POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 41st cycle

THEMATIC Research Field: HIGH-FREQUENCY TRAIN-TRACK INTERACTION MODELS CONSIDERING UNSTEADY WHEEL/RAIL CONTACT

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	Noise and vibration from wheel–rail interaction remain a major challenge for rail transport, affecting sustainability, passenger comfort, and maintenance needs. These issues are strongly linked to coupled vehicle-track vibration and involve wheel/rail contact mechanics in the medium-to-high frequency range, which is inadequately represented by conventional steady-state contact models.The research aims to develop and assess coupled vehicle-track models and unsteady wheel/rail contact models to enhance the prediction and understanding of noise- and vibration-related phenomena (e.g. rail corrugation, wheel polygonisation, rolling noise, curve squeal, ...), enabling more reliable and sustainable rail systems.This activity contributes to the UN Sustainable Development Goals, specifically SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action) by supporting efficient, low-impact, and resilient railway mobility.
Methods and techniques that will be developed and used to carry out the research	The research will combine analytical, numerical, and experimental approaches. A refined contact modelling framework will be developed, extending classical steady-state assumptions toward unsteady tangential contact formulations suitable for medium-to-high frequency regimes. This will be integrated into existing railway vehicle–track dynamic simulation tools. As a benchmark, established steady-state models such as Kalker’s

	established steady-state models such as Kalker's CONTACT theory will be used to assess improvements and ensure consistency with state-of-the-art practice.The methodology will include: • formulation and implementation of linear and potentially nonlinear unsteady contact models; • development of coupled vehicle–track dynamics models; • frequency-domain and time-domain analyses of wheel–rail interaction; • validation through laboratory data and/or on track measurements; • application of the developed models to representative case studies to evaluate their impact on the prediction and understanding of medium-to-high frequency interaction phenomena.
Educational objectives	The student will acquire advanced competencies in railway dynamics, contact mechanics, and noise and vibration modelling. Specific learning outcomes include: • ability to critically analyse state-of-the-art methods and propose innovative contact modelling solutions; • understanding of wheel–rail interaction physics and related vibration/noise mechanisms; • advanced skills in numerical modelling, simulation techniques, and algorithm development; • familiarity with experimental methods, data interpretation and model validation procedures; • development of research, scientific writing, and technical communication skills suitable for academic and industrial environments.
Job opportunities	Job opportunities in this field are diverse and include positions within: 1) transportation authorities and railway operating companies; 2) railway vehicle manufacturers

	3) track and infrastructure manufacturers;national and international railway agencies.
Composition of the research group	2 Full Professors 2 Associated Professors 1 Assistant Professors 3 PhD Students
Name of the research directors	Prof. Stefano Bruni, Prof. Egidio Di Gialleonardo

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Additional support - Financial aid per PhD student per year (gross amount)	
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, 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-levelresearch 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). Additionally, PhD candidates who spend at least 3 months abroad are eligible for an extra reimbursement of €3,000 to cover travel expenses. 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.