PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 34th cycle

Research Area n. 4 - MeccPhD International Track

<table>
<thead>
<tr>
<th>Number of scholarship offered</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department</td>
<td>DIPARTIMENTO DI MECCANICA</td>
</tr>
</tbody>
</table>

Description of the Research Area

In addition to areas 1, 2 and 3, the PhD Programme in Mechanical Engineering comprises a research area devoted to an International Track, designed to foster the development of scientific research topics in collaboration with top-level European Technical Universities. We aim to provide doctoral candidates with highest-level international scientific training in the field of Mechanical Engineering by means of transnational research collaborations and mobility between strategic academic partners. MeccPhD is thus recruiting highly talented and motivated prospective candidates with outstanding qualifications, to carry out a PhD characterized by an international co-supervision, drafted in the framework of a "cotutelle agreement", signed between Politecnico di Milano - Department of Mechanical Engineering - and Idea League Partner Institutions http://idealeague.org/.

The PhD thesis carried on by candidates enrolled within this area will foresee the supervision of two Faculty members, the first one belonging to PoliMi and the second one to one of the following universities: Chalmers University of Technology, Delft University of Technology, ETH Zurich, RWTH Aachen University.

Candidates selected in this area will be enrolled for a 3-year fully funded PhD path at Politecnico di Milano, within the Programme in Mechanical Engineering. S/he will develop her/his doctoral thesis with the simultaneous guidance of two supervisors (PoliMi and Partner University) and by spending alternative research period/s in the Home/Host University (at least 12 months at the Host University). At the end of the Programme, the thesis will be defended at Politecnico di Milano, and the candidate will receive the title of PhD in Mechanical Engineering from PoliMi.

One scholarship is currently available for the 34th cycle call within our MeccPhD International Track; prospective candidates are asked to perform their application referring to one of the thesis topics with international co-supervision listed here below, and described in the following pages. Upon conclusion of the evaluation procedure, the selected candidate will be enrolled within the framework of the chosen agreement:
• A MULTIDISCIPLINARY STUDY ON OSTEOPOROSIS: NEW TOOLS FOR DIAGNOSIS AND PREVENTION (Politecnico di Milano - ETH Zurich: supervisors prof. Laura Vergani, prof. Ralph Müller);
• DEFECT TOLERANCE AND FITNESS-FOR-PURPOSE OF HIGH SPEED WHEELSET COMPONENTS (Politecnico di Milano - Chalmers University of Technology: supervisors prof. Stefano Beretta, prof. Anders Ekberg);
• HUMAN-ROBOT INTERACTION FOR LARGE INDUSTRIAL ROBOTS (Politecnico di Milano - RWTH Aachen: supervisors prof. Francesco Braghin, prof. Robert Schmitt);
• OFF-SHORE WIND ENERGY (Politecnico di Milano - TU Delft: supervisors prof. Marco Belloli, prof. Riaan van 't Veer);
• MULTI-MATERIAL LATTICE STRUCTURES (Politecnico di Milano - TU Delft: supervisors prof. Laura Vergani, prof. Amir Zadpoor);
• NEW TOOLS FOR STRUCTURAL HEALTH MONITORING (Politecnico di Milano - ETH Zurich: supervisors prof. Alfredo Cigada, prof. Luca Benini).
Research Field: A MULTIDISCIPLINARY STUDY ON OSTEOPOROSIS: NEW TOOLS FOR DIAGNOSIS AND PREVENTION

<table>
<thead>
<tr>
<th>Context of the research activity</th>
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**Motivation and objectives of the research in this field**

Osteoporosis is a pathology characterized by low bone mass and micro-architectural deterioration of bone tissue leading to increased risk of fractures. This disease is often silent until the event of a fracture. At present, the main diagnostic tool for osteoporosis in hospitals is the dual photon X-ray absorptiometry (DXA); however, DXA does not explain all the effective disease cases; a diagnostic gap of around 30% exists and research in this field is still ongoing.

