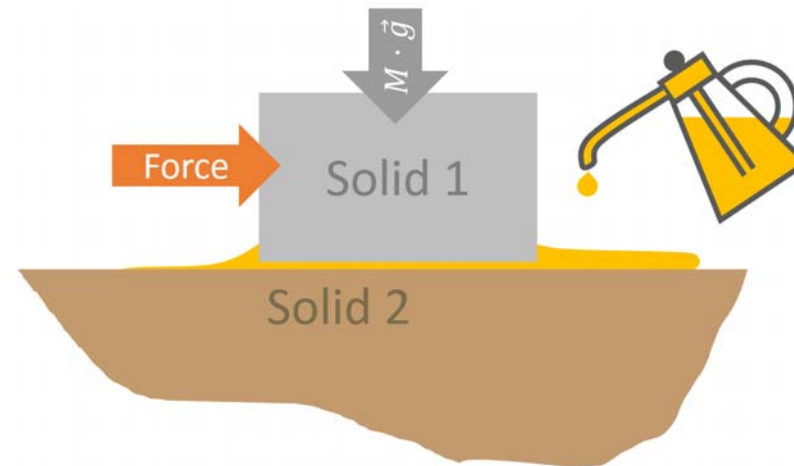


Modelling lubricated contact

22/10/2018



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Working with SIMTEC

Industry Challenges

- R&D sections: experts in their field
→ Expertise in numerical modelling?
- Lack of time
- FE modelling performed by a small group of people



SIMTEC's Solutions

- Numerical modelling project
→ SIMTEC's member as your colleague
→ Help improve your modelling knowledge!
→ Cost-effective outsourcing



Our team & Our clients

Numerical Modelling Consultants



6 Members all EngD + PhD

- Extensive research background
- Complex problems
- various fields of expertise

Successful Track Record:

- Big international companies
- Government laboratories

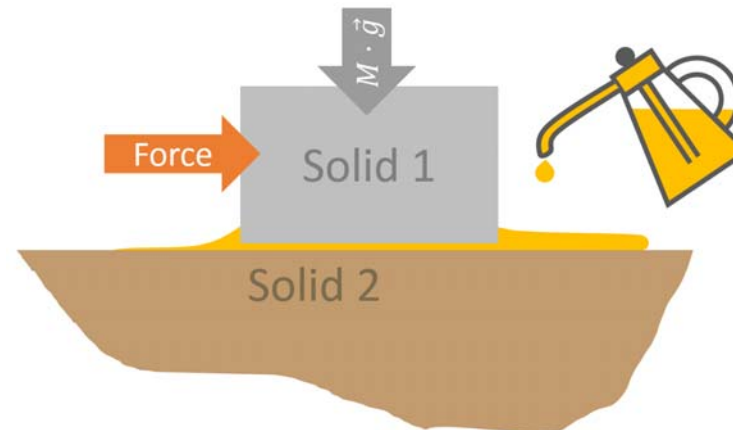
Involved in Research Consortia

- EU funded projects (REEdcover / SHARK)
- PhD projects supervision.



