

# Prof. Christian Peco

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## Professional Positions

- **Associate Professor**, Penn State (June 2024 - present)
  - **Assistant Professor**, Penn State (2018 - 2024)
  - **Post-doctoral Associate**, Duke University (2015 - 2017)
  - **Ph.D. Candidate**, Universitat Politècnica de Catalunya - BarcelonaTech (2009 - 2014)
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## Education

- **Ph.D., Computer Science**, Universitat Politècnica de Catalunya - BarcelonaTech, 2014  
*Major:* Computer Science  
*Supporting Areas of Emphasis:* Biomechanics, Data Analysis, Finite Elements, Meshfree Methods.
  - **M.S., Civil Engineering**, Universitat Politècnica de Catalunya - BarcelonaTech, 2009  
*Major:* Civil Engineering  
*Supporting Areas of Emphasis:* Numerical Methods and Data Analysis
  - **B.S., Civil Engineering**, Universitat Politècnica de Catalunya - BarcelonaTech, 2007  
*Major:* Civil Engineering  
*Supporting Areas of Emphasis:* Structural Mechanics
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## Professional Memberships

- Member and Committee Member, Bioinspiration, Biomimetics, and Bioreplication, International Society for Optics and Photonics (SPIE) (2022 - Present)
- Member, Society of Engineering Science (SES) (2019 - Present)
- Member, International Association for Computational Mechanics (IACM) (2018 - Present)
- Member, American Society of Mechanical Engineers (ASME) (2018 - Present)
- Member and Member-at-Large, Manufacturing and Materials TTA, United States Association of Computational Mechanics (USACM) (2018 - Present)
- Member, Spanish Society for Numerical Methods in Engineering (SEMNI) (2010 - Present)

## Selected Publications

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- Barai, S., Sgarrella, J., & Peco, C. Machine learning-based biomimetic optimization models for engineered materials. [Submitted June 2024].
- Barai, S., Liu, F., & Peco Regales, C. Neural Network Accelerated Training for Particle Enriched Microstructural Modeling. [Submitted June 2024].
- Sgarrella, J. (Author - Graduate Student), Barai, S. (Author - Graduate Student), & Peco, C. Biomimetic rules for coordination of robot swarms. *Swarm Intelligence*. [Submitted June 2024].
- Barai, S. (Author - Graduate Student), Kumar, M. (Author - Graduate Student), & Peco, C. Reduced dimensionality neural networks training for complex microstructures. [Submitted May 2024].
- Kumar, M., Upadhyay, N., Reinhart, W., & Peco, C. (2024). Modeling Discrete Biological Materials with a Surrogate Neural Network Bio-lattice Framework. . [Submitted May 2024].
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- Kumar, M., Sgarrella, J., Peco, C. (2024). Neural networks for emergent behavior in biological microstructures. *Engineering Computations*, Accepted and Published, Volume and pages TBD.
- Ghanbari, F., Sgarrella, J., & Peco, C. (2023). Coding soft matter with bionetworks-inspired emergent principles. *Bioinspiration, Biomimetics, and Bioreplication XIII*, 12481, 5–14.
- Xiao, Y., Halforth, N., Tavangarian, F., & Peco, C. (published). Nested structure role in the mechanical response of spicule inspired fibers. *Bioinspiration & Biomimetics*, 19(4), 046008.
- Ghanbari, F., Sgarrella, J., & Peco, C. (published). Emergent Dynamics in Slime Mold Networks. *Journal of the Mechanics and Physics of Solids*, 179, 105387.
- Shimada, T., Nishiguchi, K., Peco, C., Okazawa, S., & Tsubokura, M. (2024). Eulerian finite volume method using Lagrangian markers with reference map for incompressible fluid–structure interaction problems. *Computers&Fluids*, 274, 106210.
- Liu, F., Arguelles, A. P., & Peco, C. (published). Numerical dispersion and dissipation in 3D wave propagation for polycrystalline homogenization. *Finite Elements in Engineering Design*, 240, 104212.
- Guevel, A., Meng, Y., Peco, C., Juanes, R., & Dolbow, J. (published). A Darcy–Cahn–Hilliard model of multiphase fluid-driven fracture. *Journal of the Mechanics and Physics of Solids*, 181, 105427.
- Ghanbari, F., & Peco, C. (accepted). Analysis and Guidelines for Integration of Phase-field and FFT Techniques for Fracture Simulations. In *Fluor Marine Propulsion Laboratory*.
- Lowe, O., Peco, C., & Tavangarian, F. (2023). Modeling of the Bending Behavior to Study Nested-Cylinder Structure in Spicules. *TMS 2023 152nd Annual Meeting & Exhibition Supplemental Proceedings*, 1215–1221.
- Ghanbari, F., Rodriguez, E., Arguelles, A. P., & Peco, C. (2023). Modeling of wave propagation in polycrystalline ice with hierarchical density gradients. *Finite Elements in Analysis and Design*, 217, 103916.

