Doctoral Program in Industrial Engineering
Università degli Studi di Padova
Dipartimento di Ingegneria Industriale

Course Plan 40th cohort

Approved by the Faculty Board on 16.12.2024

Courses

Credits

Course unit	Duration (hours)	ECTS credits	AA 2024/25	AA 2025/26	AA 2026/27
Advanced methods for fatigue design	10	2	x	x	x
Bibliographic resources and research tools for PHD students in Industrial Engineering	10	2	x	x	x
Bioelectromagnetics	5	1	x	x	x
Biomedical Imaging with MEMS	10	2	x		
Coupled electrical-thermal-structural Finite Element Analyses	10	2		x	
Design and analysis of axial-flow industrial fans	25	5	x	x	x
Eco-informed Materials Choice	15	3	x	x	x
Ecotoxicology as an heuristic approach to environmental engineering	10	2	x	x	x
Electromagnetic fields and biological tissues	10	2	x	x	x
Entrepreneurship and Startup	20	4	x	x	x
Experimental measurements in thermal fluid dynamics	15	3	x	x	
Finite Element Method (FEM)	30	6	x		
From the Energy Simulation of Buildings to the Environmental Certification Protocols	15	3	x	x	x
Geometric Modeling of Anatomical Parts and Medical Devices	15	3	x	x	x
Green Chemistry and Technology	10	2	x	x	
Introduction to energy system modeling with TRNSYS	15	3	x	x	x
Introduction to Model Order Reduction	5	1	x	x	x
Introduction to Numerical Methods in Gas Dynamics for Fluid Machinery	10	2	x	x	x
Powder flowability	10	2	x	x	x
Principles and Applications of Life Cycle Assessment of Energy Systems	10	2	x	x	x
Python for numerical heat transfer modeling and building physics	15	3	x	x	
Statistics for Engineers	40	8	x	x	x
Smart Technologies for the sustainability of the food chain	15	3	x		x
Stochastic and Gradient Methods for Single- and Multi-Objective Optimization	5	1	x	x	x
Technological Advancements in Electromobility	10	2	x		
The Role of Energy Storage Technologies and Waste Heat Recovery Units in the Transition to a Future Sustainable Energy System	20	4	x	x	x
Tutela della proprietà intellettuale	20	4	x	x	x
Yield criteria for polymer materials	10	2	x		

Total number of specialization courses: 26
Total number of interdisciplinary courses: 9
Total number of ECTS credits for specialization courses: 385
Total number of ECTS credits for interdisciplinary courses: 15,5

Ph.D. students are required to register for the courses listed above by using the Moodle platform (see https://academics.dii.unipd.it/phd/training/) and going to the page dedicated to the specific course they want to attend.
Students registered for a course who decide not to attend it, must inform the professor.
Specialization courses have limited seating, as they are open to PhD students from all doctoral programs at the University of Padova.
For updated information about actual dates or delivery mode, Ph.D. students are invited to exclusively refer to the Moodle page of each specific course.

Specialization Courses

Advanced Methods for Fatigue Design

Lecturers

Prof. Giovanni Meneghetti, Department of Industrial Engineering, University of Padova
Prof. Alberto Campagnolo, Department of Industrial Engineering, University of Padova

Topics

Introduction to fatigue assessment of mechanical components in presence of cracks or notches.
Derivation of stress fields ahead of cracks/notches: Airy stress function and complex potential function method (Kolosov and Muskhelishvili).
Case study: sharp V-notches under in-plane loading. Lazzarin-Tovo analytical derivation of local stress field based on complex potential functions and comparison with Williams' solution.
Definition of Notch Stress Intensity Factors (NSIFs) and introduction to local approaches based on NSIF-concept: averaged strain energy density (SED) and peak stress method (PSM)
Practical application of local approaches to fatigue strength assessment of mechanical components by means of FE analyses (Ansys FE code).

References

- Sadd M. H. Elasticity. Theory, Applications and Numerics. Elsevier; 2004.
- Lazzarin P., Tovo R. A unified approach to the evaluation of linear elastic stress fields in the neighborhood of cracks and notches, Int. J. Fract. 78 (1996) 3–19.
- Anderson T. L. Fracture Mechanics. Fundamentals and Applications. CRC Press; 1995.
- Lazzarin P., Zambardi R. A finite-volume-energy based approach to predict the static and fatigue behavior of components with sharp V-shaped notches, Int. J. Fract. 112 (2001) 275–298.
- Meneghetti G., Lazzarin P. Significance of the elastic peak stress evaluated by FE analyses at the point of singularity of sharp V-notched components, Fatigue Fract. Eng. Mater. Struct. 30 (2007) 95–106.
- Radaj D, Vormwald M. Advanced methods of fatigue assessment. Springer; 2012.

Details

Duration: 8 hours
Academic years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on a home assignment.

Bibliographic resources and research tools for PHD students in Industrial Engineering

Lecturers

Librarians, Biblioteca Centrale di Ingegneria, University of Padova

Topics

1st Module (4 hours) - Online course: to be attended before the face-to-face module.
Engineering libraries and their services (local and interlibrary loan, document delivery, bibliographic reference, book purchase proposal...)
GalileoDiscovery as the University of Padua Library Search Tool
Engineering, Economics, Management databases (BSC, IEEE Xplore, Engineering Village, Reaxys, ACM Digital Library, ASTM Compass, DieselNET, Total Materia, BSOL)
Citation databases: Scopus (Elsevier), Web of Science (ISI).
Bibliometric indicators: quality measurements of scientific publication

2nd Module (4 hours, in two lessons) - Face-to-face course
Academic publishing and Open Access. Padua Research Archive (PRA/IRIS): the institutional repository for academic research.
Open Science and data management. Research Data Unipd, the Institutional repository for the outputs of research. (2 hours)
Bibliographic citations and citation styles. Reference management: introduction to Zotero. (2 hours)

References

- Engineering Central Library – University of Padova website: http://biblioingegneriacentrale.cab.unipd.it/
- University Library System website: https://bibliotecadigitale.cab.unipd.it/en, especially about Open Science, Open Access, Open Data, Metrics.
- The Principles of Open Scholarly Infrastructure: https://openscholarlyinfrastructure.org/
- Aliprandi, Simone, and Simone Aliprandi. Fare open access: la libera diffusione del sapere scientifico nell'era digitale. Ledizioni, 2017.
- Capaccioni, Andrea, et al. Ricerche bibliografiche: banche dati e biblioteche in rete. 2. ed, Maggioli, 2018.
- Turbanti, Simona. Strumenti di misurazione della ricerca: dai database citazionali alle metriche del web. Editrice Bibliografica, 2018.

