

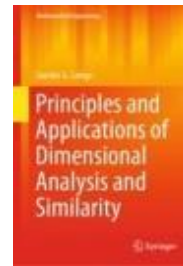
Doctorate in Civil Engineering and Architecture, University of Parma, XXXIX Cycle

Short course on

Advanced dimensional analysis and self-similarity, 2nd edition

by [S. Longo](#)

This is the second edition of a course held in June 2022. The duration of the first edition, 12 hours, proved insufficient to cover the numerous topics. For this reason, the second edition is divided in two parts: the first corresponds to the content of the first edition, the second deals with the application topics that could not be covered in the first edition. Those who have already taken the 2022 course will therefore be able to access the second part directly. The course is mainly based on the monograph 'Principles and Applications of Dimensional Analysis and Similarity', S.G. Longo, 2021.



Book Reviews by SIAM Review
[\[69 KB pdf\]](#)

"I really enjoyed this book. The writing is clear and eloquent, and it was fun to see a wide range of fundamental physical principles derived in a concise manner. The book is substantial with a wide scope, so should be valuable to

many." (D. J. W. Simpson, [SIAM Review, Vol. 65 \(3\), 2023](#))

1st part

Level: PhD course

Duration: 12 h (2 credits)

Scheduled:

Monday 24 June 2024 (3 h)

15:30-18:30 (45 min each module)

Tuesday 25 June 2024 (6 h)

9:30-12:30 and 15:30-18:30 (45 min each module)

Wednesday 26 June 2024 (3 h)

9:30-12:30 (45 min each module)

Link for the application form, 1st part

<https://forms.gle/xB4HfP9s8VpYHKEQ8>

2nd part

Level: PhD course

Duration: 12 h (2 credits)

Scheduled:

Wednesday 26 June 2024 (3 h)

15:30-18:30 (45 min each module)

Thursday 27 June 2024 (6 h)

9:30-12:30 and 15:30-18:30 (45 min each module)

Friday 28 June 2024 (3 h)

9:30-12:30 (45 min each module)

Link for the application form, 2nd part

<https://forms.gle/wWtkXsGkkLuHm7aA9>

Language: English

Exam on request: 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

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

Content 1st part

1 Dimensional Analysis 4h

- 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 Π)
- 1.7 A corollary of Buckingham's theorem: the Theorem of Sonin

2 Handling Dimensionless Groups in Dimensional Analysis 3h

- 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 2 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 3 h

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

Content 2nd part

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 3 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

8 Applications in Wind Tunnel Technology 1 h

- 8.1 Classification of Wind Tunnels
- 8.2 Aeronautical and Automobile Wind Tunnels
- 8.3 Environmental Wind Tunnels
- 8.4 Scale Effects in Wind Tunnels
- 8.5 Models for Multiphase Flows: An Application to Wind Waves

9 Physical Models in River Hydraulics 2 h

- 9.1 Similarity for a Non-prismatic Stationary (and Non-uniform) Stream
 - 9.1.1 Distorted Models of Rivers and Canals in the Gradually Varied Flow Regime
 - 9.1.2 The Scale Ratio of the Friction Coefficient and Roughness
 - 9.1.3 Distorted Models of Rivers and Canals in the Generic Flow Regime
- 9.2 Models in the Unsteady Flow Regime
- 9.3 Inclined Physical Models

10 Physical Models with Sediment Transport 2 h

- 10.1 Conditions of Similarity in Rivers in the Presence of a Movable Bed
- 10.2 Hypothesis of Sediment Transport Independent of the Depth of the Water Stream

- 10.3 The Bottom in the Presence of Dunes, Ripples and Other Bedforms: The Calculation of the Equivalent Roughness
- 10.4 Time Scales in Distorted Movable-Bed Models
- 10.5 Localised Phenomena
- 10.6 The Modelling of Sediment Transport in the Presence Of Waves

Suggested Books

Longo, S., 2021, *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.