



## Welcome to the Institut für Thermodynamik

Technische Universität Braunschweig  
Prof. Dr.-Ing. Jürgen Köhler

Besides a wide range of lectures in the field of thermodynamics and heat and mass transfer, the Institut für Thermodynamik (IfT) offers its technical expertise to an interested audience in the context of research projects, seminars and software products. A variety of measuring devices, software tools as well as theoretical and experimental knowledge are available for these purposes.

The historical roots of the IfT reach back to the year 1946. Since 1998, Prof. Dr.-Ing. Jürgen Köhler has been director of the institute. Under his leadership, the research focus of the IfT lies in alternative refrigeration technologies and natural refrigerants.

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### Lectures.

Besides the basic courses „Thermodynamics“ and „Heat and Mass Transfer“, the IfT offers a variety of courses in both summer and winter semester:

#### **Thermodynamics (Köhler, WS, 6 CP)**

Balance and conservation laws, thermodynamic relations, fundamental equations and equations of state, heat and work interactions, equilibrium criteria, ideal gas, properties of real substances, thermodynamic processes, moist air processes.

#### **Heat and Mass Transfer (Köhler, SS, 4 CP)**

Heat exchanger, steady state and transient heat conduction, convective heat transfer with/without phase change, radiation of black/real bodies, mass diffusion.

#### **Thermodynamics of Mixtures (Köhler/Raabe, WS, 5 CP)**

Basics of multicomponent systems (Gibbs fundamental and Gibbs-Duhem's equation, Legendre transformation, equilibrium conditions and stability); properties of mixtures; thermodynamic models; phase diagrams; chemical reactions and combustion processes.

#### **Thermodynamics and Statistics (Köhler, SS, 5 CP)**

Balance and conservation laws (mass, momentum, energy, entropy), thermodynamic relations, fundamental equations and equations of state, heat and work interactions, equilibrium criteria, ideal gas, properties of real substances, statistical thermodynamics, partition functions, ensembles, relationships between microscopic and macroscopic properties, intermolecular forces, applications for solids, ideal gases and real substances.

#### **Molecular Simulation (Köhler/Raabe, SS, 5 CP)**

Basics of statistical mechanics and molecular modeling; introduction to Monte Carlo and molecular dynamics, simulation in various ensembles; simulation structure.

### **Refrigeration and Mobile Air Conditioning (Köhler/Lemke, WS, 5 CP)**

Historical background, refrigerating processes, cooling circuit and mobile air conditioning, refrigerants (conventional + alternatives), components (e.g. heat exchangers, expansion valves, compressors, control units), basic processes (e.g. Evans-Perkins-process, absorption refrigerant processes, gas refrigerant processes).

### **Thermodynamics in Chemical Process Simulation (Bröcker, WS, 5 CP)**

Applications of thermodynamics in process simulations; thermodynamic modeling of devices and processes; empirical and physical models for properties of pure substances; models of real mixtures; models of chemical reactions and their kinetics.

### **Object-Oriented Methods in Thermal Engineering (Köhler/Tegethoff, SS/WS, 5 CP)**

Intensive C++ course (classes, inheritance, polymorphism, container types). Object-oriented modeling of simple energy systems on the basis of the first law of thermodynamics. Object-oriented formulation of heat transport mechanisms (conduction, convection, radiation, contact, enthalpy flow). Transient and steady state systems.

### **Modeling of thermal systems with Modelica (Köhler/Tegethoff, SS/WS, 5 CP)**

Object-oriented and equation-based formulation of linear DAE Systems (Differential Algebraic Equation Systems). Discussion of the basic concepts of Modelica. Modeling examples.

Further information about the current courses are available on our website: „Lehrangebot“ - „Lehrveranstaltungen im aktuellen Semester“.

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## **Research.**

Research at the IfT is focused on the areas of Thermal Systems, Material Data and Heat and Mass Transfer with the following thematic priorities:

### **Thermal Systems**

Please contact: Dr.-Ing. Nicholas Lemke & Dr.-Ing. Wilhelm Tegethoff

- Experimental and theoretical investigation of fuel cell cooling.
- Investigation of air conditioning and refrigeration systems for mobile and stationary applications.
- Analysis and further development of heat pump systems for heating buildings and vehicles.
- Experimental and theoretical investigation of various system versions of thermoelectric modules.

