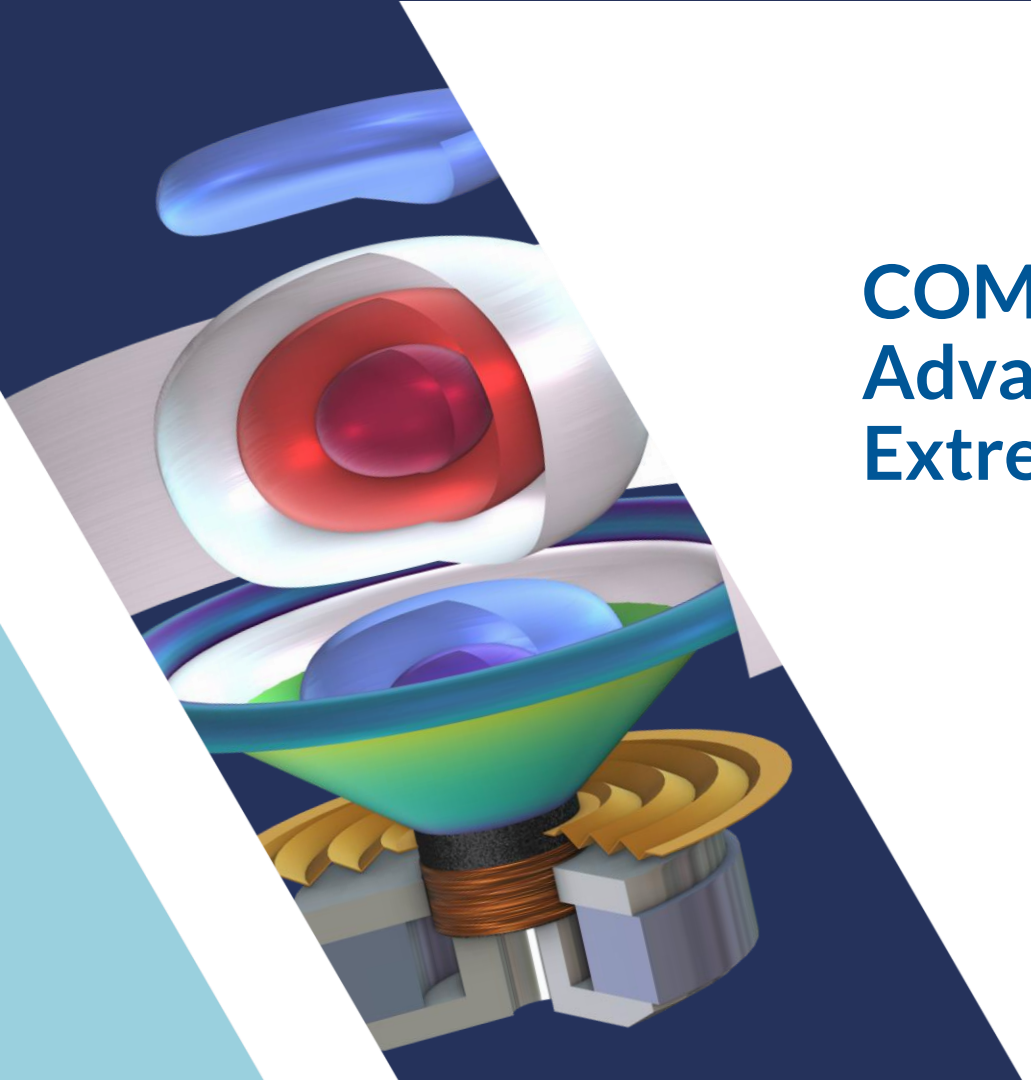


COMSOL®: Modeling Advanced Mechanisms for Extreme Environments

Shahab Eghbali

Thierry Luthy

Agenda

Time	Topics
15h00 – 15h45	Introduction to COMSOL Multiphysics Structural Mechanics Live Demos (Single Physics)
15h45 – 16h00	Break
16h00 – 16h45	Multiphysics Applications and Examples Live Demo of the Microbeam (Multiphysics)

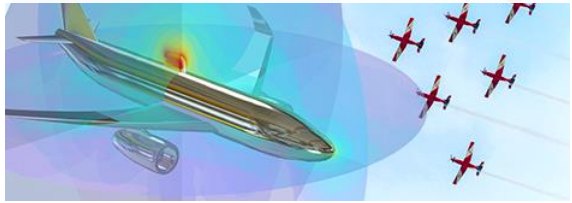
Key Requirements for Research and Development

- Most complex technical devices
- High level of collaboration
- Full control and low-level access
- Optimization and risk assessment
- Organization of large complex projects
- Independent learning
- Reliable local support

COMSOL

Simulate Real-World Designs, Devices and Processes

Aerospace & Defense

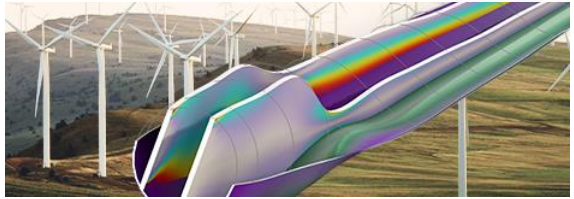


Architecture, Engineering and Construction

Automotive

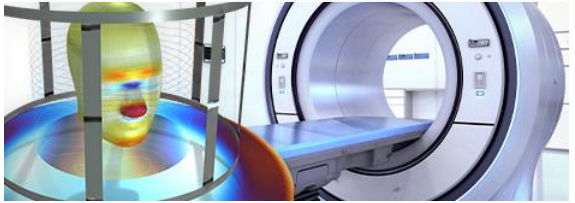
Electronics

Energy



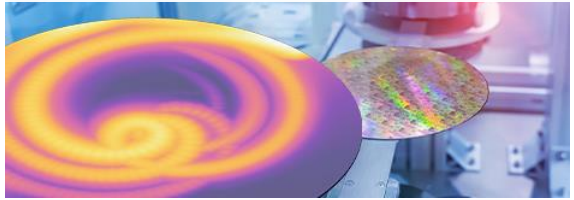
Food and Beverage

Healthcare



Manufacturing

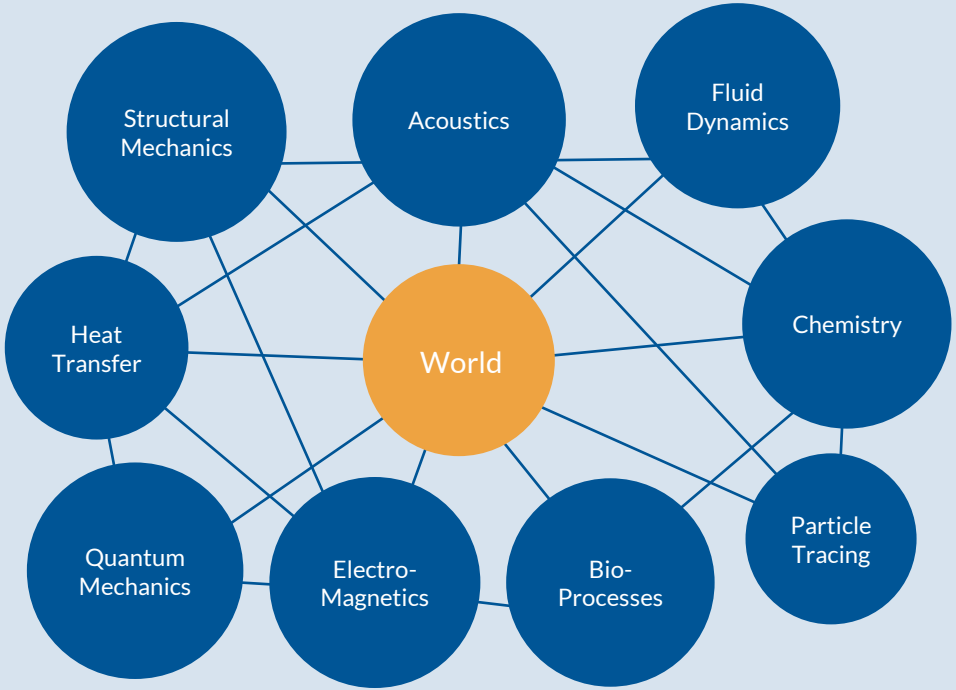
Semiconductor Manufacturing



Transportation

Simulate Real-World Designs, Devices and Processes

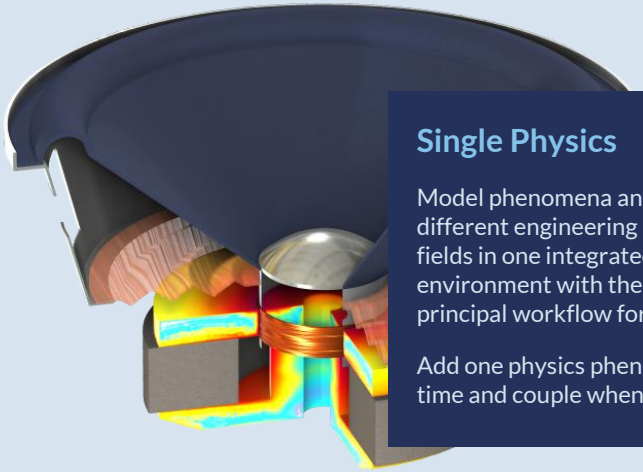
- Single-physics and Multiphysics model
- Enabling new technologies
- Unified modeling approach
- Users in all industries



COMSOL Multiphysics®

One software environment, any engineering field.

A modeling and simulation platform that provides fully coupled multiphysics and single-physics modeling capabilities.



