Corso di Dottorato in Industrial Engineering
Università degli Studi di Padova

Piano formativo 2021/22

Ph.D. students are required to register for the courses listed above by using the Moodle platform at https://elearning.unipd.it/dii/course/index.php?categoryid=230
and going to the page dedicated to the specific course they want to attend.
If a Ph.D. student has registered himself/herself for a course and then decides to not attend it anymore, he/she is warmly invited to inform the professor that he/she won't be present at the lessons.
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.

Advanced methods for fatigue design

Lecturer:
Prof. Giovanni Meneghetti, Department of Industrial Engineering, University of Padova
giovanni.meneghetti@unipd.it
Dr. Alberto Campagnolo, Department of Industrial Engineering, University of Padova
alberto.campagnolo@unipd.it

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.

Language of the course: English

Timetable:
Duration of the course: 8 hours
Schedule: 18 February 2022, from 9:00 to 18:00 (8 hours)
Location: M4 classroom, Department of Industrial Engineering, Viale Colombo 5, Padova.
Room “B Polo Meccanico”, Department of Industrial Engineering, Viale Colombo 5, Padova.

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on a case study.

Bibliographic Resources and Research Tools for Ph.D. Students in Industrial Engineering

Staff: Engineering librarians

Workshop plan: December 2021 – January 2022

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
Scholarly Communication - Open Access - Open Data
Bibliometric indicators: quality measurements of scientific publication

2nd Module
Face-to-face course (2 hours)
Workshop to improve bibliographic research with tools and resources in the Digital Library of the University of Padova.
Engineering, Economics, Management databases (BSP, IEEE, Engineering Village, Reaxys)
Citation databases: Scopus (Elsevier), Web of Science (ISI).
Author's rights and PhD Thesis
Basics of reference management software.

Registration:
Course registration is necessary.
Classroom to be determined.

Minimum attendance requirements and final test:
Attendance is necessary.
Online module gives 1 training credit and is required for attending the face-to-face module.
Face-to-face course gives 1/2 training credit.
Tests after online course and after face-to-face course.
The participation will be confirmed through the execution of a **final test**.

Additional information:
The course is organized for Industrial Engineering PhD students, but the registration is free for every PhD Student.
For any further information or for problems with the on-line module, feel free to contact us at: **biblio.inge@unipd.it**

Bioelectromagnetics

Lecturer:

Dott. Elisabetta Sieni, Dipartimento di Scienze Teoriche e Applicate, Università dell'Insubria
elisabetta.sieni@uninsubria.it

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 environment. Measurements of the intensity of the magnetic field at low frequency.
Effects of electric, magnetic and electromagnetic field 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:

Research papers and book chapters will be provided during the course.

Timetable:

8 hours

27th April 2022: 9:00 – 13:00
4th May 2022: 9:00 – 13:00

The course will be held on line
See the Moodle page of the course for actual dates and delivery mode

Examination:

Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on a multiple choice questionnaire.

Collaborative robotics: the future of smart manufacturing

Lecturer: Bottin Matteo
Department of Industrial Engineering, University of Padova
Email: matteo.bottin@unipd.it

Topics:
Collaborative robots: market demand and regulations
Examples of collaborative robots, types of collaborative applications
Collaborative robots vs. industrial robots
Throughput of collaborative applications: influence of task allocation, workspace dimensions, and product characteristics
Multi-robot and multi-operator applications
Group project: case study (2 hours)

References:
[1] International Federation of Robotics, press conference (2020)
[2] UNI EN ISO 10218-1:2012 - Robot e attrezzature per robot - Requisiti di sicurezza per robot industriali - Parte 1: Robot
[3] UNI EN ISO 10218-2:2011 - Robot e attrezzature per robot - Requisiti di sicurezza per robot industriali - Parte 2: Sistemi ed integrazione di robot
[4] Faccio, M., Bottin, M., & Rosati, G. (2019). Collaborative and traditional robotic assembly: a comparison model. *The International Journal of Advanced Manufacturing Technology*, *102*(5), 1355-1372.
[5] Faccio, M., Minto, R., Rosati, G., & Bottin, M. (2020). The influence of the product characteristics on human-robot collaboration: a model for the performance of collaborative robotic assembly. *The International Journal of Advanced Manufacturing Technology*, *106*(5), 2317-2331.
[6] Boschetti, G., Bottin, M., Faccio, M., & Minto, R. (2021). Multi-robot multi-operator collaborative assembly systems: A performance evaluation model. *Journal of Intelligent Manufacturing*, *32*(5), 1455-1470.
[7] Matheson, E., Minto, R., Zampieri, E. G., Faccio, M., & Rosati, G. (2019). Human–robot collaboration in manufacturing applications: a review. *Robotics*, *8*(4), 100.
[8] Cohen, Y., Shoval, S., Faccio, M., & Minto, R. (2021). Deploying cobots in collaborative systems: Major considerations and productivity analysis. *International Journal of Production Research*, 1-17.
[9] Colgate, J. E., Edward, J., Peshkin, M. A., & Wannasuphoprasit, W. (1996). Cobots: Robots for collaboration with human operators.
[10] Bi, Z. M., Luo, C., Miao, Z., Zhang, B., Zhang, W. J., & Wang, L. (2021). Safety assurance mechanisms of collaborative robotic systems in manufacturing. *Robotics and Computer-Integrated Manufacturing*, *67*, 102022.

