

Simulace fyzikálních dějů v COMSOL Multiphysics®



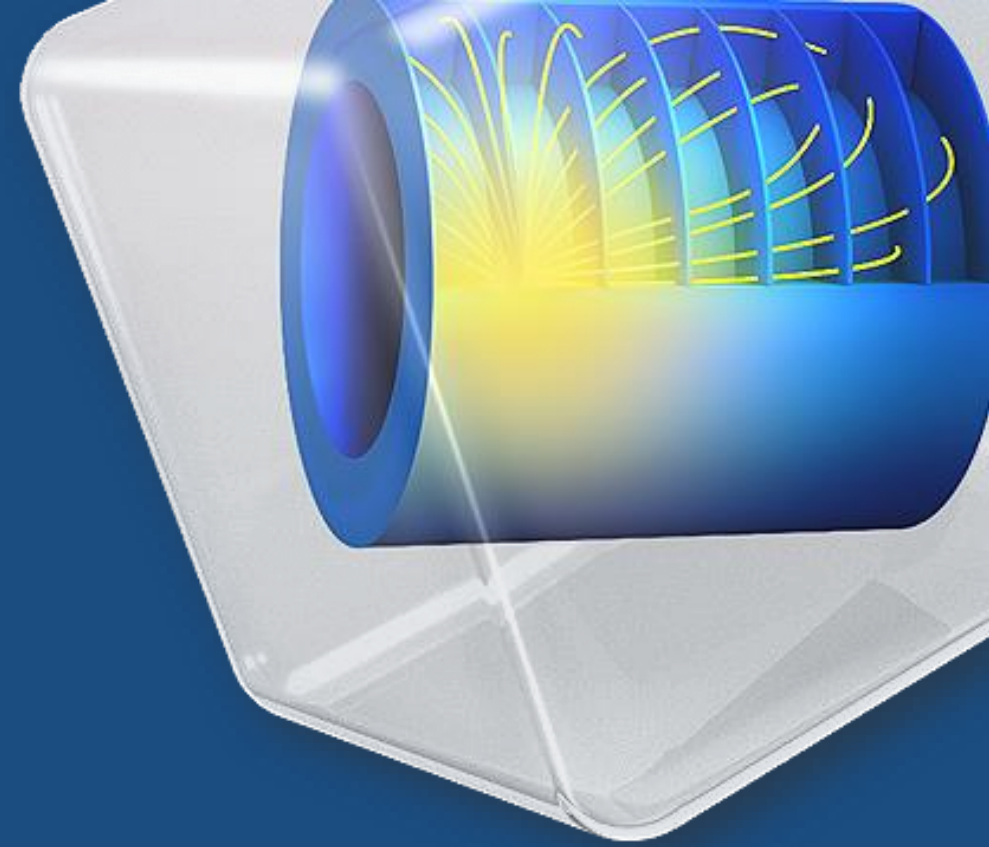
Martin Kožíšek

Produktový manažer

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Představení COMSOL Multiphysics[®], COMSOL Server[™] a COMSOL Compiler[™]

Martin Kožíšek
HUMUSOFT s.r.o.

Příklad fyzikálního děje

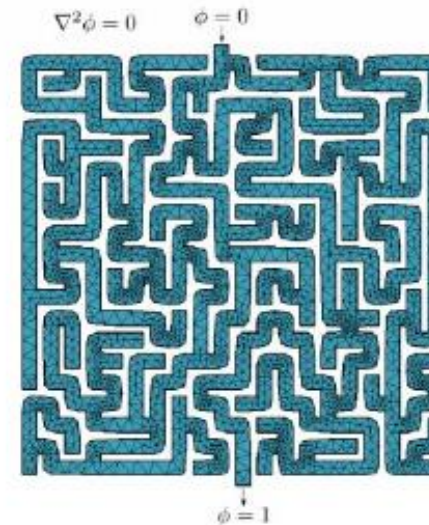
- Jak vyřešit bludiště bez umělé inteligence?
- V příspěvku doporučují bludiště vysítovat, vyřešit Laplaceovu rovnici a následovat gradient tlaku.
- Jak jde vyřešit bludiště simulací proudění tekutiny v COMSOL Multiphysics?



Jeremy Theler • 2nd
Solver Developer at OnScale
4d • 🌐

How to solve a maze without AI? Use Laplace's equation:

1. Mesh the maze
2. Set Dirichlet BCs $\phi = 0$ at start and $\phi = 1$ at end
3. Set homogeneous Neumann BCs everywhere else
4. Solve $\nabla^2 \phi = 0$
5. Go to the start and follow the gradient



Mesh it, set $\phi = 0$ at start, $\phi = 1$ at end,
 $\nabla \phi \cdot \hat{n} = 0$ otherwise and solve $\nabla^2 \phi = 0$



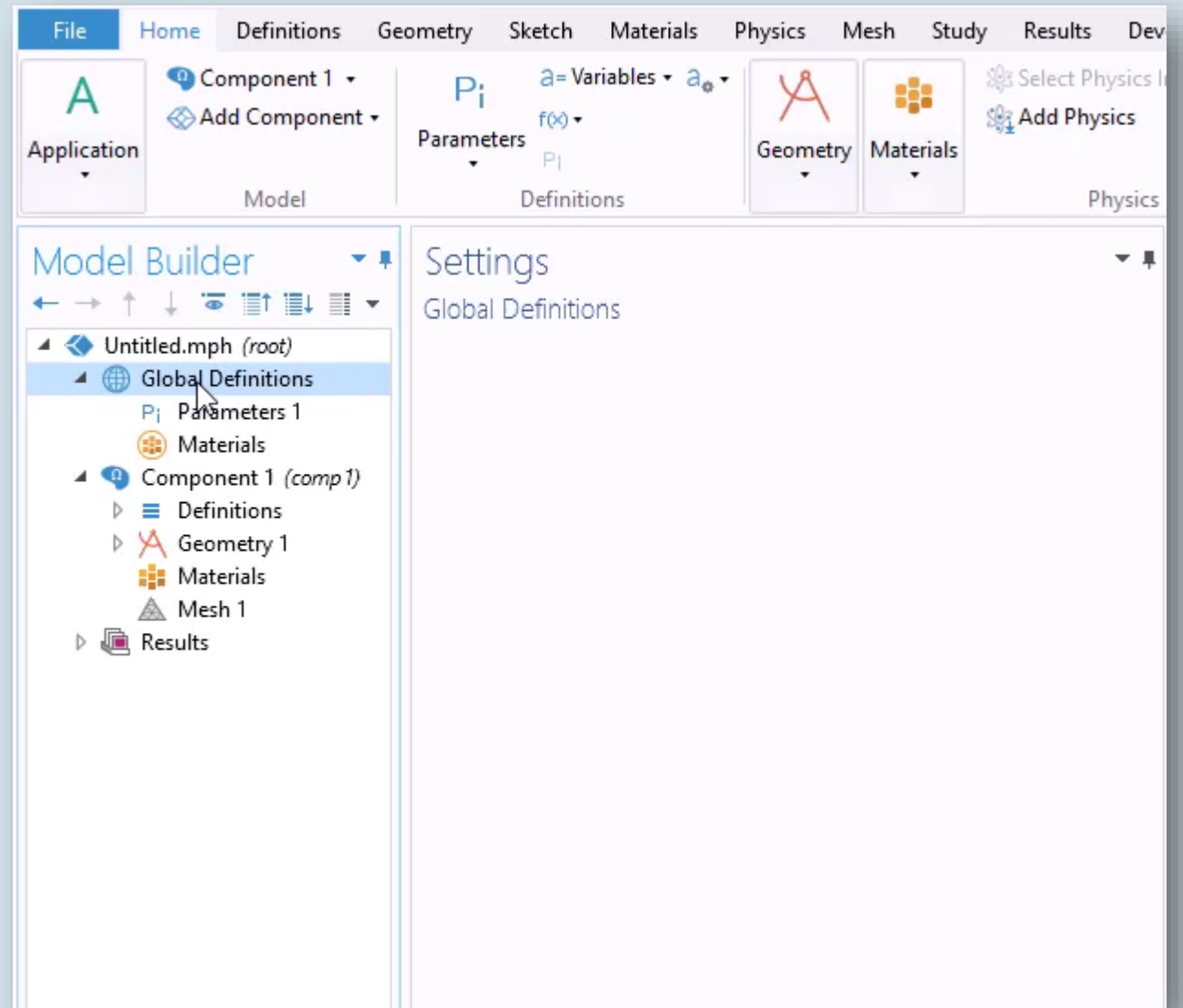
Go to start and follow the gradient $\nabla \phi$!