Single Physics

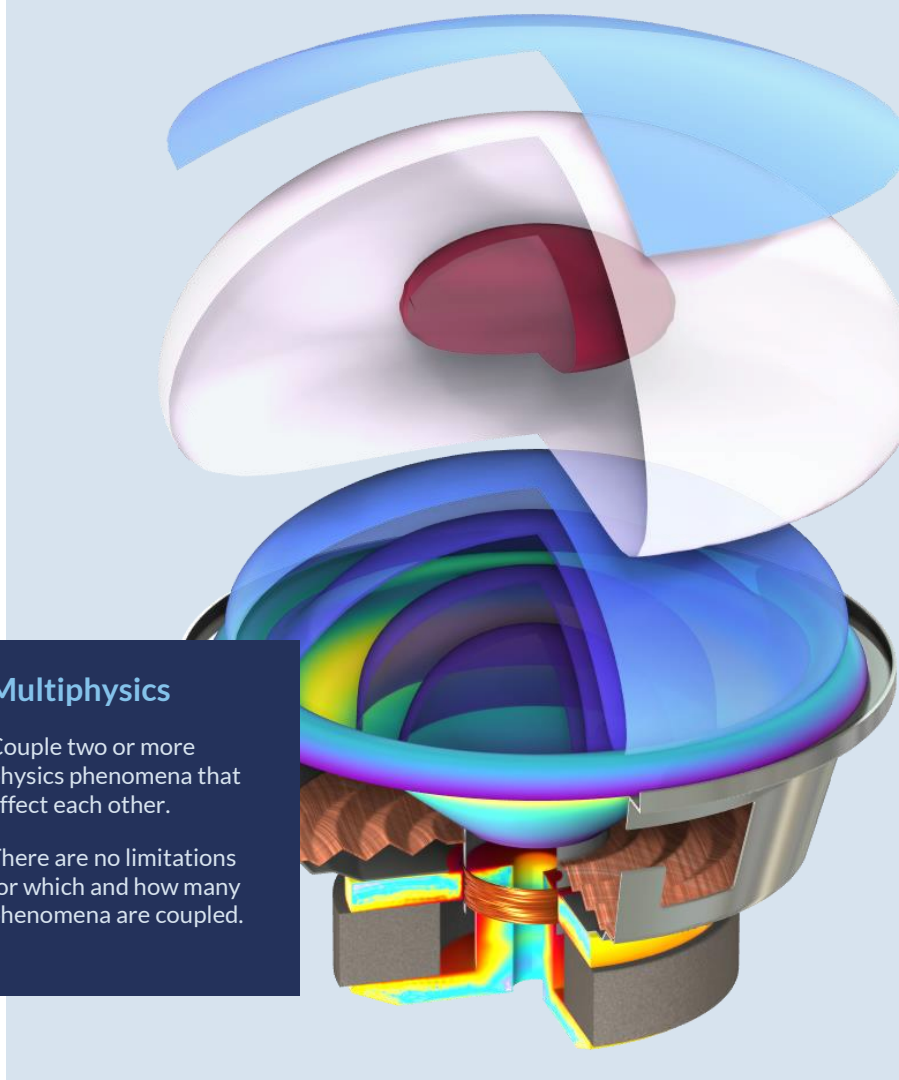
Model phenomena and processes in different engineering and physics fields in one integrated environment with the same principal workflow for all areas.

Add one physics phenomenon at a time and couple when you want.

Multiphysics

Couple two or more physics phenomena that affect each other.

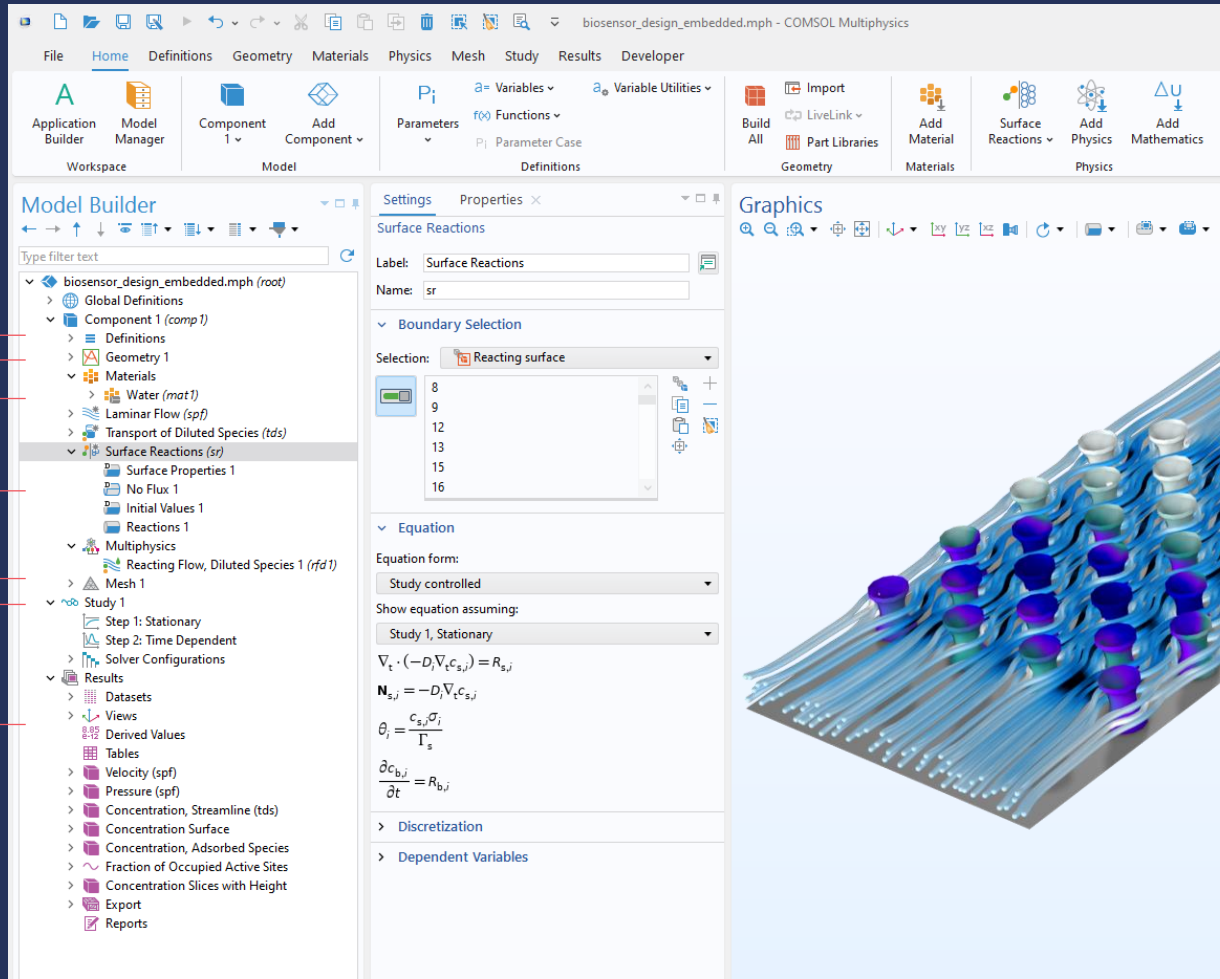
There are no limitations for which and how many phenomena are coupled.



A Look at the Model Builder

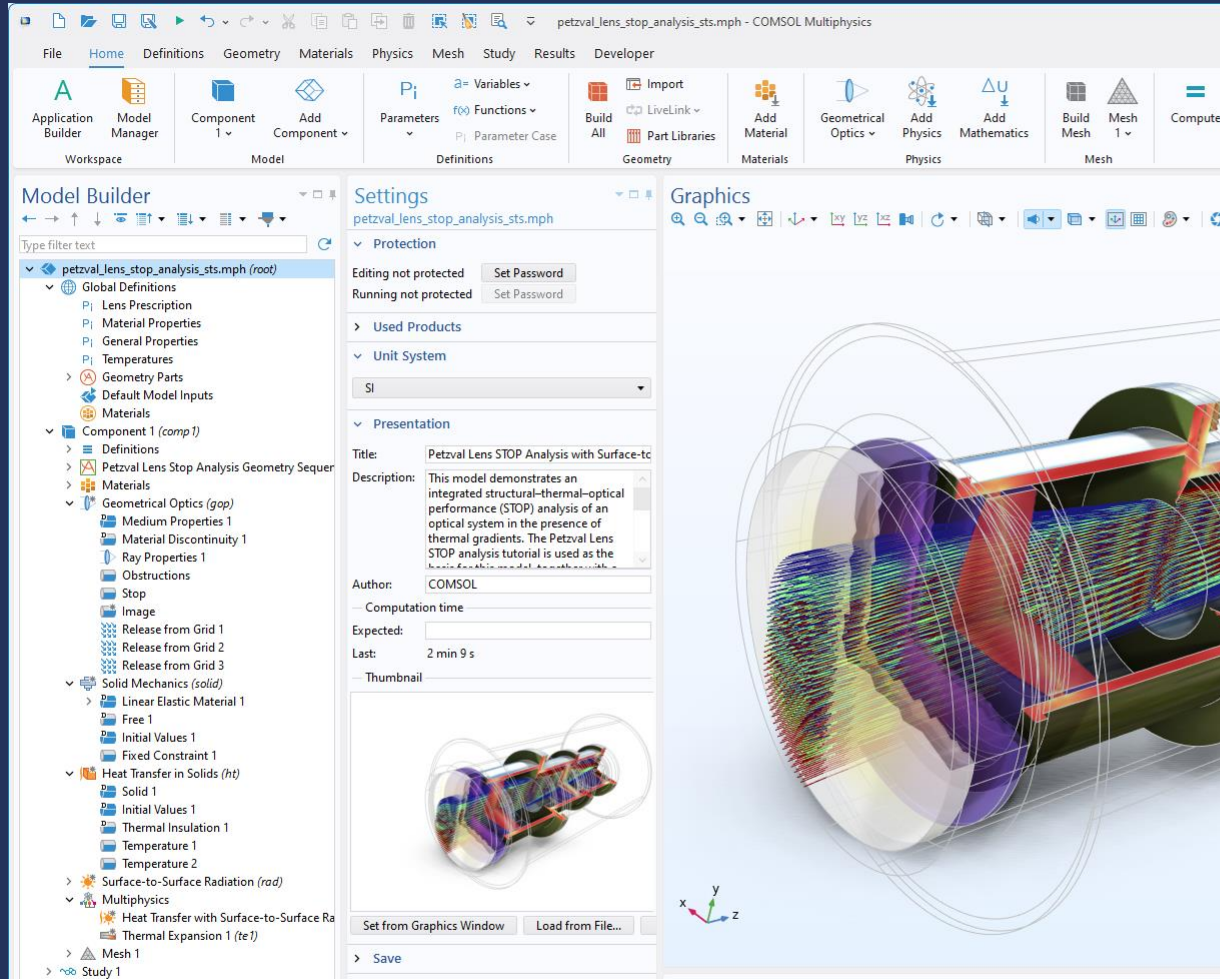
The structure of the user interface is always the same, regardless of the engineering application and physics phenomena.