Details

Duration: 8 hours
Academic years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Evaluation: Attendance is necessary. Online module is required for attending the face-to-face module. Final test after online course and after face-to-face course, to confirm the participation and the training.

Bioelectromagnetics

Lecturers

Prof. Elisabetta Sieni, Dipartimento di Scienze Teoriche e Applicate, Università dell'Insubria

Topics

Introduction to bioelectromagnetics. Electromagnetic field coupled with the human body; physical quantities involved.
Brief introduction to tissue from the point of view of electromagnetic field coupling. Electrical properties of tissue as a function of the frequency.
Protection rules from effects related to electrical and magnetic fields at low and high frequency. ICNIRP and EU regulations. Safety in working and public environments. Typical sources in industrial and public environments. Measurements of the intensity of the magnetic field at low frequency.
Effects of electric, magnetic, and electromagnetic fields on cells and tissues, e.g., heating and electric stimulation, considering the frequency spectrum of the electromagnetic field: from low frequency to microwaves. Protection rules following ICNIRP rules.

References

- ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz). Health Physics 1998, 74, 494–522.
- ICNIRP Guidelines on Limits of Exposure to Static Magnetic Fields. Health Physics 1994, 66, 100–106.
- ICNIRP Guidance on Determining Compliance of Exposure to Pulsed Fields and Complex Non-Sinusoidal Waveforms below 100 KHz with ICNIRP Guidelines. Health Physics 2003, 84, 383–387.
- ICNIRP Guidelines for Limiting Exposure to Time-Varying Electric and Magnetic Fields (1 Hz to 100 KHz). Health Physics 2010, 99, 818-836 10.1097/HP.0b013e3181f06c86.
- International Commission on Non-Ionizing Radiation Protection (ICNIRP)1 Guidelines for Limiting Exposure to Electromagnetic Fields (100 KHz to 300 GHz): Health Physics 2020, 118, 483–524, doi:10.1097/HP.0000000000001210.
- Andreuccetti, D.; Bini, M.; Checcucci, A.; Ignesti, A.; Millanta, L.; Olmi, R.; Rubino, N. Protezione Dai Campi Elettromagnetici Non Ionizzanti; IROE, 2001.

Details

Duration: 8 hours
Academic years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on a multiple-choice questionnaire.

Biomedical Imaging with MEMS

Lecturers

Dr. Monica La Mura, Researcher “type A”
Dept. of Industrial, Electronic, and Mechanical Engineering, Roma Tre University

Topics

Introduction to biomedical imaging techniques
MEMS technology for biomedical imaging applications
MEMS devices for ultrasound imaging of tissues
Circuital modeling of microfabricated acoustic transducers
FEM modeling of microfabricated acoustic transducers: electro-mechano-acoustic coupling
MEMS devices for Terahertz imaging of tissues
FEM modeling of microbolometers: thermo-opto-mechanical coupling

References

Brenner, K.; Ergun, A.S.; Firouzi, K.; Rasmussen, M.F.; Stedman, Q.; Khuri–Yakub, B. Advances in Capacitive Micromachined Ultrasonic Transducers. Micromachines 2019, 10, 152. https://doi.org/10.3390/mi10020152
Lohfink, A., & Eccardt, P.C., Linear and nonlinear equivalent circuit modeling of CMUTs, IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, vol. 52, no. 12, 2005, pp. 2163-2172, https://doi.org/10.1109/TUFFC.2005.1563260
Yaralioglu, G.G., Ergun, S.A., & Khuri-Yakub, B.T., Finite-element analysis of capacitive micromachined ultrasonic transducers, IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, vol. 52, no. 12, 2005, pp. 2185-2198, https://doi.org/10.1109/TUFFC.2005.1563262
Xiang, Y., Zhao, X., Yang, K., Liu, Y., Liu, Y., Fu, W., & Luo, Y., Biomedical Applications of Terahertz Spectroscopy and Imaging, Trends in Biotechnology, vol. 34, issue 10, 2016, pp. 810-824, https://doi.org/10.1016/j.tibtech.2016.04.008
Vicarelli, L., Tredicucci, A., & Pitanti, A., Micromechanical Bolometers for Subterahertz Detection at Room Temperature, ACS Photonics, vol. 9, no. 2, 2022, pp. 360–367, https://doi.org/10.1021/acsphotonics.1c01273

Details

Duration: 8 hours
Academic years: a.a. 2024/25
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on a written questionnaire.

Coupled Electrical-Thermal-Structural Finite Element Analyses

Lecturers

Eng. Michele Ballan, Laboratori Nazionali di Legnaro, Istituto Nazionale di Fisica Nucleare
Eng. Mattia Manzolaro, Laboratori Nazionali di Legnaro, Istituto Nazionale di Fisica Nucleare
Prof. Giovanni Meneghetti, Department of Industrial Engineering, University of Padova

Topics

Course overview and introduction. General aspects of Finite Element analyses related to the structural, thermal and electrical fields. Structural analyses with plane and solid elements. Thermal analyses with plane and solid elements, implementing thermal conduction, thermal convection and thermal radiation. Coupled field thermal-structural analyses. Coupled field electrical-thermal analyses. Coupled field electrical-thermal-structural analyses. Presentation of a complex test case implementing all the aforementioned physical fields with a specific focus on complex geometry import.

