



Technical University of Munich MSc Computational Mechanics

COME Welcome 2023

Prof. Fabian DUDDECK
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TUM Origin in 1868

King Ludwig II founded the „Polytechnische Schule“

... and some castles

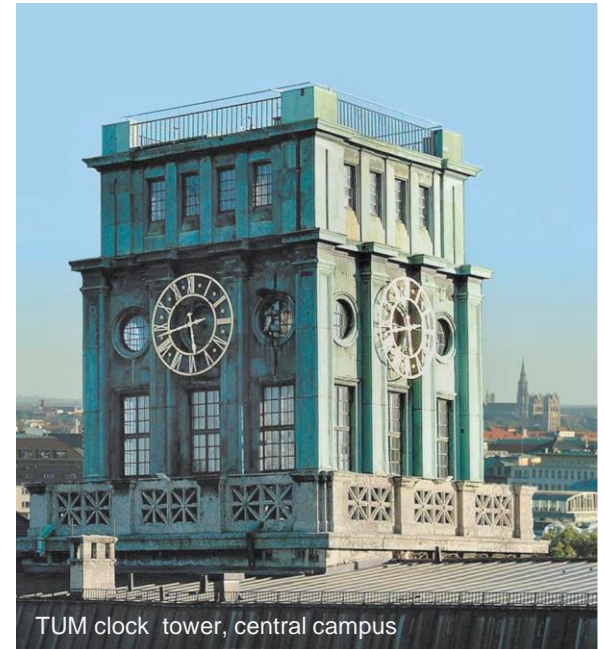


TUM History

Some milestones

- 1868** King Ludwig II founds the "Polytechnical School"
- 1877** Renaming to "Technical University"
- 1901** Right to Award Doctorates
First Doctoral Candidate: Georg Hauser (Chemistry)
- 1905** Admittance of Female Students
First Female Doctoral Candidate: Amalie Baur (Chemistry)
- 1930** Integration of the College of Agriculture and Brewing in Weihenstephan
- 1957** First Neutron Research Reactor in Germany
- 1967** TUM School of Medicine, University Hospital
- 1970** Presidential Constitution, "Technische Universität München"
- 1999** TUM's University Reform started,
Entrepreneurial University Constitution
- 2000** TUM School of Life Sciences Weihenstephan (Matrix Structure)
- 2000** Foundation of the COME program

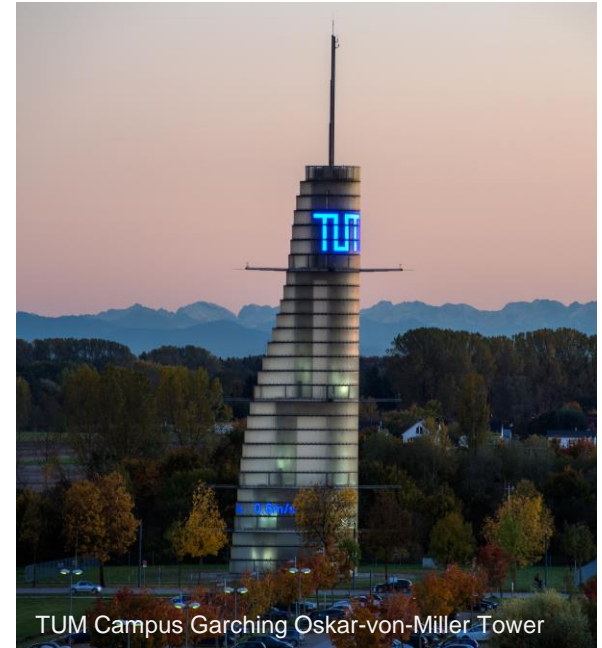
<https://www.tum.de/en/about-tum/facts-and-figures/history>