Sábado 11 - 2021-08-09 17/18

👍 🏆 ❤️ 3,255 • 275 comments

COMSOL Multiphysics®

- Definice parametrů



COMSOL Multiphysics®

- Definice parametrů
- Tvorba/import geometrie

The screenshot shows a LinkedIn post from Jeremy Theler, a Solver Developer at OnScale. The post discusses solving a maze without AI using Laplace's equation. It includes a list of five steps: 1. Mesh the maze, 2. Set Dirichlet BCs $\phi = 0$ at start and $\phi = 1$ at end, 3. Set homogeneous Neumann BCs everywhere else, 4. Solve $\nabla^2 \phi = 0$, and 5. Go to the start and follow the gradient. Two images illustrate the process: the first shows a maze with boundary conditions $\nabla^2 \phi = 0$, $\phi = 0$, and $\phi = 1$, and the second shows the resulting solution with a path highlighted in green. The post has 3,261 likes and 275 comments. Comments from Thomas Hagen and Sreemati Ghosh are also visible.

Jeremy Theler
Solver Developer at OnScale
5 d.

How to solve a maze without AI? Use Laplace's equation:

1. Mesh the maze
2. Set Dirichlet BCs $\phi = 0$ at start and $\phi = 1$ at end
3. Set homogeneous Neumann BCs everywhere else
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5. Go to the start and follow the gradient

$\nabla^2 \phi = 0$ $\phi = 0$

$\phi = 1$

Mesh it, set $\phi = 0$ at start, $\phi = 1$ at end, $\nabla \phi \cdot \hat{n} = 0$ otherwise and solve $\nabla^2 \phi = 0$

Go to start and follow the gradient $\nabla \phi$!

3 261 · 275 komentářů

Líbí se Přidat komentář Sdílet

Thomas Hagen
The tracer will still diffuse into all dead ends of the maze. So given that you let your solver run "long enough" (or as a steady-state problem), it will highlight uniformly everything that is connected to the main flow path which, depending on the maze topology, could potentially mean everywhere.

Also, this sounds to me a bird's eye view of the maze has been obtained implicitly through the elliptic nature of the Laplace equation.

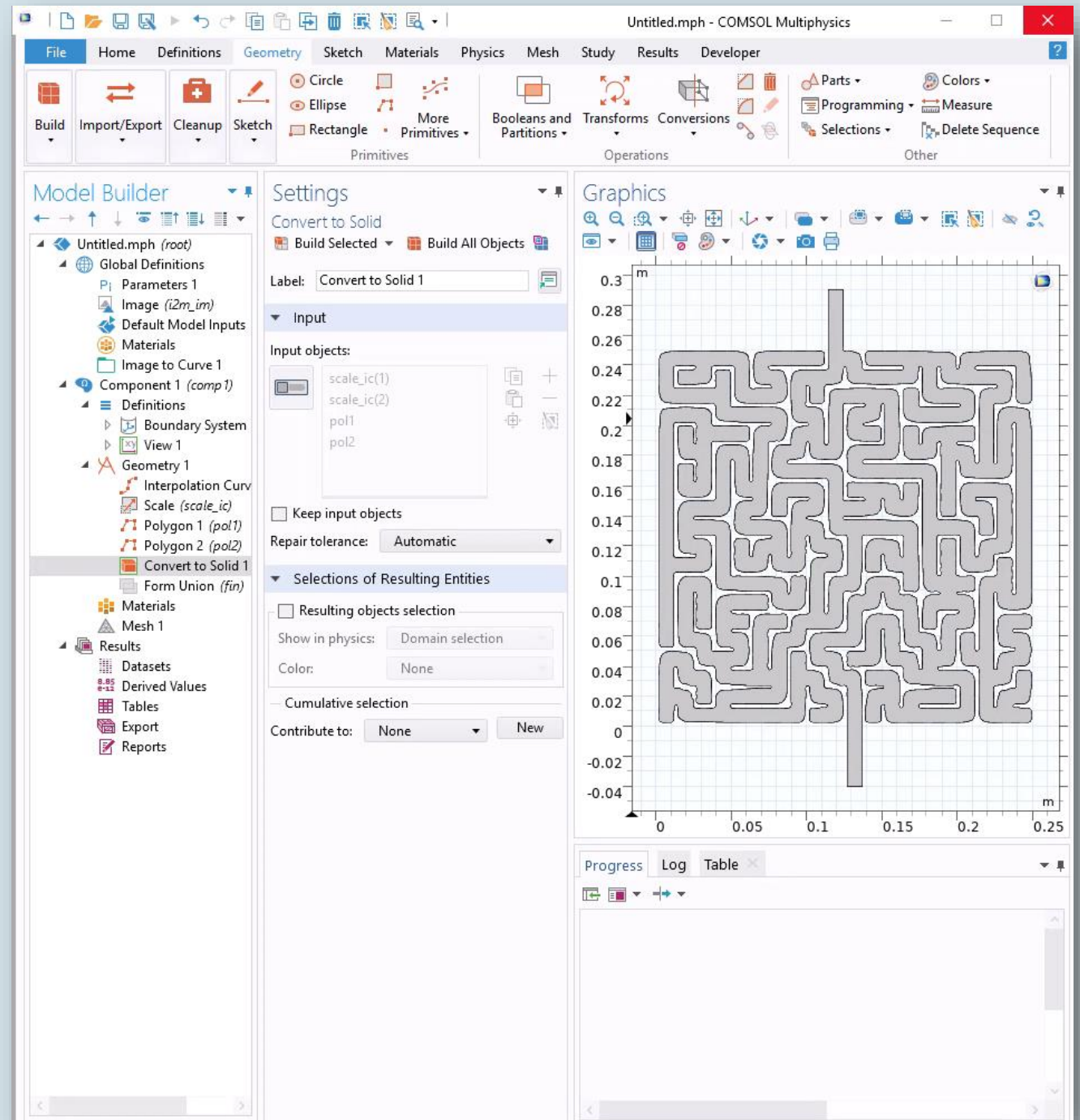
Líbí se Odpovědět 10 libí se

Sreemati Ghosh
Yesterday I went out with my daughter. She paid for several things using vemo. I see some similarities between maze and vemo....???

