POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

PNRR 630 Research Field: ELECTRIC MOTORS DESIGN FOR NVH

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	Recent progress in the area of electric machines for automotive applications, including new materials, new manufacturing technologies, new power electronics and new conceptual topologies, require a systematic design approach to ensure adequate performance and/or reduced cost for new products. A multidisciplinary approach is needed. The design conflict between electromagnetic, thermal, mechanical, and even manufacturing requirements has to be managed. With reference to DM 352 (9-4-2022), the PhD researcher objectives will address Missions #1 and #2 of the National Plan for Restart and Resileince - PNRR (Piano Nazionale Ripresa e Resilienza)Mission #1 of PNRR focuses on digital transition, competitivity of productive chains. The PhD researcher will aim at developing digital twins to evaluate the performance of electric motors for high-performance road vehicles. Mission #2 of PNRR focuses on Renewable Energy, Hydrogen, Grid and Sustainable Mobility. The PhD researcher will aim at developing electric motors with main focus on efficiency and comfort (NVH).
Methods and techniques that will be developed and used to carry out the research	The study will put special focus on the NVH behaviour of the electric motor. Numerical approaches like finite element method and finite difference method will be applied to evaluate the behaviour of electric motors in various conditions. Some recent AI techniques, like deep learning approaches, will be employed in optimisation as global approximation tools. Experimental tests will be

	performed for models validation.
Educational objectives	The Ph.D. candidate will be trained on advanced methods for the design and testing of automotive electric motors.The candidate will learn how to deal with complex design problems, how to define specific KPIs and to properly evaluate them after testing. Hard skills: •computational mechanics •experimental mechanics Soft skills: •team leadership, problem solving, dissemination, communication and outreach activities, networking, research fund procurement and management. He/she will learn to manage research as well as to coordinate small research groups. Soft skills like dissemination, communication and outreach management will be taught during the PhD course.
Job opportunities	Car manufacturers, Tier 1 suppliers, structures/organizations aimed at innovation and/or research and technical development, high-tech SMEs.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. Employment statistics of PhDs can be found at: https://cm.careerservice.polimi.it/en/employment-statistics/. List of Universities, Companies, Agencies and/or Nationalor International Institutions that are cooperating in the research include: Cranfield University; University of Michigan.
Composition of the research group	2 Full Professors 2 Associated Professors 2 Assistant Professors

	10 PhD Students
Name of the research directors	Proff. Massimiliano Gobbi, Giampiero Mastinu

Contacts
Phone: 02 2339 8214 Email: massimiliano.gobbi@polimi.it For questions regarding scholarship/support please contact 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)	--

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

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	Ferrari S.p.A.
By number of months at the company	9
Institution or company where the candidate will spend the period abroad (name and brief description)	Siemens LMS R&D, Leuven
By number of months abroad	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, fundingfor participation in courses, summer schools, workshops and conferences) for a total amount of euro 6.114, 50. Teaching assistantship: availability of funding in recognition of supporting teaching activitiesby the PhD candidate. There are various forms of financial aid for activities of support to theteaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

PNRR 630 Research Field: MEASUREMENT OF FORCES AND MOMENTS AT THE HUB OF A CAR

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	Missions of PNRR and related impact of the research •Digitalizzazione, innovazione, competitività, cultura e turismo - Measurement of forces at wheel hubs allows the creation of a digital twin of the car •Rivoluzione verde e transizione ecologica - The knowledge of forces allows lightweight construction that involves reduction of rolling resistance •Infrastrutture per una mobilità sostenibile - Measuring forces allows to estimate the tyre-road frinction coefficient and such data can be broadcasted to enhanve traffic safety •Istruzione e ricerca - Educating a ESR allows to enhance the research capabilities of bith industry and academia •Salute - A safer traffic is in favour of public health
Methods and techniques that will be developed and used to carry out the research	A PNRR project, Vesuas, based on a patent of Politecnico di Milano, will be exploited to implement measuring hub into a car. Data will be acquired and processed for structural design purposes and other aims listed above.
Educational objectives	Both hard skills and soft skills will be obtained by the ESRHard skills: structural computing, fatigue, smart manufacturing, sensorization, data acquisition and processing, vehicle dynamics, virtual reality simulations,

	human-machine interface. Soft skills: research management, networking, dissemination, communication, outreach
Job opportunities	Employment by OEMs or Automotive Suppliers (1.5million positions in EU only). Employment statistics of PhDs can be found at: https://cm.careerservice.polimi.it/en/employment-statistics/ List of Universities, Companies, Agencies and/or Nationalor International Institutions that are cooperating in the research include: TU Wien, Univeristy of Tokyo, Virginia Tech, Unversity of Michighan, Kanagawa Institute of Technology, Audi research centre
Composition of the research group	2 Full Professors 2 Associated Professors 2 Assistant Professors 11 PhD Students
Name of the research directors	Proff. Giampiero MASTINU, Massimiliano GOBBI