References

- M. Manzolaro, G. Meneghetti, A. Andrighetto, Thermal–Electric Numerical Simulation Of A Surface Ion Source For The Production Of Radioactive Ion Beams, Nucl. Instrum. Methods Phys. Res., Sect. A 623 (2010) 1061–1069.
- G. Meneghetti, M. Manzolaro, A. Andrighetto, Thermal–Electric Numerical Simulation Of A Target For The Production Of Radioactive Ion Beams, Finite Elem. Anal. Des. 47 (2011) 559–570.
- M. Manzolaro, G. Meneghetti, Introduction To The Thermal Analysis With Ansys® Numerical Code, Edizioni Libreria Progetto, 2014, Padova, Italy.
- G. Meneghetti, M. Manzolaro, M. Quaresimin, Introduction To The Structural Analysis With Ansys® Numerical Code, Edizioni Libreria Progetto, 2014, Padova, Italy.

Details

Duration: 12 hours
Academic years: 2024/2025
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on a case study developed during and after the lectures.

Design and Analysis of Axial-Flow Industrial Fans

Lecturer:

Prof. Massimo Masi, Department of Management and Engineering - DTG, University of Padova

Topics

Fundamentals of axial-flow industrial fans: applications of industrial axial-flow fans; axial-flow fan operating principle; aerodynamic performance parameters; fan internal flow approximations (from 1D to 3D); radial equilibrium model and blade aerodynamic loading. axial-flow fan aerofoil sections; cascade versus isolated aerofoil aerodynamics.
Preliminary design: similarity principles applied to axial-flow fans; selection of the fan configuration best suited to a specific performance requirement; definition of the size and rotational speed of the rotor; definition of the meridional geometry; definition of the velocity diagrams corresponding to the selected blade loading distribution.
Aerodynamic design of axial-fan bladings: aerofoil performance charts; definition of the blade geometry; stall margin; effects of the Reynolds number; secondary flows and tip clearance effects.
Computational fluid-dynamics applied to axial-flow fan analysis: computational domains best suited to support the different phases of fan design; physical models, numerical schemes and solution algorithms; use of CFD tools for fan aerodynamics (pre-processing tasks, running the simulation, post-processing the results).
Experimental fluid dynamics applied to axial-flow fan analysis: basics of fan testing; standard test rig installation types; experimental assessment of the global aerodynamic performance of an axial-flow fan; local flow field measurement techniques suited to support the fan design.

References

- Bleier P. F., 1988, Fan handbook - Selection, application and design. McGrawHill, New York.
- Masi, M., Fontana, F., Lazzaretto, A., 2017, On the choice of suitable parameters for the assessment of industrial fans performance and efficiency. Proceeding of the ASME TurboExpo 2017. GT2017-64032. Charlotte-NC, USA, June 26-30.
- Lewis, R. I., 1996, Turbomachinery performance analysis, Arnold, London.
- Masi, M., Danieli, P., Lazzaretto, A., 2021, Overview of the best 2020 axial-flow fan data and inclusion in similarity charts for the search of the best design, J. Turbomach. Paper No: TURBO-21-1157.
- Eck, B., 1973, Fans, Pergamon Press, Oxford, UK.
- Versteeg H. K., Malalasekera W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method. Pearson Education, 2007.
- Masi M., Lazzaretto A., CFD models for the analysis of rotor-only industrial axial-flow fans. Proc. International conference on fan noise, technology and numerical methods - FAN 2012, Senlis, France, April 18-20.
- ISO – International Organization for Standard - Technical Committee ISO/TC 117, Fans. Industrial fans - Performance testing using standardized airways. ISO 5801:2007, CP 401 - 1214 Vernier, Geneva, Switzerland, 2007.

Details

Duration: 24 (6 CFU)
Academic years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on a discussion of the written report on the aerodynamic design and CFD analysis of an axial-fan able to fulfil the performance requirements assigned to each student during the course lessons.

Eco-Informed Materials Choice

Lecturer

Prof. Enrico Bernardo, Department of Industrial Engineering, University of Padova

Topics

Introduction to materials selection. Definition of fundamental combinations of materials properties usable as 'performance indices' (e.g. prediction of lightness of components according to combinations of density with mechanical properties). Rapid materials selection by representation of indices in material property charts. Extension to environmental studies, by definition of environmental performance indices, with case studies. Presentation of case studies involving thermal properties. The materials life cycle. Ecological data: values, sources, precision. Eco-audits and eco-audit tools (introduction to specific software), with case studies.

References

- Course slides, provided by the lecturer
- M.F. Ashby, Materials and the Environment, Butterworth Heinemann, Oxford, UK (excerpts, provided by the lecturer)
- M.F. Ashby, Materials Selection in Mechanical Design, Butterworth Heinemann, Oxford, UK (excerpts, provided by the lecturer)

Details

Duration: 12 hours
Academic years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on a home assignment (comprising a quiz questionnaire and a short project).

Ecotoxicology as a Heuristic Approach to Environmental Engineering

Lecturer

Prof. Luca Palmeri, Department of Industrial Engineering, University of Padova

Topics

Introduction, Regulations. Classification methodologies (REACH, CLP), Toxic Chemicals in general. Chemical properties, Classification of chemicals. Partition coefficient and degradation parameters, Ecotoxicological parameters, Ecological risk assessment, Chemical properties estimation, QSAR approach. Introduction to fugacity models.

