

# Představení COMSOL Multiphysics<sup>®</sup>, COMSOL Server<sup>™</sup> a COMSOL Compiler<sup>™</sup>

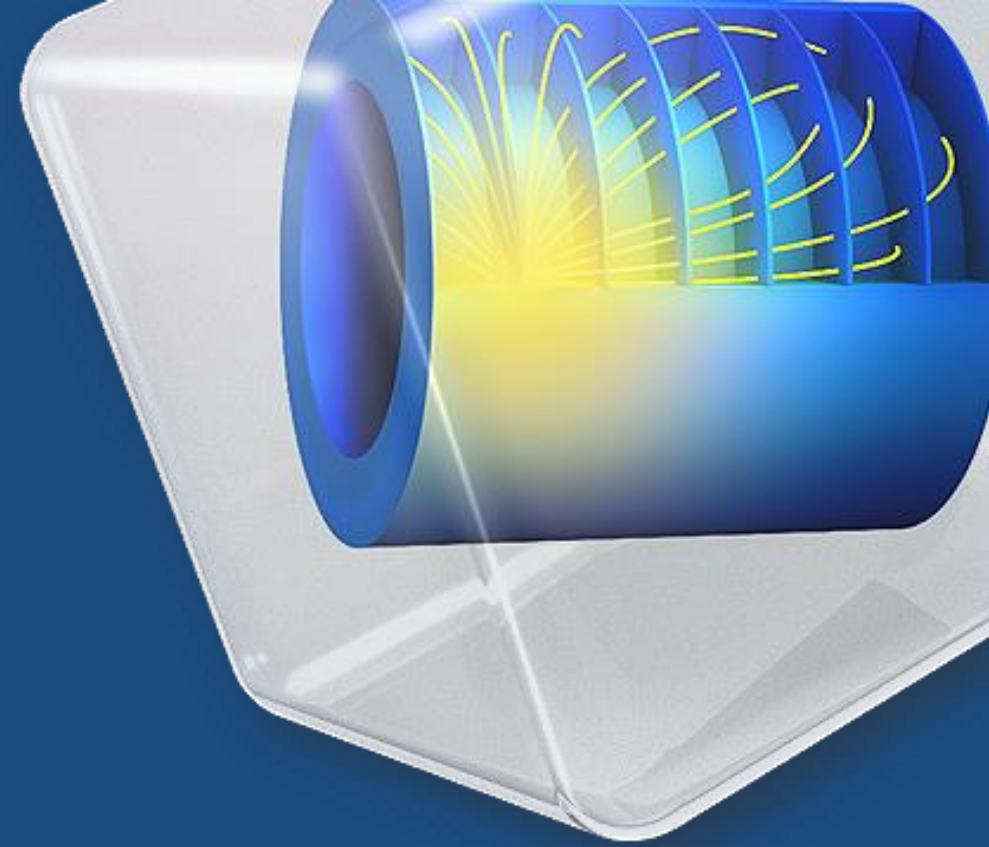


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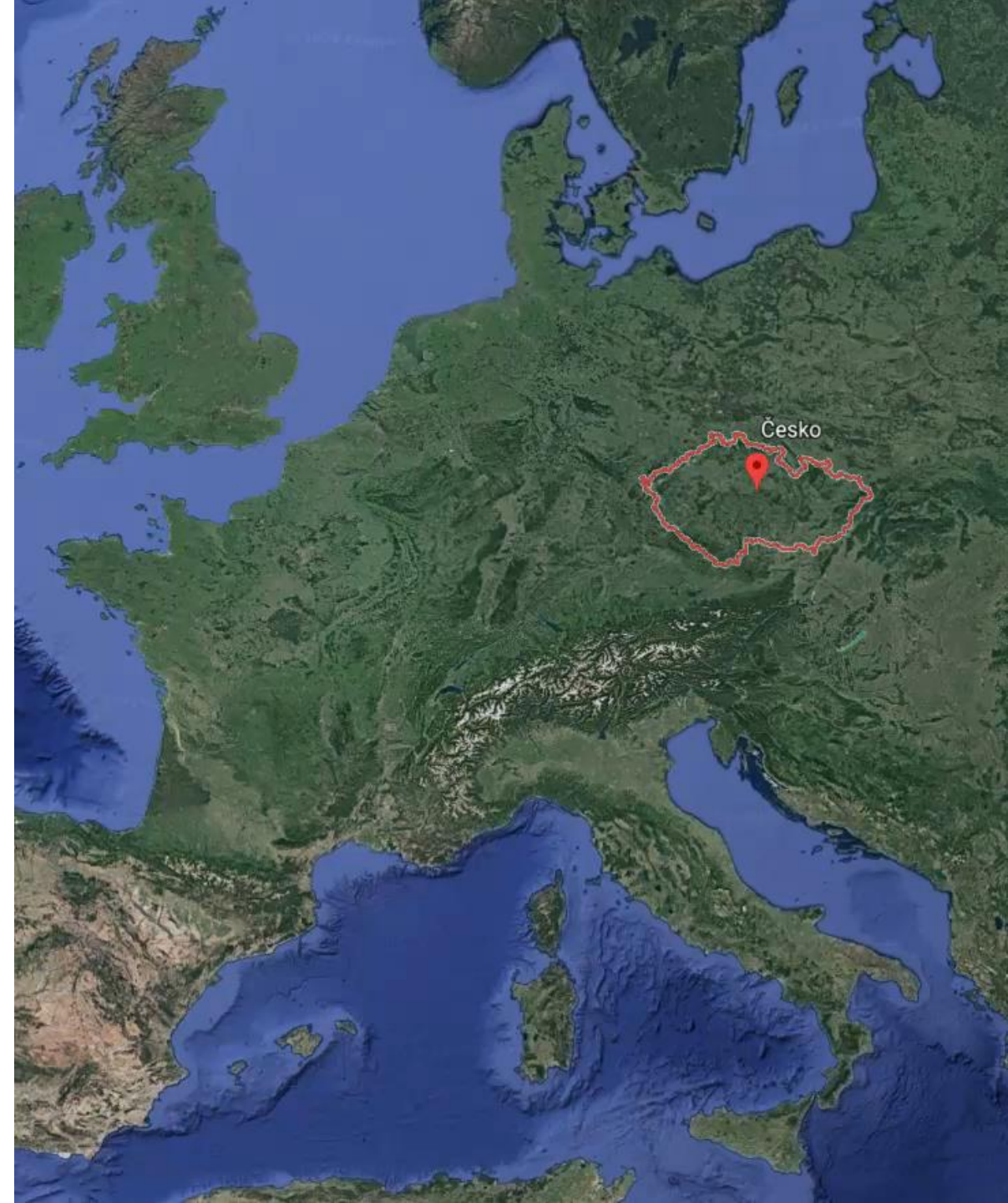
+420 284 011 745



Představení COMSOL Multiphysics<sup>®</sup>,  
COMSOL Server<sup>™</sup> a COMSOL Compiler<sup>™</sup>