TUM History

Some more milestones

- 2002** TUM Branch in Singapore: TUM. Asia Pte. Ltd.
TUM School of Management / Dep. of Sport & Health Sciences
- 2004** High-Flux Research Source Heinz Maier-Leibnitz
- 2005** TUM Institute for Advanced Study (IAS)
- 2006** TUM elected "University of Excellence"
TUM Int. Graduate School of Science and Engineering (IGSSE)
- 2009** TUM School of Education / TUM Graduate School
- 2010** TUM Munich School of Engineering (MSE)
- 2012** TUM again elected "University of Excellence"
Munich Center for Technology in Society (MCTS)
- 2014** Bavarian School of Public Policy
- 2015** Munich School of Bioengineering
- 2018** 150 years jubilee Technical University of Munich
- 2019** TUM "University of Excellence" for the third time
- 2021** TUM School of Engineering and Design
- 2023** YOUR start here at TUM



TUM Facts and Figures

(statistics 2022)



8

Schools and
Departments



more than

9,500

Graduates in 2021/22



18

Nobel Prize
Laureates



8

Humboldt
Professorships



643

Professors



176

ERC Grants
(since 2008)



>1,000

Research
Agreements p.a.



TUM Facts and Figures

(statistics 2022)



105

Tenure Track
Professorships



41%

International
Students



7,453

Researchers

11,758

Staff Members



36%

Female Students



86,153

Active Alumni



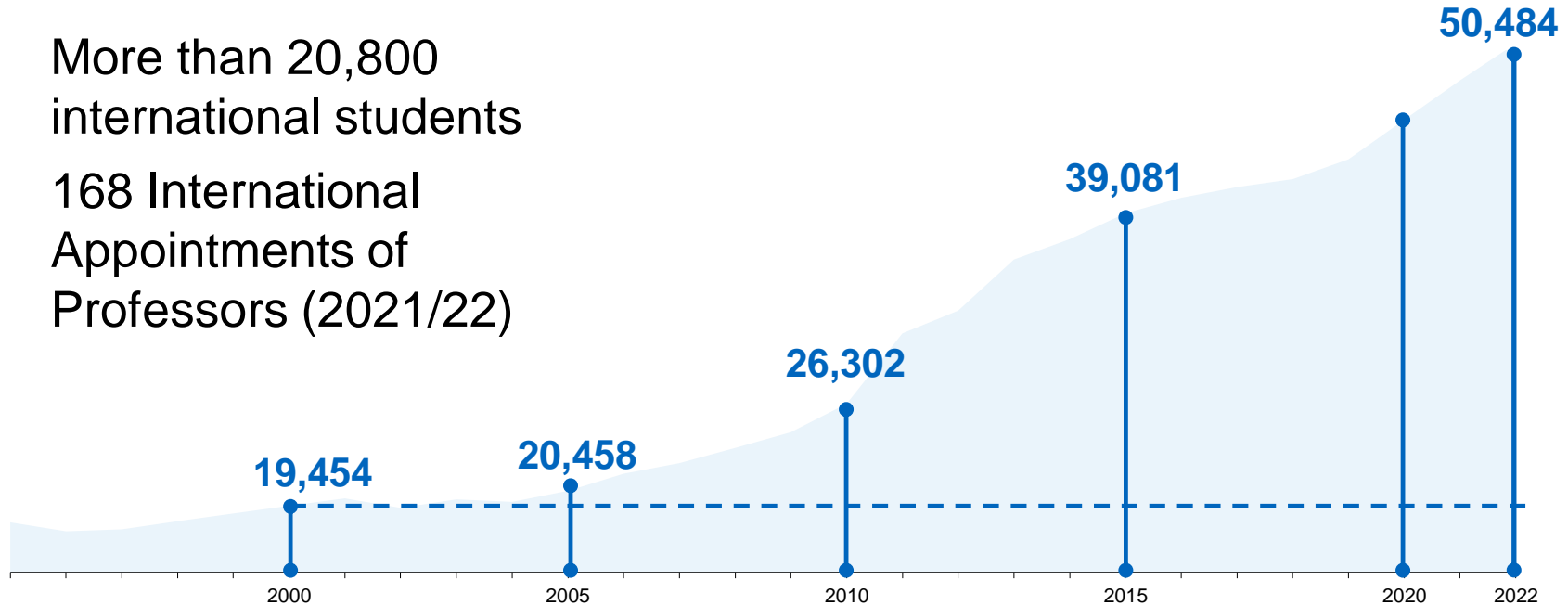
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TUM Emeriti
of Excellence