Language of the course: English

Timetable:
Duration of the course: 8 hours
Schedule: second semester, single day
Location: Department of Industrial Engineering
See the Moodle page of the course for actual dates and delivery mode

Examination:
Attendance is required for at least 2/3 of the lecture hours and for the group project.
Final evaluation will be based on: group project on a real case application

Coupled electrical-thermal-structural Finite Element Analyses

Lecturers:
Prof. Giovanni Meneghetti, Dipartimento di Ingegneria Industriale, Università di Padova
giovanni.meneghetti@unipd
Eng. Mattia Manzolaro, Laboratori Nazionali di Legnaro, Istituto Nazionale di Fisica Nucleare
mattia.manzolaro@lnl.infn.it

Topics:
Course overview and introduction. General aspects of Finite Element analyses. Structural analyses. Thermal analyses. Thermal-structural analyses. Electrical-thermal analyses. Electrical-thermal-structural analyses.

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.

Timetable:
12 hours
(subject to changes - check the Calendar of the School for actual dates and room)
Lecture 1: June 8th, 2022, from 14:00 to 18:00 (4 hours)*
Lecture 2, June 9th, 2022, from 14:00 to 18:00 (4 hours)*
Lecture 3, June 10th, 2022, from 14:00 to 18:00 (4 hours)*

*Aula A del POLO MECCANICO, Department of Industrial Engineering, University of Padova, via Venezia, 1 – Padova

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on a case study developed during the lectures.

Eco-informed Materials Choice

Lecturer:
Dr. Hamada Elsayed, Dipartimento di Ingegneria Industriale
hamada.elsayed@unipd.it

Topics:
Introduction to materials selection. Material property charts.
The materials life cycle.
Eco-data: values, sources, precision
Eco-audits and eco-audit tools. Case studies.
Strategies for eco-informed materials selection

References:
http://www.grantadesign.com/news/archive/Ashbycharts.htm
M.F. Ashby, Materials and the Environment, Butterworth Heinemann, Oxford, UK
M.F. Ashby, Materials Selection in Mechanical Design, Butterworth Heinemann, Oxford, UK

Timetable:
12 hours

25/05/2022	9.00-13.00
30/05/2022	9.00-13.00
03/06/2022	9.00-13.00

Sala Riunioni 2 Piano complesso Ex Fisica Tecnica
Dipartimento di Ingegneria Industriale
Via Marzolo 9, Padova.

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on a written questionnaire.

Ecotoxicology as an heuristic approach to environmental engineering

Lecturer:

Prof. Luca Palmeri, Dipartimento di Ingegneria Industriale, Università di Padova
lpalmeri@unipd.it

Topics:

Main objectives :
To organize knowledge, based on explanatory principles, about chemicals in the biosphere and their effects. To develop and apply methods and decision tools (ecotox models, LCI, Risk analysis, etc.) to acquire a better understanding of chemical fate and effects in the biosphere.
To use biomonitoring: use of organisms to monitor contaminations and to imply possible effects to biota or sources of toxicants to humans;
To be critical in environmental decisions. To use your ecotoxicology-knowledge in different fields (work safety, health aspects in confined spaces, etc.)
Program : 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
An 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. 2002. Fundamentals of ecotoxicology, 2nd Edition. CRC/Lewis Press, Boca Raton, FL.

Timetable:

12 hours
See the Moodle page of the course for actual dates and delivery mode

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.

Entrepreneurship and Technology-based Startups

Lecturers: Prof. Moreno Muffatto, Ing. Francesco Ferrati, Dipartimento di Ingegneria Industriale, Università degli Studi di Padova

e-mail: moreno.muffatto@unipd.it, francesco.ferrati@unipd.it

Topics:

Entrepreneurship

- Entrepreneurship and Entrepreneurial attitudes
- Entrepreneurship vs Management
- What is a technology based startup
- Venture creation: different options

The team and the early decisions

- The creation of the founders' team
- Types and characteristics of founders' teams
- Founders' decisions and their consequences
- Frequent mistakes and suggestions deriving from experience

From the idea to the market

- Innovation: technologies and markets
- Market size
- Customers profiles
- Value proposition
- Development of the product/service concept

Intellectual Property Rights

- Types of IPR (patent, copyright, trademark)
- The structure of a patent application (description, claims, etc)
- Getting a patent: the patenting process (step by step)
- When to file a patent application: priority date, Patent Cooperation Treaty (PCT)
- Where to protect an invention
- Different IPR strategies

Business Models

- Business models case studies
- Successful and problematic business models
- Revenue streams
- Cost of Customer Acquisition

The economic and financial aspects of a startup

- The financials of a startup
- The structures of the financial statements
- Income Statement
- Balance Sheet
- Cash Flow Statement
- Evaluation of the value of the company

Funding a startup

- New ventures' funding options

- Different sources of funds: Angel Investors and Venture Capital
- Investment companies and funds: how they work
- How and what investors evaluate
- How to present a business idea to investors

References:

- Noam Wasserman (2013) *The Founder's Dilemmas: Anticipating and Avoiding the Pitfalls That Can Sink a Startup*, Princeton University Press.
- 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, pp. 1-22.

