

# Contact Mechanics and Elements of Tribology

*Foreword to the 9th edition*

Vladislav A. Yastrebov

*MINES Paris - PSL, CNRS  
Centre des Matériaux, Evry, France*

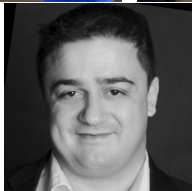
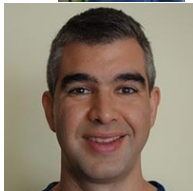


@ Centre des Matériaux (& virtually)  
January 22, 2024



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- Acquaintance
- Questionnaire
- Teaching team
- Course content
- Complexity of contact physics
- Notations



- **Henry Proudhon** (@CNRS, France) - Fretting and Wear
- **Ramin Aghababaei** (@Aarhus University, The Netherlands) - Nanoscopic wear
- **Pierre Arnaud** (@MINES, France) - Fretting wear, 3rd body & oxygenation
- **Philippe Bussetta** (@Michelin, France) - Tribology of tyres
- **Karim Demmoi** (@Safran Aircraft Engines, France) - Contact in Aircraft Engines
- **Vladislav Yastrebov** (@CNRS, France)

# Please introduce yourself

Nominally 122 participants from 26 different countries

Algeria 🇩🇿 Argentina 🇦🇷 Austria 🇦🇹 Burkina Faso 🇸🇩 Canada 🇨🇦 China 🇨🇳  
Czech Republic 🇨🇪 Denmark 🇩🇰 France 🇫🇷 Germany 🇩🇪 Greece 🇬🇷 India 🇮🇳  
Iran 🇮🇷 Iraq 🇮🇶 Italy 🇮🇹 Malaysia 🇲🇾 Morocco 🇲🇦 Netherlands 🇳🇱 Russia 🇷🇺  
Spain 🇪🇸 Sweden 🇸🇪 Tunisia 🇹🇳 Ukraine 🇺🇦 United Kingdom 🇬🇧 USA 🇺🇸  
Vietnam 🇻🇳

Welcome questionnaire



<https://forms.gle/TmJqFtSBu1kQtTsU9>

# Zoom and operational mode

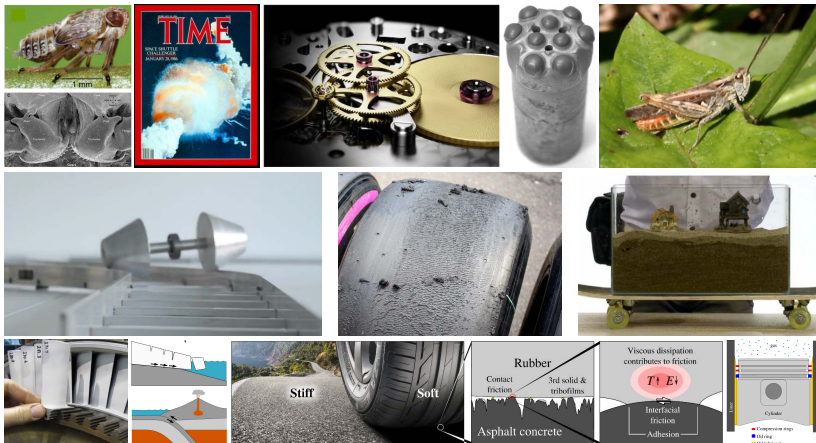
- We give this course in a hybrid mode, so please be patient with technical problems ☺.
- In case of such problems, please write in Zoom chat, we'll try to solve them asap.
- Please do not record the course, one day, I'll do it on my own ☺
- Please don't share zoom links neither. If someone would like to attend, please write me an email.
- During lectures, I'll accept oral question only from people in the classroom.
- For all Zoom participants, please write your questions in Google.Sheet, I'll try to address them asap.
- All slides are available on [cmet.yastrebov.fr](http://cmet.yastrebov.fr)
- All links will be provided in Google.Sheet of the course (please be careful with this online document).
- You can use all my figures and my slides (CC BY license) if you simply mention the author.

# Mark your assistance

- During the lecture, please mark your attendance in the Google Sheet.
- Marking is only available during the lecture/practical work

A lot of practical work was added compared to previous years.