References

- L. Palmeri, A. Barausse, and S.E. Jorgensen, Ecological Processes Handbook, CRC Press, 2013
- S.E. Jorgensen and G. Bendoricchio, Fundamentals of Ecological Modelling, third edition, Elsevier, 2001
- Newman MC, MA Unger, Fundamentals of Ecotoxicology, 2nd Edition, CRC/Lewis Press, 2002

Details

Duration: 12 hours
Academic years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on the discussion of a case study related to the individual PhD project.

Entrepreneurship and Startup

Lecturers:

Prof. Moreno Muffatto, Dipartimento di Ingegneria Industriale, Università di Padova
Ing. Francesco Ferrati, Dipartimento di Ingegneria Industriale, Università di Padova

Topics

Entrepreneurship, The team and the early decisions, From the idea to the market, Intellectual Property Rights, Business Models, The financials of a startup, Funding a startup.

References

- Thomas R. Ittelson (2009), Financial Statements: A Step-by-Step Guide to Understanding and Creating Financial Reports, Career Press.
- Ferrati, F. & Muffatto, M. (2021). Reviewing Equity Investors' Funding Criteria: A Comprehensive Classification and Research Agenda. Venture Capital, Vol. 23: No. 2.
- Noam Wasserman (2013), The Founder's Dilemmas: Anticipating and Avoiding the Pitfalls That Can Sink a Startup, Princeton University Press.

Details

Duration: 21 hours
Academic years: a.y. 2024/25, a.y. 2025/26, a.y. 2026/27
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on the discussion of a case study of a technology-based startup.

Experimental Measurements in Thermal Fluid Dynamics

Lecturers

Dr. Arianna Berto, Department of Industrial Engineering, University of Padova
Prof. Stefano Bortolin, Department of Industrial Engineering, University of Padova

Topics

Introduction to the expression of uncertainty in measurements: theory and practical examples. Measurements of pressure, temperature (thermocouples, infrared thermography, resistance temperature detectors) and flow rate. Introduction to the determination of the heat transfer coefficient during two-phase flow (condensation, flow boiling) inside channels. Liquid film thickness measurements inside channels by means of optical techniques (shadowgraphy, chromatic confocal imaging, interferometry). Heat transfer measurements during dropwise condensation. Measurements of solar radiation and concentrated solar flux. Experimental calibration of a thermocouple. Experimental measurement of temperature and mass flow rate during two-phase flow.

References:

- GUM: Guide to the Expression of Uncertainty in Measurement. http://www.bipm.org/en/publications/guides/gum.html
- Cavallini, L. Mattarolo, Termodinamica applicata, CLEUP Editore, cap. XIII.
- V.J. Nicholas, D.R. White. 1994. Traceable Temperatures – An Introduction to Temperature Measurement and Calibration, John Wiley & Sons Ltd, West Sussex, England.
- Bortolin S., Tancon M., Del Col D., Heat transfer enhancement during dropwise condensation over wettability-controlled surfaces, Springer, Cham, 2022, DOI: https://doi.org/10.1007/978-3-030-82992-6_3
- Del Col D., Bortolin S., Azzolin M., Measuring Heat Transfer Coefficient During Condensation Inside Channels, CRC Press, 2021, DOI: https://doi.org/10.1201/9780429201622

Details

Duration: 14 hours
Academic years: a.a. 2024/25, a.a. 2025/26
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on a home assignment.

Finite Element Method in Engineering: Theory and Practice

Lecturer

Prof. Giuseppe Gambolati, Department of Civil, Environmental and Architectural Engineering

Topics

Finite Element Method in Engineering: Theory and Practice.

References

- Handouts from the lectures
- Giuseppe Gambolati e Massimiliano Ferronato, Lezioni di Metodi Numerici per l'Ingegneria, Progetto, 2022
- Thomas J.R. Huges, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Prentice-Hall, 1987
- Myron B. Allen et al., Numerical Modeling in Science and Engineering, J. Wiley, 1988

Details

Duration: 32 hours
Academic years: a.a. 2024/25
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on an oral examination. The course will be activated with a minimum of 5 students.

From the Energy Simulation of Buildings to Environmental Certification Protocols

Lecturer

Prof. Giuseppe Emmi, Department of Architecture and Arts, University IUAV of Venice

Topics

Energy in buildings (thermal and energy properties of building envelopes, boundary conditions for design and energy analysis, detailed analysis of components and devices), Energy Certification in Italy, Environmental and Sustainability Protocols (GBC, Itaca, BREEAM), use of tools for Energy Simulations of buildings and plants.

References

- Ashrae Standard 90.1-2022—Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings
- Fatma S. Hafez et al. (2023), Energy Efficiency in Sustainable Buildings: A Systematic Review with Taxonomy, Challenges, Motivations, Methodological Aspects, Recommendations, and Pathways for Future Research, Energy Strategy Reviews
- Zhihang Zheng et al. (2024), Review of the building energy performance gap from simulation and building lifecycle perspectives, Developments in the Built Environment

Details

Duration: 12 hours
Academic years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on a written questionnaire and/or oral discussion.

Geometric Modeling of Anatomical Parts and Medical Devices

Lecturer

Prof. Francesca Uccheddu, Department of Industrial Engineering, University of Padova

Topics

Overview on geometric modeling techniques for digital and physical fabrication of anatomical parts and for the realization of personalized medical devices. Topics include general aspects of Reverse Engineering, external/internal anatomic parts acquisition methods, free form/surface modeling design of anatomical replicas, CAD modeling design of medical devices, clinical cases description.

References

- Mussi, E. et al. (2019), Ear reconstruction simulation: from handcrafting to 3D printing, Bioengineering
- Buonamici, F. et al. (2020), A practical methodology for computer-aided design of custom 3D printable casts for wrist fractures, The Visual Computer
- Volpe, Y. et al. (2018), Surgery of complex craniofacial defects: A single-step AM-based methodology, Computer Methods and Programs in Biomedicine
- Uccheddu, F. et al. (2018), A novel objective approach to the external measurement of pectus excavatum severity by means of an optical device, The Annals of Thoracic Surgery

Details

Duration: 12 hours
Academic years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on a clinical case study developed during the lectures.