Contacts
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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)	--

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

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	Lamborghini S.p.A.
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	to be defined
By number of months abroad	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 euro 6.114, 50. 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.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

INTERDISCIPLINARY Research Field: CONDITION-BASED MAINTENANCE AND MACHINE LEARNING IN WHEEL-RAIL DAMAGE

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	Interdisciplinary PhD Grant The PhD research will be carried out in collaboration with research groups of the PhD programme in "**INFORMATION TECHNOLOGY**". See https://www.dottorato.polimi.it/?id=422&L=1 for further information.
Methods and techniques that will be developed and used to carry out the research	The methods and techniques for this ambitious objective will be: 1) development of models for the two competing phenomena of RCf and wear with a series of dedicated experiments; 2) integration of degradation models with data about the train service to predict the development of a given detected damage 3) image analysis applied to sets of images taken by the maintenance personnel with techniques of machine learning to obtain a 'damage classification'
Educational objectives	The educational objective is to develop a new area of interaction of different disciplines that could provide the PhD student new skills to be applied to the solution of a complex problem. The objectives also require flexibility and ability to combine different techniques ranging from detailed damage calculations to data analysis. The courses that will be offered are intended to provide the students the tools for this research activity. The activity will have the support of the new master course of Mobility Engineering as well as the support by LucchiniRS to deal

	with real measurements and experimental data.
Job opportunities	Job opportunities are very wide for this topic and they could be: 1) transportation authorities and railway companies; 2) wheelset producers; 3) national railway agencies.
Composition of the research group	2 Full Professors 2 Associated Professors 3 Assistant Professors 4 PhD Students
Name of the research directors	Proff. S.Beretta, S.Foletti(DMEC),P.L. Lanzi(DEIB)

Contacts
For questions about scholarship/support please contact 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)	--

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 euro 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 theteaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

PARTENARIATO PNRR Research Field: RECYCLED PATCHED COMPOSITE LAMINATES FOR LOAD-BEARING COMPONENTS AND THE AUTOMOTIVE SECTOR

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 research here proposed falls within a PRIN project (PRIN 2022 PNRR - SELF-RE-PREG - Prot. P2022SLZY4 - CUP D53D23018700001) aiming to develop self-sensing recycled composite materials for load-earing applications.The objective of the activities is to study, define and validate a new generation of recycled composite material made from patches cut out from prepreg scrap.Nowadays up to 35% of the purchased prepreg is tossed out as cut outs and end-of-rolls: this project aims to develop a strategy to make use of such scraps to develop a new material to be used for lamination of new components. This mew material shall possess properties that make it favorable in comparison of traditional SMC, and for such reason its configuration and architecture shall be optimized. Alongside with the definition of the new material, a numerical study shall also follow in order to define a model to be used for designing new components.On the basis of a preliminary work already carried out at Politecnico di Milano, the researcher will have to: •Propose a few configurations of patched laminates; •Build up an appropriate test campaign to evaluate the mechanical response of each configuration; •Collect and process data from experiments; •Define and run a numerical model for the said material;

	•Identify the combination of parameter that would maximize the performance of the material. The researcher is expected to learn and work with numerical, analytical ad experimental approaches to make a comprehensive study of the new material.The researcher will also be encouraged to spend 6 month abroad in university where he/she could deepen and expand the understanding of the specific problem but also of the composite materials in general.
Methods and techniques that will be developed and used to carry out the research	The design and optimization of the new material involves several competences and skills. The developed methodology will be based on the combination and integration of the following elements: •Theory of laminates •Analysis of failure modes •Composite material behaviour •Stress analysis and Finite Element simulation •Optimisation Validation and testing.
Educational objectives	The challenges that the candidate will have to face are both theoretical and experimental: •Perform a systematic analysis of the concept of patched laminates, understanding their properties and application potentials •Understand how discontinuous composite laminates work •Define suitable models to simulate the behaviour of the material •Apply analytical and numerical stress analysis models to support the structural design of the material and of components made with it •Define and apply validation methods and tests •Apply optimisation techniques.
Job opportunities	Being the research carried out in the field of composite material, the job opportunities the candidate will have to choose from once completed the PhD will be in the widest range of sector: from automotive to aerospace, form

	sports equipment to high-end components, in a broad type of industries, both at national and international level. Collaborations are expected with both industries and other universities (e.g. University of Bologna). Our last survey on MeccPhD Doctorates highlighteda 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	0 Full Professors 2 Associated Professors 0 Assistant Professors 0 PhD Students
Name of the research directors	Prof. Roberto Palazzetti