- Ghanbari, F., & Peco, C. (2023). Eulerian Finite-strain Elasticity with Phase-field and the Reference Map Technique. *Transactions of the Japan Society for Computational Engineering and Science*, 27, 8–13.
- Rodriguez, E. G., Peco, C., & Millan, D. (2022). The Influence of Material Properties Distribution of Waves in 1D: Application to Cryoultrasonics. *Mecánica Computacional*, 39, 217–217.
- Sgarrella, J., Ghanbari, F., & Peco, C. (2022). I-STL2MOOSE: from STL data to integrated volumetrical meshes for MOOSE. *SoftwareX*, 21, 101273.
- Shimada, T., Nishiguchi, K., Peco, C., Okazawa, S., & Tsubokura, M. (2022). Eulerian unified formulation for fluid-structure interaction problems using marker particles with Reference map. *Transactions of the Japan Society for Computational Engineering and Science*, 2022, 20220002.
- Shimada, T., Nishiguchi, K., Peco, C., Okazawa, S., & Tsubokura, M. (2021). Eulerian Formulation Using Lagrangian Marker Particles with Reference Map Technique for Fluid-structure Interaction Problem. *9th Edition of the International Conference on Computational Methods for Coupled Problems in Science and Engineering*, 2022, 1–7.
- Ghanbari, F., Costanzo, F., Hughes, D., & Peco, C. (2020). Phase-field modeling of constrained interactive fungal networks. *Journal of the Mechanics and Physics of Solids*, 145, 104160.
- Liu, Y., Peco, C., & Dolbow, J. E. (2019). A fully coupled mixed finite element method for surfactants spreading on thin liquid films. *Computer Methods in Applied Mechanics and Engineering*, 345, 429–453.
- Peco, C., Liu, Y., Rhea, C., & Dolbow, J. (2019). Models and Simulations of Surfactant-Driven Fracture in Particle Rafts. *International Journal of Solids and Structures*, 156–157, Pages 194–Pages 209.
- Peco, C., Chen, W., Liu, Y., Bandi, M., Dolbow, J. E., & Fried, E. (2017). Influence of surface tension in the surfactant-driven fracture of closely-packed particulate monolayers. *Soft Matter*, 13(35), 5832–5841.
- Spencer, B. W., Jiang, W., Dolbow, J. E., & Peco, C. (2016). Evaluation of relocation effects modeled using discrete fracture models. In *CASL FY16 letter report, Idaho National Laboratory*. Idaho National Lab.(INL), Idaho Falls, ID (United States).
- Spencer, B. W., Jiang, W., Dolbow, J. E., & Peco, C. (2016). Pellet cladding mechanical interaction modeling using the extended finite element method. In *Idaho National Laboratory*. Idaho National Lab.(INL), Idaho Falls, ID (United States).
- Greco, F., Filice, L., Peco, C., & Arroyo, M. (2015). A stabilized formulation with maximum entropy meshfree approximants for viscoplastic flow simulation in metal forming. *International Journal of Material Forming*, 8(3), 341–353.
- Peco, C., Millan, Daniel, Rosolen, A., & Arroyo, M. (2015). Efficient implementation of Galerkin meshfree methods for large-scale problems with an emphasis on maximum entropy approximants. *Computers & Structures*, 150, 52–62.
- Abdollahi, A., Peco, C., Millan, Daniel, Arroyo, M., Catalan, G., & Arias, I. (2015). Fracture toughening and toughness asymmetry induced by flexoelectricity. *Physical Review B*, 92(9), 094101.