Definitions
Geometry
Materials
Physics
Mesh
Studies
Results



A Look at the Model Builder

The structure of the user interface is always the same, regardless of the engineering application and physics phenomena.



COMSOL

COMSOL MULTIPHYSICS®

The platform product for simulating real-world designs, devices, and processes. One user interface for all engineering applications.

- MODEL BUILDER: Combine physics phenomena in one model
- APPLICATION BUILDER: Build simulation apps from models
- MODEL MANAGER: Collaborate and organize models and apps

COMSOL Compiler™
Compile simulation apps into executable files. Run them freely on any computer.

COMSOL Server™
Host and administrate your simulation apps. Run them through a web interface.

ADD-ON PRODUCTS

ELECTROMAGNETICS

- AC/DC Module
- RF Module
- Wave Optics Module
- Ray Optics Module
- Plasma Module
- Electric Discharge Module
- Semiconductor Module

FLUID & HEAT

- CFD Module
  - Mixer Module
- Polymer Flow Module
- Microfluidics Module
- Porous Media Flow Module
- Subsurface Flow Module
- Pipe Flow Module
- Molecular Flow Module
- Metal Processing Module
- Heat Transfer Module

STRUCTURAL & ACOUSTICS

- Structural Mechanics Module
  - Nonlinear Structural Materials Module
  - Composite Materials Module
  - Geomechanics Module
  - Fatigue Module
  - Rotordynamics Module
- Multibody Dynamics Module
- MEMS Module
- Acoustics Module

CHEMICAL

- Chemical Reaction Engineering Module
- Battery Design Module
- Fuel Cell & Electrolyzer Module
- Electrodeposition Module
- Corrosion Module
- Electrochemistry Module

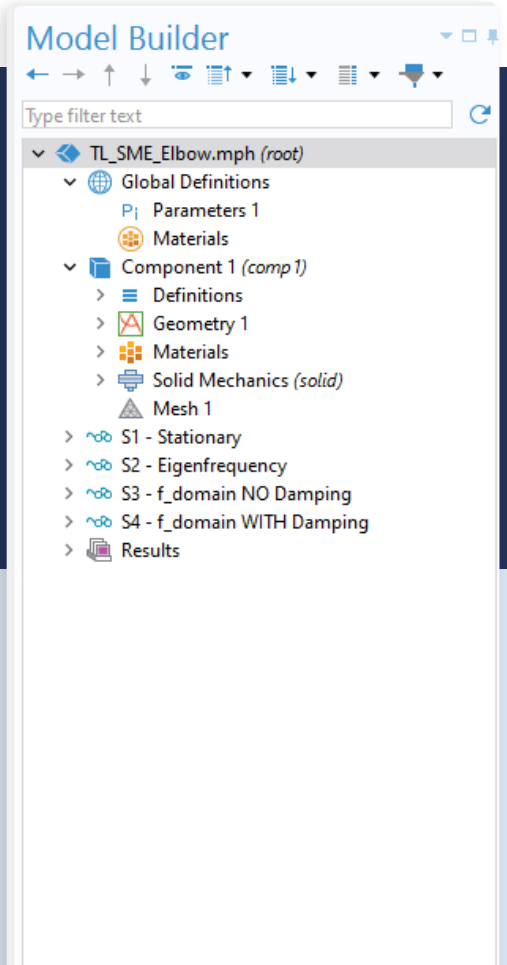
MULTIPURPOSE

- Optimization Module
- Uncertainty Quantification Module
- Material Library
- Particle Tracing Module
- Liquid & Gas Properties Module

INTERFACING

- LiveLink™ *for* MATLAB®
- LiveLink™ *for* Simulink®
- LiveLink™ *for* Excel®
- CAD Import Module
- Design Module
- ECAD Import Module
- LiveLink™ *for* SOLIDWORKS®
- LiveLink™ *for* Inventor®
- LiveLink™ *for* AutoCAD®
- LiveLink™ *for* Revit®
- LiveLink™ *for* PTC Creo Parametric™
- LiveLink™ *for* Solid Edge®
- File Import *for* CATIA® V5

COMSOL

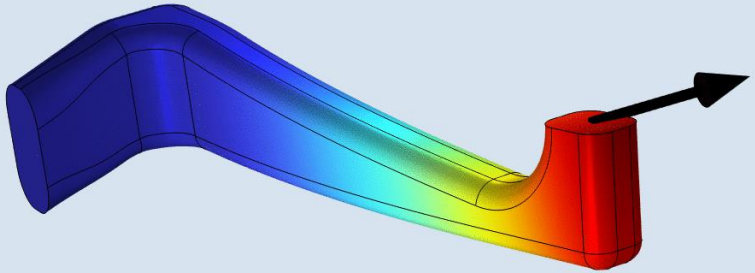


SOFTWARE DEMONSTRATION

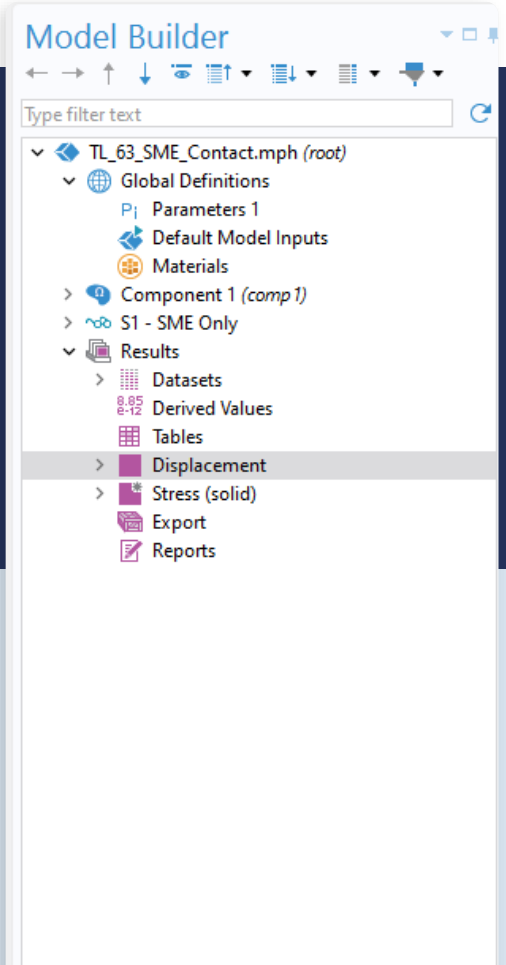
Elbow Deformation

Steel elbow deforms under an applied load

- *Single physics: Solid Mechanics*
- *Parametrization of:*
  - *loads*
  - *geometry*



COMSOL

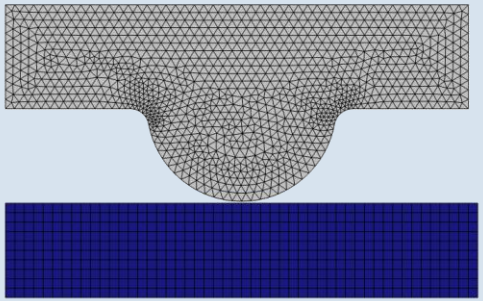


SOFTWARE DEMONSTRATION

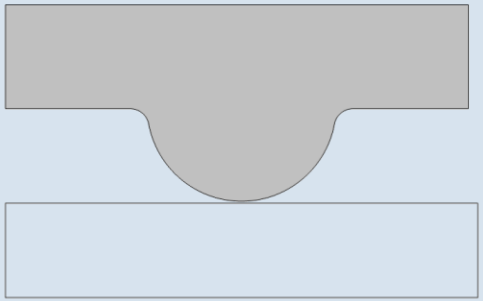
Mechanical Contact

Two solid objects come into contact

- *Single physics: Solid Mechanics*



Total Displacement



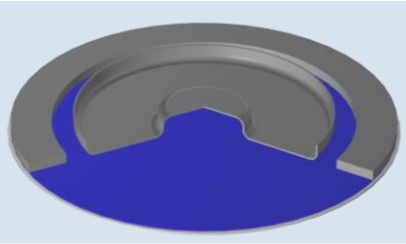
Von Mises Stress

Selected Physics Applications

The COMSOL® Software Product Suite

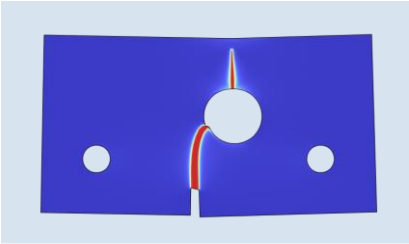
1000+ COMSOL Multiphysics® Modeling Examples for Download