Green Chemistry and Technology

Lecturers

Prof. Roberta Bertani, Prof. Alessandro Manzardo, Prof. Paolo Sgarbossa, Prof. Gioele Pagot, Dott. Giuseppe Guercio, Department of Industrial Engineering, University of Padova

Topics

Introduction to Green Chemistry and Green Technology; principles of sustainable and Green Chemistry and Engineering; Chemistry and the environment; Green chemistry and sustainable development; Introduction to Life Cycle Assessment (LCA) of products; Green Nanotechnology; Green metrics for evaluating the "Greenness" of chemical processes and products, with laboratory activities.

References

- Anastas, P. T.; Warner, J. C., Green Chemistry: Theory and Practice, Oxford University Press
- Lancaster, M., Green Chemistry: an introductory text, Royal Society of Chemistry
- Jiménez-González, C.C.; Constable, D., Green chemistry and engineering: a practical design approach, Wiley
- McKeag, Thomas, Green chemistry in practice, Elsevier, 2023
- Tiwari, Vinod K., Green chemistry: introduction, application and scope, Springer, 2022
- Lectures' slides will be made available to participants

Details

Duration: 12 hours
Academic years: a.a. 2024/25
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on an essay discussing a specific aspect or process, to be submitted and discussed by the end of September.

Introduction to Energy System Modeling with TRNSYS

Lecturer

Dr. Sara Bordignon, Department of Industrial Engineering, University of Padova

Topics

Introduction to TRNSYS software for energy systems modeling. TRNSYS is a software environment for simulating transient systems, offering a library for modeling hydronic, electrical, thermal systems, and more. The course will introduce students to TRNSYS, enabling them to create and analyze a simple energy system model.

References

Transient System Simulation Tool. [Online]. Available: http://www.trnsys.com/

Details

Duration: 12 hours
Academic years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Evaluation: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on the discussion of a case study investigated during class.

Introduction to Model Order Reduction

Lecturers

Prof. Riccardo Torchio and Prof. Francesco Lucchini, Department of Industrial Engineering, University of Padova

Topics

Model order reduction (MOR) is a technique for reducing the computational complexity of mathematical models in numerical simulations. As such it is closely related to the concept of metamodeling, with applications in all areas of mathematical modelling. In this short course, the main numerical approaches to perform MOR will be presented. In particular, the Proper Orthogonal Decomposition (POD) will be discussed, and a basic implementation of the algorithm will be presented. This basic POD algorithm will be then applied to speed up time domain simulations of a thermal problem in MATLAB.

References

- Benner P., Grivet-Talocia S., Quarteroni A., Rozza G., Schilders W., Magdeburg L. M. S. Model Order Reduction. Three volumes.
- Benner, P., Feng, L. (2014). A Robust Algorithm for Parametric Model Order Reduction Based on Implicit Moment Matching. In: Quarteroni, A., Rozza, G. (eds) Reduced Order Methods for Modeling and Computational Reduction. MS&A - Modeling, Simulation and Applications, vol 9. Springer, Cham.
- Y. Liang, H. Lee, S. Lim, W. Lin, K. Lee, and C. Wu. Proper orthogonal decomposition and its applications—part i: Theory. Journal of Sound and Vibration, vol. 252, no. 3, pp. 527–544, 2002.
- S. Brunton, J. Nathan Kutz, Data-Driven Science and Engineering.

Details

Duration: 5 h
Academic Years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Examination: Attendance is required for all the lecture hours. Final evaluation will be based on the code implemented during the course.

Introduction to Numerical Methods in Gas Dynamics for Fluid Machinery

Lecturers

Dr. Francesco De Vanna, PhD, Department of Industrial Engineering, University of Padova

Topics

The course focuses on the principles and applications of unsteady gas dynamics in the context of turbomachinery, exploring the behavior of compressible flow under high-speed conditions prevalent in modern gas turbines and compressors. The focus is related to unsteady flow phenomena and their numerical modeling aspect which are fundamental for understanding turbomachinery performance and optimization.
Thus, the course covers the fundamental concepts related to the theory of hyperbolic systems of equations, focusing on non-stationary phenomena in compressible flows. It begins with an introduction to the hyperbolic system of equations, specifically the Euler equations of gas dynamics. The theory of characteristics is then presented, with a discussion on its applications to conservative systems. The course also introduces Riemann problems, including jump relations and the dynamics of shock waves and expansion fans. Practical application is explored through a time-dependent gas dynamics problem in the turbomachinery field. Additionally, the course provides basic knowledge of compiled programming languages, emphasizing modern Fortran90 for high-performance computing and applications to compressible flows in turbomachinery.

References

- De Vanna, F., et al. (2020). A sharp-interface immersed boundary method for moving objects in compressible viscous flows. Computers and Fluids, 201, 104415.
- De Vanna, F., et al. (2021). Unified wall-resolved and wall-modeled method for large-eddy simulations of compressible wall-bounded flows. Physical Review Fluids, 6(3), 034614.
- De Vanna F., et al. (2023). Effect of convective schemes in wall-resolved and wall-modeled LES of compressible wall turbulence, Computers and Fluids
- De Vanna, F., et al. (2023). URANOS: A GPU accelerated Navier-Stokes solver for compressible wall-bounded flows. Computer Physics Communications, 287, 108717.

Details

Duration: 10 h
Academic Years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Examination: Attendance is required for at least 2/3 of the lecture hours. Final evaluation is based on an oral discussion.

