MINES PARIS | PSL | Cemef

Year 2024 - 2025

CATALOGUE OF DOCTORAL COURSES

DOCTORAL PROGRAMS

- Computational Mechanics & Materials (MNM)
- Computational Mathematics, HPC & Data (MathNum)

EDSFA

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ED SFA

Ecole Doctorale Sciences Fondamentales et Appliquées

Doctoral programs:

>> COMPUTATIONAL MECHANICS & MATERIALS >> MNM

>> COMPUTATIONAL MATHEMATICS, HPC & DATA >> MathNum

As part of your doctoral training at CEMEF, it is required that you follow and validate a certain number of scientific and professional classes.

Within the doctoral school **Sciences Fondamentales et Appliquées** (ED SFA) and in the doctoral programs *Computational Mechanics and Materials* and *Computational Mathematics, High Performance Computing and Data* of Mines Paris - PSL, you are required to attend a minimum of **90 hours** of classes to validate your doctoral training. This is usually split in 45 hours of scientific classes (specialized in research themes or cross-disciplinary) and 45 hours of professional classes.

This document regroups the choice of scientific classes available at CEMEF Mines Paris for the validation of your doctoral training.

In addition to these classes available at CEMEF, you can also attend classes from other doctoral schools. It is also possible to validate some doctoral training hours from thematic schools, scientific conferences, seminars and e-courses with the following rules. They must be discussed first with one of us for validation:

- National and international conferences: recognized at a rate of two hours per half-day subject to an oral presentation or in the form of a poster.
- Thematic schools (CNRS or others): recognized for two hours per half-day.
- Workshops: recognized at the rate of 2 hours per half-day, subject to a certificate indicating the number of hours.
- Specialized seminars: recognized for 1 hour if other than the regular seminars of the host laboratory
- e-courses (MOOC, SPOC ...) are validated on a case-by-case basis, contact the head of the doctoral school and/or doctoral program.

The choice of scientific classes should be defined as soon as possible with your supervisors so as to fulfil the **total of 45 hours required**.

For each class presented in this document, please refer to the teaching team for details regarding evaluation and validation.

ECOLE DOCTORALE
Sciences Fondamentales et Appliquées
Directeur-Adjoint
Elie HACHEM

Elie Hachem
Head of CEMEF Doctoral School
ED SFA n°364

HOW TO REGISTER & TO VALIDATE YOUR CLASSES?

GUIDE LINES

OVERVIEW

Please read these guidelines carefully.

- **We explain you the process for registering for the classes you have selected.**
- **We explain also how to add yourcompleted courses hours in your Adum profile once they have been validated.**

REGISTRATION AND FOLLOW-UP

SELECT YOUR COURSES IN THIS CATALOGUE

- Consult the catalogue of courses, select those you wish to attend by discussing them with your supervisors.
- Decide which courses you will validate and which, if any, you will take as an auditor (without taking an exam).
- As a reminder, you must validate 45 hours of scientific courses.
- **Email your selected list with the course acronym followed by "to be validated" to Florence Morcamp**

DECLARE YOUR COURSES IN YOUR ADUM PROFIL (to be done afterwards)

- Go to your Adum profile, Trainings section.
- Click on "Attestation de suivi à cours". This document has to be printed, completed and signed by the course responsible.
- Scan this document.
- Then, go back in the "Trainings" section and click on "Declaration of external training courses", then on the line "Add an external training module". Fill in the online form, upload your attestation de suivi de cours. Save and send your request.
- We receive your request and validate it.
- The hours of the course are added to your training account.

