

## Tárgytematika / Course Description Digital twins

GKNM\_MSTA035

Tárgyfelelős neve /

Teacher's name: dr. Horváth Zoltán

Félév / Semester: 2023/24/1

Beszámolási forma /

Assesment: Vizsga

Tárgy heti óraszám /

Teaching hours(week): 2/4/0

Tárgy féléves óraszám /

Teaching hours(sem.): 0/0/0

### OKTATÁS CÉLJA / AIM OF THE COURSE

The main goal of the course is to introduce, practice and deepen the necessary mathematical tools for the curriculum and provide the students with a detailed overview of all components of the model based digital twins and construct one actual digital twin at the end of the course.

### TANTÁRGY TARTALMA / DESCRIPTION

- 1.hét The concept of digital twins with examples from industry and global challenges.
- 2.hét Vector spaces, norms, scalar product, Hilbert spaces. Function spaces.
- 3.hét Ordinary differential equations, initial and boundary value problems, linearization.
- 4.hét Linear ordinary differential equations, exact and numerical solutions in the state space
- 5.hét Linear input-output systems, control systems.
- 6.hét Laplace transformation, transfer function; approximation with the transfer function.
- 7.hét Model order reduction with the balanced truncation method.
- 8.hét Model order reduction with the proper orthogonal decomposition for linear input-output systems
- 9.hét Parameter dependent problems and their model reduction methods.
- 10.hét Introduction to data assimilation to linear dynamical systems.
- 11.hét The variational data assimilation to linear dynamical systems (4DVAR).
- 12.hét Construction of a model based digital twin: thermal predictive maintenance of a simplified motor (modelling, simulations, systems).
- 13.hét Construction of a model based digital twin: thermal predictive maintenance of a simplified motor (reduction, data assimilation).

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## SZÁMONKÉRÉSI ÉS ÉRTÉKELÉSI RENDSZERE / ASSESSMENT'S METHOD

A kollokvium írásbeli és szóbeli részből áll, súlyuk az értékelésben rendre 60-40%. Az írásbeli rész a félév anyagából való számítógépes problémamegoldás, a szóbeli elsősorban az elméleti ismeretek ellenőrzésére szolgál.

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## KÖTELEZŐ IRODALOM / OBLIGATORY MATERIAL

Kötelező irodalom:

[1] Athanasios C. Antoulas, Approximation of large-scale dynamical systems. Society for Industrial and Applied Mathematics (SIAM)}, Philadelphia, PA. ISBN: 0-89871-529-6/hbk; 978-0-89871-871-3/ebook, pp. 493. 2005.

Ajánlott irodalom:

[2] Peter Benner, Albert Cohen, Mario Ohlberger, and Karen Willcox (Eds.): Model Reduction and Approximation: Theory and Algorithms. Computational Science and Engineering Vol. 15, SIAM Publications, Philadelphia, PA, 2017. ISBN: 978-1-611974-81-2

[3] Varga, Andreas: Solving Fault Diagnosis Problems - Linear Synthesis Techniques. Springer, 2018. ISBN 978-3-319-51559-5

[4] EU-MATHS-IN: Modeling, Simulation and Optimization in a Data-rich Environment.  
<https://www.eu-maths-in.eu/EUMATHSIN/wp-content/uploads/2018/05/MSO-vision.pdf>

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## AJÁNLOTT IRODALOM / RECOMMENDED MATERIAL