Structural Mechanics



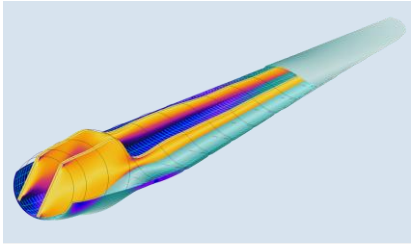
Contact Modeling

Die forming



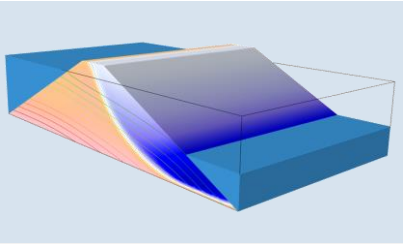
Nonlinear materials

Brittle fracture of a holed plate



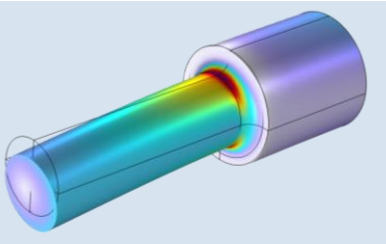
Composites

Wind turbine composite blade



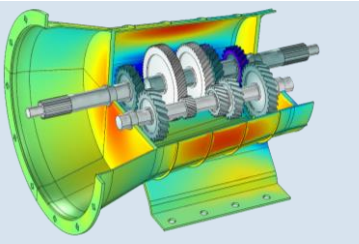
Geomechanics

Stability in an embankment dam



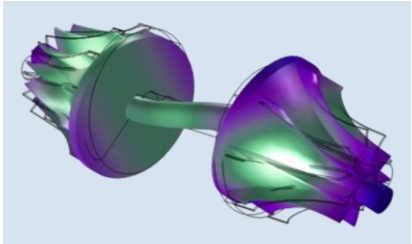
Fatigue

Loaded shaft with a fillet



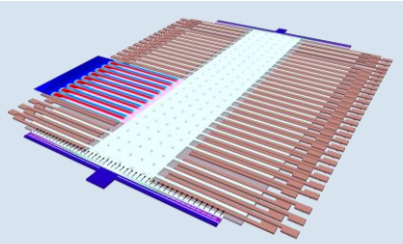
Multibody dynamics

Vibration and noise in a gearbox



Rotordynamics

Stability of a turbocharger



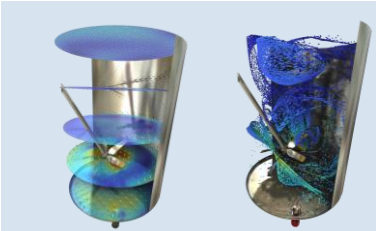
MEMS

Micromachined accelerometer

Fluid Flow

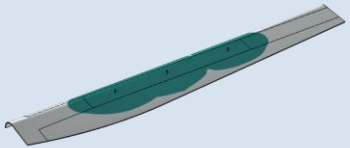
CFD

Sports car aerodynamics



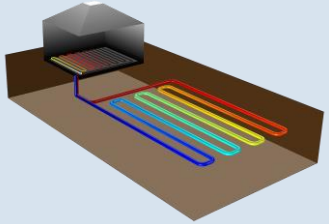
Mixer

Continuous Mixer



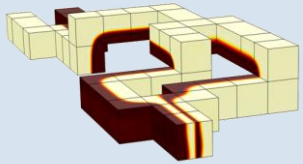
Polymer Flow

Molding of a Wind Turbine Blade



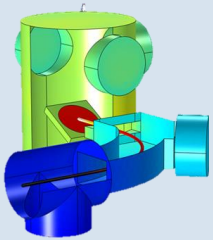
Pipe Flow

Ground heat recovery for radiant floor heating



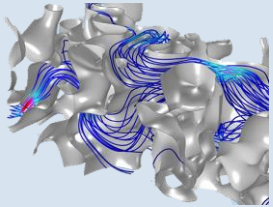
Microfluidics

Split and recombine mixer



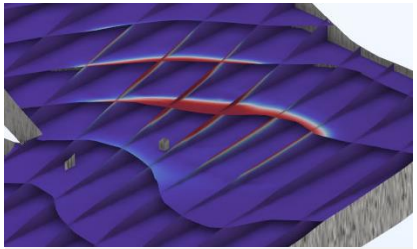
Molecular Flow

Ion-impant vacuum system



Porous Media

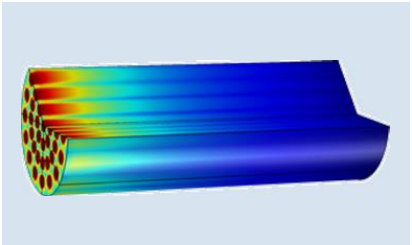
Microscopic porous structures



Subsurface Flow

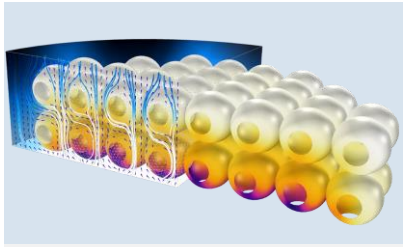
CO2 Storage in a Geologic Formation

Chemical Engineering



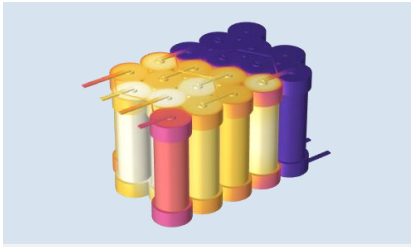
Packed Bed Reactors

Heterogeneous catalysis



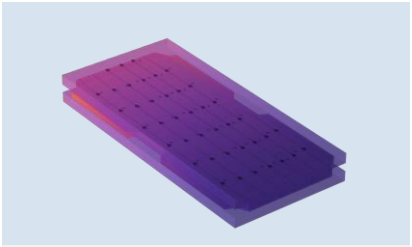
Mixing and Separation

Thermodynamic properties



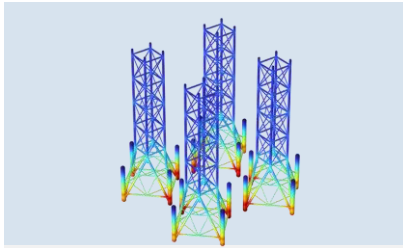
Battery Design

Thermal Runaway Propagation



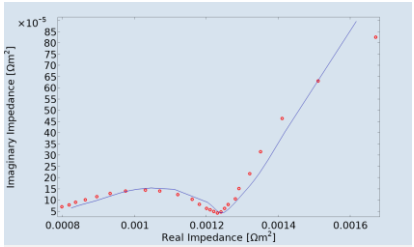
Fuel Cells and Electrolyzers

Fuel Cell Stack Cooling



Corrosion and Deposition

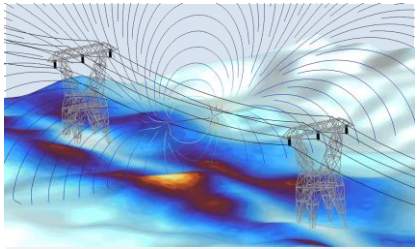
Cathodic protection



Electrochemistry

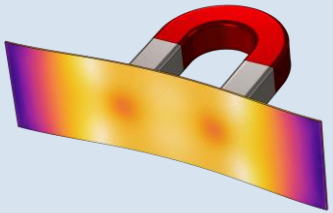
Impedance spectroscopy

AC/DC



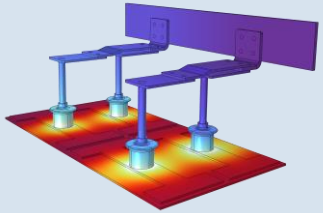
Electrostatic

Overland line



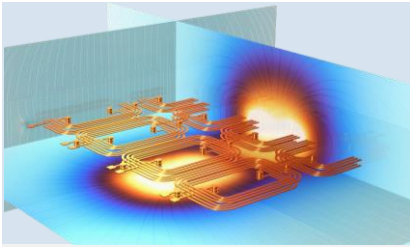
Magnetostatic

Iron plate deformed by magnet



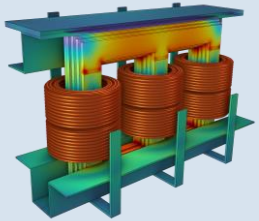
Electric Currents

Busbar



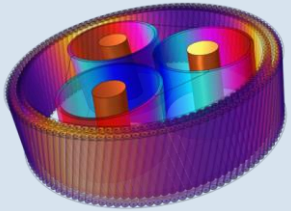
Magnetic Fields, Currents Only

Printed circuit board



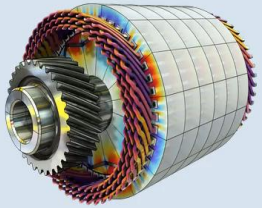
Magnetic Fields

Transformer



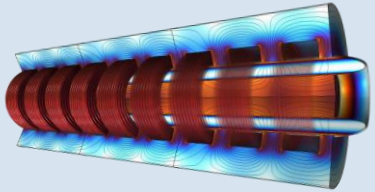
Magnetic and Electric Fields

Cable



Rotating Machinery

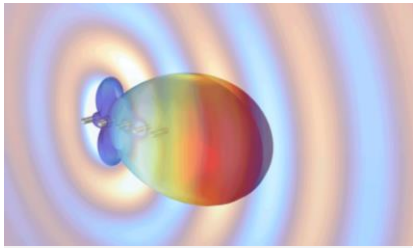
3-phase synchronous machine



Magnetohydrodynamics

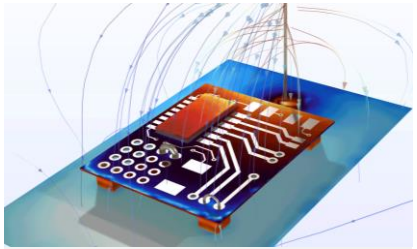
Magnetohydrodynamics pump

High-Frequency Electromagnetics