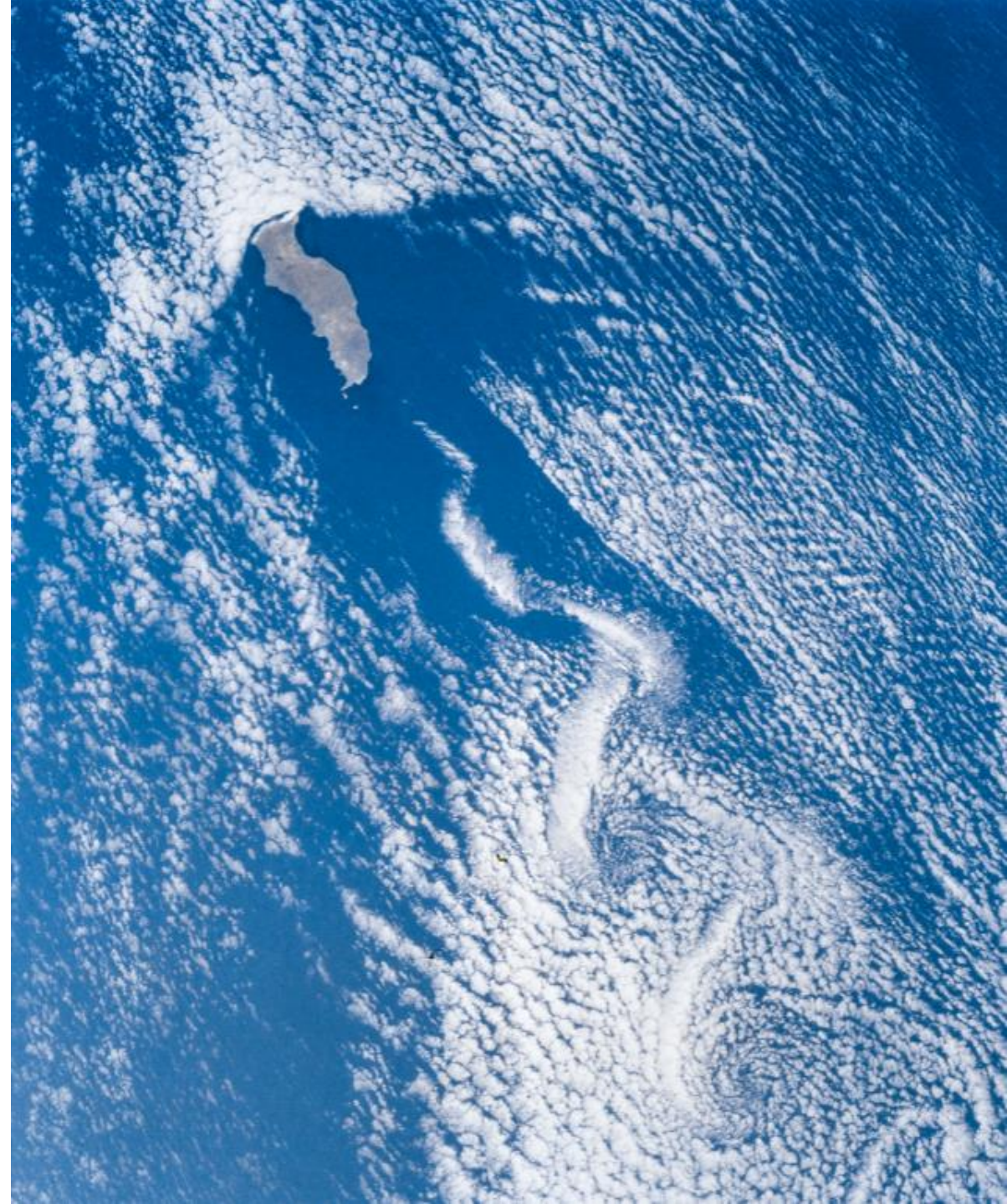
# Příklad fyzikálního děje

- Ostrov Guadelupe
- Karibské moře, 600 km severně od Jižní Ameriky
- 9. května 2018, severozápadní vítr 10 m/s



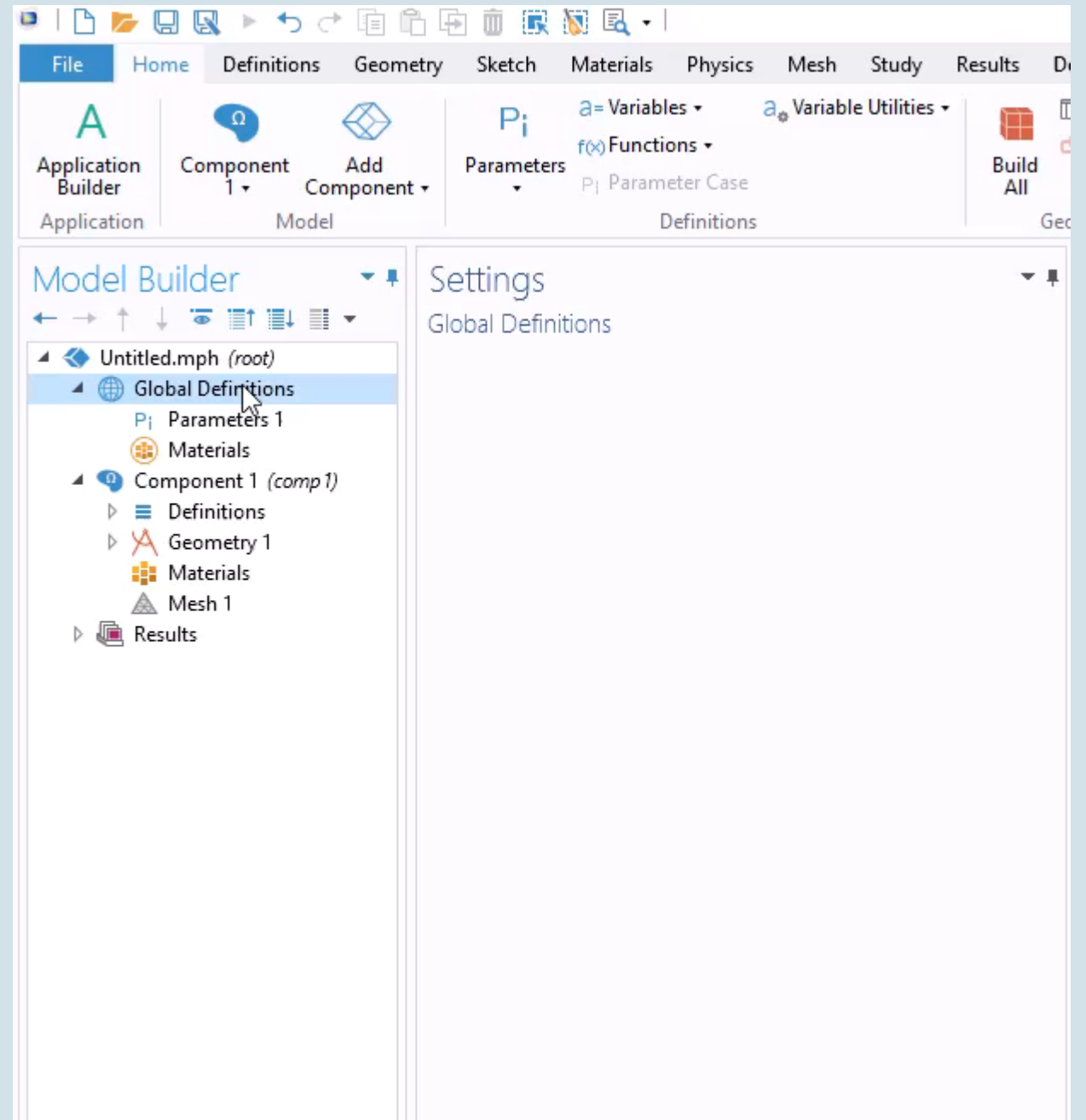
# Příklad fyzikálního děje

- Ostrov Guadalupe
- Karibské moře, 600 km severně od Jižní Ameriky
- 9. května 2018, severozápadní vítr 10 m/s
- Von Kármánova vírová řada
  - Aerodynamický jev
  - Střídavě se odtrhávající víry



# COMSOL Multiphysics®

- Definice parametrů



# COMSOL Multiphysics®

- Definice parametrů
- Tvorba/import geometrie

The screenshot displays the COMSOL Multiphysics software interface. The **Model Builder** window on the left shows a hierarchical tree structure for an untitled model. The **Settings** window in the center is focused on the **Parameters** section, showing a table of defined parameters. The **Graphics** window on the right shows a blank coordinate system with axes ranging from -1 to 1.2 on the y-axis and 0 to 2 on the x-axis.

Name	Expression	Value	Description
rho	1.2 [kg/m^3]	1.2 kg/m³	
mu	1.81e-5 [Pa*s]	1.81E-5...	
D	0.08 [m]	0.08 m	
Re	200	200	
U_inlet	Re*mu/D/rho	0.037708...	

# COMSOL Multiphysics®

- Definice parametrů
- Tvorba/import geometrie
- Definice materiálu

The screenshot displays the COMSOL Multiphysics software interface. The **Model Builder** window on the left shows a hierarchical tree with 'Import 1 (imp)' selected under 'Geometry 1'. The **Settings** window in the center is configured for the 'Import' operation, showing the source as 'COMSOL Multiphysics file' and the filename as '\\hay\ARCHIVE\USERS\kozisek\PROFILE\Desktop\Guad'. The **Graphics** window on the right shows a 2D plot of the imported geometry, a white irregular shape on a gray background, with axes ranging from -0.6 to 0.2 meters. A **Messages** window at the bottom right displays the following log entries:

```
[May 14, 2021 1:11 PM] Imported 1 solid object from \\hay\ARCHIVE\USERS\kozisek\PRC  
[May 14, 2021 1:14 PM] Finalized geometry has 1 domain, 20 boundaries, and 20 vertices.
```

# COMSOL Multiphysics®

- Definice parametrů
- Tvorba/import geometrie
- Definice materiálu
- Okrajové a počáteční podmínky

The screenshot displays the COMSOL Multiphysics software interface with four main panels:

- Model Builder:** Shows a hierarchical tree of the model structure. The 'Materials' folder is expanded, showing 'Air (mat1)' selected.
- Settings:** Shows the 'Material' settings for 'Air'. The 'Geometric Entity Selection' section is active, showing 'Domain' as the level and 'All domains' as the selection. Below, the 'Material Contents' table lists various properties and their values.
- Graphics:** Shows a 2D plot of a domain with a white irregular shape cutout, set against a purple background. The axes are labeled 'm' and range from -0.6 to 0.2.
- Add Material:** Shows a search bar and a list of materials. 'Air' is selected in the 'Built-in' category.