- Li, B., Peco, C., Millan, Daniel, Arias, I., & Arroyo, M. (2015). Phase-field modeling and simulation of fracture in brittle materials with strongly anisotropic surface energy. *International Journal for Numerical Methods in Engineering*, 102(3-4), 711–727.
- Abdollahi, A., Millan, Daniel, Peco, C., Arroyo, M., & Arias, I. (2015). Revisiting pyramid compression to quantify flexoelectricity: A three-dimensional simulation study. *Physical Review B*, 91(10), 104103.
- Abdollahi, A., Peco, C., Millan, Daniel, Arroyo, M., & Arias, I. (2014). A computational study of flexoelectricity in nanostructures. *11th World Congress on Computational Mechanics (WCCM XI)*, 1, 2.
- Abdollahi, A., Peco, C., Millan, D., Arroyo, M., & Arias, I. (2014). Computational evaluation of the flexoelectric effect in dielectric solids. *Journal of Applied Physics*, 116(9), 093502.
- Peco, C. (2014). Approximation of phase-field models with meshfree methods: exploring biomembrane dynamics. In *Universitat Politècnica de Catalunya - BarcelonaTech*. Universitat Politècnica de Catalunya.
- Peco, C., Rosolen, A., & Arroyo, M. (2013). Simulation of the dynamics of bio-membranes in a viscous fluid with a phasefield variational lagrangian approach. *XI International Conference on Computational Plasticity. Fundamentals and Applications COMPLAS XI*, 1, 13.
- Rosolen, A., Peco, C., & Arroyo, M. (2013). An adaptive meshfree method for phase-field models of biomembranes. Part I: Approximation with maximum-entropy basis functions. *Journal of Computational Physics*, 249, 303–319.
- Peco, C., Rosolen, A., & Arroyo, M. (2013). An adaptive meshfree method for phase-field models of biomembranes. Part II: A Lagrangian approach for membranes in viscous fluids. *Journal of Computational Physics*, 249, 320–336.
- Rosolen, A., Peco, C., & Arroyo, M. (2010). Stabilized, multiscale, and multiphysics modeling in fluid mechanics. *Mecanica Computacional 2010*, 29(81), 8001–8008.

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### **Selected Presentations**

- Peco, C. (Author and Presenter), DTE & AICOMAS 2025. 3rd IACM Digital Twins in Engineering Conference (DTE 2025) & 1st ECCOMAS Artificial Intelligence and Computational Methods in Applied Science. Paris, France 2025.
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Sgarrella, J. (Author), Xiao, Y. (Author), Barai, S. (Author), Barai, S. (Author), ICTAM2024, "Emergent network biomimicry: from bionetwork simulations to robotic swarm applications," Daegu, Korea.
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Sgarrella, J. (Author), Xiao, Y. (Author), Barai, S. (Author), Barai, S. (Author), SES2024, "Emergent Biomimicry Networks: Bridging Bionetwork Simulations to Robotic Swarm Applications," Hangzhou, China.
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Sgarrella, J. (Author), Xiao, Y. (Author), Barai, S. (Author), Barai, S. (Author), WCCM24/PANAM24, "Emergent network morphology in soft materials: from biological to robotic swarms," Vancouver, Canada.

- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Sgarrella, J. (Author), Xiao, Y. (Author), Barai, S. (Author), Barai, S. (Author), ACEX2024, "Emergent behavior in soft matter: from slime molds to kilobot swarms," Barcelona, Spain.
- Rodriguez, E. E. (Author and Presenter), Millan, D. (Author), Peco, C. (Author), MECOM 2023, "Representative Volume Element (RVE) Analysis for mechanical characterization of ice with metallic's inclusion of micro/nano particles," Ciudad de Concordia, Uruguay.
- Peco, C. (Author and Presenter), Sgarrella, J. (Author), Ghanbari, F. (Author), Xiao, Y. (Author), SES 2023, "Emergence in Biological Networks via Phase-field Modeling of Slime Molds," Society of Engineering Science (SES), Minneapolis, Minnesota, USA.
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Sgarrella, J. (Author), Xiao, Y. (Author), Barai, S. (Author), Barai, S. (Author), CM4P 2023, "Unveiling the Dynamics of Biological Materials in Multiscale Adaptive Networks," ECCOMAS, Porto, Portugal.
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Sgarrella, J. (Author), USNCCM17 (2023), "Modeling Growth, Biological Networks Development, and Interfaces in Soft Matter," USACM, Albuquerque, New Mexico.
- Liu, F. (Author and Presenter), Ghanbari, F. (Author), Arguelles, A. P., Simonetti, F., Peco, C. (Author), USNCCM17 (2023), "Multiscale finite element analysis of elastic wave propagation in reinforced ice composites," USACM, Albuquerque, New Mexico, US.
- Sgarrella, J. (Author and Presenter), Ghanbari, F. (Author), Peco, C. (Author), USNCCM17 (2023), "Biomimetic coordination rules for swarm robotics," USACM, Albuquerque, New Mexico, USA.
- Barai, S. (Author and Presenter), Peco, C. (Author), USNCCM17 (2023), "Dimensionality Reduction of Nanoparticles Reinforced Ice Microstructures," USACM, Albuquerque, New Mexico, USA.
- Kumar, M. (Author and Presenter), Peco, C. (Author), USNCCM17 (2023), "Machine Learning for Bio-inspired Lattice Models," USACM, Albuquerque, New Mexico, USA.
- Xiao, Y. (Author and Presenter), Tavangarian, F., Peco, C. (Author), USNCCM17 (2023), "Mechanical response of spicule nested structure," USACM, Albuquerque, New Mexico, USA.
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Sgarrella, J. (Author), CM3 - TRANSPORT 2023, "Biomimetic Coordination and Optimization Models for Transport Networks," ECCOMAS, Helsinki, Finland.
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Sgarrella, J. (Author), SPIE Smart Structures 2023, "Coding soft matter with bionetworks-inspired emergent principles," SPIE, Long Beach, California.
- Rodriguez, E. (Author and Presenter), Ghanbari, F. (Author), Arguelles, A. P., Simonetti, F., Millan, D., Peco, C. (Author), MECOM 2022, "The influence of material properties distribution of waves in 1D: application to cryoultrasonics," MECOM, Bahía Blanca, Buenos Aires, Argentina.
- Peco, C. (Author and Presenter), Sgarrella, J. (Author), Ghanbari, F. (Author), SES 2022, "Interactive Biological Networks: Phase-field Modeling of Fungi and Slime Molds," Society of Engineering Science (SES), College Station, Texas, USA.