**Methods and techniques that will be developed and used to carry out the research**

The main aim of this thesis work consists in obtaining tools, easily applicable in hospitals, for the diagnosis of osteoporosis and of the effective fracture risk. In order to deeply understand the mechanisms that really determine the healthy and osteoporotic behavior of bones, the work will correlate clinical with morphological and mechanical measures on ex-vivo porcine bones, to find the factors accounting for and increasing the effective risk of osteoporosis-associated fractures.

**Educational objectives**

This PhD Thesis will be conducted under the framework of a *cotutelle* agreement between Politecnico di Milano and ETH Zurich, and with the co-supervision of prof. Laura Vergani (PoliMi) and prof. Ralph Muller (ETH Zurich).
Job opportunities

List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:

- Politecnico di Milano
- ETH Zurich

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.

Composition of the research group

- 2 Full Professors
- 1 Associated Professors
- 2 Assistant Professors
- 1 PhD Students

Name of the research directors

Prof. Laura Vergani, prof. Ralph Muller

Contacts

- laura.vergani@polimi.it
- ram@ethz.ch
- phd-dmec@polimi.it

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

| Housing - Foreign Students | -- |
| Housing - Out-of-town residents (more than 80Km out of Milano) | -- |

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):

- 2nd year: 1.534 euro
- 3rd year: 1.534 euro

**Accommodation** in Politecnico’s Residences (http://www.residenze.polimi.it) is available for PhD Candidates; special rates (250 euro/month) will be applied to selected out-of-town candidates (detailed info in the call for application).
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 550 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.

**Computer availability:**
1st year: individual use
2nd year: individual use
3rd year: individual use

**Desk availability:**
1st year: individual use
2nd year: individual use
3rd year: individual use
**PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 34th cycle**

Research Area n. 4 - MeccPhD International Track

**Research Field: DEFECT TOLERANCE AND FITNESS-FOR-PURPOSE OF HIGH SPEED WHEELSET COMPONENTS**

### Monthly net income of PhD scholarship (max 36 months)

€ 1325.0

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

<table>
<thead>
<tr>
<th>Context of the research activity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motivation and objectives of the research in this field</strong></td>
</tr>
<tr>
<td>Wheelset are primary safety components designed for an infinite life and real their service life can last 30 years. The current design rules, incorporated in standards, are based onto fatigue properties of pristine materials, without considering nor the in-service degradation (corrosion, impacts) nor the manufacturing defects. It is very important to develop dedicated fitness-for-purpose criteria for wheelset components, considering the challenging requirements of high-speed trains and the new opportunities for qualification of materials and components (e.g. tomography), also considering possible applications of composite materials.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Methods and techniques that will be developed and used to carry out the research</th>
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<tbody>
<tr>
<td>The research activity will be concentrated on wheelset components subjected to cyclic contacts stresses (wheels, press-fits) , where the propagation of defects and inhomogeneities is driven by multiaxial stress conditions. A thorough analysis of the local stress/strain cycles by FE analyses, will then be combined with special experiments for analysing the growth rate of small defects. The ability to analyze results from CT-scans/NDE will allow the candidate to obtain relationships between the material quality (expressed in terms of a proper statistical description of inhomogeneities) and the service conditions of wheelset components.</td>
</tr>
</tbody>
</table>
### Educational objectives

The educational objective is to train a researcher in the area of development of design and structural integrity for modern components - in particular wheelsets - subjected to complex loads and very high requirements on reliability. The PhD student will learn how to derive fitness-for-purpose requirements for wheelset components from a thorough analysis of service state of stress and know-how about NDE / integrity assessment techniques.

This ambition is backed by the solid international experience of the research directors in the areas of Structural Integrity and Design of Railway Components at the two Institutions (PoliMI and Chalmers): the successful candidate will spend 12 months at Charmec and his activity will be co-supervised.

### Job opportunities

The topic of the PhD scholarship is very relevant for railway companies, manufacturers of wheelsets and railway components, companies working in the railway maintenance.