Líbí se Odpovědět 1 libí se

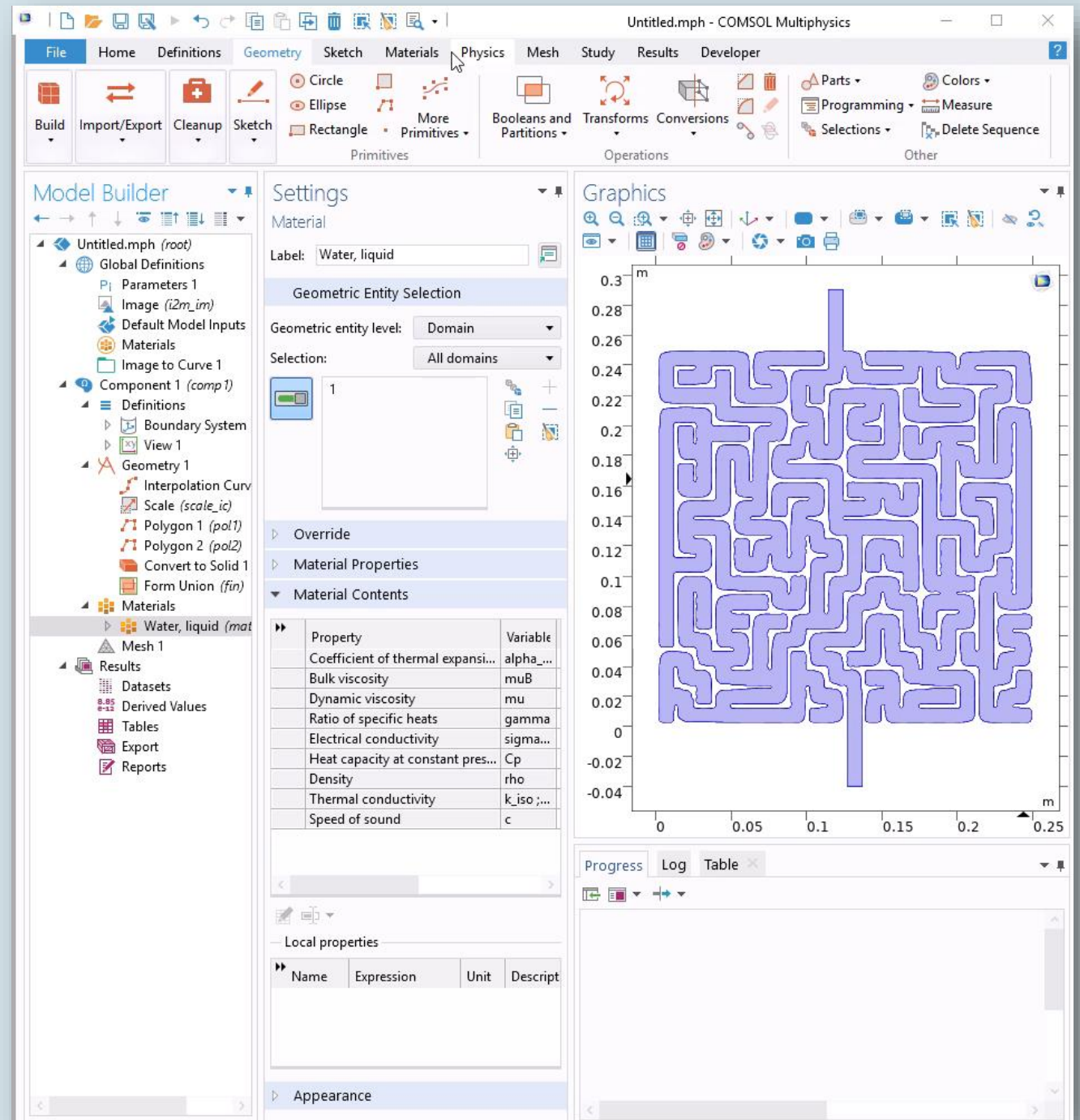
COMSOL Multiphysics®

- Definice parametrů
- Tvorba/import geometrie
- Definice materiálu



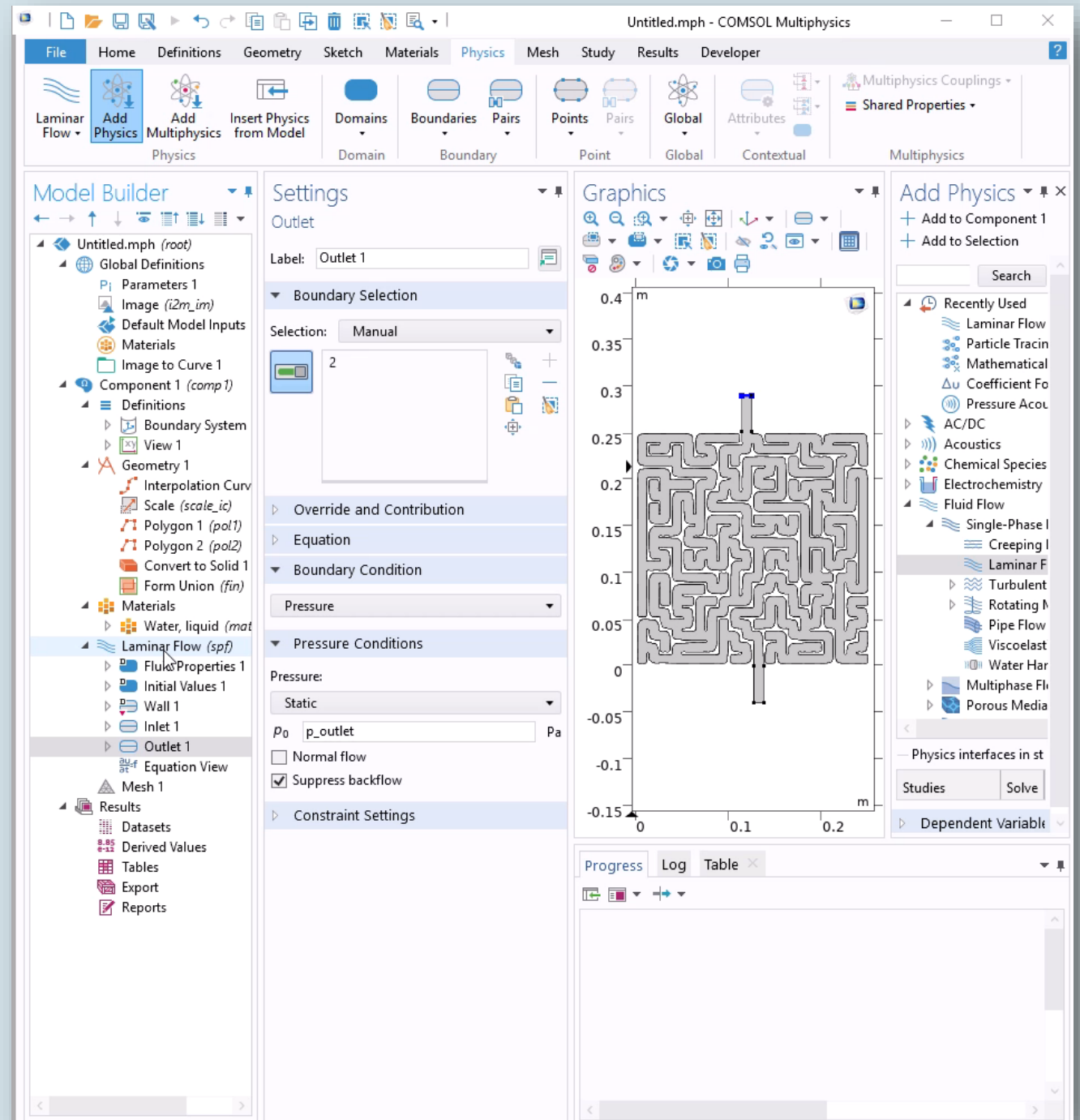
COMSOL Multiphysics®

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



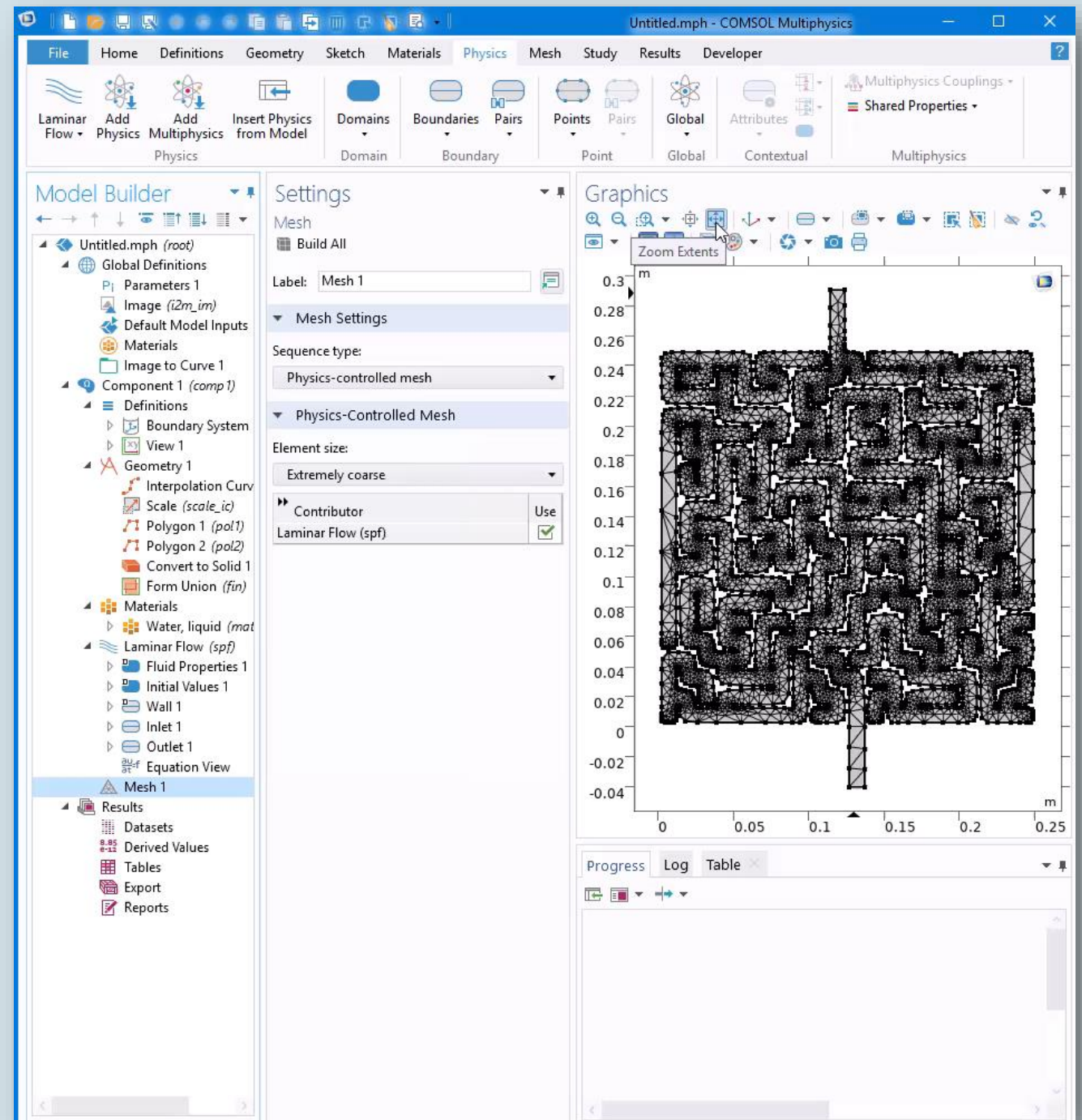
COMSOL Multiphysics®

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



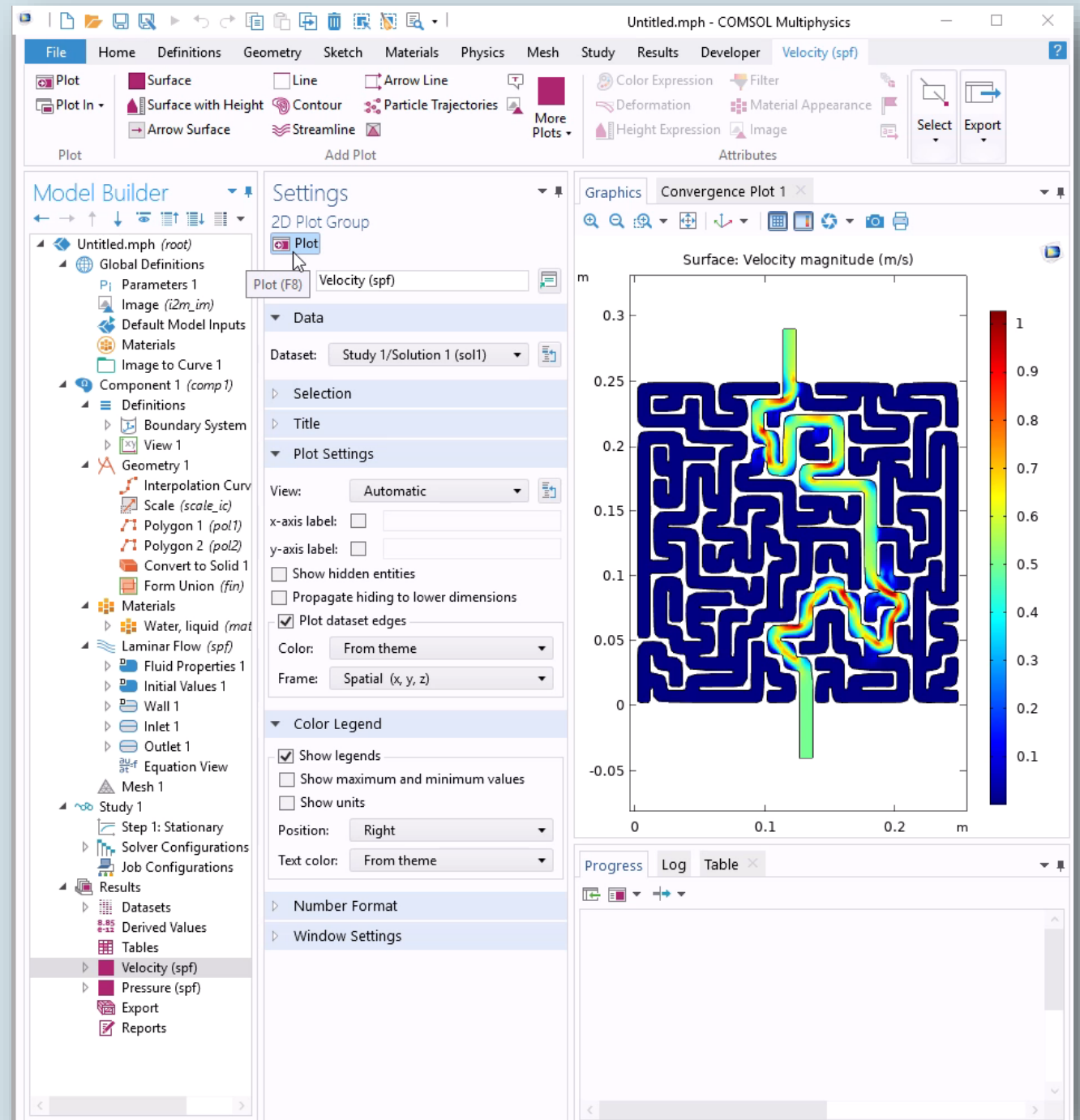