- Sgarrella, J. (Author and Presenter), Ghanbari, F. (Author), Peco, C. (Author), ICDS Symposium 2022, "I-STL2MOOSE: from STL data to integrated volumetrical meshes for MOOSE," ICDS, State College, Pennsylvania, USA.
- Ghanbari, F. (Author and Presenter), Sgarrella, J. (Author), Peco, C. (Author), ICDS Symposium 2022, "Phase-field modeling of the slime mold *Physarum polycephalum*," ICDS, State College, Pennsylvania, USA.
- Shimada, T. (Author), Nishiguchi, K., Peco, C. (Author and Presenter), Okazawa, S., Tsubokura, M., MFEM 22 - Meshfree and Novel Finite Element Methods with Applications, "Unified Eulerian Formulation for Large-scale Combined Fluid-Solid Behavior in Biomaterials," USACM, Berkeley, California.
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Costanzo, F., WCCM-APCOM 2022, "Phase-field Modeling of Slime Molds," IACM, Yokohama, Japan.
- Ghanbari, F. (Author and Presenter), Costanzo, F., Hughes, D. P., Peco, C. (Author), ESMTODAY'22, "Modeling Fungal Infections: Matrix Development in Zombie Ants," ESM, State College, Pennsylvania, USA.
- Peco, C., Michigan Technological University, "A Phase-field Approach to Biological Network Modeling," Michigan Technological University, Hancock, Michigan, US.
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Costanzo, F. (Author), 16th U.S. National Congress on Computational Mechanics, "Simulation of Interactive Biological Networks: A Phase-field Approach to Slime Molds Development," Chicago, Illinois, USA (Virtual).
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), WCCM ECCOMAS 2021, "Eulerian Fluid-Structure Interaction Method using Marker Particles and Reference Map Technique," Paris, France.
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), WCCM ECCOMAS 2021, "Modeling the Fungal Matrix Development of *Ophiocordyceps* in Zombie Ants: a Phase-field Approach," Virtual event.
- Peco, C., 14th World Congress of Computational Mechanics, "Modeling the matrix development of *Ophiocordyceps* in Zombie Ants: a phase-field approach," ECCOMAS, Paris, France (Online).
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Costanzo, F. (Author), COMPSAFE 2020, "Self-Developing Systems: From Zombie Ants to Constrained Interactive Networks," The Japan Society for Computational Engineering and Science, Japan, Online.
- Peco, C. (Author and Presenter), IWACOM IV (changed to virtual due to COVID19), "Advanced Machine Learning for Phase-field Models," Nagoya, Japan.
- Peco, C. (Author and Presenter), Ghanbari, F. (Author), Society of Engineering Science SES2019, "Phase-field Modeling of Fungal Infection in Zombie Ants: Understanding the Matrix Development," St. Louis, Missouri, USA.
- Peco, C., RIKEN, "Fracture Modeling in Particulate Rafts: Surface Difference Tension and Packing Fraction Variability," Kobe, Japan.
- Peco, C., MIT, "Simulation of surfactant-driven fracture on particulate rafts," Boston, Massachusetts, US.
- Peco, C., Idaho National Lab, "On surfactant-driven phenomena of particle rafts," Idaho Falls, Idaho.

## Teaching Experience

- **Finite Elements (560):** Taught with enrollments between 16 and 25 students per section.
- **Numerical Methods (407):** Taught with 15 to 26 students per section.
- **Mechanical Response of Engineering Materials(315):** Taught multiple sections with enrollments ranging from 77 to 130 students per section.

An example of recent scores for these courses:

ESC 407 - 001, UP, 9, 88.9% responded

	1	2	3	4	5	6	7	Median	Mode
Rate how well this course increased your understanding of the course topics								6	7
Rate how well the instructor promoted a meaningful learning experience for you								6.5	7

EMCH 315 - 001, UP, 76, 72.4% responded

	1	2	3	4	5	6	7	Median	Mode
Rate how well this course increased your understanding of the course topics.	0 (0%)	0 (0%)	1 (1%)	5 (9%)	8 (14%)	22 (40%)	19 (34%)	6	6
Rate how well the instructor promoted a meaningful learning experience for you.	0 (0%)	0 (0%)	1 (1%)	6 (10%)	4 (7%)	16 (29%)	28 (50%)	7	7

EMCH 560 - 001, UP, 14, 85.7% responded

	1	2	3	4	5	6	7	Median	Mode
Rate how well this course increased your understanding of the course topics.	0 (0%)	0 (0%)	0 (0%)	0 (0%)	3 (25%)	4 (33%)	5 (41%)	6	7
Rate how well the instructor promoted a meaningful learning experience for you.	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	4 (33%)	8 (66%)	7	7

## Directed Student Learning

*Dissertation Committee Advisor:* Luyi Feng, Ferris Isa Arnous, Nolan Roth, Feihong Liu, Joe Sgarrella, Manik Kumar, Nilay Upadhyay, Shishir Barai, Yuanxin Xiao, Eduardo Rodriguez.

*Dissertation Committee Member:* Andrew Barry Groeneveld, Hyeeyun Kong, Prabhakaran Manogharan, Tiankai Zhao, Zhifeng Zhang, Yingjie Liu.

*Postdoctoral Research Advisor:* Farshad Ghanbari.

*Master's Thesis Advisor:* Cate Rollins, Joe Sgarrella, Yanran Wang, Elizabeth Nicole Trautman, Pranjali Singh.

*Honors Thesis Advisor:* William Laplante, Aryan Patil, Nawaf Alhezab, Tyler Locher, Ryan Allen Lee, Evan Carr, Joe Sgarrella.

*Funded Undergraduate Research Advisor:* Olivia Ruth Lowe, Colin Miller, Michael Szczesniak.