Growth Path Student Enrollment

- More than 20,800 international students
- 168 International Appointments of Professors (2021/22)



Academic Rankings

QS World University
Rankings 2022

No. **1** 
in Germany

 No. **49**
in the world

THE World University
Rankings 2022

No. **1** 
in Germany

 No. **30**
in the world

Shanghai World University
Ranking 2022

No. **1** 
in Germany

 No. **56**
in the world

18 Nobel Prize Laureates

TUM scientists and alumni have received the Nobel Prize in four fields:

- Chemistry,
- Literature,
- Medicine, and
- Physics.

Prof. Robert Huber
Nobel Prize 1988 / Chemistry
For the determination of the
3D structure of a
photosynthetic reaction center



24 Leibniz Prize Laureates

(Deutsche Forschungsgemeinschaft DFG)

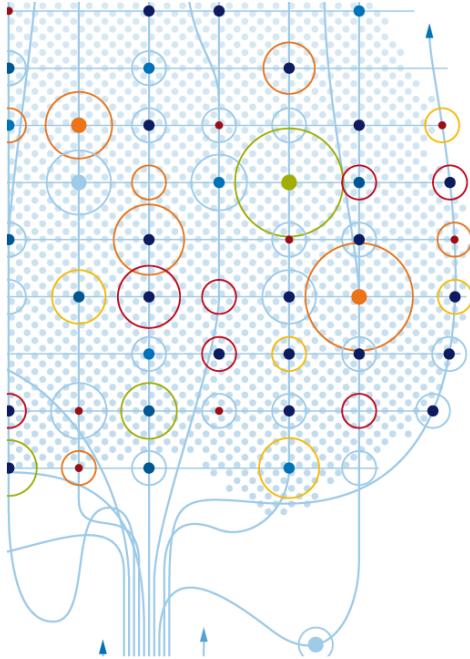
TUM members received the most prestigious award for scientists and scholars at German research institutions 24-times, including 10 distinctions in the last decade alone

Prof. Barbara Wohlmuth
Leibniz Prize (DFG) 2012

For her research achievements in numerical analysis in scientific and engineering computing. A focus of her research is the numerics of partial differential equations, to which she has made key contributions, especially with her theoretical study of mortar domain decomposition methods.



TUM Partners of Excellence



Airbus Group
 ALTANA AG
 AUDI AG
 Bayerischer Bauindustrieverband e. V.
 BMW AG
 Robert Bosch GmbH
 Busch Vacuum
 Clariant International AG
 Dräxlmaier Group
 Evonik Industries AG
 Google
 Herrenknecht AG
 HUAWEI
 Infineon Technologies AG

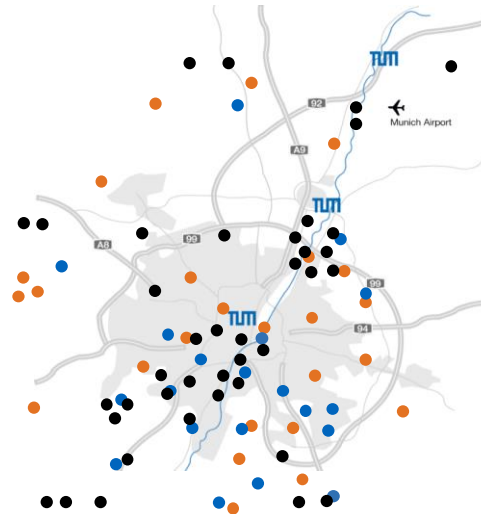
Linde AG
 MAN SE
 Nestlé AG
 Rohde & Schwarz GmbH & Co. KG
 RWE Group
 SAP SE
 SGL CARBON SE
 Siemens AG
 TRUMPF GmbH + Co. KG
 TÜV SÜD AG
 vbw – Vereinigung der Bayerischen
 Wirtschaft e. V.
 Volkswagen AG
 Wacker Chemie AG

