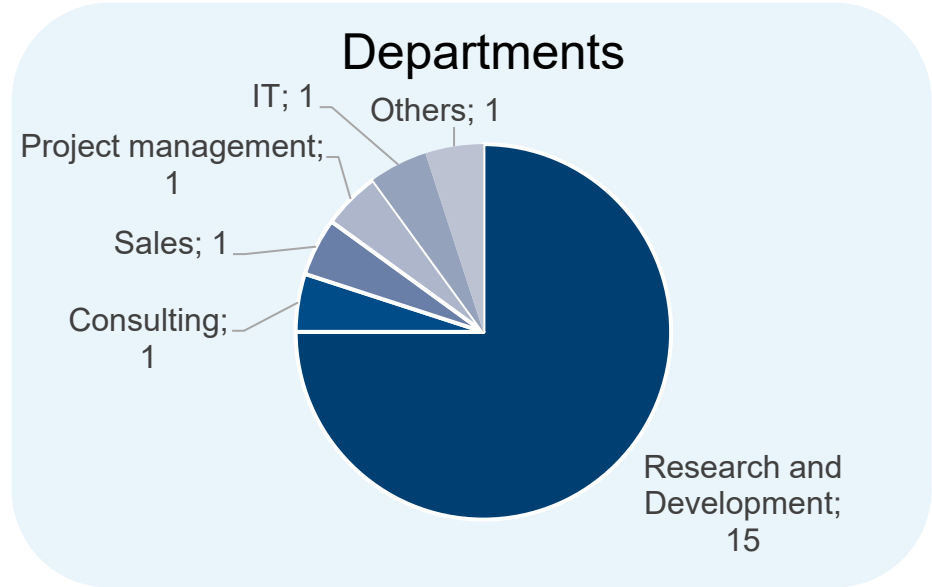
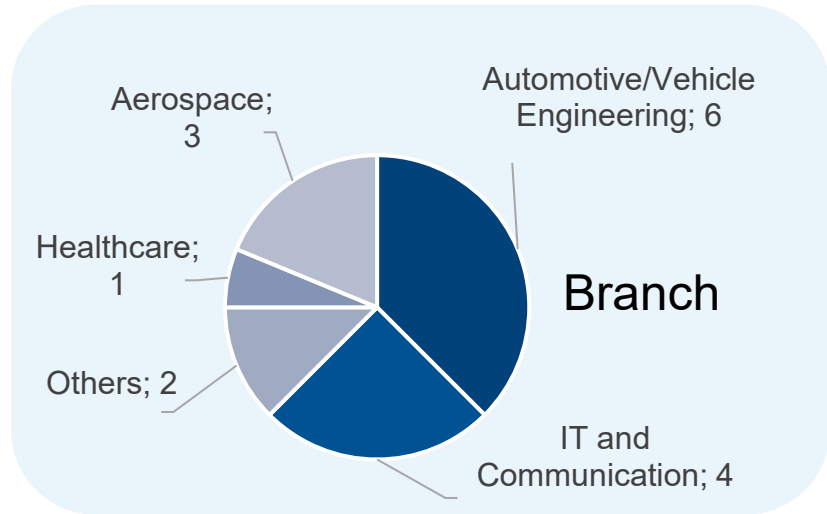
# Nationalities I

## WS 25/26



# Career I

## Graduate Poll 2023



### Further study-specific areas:

- Structural Analysis
- Software development

# Requirements, Application & What to Expect

→ [Further info and details on homepage](#)

# Requirements

Above average Bachelor's degree

Sound knowledge of mathematics & mechanics (fluid & structural mechanics)

Fundamental knowledge in informatics

English language proficiency

TOEFL (IBT  $\geq 88$ )

IELTS ( $\geq 6,5$ )

CAE, CPE (A,B,C)

Bachelor's in English

→ Pass Aptitude Assessment

# Aptitude Assessment

Two stage procedure

Submission of

Transcript

CV

Letter of Motivation

Essay

Letter of Reference

First stage: assessment of application in first stage: up to 100 points

< 65 points: rejection

≥ 65 points,  
< 75 points:

interview

≥ 75 points: admission

Second stage: interview

< 90 points: rejection

≥ 90 points: admission

# Related Programs at TUM

## Computational Science and Engineering

TUM School of Computation, Information and Technology

## Mathematics in Science and Engineering

TUM School of Computation, Information and Technology

## Applied and Engineering Physics

TUM School of Natural Sciences, Department of Physics

## Materials Science and Engineering

TUM School of Engineering and Design

→ [Further info and details on TUM-webpage](#)



