Corso di Dottorato in Industrial Engineering  
Università degli Studi di Padova  

**Piano formativo 2020/21**

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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.
- 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:**

**Language of the course:** English

**Timetable:**
Duration of the course: 8 hours
Schedule: 19 February 2021, from 9:00 to 18:00 (8 hours) (subject to changes - check the Calendar of the School for actual dates)
Location: M4 classroom, Department of Industrial Engineering, Viale Colombo 5, Padova.
Room "B Polo Meccanico", Department of Industrial Engineering, Viale Colombo 5, Padova.

**Admission:**
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer.

**Examination:**
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on a case study.
Analysis and Optimization of Sustainable Energy Technologies in Buildings

Lecturer:
Dr. Jacopo Vivian, Dipartimento di Ingegneria Industriale, Università di Padova
jacopo.vivian@unipd.it

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 reviews the definitions of concepts such as energy communities, plus energy districts and energy flexibility. Then, two lectures will explain different optimization methods for the optimal management of both single buildings and entire districts. 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 course will be organized as follows:

Lecture 1
- Energy communities and plus energy districts: rules and calculation methods (1.5 hours).
- Flexibility in building energy systems: theory and applications (1.5 hours).

Lecture 2
- Introduction at the optimization methods and linear programming applied to building energy technologies (3 hours).

Lecture 3
- Model predictive control applied to the system based on a heat pump coupled with PV panels by means of linear programming and heuristic methods for optimization (3 hours).

Lecture 4
- Calibration of the building model via heuristic optimization and application of Building Energy Management Systems (BMS) in smart low energy buildings (2 hours)
- Brainstorming and short presentation of individual case-studies (1 hour).

References:

Timetable:
12 hours
(subject to changes - check the Calendar of the School for actual dates)
April-May 2021
Seminar Room, Third floor of building “Corpo E”, via Venezia 1, Dipartimento di Ingegneria Industriale, Padova
Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer.

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

**Staff:** Engineering librarians

**Period:** December 2020 – January 2021

**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 one training credit and is required for attending the face-to-face module.
- Face-to-face course gives one 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.
Brief introduction on cell membrane and cell biology from the point of view of electromagnetic field
coupling. Electrical models. Electrical properties of tissue as a function of the frequency.
Mechanisms involved in the interaction of cells/tissues with electric and magnetic field. Effects of
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.
Medical uses of electromagnetic fields (e.g. electrochemotherapy, ECT, and magneto fluid
Hyperthermia, MFH).

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

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

February-May 2021

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in
order to enter the Moodle platform click on “dettagli” of the course at the page
http://www.cdii.dii.unipd.it/corsi/) . Once you are registered, if you can not attend the course, please
inform the lecturer.

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

References:
- 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: February 10th, 2021, from 14:00 to 18:00 (4 hours) – Room A
Lecture 2, February 11th, 2021, from 14:00 to 18:00 (4 hours) – Room A
Lecture 3, February 12th, 2021, from 14:00 to 18:00 (4 hours) – Room A

Room A: “Polo di Calcolo ex-D2”, Department of Industrial Engineering, University of Padova, via Venezia, 1 – Padova

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer.

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:
Prof. Enrico Bernardo, Dipartimento di Ingegneria Industriale
enrico.bernardo@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:
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
(subject to changes - check the Calendar of the School for actual dates)
12/07/2021  9.00-13.00
14/07/2021  9.00-13.00
16/07/2021  9.00-13.00

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

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in
order to enter the Moodle platform click on “dettagli” of the course at the page
http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please
inform the lecturer.

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

**Lecturer:** Prof. Alberto Barausse  
Department of Biology, University of Padova  
Email: alberto.barausse@unipd.it

**Topics:**
- Introduction to ecological modelling
- Ecotoxicology. Balance, transport and chemical reaction models
- Nitrogen cycle; settling and resuspension; energetic factors.
- Metabolic - Fish growth models

The focus on these different topics will be tailored according to the background of the students and their specific PhD projects.

**References:**

**Language of the course:** English

**Timetable:**
- Duration of the course: 16 teaching hours
- Schedule: second semester
- Location: Padova

**Admission:**
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page [http://www.cdii.dii.unipd.it/corsi/](http://www.cdii.dii.unipd.it/corsi/)). Once you are registered, if you can not attend the course, please inform the lecturer.