Powder flowability

Topics

The course presents the basic knowledge and theory needed by engineers dealing with problems related to powder flowability.
PART 1: Relevant properties and characterization of particulate materials (particle shape, size, apparent density, surface area, porosity). Types of interactions between particles (solid-solid contact) and definition of cohesion. Definition and measurement of powder flowability.
PART 2: Static and dynamic analysis of stresses in solids (solid mechanics). Yielding criteria in powders (Mohr-Coulomb analysis). Active and passive state of stresses. Criteria of storage design units for flow (Jenike approach).

References

- Holdich, Richard G., Fundamentals of Particle Technology. Shepshed: Leicestershire, Midland Information Technology & Publishing, 2002.
- Rhodes, Martin J., Introduction to Particle Technology. Chichester: Wiley, 1998.

Details

Duration: 8 hours
Academic Years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Examination: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on a written questionnaire.

Principles and Applications of Life Cycle Assessment of Energy Systems

Lecturers

Prof. Alberto Benato and Prof. Anna Stoppato, Department of Industrial Engineering, University of Padova

Topics

Life Cycle Assessment (LCA) is today one of the most accredited assessment methods at the international level for the quantification of the environmental impact of a product or a process. It assesses, in a systematic way, the environmental aspects and potential environmental impacts throughout a product's life cycle from raw material acquisition through production, use, end-of-life treatment, recycling and final disposal.

References

- Stoppato A., Benato A., De Vanna F. (2021), Environmental impact of energy systems integrated with electrochemical accumulators and powered by renewable energy sources in a life-cycle perspective, Applied Sciences, Volume 11, Issue 62.
- Stougie, L., Giustozzi, N., van der Kooi, H., Stoppato, A. (2018), Environmental, economic and exergetic sustainability assessment of power generation from fossil and renewable energy sources, International Journal of Energy Research 42(9), pp. 2916-2926.

Details

Duration: 12 hours
Academic Years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Examination: Attendance is required for at least 2/3 of the lecture hours. The final evaluation will be based on a report that describes how a basic LCA analysis performed in SimaPro has been performed.

Python for Numerical Heat Transfer Modeling and Building Physics

Lecturer

Dr. Enrico Prataviera, Department of Industrial Engineering, University of Padova

Topics

Despite the great rise of data-driven methods, physics-based modeling still represents a crucial tool for engineering Ph.D. students and researchers, as it represents a flexible and adaptable tool. This course aims to give an introduction and a practical guideline to transient heat transfer and building physics modeling through Python programming language.

References:

- Transition from MATLAB to Python, Enthought.
- ASHRAE Fundamentals. Incropera F., De Witt D. Fundamentals of Heat Transfer, John Wiley & Sons.

Details

Duration: 12 hours (3 credits)
Academic Years: 2024/25, 2025/26
Language: English
Examination: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on the discussion of a case study within the individual PhD project.

Statistics for Engineers

Lecturers

Prof. Luigi Salmaso, Prof. Rosa Arboretti, Prof. Marta Disegna, Prof. Livio Corain, University of Padova

Topics

Statistical methods for engineering, data analysis, design of experiments, machine learning (supervised/unsupervised), with practical applications in MINITAB and R

References

- Stark, P.B., 1997. SticiGui: Statistics Tools for Internet and Classroom Instruction with a Graphical User Interface.
- Montgomery DC, Design and Analysis of Experiments, 2010, Wiley.
- Lattin J, Carroll JD, Green PE, Analyzing Multivariate Data, 2003, Duxbury Applied Series.
- Johnson RA, Wichern DW, Applied Multivariate Statistical Analysis,1998, Prentice Hall. 4th edition.
- Hollander and Wolfe, Nonparametric Statistical Methods, 2nd edition, 1999, Wiley Series in Probability and Statistics.
- Shumway RH, Stoffer DS, Time Series Analysis and Its Applications (With R Examples), 2nd Edition, 1998, Springer Texts in Statistics, NewYork.
- Everitt, B. S., Landau, S., Leese, M., & Stahl, D. (2011). Cluster analysis (Fifth ed.). Wiley series in probability and statistics: John Wiley & Sons, Ltd.

Details

Duration: 40 hours
Academic Years: 2023/24, 2024/25, 2025/26
Language: English
Evaluation: Attendance (2/3 required), case study discussion

Smart Technologies for the Sustainability of the Food Chain

Lecturers

Ing. Silvia Minetto, Ing. Antonio Rossetti, Ing. Francesco Fabris, CNR-ITC

Topics

Technologies for the sustainability of the food chain: integration, interaction and optimization of energy flows within and between food chain sectors, energy efficiency and improved preservation conditions. Refrigeration systems and heat pumps working with natural refrigerants. State-of-the art technologies in commercial refrigeration and in transport refrigeration and last mile delivery. Field monitoring, control and management, field data processing. Experience with a CO2 unit for transport refrigeration at thermal-fluid dynamic lab at CNR-ITC.

References

- IEA, HPT Annex 58, 2023 Report no. HPT-AN58-2 High-Temperature Heat Pumps-Task 1 – Technologies-Task Report
- Fabris, F, Fabrizio, M., Marinetti, S., Rossetti, A., Minetto, S., 2024. Evaluation of the carbon footprint of HFC and natural refrigerant transport refrigeration units from a life-cycle perspective. International Journal of Refrigeration Volume 159, Pages 17 – 27 March 2024
- F. Fabris, P. Artuso, S. Marinetti, S. Minetto, A. Rossetti, 2021. Dynamic modelling of a CO2 transport refrigeration unit with multiple configurations. Applied Thermal Engineering, Vol. 189
- MultiPACK -H2020 No 723137, 2021 Demonstration of the next generation standardised integrated cooling and heating packages for commercial and public buildings based on environment-friendly carbon dioxide vapour compression cycles- Deliverable D4.7-Technical Report on verified supermarket packs
- Selvnes, H., Jenssen, S., Alexis Sevault,A., Widell,K.N., Ahrens, M.U., Ren, S., Hafner, A.2022 Integrated CO2 refrigeration and heat pump systems for dairies. 15th IIR-Gustav Lorentzen conference on Natural Refrigerants | June 13-15 | Trondheim, Norway
- ENOUGH- European Food Chain Supply to reduce GHG emissions by 2050- PROJECT NO: 101036588, 2023 Deliverable D1.1 A model for calculating emissions from food

Details

Duration: 16 hours
Academic Years: a.y. 2024/25, a.y. 2026/27
Language: English
Examination: Attendance is required for at least 2/3 of the lecture hours. Final evaluation based on the analysis and discussion of a case study.