List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:

- ESIS TC24
- Lucchini RS

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### Composition of the research group

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<td>Full Professors</td>
<td>2</td>
</tr>
<tr>
<td>Associated Professors</td>
<td>5</td>
</tr>
<tr>
<td>Assistant Professors</td>
<td>3</td>
</tr>
<tr>
<td>PhD Students</td>
<td>9</td>
</tr>
</tbody>
</table>

### Name of the research directors

Prof. Stefano Beretta, prof. Anders Ekberg

### Contacts

Prof. Stefano Beretta - PoliMI  
Prof. Anders Ekberg - Chalmers
stefano.beretta@polimi.it
anders.ekberg@chalmers.se
phd-dmec@polimi.it

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<thead>
<tr>
<th>Additional support - Financial aid per PhD student per year (gross amount)</th>
</tr>
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<tr>
<td>Housing - Foreign Students</td>
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**Computer availability:**  
1st year: individual use  
2nd year: individual use  
3rd year: individual use

**Desk availability:**  
1st year: individual use  
2nd year: individual use
3rd year: individual use
PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 34th cycle

Research Area n. 4 - MeccPhD International Track

Research Field: HUMAN-ROBOT INTERACTION FOR LARGE INDUSTRIAL ROBOTS

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<th>Monthly net income of PhD scholarship (max 36 months)</th>
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<tbody>
<tr>
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In case of a change of the welfare rates during the three-year period, the amount could be modified.

**Context of the research activity**

Human-robot interaction (HRI) tries to "humanize" the interaction between human operators and robots thus leading to safer and simpler ways of interacting. This is obtained through a multidisciplinary approach that couples knowledge from different research fields ranging from robotics to sensor fusion, from advanced control logics to artificial intelligence. Tasks are even more complicated if robots are industrial robots, i.e. have been designed not taking into account the possible interaction with human operators. The research that will be carried out within this PhD aims at defining the best sensor set-up (either directly placed on the robot and/or such that the working environment is fully monitored), the most effective sensor fusion approach to clearly identify the dynamic working environment and the optimal control logic to effectively have the robot interact with human operators. This optimal control logic will have to account for the dynamics of both the robot and the operator. Thus, model predictive features as well as machine learning capabilities will have to be embedded.

**Motivation and objectives of the research in this field**

State of the art sensor fusion algorithms as well as advanced control logics will be the starting point of this PhD thesis. These tools will then be integrated in order to achieve the above stated results. Of course, the overall HRI control will be developed in different layers in order to...
account for the different priorities of the tasks the robot will have to carry out as well as to maximize the safety of the interaction.

**Educational objectives**
Being the research project highly multi-disciplinary, the candidate will have the opportunity to work in laboratories and research groups both at POLIMI and RWTH. In addition, the candidate will acquire specialized knowledge on robot technology, advanced sensors and sensor fusion as well as active control.

**Job opportunities**
Direct employment in research centers and industries in Europe and all-over the world. Job opportunities in other fields, where experts in sensor fusion and/or human-machine interaction and/or advanced control strategies based on MPC are required.

List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:
1. POLITECNICO DI MILANO
2. RWTH
3. CNR-ITIA
4. KAIST
5. GEORGIA TECH

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.

**Composition of the research group**
- 2 Full Professors
- 2 Associated Professors
- 1 Assistant Professors
- 2 PhD Students

**Name of the research directors**
Prof. Francesco Braghin, prof. Robert Schmitt

**Contacts**
Francesco Braghin (POLIMI)
http://www.mecc.polimi.it/en/research/faculty/faculty/prof-francesco-braghin/

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

<table>
<thead>
<tr>
<th>Housing - Foreign Students</th>
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<tbody>
<tr>
<td>Housing - Out-of-town residents (more than 80Km out of Milano)</td>
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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):