**Material Contents Table:**

Property	Variable	Value
Coefficient of thermal expansi...	alpha...	alph...
Mean molar mass	Mn	0.02
Bulk viscosity	muB	mu
Relative permeability	mur_i...	1
Relative permittivity	epsilo...	1
Dynamic viscosity	mu	eta(...)
Ratio of specific heats	gamma	1.4
Electrical conductivity	sigma...	0[S/...
Heat capacity at constant pres...	Cp	Cp(...)
Density	rho	rho(...)
Thermal conductivity	k_iso;...	k(T)

**Messages Log:**

```
[May 14, 2021 1:11 PM] Imported 1 solid object from \\hay\ARCHIVE\USERS\kozisek\PRC  
[May 14, 2021 1:14 PM] Finalized geometry has 1 domain, 20 boundaries, and 20 vertices.
```



# COMSOL Multiphysics®

- Definice parametrů
- Tvorba/import geometrie
- Definice materiálu
- Okrajové a počáteční podmínky
- Síťování výpočetní oblasti

The screenshot displays the COMSOL Multiphysics software interface with the following panels:

- Model Builder:** Shows a tree view of the model structure. The selected item is "Open Boundary 1" under "Laminar Flow (spf)".
- Settings:** Shows the configuration for "Open Boundary 1". The "Boundary Selection" is set to "Manual" with items 2 and 3. The "Boundary Condition" is set to "Normal stress" with a value of  $f_0 = 0$  N/m<sup>2</sup>.
- Graphics:** Shows a 2D plot of the geometry, a rectangular domain, with a blue selection box around the top boundary.
- Add Physics:** Shows a list of physics interfaces. "Laminar Flow (spf)" is selected.
- Messages:** Shows a log of operations: "[May 14, 2021 1:11 PM] Imported 1 solid object from ...", "[May 14, 2021 1:14 PM] Finalized geometry has 1 domain, 20 boundaries, and 20 vertices.", and "[May 14, 2021 2:33 PM] Complete mesh consists of 5527 domain elements and 303 boun...".

# COMSOL Multiphysics®

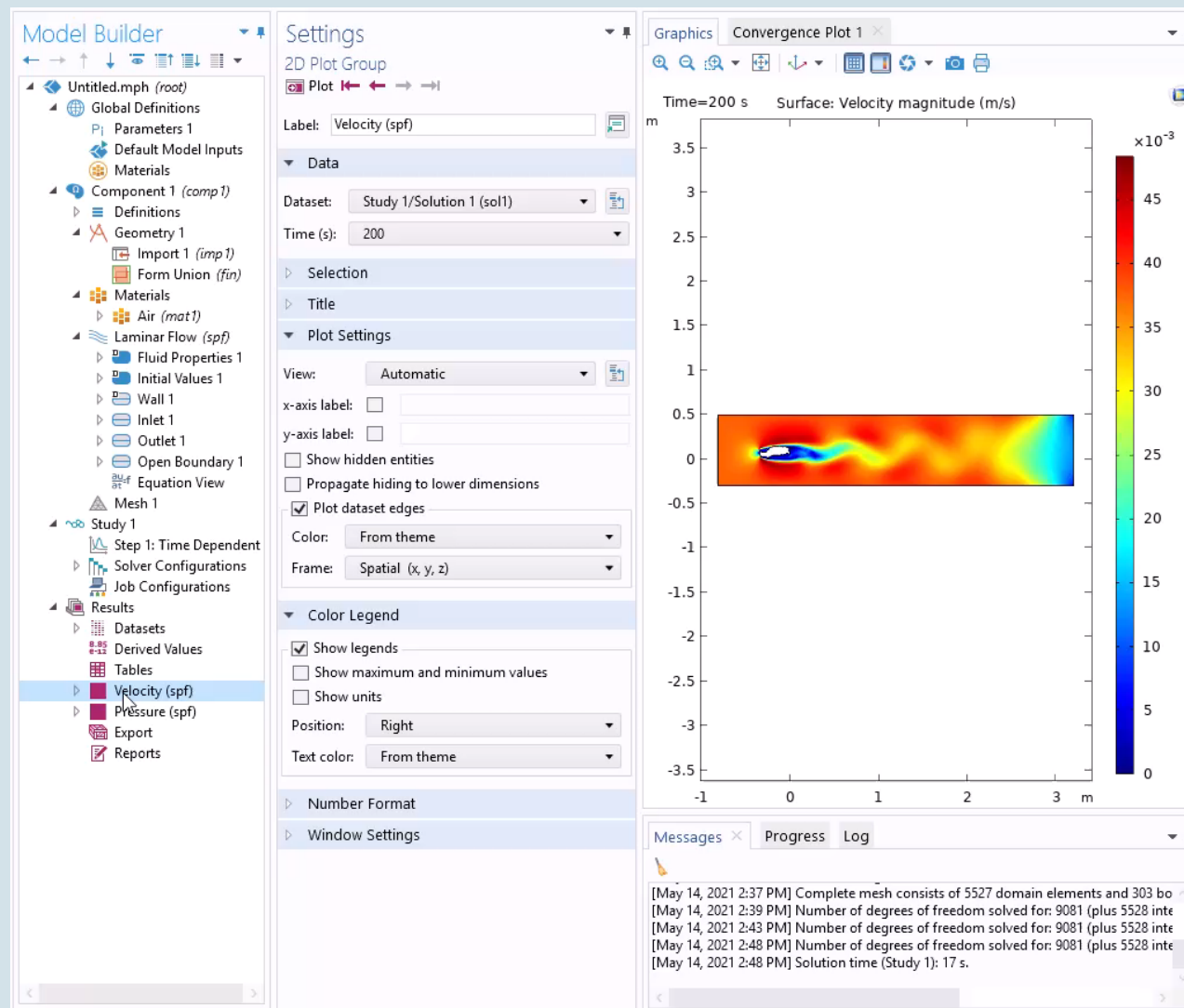
- Definice parametrů
- Tvorba/import geometrie
- Definice materiálu
- Okrajové a počáteční podmínky
- Síťování výpočetní oblasti
- Výpočet simulace fyzikálního děje

The screenshot displays the COMSOL Multiphysics software interface. The **Model Builder** window on the left shows a hierarchical tree structure for an untitled model. The **Settings** window in the middle is configured for a **Mesh** with a **Physics-controlled mesh** sequence type, **Normal** element size, and **Laminar Flow (spf)** as the contributor. The **Graphics** window on the right shows a 2D mesh of a domain with a central hole, with axes ranging from -0.4 to -0.15 on the x-axis and -0.1 to 0.3 on the y-axis. A **Messages** window at the bottom right contains the following log entries:

```
[May 14, 2021 2:36 PM] Mesh warning (ref1): None of the selected entities has a mesh.
[May 14, 2021 2:37 PM] Mesh warning (ref1): None of the selected entities has a mesh.
[May 14, 2021 2:37 PM] Complete mesh consists of 5527 domain elements and 303 bo
[May 14, 2021 2:39 PM] Number of degrees of freedom solved for: 9081 (plus 5528 inte
[May 14, 2021 2:43 PM] Number of degrees of freedom solved for: 9081 (plus 5528 inte
```