SCIENTIFIC COURSES

- 45hrs in total of validated courses are compulsory

AUDIENCE

- ED SFA PhD Students

CONTACT

- Florence MORCAMP for administrative issues
- Your supervisors

- Elie HACHEM
- Marc BERNACKI
- Aurélien LARCHER
- Pierre-Olivier BOUCHARD
- Edith PEUVREL-DISDIER
- David RYCKELYNCK

CONTINUUM MECHANICS AND HEAT TRANSFER

Acronym

CMHT

OBJECTIVES

- **Review of basic conservation equations governing mechanics of deformable media and heat transfer: conservation of mass, of momentum, of energy.**
- **Review of fundamental notions in mechanics: stress, strain, rate of strain.**
- **Introduction of the main constitutive equations for metals, polymers, and glasses● Review of boundary conditions in heat transfer**

PROGRAM

MECHANICS OF DEFORMABLE MEDIA

- Strain, rate of strain, stress
- Dissipated power, conservation equations
- Weak form of momentum conservation

BASIC CONSTITUTIVE EQUATIONS

- Elasticity, elasto-plasticity
- Newtonian behaviour, viscoplasticity/pseudoplasticity

ADVANCED MODELS FOR SOLIDS

- Elastoviscoplasticity
- Crystal plasticity

ADVANCED MODELS FOR FLUIDS

- Granular media
- Lubrication theory and applications
- Free surface flows, triple lines, permeability

DURATION

- 45 hrs: courses & exercises

ASSESSMENT

- Examination

AUDIENCE

- ED SFA PhD Students

TEACHING TEAM

Michel BELLET
Rudy VALETTE

ADVANCED NUMERICAL METHODS AND SIMULATION

Acronym

ANMS

OBJECTIVES

The course covers several numerical methods to solve time-dependent Partial Differential Equations using adaptive stabilized finite elements.

Advanced methods for turbulence modelling, multiphase flows, complex fluid flows, and aerothermal modelling of complex systems will be introduced.

Finally, the course will be completed by a posteriori error estimation techniques needed for anisotropic parallel mesh adaptation.

PROGRAM

NUMERICAL METHODS

- Parallel computing and HPC
- Convection Diffusion Reaction: stabilized finite elements
- Navier-Stokes: variational multiscale approaches
- Mesh adaptation
- Error estimators and anisotropic remeshing

MODELLING AND SIMULATION

- Turbulence modelling
- Two-fluid flows
- Newtonian and Non-Newtonian Fluids
- Flow control and optimization
- Deep Reinforced Learning for Fluid Mechanics

DURATION

- 42 hours + exercises

ASSESSMENT

- Evaluation based on the results obtained during numerical simulation labs and a final written examination covering the theoretical arguments developed during the lectures: Lab exercises (25%) & Examination (75%)

AUDIENCE

- ED SFA PhD Students

TEACHING TEAM

Aurélien LARCHER
Elie HACHEM
Thierry COUPEZ
Rudy VALETTE
Philippe MELIGA
Franck PIGEONNEAU
Jonathan VIQUERAT

PROGRAMMING AND PARALLEL SCIENTIFIC COMPUTING

Acronym

PPSC

OBJECTIVES

The course provides an introduction to C++ programming and algorithms with a focus on scientific computing for solving PDEs.

An overview of the C++ language is provided : specification, arithmetics, memory management, object-oriented design for component-based software, and advanced topics using templates.

Distributed and shared-memory parallel computing are then approachedwith exercises related to numerical linear algebra and solution methodsfor Partial Differential Equations.

PROGRAM

IMPLEMENTATION OF NUMERICAL ALGORITHMS

- Environment (UNIX/Linux) and standards
- Integer and Floating-point arithmetics
- Object-Oriented concepts in C++
- Template and meta-programming in C++
- Advanced numerics with the STL

PARALLEL SCIENTIFIC COMPUTING

- Parallel computing architectures
- Distributed programming models (MPI)
- Shared memory models (OpenMP)
- Performance for numerical linear algebra
- Applications to finite element/finite difference methods

DURATION

- 30 hours + exercises

ASSESSMENT

- Evaluation based on the results obtained during numerical simulation labs and a final written examination covering the theoretical arguments developed during the lectures: Lab exercises (25%) & Examination (75%)

AUDIENCE

- ED SFA PhD Students

TEACHING TEAM

Aurélien LARCHER
Jonathan VIQUERAT

MECHANICAL TESTING AND INVERSE ANALYSIS

Acronym

MechTes

OBJECTIVES

The objective of this course is:

i) to illustrate the links between constitutive modelling, continuum mechanics and experimental tests known as “mechanical characterisation”;

ii) to give a road map to accurately characterize materials in an engineering context.