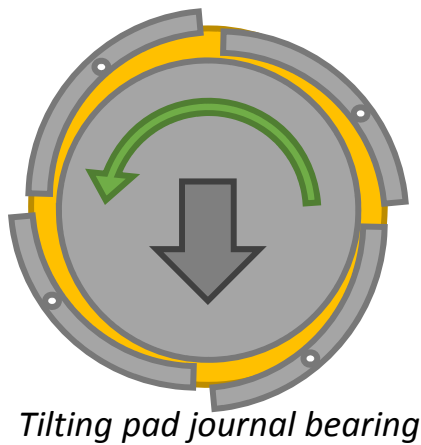
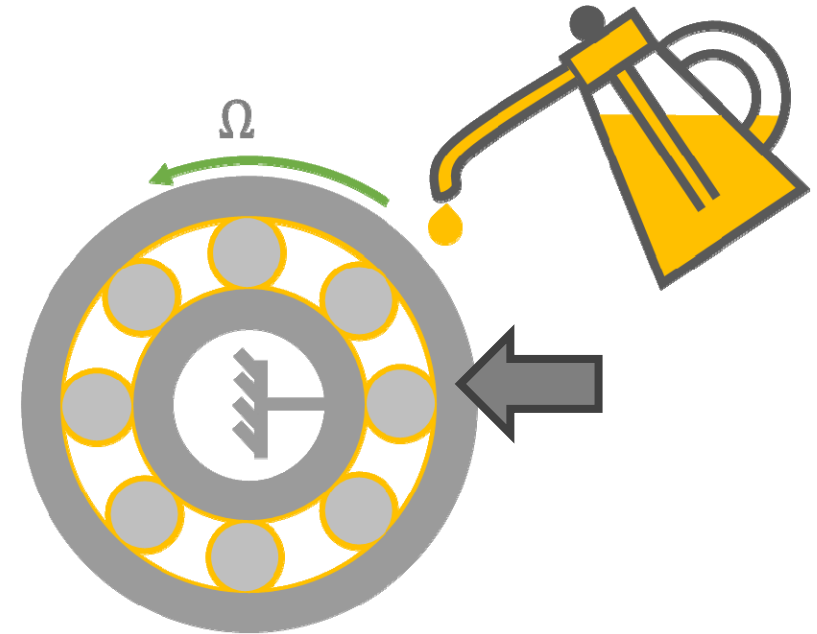
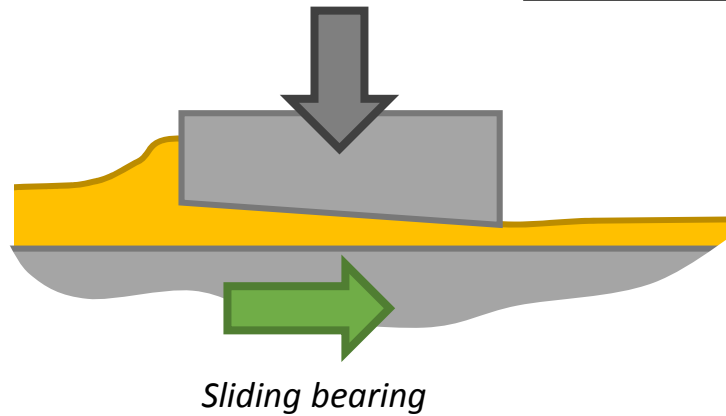
Summary

- Introduction
- Study Case with COMSOL Multiphysics®
- Application with COMSOL Server™
- Conclusions



Introduction

Wear?
Friction force \vec{F}_f ?



Legend:

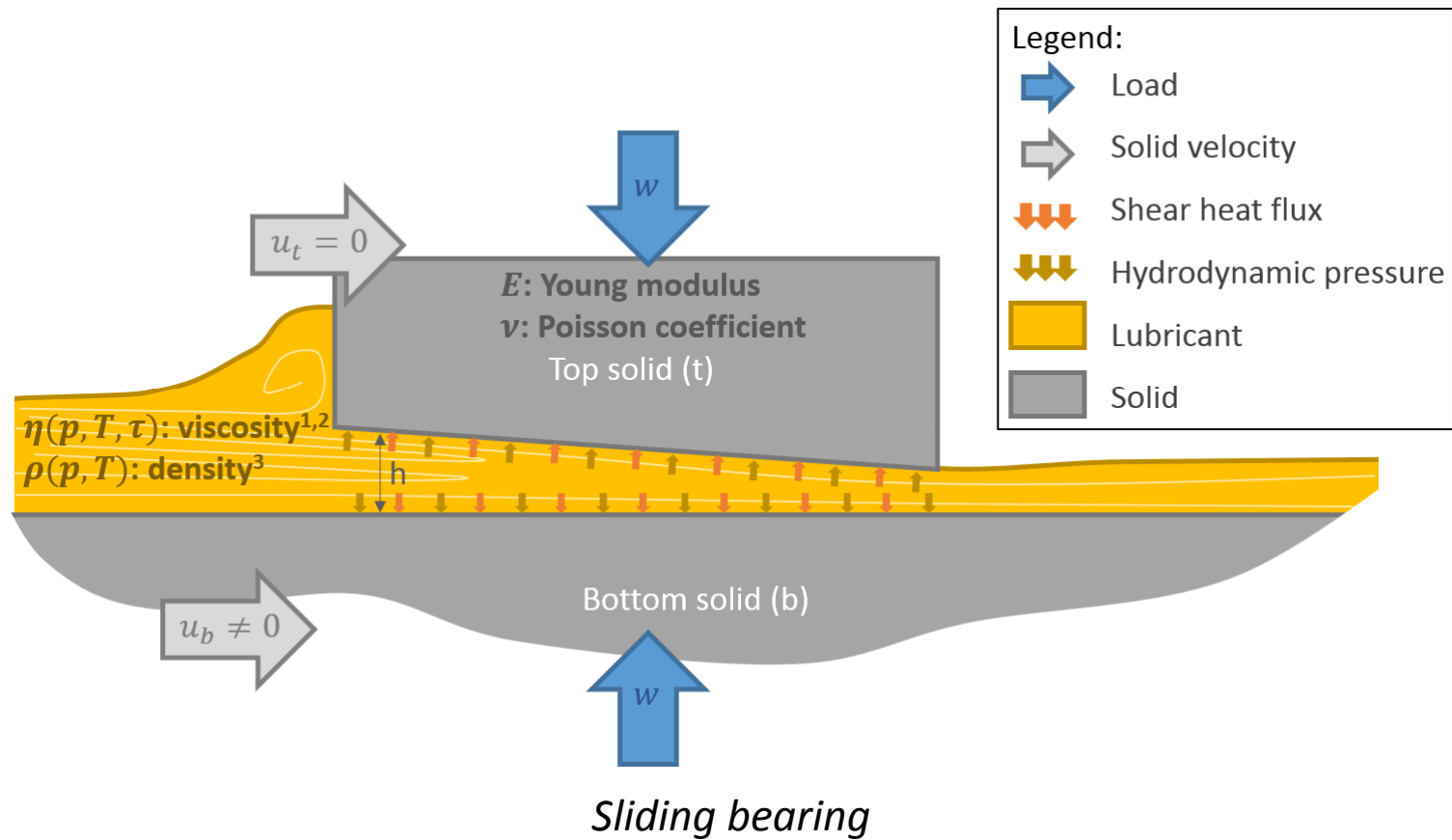
- Load
- Solid motion
- Lubricant
- Solid

Introduction

- Typical physical phenomena

- **High pressure inside of the contact / at the inlet**
 - Piezoviscous lubricant
 - Compressible lubricant
 - Non-Newtonian lubricant → lubricant thinning
 - Shear and compression heating → lubricant thinning
 - Limiting shear stress
- **Solids**
 - Deformations
 - Roughness
 - Heat accumulation
 - Tribofilm

Study case with COMSOL Multiphysics®



Study case with COMSOL Multiphysics®

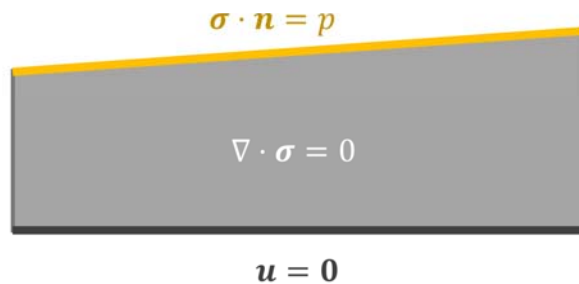
$$\frac{\partial}{\partial x} \left(\frac{\rho h^3}{12\eta} \frac{\partial p}{\partial x} \right) - u_e \frac{\partial(\rho h)}{\partial x} = 0$$