COMSOL Multiphysics®

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



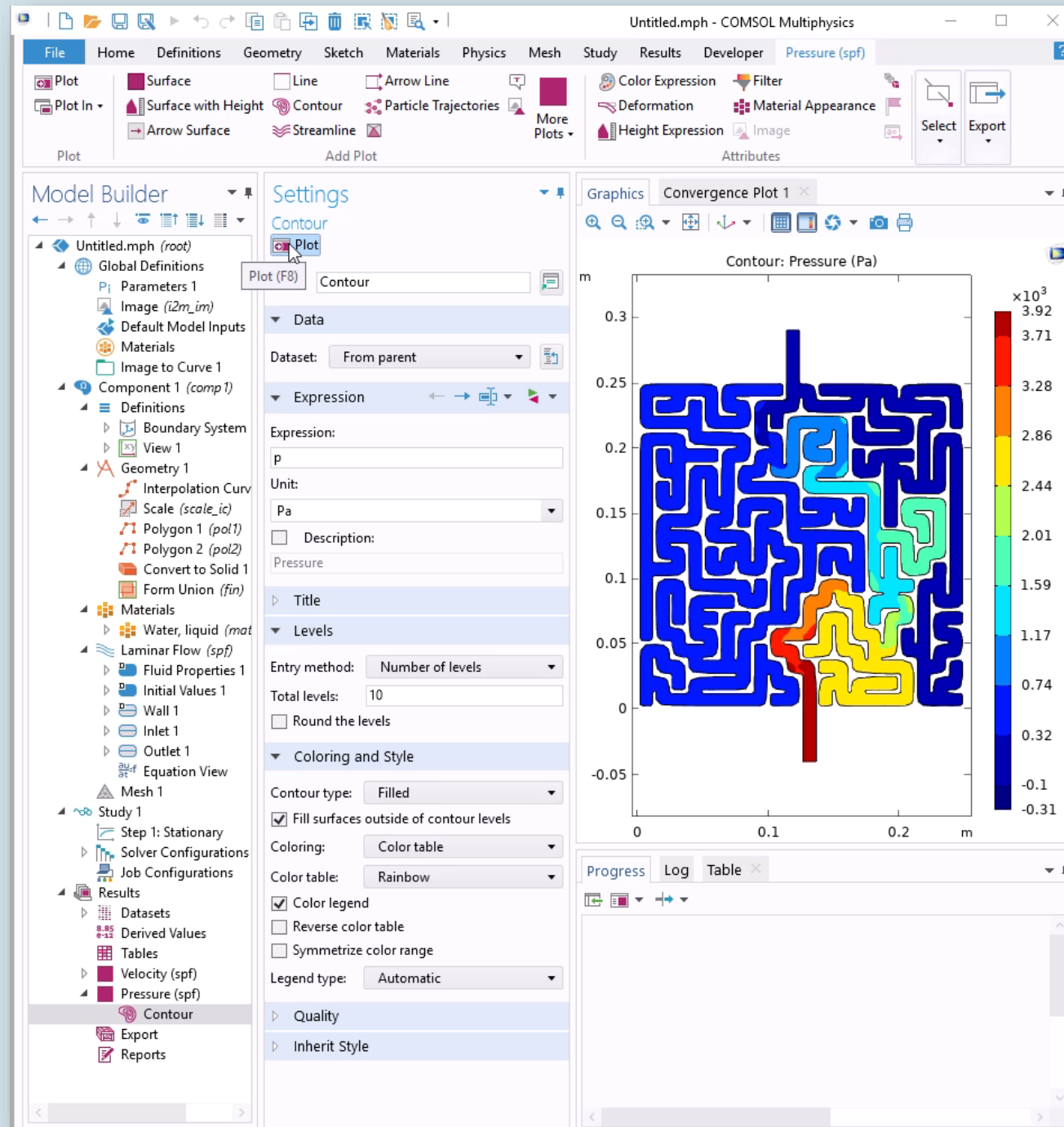
COMSOL Multiphysics®

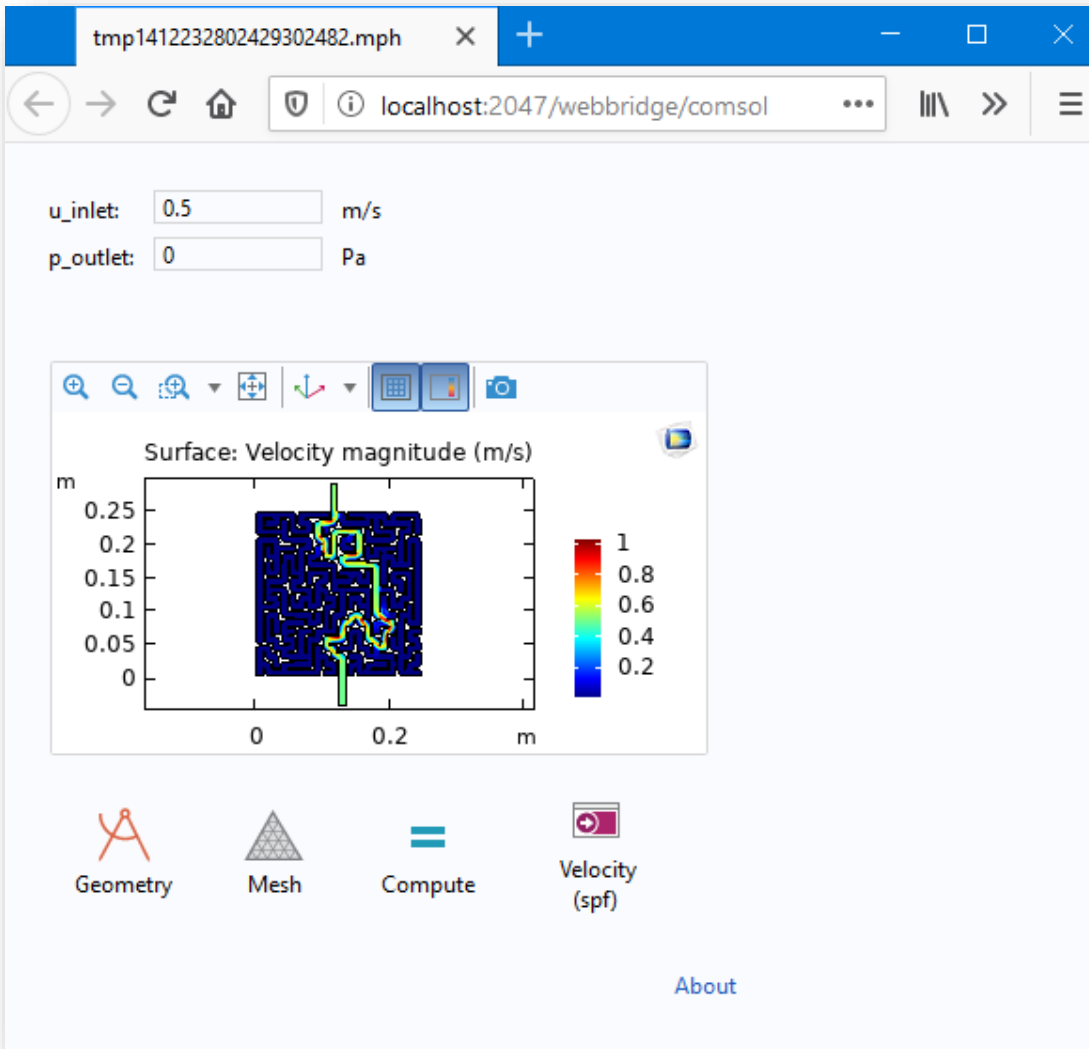
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- Tvorba/import geometrie
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- Okrajové a počáteční podmínky
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- Výpočet simulace fyzikálního děje
- Zpracování výsledků