Prereading: [Applications](#)



## Monday

- Lecture 1: Continuum Contact Mechanics I
- Practical work 1: Flamant's problem
- Lecture 2: Continuum Contact Mechanics II
- Practical work 2: Frictional sliding

## Tuesday

- Lecture 3: Contact mechanics and mechanics of Materials
- Practical work 3: Inelastic deformation in contact
- Lecture 4: Surface roughness and contact of rough surfaces
- Practical work 4: Characterisation of rough contact

## Wednesday

- Lecture 5: Fretting and Wear (H. Proudhon)
- Practical work 5: Solving fretting problem using Flamant solution
- Lecture 6: Computational contact mechanics: Finite Element Method
- Practical work 6: Contact algorithms (FEM)



## Thursday

- Lecture 7: Lubrication and Sealing
- Practical work 7: Solving 1D & 2D Reynolds equation
- Lecture 8: Computational contact mechanics: Boundary Elements
- Practical work 8: Solving rough contact problem in Tamaas code

## Friday

- Seminar: *Nano-/micro-scale wear* (R. Aghababaei)
- Seminar: *Tribology of tyres* (P. Bussetta, Michelin)
- Seminar: *Contact in Aircraft Engines* (K. Demmou, Safran)
- Seminar: *Third body and oxygenation in fretting wear* (P. Arnaud, MINES)
- Exam for all
- Concluding remarks

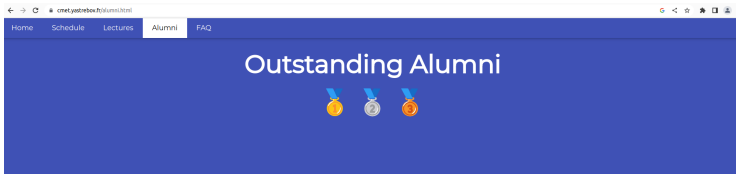
# Exam, certificates & notes

- On Friday, January 26th at 13h45.
- 20-25 questions on lectures of the first four days (Monday-Thursday)
- Duration: 2 hours 45 minutes
- Type of questions: technical questions which generally require some calculations
- Please take notes during the class, I give extra information on the "blackboard"
- You will be allowed to use whatever source of information you need, but not be helped by others or chatbots (ChatGPT, Bard, Mistral, etc) 😊
- The exam is "mandatory" for all the participants:
  - If you need a certificate of attendance. By the way to get it, you'll need to attend 7/8 lectures and practical sessions...
  - If you would like to try to get a certificate of excellence
- Final notes are essential for DMS participants to validate the course

Outstanding alumni receive a diploma and appear on the dedicated web-page ☺



Outstanding alumni receive a diploma and appear on the dedicated web-page 😊



## 2023

- Rihay DUQUESNE
- Amirhossein ZABIH
- Dayash-AZJUNA
- Samer SEMANN

## 2022

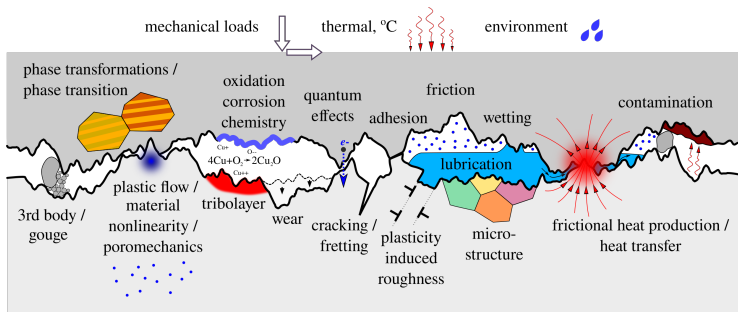
- António Manuel Couto Carneiro
- Quentin Caradec
- Rodrigo Pinto Carvalho
- AHYEE Annalise
- Victor Pivovarov
- Michon Audrey
- Pierre Gardier



# Contact complexity: physics and mathematics

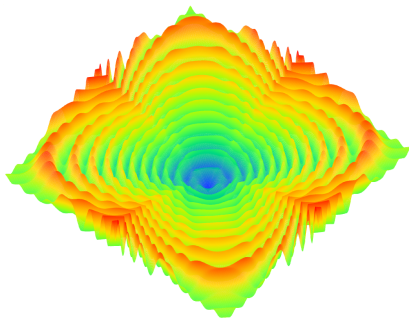
## Particular difficulties related to contact problems: **multiphysical aspects**, mathematical aspects

- Roughness of surfaces
- Interface chemistry
- Hardly accessible contact interface for measurements
- Generation and diffusion of heat
- Multiscale and multiphysical nature of friction



**Particular difficulties related to contact problems:**  
multiphysical aspects, **mathematical aspects**

- One of the most hard problems in mechanics
- Lack of standard optimization problem
- Non-convexity and non-differentiability
- Bad scalability





Welcome to the CMET course!

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