TUM Local Network

Academic Network



TUM Joint Appointments: 51



Industry Network



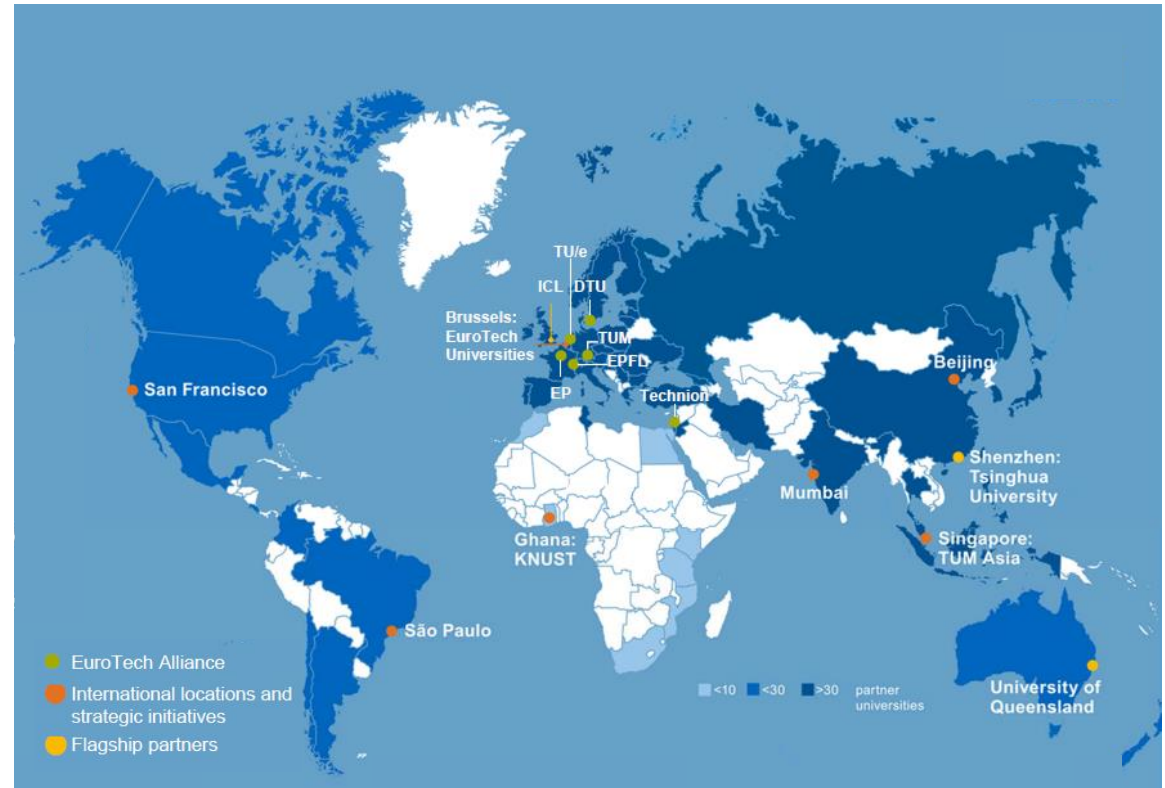
Start-up Network



TUM Global

150+ partner universities worldwide

350+ Erasmus partnerships across Europe



TUM Locations

Six large sites in Bavaria and one in Baden-Wuerttemberg:

- Munich
- Garching
- Freising-Weihenstephan
- Ottobrunn
- Straubing
- Raitenhaslach
- Heilbronn



TUM Campus Downtown Munich

- TUM School of Computation, Information and Technology
- TUM School of Engineering & Design
- TUM School of Management
- TUM School of Social Sciences & Technology
- Hochschule für Politik München



TUM Campus Garching

- TUM School of Natural Sciences
- TUM School of Computation,
Information and Technology
- TUM School of Engineering & Design