Schedule and room: See the Moodle page of the course for actual dates and delivery mode

Hours: 20

12 January 2022,	9:30 – 12:30
19 January 2022,	9:30 – 12:30
26 January 2022,	9:30 – 12:30
2 February 2022,	9:30 – 12:30
9 February 2022,	9:30 – 12:30
16 February 2022,	9:30 – 12:30
2 March 2022,	9:30 – 12:30

Examination and grading:
Attendance is required for at least 70% of the lecture hours (i.e. 14 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. Andrea Diani, Department of Industrial Engineering, University of Padova
andrea.diani@unipd.it (4 hours)
Dr. Marco Azzolin, Department of Industrial Engineering, University of Padova
marco.azzolin@unipd.it (4 hours)
Dr. Arianna Berto, Department of Industrial Engineering, University of Padova
arianna.berto@unipd.it (4 hours)

Topics:
Measurements of pressure, temperature and flow rate. (2 hours)
Thermocouples: theory and experimental calibration (2 hours).
Uncertainty in measurements: theory and practice (2 hours).
Experimental temperature and flow rate measurements during two-phase flow (2 hours).
Introduction to the experimental measurement of the heat transfer coefficient. (1 hour).
Measurements of solar radiation and concentrated solar flux (3 hours).

References:
GUM: Guide to the Expression of Uncertainty in Measurement.
http://www.bipm.org/en/publications/guides/gum.html
Termodinamica applicata, A. Cavallini, L. Mattarolo, 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.

Language of the course: English

Timetable:
12 hours

Tuesday, 18th January 2022: h. 9:00-13:00
Wednesday, 19th January 2022: h. 9:00-13:00
Tuesday, 25th January 2022: h. 9:00-13:00

Aula Seminari, Department of Industrial Engineering, 3rd floor (building E) Via Venezia 1, Padova;
Laboratorio di Trasmissione del Calore in Microgeometrie
Department of Industrial Engineering (building E), Via Venezia 1 - Padova.

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on a home assignment.

Finite Element Method (FEM)

Lecturer:
Prof Giuseppe Gambolati, Dipartimento di Ingegneria Civile, Edile e Ambientale (DICEA), Università di Padova, gambo@dmsa.unipd.it

Topics:
Introduction. Sparse linear systems of large size. Conjugate gradient like methods for symmetric positive definite matrices. Acceleration of convergence by preconditioning. Preconditioners. Computation of the smallest eigenvalues of symmetric eigenproblems. Outline of PDEs' of second order of elliptic, parabolic and hyperbolic type. Interpolation with piecewise polynomials. Linear, bilinear, biquadratic, bicubic, quadrilateral, serendipity and isoparametric finite elements. Variational principles. FEM (Finite Element Method). Variational approaches of Ritz and Galerkin. Weak formulations. Method of weigthed residuals. Non conforming elements and patch test. Integration in time by Finite Differences (FD). Stability analysis. Solution to sets of nonlinear equations

References:
Handouts from the lectures.
Giuseppe Gambolati and Massimiliano Ferronato, Lezioni di Metodi Numerici per Ingegneria, Progetto, 2° Ed., 571 pp, 2017.
Thomas J.R. Huges, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Prentice-Hall, 833 pp, 1987.
Myron B. Allen et al., Numerical Modeling in Science and Engineering, J. Wiley, 412 pp, 1988.
O.C. Zienkiewicz and R.L. Taylor. The finite element method. Fifth edition. Butterworth-Heinemann, Oxford (UK), 2000.

Timetable:32 hours

18 October 2021: 16:00 – 18:00
21 October 2021: 16:00 – 18:00
25 October 2021: 16:00 – 18:00
28 October 2021: 16:00 – 18:00
4 November 2021: 16:00 – 18:00
8 November 2021: 16:00 – 18:00
15 November 2021: 16:00 – 18:00
22 November 2021: 16:00 – 18:00
25 November 2021: 16:00 – 18:00
29 November 2021: 16:00 – 18:00
2 December 2021: 16:00 – 18:00
6 December 2021: 16:00 – 18:00
13 December 2021: 16:00 – 18:00
16 December 2021: 16:00 – 18:00
20 December 2021: 16:00 – 18:00
22 December 2021: 16:00 – 18:00

Venue: room M6, via Venezia 1

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on an oral examination.

Fundamentals of Materials Selection

Lecturer:
Dr. Hamada Elsayed; Dipartimento di Ingegneria Industriale
hamada.elsayed@unipd.it

Topics:
Introduction to materials selection.
Material property charts. Selection strategies
Material indices. Case studies in construction of materials indices.
Application of material property charts in simple materials selection and in the design of composite materials.
Introduction to shape factors. Combination of shape factors and materials indices, with case studies.
Strategies for selection with multiple constraints and objectives.

References:
http://www.grantadesign.com/news/archive/Ashbycharts.htm
M.F. Ashby, Materials Selection in Mechanical Design, Butterworth Heinemann, Oxford, UK
M.M. Farag, Materials and Process Selection for Engineering Design, CRC Press, Boca Raton, FL

Timetable:
12 hours

06/05/2022 9.00-13.00
11/05/2022 9.00-13.00
16/05/2022 9.00-13.00
Sala Riunioni 2 Piano complesso Ex Fisica Tecnica
Dipartimento di Ingegneria Industriale
Via Marzolo 9, Padova.

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on a written questionnaire.

Green Chemistry and Technology

Lecturers: Prof. Bertani Roberta (in charge)
Department *of Industrial Engineering*, University *of Padova*
Email: *roberta.bertani@unipd.it*

Prof. Paolo Sgarbossa
Department *of Industrial Engineering*, University *of Padova*
Email: *paolo.sgarbossa@unipd.it*

Prof. Keti Vezzù
Department *of Industrial Engineering*, University *of Padova*
Email: *keti.vezzu@unipd.it*

Dr. Gioele Pagot
Department *of Industrial Engineering*, University *of Padova*
Email: *gioele.pagot@unipd.it*

Prof. Alessandro Scarso
Department *of Molecular Sciences and Nanosystems*, University *of Venice Ca' Foscari*
Email: *alesca@unive.it*

Dr. Giuseppe Guercio
Lundbeck Italia
Email: *GUER@lundbeck.com*

Topics:
The aim of the course is to cover the various aspects of a new way of looking at and designing industrial chemical processes that goes by the name of green chemistry or sustainable chemistry.