Reynolds domain and boundary conditions

$$h = h_0 + h_{rigid} + deformations$$

Film thickness expression



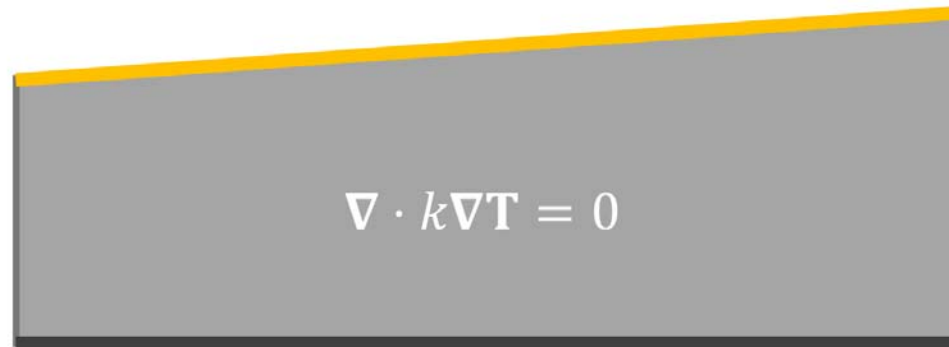
Equivalent elastic solid deformation equation and boundary conditions

$$\int p = w$$

Load balance equation

Study case with COMSOL Multiphysics®

$$Q_s = h \cdot \eta \cdot \dot{\gamma}^2$$

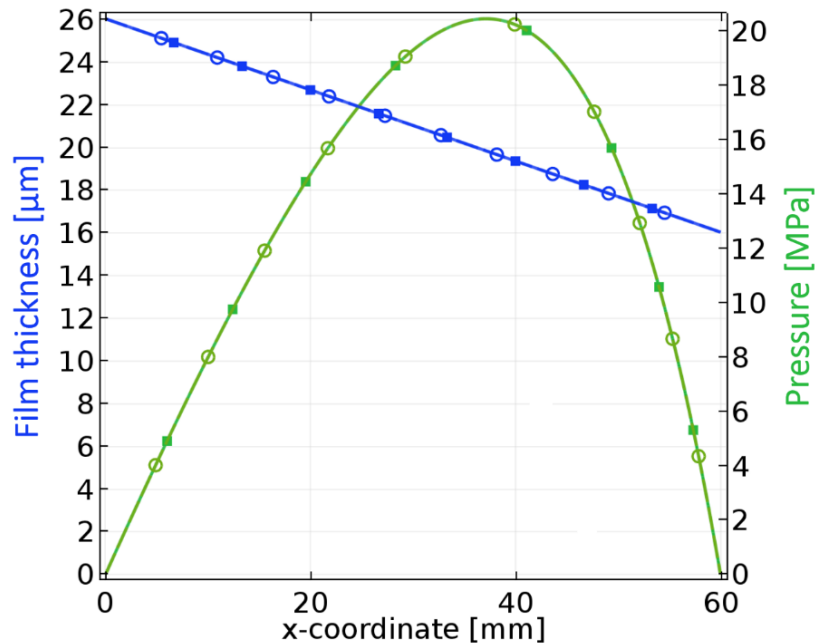


$$T = T_0$$

*Heat transfer equation and boundary conditions on an equivalent solid**

* Yes, it is a bit oversimplified!

Study case with COMSOL Multiphysics®



Isothermal rigid contact with an isoviscous and incompressible Newtonian lubricant - comparison between analytical¹ (·o·) and numerical (—■—) results

Solid model	
Deformations	None
Surface roughness	None

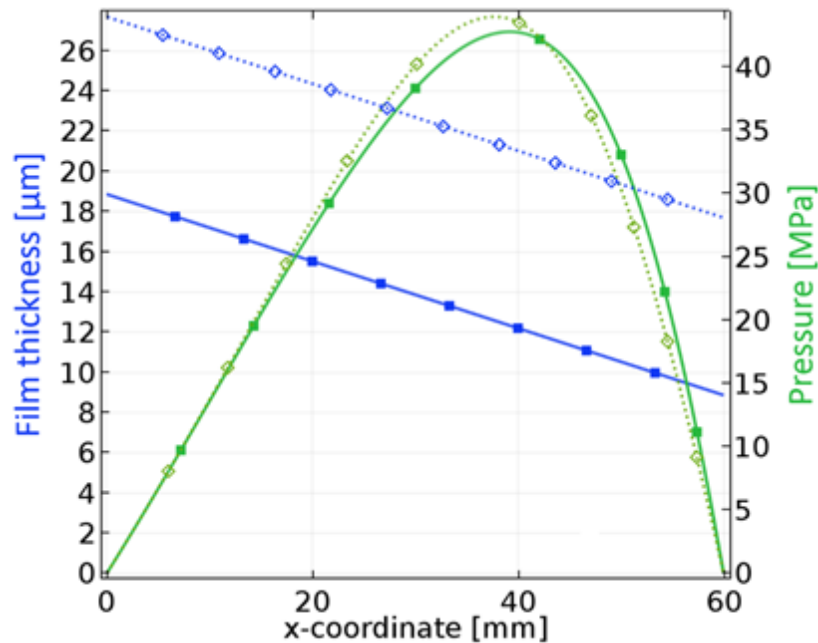
Lubricant density dependence	
Temperature	No
Pressure	No