TUM Campus Heilbronn

- TUM School of Management



TUM Campus Straubing

- Biotechnology
- Sustainability



TUM Campus Freising / Weißenstephan

- TUM School of Life Sciences

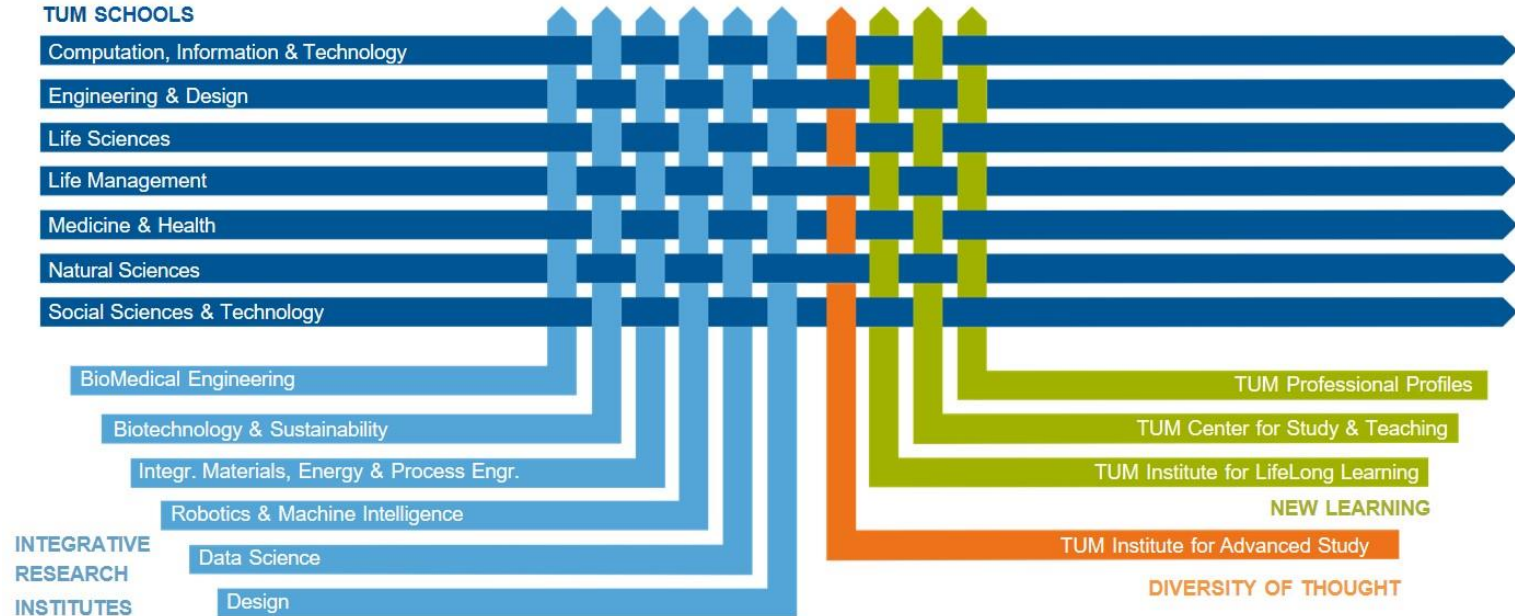


TUM Science & Study Center Raitenhaslach

- Former monastery in Raitenhaslach in the Southeast of Bavaria
- Full service, year-round conference facility