Contacts
Email: roberto.palazzetti@polimi.it For questions about scholarship/support: 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)	--

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 euro 6.114,50. Our candidates are strongly encouraged to spend a research period abroad, joining high-level esearch 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 theteaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: BIO-INSPIRED WASTE-DERIVED META-ARCHITECTURES FOR DIGITAL SUSTAINABLE BUILDINGS

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	Buildings account for over 30% of global energy use and 19% of greenhouse gas emissions. They significantly impact the environment, consuming vast natural resources and contributing to global warming. Due to their environmental impact, there is an increasing focus on evaluating and reducing these effects. This has led to the concept of Net-Zero Energy Buildings (NZEBs), which generate as much energy as they consume annually. Advancements in digital technologies and fabrication are crucial for reducing embodied CO2 and improving building sustainability. Innovative design solutions, such as topological optimization To achieve NZEBs, there is a need to bridge the gap between digital technologies and sustainable materials. Current computational models struggle to accurately represent complex natural materials. A validated multi-scale digital model could demonstrate the functionality of bio-waste derived meta-structures, reducing the need for costly experimental campaigns. The "digital based bio-waste derived meta-PANels Towards A REvolutionary building Identity" (**PANTAREI**) project aims to design and assess novel bio-waste-derived meta-structures to reduce embodied CO2 in buildings. PANTAREI will develop adaptive computational tools for bio-inspired material design based on physics of failure and non-equilibrium thermodynamics. This project promotes digital design and fabrication, enabling the generation of climate-neutral, sustainable, and inspiring

	buildings. PANTAREI **aims** to achieve NZEBs by synergizing adaptive multi-scale models, bio- derived materials, and a human-centered framework. This approach allows for adaptive digital design and scaling of bio-waste derived meta-structures to reduce embodied CO2 in construction. The methodology will be validated through a case study designing thermal-efficient panels inspired by bone architecture, using 3D-printed recycled transparent wood, thermoplastic polyurethane, wheat stem fibers, and eggshell powder. These panels offer benefits like UV-blocking, thermal insulation, and aesthetic appeal.
Methods and techniques that will be developed and used to carry out the research	This research requires a multi-faceted range of methods and techniques to investigate a novel triad of digital design, digital fabrication and bio-derived materials and to translate this understanding to the design of sustainable meta-structures, including: 1. Adaptive multi-scale meta-material modeling, to generate a novel database of bio-derived material properties and mechanical/thermal responses and to predict their behaviour to external stimuli; 2. Bio-inspired design, to seek inspiration from natural efficient multi-scale architectural organization; 3. 3D printing of novel bio-waste derived materials complex structure realization; 4. Multi-scale mechanical testing to study material mechanical properties, including its strength, toughness, and elasticity; 5. Computational modeling, to simulate damage evolution, weakening and toughening phenomena at the multi-scale, including extended finite element (XFEM) strategies to model fracture progression; 6. Imaging techniques: micro-computed tomography, synchrotron analyses, scanning electron microscopy are especially useful for identifying microstructural features that may contribute to a material resilience; 7. Image analysis, adopting effective artificial intelligence-based tools for the post-processing of large size

	datasets, such as high-resolution imaging.
Educational objectives	This cutting-edge research perspective on tailored green solutions for net-zero energy buildings is a unique opportunity for PhD students to: 1. Elucidate the complexity of the multi-scale structure and characteristics of bio-waste derived materials, as well as the fundamental principles governing their response to damage towards sustainable engineered solutions. 2. Employ a diverse array of methodologies and approaches, encompassing advanced imaging techniques, mechanical testing, and computational modeling, to investigate and analyze these meta-materials. 3. Cultivate critical thinking and problem-solving abilities while nurturing innovation and creativity by providing guidance to doctoral students in the creation of novel sustainable structures that exhibit improved mechanical and thermal properties. Establish interdisciplinary collaboration among students and faculty from various disciplines, including biomechanics, physics, computer science, mechanical engineering, and material engineering, to foster cross-pollination of ideas and expertise.
Job opportunities	Our last survey on MeccPhD Doctorates highlighteda 100% employment rate within the first year and a 35% higher salary, compared to Master of Science holders in the same field. This project has received funding from The European Innovation Council (EIC) within the framework of EIC Pathfinder Challenge: AEC digitalisation for a new triad of design, fabrication, and materials, Grant agreement ID: 101161602. List of Universities, Companies, Agencies and/or Nationalor International Institutions that are cooperating in the research include: 1. TU, Delft - bio-inspired meta-materials; 2. University of Luxembourg - artificial

	intelligence strategies for human-centered design; 3. University of Derby - adaptive multi-scale modelling; 4. 10XL - company working in the field of advanced bio-printing; 5. Fantoni - company working on sustainable strategies for panels.
Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 7 PhD Students
Name of the research directors	Prof. Laura Maria Vergani