2nd year: 1.534 euro
3rd year: 1.534 euro

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Computer availability:
1st year: individual use
2nd year: individual use
3rd year: individual use

Desk availability:
1st year: individual use
2nd year: individual use
3rd year: individual use
**Motivation and objectives of the research in this field**

Recent progress in additive manufacturing allows for printing customized products with multiple materials and complex geometries. Effectively designing such complex products for optimal performance within the confines of additive manufacturing constraints is challenging, due to the large number of variables in the search space and uncertainties about how the manufacturing processes affect fabricated materials and structures. The aim of this research project is to find a computational optimization process in configuring multi-material lattice structures. The characteristics of materials, i.e. Young's modulus (E), ultimate tensile strength (UTS) and density (\(\rho\)), will be changed and the structures will be manufactured by a multi-material 3D-printer.

**Methods and techniques that will be developed and used to carry out the research**

The work will focus on multi-material lattice structures, which are characterized by improved strength-to-weight ratio compared with stochastic foams alone. The study will be performed by combining experiments, on 3D printed specimens, and numerical simulations.

**Educational objectives**

This PhD Thesis will be conducted under the framework of a *cotutelle* agreement between Politecnico di Milano and TU Delft, and with the co-supervision of prof. Laura Vergani (PoliMi) and prof. Amir Zadpoor (TU Delft).
### Job opportunities

List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:

- Politecnico di Milano
- TU Delft

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.

### Composition of the research group

<table>
<thead>
<tr>
<th>Role</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Full Professors</td>
<td></td>
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<tr>
<td>2 Associated Professors</td>
<td></td>
</tr>
<tr>
<td>2 Assistant Professors</td>
<td></td>
</tr>
<tr>
<td>3 PhD Students</td>
<td></td>
</tr>
</tbody>
</table>

### Name of the research directors

Prof. Laura Vergani, prof. Amir Zadpoor

### Contacts

- Laura.vergani@polimi.it
- A.A.Zadpoor@tudelft.nl
- phd-dmec@polimi.it

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

| Housing - Foreign Students | -- |
| Housing - Out-of-town residents (more than 80Km out of Milano) | -- |

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

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An increase in the scholarship will be applied for periods up to 6 months (approx 550 euro/month - net amount).

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Computer availability:
- 1st year: individual use
- 2nd year: individual use
- 3rd year: individual use

Desk availability:
- 1st year: individual use
- 2nd year: individual use
- 3rd year: individual use
Monthly net income of PhD scholarship (max 36 months)

€ 1325.0

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 recent spread of cloud-based monitoring systems for civil structures has created a sort of data traffic jam. To make monitoring sustainable, there is the need to develop tools for the so-called "edge computing" bringing back some basic operation at the sensor or at the gateway level.

**Methods and techniques that will be developed and used to carry out the research**

Both software and hardware tools will be developed to get the goal of a prompt warning for decision making. The two research groups will join different skills in dynamic measurements and computer sciences to design new and more effective monitoring tools. Concerning the hardware design the group is expected to work in close co-operation with one of the world's leading semiconductor companies offering the hardware bricks needed for the research project.

**Educational objectives**

The foreseen activity can be directed towards different areas, ranging from Structural Health Monitoring to Data Analytics, to Machine Learning, or again to Electronic Design and Computer Sciences. Cross skills in these disciplines are strongly fostered and this is one of the reasons why SHM is hardly accepted today. The need to be fast in providing a solution to the mentioned problems pushes towards a light co-tutorship between the two institutions.
Great attention is being paid at the moment to what we can do to manage big amounts of data: it is a growing market which offers a lot of new positions. A candidate can be of great interest for both some of the big partners at present cooperating with the research group members (STMicroelectronics, IBM, ENEL) or small companies providing services of data management.