Lubricant viscosity dependence	
Temperature	No
Pressure	No
Shear stress	No

Parameter	Value [Unit]
Slider velocity u_b	10 [m/s]
Load w	$8 \cdot 10^5$ [N/m]
Slider length	60 [mm]

¹ Hamrock, B. J., Schmid, S. R. & Jacobson, B. O. Fundamentals of Fluid Film Lubrication. (2004)
Wheeler, J.-D., Bruyere, V., Namy, P., COMSOL Conference, Boston (2018) – to be published

Study case with COMSOL Multiphysics®



Influence of the lubricant temperature on the contact behaviour - comparison between isothermal (····) and thermal (—■—) results

Solid model	
Deformations	None
Surface roughness	None

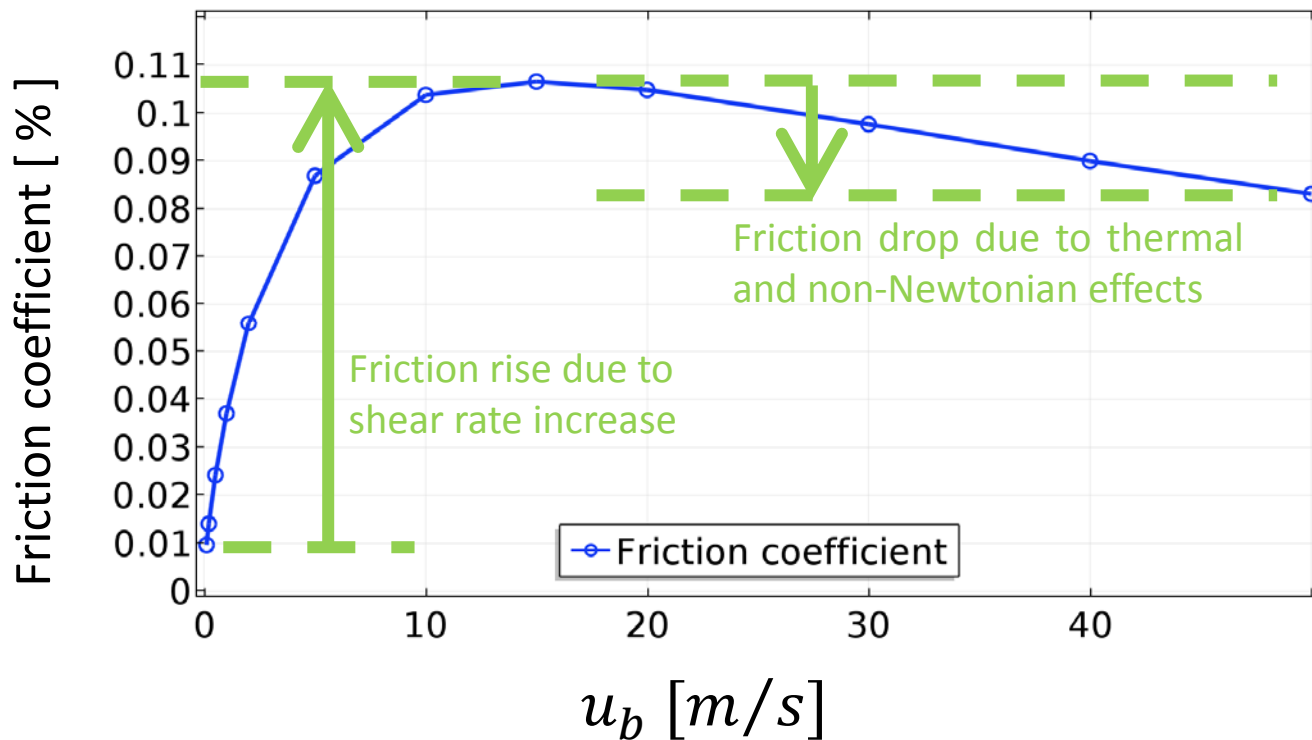
Lubricant density dependence	
Temperature	Yes
Pressure	No

