Politecnico di Torino
Department of Mechanical and Aerospace Engineering

MARINE OFFSHORE RENEWABLE ENERGY LAB

DIMEAS
Department of Mechanical and Aerospace Engineering

MSC THESIS PROPOSAL | MORENERGY LAB

A pendulum that spins with the waves: modelling, control and design of a flexible N-pendulum prototype

No gearbox, no rectifier: let parametric excitation turn waves into rotation.

Wave energy | Nonlinear dynamics | 6-month MSc thesis

THE CHALLENGE

A pendulum whose pivot moves up and down can be driven, through parametric excitation, into continuous rotation: an attractive way to turn the oscillations of a floating body into the unidirectional rotation of a generator, potentially without gearboxes or motion-rectifying mechanisms. Ocean waves are slow, and a simple pendulum would have to be unrealistically long to be parametrically resonant. The N-pendulum concept decouples the natural frequency of the pendulum from its length, allowing easy tuning of frequency and torque. Its dynamics are strongly nonlinear, with coexisting oscillating, rotating and chaotic regimes: a flexible prototype with tunable parameters and a controllable PTO is the key to explore them experimentally.

WHAT YOU WILL DO

1. Model the N-pendulum under vertical and multi-DOF base excitation, mapping rotating, oscillating and chaotic regimes (bifurcation diagrams, basins of attraction).
2. Study PTO control strategies to initiate and sustain rotation and maximise harvested power, including latching control and active control.
3. Design a flexible small-scale N-pendulum prototype, with adjustable inertias, masses and arm lengths covering a wide range of frequencies and torques.
4. Select and size a PTO (e.g. motor-generator and drive) able to implement latching and active control, up to a detailed CAD design compatible with future tests on the lab Stewart platform.

WORK PLAN

MONTHS 1-2	MONTHS 3-4	MONTHS 5-6
Parametric pendulum dynamics, N-pendulum concept, modelling	PTO control: latching and active control	Flexible prototype and PTO design, writing

REQUIRED SKILLS

Applied mechanics and mechanical vibrations; basics of machine design, electrical machines and automatic control; MATLAB/Simulink or Python. Experience with CAD is a plus.

WHO WE ARE LOOKING FOR

- Mechanical, Mechatronic, Aerospace or Electrical student
- Interested in nonlinear dynamics and control
- Enjoys mechanical design and choosing real components

WHAT YOU WILL GAIN

- Modelling, control and mechanical design skills on a novel concept
- A prototype design meant for future experiments in the lab
- Results with publication potential

TOOLS

MATLAB/Simulink or Python, Simscape, CAD

KEY REFERENCES

- D. Yurchenko, P. Alevras, Int. J. Dyn. Control 1, 290-299 (2013). doi:10.1007/s40435-013-0033-x

Interested? Send a short email with your CV and transcript of records. Informal chats are welcome.

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WHERE YOU WILL WORK

A young and informal working environment: you will be fully integrated within a large lab of MSc students, PhD students and researchers, working side by side in a shared open space.

BEYOND THE THESIS

For motivated students, research opportunities beyond the thesis will be promoted: scientific publications, research grants and PhD positions at the MOREnergy Lab.

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