# Tuition Fees

No tuition fees for students

from Germany, the EEA (EU + Iceland, Liechtenstein and Norway) and some more

who have acquired their Bachelor's or higher education in the German education system

Tuition fees: 6,000 € per semester

Various scholarships and exemptions

Deadline for Application: 31 May 2026

## What to expect

- Interdisciplinary & intercultural teaching and studying
- Onboarding at beginning of studies: welCoMe week & C++ introduction
- Project work: Software Lab in Computational Mechanics
- Care and support in small groups
- Individualizable curricula through "individual electives"

# Software Lab in Computational Mechanics

- Implementation of a mechanical/engineering problem into a software solution
- Projects from academic and industrial background
- Simulation of team-oriented and hands-on software development
- Work in small groups (3-4 students)

## Software Lab 2021: Stabilization methods for immersed finite element discretization of scalar wave equation

Praveen Kumar Mukala, Francisco Garcia Villanueva, Torsten Schmid  
Philipp Kopp, Tim Burchner

**WAVE EQUATION**

$$u_{tt} - c^2 \nabla \cdot \nabla u = f \quad \text{in } (0, T) \times \Omega, \quad \Omega \subset \mathbb{R}^2 \text{ or } \mathbb{R}^3$$

$$\text{BC: } u = \bar{u} \quad \text{on } \Gamma_D, \quad \text{IC: } u(0) = u_0, \quad u_t(0) = v_0$$

$$\text{E.g. } \nabla u \cdot \nu = \bar{g} \quad \text{on } \Gamma_N, \quad u_p(0) = u_{0,p}, \quad u_{p,t}(0) = v_{0,p}$$

**WEAK FORM FORM**

**INTRODUCTION FEM**

**STABILIZATION**

**RESULTS**

**Time Restrictions**

**Conditioning number for the Mass Matrix**

## Software Lab Project 2021 Implementing Free-Surface Flows using the VOF Method in a Distributed CFD Framework

Group 5 : Arda Safak, Emre Işık, Mao Watanabe  
Supervisor: Christoph Ertl

### Introduction

CFD of free-surface flows is an important tool in predicting and analyzing natural disasters such as floods. However, such two-phase flows are usually demanding in computational effort so that parallel computing becomes a must. In this project, we aim to build a multiphase module based on the VOF method upon an existing distributed CFD framework.

### Theory

Volume of Fluid (VOF) is an interface-capturing method for two-phase flows, addressing phases to volume fractions  $f \in [0, 1]$ . Then, the interface must be reconstructed from volume fractions.



Fig. 1 The volume fraction profile (1)

### Implementation



Our implementation is built on a variable density Navier-Stokes solver with extensions.

### 1. Surface Tension

The surface tension  $F$  is the force acting between different fluids. To calculate this force, the Continuum Surface Force (CSF) method is chosen, which allows us to estimate the curvature by using fractions.

$$F = \sigma \kappa \nu$$

if  $\sigma$  is a surface tension coefficient,  $\kappa$  is a curvature.

### 2. Advection

Volume fractions must be advected at each time step so that the density and the viscosity can be interpolated by using the volume fraction. Volume fractions in the advection equation are retrieved directly from the reconstructed interface only for the donoring region, whose size and location is determined by the local velocity.



### 3. Reconstruction

Interface reconstruction is performed by the Piecewise Linear Interface Construction (PLIC) method, which approximates the local interface fitting a straight line segment to each grid cell. Estimation of the normal vector is conducted by the ELVIRA algorithm. All reconstruction and surface tension operations are performed only at the proximity of the interface.

### Results and Discussion

Several benchmark cases are tested to validate our solver.