References:
The lecturers will provide them to the enrolled students.

Language of the course: English

Timetable:
Duration of the course: *14 hours.*
Schedule: *to be defined* (approximately June-July 2022).
Location: *to be defined*.
See the Moodle page of the course for actual dates and delivery mode

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on: *Students will be asked to carry out a study on a specific aspect or process among those treated. The essay (in English) will be submitted and discussed on a date to be agreed by the end of September*.

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Introduction to numerical methods for unsteady gasdynamics

Lecturer: Ing. *Francesco De Vanna*, PhD, Department *of Industrial Engineering*, University *of Padova*, *francesco.devanna@unipd.it*

Topics:
Gasdynamics is the branch of fluid dynamics that studies the motion of gaseous systems. It is a tradition of introductory gas dynamics courses to detail the main effects of the motion of a compressible flow such as shock waves, nozzle and diffuser internal fluid dynamics and aerodynamics of airfoils affected by high Mach number conditions. It is always a tradition of introductory courses to develop such concepts in a steady-state path, that is, for flowing systems in which the temporal variability can be neglected. Usually this approximation may be sufficient at an applicative level. However, if the investigation of more complex phenomena such as turbulent wakes, interactions between shock waves and boundary layer, multiple interactions between shock waves is of interest, temporal dependency plays a primary role. The present course addresses the basics concerning the theory of the hyperbolic system of equations providing the minimal aspect of non-stationary phenomena inherent to compressible fluids.

1) Introduction to hyperbolic system of equations: the Euler equations of gasdynamics;
2) Theory of characteristics and its applications to conservative systems;
3) Introduction the Riemann problems. Jump relations and dynamical shock wave and expansion fans;
4) Application to a time-dependent gasdynamics problem: the shock tube.

The course will provide some basic notions of compiled programming languages with a focus on modern Fortran90 for high-performance computing.

References:
- *De Vanna F., Picano F., Benini E. "*A sharp-interface immersed boundary method for moving objects in compressible viscous flows*", Computer & Fluids (2020)*
- *Pirozzoli S. "*Numerical Methods for High-Speed Flows*",* Annual Review of Fluid Mechanics (2011)
- Toro E. F. "Riemann solvers and numerical methods for fluid dynamics: A practical introduction" (2009)

Language of the course: English

Timetable:
Duration of the course: *8 hours* (check the calendar for actual dates)
Actual dates to be defined
See the Moodle page of the course for actual dates and delivery mode

Examination:
Attendance is required for at least 2/3 of the lecture hours while final evaluation is based on an oral discussion about the course contents.

Life Cycle Assessment: fundamentals and applications

Lecturers:

- Alberto Benato - Department of Industrial Engineering - University of Padova – alberto.benato@unipd.it
- Anna Stoppato - Department of Industrial Engineering - University of Padova – anna.stopato@unipd.it

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.
The National Risk Management Research Laboratory of the United States Environmental Protection Agency, stated that "LCA is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service, by:

- Compiling an inventory of relevant energy and material inputs and environmental releases.
- Evaluating the potential environmental impacts associated with identified inputs and releases.
- Interpreting the results to help you make a more informed decision."

Therefore, LCA is a technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. In practice, the associated environmental impacts are evaluated with a cradle-to-grave or cradle-to-cradle approach. This investigation technique guarantees to go beyond the geographical boundaries of the production process and to assess the impacts throughout the "value chain", such as those associated with emissions due to the entire energy and materials supply chain as well as construction, operation and decommissioning phases of plants.
Then, LCA information can be used to improve processes, support policy, and provide a sound basis for informed decisions.

During the Ph.D. course lessons, the four stages of the LCA will be presented following the specifications stated on the standards ISO 14040 and 14044:

- Goal and scope.
- Inventory analysis.
- Impact assessment.
- Interpretation.

The most used and complete models and methods for the impact assessment and updated databases for the Inventory analysis will be presented. The use of LCA for the environmental labels system will be analyzed.
The course focuses on the assessment of energy systems and the energetic aspects; for this reason, the proper evaluation of the reference system for the electricity and heat production will be deepened.
Several examples of LCA will be presented with the aim of understanding the importance of:

- The functional unit.
- The system boundaries.
- Any assumptions and limitations.
- Data quality requirements.
- The allocation methods.
- The impact categories.
- Etc..

Finally, the code SimaPro, a professional tool to collect, analyze and monitor the sustainability performance data of products, services, etc., will be presented and used to conduct a Life Cycle Analysis of a Renewable Plant.

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.
- Stoppato A. and Benato A. (2020), "Life cycle assessment of a commercially available organic Rankine cycle unit coupled with a biomass boiler", Energies 13(7),1835.
- Cavallin Toscani A., Stoppato A., Benato A. (2019), "LCA of a concert: Evaluation of the Carbon footprint and of Cumulative energy demand", ECOS 2019 - Proceedings of the 32nd International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems pp. 3203-3213.
- Fantinato, D., Stoppato A., Benato A. (2019), "LCA analysis of a low-energy residential building", ECOS 2019 - Proceedings of the 32nd International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems pp. 3153-3165.
- 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.
- Stoppato A. (2008), "Life cycle assessment of photovoltaic electricity generation", Energy 33(2), pp. 224-232.