COMSOL Multiphysics®

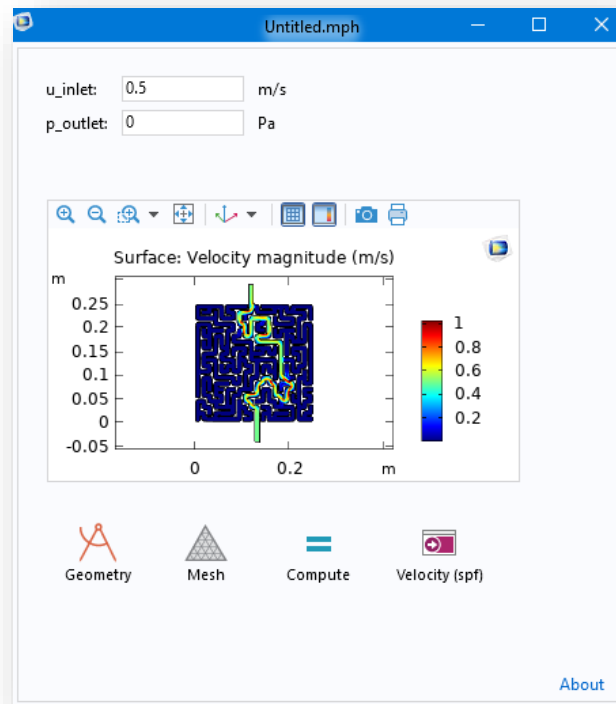
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- Výpočet simulace fyzikálního děje
- Zpracování výsledků
- Tvorba aplikace





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



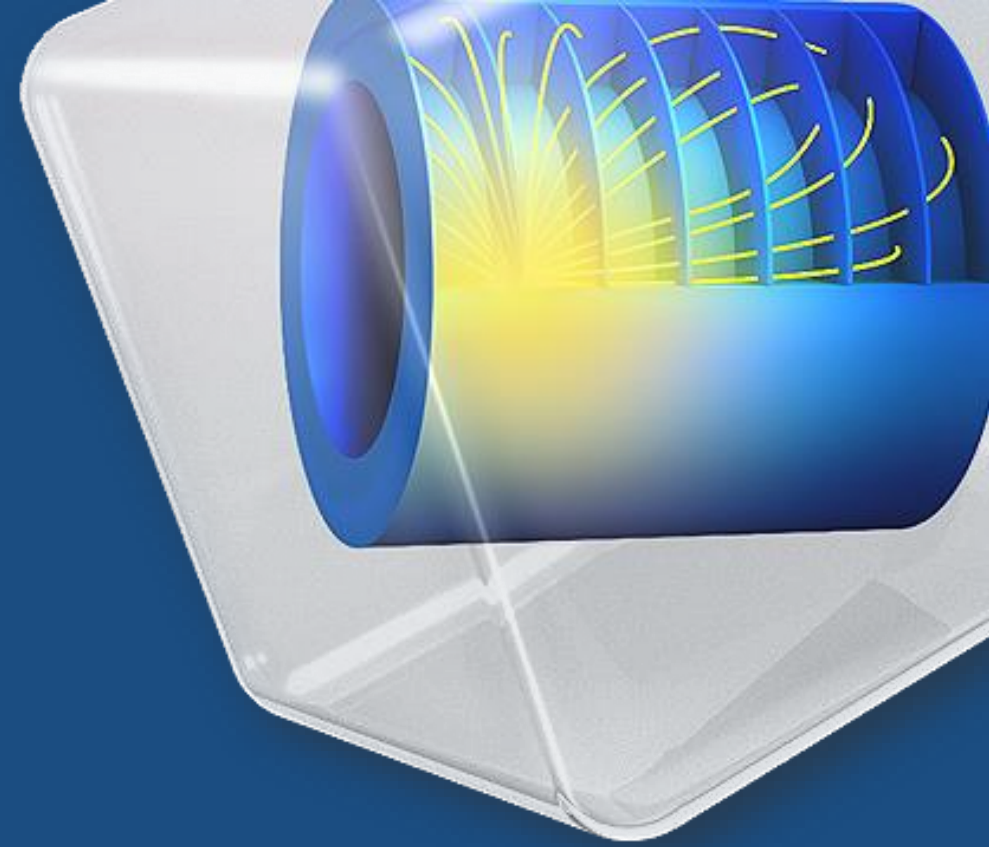
COMPILE and DISTRIBUTE multiple apps
with COMSOL Compiler™

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



Moduly 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

Γ

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

1	0
0	1

Mass Coefficient

0	0
0	0

Mathematics

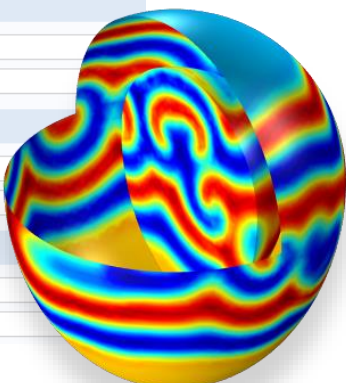
- PDE Interfaces
- ODE and DAE Interfaces
- Optimization and Sensitivity
- Classical PDEs
- Moving Interface
- Deformed Mesh
- Wall Distance (wd)
- Mathematical Particle Tracing (pt)
- Curvilinear Coordinates (cc)

Show equation assuming:

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

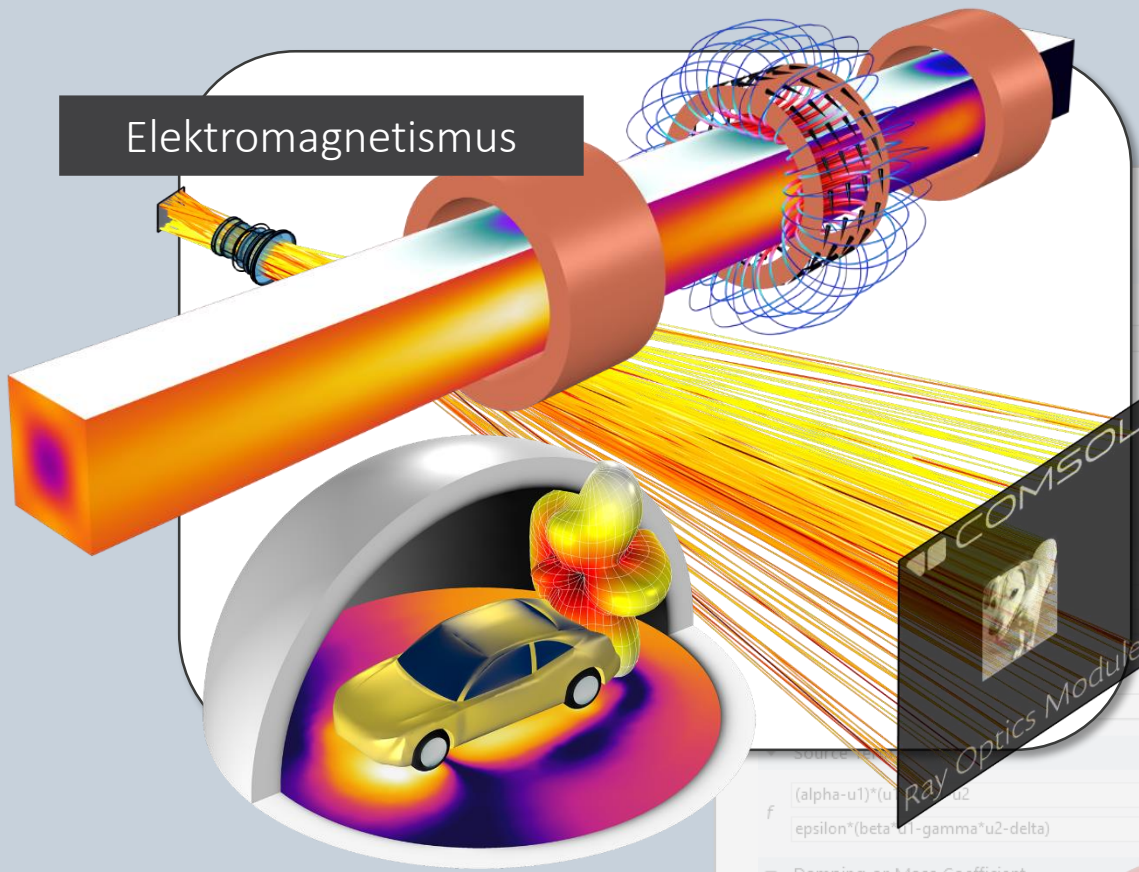
Weak Expressions

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



Vlastní PDR / ODR

Elektromagnetismus



- Mathematics
 - PDE Interfaces
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Show equation assuming:

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

Weak Expressions

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

Source

$(\alpha - u1) * (u1 - u2)$

f

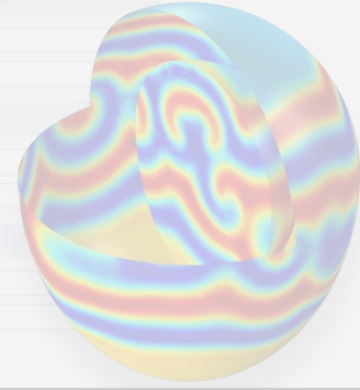
$\epsilon \text{psilon} * (\beta * u1 - \gamma * u2 - \delta)$

Damping or Mass Coefficient

d_a	1	0
	0	1

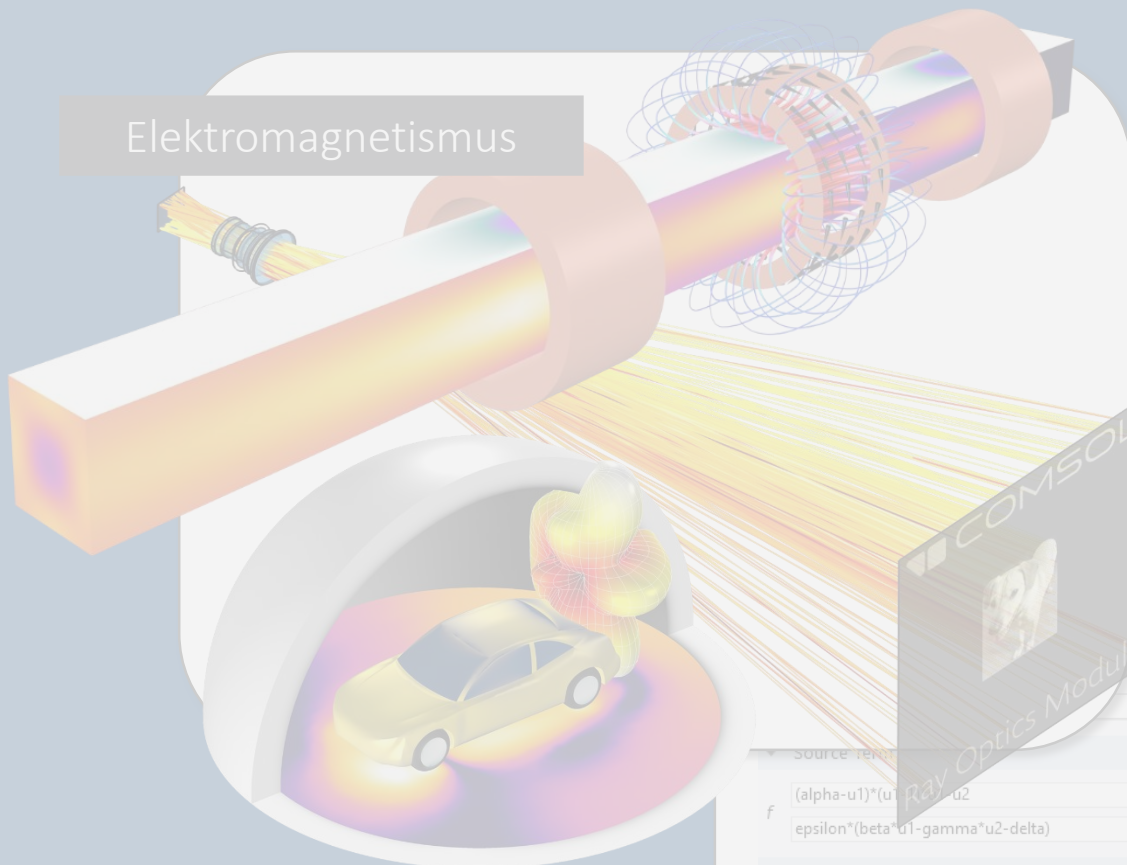
Mass Coefficient

e_a	0	0
	0	0

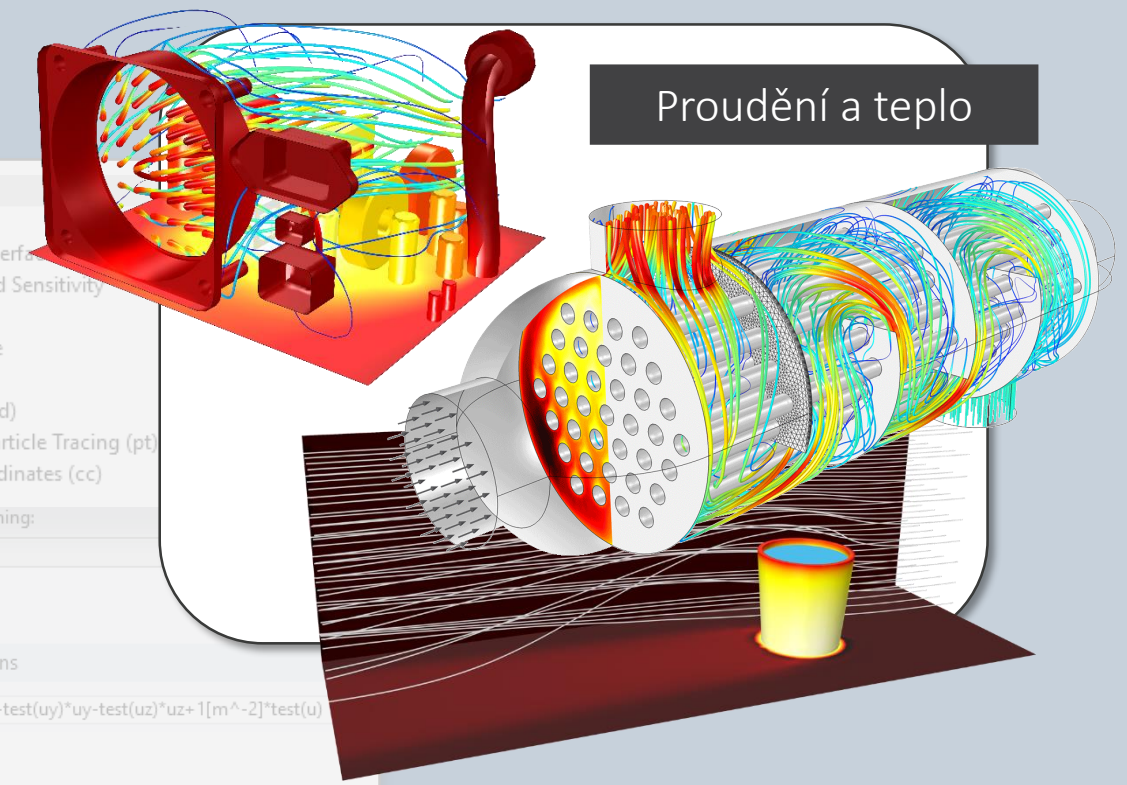


Vlastní PDR / ODR

Elektromagnetismus



Proudění a teplo



Mathematics

- ▷ PDE Interfaces
- ▷ ODE and DAE Interfaces
- ▷ Optimization and Sensitivity
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- ▷ Wall Distance (wd)
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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

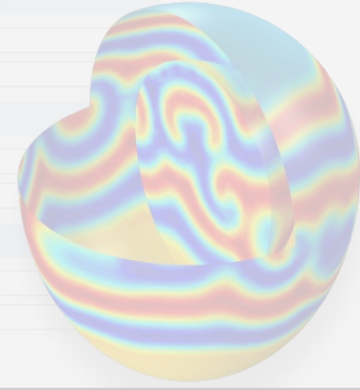
$f = (\alpha u_1)(u_1 - u_2) + \epsilon \text{div}(\beta \nabla u_1 - \gamma \nabla u_2 - \delta \nabla u)$