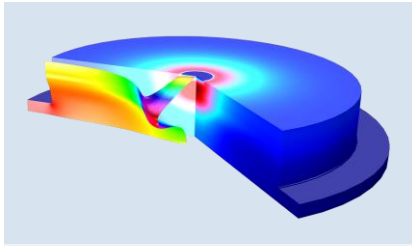
Antennas

Yagi-Uda Antenna



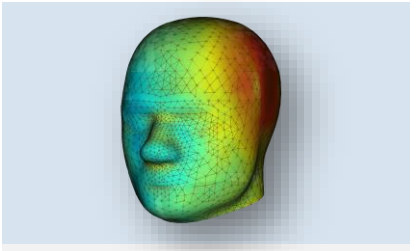
Devices

Electrostatic Discharge Test



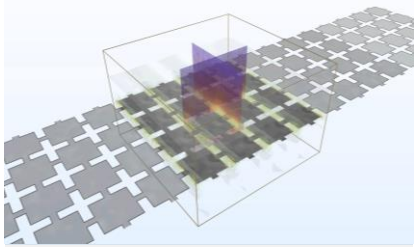
Optoelectronics

P-N junction of an infrared LED



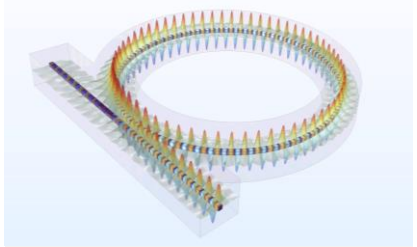
Biomedical

Absorbed Radiation (SAR) in the Human Head



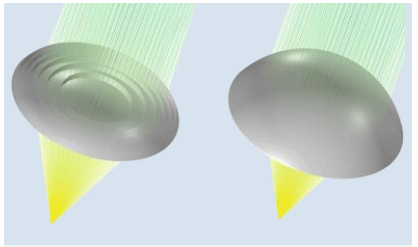
Micro/Nanooptics

Graphene Metamaterial Absorber



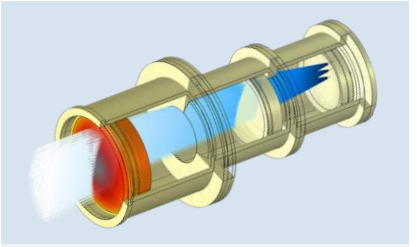
Waveguides

3D Optical Ring Resonator



Optical Systems

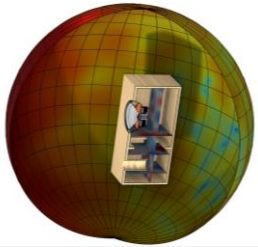
Ray Optics Modeling of a Fresnel Lens



STOP Analysis

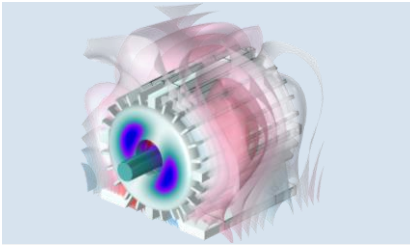
Thermally deformed Petzval lens

Acoustics



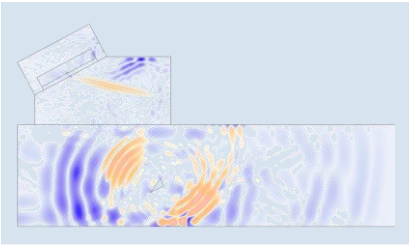
Speakers / Microphones

Loudspeaker simulation (BEM-FEM)



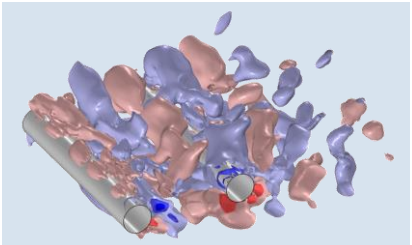
Noise emission

Electric motor noise



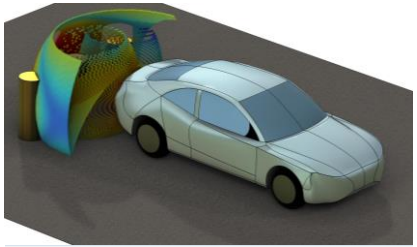
Nondestructive testing

Angle beam ultrasound NDT



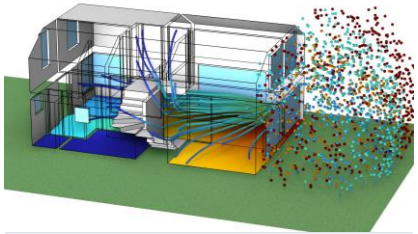
Flow-induced noise

Cavity flow noise



Sensors

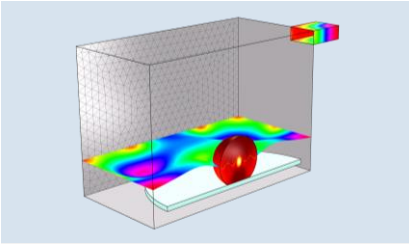
Ultrasonic car parking sensor



Architectural acoustics

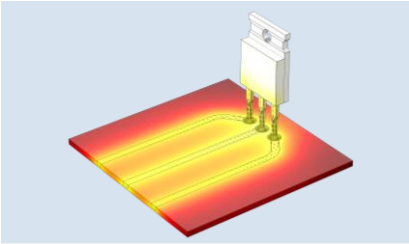
One-Family House Acoustics

Heat Transfer



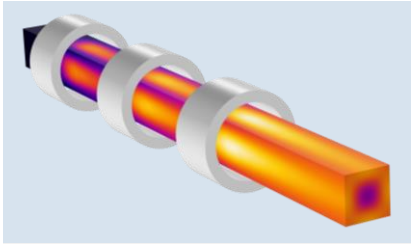
Microwave heating

Potato in a microwave oven



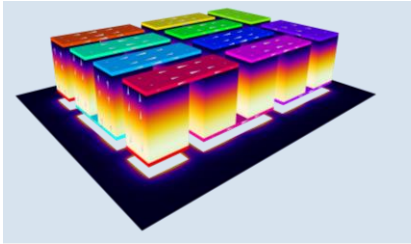
Joule heating

Transistor on a circuit board



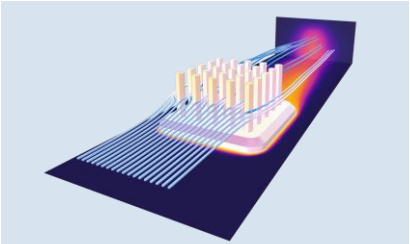
Inductive heating

Induced eddy current heating



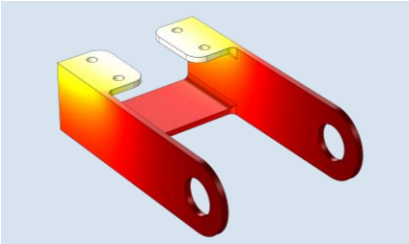
Thermoelectric effects

Thermoelectric cooler



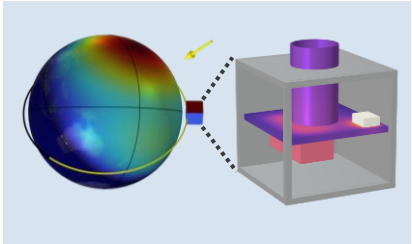
Conjugate heat transfer

Pin heat sink



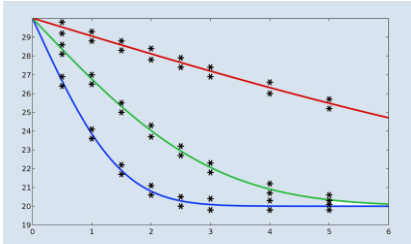
Thermal expansion

Heated bracket



Orbital Thermal Loads

Spacecraft Thermal Analysis



Heat and moisture

Heat and moisture transport in building materials

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Model Builder

Type filter text

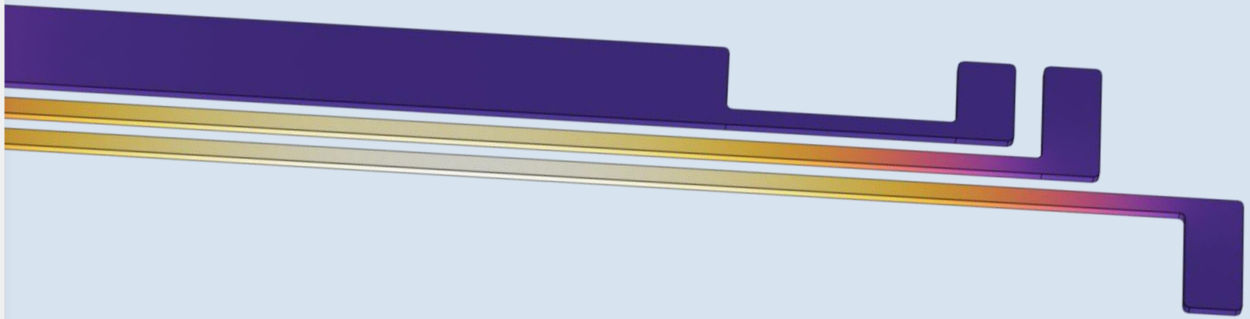
- Untitled.mph
  - Global Definitions
  - Component 1 {comp 1}
    - Definitions
    - Geometry 1 {geom1}
    - Materials
    - Electric Currents {ec}
    - Heat Transfer in Solids {ht}
    - Solid Mechanics {solid}
    - Multiphysics
      - Electromagnetic Heating 1 {emh1}
      - Thermal Expansion 1 {te1}
    - Mesh 1 {mesh1}
  - Study 1 {std1}
  - Results
    - Datasets
    - Derived Values
    - Tables
    - Electric Potential {pg1}
    - Electric Field Norm {pg2}
    - Tempurature {pg3}
    - Von Mises Stress {pg4}
    - Displacement {pg5}
    - 1D Plot Group 6 {pg6}
    - Export
    - Reports