Timetable: 12 hours (subject to changes - check the Calendar of the School for actual dates)

Lesson 1: September 9, 2022 – From 9:00 to 13:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

Lesson 2: September 16, 2022 – From 9:00 to 13:00 – Sala Riunioni Grande Corpo A e Aula A del Polo Meccanico, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

Lesson 3: September 23, 2022 – From 9:00 to 13:00 – Sala Riunioni Grande Corpo A e Aula A del Polo Meccanico, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

See the Moodle page of the course for actual dates and delivery mode

Examination:

Attendance is required for at least 2/3 of the lecture hours while final evaluation is based on an oral examination.

Optimization methods for Sustainable Energy Technologies in Buildings

Lecturer: Jacopo Vivian, PhD
Department of Industrial Engineering, University of Padua
Email: *jacopo.vivian@hotmail.com*

Topics: Heating and cooling of buildings accounts for up to 40% of energy use and 20% of greenhouse gas emissions. The ongoing electrification of the heating sector via electric heat pumps, the refurbishment of existing buildings to low-energy standards and the increasing penetration of renewable sources will severely affect the patterns of power supply and consumption in the electrical distribution systems. In this context, the optimal use of energy in buildings will play an important role to maximize the energy efficiency at system level without affecting the comfort of the users. This course will focus on different optimization methods that can be used both for design and operation of HVAC systems in buildings. During the course some examples will be provided about real applications and Matlab code will assist students in the development of their own case-study, that will be openly discussed at the end of last lecture. The lectures will cover the following topics:

- Introduction to optimization: definition and concepts, optimality criteria for constrained and unconstrained problems, methods for nonlinear problems, examples using steepest descent, fminunc, fmincon.
- Optimization applied to energy systems: design, operation and synthesis, the process of problem formulation, a design optimization example.
- Linear programming and mixed integer linear programming (MILP): A design optimization example using MILP; a control optimization example using MILP
- Introduction to metaheuristics: Particle Swarm Optimization (PSO) and other algorithms, examples using PSO
- Some concepts about optimization in buildings: energy flexibility sources, demand response and other services, presentation of a BEMS based on different optimization methods
- Final overview on optimization methods and short presentations about cases of study

References:

- Ravindran, K. M. Ragsdell and G. V. Reklaitis. Engineering Optimization: Methods and Applications, 2nd ed. © 2006 John Wiley & Sons, Inc. ISBN: 978-0-471-55814-9
- Yang, X-S. Nature-Inspired Optimization Algorithms. Elsevier (2014) ISBN 978-0-12-416743-8.

Language of the course: English

Timetable:
Duration of the course: *16 hours (4 CFU) divided in 5 lectures (3 hours each) + 1 hour for presentations/discussion (subject to changes depending on the number of participants)*
Schedule: *February 2022*
Location: *to be defined*
See the Moodle page of the course for actual dates and delivery mode

Examination:
Attendance is required for at least 3/4 of the lecture hours. Final evaluation will be based on a short presentation/discussion of a case study related to the individual PhD project.

Powder flowability

Lecturer:
Prof. Santomaso Andrea
Department of Industrial Engineering, University of Padua
Email: andrea.santomaso@unipd.it

Topics:
The course presents the basic knowledge and fundamental concepts that are 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 assessment 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 for flow (Jenike analysis).

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.

Language of the course: English

Timetable:
Duration of the course: 8 hours
Schedule: July 2022
Location: to be defined

See the Moodle page of the course for actual dates and delivery mode

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on an oral examination.

Reactive Fluid Mechanics

Lecturer:
Prof. Paolo Canu Dipartimento di Ingegneria Industriale, Università di Padova
paolo.canu@unipd

Topics:
The course aims at critically and 'experimentally' analyze the role of chemical reactions in single-(homogeneous) and multi-(heterogeneous) phases configurations, with real examples. The focus is on the mutual interplay among temperature, composition and flow distribution in several industrially relevant processes.
The course addresses the following topics

- Review of the essential of non-reactive, isothermal, incompressible flow field computation and coupled effects.
- The prediction of temperature distribution in convective, unreactive flows. The variable density case, including buoyancy (subsonic flows). Mixing.
- Homogeneous and heterogeneous reactions: concepts, examples, implementation, effects.
- The specific case of porous materials.

The course is based on a few introductory lessons and mostly hand-on applications, with direct use of a commercial code (Comsol Multiphysics).
The course will be on-line, using personal computers and temporary licenses or remote access to the dept. computer rooms.
Some background in momentum-, heat-, and mass transfer fundamentals is useful.

References:

- Multiphase reacting flows: modelling and simulation, Marchisio D and Fox, R. (Eds.) Springer, 200
- Lanny D. Schmidt, "The Engineering of Chemical Reactions" 2nd Ed. Oxford Univ. Press, 2004
- "COMSOL Multiphysics Reference Manual, version 5.5", COMSOL, Inc, www.comsol.com

Language of the course: English

Timetable:
Duration of the course:12 hours
Schedule: The course will be organized as 3 sessions of 4 teaching hours (1.5h+1.5h) in 3 different days, November 10th, 17th, 24th, 2021.

Examination:
Attendance is required for all the course.
The final evaluation is based on the oral discussion of one of the case studies developed during the course or independently by the student, on a specific application of his/her interest.

Recycling of Copper, Zinc and Lead: advantages and problems.