### **Material Data**

Please contact: Dr.-Ing. Gabriele Raabe

- Molecular simulation of thermophysical properties of pure substances and mixtures, e.g. alternative refrigerants and ionic liquids.
- Development of Force Field Models for molecular simulation.
- Model-based prediction of material data and phase behaviour of pure substances and mixtures, e.g. mixtures of refrigerants and lubricating oil.

### **Heat and Mass Transfer**

Please contact: Dipl.-Ing. Martin Buchholz

- Experimental and theoretical investigation of flow and heat transfer in narrow channels with fixtures.
  - Laser optical velocity measurements in complex geometries.
  - Simulation of air flow and heat transfer in high-performance heat exchangers.
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## Service.

The services at the IfT cover measurement, computer simulation, software, consulting and training. For further information please contact Dr.-Ing. Wilhelm Tegethoff or Dr.-Ing. Nicholas Lemke.

## Measurement

For steady state and transient measurements, numerous test rigs are available such as:

- Calorimetric test rig for air conditioning and heat pump systems and their components.
- Test rig for R134a TXV and R744 valves.
- Test rig for R744 accumulators including a glass accumulator for measurements of refrigerant mass and outlet quality.
- Test rig for R744 compressors with large range of speed and refrigerant flow rates for measurement of efficiencies and indicator diagrams.
- Test rig for condensers with detailed online-analysis of refrigerant mass and distribution.
- Thermal imaging with 14 bit temperature resolution and high accuracy calibration.
- Investigation of high-efficient heat transfer fluids (e.g. nanofluids)
- Air flow visualization with Particle Image Velocimetry (PIV) and 2-D Laser Doppler Anemometry (LDA).
- Investigation of the local heat transfer with ammonia absorption method (AAM)

## Software

In cooperation with the TLK-Thermo GmbH, the IfT offers the following software products:

- TIL: Advanced Modelica library for steady-state and transient simulation of fluid systems such as heat pump, a/c, refrigeration or cooling systems.
- TILMedia: Interface library to provide fluid properties from various existing fluid and solid property databases like the IfTLibrary, Refprop or FluiEXL to different applications.

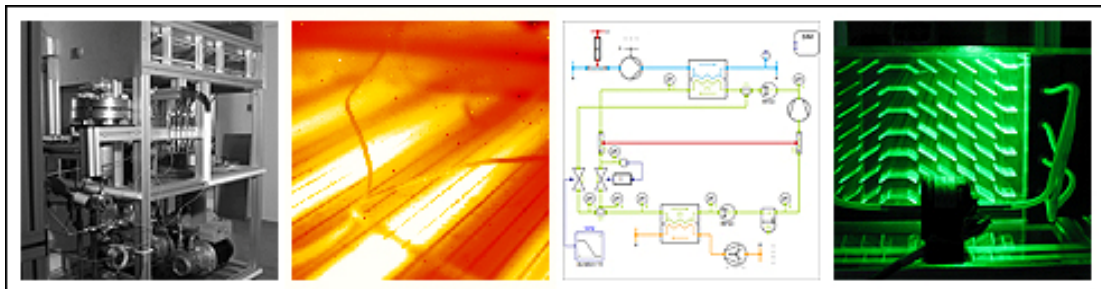
In addition, the following software is used at the IfT:

- ANSYS/FLUENT, DL-Poly, Gaussian, gOpenMol, LabVIEW, MATLAB/Simulink, Modelica/Dymola, Modelica/SimulationX, openFOAM, TINKER, TISC Software Paket, TOWHEE, ...

## Training

The IfT offers - partly in cooperation with the TLK-Thermo GmbH - the training courses listed below:

- Modelica introduction: Two days training for learning basic and advanced object oriented modeling of thermal systems using Modelica. Please have a look on our web site for the next course dates.
- Modelica & TIL: Training on mobile air conditioning systems with the Modelica library TIL. The next course dates are available on our web site.
- Vehicle air conditioning: Basic structure of refrigeration and cooling systems. Discussion of current issues such as refrigerants and alternative applications.



## Research Team.



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