**Examination:**
- Attendance is required for at least 2/3 of the lecture hours.
- Final evaluation will be based on: oral discussion of the lecture topics, in relation to a case study related to the individual PhD project if feasible.
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:

Timetable:
12 hours
(check the Calendar of the School for actual dates)

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer.

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, Dipartimento di Ingegneria Industriale, Università di Padova
moreno.muffatto@unipd.it
Ing. Francesco Ferrati, Dipartimento di Ingegneria Industriale, Università di Padova
francesco.ferrati@unipd.it

Topics

From the idea to the market
• Entrepreneurship attitudes
• What is a startup
• From a research project to an entrepreneurial project
• Market dimension, customers profiles and 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

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

The economic and financial aspects of a startup
• The fundamental economic and financial operations of a technology-based startup
• The structures of the financial statements
• Income Statement, Balance Sheet, Cash Flow
• Evaluation of the value of the company
• Sources and cost of capital

Funding a startup
• Different sources of funds: Angel Investors and Venture Capital
• Investment companies and funds: how they work
• How and what investors evaluate
• The investment agreements between investors and startups
• New ventures’ funding options

References:

**Timetable:**
20 hours: January - March 2021

Wednesday, January 20,  9:30 -12:30  
Wednesday, January 27,  9:30 -12:30  
Wednesday, February 3,  9:30 -12:30  
Wednesday, February 10,  9:30 -12:30  
Wednesday, February 17,  9:30 -12:30  
Wednesday, February 24,  9:30 -12:30  
Wednesday, March 3,  9:30 -11:30

**Location:** To be Defined. Lectures could be organized via Zoom. In this case lectures are not recorded.

**Admission:**
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page [http://www.cdii.dii.unipd.it/corsi/](http://www.cdii.dii.unipd.it/corsi/)). Once you are registered, if you can not attend the course, please inform the lecturer.

**Examination:**
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 (6 hours)
Dr. Marco Azzolin, Department of Industrial Engineering, University of Padova
marco.azzolin@unipd.it (6 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 air and liquid 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:
Termodinamica applicata, A. Cavallini, L. Mattarolo, CLEUP Editore, cap. XIII.

Language of the course: English

Timetable:
12 hours
(subject to changes - check the Calendar of the School for actual dates)
Tuesday, 20th October 2020: h. 9:00-13:00
Wednesday, 21st October 2020: h. 9:00-13:00
Tuesday, 27th October 2020: 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 e Laboratorio Scambiatori di Calore
Department of Industrial Engineering (building E), Via Venezia 1 - Padova

Admission:
To attend the course, registration is compulsory by using the Moodle platform of the PhD Course
(in order to enter the Moodle platform click on “dettagli” of the course at the page
http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturers.

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

References:
Handouts from the lectures.

Timetable:
32 hours, DIM, room M6

12 October: 16:30 – 18:30
15 October: 16:30 – 18:30
19 October: 16:30 – 18:30
02 November: 16:30 – 18:30
05 November: 16:30 – 18:30
09 November: 16:30 – 18:30
12 November: 16:30 – 18:30
16 November: 16:30 – 18:30
19 November: 16:30 – 18:30
23 November: 16:30 – 18:30
26 November: 16:30 – 18:30
30 November: 16:30 – 18:30
03 December: 16:30 – 18:30
07 December: 16:30 – 18:30
14 December: 16:30 – 18:30
21 December: 16:30 – 18:30

Venue: room M6, via Venezia 1
No more than 11 students will be allowed to attend the course due to the room M6 capacity.

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page
http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer.

**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:
Prof. Enrico Bernardo, Dipartimento di Ingegneria Industriale
enrico.bernardo@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:
M.F. Ashby, Materials Selection in Mechanical Design, Butterworth Heinemann, Oxford, UK

Timetable:
12 hours
(subject to changes - check the Calendar of the School for actual dates)
28/06/2021 9.00-13.00
30/06/2021 9.00-13.00
02/07/2021 9.00-13.00
Sala Riunioni I Piano complesso Ex Fisica Tecnica
Dipartimento di Ingegneria Industriale
Via Marzolo 9, Padova

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer.

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 (tentatively June-July 2021).
Location: to be defined.

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “detttagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer.