Damping or Mass Coefficient

d_a	1	0
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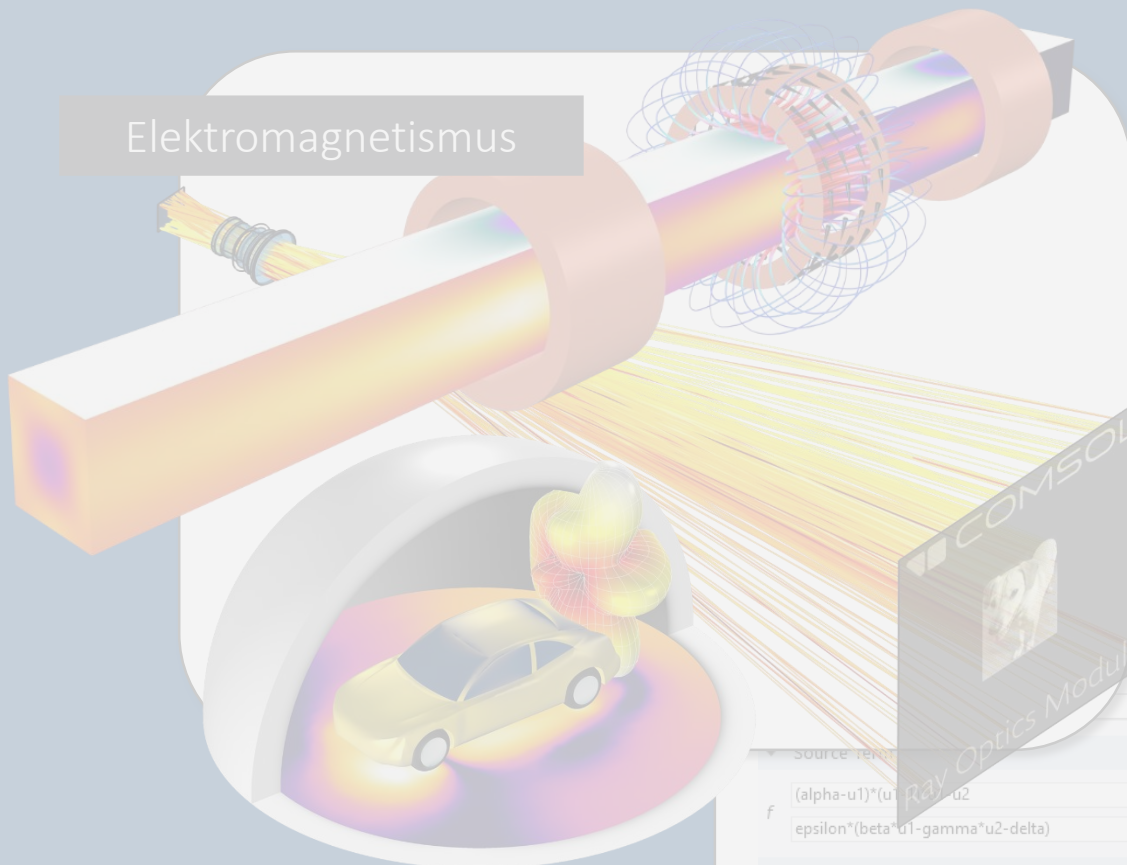
Mass Coefficient

e_a	0	0
	0	0

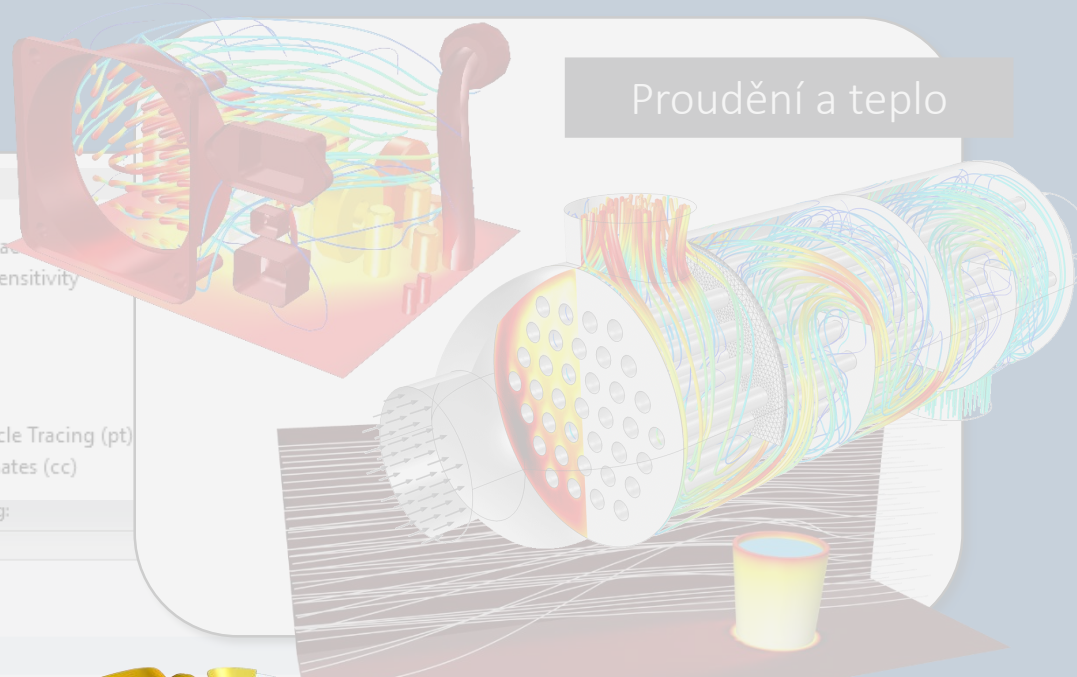


Vlastní PDR / ODR

Elektromagnetismus



Proudění a teplo



Δu Mathematics
 ▷ Δu PDE Interfaces
 ▷ ODE and DAE Interfaces
 ▷ Optimization and Sensitivity
 ▷ ∇^2 Classical PDEs
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 ▷ Deformed Mesh
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 ▷ 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

$$(\alpha - u_1) * (u_1 - u_2) + \epsilon * (\beta * u_1 - \gamma * u_2 - \delta)$$