Contacts
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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)	--

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, fundingfor 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.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: ADVANCED BATTERY MANAGEMENT SYSTEMS AND STRUCTURAL BATTERIES FOR NEXT-GENERATION ENERGY SOLUTIONS

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 efficient management and innovative application of battery systems are crucial for the advancement of sustainable energy technologies. Battery management systems (BMS) and structural batteries are pivotal in optimizing energy storage and usage in various engineering systems, including automotive, aerospace, and renewable energy sectors. The primary goals in this field involve ensuring battery safety, enhancing performance, extending lifespan, and reducing costs and environmental impact. The frameworks for assessing the health of battery systems include the following steps: •Degradation Diagnosis: Identifying, quantifying, and locating degradation within battery cells and systems. •Degradation Prognosis: Predicting the remaining useful life (RUL) of batteries after diagnosing degradation. Health and Usage Monitoring Systems (HUMS) are integral to improving the performance and reliability of battery management systems. These systems enable real-time condition-based and predictive maintenance strategies by utilizing permanently installed diagnostic units for real-time monitoring of battery health. The advent of advanced sensors and data fusion techniques has further enhanced the accuracy of degradation diagnosis and prognosis in battery systems.

	However, the complex data processing required demands robust machine learning (ML) solutions to manage and interpret vast amounts of diagnostic data effectively. Researchers are now focusing on integrating high-fidelity models with advanced ML algorithms to accurately describe the complex dynamics associated with battery degradation and to detect even the smallest deviations from normal operational conditions.
Methods and techniques that will be developed and used to carry out the research	To conduct this research, the Ph.D. candidate will develop high-fidelity and digital twin (DT) models of battery systems. These models will enable numerical analysis of real system behaviors through validated simulations that account for various environmental and operational conditions. Digital twins, serving as virtual counterparts of real battery systems, will typically be multi-physics and include high-fidelity models of subsystems. They will facilitate the acquisition of diagnostic signals through virtual sensor networks, replicating real system behaviors under external stimuli and environmental conditions. The candidate will analyze these signals alongside experimental observations to identify and extract damage-related features. These features will inform diagnostic and prognostic algorithms and aid in developing advanced BMS frameworks. The candidate will train ML algorithms using experimental data, numerical data, or a combination of both, collected under various conditions, including signals representing both healthy and damaged states of the battery systems. The research will establish ML-based frameworks for battery degradation diagnosis and prognosis, incorporating state-of-the-art solutions such as: •Deep Learning •Convolutional Neural Networks (CNNs) •Physics-Informed Neural Networks (PINNs) •Graph Neural Networks (GNNs) •Recurrent Neural Networks (RNNs) •Transfer Learning Explainability techniques, such as Layer-Wise Relevance Propagation (LRP) for CNNs, will be used where possible to ensure the ML algorithms are interpretable.

Educational objectives	The Ph.D. program aims to provide candidates with high-level scientific training, enhancing their research and problem-solving capabilities. By the end of the PhD cycle, the candidate will be able to plan and carry out original research, either independently or as part of a team, in the field of battery management systems and structural batteries. The candidate will develop strong theoretical and experimental skills, with opportunities to collaborate with project partners and spend visiting periods abroad. Specifically, the candidate will gain expertise in: •BMS development and optimization •Performance assessment •Sensor installation, acquisition, and data processing- •Advanced ML algorithms (deep learning, transfer learning, explainability methods, etc.) •Bayesian model identification and updating •Methods for diagnosis and prognosis of battery systems under degradation •High-fidelity system model development (digital twin)
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. A recent survey showed that PhD candidates are 100% employed after one year, in national and international companies and academic and non-academic research institutions, engaged in innovation, research and technical development. On average the survey showed that people earning our PhD title obtain 35% higher salary than the corresponding employers with a Master of Science degree. Specifically, the skills and know-how developed during the PhD will allow to cover positions for design, maintenance and integrity assessment of advanced systems and components in aerospace, automotive and mechanical companies.

