UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Innovation and Sustainability

2627-2-E3004Q011

Aims

This course introduces students to the role of physics in the development of innovative and sustainable technologies. The course is designed for students in Physical Sciences for Innovative Technologies and provides a broad, application-oriented perspective on how physical principles are translated into technological solutions.
The course will show how concepts such as energy, efficiency, measurement, uncertainty, sensors, materials, light, imaging, fluid transport and automation are central to modern innovation. Sustainability will be discussed not only in terms of renewable energy and climate mitigation, but also as efficient use of resources, reduction of waste, reliability, quality control, process optimization and responsible technological development.
A specific part of the course will be devoted to industrial case studies, with particular attention to biomedical and laboratory automation technologies. These case studies will illustrate how physics-based methods support innovation in real industrial contexts, from sample collection and handling to imaging, automation, data interpretation and process sustainability.
By the end of the course, students will be able to understand how physical principles contribute to technological innovation, critically assess the sustainability of technological solutions, and discuss the connection between scientific knowledge, industrial applications and societal needs.

Contents

• Physics as a foundation for technological innovation.
• Sustainability in technological systems: energy, materials, processes and environmental impact.
• Energy, power, efficiency and resource use in modern technologies.
• Measurement, uncertainty, sensors and data acquisition.
• Light, imaging and digital information in technological and biomedical applications.
• Fluids, surfaces, diffusion and sample handling.
• Automation, robotics and process optimization.
• Industrial case studies in energy technologies and biomedical/laboratory automation.
• Introductory examples of data analysis and artificial intelligence in physics-based technological systems.

Detailed program

1. Physics, innovation and sustainability
   • What is technological innovation?
   • From physical principles to industrial applications.
   • Invention, innovation and technology transfer.
   • Sustainability as a multidimensional concept.
   • Environmental, energetic, material and social dimensions of sustainability.
   • Technology readiness levels and scale-up issues.

2. Energy, power and efficiency in technological systems
   • Energy and power: physical meaning and orders of magnitude.
   • Efficiency and losses in real systems.
   • Renewable energy technologies as examples of physics-based innovation.
   • Energy use in industrial and laboratory processes.
   • Electrification, storage and energy management.
   • Energy efficiency as a sustainability strategy.

3. Measurement, uncertainty and sensors
   • Physical quantities and measurement principles.
   • Signal, noise, resolution and sensitivity.
   • Calibration and uncertainty.
   • Sensors and transducers.
   • Data acquisition and digital signals.
   • Examples from energy monitoring, environmental sensing and biomedical technologies.

4. Light, imaging and digital technologies
   • Light as a probe of matter.
   • Basic principles of optical imaging.
   • Resolution, contrast and signal-to-noise ratio.
   • Digital image acquisition and processing.
   • Imaging in diagnostics and industrial quality control.
   • Introduction to machine vision and AI-assisted interpretation.

5. Fluids, surfaces and sample handling
   • Transport phenomena in technological systems.
   • Diffusion, flow and mixing.
   • Capillarity, wetting and surface interactions.
   • Contamination, sampling and preservation.
   • Physical aspects of biological sample collection and transport.
   • The importance of pre-analytical processes in diagnostic technologies.

6. Automation and sustainable industrial processes
   • Principles of automation and robotics.
   • Sensors, actuators and feedback.
   • Process control and reproducibility.
   • Automation as a tool for quality, safety and sustainability.
   • Reduction of waste, errors and resource consumption.
   • Laboratory automation as a case study of integrated technological innovation.

7. Industrial case studies
   • Physics-based innovation in renewable energy systems.

- Physics-based innovation in biomedical and diagnostic technologies.
- Sample collection, transport and processing.
- Automated laboratory workflows.
- Imaging, AI and digital microbiology.
- Sustainability assessment of technological processes.

8. Final discussion and student project work
   - Critical comparison of different technological solutions.
   - How to evaluate whether an innovation is sustainable.
   - Student discussion of selected case studies.
   - Connection between physics, industry and society.

Prerequisites

- Basic knowledge of classical physics, including mechanics, thermodynamics, electromagnetism and elementary optics.
- Basic mathematical tools, including functions, derivatives, integrals and simple data representation.
- Basic knowledge of chemistry is useful but not mandatory.
- No previous knowledge of biomedical technologies or industrial automation is required.

Teaching form

- Lectures introducing the physical principles and technological context.
- Online modules with guided readings, short videos and self-assessment questions.
- Case-study sessions based on real industrial technologies.
- Laboratory or project-based activities focused on measurement, data interpretation and sustainability assessment.
- Guest lectures and industrial seminars will provide examples of how physics-based technologies are implemented in real industrial contexts, with particular attention to laboratory automation, diagnostic workflows, imaging, process control and sustainability.

Textbook and teaching resource

- Lecture slides and notes.
- Additional reading materials, including scientific articles and reports, available on the e-learning platform.

Semester

Second

Assessment method

The final assessment consists of an oral examination, graded on a scale from 18 to 30/30. The oral examination will evaluate the student's understanding of the physical principles discussed in the course and their ability to connect these principles to technological applications and sustainability issues.
During the oral examination, students may be asked to discuss a short individual or group case study on a physics-based innovation, selected among the topics covered in the course. The case study will be used to assess the ability to analyse a technological system in terms of physical principles, technological implementation and sustainability implications.

Assessment criteria:

1. Knowledge and understanding of the physical principles discussed in the course.
2. Ability to connect physical principles with technological applications.
3. Ability to critically analyse sustainability aspects, including energy use, resource efficiency, waste reduction and process reliability.
4. Clarity and accuracy of scientific and technical communication.
5. Ability to discuss industrial case studies using appropriate terminology and considering both physical and technological constraints.

Students with Specific Learning Disorders should refer to the Student Guide and the DSA Service at the University (https://en.unimib.it/services/offices-and-facilities/disability-sld-binclusion-space).

Office hours

Available by appointment via email.

Sustainable Development Goals

GOOD HEALTH AND WELL-BEING | AFFORDABLE AND CLEAN ENERGY | INDUSTRY, INNOVATION AND INFRASTRUCTURE | RESPONSIBLE CONSUMPTION AND PRODUCTION | CLIMATE ACTION