Lubricant viscosity dependence	
Temperature	Yes
Pressure	No
Shear stress	No

Parameter	Value [Unit]
Slider velocity u_b	10 [m/s]
Load w	$8 \cdot 10^5$ [N/m]
Slider length	60 [mm]

Study case with COMSOL Multiphysics®

FRICITION PREDICTIONS:



Solid model	
Deformations	Yes
Surface roughness	None

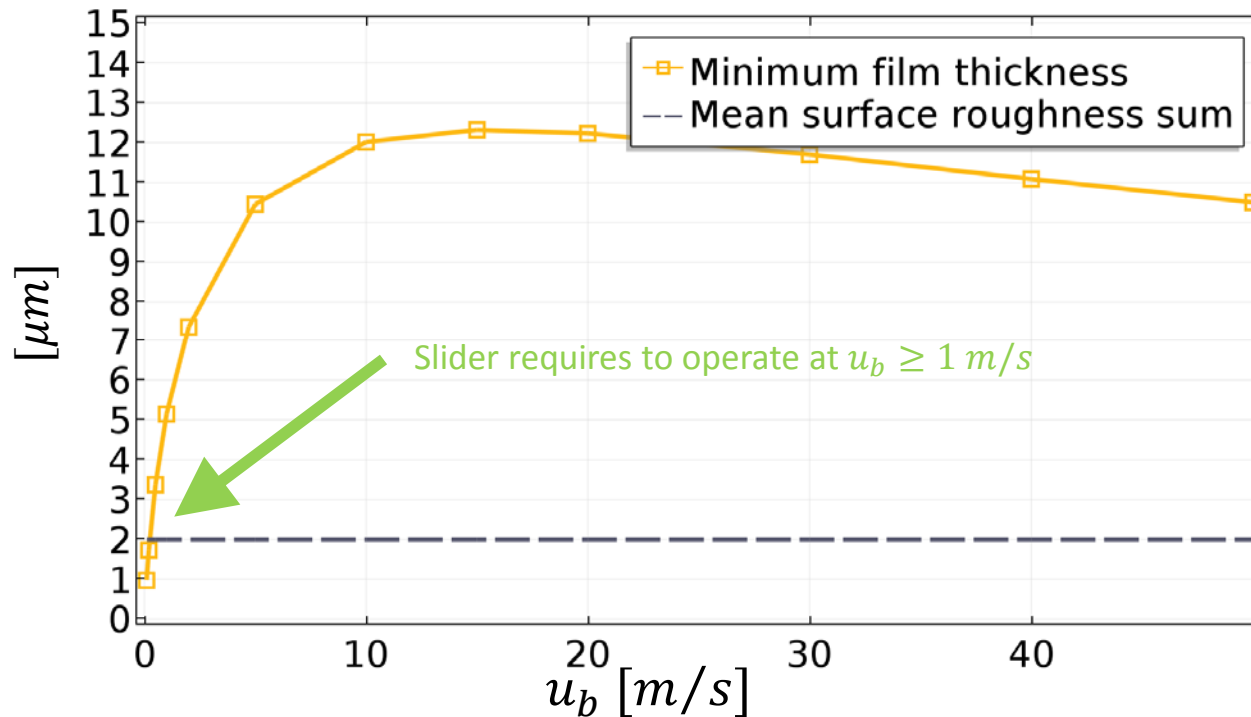
Lubricant density dependence	
Temperature	Yes
Pressure	Yes

