

## PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 41st cycle

## THEMATIC Research Field: PHYSICS-INFORMED GENERATIVE AI IN TOPOLOGICAL OPTIMIZATION OF MEMS DEVICES

Monthly net income of PhDscholarship (max 36 months)

1500.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The industry of MEMS (Micro Electro-Mechanical Systems) devices is a flourishing field that in the last decades have been fueling the technological progress in many fields, providing essential sensors, actuators and components. Microphones, PMUT, accelerometer and gyroscopes, just to name a few, can be found in applications as different as smartphones, computers, and automotive. The demand of such devices is ever increasing, the required performances always higher, and the desired sizes smaller and smaller.So far, MEMS design have been pushed forward by the experience of the engineers on a trial-and-error basis. The main disadvantages of such an approach are that (i) it's user- dependent and (ii) it is inevitably time expensive. Furthermore, (iii) the design process is typically based on simplified models.In this research work, the aim is to develop an optimization framework to define the 2D shape (topology) of a MEMS device, using a generative AI (GenAI) based topology optimization (TopOpt) approach.
Methods and techniques that will be developed and used to carry out the research	The candidate will start with the study of state-of-the-art TopOpt approaches. This step will serve both as a reference for future work, and to get acquainted with the perks and the limits of current technology, to be surpassed with the GenAI. Forinstance, in standard TopOpt approaches, setting a minimum size for the feature is troublesome, and expensive optimization processes may converge to unfeasible (i.e.,



	processes may converge to unfeasible (i.e., unmanufacturable) designs. With GenAI, instead, such constraints are easily managed. The candidate will then explore the possibility to use generative AI to replace TopOpt algorithms. In particular, the GenAI will be embedded with the physics of the problem, so to produce feasible designs. The physics considered may vary from simple static linear analysis, to nonlinear dynamics and/or multiphysics.Following, components and full systems will be optimized with the developed tools, and will be compared to state-of-the-art devices (e.g. accelerometers) provided by our industrial partner, STMicroelectronics.Finally, based on the outcome of the previous steps, a MEMS prototype will be produced and tested in our laboratory to validate the proposed methods.
Educational objectives	The PhD candidate in this program is expected to develop a solid competence in optimization procedures for dynamical problems, and in particular on GenAI. The candidate is also expected to acquire (at least) the rudiments of nonlinear dynamics, multi-physical modelling, and MEMS technology. Contextually, strong coding skills in Matlab/Python/C++ will be developed.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared Master of Science holders in the same field. Partners: STMicroelectronics, University of California San Diego, Delft Institute of Technology, ETH Zurich.
Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Prof. F. Braghin, Ing. J. Marconi

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Additional support - Financial aid per PhD student per year (gross amount)

## POLITECNICO DI MILANO



Housing - Foreign Students	
Housing - Out-of-town residents	

Scholarship Increase for a period abroad		
Amount monthly	750.0 €	
By number of months	6	

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of € 6.114,50. Our candidates are strongly encouraged to spend a research period abroad, joining high-level research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approx. 750 euro/month - net amount). Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.