SOFTWARE DEMONSTRATION

Thermal Actuator

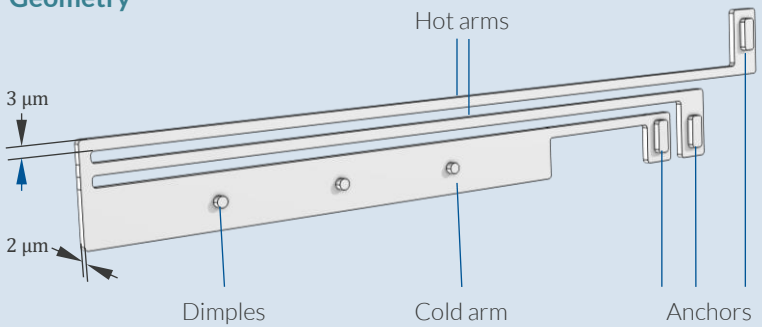
Joule Heating and Thermal Expansion

- *Electric Currents*
- *Heat Transfer in Solids*
- *Solid Mechanics*



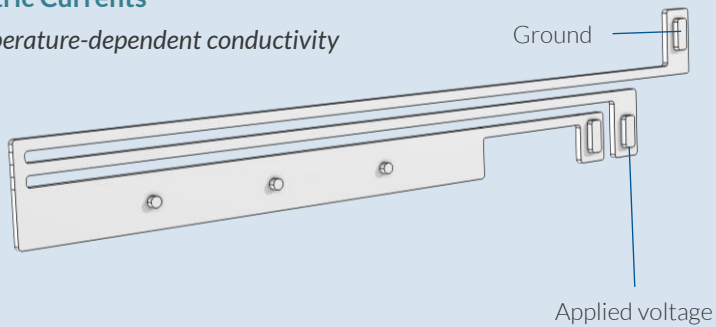
Model Definition and Physics Settings

Geometry



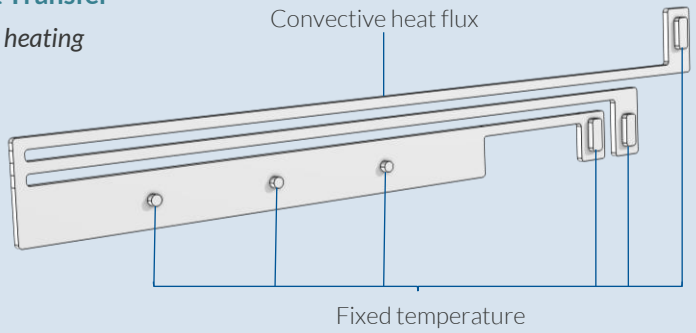
Electric Currents

Temperature-dependent conductivity



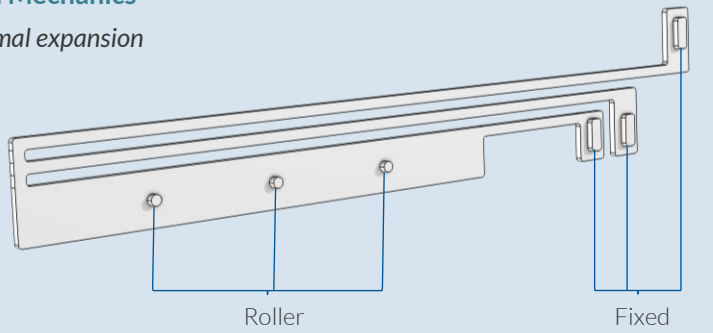
Heat Transfer

Joule heating



Solid Mechanics

Thermal expansion



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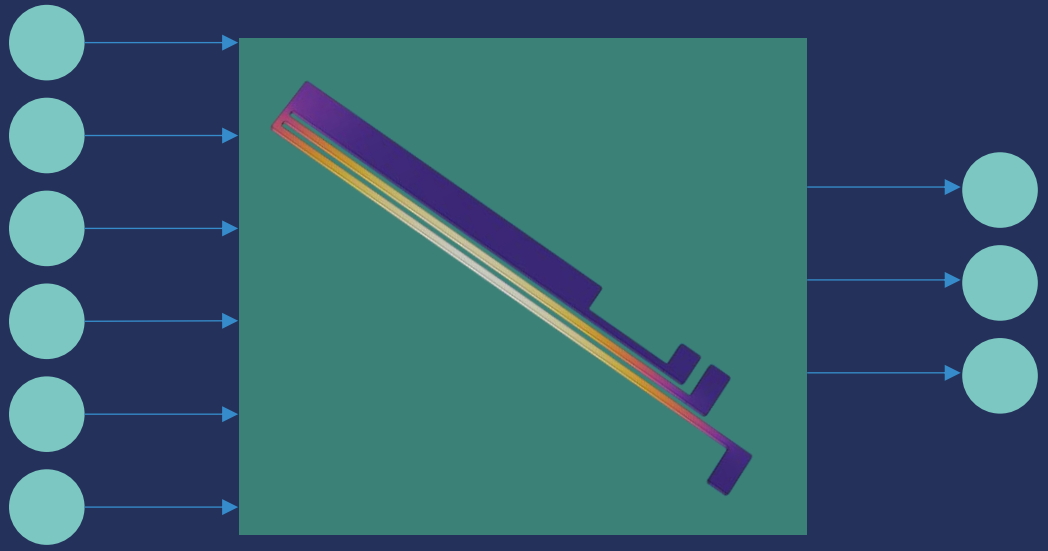
ADVANCED MODELING

Workflow Extensions

- Parameterization
- Optimization
- Uncertainty Quantification
- Surrogate Modeling

Model Input X

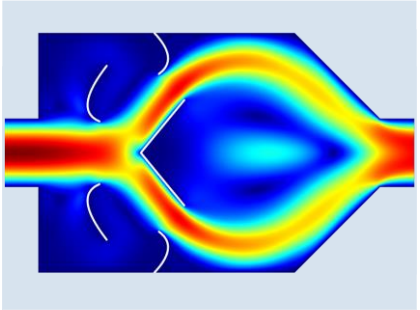


Model Output Y

Geometry
Materials
Loads
Operating conditions
Numerical settings (mesh, solver)

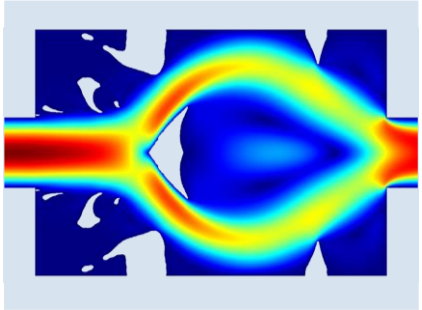
Fields
Lumped parameters
Fitness objective

Optimize Design and Enhance Performance in COMSOL Multiphysics®



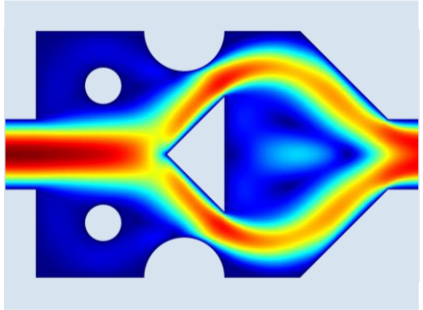
Shape Optimization

Find the optimal shape so that it minimizes an objective function given a set of constraints.



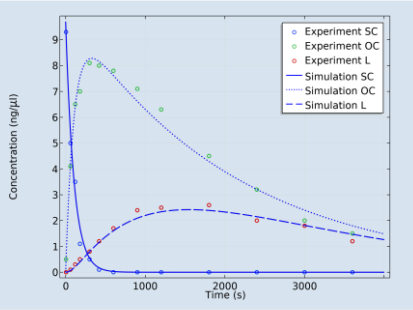
Topology Optimization

Optimize the material distribution to minimize an objective function given a set of constraints.



Parameter Optimization

Find the optimal dimensions and position so that they minimize an objective function given a set of constraints.



Parameter Estimation

Find a set of parameter values that minimizes the discrepancy between a model and measurement (objective).

Simulation Optimization Software - Improve Your Engineering Designs

Key Requirements for Research and Development

- Most complex technical devices
- High level of collaboration
- Full control and low-level access
- Optimization and risk assessment
- Organization of large complex projects
- Independent learning
- Reliable local support

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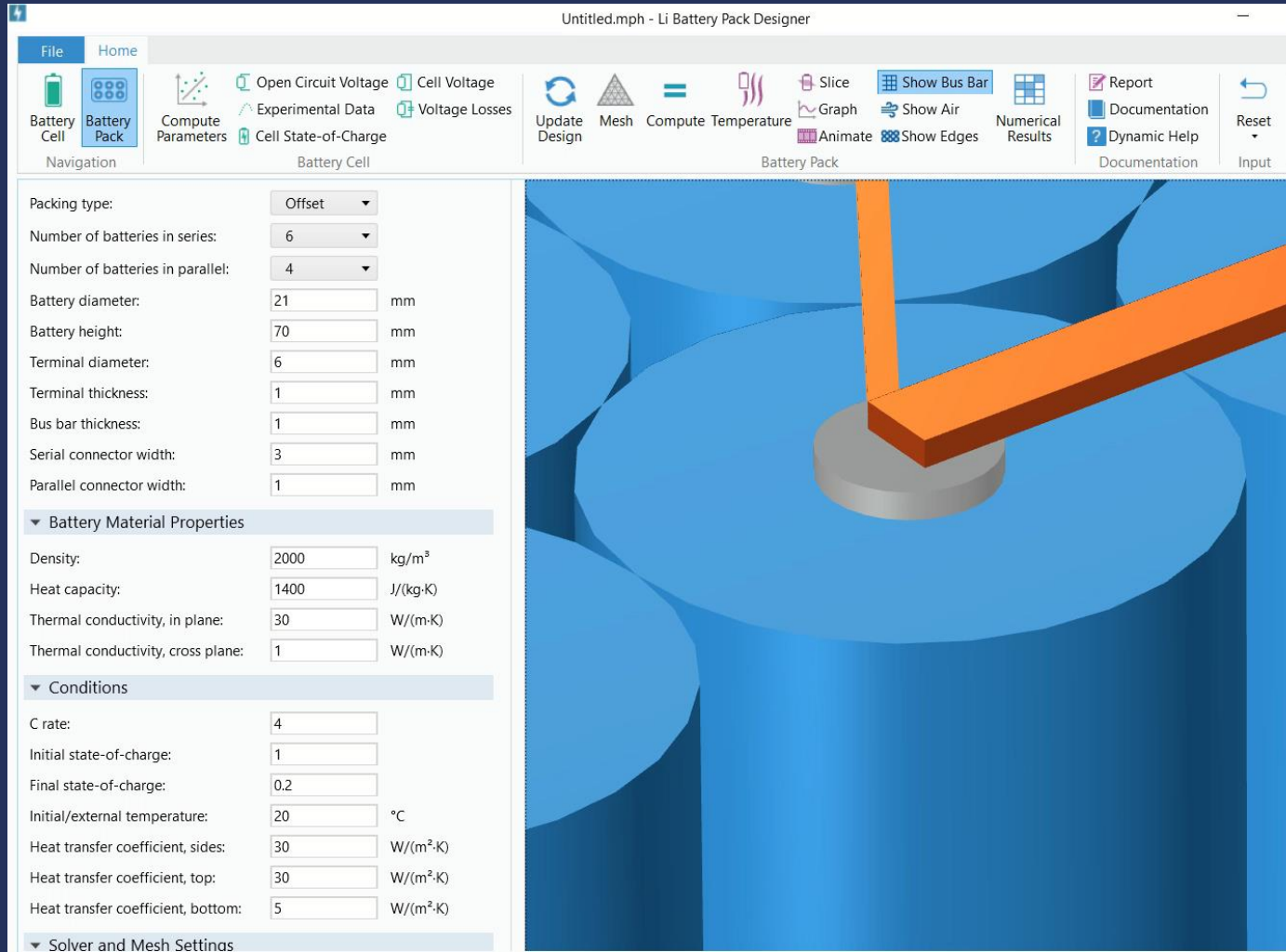
CLOSER LOOK AT THE

Application Builder

Create custom-made simulation apps based on multiphysics models.

Design the app UI so that users can change the model settings that are relevant to the task at hand.