Lecturer:
Prof. Katya Brunelli, Department of Industrial Engineering, University of Padova
katya.brunelli@unipd.it

Topics:
General aspects of recycling and of circular economy. Metallurgical process of production and recycling of copper. Advantages of recycling copper in comparison with the production starting from ores. Problems related to the recycling of copper. Classification of the copper scraps. General properties and use of lead. Recycling of lead battery: advantages and problems. General properties and use of zinc. Recovery of zinc from electric arc furnace dust: advantages and problems.

References:
The students registered for the course will receive the list of literature references
and the slides of lessons.

Timetable:
Duration of the course: 12 hours
Schedule:
27/05/2022 14.30-18.30
30/05/2022 16.30-18.30
06/06/2022 16.30-18.30
10/06/2022 14.30-18.30
Location: M5 classroom, Department of Industrial Engineering, Viale Colombo 5, Padova.

See the Moodle page of the course for actual dates and delivery mode

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on an oral exam.

Recycling of Precious Metals, Rare Earth Metal and Other Metals: advantages and problems

Lecturer:
Prof. Katya Brunelli, Department of Industrial Engineering, University of Padova
katya.brunelli@unipd.it

Topics:
General aspects of recycling and of circular economy. Critical raw materials. General properties and use of precious metals. Recovery of precious metals from electronic waste, and from catalytic converters. Advantages of recovery precious metals from wastes in comparison with the production starting from ores. General properties and use of rare earth metals, Advantages of recovery rare earth metals from wastes in comparison with the production starting from ores. General properties and use of other rare meta, Advantages of recovery rare earth metals from wastes in comparison with the production starting from ores. General properties of Silicon, Lithium, Gallium Indium and Tellurium. Advantages of recovery these metals from wastes in comparison with the production starting from ores. The issue of recycling Li-ion batteries and silicon PV panels.

References:
The students registered for the course will receive the list of literature references
and the slides of lessons.

Timetable:
Duration of the course: 20 hours
Schedule:
16/06/2022 14.00-18.00
17/06/2022 14.00-18.00
20/06/2022 14.00-18.00
23/06/2022 14.00-18.00
24/06/2022 14.00-18.00
Location: ICH 1 “I. Sorgato” classroom, Department of Industrial Engineering, Via Marzolo 9. Padova.
See the Moodle page of the course for actual dates and delivery mode

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on an oral exam.

Recycling of Steels and Aluminum Alloys: advantages and problems

Lecturer:
Prof. Katya Brunelli, Department of Industrial Engineering, University of Padova
katya.brunelli@unipd.it

Topics:
General aspects of recycling and of circular economy. Metallurgical process production and recycling of steels. Advantages of production of steel using scraps in comparison with the production starting from ores. Problems related to the recycling of steels. Classification of the steel scraps. Metallurgical process of production and recycling of aluminum. Advantages of production of aluminum using scraps in comparison with the production starting from ores. Problems related to the recycling of aluminum. Classification of the aluminum scraps.

References:
The students registered for the course will receive the list of literature references
and the slides of lessons.

Timetable:
Duration of the course: 16 hours
Schedule:
06/05/2022 14.30-18.30
09/05/2022 16.30-18.30
13/05/2022 14.30-18.30
16/05/2022 16.30-18.30
20/05/2022 14.30-18.30
Location: M5 classroom, Department of Industrial Engineering, Viale Colombo 5, Padova.

See the Moodle page of the course for actual dates and delivery mode

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on oral exam.

Research and Entrepreneurship: from scientific papers and IP to startup creation

Lecturer: Prof. *Fabrizio Dughiero*
Department *of Industrial Engineering*, University *of Padova*
Email: *Fabrizio.dughiero@unipd.it*

Topics:
The course aims to develop PhD candidates' ability to transform an idea, linked to a patent owned by our University, into a business model for a technological startup.
Intellectual property protection mechanisms, rights of university employees, private employees and freelancers. What is a startup, a spin-off and laws and regulations that govern its constitution and development. Funding sources. Intellectual property analysis proposed by the teacher and choice of patents on which to develop the team work.
Choice of the patent to be developed. Analysis of the technology, idea or business model underlying the patent. Setting up the analysis work using "design thinking" techniques. First report about planning of the work to be done.
Market and competition analysis. Introduction to the Business Model Canvas and compilation of the main parts of the Canvas. Preparation of a concise and effective draft business plan.
Preparation of the pitch to be presented to investors. Presentation session to other teams of the project work and discussion about strengths and weaknesses of business idea.

References:
Clayton M. Christensen: "The innovation Dilemma – when new technologies cause great firms to fail" Harvard Business Review Press
Steve Blank and Bob Dorf: "The startup Owner's Manual – the step by step Guide for building a Great Company -K&S Ranch Inc. Publishers
Some papers from HBR

Language of the course: English

Timetable:
Duration of the course: *24 hours divided into theoretical lectures and team work.*
Schedule: *three full days June-july.*
Location: *A room with at least four tables (Laboratory of Electroheat is available)*

See the Moodle page of the course for actual dates and delivery mode

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 related to the individual or team project*

Short overview on ceramic materials for energy applications - thermoelectricity and H_2 separation

Lecturer:
Dr Monica Fabrizio, ICMATE Padova, CNR
monica.fabrizio@cnr.it

Topics:
- Introduction to thermoelectricity: figure of merit, Seebeck coefficient, and thermal and electric conductivity. The role of thermoelectrics in the low carbon energy applications.
- Thermoelectric materials for medium-high working temperatures; polymeric thermoelectric materials for near-room temperature heat harvesting for micropower generation; brief notes on thermoelectric modules.
- Introduction to membrane technology, H transport, H permeation
- Dense ceramic membranes: proton conducting ceramics, MIEC, membrane architectures

References:
Before the start, the students registered for the course will receive the list of literature references and the slides of lessons.
The classes will be held on condition that almost 5 students registered.