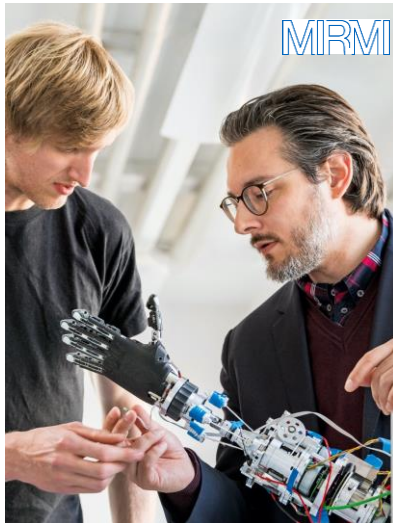


TUM Innovative University Structure

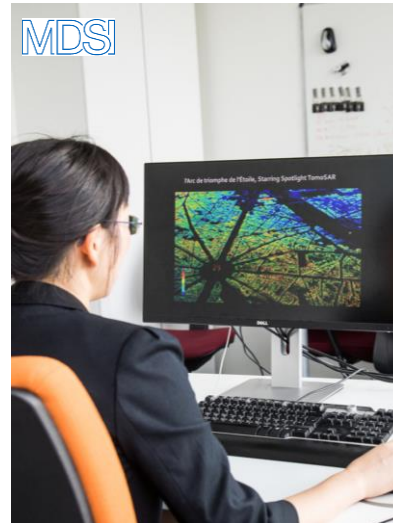


Integrative Research Institutes (IRI)

Munich Institute of Robotics and Machine Intelligence (MIRMI)



Munich Data Science Institute (MDSI)



Munich Institute of Integrated Materials, Energy and Process Engineering (MEP)



Munich Institute of Biomedical Engineering (MIBE)



TUM Master's Programs (105 in 2023)

Master (incomplete)

Aerospace

Automotive Engineering

Bioinformatics

Biomedical Engineering & Medical Physics

Civil Engineering

Computational Mechanics (CoMe)

Computational Science and Engineering (CSE)

Data Engineering & Analytics

Ecological Engineering

Electrical Engineering & Information Technology

Energy & Process Engineering

Environmental Engineering

Ergonomics - Human Factors Engineering

ESPACE Earth Oriented Space Sci. & Techn.

Informatics / Games Engineering

Materials Science & Engineering

Mathematics in Data Science

Mathematics in Science and Engineering

Mechanical Engineering

Mechatronics, Robotics & Biomechanical Engineering

Medical Engineering & Assistance Systems

Physics (Applied and Engineering Physics)

Power Engineering

Quantum Science & Technology

Rail, Transport & Logistics

Research on Teaching and Learning

Responsibility in Science, Engineering & Technology

Risk and Safety

Robotics, Cognition, Intelligence

Science and Technology of Materials

Software Engineering

Sustainable Management and Technology

M.Sc. Computational Mechanics (COME)

- The M.Sc. *Computational Mechanics* was founded in 2000
- It aims for educating experts for industry and academia in the field of computational methods in mechanics for all areas of engineering



Logo by COME students 2011/12

<http://www.come.tum.de>

M.Sc. Computational Mechanics (COME)

Lectures are offered at the central campus.

Main chairs involved are:

- Structural Mechanics, Prof. Gerhard MÜLLER
- Structural Analysis, Prof. Kai-Uwe BLETZINGER
- Computation in Engineering, Prof. André BORRMANN / Stefan KOLLMANNSSBERGER
- Hydromechanics, Prof. Michael MANHART
- Computational Solid Mechanics, Prof. Fabian DUDDECK



M. Manhart



K.-U. Bletzinger



G. Müller



F. Duddeck



A. Borrmann / S. Kollmannsberger



M.Sc. Computational Mechanics (COME)

Semester 1	Semester 2	Semester 3	Semester 4
	Software Lab (6 ECTS)		Master's thesis (30 ECTS)
Continuum Mechanics (6 ECTS)	Electives Mechanics (12 ECTS)		
Advanced Fluid Mechanics (6 ECTS)	Electives Computation (12 ECTS)		
Finite Element Methods 1 (6 ECTS)	General education electives (3 ECTS)		
Computational Material Modeling 1 (6 ECTS)	Elective modules of various competence fields (17 + 10 ECTS)		
Computation in Engineering 1 (6 ECTS)			

M.Sc. Computational Mechanics (COME)

2-years program (120 ECTS credits)

- 36 ECTS compulsory courses
- 24 ECTS core elective courses
- 27 ECTS elective courses
- 3 ECTS general education (language)
- 30 ECTS master's thesis

- **Additional qualification during your COME studies (optional)**
 BGCE - Bavarian Graduate School of Computational Engineering