PROGRAM

MECHANICAL APPROACH OF DEFORMATION (C. Combeaud, 3h30)

HOW TO PERFORM A MECHANICAL TEST? (C. Combeaud, 2h)

INSTRUMENTATION AND METROLOGY (A. Pignolet, 1h30)

NOTIONS OF THERMOGRAPHY (G. Corvec, 1h30)

- A brief introduction to the basic concepts of the infrared thermography and live demo of the use of an infrared camera.

DIC1 AND DIC2 (7h)

FROM TESTS TO INVERSE ANALYSIS (Y. Tillier, 5h)

- How to identify parameters

LAB WORK

- Lab work 1 (A. Pignolet, G. Corvec)
- Lab work 2 (C. Combeaud)
- Lab work 3
- Lab work 4 (S. Kraria, Y. Tilllier)

DURATION

- 45 hours

ASSESSMENT

- Students will be graded based on their project work

AUDIENCE

- ED SFA PhD Students

TEACHING TEAM

Guillaume CORVEC
Christelle COMBEAUD
Yannick TILLIER
Arnaud PIGNOLET
Sélim KRARIA

MATERIALS PHYSICS – MICROSTRUCTURE EVOLUTION

Acronym

MatPhy

OBJECTIVES

This teaching will provide students with basic knowledge on microstructural evolution in metallic materials during forming processes.

The effects of these evolutions - and the final microstructures obtained - on the end-use mechanical properties will be discussed and analyzed on the materials of interest.

PROGRAM

MATERIALS PHYSICS - THEORY: FROM MATTER TO MATERIALS

- Crystallography, order, lattice, grains
- Thermodynamic, Gibbs energy

MICROSTRUCTURAL EVOLUTIONS IN METALS

- Equilibrium state, Phase diagram, construction of diagrams, reading and use, CALPHAD approach
- Practical work
  - Use of the software Thermocalc®
  - Equilibrium and phase diagrams computations
- Microstructure evolution in solid state, Grain growth, Phase change kinetics, Effect of cooling rate, Non-equilibrium transformations in steels CCT, TTT diagrams

DURATION

- 36 hours

ASSESSMENT

- Final examination

AUDIENCE

- ED SFA PhD Students

TEACHING TEAM

Gildas GUILLEMOT
Oriane SENNINGER

POLYCRISTALLINE MATERIALS EVOLUTION AT SOLID-STATE

Acronym
PolyCri

OBJECTIVES

- Introduction to physical and computational metallurgy at the solid state
- Description of the recrystallization and grain growth mechanisms
- Description of the existing mean-field models
- Introduction to the full-field numerical frameworks

Measure, understand, model and simulate polycristalline materials and their evolution mechanisms at the solid-state

PROGRAM

INTRODUCTION

- A brief history of our understanding of recrystallization & grain growth mechanisms - Marc Bernacki
- A short introduction to Materials Forming - Charbel Moussa

GRAIN BOUNDARY & GRAIN GROWTH - Marc Bernacki

- Basics & Advanced

PLASTICITY, RECOVERY & STATIC RECRYSTALLIZATION - Charbel Moussa

DYNAMIC & POST-DYNAMIC RECRYSTALLIZATION - Marc Bernacki

FULL FIELD MODELS - Marc Bernacki

TESTING & ANALYZING

- Parameters identificiation - Baptiste Flipon, Malik Durand, Alexis Nicolaÿ, Cyrille Collin

MEAN-FIELD MODELS - Baptiste Flipon

OTHER DIFFUSIVE MECHANISMS FOR POLYCRYSTALLINE MATERIALS

- Introduction - Marc Bernacki

OUTDOOR TP

- Study of a real case of grain growth on a material of great interest - Collective