#### 1. Falling drop case

Falling the drop case is one of the most well-known benchmark cases that is available in the literature. In this case a water droplet is fallen from a height towards the ground by the help of gravitational acceleration. In Figure 5 the stages of the fallen drop can be seen. Here the blue part represents the water (fraction of 1), while the gray part represents the air. It can be observed from the figure that the shape of the droplet develops into a shape that is expected and we can observe in nature. Additionally, the program implemented enables the formation of smaller droplets depending on the resolution used.



Fig. 5 Development of falling droplets with respect to time

#### 2. Rayleigh-Taylor instability

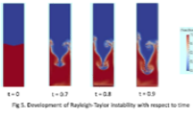


Fig. 6 Development of Rayleigh-Taylor instability with respect to time

Rayleigh-Taylor instability is another typical two-phase problem where a denser fluid tries to replace the lighter fluid below under the action of downwards gravity. The case is initialized with a sinusoidal interface profile and at time certain flow fields can be observed as seen in Figure 5. The results are compared with [1] and considered to be reasonable.

### Conclusion

In this project, we have managed to implement VOF method on a highly-parallelized CFD framework. Future developments to the present work would include optimization of VOF modules for parallel applications and extension to solve for 3D problems.

### References

- [1] Kawah, Ken; Mitsuyoshi, A. Navier-Stokes Solver for Single- and Two-Phase Flow. WU: Theses, University of Oslo, Faculty of Mathematics and Natural Sciences, September 2008.
- [2] U. Brackbill, D. B. Kothe, and C. Zemach. A continuum method for modeling surface tension. Journal of Computational Physics. 100:33-55A, 1992.

## Racing-line Optimization using Multibody Models

Software Lab Project 2021  
Georgios Papageorgiou, Daniel Krivacic, Tianyi Wang  
Andreas Apostolatos, Steve Miller, Jan van Renburg

### ABSTRACT AND MOTIVATION

The need to design vehicles without using hardware prototypes has led to widespread use of simulation. We explored the use of simulation to identify methods of adapting vehicle design to reduce lap time.

We added new physical models and control algorithms to an existing Simulink model. Using simulation, we evaluated those designs by comparing them to a baseline. An outlook for next steps is discussed.

### OBJECTIVE

Use simulation to evaluate the possible reduction of lap time by modifying design characteristics of the vehicle, control algorithms, and driver behavior

### RESULTS

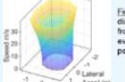
#### Suspension Design

Figure 2: Suspension and chassis designed for racing integrated into model



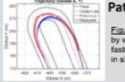
#### GGV Diagram

Figure 4: GGV Diagram generated from model enables evaluation of performance envelope



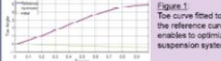
#### Path Optimization

Figure 6: Path defined by waypoints enables fastest path to be found in simulation



#### Suspension Tuning

Figure 1: The curve fitted to the reference curve enables to optimize suspension system



#### Location of Battery CG

Figure 3: Battery incorporation and optimization reduces lap time by 10%



#### Four-Wheel Steering

Figure 5: Four-wheel steering reduces lap time by 6.5%



### CONCLUSIONS/OUTLOOK

- Added new vehicle templates and algorithms to library
- Extended use of optimization in evaluating designs

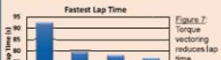
#### Simscape Vehicle Templates

Set of templates for creating custom vehicle models. [https://github.com/mathworks/SimscapeVehicle\\_Templates](https://github.com/mathworks/SimscapeVehicle_Templates)



#### Torque Vectoring Algorithm

Figure 7: Torque vectoring reduces lap time by up to 1.7%



# Your Questions

## Organization and Teaching

- What are specific applications, simulation programs that are used and taught at TUM in terms of Computational Mechanics?

# Aptitude Assessment

- How to Apply for a Master's Degree
- What are the prerequisites?
- Details about Aptitude Assessment and Additional Exams

## Related to Internships / Exchange / Scholarships

- What scholarship opportunities are available for Industrial engineering specialization Masters programmes?
- Internship opportunities, Teacher's assistant at research as a student

## Further Questions

# Further Information and Contact



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Wilhelm Fischer, M. Sc.

**Email:** [come@tum.de](mailto:come@tum.de)

**Homepage:** [www.come.tum.de](http://www.come.tum.de)

## Links

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