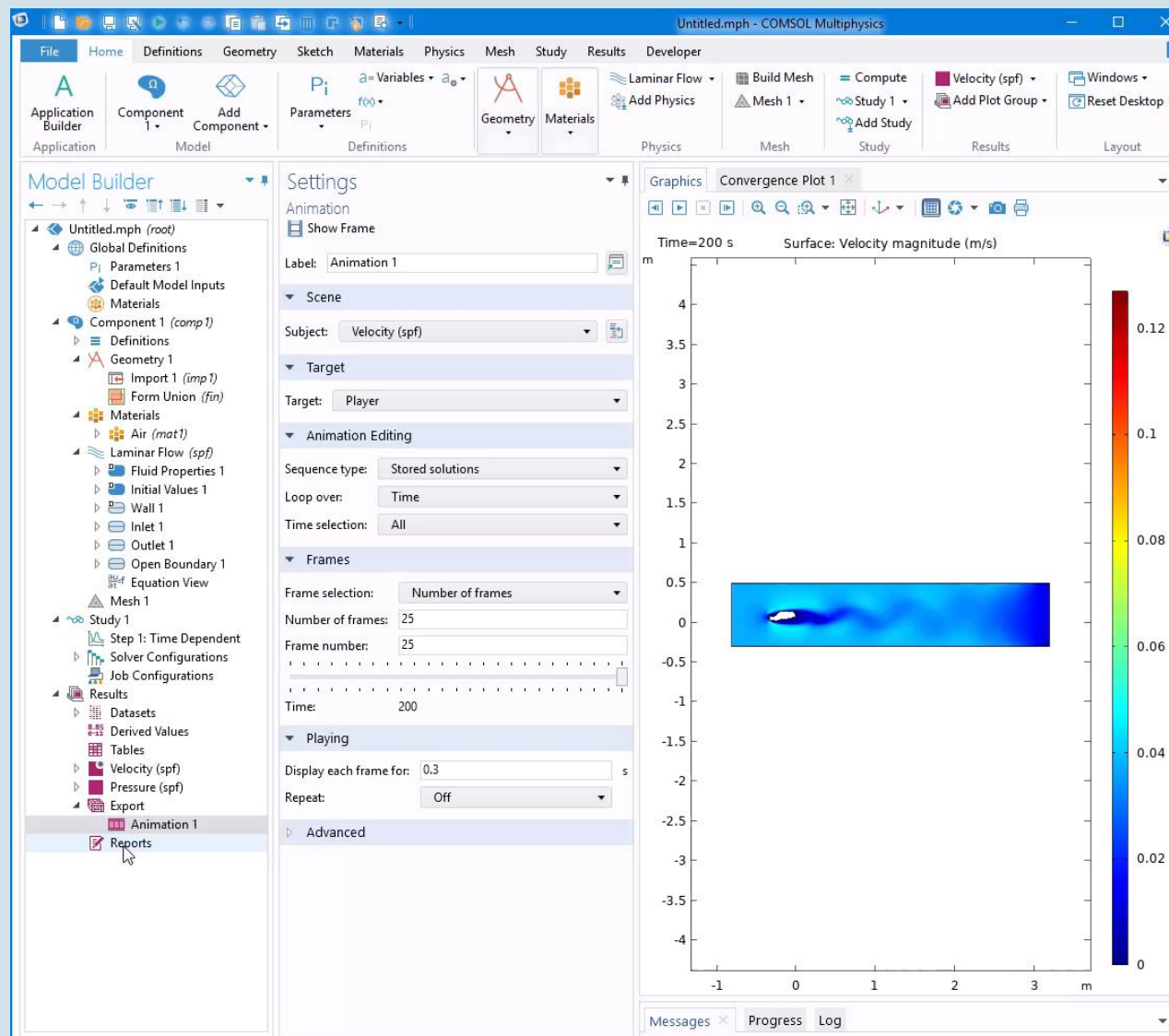
# COMSOL Multiphysics®

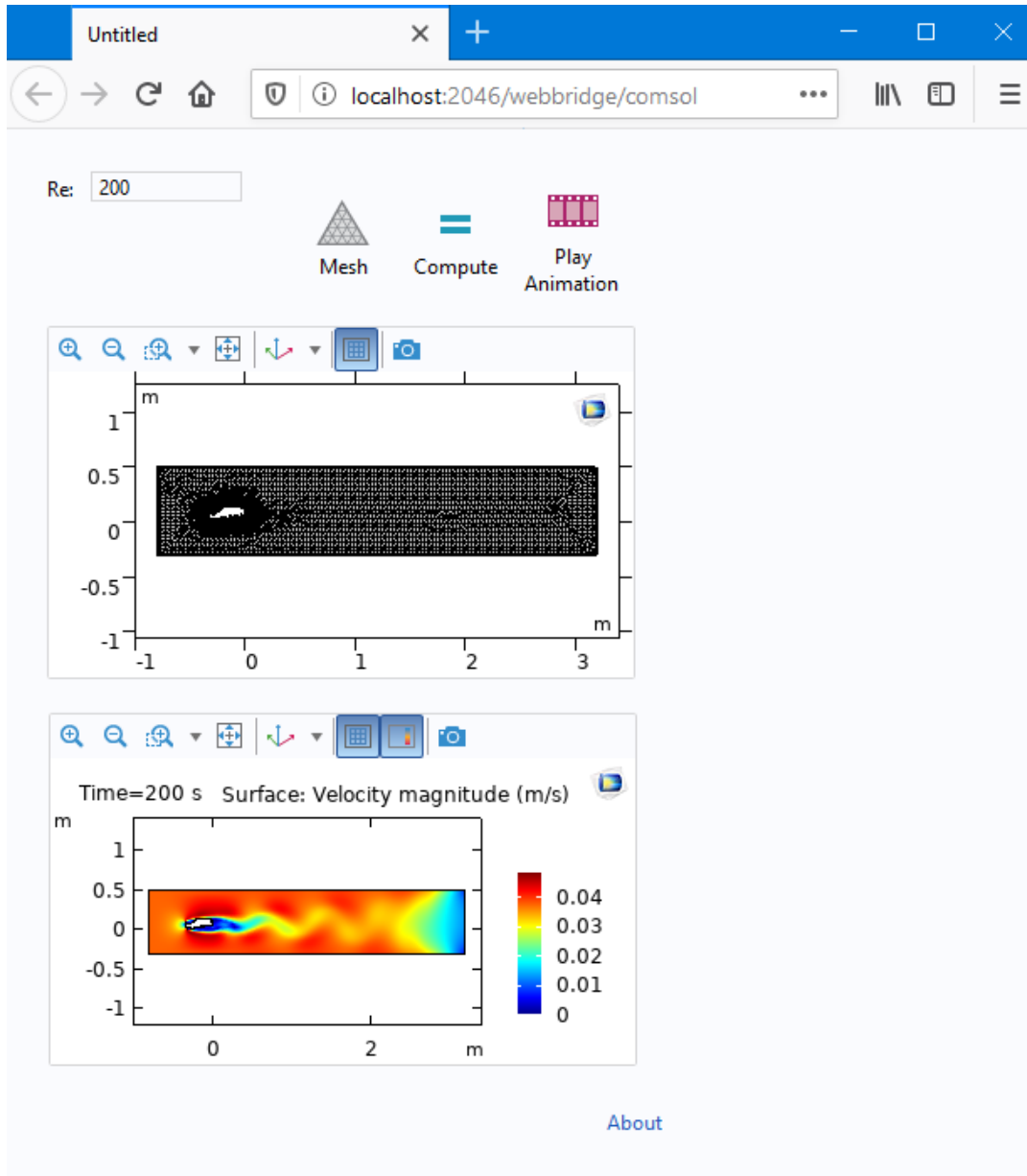
- Definice parametrů
- Tvorba/import geometrie
- Definice materiálu
- Okrajové a počáteční podmínky
- Sítování výpočetní oblasti
- Výpočet simulace fyzikálního děje
- Zpracování výsledků



# COMSOL Multiphysics®

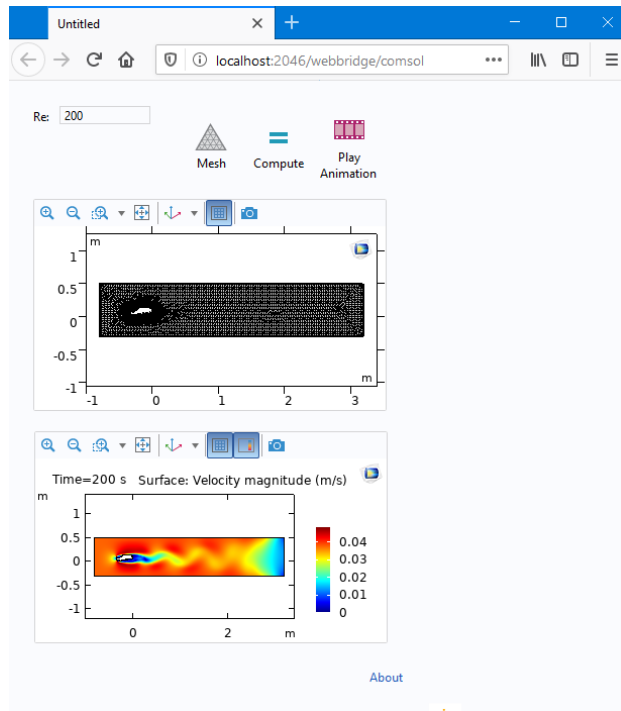
- Definice parametrů
- Tvorba/import geometrie
- Definice materiálu
- Okrajové a počáteční podmínky
- Sítování výpočetní oblasti
- Výpočet simulace fyzikálního děje
- Zpracování výsledků
- Tvorba aplikace





## Možnosti COMSOL Server™

- Sdílení aplikace přes webové rozhraní
- Server běží u vás na počítači
- Komu vygenerujete heslo, ten může ovládat aplikace
- Aplikace pro mobilní telefony



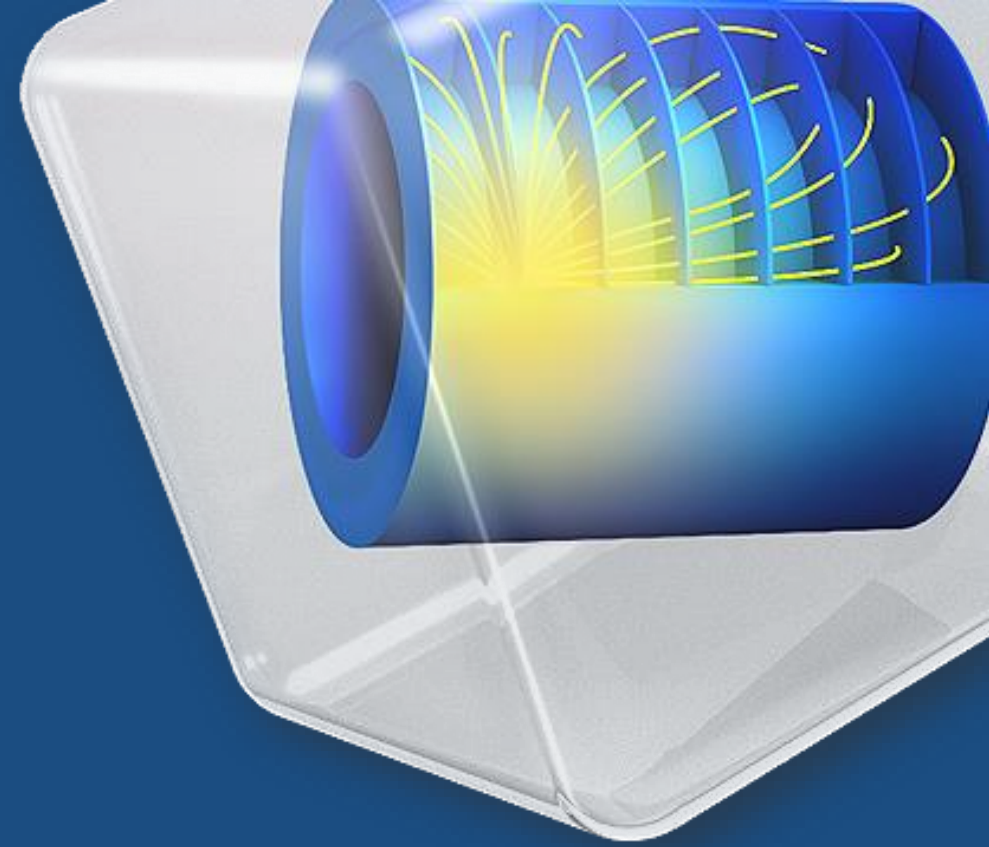
COMPILE and DISTRIBUTE multiple apps  
with COMSOL Compiler™