Compulsory courses

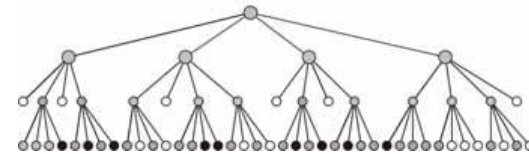
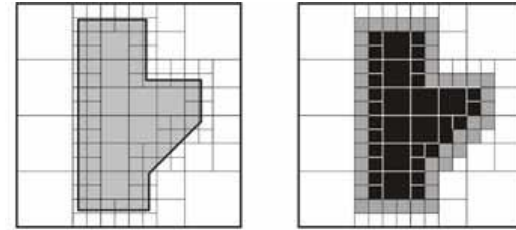
Semester 1				
Computation in Engineering 1 (6 ECTS)	Advanced Fluid Mechanics (6 ECTS)	Finite Element Methods 1 (6 ECTS)	Computational Material Modelling I (6 ECTS)	Continuum Mechanics (6 ECTS)
				TOTAL: 30/120 ECTS
Semester 3				
Software Lab Project with focus on one of the specialisations (6 ECTS)				
Computer Science	Fluids	Solids & Structures	Materials	Mechanics
				TOTAL: 6/120 ECTS
Semester 4				
Master Thesis (30 ECTS)				
				TOTAL: 30/120 ECTS

Compulsory Modules

Computation in Engineering 1

CONTENT

- Object oriented modeling and programming (C++)
- Data structures, classes, etc.
- Sets, relations, and graphs
- Geometrical modeling
- Direct and indirect representations
- Space trees (octrees etc.)
- Curve representations
- Approximation methods
- Implementation schemes



Quadtree for discretisation of a 2D region.

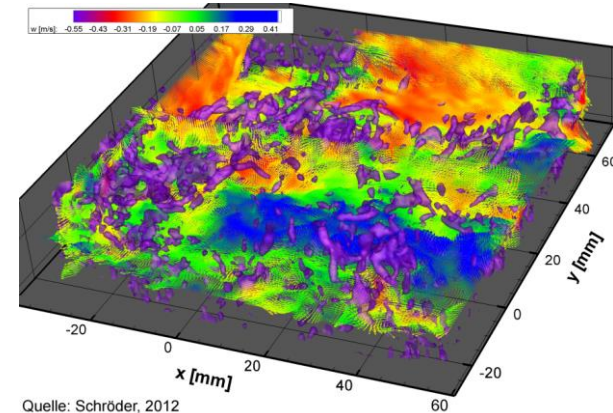
Stefanie Schraufstetter, André Borrmann, Ernst Rank

Compulsory Modules

Advanced Fluid Mechanics

CONTENT

- Continuum hypothesis, kinematics
- Transport equation, equation of motion
- Navier-Stokes equations
- Fundamentals of fluid mechanics
- Scaling laws, Dimensional analysis
- Advection and diffusion
- Boundary layer theory
- Flow instabilities
- Introduction to turbulent flows



Compulsory Modules

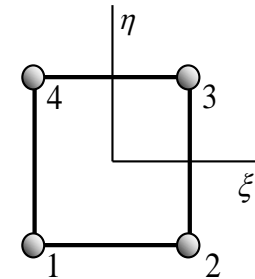
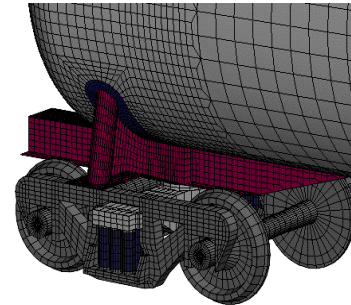
Finite Element Methods 1

CONTENT (FEM1 – Part 1)

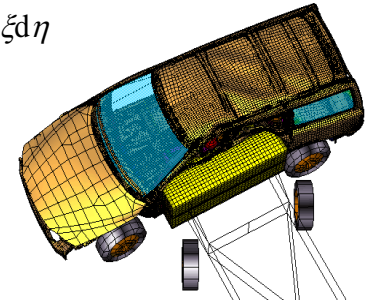
- Direct Stiffness Method, Variational Formulation
- Beam, Plane Stress, Plate Elements
- Convergence, Locking and FE Technology
- Implementation etc.