Stochastic and Gradient Methods for Single- and Multi-Objective Optimization

Lecturers

Prof. Francesco Lucchini, Prof. Riccardo Torchio, Department of Industrial Engineering, University of Padova

Topics

Numerical optimization is a powerful method aimed at improving a given objective function by acting on a set of parameters called design variables. This approach holds significant importance in engineering scenarios to increase the performance of a device by modifying, for example, its geometric parameters corresponding to the design variables. However, when dealing with complex problems featuring numerous parameters and objective functions, relying solely on a "try-and-catch" approach becomes impractical for identifying the optimal configuration. In this short course, the main approaches to perform single- and multi-objective optimizations will be presented. Specifically, stochastic and gradient-based techniques will be discussed, and basic implementations of the algorithms in MATLAB language will be presented.

References

- Kennedy, J., & Eberhart, R. (1995, November). Particle swarm optimization. In Proceedings of ICNN'95-international conference on neural networks (Vol. 4, pp. 1942-1948). IEEE.
- Storn, R., & Price, K. (1997), Differential evolution-a simple and efficient heuristic for global optimization over continuous spaces. Journal of global optimization, 11, 341-359.
- Deb, K., Pratap, A., Agarwal, S., & Meyarivan, T. A. M. T. (2002). A fast and elitist multiobjective genetic algorithm: NSGA-II. IEEE transactions on evolutionary computation, 2002, 6(2), 182-197.
- Bendsoe, M. P. & Sigmund, O. (2013). Topology optimization: theory, methods, and applications. Springer Science & Business Media.

Details

Duration: 5 h
Academic Years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Examination: Attendance is required for at least 2/3 of the lecture hours. The final evaluation will be based on the code implemented during the course.

Technological Advancements in Electromobility

Lecturer

Prof. Manuele Bertoluzzo, Department of Industrial Engineering, University of Padova

Topics

First lesson deals with the conventional battery chargers for electric vehicles. Second lesson deals with the working principles of wireless power transfer systems (WPTSs). Third lesson gives a detailed description of the characteristics of a WPTS with series-series compensation. Fourth lesson consists in a demonstration of the functioning of a prototypal WPTS.

References

- Slides, selected papers

Details

Duration: 4 lessons of two hours each
Academic Years: a.a. 2024/25
Language: English
Examination: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on: oral questions.

The Role of Energy Storage Technologies and Waste Heat Recovery Units in the Transition to a Future Sustainable Energy System

Lecturer

Prof. Alberto Benato, Department of Industrial Engineering, University of Padova
Email: alberto.benato@unipd.it

Topics

To move towards a sustainable power generation system, there is a need to properly use the energy produced by renewable energy plants, as well as to better exploit each source of waste heat. To do that, the point is to have access to energy storage technologies and waste heat recovery units as well as to be able to integrate them into more complex energy systems. The idea is to build up hybrid energy systems in which renewable and fossil-based plants, energy storage systems, and waste heat recovery units work in synergy to supply electricity, heat, cold, water, and fuels (e.g., hydrogen, biogas, biomethane, etc.) in the most effective mode.
In this context, the first objective of the COURSE is to present and classify the energy storage technologies and the waste heat recovery units as well as to define the concept and working principle of the hybrid system.
After that, attention will be paid to the design of the storage technologies and the waste heat recovery units.
In particular, for the storage units, the focus will be on the mechanical and thermal energy storage technologies and will consider the thermodynamic cycles, the up-to-date ways of construction, and the economic aspects. In this way, the technologies will not be analysed only as black-box storage devices, but considering, e.g., the thermodynamic cycles themselves allowing the conversion of electricity into heat during the charging phase and the conversion of heat into electricity during the discharge process. In addition to that and according to the needs of the grid or the renewable plant, different reference cycles and configurations will be presented, as well as their control strategies.
In a similar way, the waste heat recovery units will be presented taking into account the thermodynamic, the economic, and the technical point of view.
After the technology overview, they will be compared on the basis of technical, economic, and environmental indexes.
Finally, being storage and waste heat technologies fundamental to boost energy efficiency and spread renewable plants, the benefits of inserting all of them into a unique hybrid system will be presented in conjunction with optimisation techniques able to take into account not only the requested fluxes (electricity, heat, cold, etc.) but also the specific features of each technology. In this manner, the most suitable hybrid system configuration can be designed.

References

- Redjeb Y, Kaabeche-Djerafi K., Stoppato A., Benato A. (2021), “The IRC-PD Tool: A Code to Design Steam and Organic Waste Heat Recovery Units”, Energies, 14(18), 5611.
- Cavazzini G., Pavesi G., Ardizzon G. (2018), “A novel two-swarm based PSO search strategy for optimal short-term hydro-thermal generation scheduling”, Energy Conversion and Management, 164, 460-481.
- Benato A. and Stoppato A. (2018), “Pumped Thermal Electricity Storage: A technology overview”, Thermal Science and Engineering Progress, Vol. 6, pp. 301–315.