RUN simulation apps  
on any machine



# Možnosti COMSOL Compiler™

- Aplikace kompilovaná s RunTime knihovnamí COMSOL Multiphysics
- Vytvoří stand-alone program pro simulaci dané úlohy
- Vygenerujete licenční soubor
- Prodáte program



Oblasti použití COMSOL Multiphysics

Equation

Show equation assuming:  
Study 1, Time Dependent

$$e_a \frac{\partial^2 \mathbf{u}}{\partial t^2} + d_a \frac{\partial \mathbf{u}}{\partial t} + \nabla \cdot \Gamma = f$$

$$\mathbf{u} = [u_1, u_2]^T$$

$$\nabla = \left[ \frac{\partial}{\partial x}, \frac{\partial}{\partial y}, \frac{\partial}{\partial z} \right]$$

Conservative Flux

-u1x	x
-u1y	y
-u1z	z
$\Gamma$	
0	x
0	y
0	z

Source Term

$f$

(alpha-u1)\*(u1-1)\*u1-u2  
epsilon\*(beta\*u1-gamma\*u2-delta)

Damping or Mass Coefficient

$d_a$	1	0
	0	1

Mass Coefficient

$e_a$	0	0
	0	0

Mathematics

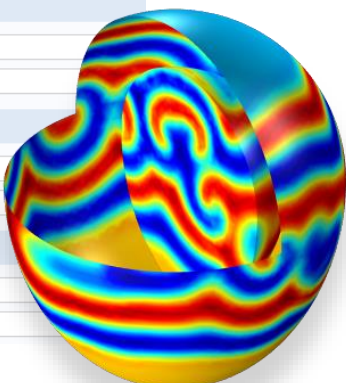
- $\Delta u$  PDE Interfaces
- $\frac{d}{dt}$  ODE and DAE Interfaces
- Optimization and Sensitivity
- $\nabla^2$  Classical PDEs
- Moving Interface
- Deformed Mesh
- Wall Distance (wd)
- Mathematical Particle Tracing (pt)
- Curvilinear Coordinates (cc)

Show equation assuming:

$0 = \int_{\Omega} \text{weak } \partial v$

Weak Expressions

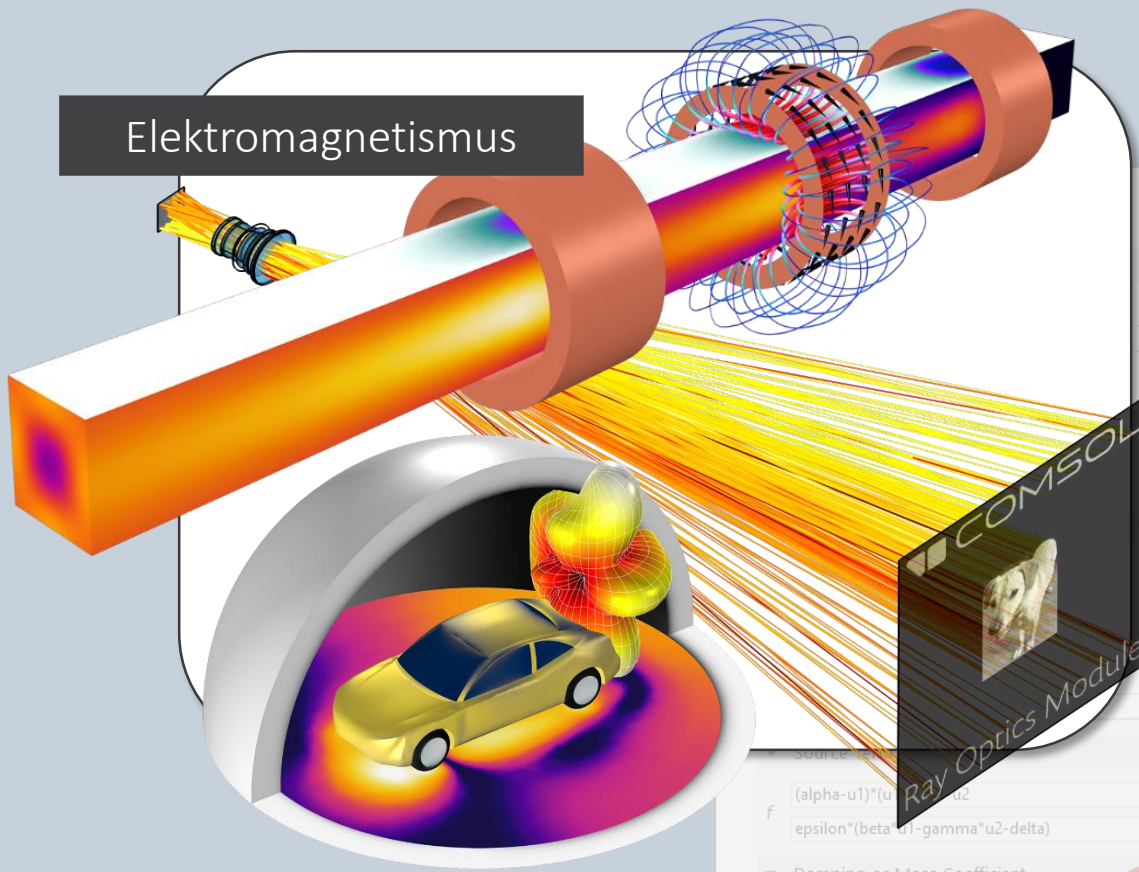
weak -test(ux)\*ux-test(uy)\*uy-test(uz)\*uz+1[m^-2]\*test(u)



Vlastní PDR / ODR



# Elektromagnetismus



Mathematics

- PDE Interfaces
- ODE and DAE Interfaces
- Optimization and Sensitivity
- Classical PDEs
- Moving Interface
- Deformed Mesh
- Wall Distance (wd)
- Mathematical Particle Tracing (pt)
- Curvilinear Coordinates (cc)

Show equation assuming:

$0 = \int_{\Omega} \text{weak } \partial v$

Weak Expressions

weak  $-\text{test}(ux)^*ux - \text{test}(uy)^*uy - \text{test}(uz)^*uz + 1[m^{^-2}] * \text{test}(u)$

