Mathematical Modeling: Forward and Inverse Problems in Seismology

Michael A. Slawinski

1Department of Earth Sciences, Memorial University of Newfoundland, Canada
email: mslawins@mun.ca

Timetable: 16 hrs. First lecture on June 3, 2019, 16:00, (dates already fixed, see calendar), Torre Archimede, Room 2BC/30.

Course requirements: Students are expect to have a comfortable familiarity with
- Linear algebra
- Tensor algebra and calculus
- Distributions
- Ordinary and partial differential equations
- Differential geometry
- Continuum mechanics
- Numerical issues of nonlinear processes.
However, each subject will be sufficiently reviewed—based on the course needs—to provide the necessary background.

Examination and grading: Brief presentation on a course-pertinent subject, Oral examination/discussion

SSD: MAT/07-08: Mathematical Modeling

Aim:
- To familiarize the students with the mathematical wealth and complexities of problems encountered in quantitative seismology.
- To examine the meaning of mathematical entities and models used as analogies for physical objects and phenomena
- To understand limitations imposed by assumptions and approximations on predictions provided by forward problems
- To recognize, and deal with, unavoidable issues of inverse problems, such as singularities and nonuniqueness

Course contents:
1. Rudiments of continuum mechanics
   - Reference and current configurations
   - Finite and infinitesimal elasticity theory
   - Balance principles
   - Constitutive equations
   - Material symmetry
2. Equations of motion in isotropic homogeneous continua
   - Wave equations
• Solutions of wave equations (including weak solutions)
• Surface, guided and interface waves

3. Equations of motion in anisotropic inhomogeneous continua
• Christoffel equations
• Hamilton equations
• Lagrange equations
• Legendre transformation and its singularities
• Characteristic equations of linear and nonlinear PDEs
• Caustics

4. Variational principles in seismology
• Fermat’s principle
• Hamilton’s principle

5. Foundational issues of modeling
• Prediction versus explanation
• Underdetermination of theory by evidence
• Falsificationism