- Benato A. and Stoppato A. (2018), “Energy and cost analysis of an Air Cycle used as prime mover of a Thermal Electricity Storage”, Journal of Energy Storage, Volume 17, June 2018, Pages 29–46.
- Benato A. (2017), “Performance and Cost Evaluation of an Innovative Pumped Thermal Electricity Storage Power System”, Energy, Volume 138, 1 November 2017, Pages 419-436
- Stoppato A. and Benato A. (2017), “The Importance of Energy Storage”. World Scientific Series in Current Energy Issues, Energy Storage - Volume 4, Pages: 1-26, Marcus Enterprise LLC, USA & University of South Carolina, USA.
- Pezzuolo A., Benato A., Stoppato A., Mirandola A. (2016), “The ORC-PD: A versatile tool for fluid selection and Organic Rankine Cycle unit design”, Energy, Volume 102, 01 May 2016, Pages 605-620.
- Benato A., Stoppato A., Mirandola A. (2016), “Renewable Energy Conversion and Waste Heat Recovery Using Organic Rankine Cycles”, Edited Book “Renewable Energy Systems”. Published by Nova Science Publishers, USA, 1 January 2016.
- Destro, N., Benato, A., Stoppato, A., Mirandola, A. (2016), “Components design and daily operation optimization of a hybrid system with energy storages”, Energy, 2016, 117, pp. 569–577.
- Cavazzini, G. and Dal Toso, P. (2015), “Techno-economic feasibility study of the integration of a commercial small-scale ORC in a real case study”, Energy Conversion and Management, 99, 161-175.
- Pérez-Díaz, J. I., Chazarra, M., García-González, J., Cavazzini, G., Stoppato, A. (2015), “Trends and challenges in the operation of pumped-storage hydropower plants”, Renewable and Sustainable Energy Reviews, 44, 767-784.
- Ardizzon, G., Cavazzini, G., Pavesi, G. (2014), “A new generation of small hydro and pumped-hydro power plants: Advances and future challenges”, Renewable and Sustainable Energy Reviews, 31, 746-761.

Details

Duration: 24 hours
Academic Years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: English
Examination: Attendance is required for at least 2/3 of the lecture hours. The final evaluation will be based on the discussion of a case study proposed during the course.

Tutela della Proprietà Intellettuale

Lecturer

Prof. Luca Giove, Department Ingegneria Industriale, University Padova

Topics

Introduction to the legislation applicable to patents, utility models and trade secrets with a focus on patents (patentable items, criteria for patentability, process for granting, ownership and circulation of patent rights, enforcement of patent rights).

References

- VANZETTI – DI CATALDO, Manuale di diritto industriale, Giuffré (2021), pp. 375-500.
- Slides prepared by the lecturer to be provided to students.

Details

Duration: 8 hours
Academic Years: a.a. 2024/25, a.a. 2025/26, a.a. 2026/27
Language: Italian
Examination: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on: written questionnaire with open questions.

Yield Criteria for Polymer Materials

Lecturer

Prof. Mauro Ricotta, Department of Industrial Engineering, University of Padova

Topics

Introduction to polymer materials. Stress-strain curve. Tensile and compressive static tests according to International Standards. Macroscopic and microscopic yielding: damage mechanisms. Definition of multiaxial stress state: octahedral normal and tangential stress components. Yield criteria for macroscopic yielding: Bauwens criterion, Raghava Caddel Yeh criterion. Yield criteria for microscopic yielding: Sternstein criterion. Strain Energy Release Rate: definition, experimental evaluation according to the International Standards. The Bucknall criterion. Examples.

References

- Raghava et al, J Mater Science 1973
- Bucknall, Polymer 48, 2007

Details

Duration: 8 hours
Academic Years: a.a. 2024/25
Language: English
Examination: Attendance is required for at least 2/3 of the lecture hours. Final evaluation will be based on written questionnaire.

Interdisciplinary Courses

Public speaking

Lecturer

Francesca Trevisi, MoBI Human Training

Details

Area: Cognitive abilities
Competence: Creativity
Duration: 5 hours
ECTS credits: 1

Introduction to machine learning and artificial intelligence: methods and applications

Lecturer

Prof. Fabio Vandin

Details

Area: Doing research
Competence: Perform scientific research
Duration: 10 hours
ECTS credits: 2

How not to submit a paper. Pressures, predators, preprints and other oddities scientific literature

Lecturer

Prof. Stefano Bagnasco

Details

Area: Doing research
Competence: Communicate to the broad public
Duration: 3 days
ECTS credits: 3

Funding opportunities for Postdocs with a focus on MSCA-PF/Strategies and tools for Career Development in Research: The new European Charter for Researchers, Euraxess, International Foundations

Lecturer

Dott.ssa Viviana Gialain

Details

Area: Managing research
Competence: Mobilize resources
Duration: 9 hours
ECTS credits: 1,5

Science communication and knowledge valorization: practices and tools

Lecturer

Ufficio Public Engagement e VIU

Details

Area: Managing research tools
Competence: Promote citizen science
Duration: 20 hours
ECTS credits: 2 CFU: module 1 + module 2
1,5 CFU: module 1 + Keynote + 2 labs
1 CFU: module 1 + Keynote

Research, Intellectual Property and Exploitation: the PhD perspective

Lecturer

Ufficio Public Engagement e VIU

Details

Area: Managing research tools
Competence: Manage intellectual property rights
Duration: 5 hours
ECTS credits: 1

Introduction to big data science: methods and tools

Lecturer

Prof. Melucci, dott. Di Buccio, University of Padova

Details

Area: Managing research tools
Competence: Manage research data
Duration: 7 hours
ECTS credits: 1

Introduction to big data science: methods and tools

Lecturer

Prof.ssa Rafaghelli, Dott.ssa Zorzi - SBA

Details

Area: Managing research tools
Competence: Manage research data
Duration: 13 hours
ECTS credits: 2

The impact of my research: bridging knowledge to people needs

Lecturer

Settore qualità della terza missione e fondi strutturali

Details

Area: Making an impact
Competence: Increase the impact of Science on Policy and Society
Duration: 10,5 hours
ECTS credits: 2