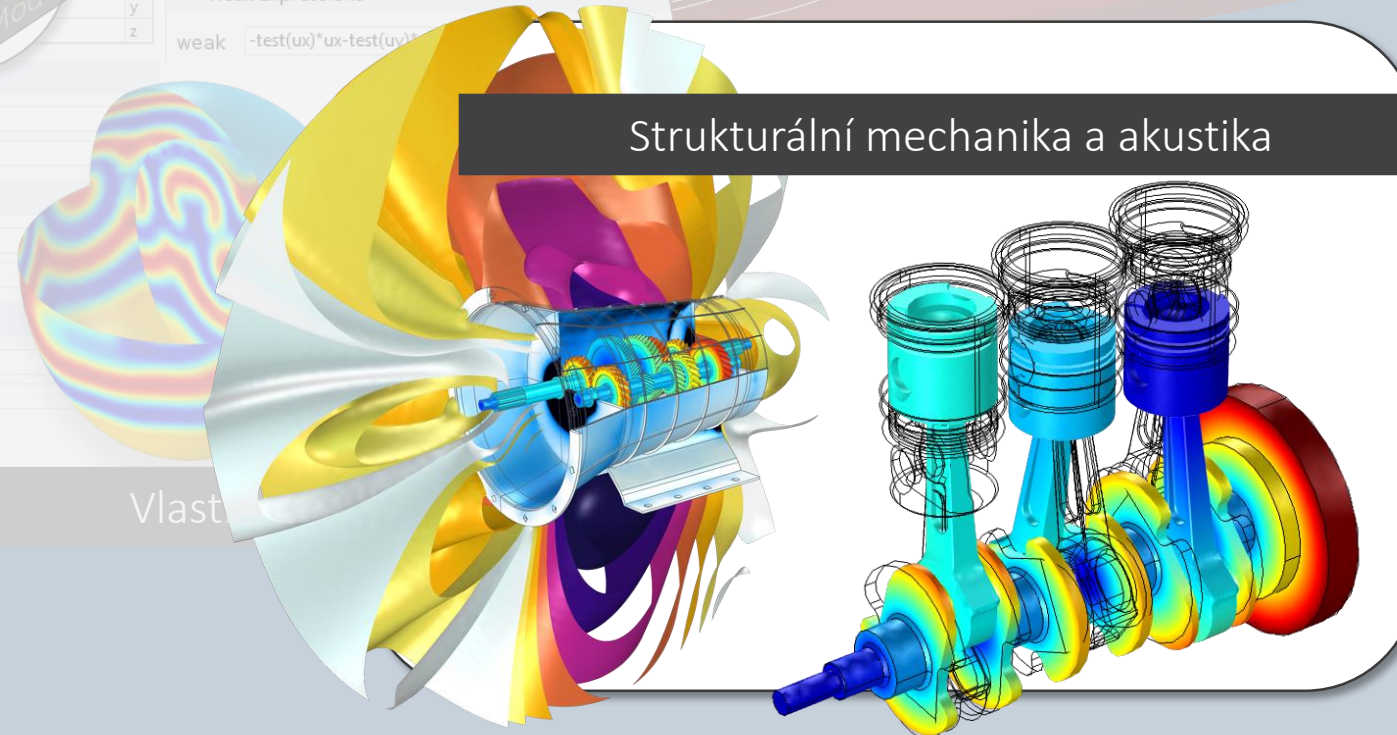
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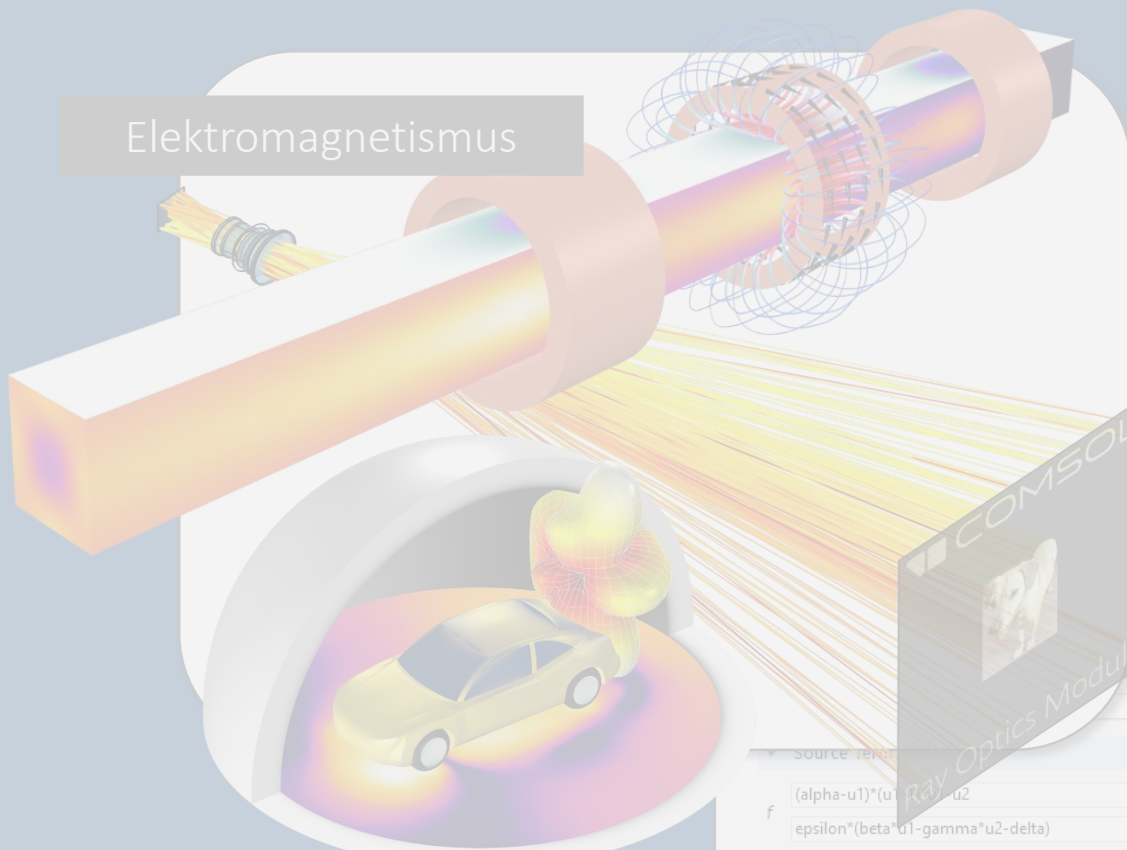
Mass Coefficient

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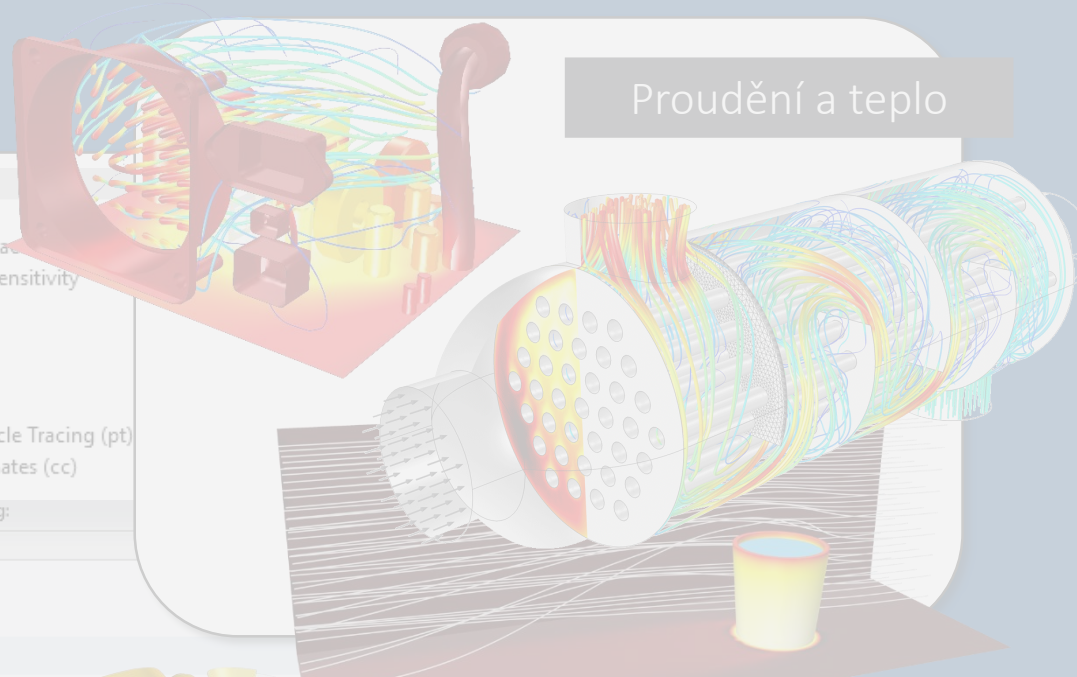
Strukturální mechanika a akustika



Elektromagnetismus



Proudění a teplo



Δu Mathematics
 ▷ Δu PDE Interfaces
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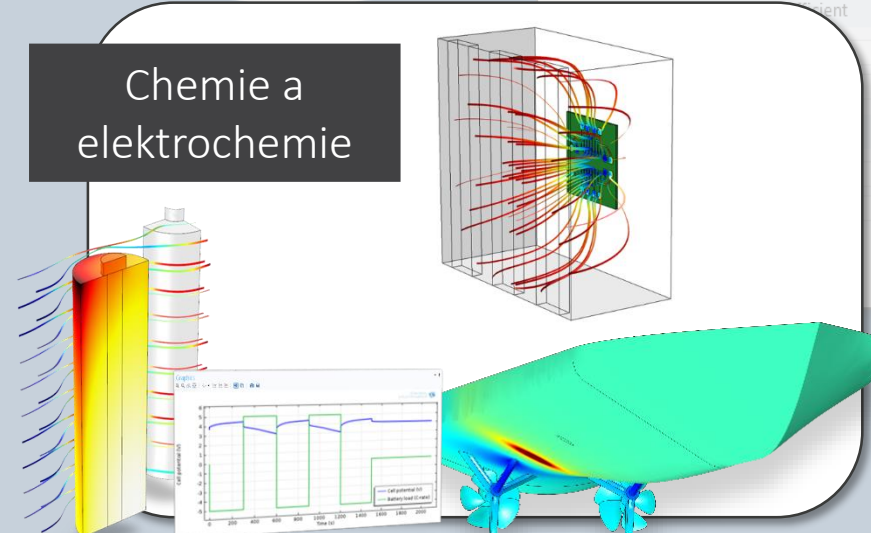


source term
f
 $(\alpha u_1) * (u_1 - u_2)$
 $\epsilon \text{psilon} * (\beta u_1 - \gamma u_2 - \delta)$

Strukturální mechanika a akustika



Chemie a elektrochemie



Vlast

Technical Computing Camp 2021



COMSOL na TCC 2021

COMSOL na TCC 2021

- Čtvrteční odpoledne: 14:15 – 18:00, diskuzní a konzultační okénko
- Pátek dopoledne: 9:30, digitální FEM dvojče integrované do prostředí MATLAB a Simulink
- Pátek dopoledne: 10:45, prezentace živých ukázek
 - ukázka bludiště řešené pomocí FEM
 - simulace chladiče a jeho propojení s řízením
- Pátek dopoledne: 10:45, soutěž o nejlepší uživatelský projekt
 - Metóda pre výber plôch plan-paralelných so súradnicovou sústavou
 - Simulační výuková aplikace - Baterie z citronu

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- Molecular Flow Module
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 - Nonlinear Structural Materials Module
 - Composite Materials Module
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 - Fatigue Module
 - Rotordynamics Module
- Multibody Dynamics Module
- MEMS Module
- Acoustics Module

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- Electrochemistry Module

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- Particle Tracing Module
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