### Sorbonne Université

#### The bases of functional analysis (4M005)

<table>
<thead>
<tr>
<th>Course description</th>
<th>The course covers basic functional analysis in its own right together with an orientation towards applications to partial differential equations.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domain</strong></td>
<td>Mathematics</td>
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<tr>
<td><strong>Keywords</strong></td>
<td>Functional analysis</td>
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<tr>
<td><strong>Prerequisites</strong></td>
<td>Linear algebra and topology of the third year of Bachelor’s degree are imperative.</td>
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<tr>
<td><strong>Level</strong></td>
<td>Master 1</td>
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<tr>
<td><strong>Language</strong></td>
<td>English</td>
</tr>
<tr>
<td><strong>Number of credits and workload</strong></td>
<td>12 credits</td>
</tr>
<tr>
<td><strong>Semester period and Start date course</strong></td>
<td>Semester 1</td>
</tr>
<tr>
<td><strong>Application deadline</strong></td>
<td>3-Sep-18</td>
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</table>

**Full course description**

In the first chapter, we show basic results on the topology of metric spaces, including the notions of complete metric spaces and compact metric spaces. The second chapter deals with the study of normed vector spaces, fundamental examples of which are function spaces. A key point here is understanding the effects of working in infinite dimension (which is the case in function spaces) on topology. Ascoli’s theorem, a compactness criterion for parts of continuous function spaces, illustrates the difficulties which appear in infinite dimension frameworks. The third chapter deals with the notion of duality. Duality is the basis of the theory of distributions, a major breakthrough in analysis at the start of the XXth century - this will be studied in chapter 8. Beyond the concept of transposes of linear maps, this chapter explains the procedure which allows one to identify the dual of a Banach space - another Banach space with a weaker notion of convergence, induced by the fact that it is a dual space, that we call “weak-star convergence”.

The fourth chapter is a classic: Hilbert spaces, which extend the notion of Euclidean spaces to infinite dimension.

The fifth chapter studies the spaces of functions which have a finite integral relative to a measure when elevated to a power p. We start by recalling fundamental results of integration theory, without proof. Another important notion, the convolution of functions, is defined, studied, then applied to approximation.

The sixth chapter studies the Dirichlet problem on a bounded domain.

The seventh chapter deals with the Fourier transform on the space of integrable functions on Rd and many applications. This chapter is fundamental and will be crucial in the following two.

The eighth chapter presents the theory of tempered distributions. We choose not to go into the general theory of distributions to keep things simple. The basic idea is that, when we know how to define an operation on very smooth and rapidly decreasing functions on Rd (e.g. functions in the Schwartz space), we can use duality to extend it to a space of tempered distributions, which contain functions (hence “distributions” are also called “generalised functions”) as well as some very singular objects. Of course, this chapter contains examples which must be studied and understood in order to properly comprehend and apply this theory.
## European Virtual Exchange

<table>
<thead>
<tr>
<th>Platform and link to course description</th>
<th>Moodle Sciences</th>
<th><a href="https://moodle-sciences.upmc.fr">https://moodle-sciences.upmc.fr</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>Course description in study guide</td>
<td><a href="https://www.ljll.math.upmc.fr/chemin/cours/4M005.html">https://www.ljll.math.upmc.fr/chemin/cours/4M005.html</a></td>
<td></td>
</tr>
<tr>
<td>Lecturer(s)</td>
<td>Jean-Yves Chemin</td>
<td></td>
</tr>
<tr>
<td>Extra Course information</td>
<td>Information relevant for selection process or for students</td>
<td></td>
</tr>
</tbody>
</table>

### Final examination date and time /period
- **Examination date**: 7-12 January 2019
- **Examination time**: UTC + or -

### Examination registration before
- **Examination registration before**: If applicable, enter examination registration date.
- **NO** Drop-out deadline: If applicable, enter last drop-out date.
  - **NO**

### Type of examination
- **Written**

### Midterm examination?
- ☐ yes ☒ no

### Previous exam papers available
- ☐ yes ☒ no

### Specific rules for examinations
- Give details if particular rules apply like no use of calculator, watches etc

### Resit? and date
- ☒ yes ☐ no
  - Enter resit date: 11-17 June

### Grade release and transcript release
- February
  - Transcript release date if more than 1 week after grade release.
### Available places

<table>
<thead>
<tr>
<th>University</th>
<th>Interested</th>
<th>Note</th>
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<tbody>
<tr>
<td>UC Louvain</td>
<td>☐ yes</td>
<td>Click or tap here to enter number</td>
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<tr>
<td>EPFL</td>
<td>☐ yes</td>
<td>Click or tap here to enter number</td>
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<tr>
<td>UC3M</td>
<td>☐ yes</td>
<td>Click or tap here to enter number</td>
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<tr>
<td>Leiden</td>
<td>☐ yes</td>
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<tr>
<td>Wageningen</td>
<td>☐ yes</td>
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<tr>
<td>TU Delft</td>
<td>☐ yes</td>
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### General information

**Sorbonne Université**

**Date start academic year:** 3-Sep-18

**Semester periods:**
- **1st from 3-Sep-18 to 21-Dec-18**
- **2nd from 21-Jan-19 to 11-May-19**

**Application deadline semester 1:** 3-Sep-18 or enter text

**Application deadline semester 2:** 21-Jan-19 or enter text

**Holiday periods:**
- 27.10.2018 to 04.11.2018
- 22.12.2018 to 06.01.2019
- 20.04.2019 to 05.05.2018

**Student data required for application:**
- First and last name, email address, study level, home university

**General website:** [https://www.sorbonne-universite.fr/](https://www.sorbonne-universite.fr/)

**Virtual Exchange website:** [http://www.telesciences.upmc.fr/fr/european-virtual-exchange.html](http://www.telesciences.upmc.fr/fr/european-virtual-exchange.html)

**Virtual Exchange contact person(s) operational:** Sabine Bottin-Rousseau

**Virtual Exchange Email address:** bottin@insp.jussieu.fr

**List of courses available per semester**

**1st semester:**
- Introduction à la mécanique (BA 1)
- Calculus (BA 1)
- Si on parlait sciences (BA1)
- Thermodynamics (BA3)
- Introduction to Quantum Mechanics (BA3)
- Concurrent Programming (Bachelor 3)
- Bases of functional analysis 1 and 2 (Master 1)
- Programming on mobile platform IOS (Master 2)

**2nd semester:**
- Calcul matriciel (BA 1)
- Systèmes mécaniques et systèmes électroniques (BA 1)