Damping or Mass Coefficient

$d_a$	1	0
	0	1

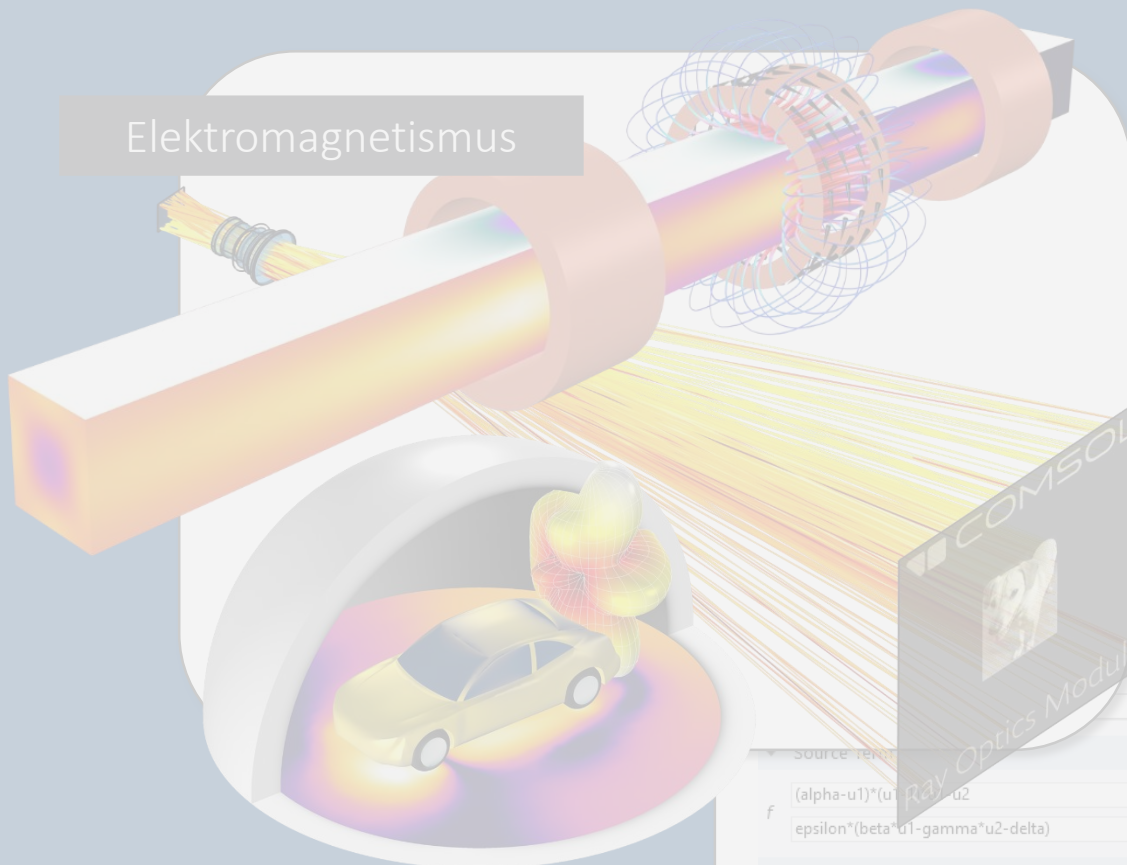
Mass Coefficient

$e_a$	0	0
	0	0

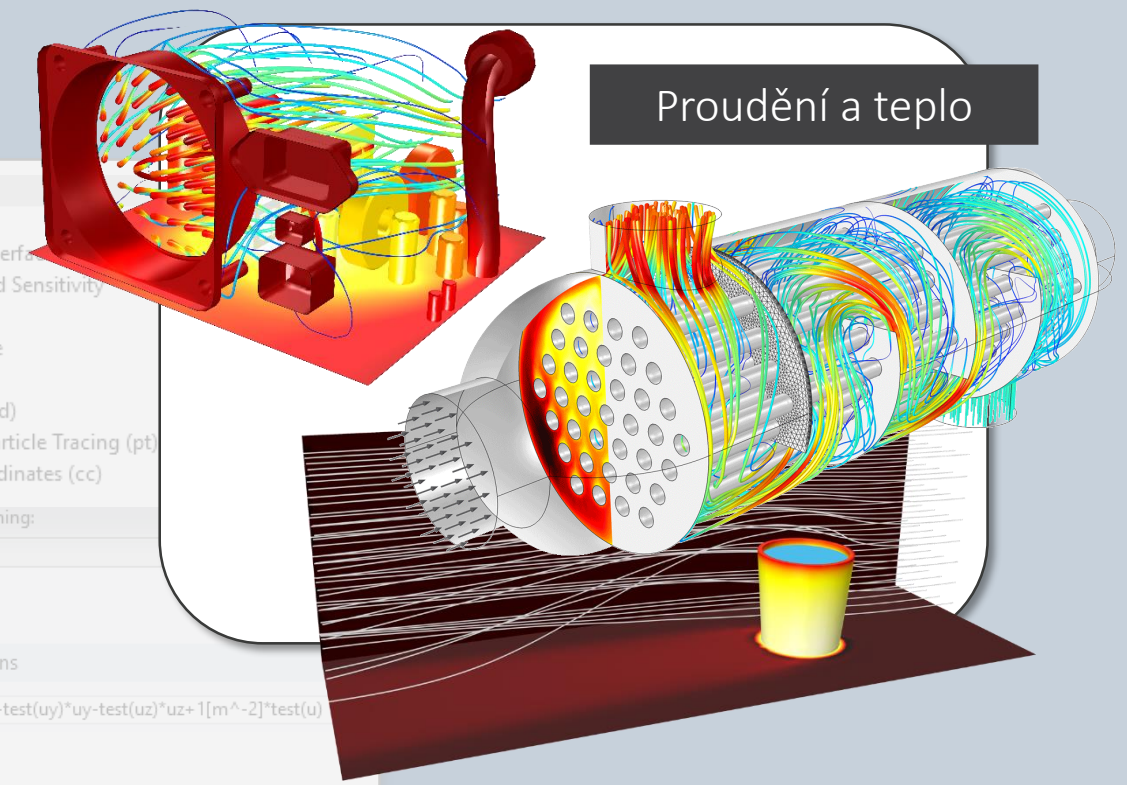
A 3D visualization of a wave pattern on a sphere, showing colorful interference fringes.

Vlastní PDR / ODR

# Elektromagnetismus



# Proudění a teplo



Mathematics

- PDE Interfaces
- ODE and DAE Interfaces
- Optimization and Sensitivity
- Classical PDEs
- Moving Interface
- Deformed Mesh
- Wall Distance (wd)
- Mathematical Particle Tracing (pt)
- Curvilinear Coordinates (cc)

Show equation assuming:

$0 = \int_{\Omega} \text{weak} \, dV$

Weak Expressions

weak  $-\text{test}(ux)*ux-\text{test}(uy)*uy-\text{test}(uz)*uz+1[m^{-2}]*\text{test}(u)$

Source term

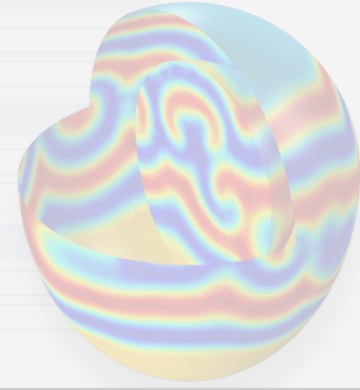
$f = (\alpha u_1)(u_1 - u_2) + \epsilon \text{div}(\beta \nabla u_1 - \gamma \nabla u_2 - \delta \nabla u)$