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.
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:**

**Language of the course:** English

**Timetable:**
Duration of the course: 8 hours

**Lesson 1:** March 5, 2021 from 9:00 to 11:00 Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia 1, 35129, Padova

**Lesson 2:** March 12, 2021 from 9:00 to 11:00 Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia 1, 35129, Padova

**Lesson 3:** March 19, 2021 from 9:00 to 11:00 Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia 1, 35129, Padova

**Lesson 4:** March 26, 2021 from 9:00 to 11:00 Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia 1, 35129, Padova

**Admission:**
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer.

**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.stoppato@unipd.it

Topics:
Life Cycle Assessment (LCA) is today one of the most accredited assessment method 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, in the case, e.g., of a power plant to go beyond its geographical boundaries and to assess the impacts throughout the “value chain”, such as those associated with emissions due to the entire fuel 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.

Being the course focuses on the assessment of energy systems and the energetic aspects, several examples of performed 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:

Timetable: 12 hours

**Lesson 1: September 3, 2021** – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

**Lesson 2: September 10, 2021** – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

**Lesson 3: September 17, 2021** – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

**Lesson 4: September 24, 2021** – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page [http://www.cdii.dii.unipd.it/corsi/](http://www.cdii.dii.unipd.it/corsi/) . Once you are registered, if you can not attend the course, please inform the lecturer.

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

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:
In the recent years, a large number of plants fed by Variable Renewable Energy Sources (mainly wind and solar) have been added to the electric grid introducing management and control issues. In fact, with a large number of users and producers, the demand and plants production become difficult to forecast. Thus, there can be areas characterized by over-capacity and zones with under-capacity. Unbalance between production and demand which are difficult to predict and manage and that can cause local or even global blackouts. Therefore, there is an urgent need of developing and installing large-scale Energy Storage units.

On the basis of the above considerations, the first aim of the COURSE is to present and classify the energy storage technologies. Then, the focus is posed on large-scale Electricity Storage technologies. These Units are “in-depth” analyzed with the aim of identifying characteristics, advantages and drawbacks.

The Storage Technologies analyzed in the course are:
- Pumped Hydro Storage or Pumped Hydroelectric Energy Storage.
- Compressed Air Energy Storage.
- Pumped Thermal Electricity Storage or Pumped Heat Energy Storage.
- Air based Thermal Electricity Storage Technology.

Finally, the analyzed technologies are compared based on technical and economic indexes. Particular attention will be paid on the environmental impact considering the entire life cycle according to a LCA approach.

References:

Timetable: 16 hours

Lesson 1: February 26, 2021 – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

Lesson 2: March 5, 2021 – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

Lesson 3: March 12, 2021 – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

Lesson 4: March 19, 2021 – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

Lesson 5: March 26, 2021 – From 9:00 to 13:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer about that.

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

Lecturer:
Dr Saeed Khademzadeh, Dipartimento di Ingegneria Industriale, Università di Padova
saeed.khademzadeh@unipd.it

Course description:
This course provides students with the basic knowledge and skills for metal Additive Manufacturing (AM) including AM processes and their capabilities, designing AM parts, and procedures.

Day 1: (4 hours)
Topics:
- Introduction to net-shape manufacturing and Additive Manufacturing (AM)
- Economics of AM
- Metal-AM digital workflow (from CAD to part)
- Metal AM Processes (an overview of the technologies used in metal AM)

Day 2: (4 hours-)
Topics:
- Powder fusion AM processes (DED, LPBF, EBM …)
- Material aspects in metal AM
- Metal Additive Manufacturing Metallurgy (micro-structures and metallurgical characteristics of AM metallic parts)
- Quality control of AM metallic parts (defects, standards, procedures, and statistical control)

Day 3: (4 hours)
- Topology optimization for AM (concept and tutorial)
- Modeling and simulation of Metal-AM processes
- Post-processing for AM (understanding and selecting the most appropriate post-processing techniques)
- AM software for build preparation. Edit, fix and manipulation of CAD design (STL files) and preparation of platform for laser powder-bed fusion technology using Magics materialise software

References:

Timetable:
Duration of the course: 12 hours
(check the Calendar of the School for actual dates)
Location: sala riunioni grande, 3rd floor, Dept. of Industrial Engineering, via Venezia 1.

