École Normale Supérieure de Paris (ENS–PSL)

Master IMaLiS M1

Year 2024–25

UE Mathematics II : What a biologist might like to know

Program

In charge	**:**	Amaury Lambert
		Institute of Biology of ENS (IBENS)
	&	Center for Interdisciplinary Research in Biology (CIRB) – Collège de France
Contact	**:**	01 44 32 23 62 or `amaury.lambert@ens.psl.eu`
	&	01 44 27 13 91 or `amaury.lambert@college-de-france.fr`
Lecturers	**:**	AL and Philibert Courau (`philibert.courau@college-de-france.fr`)
Timetable	**:**	Each session lasts 3 hours and starts at 9 am
Location	**:**	All lectures take place in Room 324, including computer-based tutorials (CBT)
Prerequisites	**:**	Lectures of L3 "Mathematics I : What a biologist should like to know".

1. **Fri 20 Sep.** Topology.

2. **Fri 27 Sep.** Measure. Inner product.

3. **Fri 4 Oct.** Harmonic analysis (I). Fourier series. Fourier transform. Characteristic function.

4. **Fri 11 Oct (CBT1).** Harmonic analysis (II). Introduction to programming in Python. Fourier calculus. Central Limit Theorem.

5. **Fri 18 Oct.** Dynamical systems (I). Invariant sets, irreducible sets, attractors. Ergodic measure. Ergodic Theorem.

6. **Fri 25 Oct.** Dynamical systems (II). Lyapunov exponent. Canonical examples : Bernoulli shift, logistic map.

   Probability (I). Time-discrete Markov chains. Reminders, stationary distribution, hitting probability. Canonical examples : random walk, Bienaymé–Galton–Watson process, Wright–Fisher model.

7. **Fri 8 Nov (CBT2).** Dynamical systems (III). Chaotic population dynamics, May's logistic model, Lorenz attractor.

8. **Fri 15 Nov.** Probability (II). Time-continuous Markov chains. Definition, Kolmogorov Equations. Transition rate, notion of generator. Canonical examples : time-continuous random walk, linear birth-death process, Moran model. Stationary probability, hitting probability.

9. **Fri 22 Nov.** Probability (III). Brownian motion and stochastic differential equations. Canonical examples : Feller diffusion, Fisher–Wright diffusion.

10. **Fri 6 Dec.** Partial differential equations (I). Conservation law, transport equations, McKendrick–von Foerster Equation.

11. **Fri 10 Jan (CBT3).** Probability (IV). Diffusion processes in neuroscience and in ecology.

12. **Fri 17 Jan.** Partial differential equations (II). Heat equation, reaction-diffusion equations, Fisher-KPP Equation.

13. **Fri 24 Jan (CBT4).** Partial differential equations (III). Simulation of a few PDEs.

14. **Fri 7 Fev.** Working session on project (in presence of P. Courau).

15. **Fri 14 Fev.** Oral presentations.