Stability of Physical Systems

ECTS: 6 ECTS

COORDINATOR: Jeff Porter (jeff.porter@upm.es)

UNIVERSITY WHERE THE COORDINATOR IS: UPM

HAVE YOU GIVEN PERMISSION TO RECORD YOUR CLASSES? Yes

LECTURER 1: Jeff Porter (jeff.porter@upm.es)

UNIVERSITY WHERE THE LECTURER 1 IS: UPM

HAVE YOU GIVEN PERMISSION TO RECORD YOUR CLASSES? Yes

LECTURER 2: Fernando Varas Mérida (fernando.varas@upm.es)

UNIVERSITY WHERE THE LECTURER 2 IS: UPM

HAVE YOU GIVEN PERMISSION TO RECORD YOUR CLASSES? Yes

SUBJECT CONTENTS

- Definition of dynamical systems.

- Ordinary differential equations: properties, solutions.

- Linear analysis: linearization, fundamental matrices, eigenvalues, Floquet multipliers, stability, adjoint systems, characterization of fixed points, regions of validity.

- Weakly nonlinear analysis: perturbation series, local bifurcations, global bifurcations, codimension.

- Local bifurcations: saddle-node, transcritical, pitchfork, Hopf, period-doubling, etc.

- Center manifold reduction.

- Introduction to the software MatCont and applications.

- Direct and parametric forcing.

- Symmetries: group theory, equivariance, isotropy subgroups, fixed point subspaces.

- Global bifurcations and chaos: Smale horseshoes, strange attractors.

- Mode interactions: resonances, forced systems.

- Distributed systems.

METHODOLOGY: Class presentations of theory combined with examples, exercises using MatCont.

LANGUAGE USED IN CLASS: Spanish, English

IS IT COMPULSORY TO ATTEND CLASS? Students can attend in person (recommended) or using the videoconference system.

BIBLIOGRAPHY

- V. Arnold, Ordinary Differential Equations, MIT Press, 1973.- V. Arnold, Geometrical Methods in the Theory of Ordinary Differential Equations, Springer-Verlag, 1983.

- S.N. Chow y J.K. Hale, Methods of Bifurcation Theory, Springer-Verlag, 1982.

- P. Glendinning, Stability, Instability and Chaos, Cambridge University Press, 1994.

- J. Guckenheimer y P. Holmes, Nonlinear Oscillations, Dynamical Systems and Bifurcation of Vector Fields, Springer-Verlag, 1983.

- W. Hahn, Stability of Motion, Springer-Verlag, 1977.

- J.K. Hale y H. Kocac, Dynamics of Bifurcations, Springer-Verlag, 1991. F. Verhulst, Nonlinear Equations and Dynamical Systems, Springer-Verlag, 1990.

- Y.A. Kuznetsov, Elements of Applied Bifurcation Theory, Springer, 1998.

- S.H. Strogatz, Nonlinear Dynamics and Chaos, Westview Press, 2001.

- S. Wiggins, Introduction to Applied Nonlinear Dynamical Systems and Chaos, Springer-Verlag, 1990.

SKILLS

<u>General</u>:

CG1: To have knowledge that provide a basis or opportunity for originality in developing and / or applying ideas, often within a research context, knowing how to translate industrial needs in terms of R & D in the field of mathematics Industrial.

CG3: To be able to integrate knowledge in order to state opinions using information that even incomplete or limited, include reflecting on social and ethical responsibilities linked to the application of their knowledge.

CG4: To have the ability to communicate the findings to specialist and non-specialist audiences in a clear and unambiguous way.

CG5: To have the appropriate learning skills to enable them to continue studying in a way that will be largely self-directed or autonomous, and also to be able to successfully undertake doctoral studies.

<u>Specific</u>:

CE3: To determine if a model of a process is well made and well mathematically formulated from a physical standpoint.

CE5: To be able to validate and interpret the results, comparing them with visualizations, experimental measurements and functional requirements of the physical engineering system.

<u>Modelling specialization</u>:

CM1: To be able to extract, using different analytical techniques, both qualitative and quantitative models.

WILL YOU BE USING A VIRTUAL PLATFORM? Moodle (UPM)

WILL YOU BE USING ANY SPECIFIC SOFTWARE? MatCont

CRITERIA FOR THE 1ST ASSESSMENT OPPORTUNITY

Homework/projects to be completed in groups and final presentation of this work.

CRITERIA FOR THE 2ND ASSESSMENT OPPORTUNITY

Homework/projects to be completed in groups and final presentation of this work.