International Doctorate in Civil and Environmental Engineering

DOCTORAL COURSE – A.Y. 2020/21

Random dynamics of linear systems and Bayesian update of engineering models

Teachers: Dr. Ing. **Claudio Mannini**, Dr. Ing. **Antonino Maria Marra**

DICEA, Università degli Studi di Firenze

Email: claudio.mannini@unifi.it; antoninomaria.marra@unifi.it

Calendar	
28/01/2021, 10:00-12:00	Dr. Ing. A. M. Marra – Basics of Probability theory with examples for civil engineering
02/02/2021, 10:00-12:00	Dr. Ing. A. M. Marra – Introduction to random variables with examples for civil engineering
04/02/2021, 10:00-12:00	Dr. Ing. A. M. Marra – The total probability theorem and its applications to seismic risk
09/02/2021, 09:00-12:00	Dr. Ing. A. M. Marra – The Bayes theorem and its applications to engineering model updating
11/02/2021, 09:00-12:00	Dr. Ing. C. Mannini – Introduction to random processes and random fields
15/02/2021, 09:00-12:00	Dr. Ing. C. Mannini – Random dynamics of one-degree-of-freedom linear systems
19/02/2021, 09:00-12:00	Dr. Ing. C. Mannini – Multivariate random processes and random dynamics of multi-degree-of-freedom linear systems
24/02/2021, 10:00-12:00	Dr. Ing. C. Mannini – Application examples for civil engineering
Total	20 hours – 10 credits

Program

The course is framed in the modern tendency of treating the response of engineering systems through probabilistic approaches. The lecturers, starting from the experience acquired during their research activity, will present some basic elements that allow the transition from deterministic to probabilistic response calculations of engineering systems. The methods presented during the Course refer not only to applications in the Civil Engineering field but also to several other problems

in the engineering science.

After a review of the theory of probability and random variables, focused on the problems later treated in the course, the total probability theorem is presented with applications to seismic engineering.

The course then moves to the problem of probabilistic treatment of new information coming from experiments on real systems for the updating of the associated numerical models. The Bayesian approach, introduced in the lectures, faces the problem in a rigorous manner allowing the updating of the prior probability distributions of the input parameters. Some illustrative examples are used to make simpler the understanding of the topic.

The concept of random process is introduced, along with those of ensemble and time averages, stationarity, ergodicity and gaussianity. Particular attention is devoted to the characterization of power spectral density.

The central part of the course deals with the response of linear systems subjected to random external inputs/forces. Distinction is made between stationary and non-stationary inputs, and between time- and frequency-domain analyses, focusing on the latter. A system with one degree of freedom is considered first, highlighting the quasi-static and resonant contributions to the dynamic response. Then, the results are extended to the case of a multi-degree-of-freedom linear system subjected to either a mono-variate or a multi-variate and partially correlated input/force. The issue of correlation between the modal response contributions is addressed. Afterwards, the statistical concept of maximum (or minimum) of the random process describing the response of the system is introduced, and the theoretical basics are provided in the special case of gaussian stationary random processes. An example of application is finally illustrated for the case of a tower subjected to turbulent wind load.

Assessment: project/exercise to be done at home by the students.