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer

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 project
Particle Image Velocimetry: theory and applications

Ing. Antonio Rossetti,
Istituto per le Tecnologie della Costruzione, Sede di Padova
antonio.rossetti@itc.cnr.it

Topics:
The course will focus on the theoretical and practical aspects of the Particle Image Velocimetry. The main physical principles involved and the main elements of the measurements technique (the laser source, the imaging devices and the tracer) will be presented. Application examples to real cases will be discussed, highlighting the actual peculiarities of setting up a PIV experiment for a given problem. The course includes experimental activity at the ITC CNR thermo-fluid dynamic laboratory in Padua.

References:

Language of the course: English

Timetable:
Duration of the course: 12 hours
Schedule: November 2020, articulated in three lessons as follow (check the Calendar of the School for actual dates):

## / 11 / 20 9:00-13:00
## / 11 / 20 9:00-13:00
## / 11 / 20 9:00-13:00

Location: Biblioteca, Istituto per le Tecnologie della Costruzione, Sede di Padova, c.o. CNR - Area della Ricerca di Padova, Corso Stati Uniti,4 - 35127 Padova – Italy

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer.

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

Lecturer: Ing. Massimo Malaguti – Independent Consultant
Email: massimo.malaguti.56@gmail.com

Topics:
The course *Principles of visual information* will provide an overview on the main aspects of visual information techniques and their main applications.
The course will begin by analyzing what visual information means today, relating to the general concept of "communication". The course will provide an excursus of historical evolution of visual information, through the presentation and discussion of some relevant and famous examples of application. These examples will concern three main categories: "how it works", "where are we" and "what happens".
In the end, the course focuses on how use digital tools correctly to present data and conclusions.

References:

Language of the course: English

Timetable:
Duration of the course: 8 h.
Schedule: …
Location: …

Admission:
To attend the course, registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform, click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/).
If a student has registered himself for the course and then decides to not attend the course anymore, he/she should inform the lecturer that he won’t be present at the lessons.

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on: written questionnaires and other exercises during the course; a final discussion of a case study, closely related to the student’s individual PhD project.
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:
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)

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer.

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 H2 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.
- Specific contact resistance in thermoelectrics; metal – semiconductor contacts; effect of contact resistance on ZT; measurement of contact resistance; effect of contact resistance on TE module.
- 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.

Timetable:
12 hours (subject to changes - check the Calendar of the School for actual dates)
March - April
c/o CNR Area della ricerca, ICMATE Edificio 6, Biblioteca
Corso Stati Uniti 4, Padova

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). After registration, please send the registration data to Dr. Monica Fabrizio monica.fabrizio@cnr.it. Once you are registered, if you can not attend the course, please inform the lecturer.

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

Lecturers: Prof. Luigi Salmaso, in collaboration with Prof. Livio Corain, Prof. Rosa Arboretti
Department Dipartimenti DTG e ICEA, Università degli Studi di Padova
Email: luigi.salmaso@unipd.it

Topics:
The course will focus on the discussion of the main statistical tools which can be applied to problems in the field of engineering. The aim is to provide to PhD students the theoretical knowledge and the practical means to carry out quantitative analysis on data of different nature including data from their PhD project. The statistical software “Minitab” will be extensively used to apply the techniques to practical case studies.
The main topics of the course are:
- Descriptive statistics
- 1 sample hypothesis tests
- 2 sample hypothesis tests
- Linear regression
- Analysis of variance (ANOVA)
- Design of experiments: 2 level factorial designs
- Design of experiments: general factorial and response surface designs

References:

Language of the course: English

Timetable:
Duration of the course: 32 (check the Calendar of the School for actual dates)

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/) . Once you are registered, if you can not attend the course, please inform the lecturer.

Examination:
Attendance is required for at least 2/3 of the lecture hours.
Final evaluation will be based on: a personal project (home assignment) in which the student is asked to apply the techniques learned to their individual PhD project or other data of their choice.
Sustainable Energy in Buildings

Lecturers:
Dr. 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.decari@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
Prof. Roberto Zecchin, Studioso Senior, Università di Padova
roberto.zecchin@unipd.it

Topics:
Efforts to reduce CO₂ 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 greatest challenge at the moment is, however, that of retrofitting already existing buildings which represent the largest segment of the built environment, and thus offer a high potential of reducing energy consumption. 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 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 methods, simulation tools (TRNSYS) 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
(subject to changes - check the Calendar of the School for actual dates)
March-April 2021
Seminar Room, Third floor of building “Corpo E”, via Venezia 1, Dipartimento di Ingegneria Industriale, Padova

Admission:
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page http://www.cdii.dii.unipd.it/corsi/). Once you are registered, if you can not attend the course, please inform the lecturer.