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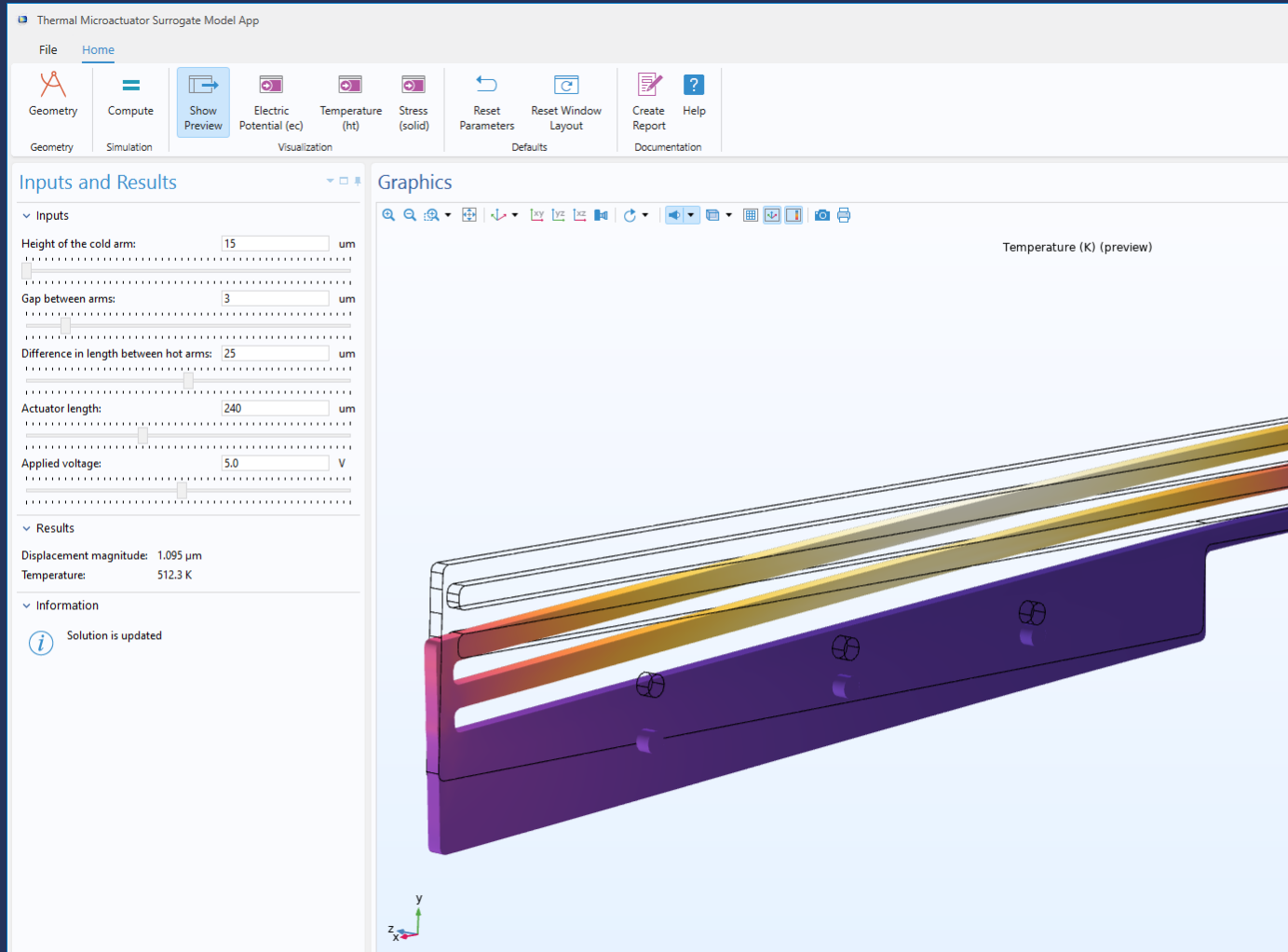
SOFTWARE DEMONSTRATION

Thermal Actuator App

Extend the value of modeling and simulation to a larger group of engineers and scientists, within or outside your organization.



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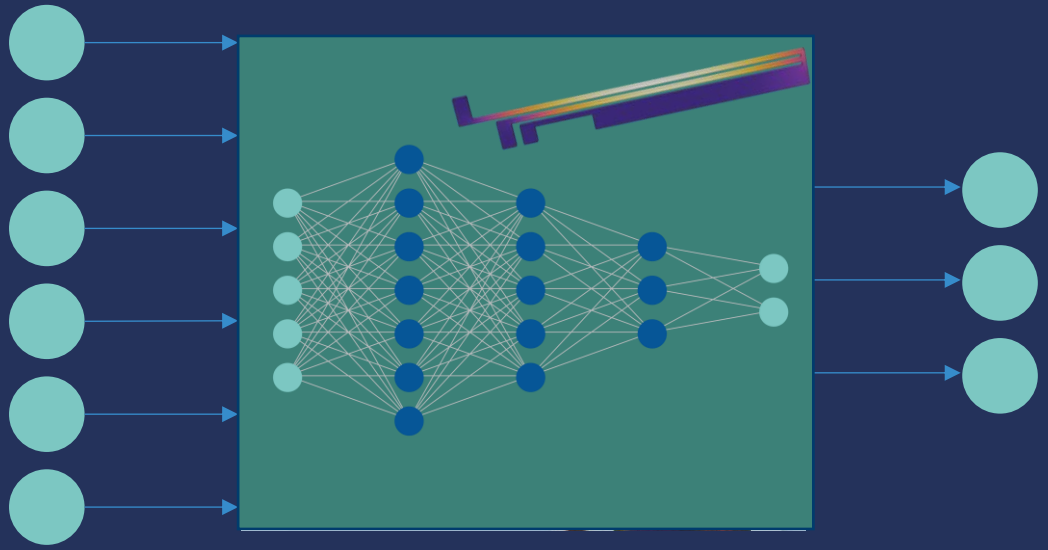
ADVANCED MODELING

Workflow Extensions

- Parameterization
- Optimization
- Uncertainty Quantification
- Surrogate Modeling

Model Input X

Model Output Y



Geometry
Materials
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Numerical settings (mesh, solver)

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SOFTWARE DEMONSTRATION

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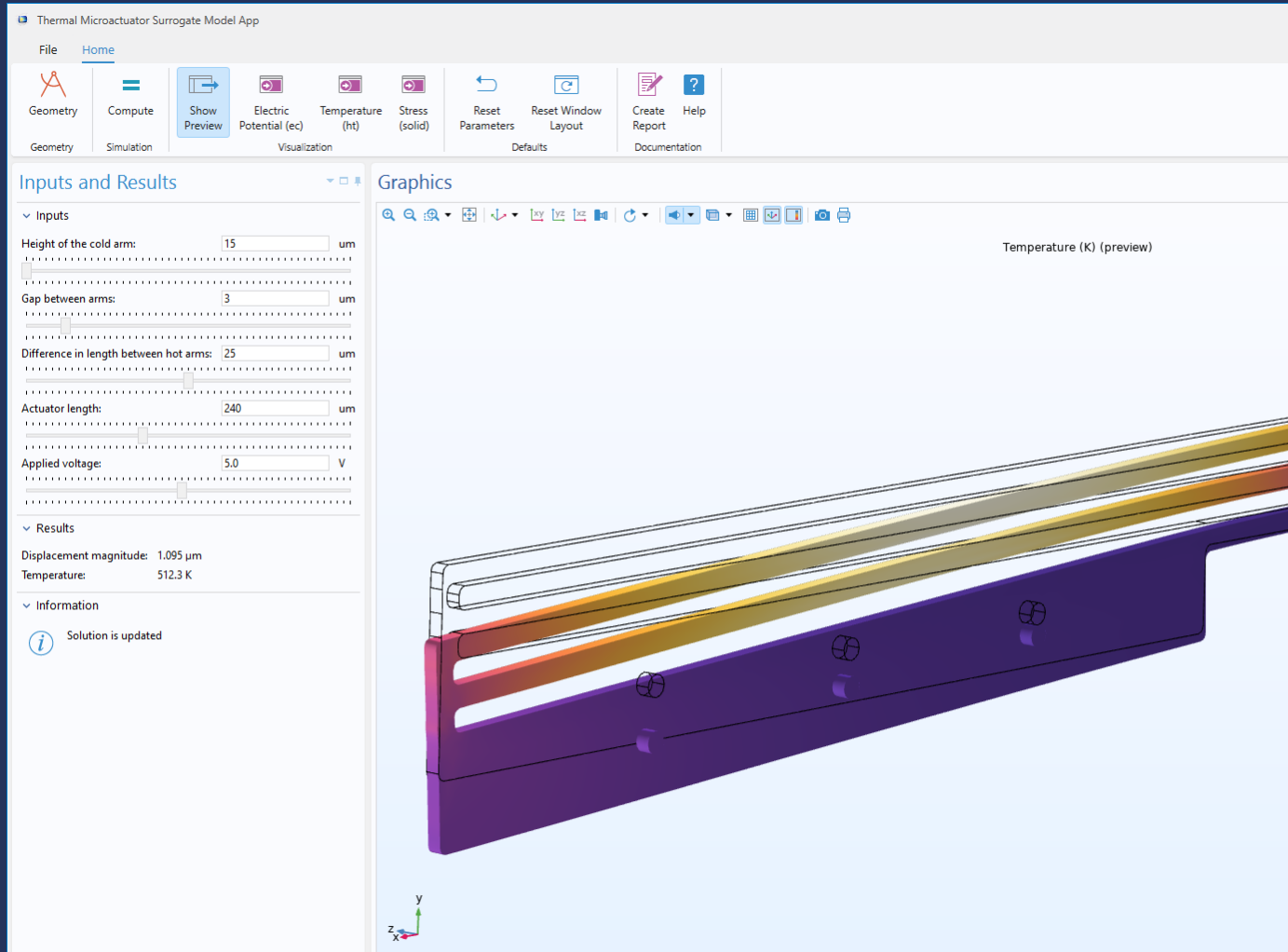