DURATION

- 35 hours

ASSESSMENT

- based on the restitution of an article describing a case study related to the recrystallization and grain growth mechanisms

AUDIENCE

- ED SFA PhD Students

TEACHING TEAM

Marc BERNACKI
Cyrille COLLIN
Malik DURAND
Baptiste FLIPON
Charbel MOUSSA
Alexis NICOLAY

POLYMER MATERIALS, POLYMER PROCESSING AND PROPERTIES

Acronym

POL

OBJECTIVES

- To understand the main aspects of polymer chemistry and physics
- To learn about various polymer materials
- To learn about polymer properties and characterization methods
- To practice various methods of polymer characterization

PROGRAM

POLYMERS & POLYMER MATERIALS: FUNDAMENTALS

- Introduction to polymers and polymer chemistry (2h)
- Polymer physics & thermodynamics (2h)
- Polymer gels & networks (1h)
- Semi-crystalline polymers (3h)
- Physical approach to polymer solid deformation (3h)
- Polymers blends & nanocomposites (3h)
- Porous materials (2h)
- Biobased polymers (3h)

POLYMERS PROCESSING & PROPERTIES

- Polymer rheology (4.5h)
- Mechanical properties of polymers (4.5h)
- Surface properties of polymers (1.5h)
- 3D printing of polymers (3h)
- Surface characterisation (3h)
- Rheological characterisation of polymers (3h)
- Mechanical characterisation of polymers (3h)
- Optical microscopy (2h)
- 3D printing of polymers (1.5h)