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, Dipartimento di Ingegneria Industriale, 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 onboard the electric vehicles. Third lesson deals with the infrastructures for the wired charging of the batteries of the electric vehicles. Fourth lesson addresses the fuel cell vehicles and the wireless charging of the electric vehicles.

References:
Course notes (slides)

Timetable:
8 hours
(subject to changes - check the Calendar of the School for actual dates)
18/05/2021 15.00-16:30
20/05/2021 15.00-16:30
25/05/2021 15.00-16:30
27/05/2021 15.00-16:30
Saletta “gialla” I Piano, Dip. di Ingegneria Industriale, Via Gradenigo 6a, Padova.

Admission:
Students should register for the course by using the Moodle platform of the PhD Course. (in order to enter the Moodle platform click on “dettagli” of the course at the following webpage: http://www.cdii.dii.unipd.it/corsi/).
If a student has registered himself for the course and then decides to not attend the course anymore, he/she should inform the professor that he won’t be present at the lessons. The course will be held only if the number of attendees is not less than 3.

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

Docenti:
Avv. Luca Giove - Libero professionista
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 (check the Calendar of the School for actual dates)

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

Modalità di iscrizione:
Per frequentare il corso è necessario iscriversi utilizzando la piattaforma Moodle del Corso di dottorato (per accedervi cliccare su “dettagli” in corrispondenza al titolo del corso alla pagina http://www.cdii.dii.unipd.it/corsi/). Una volta iscritti, se non è più possibile partecipare, si prega di informare il docente.

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:**  
Please describe the main topics covered by the course  
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:**  
List some bibliographical references (these could/should be provided by the lecturer to the students)


**Language of the course:** English

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

**Admission:**  
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on "dettagli" of the course at the page [http://www.cdii.dii.unipd.it/corsi/](http://www.cdii.dii.unipd.it/corsi/) ). Once you are registered, if you can not attend the course, please inform the lecturer.

**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
Waste Heat Recovery Units for Industrial Energy Efficiency

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:
In process industries, large amount of medium and low-grade heat is generated and wasted due to the absence of internal heat demand. However, in the last decades, several technologies have been proposed to convert waste heat into useful electricity. For this reason, the COURSE aim is to analyze the Waste Heat Recovery Technologies based on an “in-depth” state of the art analysis.
In the first part of the course, the attention is devoted to the motivation that force researchers to develop Waste Heat Recovery Units (WHRUs). Then, energy sectors, sources types and temperature ranges as well as WHRU technologies are analyzed. In this context, the state of the art in terms of plant layouts and fluids of
- Steam Rankine Cycle.
- Organic Rankine Cycle.
- Air Bottoming Cycle.
- Supercritical CO2 cycle.
- Kalina Cycle.
- Trilateral Flash Cycle.
are presented and discussed with the aim of identifying the most suitable technology for each temperature range and source type. Optimization methods for fluid and plant layout selection is also presented during the course.
Finally, several examples, based on real application, are given.

References:

**Timetable:** 16 hours

**Lesson 1: May 28, 2021** – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

**Lesson 2: June 4, 2021** – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

**Lesson 3: June 11, 2021** – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

**Lesson 4: June 18, 2021** – From 9:00 to 12:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

**Lesson 5: June 25, 2021** – From 9:00 to 13:00 – Sala Riunioni Grande Corpo A, Complesso di Ingegneria Meccanica, Via Venezia, 1, 35129, Padova.

**Admission:**

To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on "dettagli" of the course at the page [http://www.cdii.dii.unipd.it/corsi/](http://www.cdii.dii.unipd.it/corsi/) ). Once you are registered, if you can not attend the course, please inform the lecturer.

**Examination:**

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

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

**Topics:**  
Examples

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

**Timetable:**  
8 hours  
November 2020

**Admission:**  
To attend the course registration is compulsory by using the Moodle platform of the PhD Course (in order to enter the Moodle platform click on “dettagli” of the course at the page [http://www.cdii.dii.unipd.it/corsi/](http://www.cdii.dii.unipd.it/corsi/) . Once you are registered, if you can not attend the course, please inform the lecturer.

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