Timetable:
10 hours
March – April 2022
on-line mode, the platform will be confirmed

See the Moodle page of the course for actual dates and delivery mode

After registration, the student can send the registration data to Dr. Monica Fabrizio monica.fabrizio@cnr.it

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on written questionnaire.

Statistics for Engineers

Course Area: Managerial Engineering, Information Engineering, Industrial Engineering, Civil and Environmental Engineering

Lecturers: Prof. Luigi Salmaso, University of Padova (coordinator), Prof. Rosa Arboretti, University of Padova, Prof. Marta Disegna, University of Padova.

e-mail: luigi.salmaso@unipd.it, rosa.arboretti@unipd.it, marta.disegna@unipd.it

Outline of lecture and lab: The course is structured into 2 on-campus lectures and a Summer School of 4 days. A total of 40 hours in-person course will be delivered.

The on-campus lectures will take place on Wednesday the 2nd February 2022 and Wednesday the 9th February 2022. Classes will take place in the morning, 9am to 1pm, and in the afternoon, 2pm to 4pm for a total of 6 hours per day.
The Summer School will take place in Villa San Giuseppe, Monguelfo, Bolzano province (https://www.villasangiuseppemonguelfo.com) from Tuesday the 28th June 2022 to Friday the 1st July 2022 for a total of 28 hours. The Summer school will start at 2pm on Tuesday and will finish at 4pm on Friday.

Villa San Giuseppe offer a full board accommodation and rooms are of different size. The cost of the Summer School is €150 (for the full board accommodation to be paid on site) for the entire period.

Aim: The course is an introduction to statistical methods most frequently used for experimentation in Engineering. Lectures are planned both in the classroom and in computer lab also for an introduction to the use of the following statistical software:

- R and Rstudio, both open-source software.
- MINITAB, licensed to University of Padova.

Topics:

1. Elements of univariate statistical methods:
    a. Elements of descriptive statistics: frequency, indices of synthesis (position, variability and shape) and graphical representations (histogram, boxplot, scatterplot).
    b. Elements of probability theory: discrete and continuous probability distributions.
    c. Elements of statistical inference: sampling distributions, point and interval estimation, hypothesis testing, One-way ANOVA.
2. Linear and non-linear regression models:
    a. Simple and multiple linear regression model
    b. Logit model

3. Multivariate data analysis:

    a. Cluster Analysis: idea and steps
    b. Multidimensional data, matrix representation and data preparation.
    c. Distance and dissimilarity matrices.
    d. Hard clustering algorithms: hierarchical clustering algorithms, non-hierarchical clustering algorithms and Bagged clustering algorithm.
    e. Fuzzy clustering algorithms: fuzzy C-means and fuzzy C-medoids.
    f. Validity indices and optimal number of clusters.
    g. Labelling and profiling the clusters: an application of suitable tests and regression models.

4. DOE: Introduction to Factorial Designs, Two level and general factorial designs. Tutorials in MINITAB.

Examination and grading: 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.

Sustainable Energy in Buildings

Lecturers:
Prof. Angelo Zarrella, Dipartimento di Ingegneria Industriale, Università di Padova
angelo.zarrella@unipd.it
Prof. Michele De Carli, Dipartimento di Ingegneria Industriale, Università di Padova
michele.decarli@unipd.it
Dr. Giuseppe Emmi, Dipartimento di Ingegneria Industriale, Università di Padova
giuseppe.emmi@unipd.it
Dr. Jacopo Vivian, Dipartimento di Ingegneria Industriale, Università di Padova
jacopo.vivian@unipd.it

Topics:
Efforts to reduce CO_2 emissions have become a pivotal environmental priority of this century. Buildings are responsible for about 40% of total energy consumption in Europe and similar values are also found in other countries. To decrease this value some of the open options are those of improving the quality of buildings' envelopes or of using energy-efficient heating and cooling technologies based on renewable energies. The current tendency when new constructions are being designed is to plan low or nearly zero energy buildings.
The course looks at the assessment of current and potential future energy systems in buildings, covering conversion, and end-use, with emphasis on meeting regional and global energy needs in a sustainable manner. Different renewable and conventional energy technologies will be presented and their attributes described within a framework that aids in evaluation and analysis of energy technology systems in the context of environmental goals. During the course modelling approaches, methods, simulation tools and instruments to evaluate the energy performance of buildings and indoor environmental quality will be also presented and used. During the course, the CoreCare Laboratory to evaluate the thermal comfort and indoor environmental quality will be also presented.

References:
ASHRAE Handbooks and Standards, AiCARR guidelines, international standards, examples of design of efficient buildings and systems.

Timetable:
12 hours
March-April 2022

See the Moodle page of the course for actual dates and delivery mode

Seminar Room, Third floor of building "Corpo E", via Venezia 1, Dipartimento di Ingegneria Industriale, Padova

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.

Technological Advancements in Electromobility

Lecturer:
Profs. Manuele Bertoluzzo and Giuseppe Buja, Department of Industrial Engineering, Università di Padova,
manuele.bertoluzzo@unipd.it, giuseppe.buja@unipd.it

Topics:
The course is divided into four 2-hour lessons. First lesson deals with the powertrains of the purely electric and hybrid vehicles. Second lesson deals with the energy storage devices on-board the electric vehicles. Third lesson deals with the infrastructures for the wired charging of the batteries of the electric vehicles. Fourth lesson addresses the wireless charging of the electric vehicles.