DATES & DURATION

- 45 hours

ASSESSMENT

- Examination

AUDIENCE

- ED SFA PhD Students

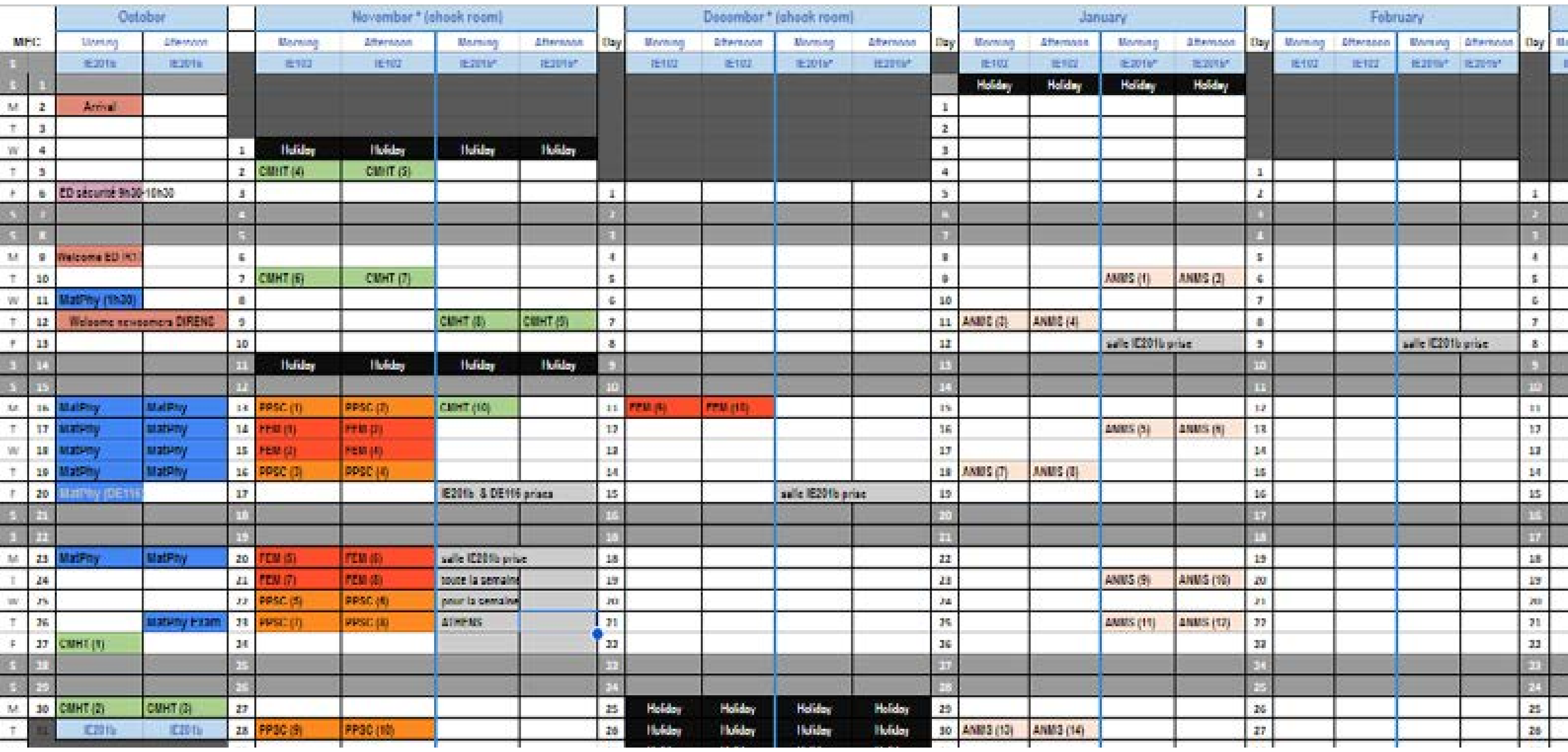
TEACHING TEAM

Tatiana BUDTOVA
Séverine BOYER
Sijtze BUWALDA
Romain CASTELLANI
Christelle COMBEAUD
Edith PEUVREL-DISDIER
Franck PIGEONNEAU
Rudy VALETTE

SCIENTIFIC PROGRAM

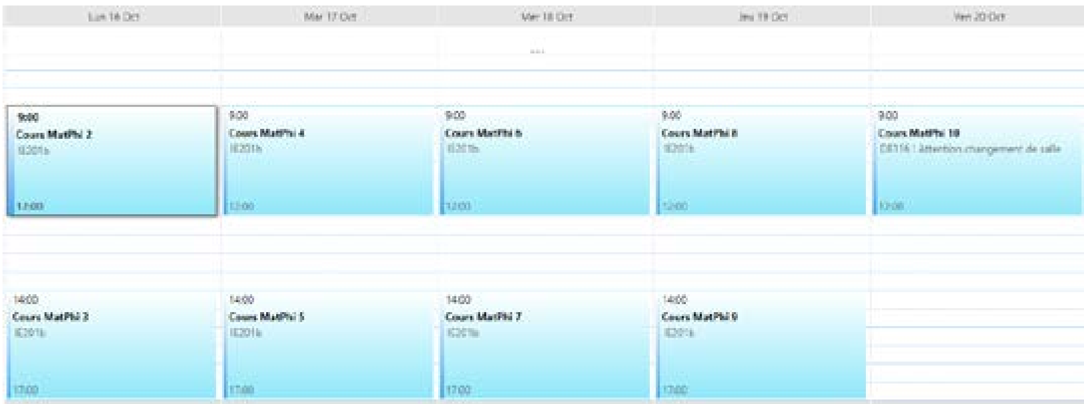
SUMMARY TIMETABLE

ON OUR SHAREPOINT ➲ **click on the image to access the document**



DETAILED TIMETABLE

ON ZIMBRA CALENDAR ➲ **To display on your zimbra calendar**



- Select the calendar tab on zimbra and then click on the little wheel to the right of “Calendriers”
- Click on "Rechercher des partages". In the window, type in "rechercher des partages": florence.morcamp@minesparis.psl.eu
- Click on « rechercher » button and select the **two calendars** one after another: "**Cours scientifiques SFA CEMEF**"and "**Evénements CEMEF**" (all the events such as seminars, general assemblies...). Add them. Updates will be available there
- Repeat the operation to get the Professional courses calendar from "isabelle.liotta@minesparis.psl.eu