CONTENT (FEMSV – Part 2)

- Modelling, Simulation, and Validation (2D / 3D)
- Introduction to an FE software (ANSYS)
- Applications (elasticity, plasticity, heat transfer)



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



Compulsory Modules

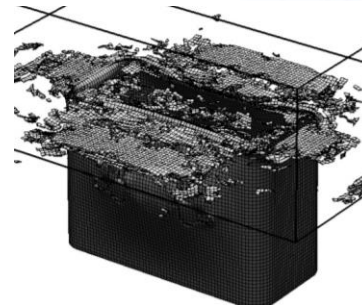
Computational Material Mechanics 1

CONTENT (Basic Materials – Part 1 “mechanics”)

- Elasticity
- Plasticity
- Visco-elasticity
- Visco-plasticity

CONTENT (Composites – Part 2 “materials”)

- Composites, Fiber-reinforced polymers
- Honeycombs, Foams, Biomaterials (bones)



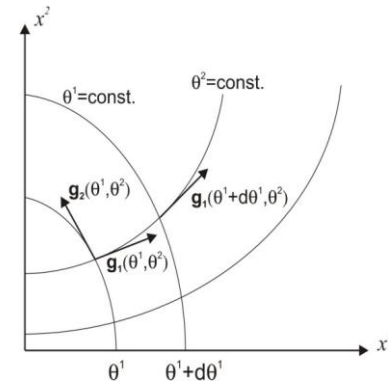
Compulsory Modules

Continuum Mechanics

CONTENT

- Introduction into tensor analysis
- Description of stress states in arbitrary, curvilinear coordinates
- Lagrangian description of strain states
- Conservation of energy
- Conservation of mass
- Constitutive relations
- General treatment of continuum mechanical knowledge in order to solve non-linear problems

$$\tau^{im} \Big|_i + Q^m - \rho b^m = 0$$

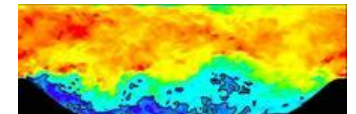
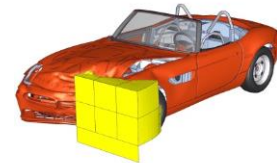
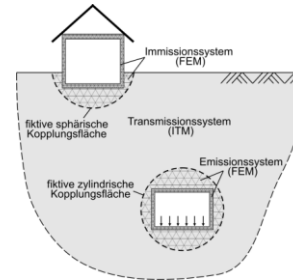
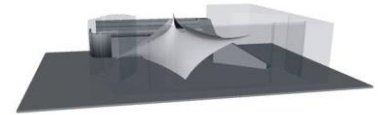
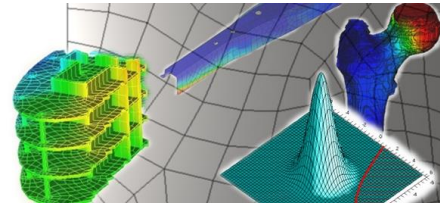


Compulsory Modules

Software Lab (2nd / 3rd Semester)

CONTENT

- Group work on software development.
- Engineering problems from different application fields.
- Collaboration with industry and academia



Bavarian Graduate School of Computational Engineering BGCE

The Bavarian Graduate School ...

of Computational Engineering is an association of three Master programs:

1. **Computational Engineering (CE)** at the Friedrich-Alexander-Universität Erlangen-Nürnberg,
2. **Computational Mechanics (COME)**, and
3. **Computational Science and Engineering (CSE)** at the Technische Universität München.
 - “Elite” degree program for our best MSc students
 - Additional exclusive course offers and training
 - Intensive interaction with research staff
 - Additional certificate

Elitenetzwerk
Bayern



<http://www.bgce.de/>

Thanks for joining us – Have fun and success ...