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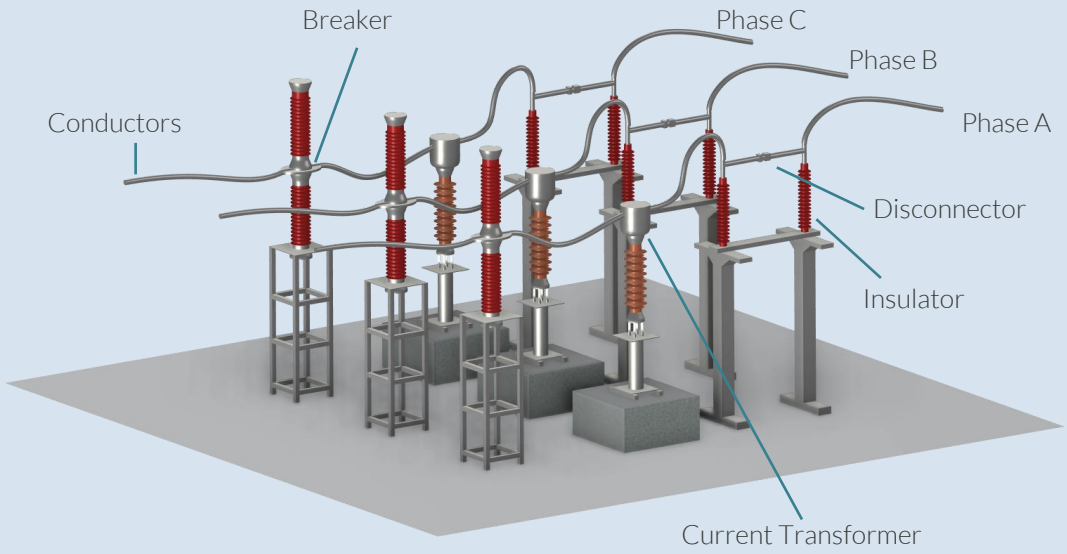
The Need for Faster Models

Digital Twins

110kV high-voltage switchgears include circuit-breakers, current transformers, disconnectors, conductors and other devices.

Simulation wanted in real time.



HV Switchgears

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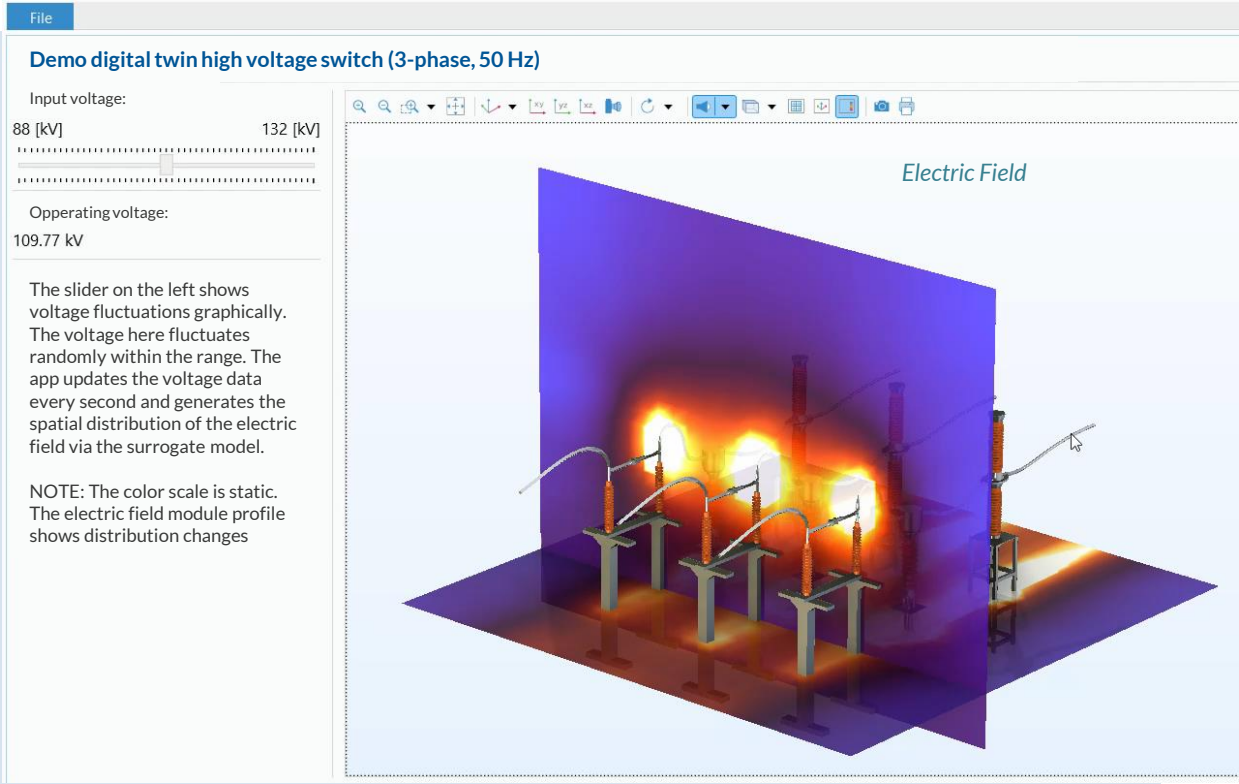
Real-time Updating

Digital Twins

This app of a 3-Phase AC breakers & disconnectors system reads measured data every second. The surrogate model updates the plot in real-time.



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CONTACT

Get in touch with your CSR if you have any questions

Thierry Luthy

Thierry.luthy@comsol.com

Shahab Eghbali

Shahab.eghbali@comsol.com

COMSOL Day
Medtech

Thursday, June 5
9:30–16:30 CEST

See what is possible with modeling

for medical devices and processes

Join us for this COMSOL Day to see how multiphysics modeling and simulation can address important issues in the field of medical technology relating to patient safety, product quality, efficacy, and regulatory compliance.

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Topics Include

- Biochemical Sensors & Tests
- CFD in Medical Technologies
- Bioelectromagnetics and Tissue Heating
- Biomaterials and Tissue Biomechanics

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Meervaart Theater

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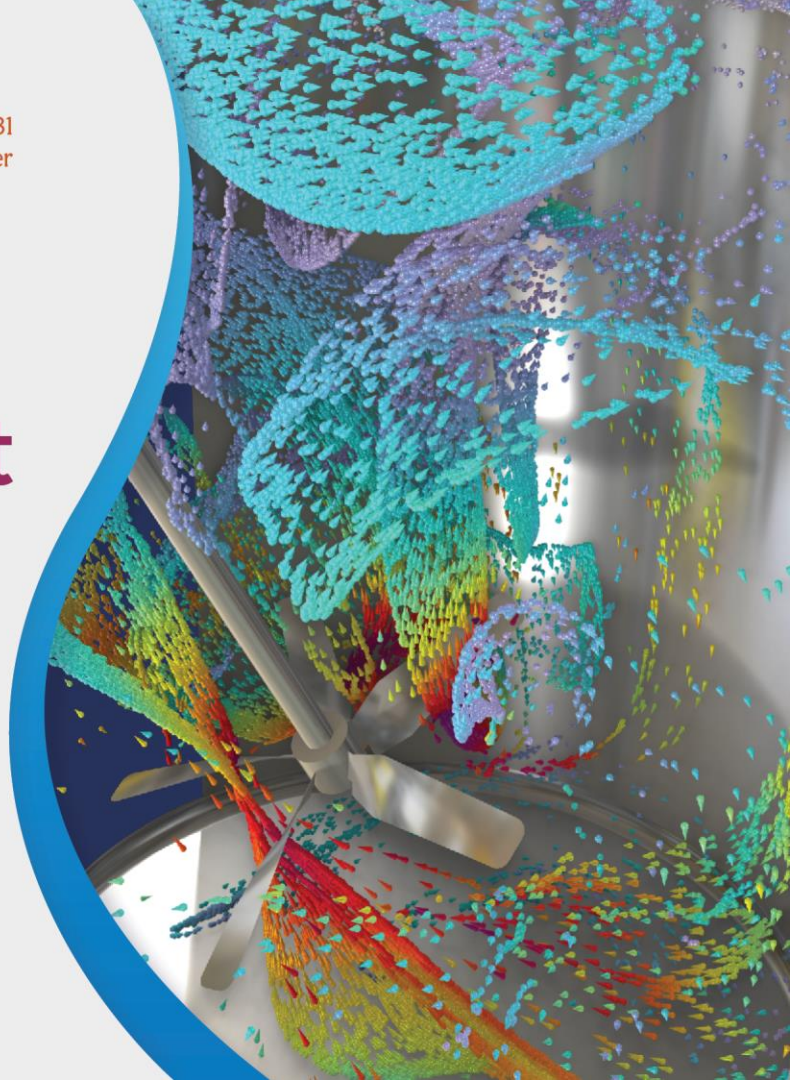

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Further Resources to Get Started

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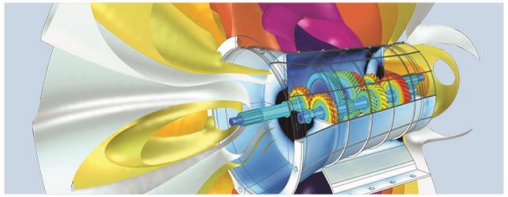

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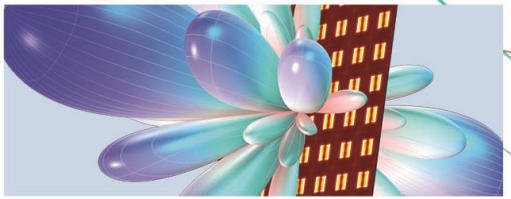
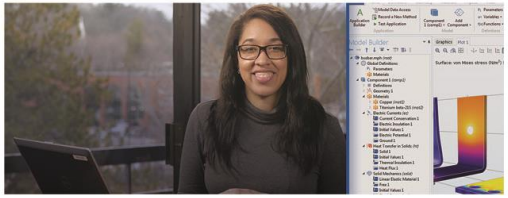
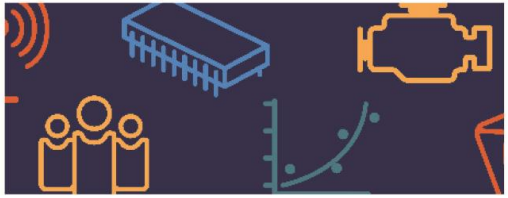


MODELS & APPLICATIONS



LEARNING CENTER



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