Damping or Mass Coefficient

$d_a$	1	0
	0	1

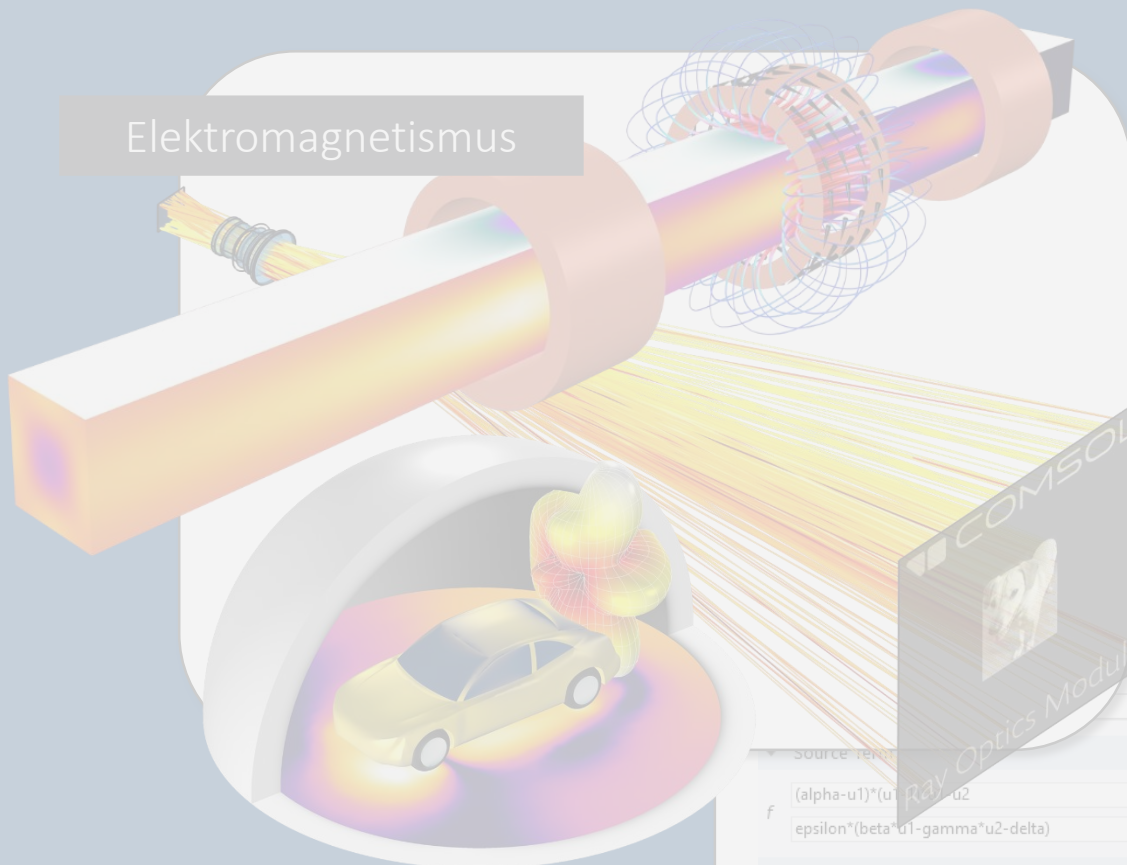
Mass Coefficient

$e_a$	0	0
	0	0

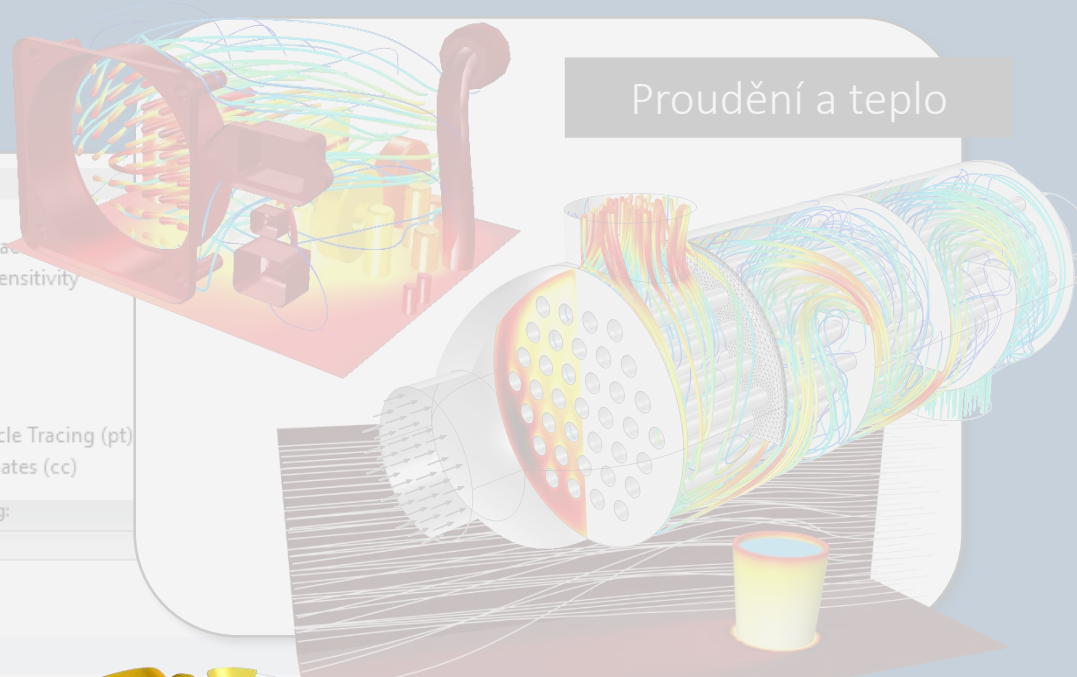


# Vlastní PDR / ODR

Elektromagnetismus



Proudění a teplo



$\Delta u$  Mathematics  
 ▷  $\Delta u$  PDE Interfaces  
 ▷ ODE and DAE Interfaces  
 ▷ Optimization and Sensitivity  
 ▷  $\nabla^2$  Classical PDEs  
 ▷ Moving Interface  
 ▷ Deformed Mesh  
 ▷ Wall Distance (wd)  
 ▷ Mathematical Particle Tracing (pt)  
 ▷ Curvilinear Coordinates (cc)

Show equation assuming:

x  
y  
z

$$0 = \int_{\Omega} \text{weak} \partial v$$

x  
y  
z

Weak Expressions

weak  $-\text{test}(ux)*ux-\text{test}(uy)*uy$

Source term

f

$$(\alpha - u_1) * (u_1 - u_2)$$

$$\epsilon \text{psilon} * (\beta * u_1 - \gamma * u_2 - \delta)$$

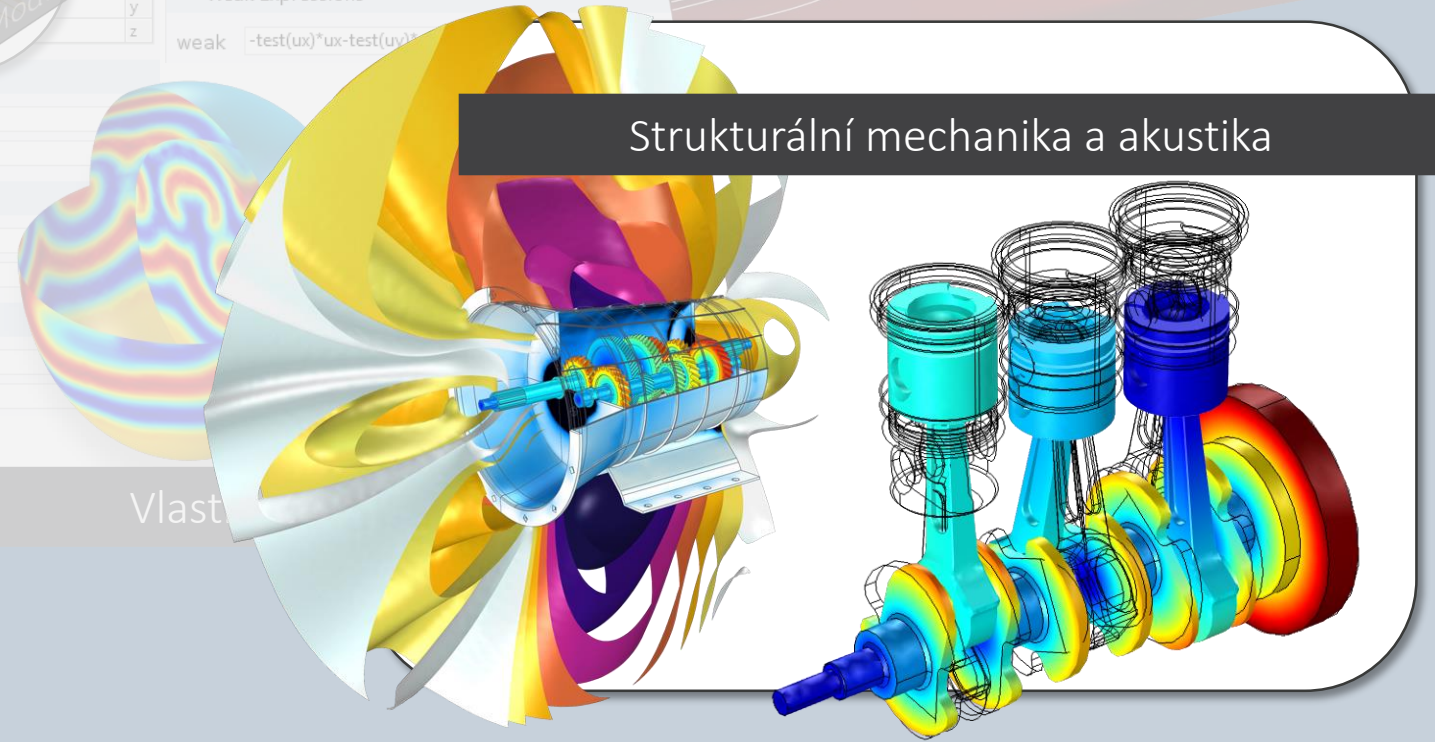
Damping or Mass Coefficient

$d_a$	1	0
	0	1

Mass Coefficient

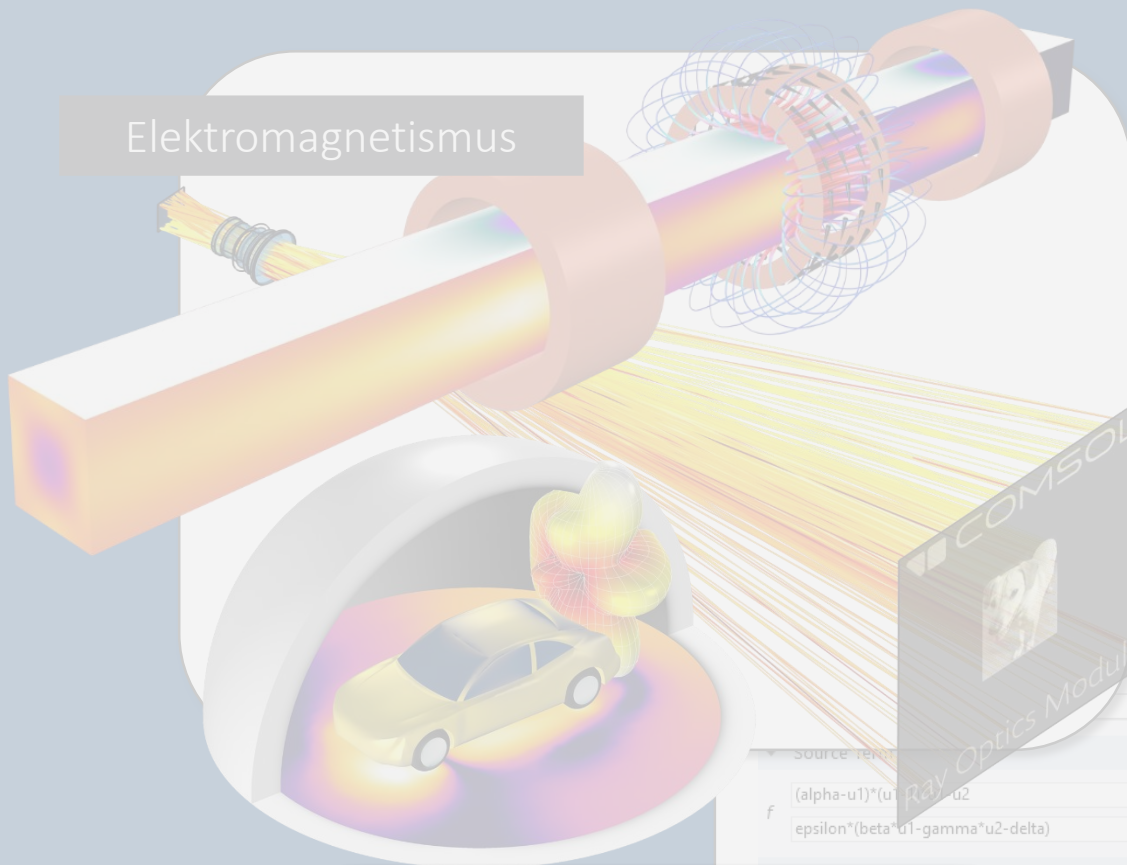
$e_a$	0	0
	0	0

Strukturální mechanika a akustika

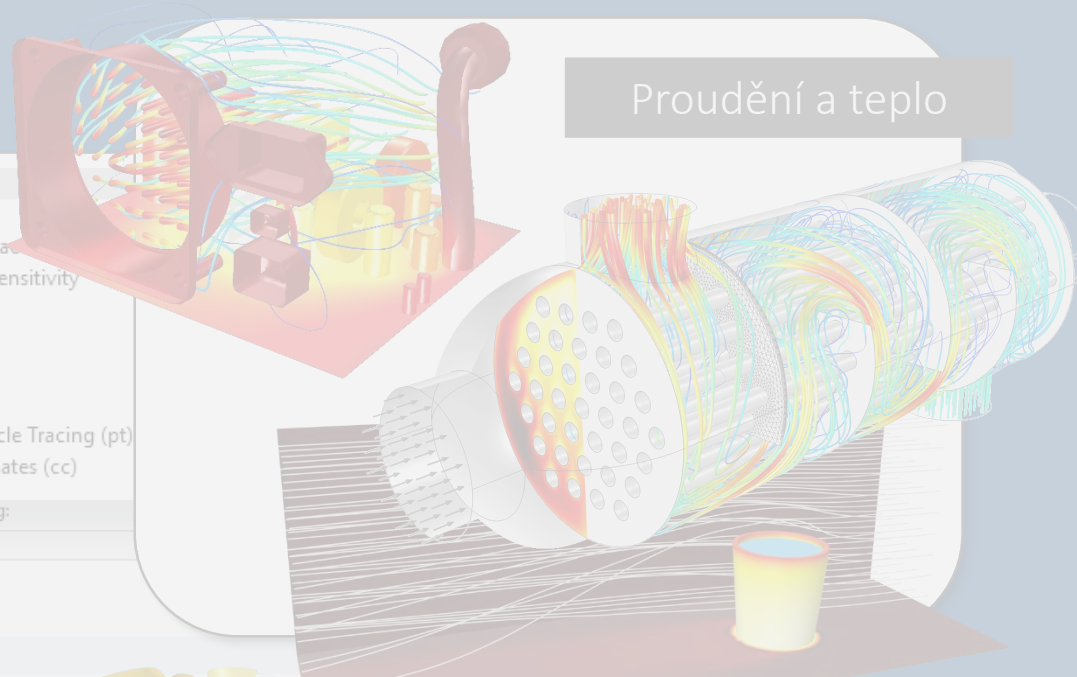


Vlast

# Elektromagnetismus



# Proudění a teplo



$\Delta u$  Mathematics  
 PDE Interfaces  
 ODE and DAE Interfaces  
 Optimization and Sensitivity  
 Classical PDEs  
 Moving Interface  
 Deformed Mesh  
 Wall Distance (wd)  
 Mathematical Particle Tracing (pt)  
 Curvilinear Coordinates (cc)

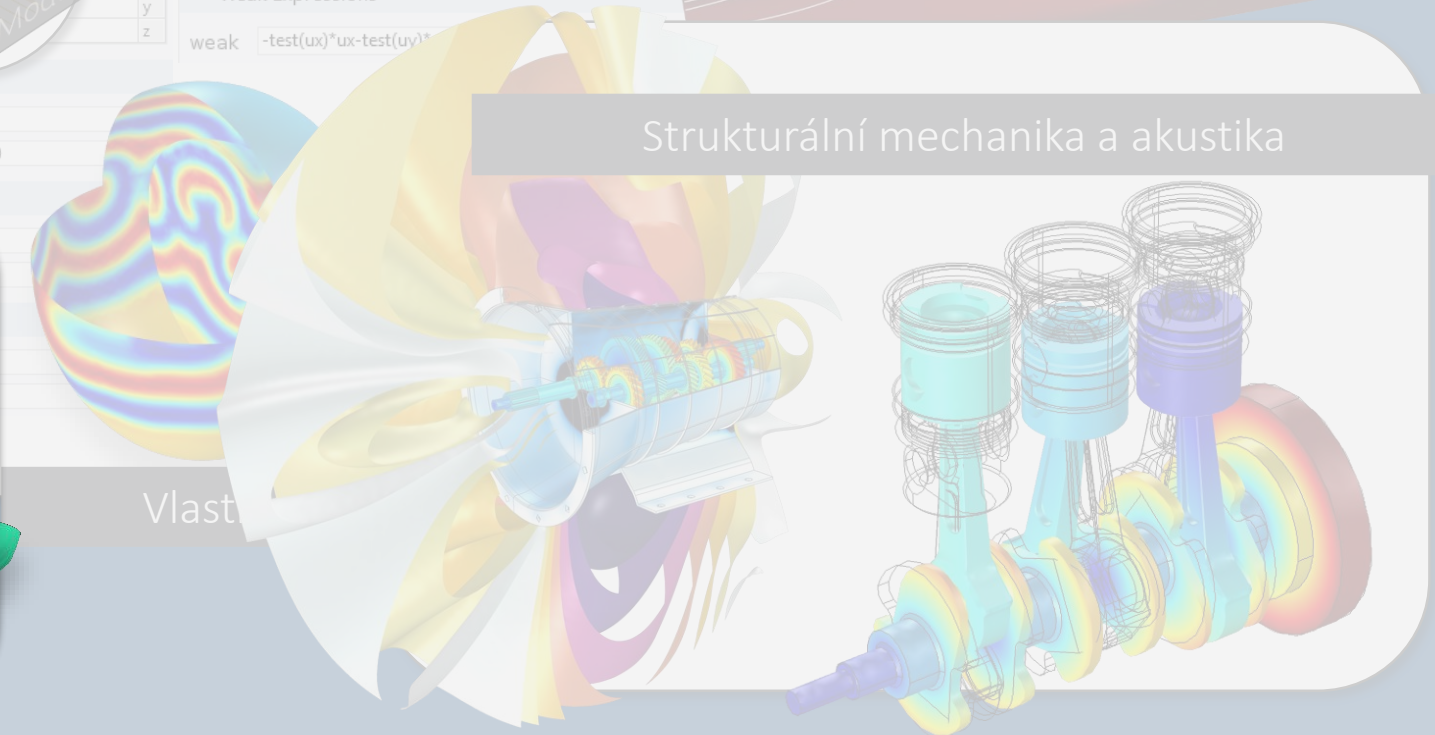
Show equation assuming:

$$0 = \int_{\Omega} \text{weak} \partial v$$

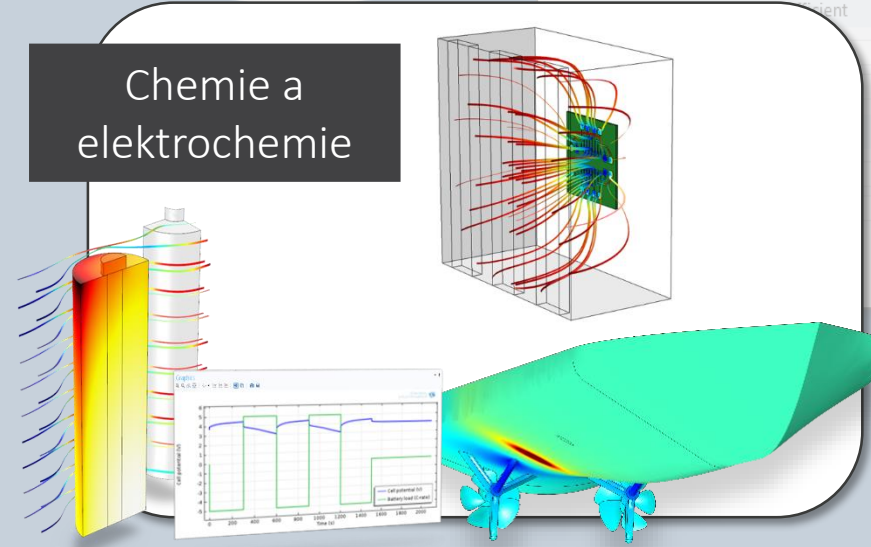
Weak Expressions

$$\text{weak} \quad -\text{test}(ux) * ux - \text{test}(uy) * uy$$

# Strukturální mechanika a akustika



# Chemie a elektrochemie



Vlast

# Tipy na zdroje informací

- Vyhledávání dotazu: [www.comsol.com](http://www.comsol.com)
- Modely s návody ke stažení (1000+): [www.comsol.com/models](http://www.comsol.com/models)
- COMSOL Blog (1500+): [www.comsol.com/blogs](http://www.comsol.com/blogs)
- Články a prezentace z konferencí (5000+): [www.comsol.com/papers-presentations](http://www.comsol.com/papers-presentations)

Contact COMSOL >

## Product Information

Products

Specification Chart

License Options

System Requirements

Release History

## Use Cases

Model and Application Files

Product Demo Videos

User Stories

Papers and Research

Books

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Discussion Forum

Application Exchange

COMSOL Blog

Multiphysics Cyclopedia

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