References:
Course notes (slides)

Timetable:
8 hours

17/05/2022 15.00-16:30
19/05/2022 15.00-16:30
24/05/2022 15.00-16:30
26/05/2022 15.00-16:30
Saletta "gialla" I Piano, Dip. di Ingegneria Industriale, Via Gradenigo 6a, Padova.

See the Moodle page of the course for actual dates and delivery mode

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on a colloquium.

Technologies for boosting energy efficiency and spreading renewable plants

Lecturers:

- Alberto Benato - Department of Industrial Engineering - University of Padova – alberto.benato@unipd.it
- Anna Stoppato - Department of Industrial Engineering - University of Padova – anna.stopato@unipd.it
- Giovanna Cavazzini - Department of Industrial Engineering - University of Padova – giovanna.cavazzini @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, bio-methane, etc.) in the most effective mode.

In this context, the first aim of the COURSE is to present and classify the energy storage technologies and the waste heat recovery units as well as to define the hybrid system concept and working principle.

After that, the attention will be paid on the design of the storage technologies and of 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 analyzed only as a black-box storage devices, but considering, e.g., the thermodynamic cycles itself 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 based on the grid or renewable plant's needs, 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 views.

After the technologies overview, they will be compared based on technical, economic, and environmental indexes.

Finally, being storage and waste heat technologies fundamental to boost energy efficiency and spreading renewable plants, the benefits of inserting all of them in a unique hybrid system will be presented in conjunction with optimization 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.

Timetable:

20 hours (subject to changes - check the Calendar of the School for actual dates)

Lesson 1: March 4, 2022 – From 9:00 to 13:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.
Lesson 2: March 11, 2022 – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.
Lesson 3: March 18, 2022 – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.
Lesson 4: March 25, 2022 – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.
Lesson 5: April 1, 2022 – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.
Lesson 6: April 8, 2022 – From 9:00 to 13:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

See the Moodle page of the course for actual dates and delivery mode

Examination:
Attendance is required for at least 2/3 of the lecture hours while final evaluation is based on an oral examination.

Tutela della proprietà intellettuale

Docenti:
Avv. Luca Giove - Libero professionista
Ing. Gianluigi Zanettin - Patent Attorney, Jacobacci & Partners Spa
Personale interno – Ufficio valorizzazione della ricerca, Università di Padova

Programma:
1. La tutela dell'innovazione tecnologica: brevetti, modelli di utilità, altre privative e segreto industriale (Avv. Luca Giove)

2. Aspetti tecnici dei brevetti nel settore ingegneristico (Ing. Gianluigi Zanettin)
- Introduzione generale alla tutela della Proprietà Intellettuale
- Funzione e struttura del brevetto d'invenzione
- Esclusioni dalla brevettabilità: cenni alla brevettazione del software
- I requisiti di brevettabilità
- I diritti conferiti dal brevetto
- La valutazione dell'interferenza con diritti brevettuali di terzi
- Tutelabilità vs attuabilità, brevettabilità vs interferenza
- Esempi
- Le ricerche di anteriorità

3. I servizi dell'Ateneo ai dottorandi e ricercatori nel campo della proprietà intellettuale (Personale interno – Ufficio valorizzazione della ricerca, Università di Padova)

Calendario:
18 ore (subject to changes - check the Calendar of the School for actual dates)

Sala riunioni grande, terzo piano dalla sede del DII in via Venezia 1.

Modalità di valutazione:
Obbligo di frequenza per almeno 2/3 della durata prevista.
È prevista una prova scritta finale.

Vibration energy harvesting

Lecturer: Prof. *Alberto Doria*
Department *DII*, University *of Padova*
Email: *alberto.doria@unipd.it*

Topics:
Review on mechanical vibrations.
Fundamentals of vibration harvesting technologies, piezoelectric, electromagnetic and capacitive harvesters.
Mathematical modeling of piezoelectric harvesters.
Testing of piezoelectric harvesters
Applications of harvesters
Applications of piezoelectric harvesters (harvesters for vehicles, rain-drop harvesters)

References:

PRIYA, S., INMAN,D., Energy Harvesting Technologies, Springer 2009.

DORIA, A. MORO F., DESIDERI D., MASCHIO A., ZHANG Z., (2016), An impulsive method for the analysis of piezoelectric energy harvesters for intelligent tires. In Proceedings of the ASME 2016 International Design Engineering Technical Conference and Computers and Information in Engineering Conference IDETC/CIE 2016, paper DETC2016-59105.

DORIA A., C. MEDÈ C., D. DESIDERI D., MASCHIO A., CODECASA L., MORO F., (2018), On the performance of piezoelectric harvesters loaded by finite width impulses, Mechanical Systems and Signal Processing, Vol. 100 (2018) 28–42.

Language of the course: English

Timetable:
Duration of the course: 8 hours
Schedule: second semester (actual dates to be defined – check the calendar of the school)
Location: Lab of Mechanical Vibrations of DII

See the Moodle page of the course for actual dates and delivery mode

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 related to the individual PhD project

Yield criteria for polymer materials

Lecturer: Mauro Ricotta
Department *of Industrial Engineering*, University *of Padova*
mauro.ricotta@unipd.it

Topics:
Introduction. Stress-strain curve. Macroscopic and microscopic yielding. Definition of multiaxial stress state. Yield criteria for macroscopic yielding. Yield criteria for microscopic yielding. Examples

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

Timetable:
8 hours
February 2022

See the Moodle page of the course for actual dates and delivery mode

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on written questionnaire.