List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:

1. Politecnico di Milano
2. ETH Zurich
3. Università degli Studi di Bologna
4. Politecnico di Torino
5. Università degli Studi di Tor Vergata
6. Università degli Studi di Bergamo
7. ST Microelectronics
8. IBM

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<tr>
<th>Composition of the research group</th>
<th>2 Full Professors</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1 Associated Professors</td>
</tr>
<tr>
<td></td>
<td>2 Assistant Professors</td>
</tr>
<tr>
<td></td>
<td>4 PhD Students</td>
</tr>
</tbody>
</table>

Name of the research directors

Prof. Alfredo Cigada, prof. Luca Benini

Contacts

Alfredo Cigada: alfredo.cigada@polimi.it
Ph +39 02 2399 8487
http://www.mecc.polimi.it/index.php?id=194&L=1

Luca Benini: lbenini@iis.ee.ethz.ch
Ph +41 44 632 66 64
https://www.ee.ethz.ch/the-department/people-a-z/person-detail.html?persid=194234
**Additional support - Financial aid per PhD student per year (gross amount)**

<table>
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**Computer availability:**
- 1st year: individual use
- 2nd year: individual use
- 3rd year: individual use

**Desk availability:**
- 1st year: individual use
- 2nd year: individual use
- 3rd year: individual use
**PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 34th cycle**

Research Area n. 4 - MeccPhD International Track

Research Field: OFF-SHORE WIND ENERGY

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<th>Monthly net income of PhDscholarship (max 36 months)</th>
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In case of a change of the welfare rates during the three-year period, the amount could be modified.

**Context of the research activity**

Within last years, the wind energy world has focussed on offshore wind turbines, installed on fixed-bottom foundations, at water depths up to 30 m. However, the cost of energy generated by such installations is not competitive if compared to fossil fuels. A possible solution is Floating Offshore Wind Energy, that increases the range of production sites, making possible to deploy wind turbines in coastal areas with a higher wind quality. Placing a multi-megawatt wind turbine on a floating substructure also introduces new challenges from a design point of view. Additional structural loads rise from the combination of wind and waves and interactions between the platform modes and the turbine controller can destabilize the entire system, making operations unsafe. It is fundamental to develop control strategies, designed together with the structure components, capable of capturing the dynamics of Floating Offshore Wind Turbines, regulating the produced power and reducing fatigue loads, enhancing, as consequence, the machine life and reducing the LCOE. To design FOWTs controllers it is needed to have reduced-order models, that include mooring lines, simplified hydrodynamics to determine the interaction with the sea waves.

**Motivation and objectives of the research in this field**

Methods and techniques that will be developed and used to carry out the research

Research objectives will be pursued combining numerical modelling and experimental tests. Reduced analytical
| Educational objectives | We provide doctoral candidates with high-level scientific training, fostering and refining research and problem solving abilities by focusing on both theoretical and experimental skills. A PhD in Mechanical Engineering will be able to layout, draft and carry on original research, by leading a research group or working in a team. This PhD thesis will be developed within the framework of a co-supervision agreement between Politecnico di Milano - Department of Mechanical Engineering, and the Technical University of Delft - Faculty of Mechanical, Maritime and Materials Engineering (3mE). The research activity will be supervised by prof. Marco Belloli and prof. Riaan van ’t Veer. |
| Job opportunities | Wind Energy industries  
Floating wind energy industries  
Energy Companies  

List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:  

- Politecnico di Milano  
- TU Delft  
- NTNU  
- University of Stuttgart  
- DTU  
- DNV GL  
- RINA  

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a **100% employment rate** within the first year and a **35% higher salary**, compared Master of Science holders in the same field.

| Composition of the research group | 12 Full Professors  
| 9 Associated Professors  
| 10 Assistant Professors  
| 20 PhD Students |

| Name of the research directors | Prof. Marco Belloli, Prof. Riaan van ‘t Veer |

| Contacts | marco.belloli@polimi.it  
| phd-dmec@polimi.it |

| Additional support - Financial aid per PhD student per year (gross amount) |  
| Housing - Foreign Students | --  
| Housing - Out-of-town residents (more than 80Km out of Milano) | -- |

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