Composition of the research group	2 Full Professors 2 Associated Professors 0 Assistant Professors 10 PhD Students
Name of the research directors	Proff. Francesco Cadini, Marco Giglio

Contacts
Prof. Francesco Cadini: Phone: +39 022399 8213; Email: francesco.cadini@polimi.it Prof. Marco Giglio: Phone +39 022399 8234: Email marco.giglio@polimi.it For questions about scholarship/support: 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)	--

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 Euro 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.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: ADVANCED MODELLING AND TESTING OF THE MECHANICAL BEHAVIOUR OF COMPOSITE MATERIALS AND POLYMERS

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	Although composite materials and technical polymers, both reinforced and unreinforced, are widely employed for mechanical applications, several aspects of their mechanical behavior still require careful investigation to achieve reliable design tools, particularly in the framework of durability (fatigue and creep). Understanding these aspects is crucial for the development of components that can withstand long-term use in demanding environments without failure.The increasing adoption of new technologies, like additive manufacturing (AM), poses new challenges, related to the specific microstructure and the different manufacturing routes. Additive manufacturing introduces complexities due to layer-by-layer construction, leading to anisotropic properties and unique microstructural features that differ from conventionally manufactured materials.The proposed research aims at investigating and modelling the mechanical behavior of composite materials and polymers, with a focus on additively manufactured materials. This involves a comprehensive approach that combines experimental testing, advanced monitoring techniques, and simulation tools to develop a thorough understanding of the materials' behavior under various conditions.
Methods and techniques that will be developed and used to carry out the research	The research activities will be divided into two main components: experimental and modelling activities. Experimental Activities:The experimental activities will focus on both quasi-static and fatigue testing of materials

	focus on both quasi-static and fatigue testing of materials and structures. These tests will be enhanced by advanced monitoring techniques to ensure precise and comprehensive data collection. Key techniques to be employed include: Digital Image Correlation (DIC), Micro Computed Tomography (Micro-CT), particularly useful for identifying internal defects, porosities, and the overall internal structure of the materials being tested, and various Non-Destructive Testing (NDT) Methods to assess the integrity and properties of the materials without causing any damage. Modelling Activities:The modelling activities will be centered around the development and refinement of simulation tools within the framework of Finite Element Modelling (FEM). These activities will include: Development of Simulation Tools: Creating accurate and efficient simulation models to predict the behavior of materials and structures under various conditions. This involves developing new algorithms and improving existing ones to enhance the precision and reliability of the simulations. Finite Element Modelling (FEM): Utilizing FEM to simulate the mechanical response of materials and structures. FEM will be used to analyze the stress, strain, and deformation of the specimens under different loading scenarios. The aim is to gain a deeper understanding of the material behavior and to validate the experimental results. Integration of Experimental Data: Incorporating data obtained from experimental activities into the simulation models to improve their accuracy. This includes using DIC data for surface strain validation and Micro-CT data for internal structure representation in the models. The research activity is particularly suited for candidates who have experience in either experimental techniques, such as DIC and Micro-CT, or modelling activities, particularly in FEM. Ideally, the candidate will have experience in both fields, as this dual expertise will allow for a more integrated and comprehensive approach to the research. Candidates with a background in material science, mechanical engineering, or a related field, and who have hands-on experience with these advanced techniques and modelling tools, will be well-prepared to contribute to and benefit from this research project.

Educational objectives	The Doctor in Mechanical Engineering will be able to define, start and carry out original research by working in a team or leading a research group. Both theoretical and experimental skills will be mastered.
Job opportunities	The Doctor in Mechanical Engineering will be able to define, start and carry out original research by working in a team or leading a research group. Both theoretical and experimental skills will be mastered. The holder of a PhD in Mechanical Engineering will have job opportunities in structures/organizations aimed at innovation and/or research and technical development, high-tech SMEs, and government departments ruling on public needs. Specifically, the proposed research topic can offer job opportunities in the field of advanced manufacturing of composite structures.Employment statistics of PhDs can be found at: https://cm.careerservice.polimi.it/en/employment-statistics/ List of Universities, Companies, Agencies and/or Nationalor International Institutions that are cooperating in the research include: •AMADE (Analysis and Advanced Materials for Structural Design) research group of the University of Girona; •KU Leuven; •University of Bristol; •EPFL.
Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 4 PhD Students
Name of the research directors	Proff. A. Bernasconi, M. Carboni, Eng. L. Martulli

Contacts
Phone:+39 02 2399 8222, Email: andrea.bernasconi@polimi.it For questions about scholarship/support 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)	--

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 euro 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.