

## **Doctorate in Civil Engineering and Architecture, University of Parma, XXXVII Cycle**

Short course on

### **Advanced dimensional analysis and self-similarity**

by [S. Longo](#)

Level: PhD course

Duration: 12 h (2 credits)

Scheduled:

Thursday 14 July 2022 (6 h) 9:30-12:30 and 15:30-18:30 (45 min each module)

Friday 15 July 2022 (6 h) 9:30-12:30 and 15:30-18:30 (45 min each module)

Language: English

Exam: oral or written, only for the students attending lessons in presence

Place: Auditorium Centro S. Elisabetta, Parco Area delle Scienze, 181 – 43124 Parma, Italy

We are also streaming the short course via web.



map

Participation is free of charge; registration is required at the following link

<https://forms.gle/CcBfcB9DiRjktMdl6>

Contact: [Sandro Longo](#), [sandro.longo@unipr.it](mailto:sandro.longo@unipr.it), +39 0521 905157

## **Content**

### **1 Dimensional Analysis 2h**

- 1.1 The classification of physical quantities
- 1.2 Systems of units of measurement
- 1.3 The dimension of a physical quantity and the transformation of the units of measurement
- 1.4 The principle of dimensional homogeneity
- 1.5 The structure of the typical equation based on the Dimensional Analysis
- 1.6 The Buckingham method (Theorem of  $\Pi$ )
- 1.7 A corollary of Buckingham's theorem: the Theorem of Sonin

### **2 Handling Dimensionless Groups in Dimensional Analysis 1h**

- 2.1 The Dimensional and Physical Relevance of Variables
- 2.2 Reducing the Number of Dimensionless Groups
- 2.3 Formalisation of Matrix Methods
- 2.4 A Recipe for Dimensionless Groups

### **3 Symmetry and affine transformations 1.5 h**

- 3.1 The structure of the functions of dimensionless groups
- 3.2 The Use of Symmetry to Specify the Expression of the Function
- 3.3 Group Theory and Affine Transformations for Self-similar Solutions

### **4 The Theory of Similarity and Applications to Models 1 h**

- 4.1 Similarities
- 4.2 The Condition of Similarity based on Dimensional
- 4.3 The Condition of Similarity based on Direct Analysis

### **5 Applications of Dimensional Analysis to problems of forces and deformations 2 h**

- 5.1 Classification of structural models
- 5.2 The similarity in structural models
- 5.3 Statically stressed structures
- 5.5 The phenomena of instability
- 5.6 Dynamically stressed structures
- 5.7 Shock forces
- 5.8 Aero-elastic models
- 5.9 Models of explosive loads outside the structure
- 5.10 Dynamic models with earthquake action
- 5.11 Scale effects in structural models

### **6 Applications in Geotechnics 2 h**

- 6.1 The vibrating table
- 6.2 The similarity conditions for a model on a vibrating table
- 6.3 The similarity conditions for centrifugal models
- 6.4 Scale in centrifugal models
- 6.5 Scaling effects and anomalies in centrifuges
- 6.6 Transport models for contaminants in centrifuges
- 6.7 Similarity for dynamical models in centrifuges
- 6.8 Similarities in tectonic processes
- 6.9 Some applications for solving classic problems
- 6.10 Dimensional Analysis of debris flow
- 6.11 Physical process in scouring of Phalesie

### **7 Applications in Fluid Mechanics and Hydraulics 2.5 h**

- 7.1 The dimensionless groups in Fluid Mechanics
- 7.2 Similarity conditions in hydraulic models
- 7.3 The similarity of Reynolds
- 7.4 The similarity of Froude
- 7.5 The similarity of Mach
- 7.6 Similarities in filtration processes
- 7.7 Geometrically distorted hydraulic models
  - 7.7.1 Scaling effects in hydraulic models
  - 7.7.2 Analogue models

### Suggested Books

Longo, S., 2022, *Principles and Applications of Dimensional Analysis and Similarity*. Springer, <https://doi.org/10.1007/978-3-030-79217-6>. Print hardcover ISBN 978-3-030-79216-9, softcover ISBN 978-3-030-79219-0, Online ISBN 978-3-030-79217-6, XXXI+428 pp.

Longo, S., 2011, *Analisi Dimensionale e Modellistica Fisica – Principi e Applicazioni alle Scienze Ingegneristiche* (Dimensional Analysis and Physical Modeling – Principles and Engineering Applications). Springer & Verlag Italia, Collana **UNITEXT** Ingegneria (in italian). ISBN 978-88-470-1871-6, X+370 pp.

Barenblatt, G. I., 1996, *Scaling, self-similarity, and intermediate asymptotics*. Cambridge University Press.

### Venue



*Aerial view of the Campus of the University of Parma*

### How to reach the Campus

#### By bus

Take one of the following buses:

**Line 7** from Railway station, downtown Parma or other stops (check maps and timetable at this [link](#)).

**Line 21** from Railway station downtown Parma or other stops (check maps and timetable at this [link](#)).

#### By taxi

You can take a taxi at the Railway station or at the other designated areas within the city or call the number +39 0521 252562.

#### By car

Follow directions to Langhirano (exit 15 of the Parma ring road, named 'tangenziale'). Follow the exit with direction 'Università', passing about a cinema and a mall. The address is Parco Area delle Scienze, 43124 Parma.

## How to reach Parma

### By plane

From the Giuseppe Verdi airport, only 5 km away from the heart of the city, downtown can be easily reached by taxi, rental cars or by bus n. 6. Unfortunately, only very few flights reach Parma directly. More likely landing airports are Milan Malpensa, Milan Linate, Milan Orio al Serio (located in Bergamo, hub for many low-cost airlines) and Bologna Marconi (advised). All these airports provide shuttle bus or train services to the corresponding central stations in Milan or Bologna.

### By train

Train connections to Parma from Bologna Centrale and Milano Centrale are very frequent and run from the very early morning to around 11 pm. Travel times are between 45 minutes (Trenitalia Frecciabianca trains) and 70 minutes (very cheap regional trains) to/from Bologna and between 55 and 80 minutes to/from Milan. Tickets can be bought at vending machines, ticket booths inside the stations or on-line. Train time-tables can be found at this [link](#) (regional and high-speed connections by Trenitalia) or at this [link](#) (high-speed connections by NTV). High-speed trains reach Parma (few), Bologna Centrale or Reggio Emilia Mediopadana stations. From Reggio Emilia Mediopadana high-speed train station, Parma can be reached by the ItaloBus service (included in the train price if you have traveled by NTV Italo high-speed train). Be aware that no direct train connections exist between Reggio Emilia Mediopadana station and Parma station.

### By car

Parma is located along the motorway A1 Milan-Bologna and along the A15 Parma-La Spezia. Parma has two motorway exits:

1. exit "Parma" from A1;
2. exit "Parma Ovest", from A15, about 10 Km from the city.

Located at the access points of the town there are the exchange car parks, free and open 24 hours a day. You can leave your car there and reach the city center by shuttle buses. Indoor toll parking is available closer to the center of town, as well as outdoor parking along the city streets marked by blue lines: toll parking in the mornings and afternoons using park meters, free around lunchtime and at night. Prices may vary depending on the location.

## Lunch options

Different alternatives are available for lunch inside the Campus: 3 canteens and 2 bars.

Vending machine are located inside the building.

A supermarket with a bar, two restaurants/pubs (Wiener House and Old Wild West) and a Piada Point are located just outside the main Campus entrance.

More information will be provided onsite.