Lubricant viscosity dependence	
Temperature	Yes
Pressure	Yes
Shear stress	Yes

Parameter	Value [Unit]
Load w	$8 \cdot 10^5$ [N/m]
Slider length	60 [mm]

Study case with COMSOL Multiphysics®

WEAR: required operating conditions



Solid model	
Deformations	Yes
Surface roughness	None

Lubricant density dependence	
Temperature	Yes
Pressure	Yes

Lubricant viscosity dependence	
Temperature	Yes
Pressure	Yes
Shear stress	Yes

Parameter	Value [Unit]
Load w	$8 \cdot 10^5$ [N/m]
Slider length	60 [mm]



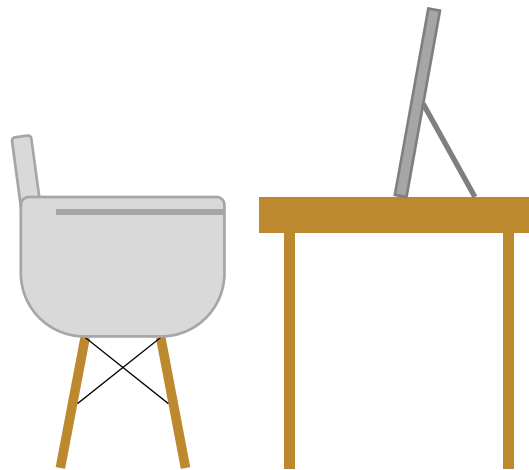
Numerical modeling

that predicts, optimizes and innovates

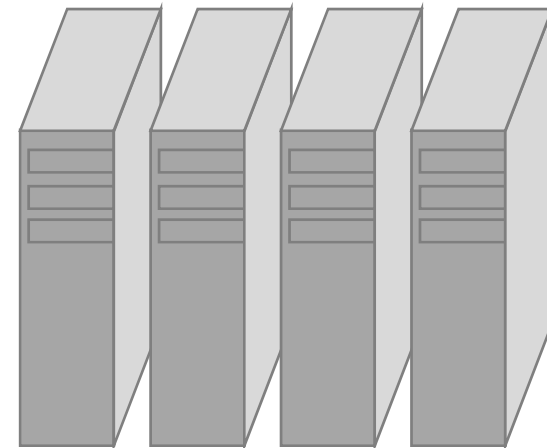
Application with COMSOL Server™

Application with COMSOL Server™

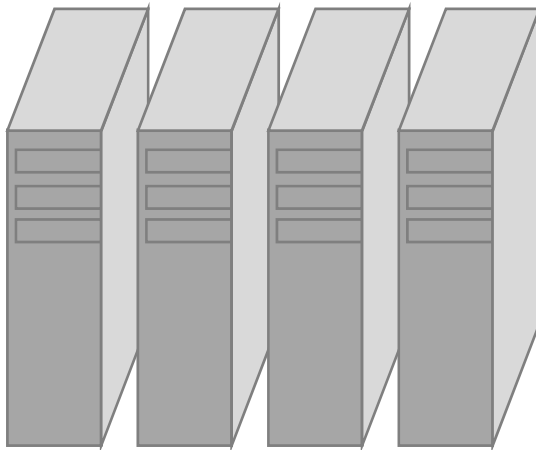
You only need a web browser!



High speed
secured
connexion



Application with COMSOL Server™



SIMTEC provides:

- New generation workstations
- Hardware maintenance
- Software maintenance
- Scientific validation at the updates
- COMSOL Server™ licence management
- Hotline
- Confidentiality

You:

- **focus only on your topic!**

Application with COMSOL Server™

Ask for a free secured access to the
[slider bearing app](#)

to test the SIMTEC modelling skills!

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vincent.bruyere@simtecsolution.fr

Conclusions

- Modelling lubrication is not an easy task!
- However, the tribology research field provides quantitative understanding on some topics
- SIMTEC develops physical models for quantitative predictions
- SIMTEC provides apps to make these models more accessible