UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Physics of Vision

2526-1-F1702Q004

Aims

This course provides an in-depth study of the physical principles underlying vision. The course focuses on the optical properties of materials, the origin of colour, visual perception and the physical mechanisms involved in the physiological mechanisms of the eye.

Contents

- Recall of electromagnetism and wave physics
- Light and color
- Methods and approaches to induce coloration in materials
- Physics of vision

Detailed program

- Recall of electromagnetism and wave physics
  The main physical laws of interest for the description of light and color will be summarized: Maxwell's equations, wave equation, law of reflection and refraction, dispersion

- Light and color
  Historical excursus of the definition of colors, the spectrum and the "color" of light, physical origin of the apparent color of objects

- Electromagnetic spectrum and notes on color measurement
  The electromagnetic spectrum: definitions, intervals and units of measurement. Description of the main

spectroscopic techniques for the determination of quantities relating to the description of color and definition of absorbance, transmission, reflection, Lambert-Beer law, quantitative representation of color (color coordinates).

- Physical origin of the color of light sources
  Incandescence and black body law, the color of flames and fireworks, gas line emission and hints of quantum mechanics, the color of discharges, plasmas and coronas, fluorescence, phosphorescence and bio-chemiluminescence. Notes on how LEDs and lasers work.

- Physical origin of the color of metals, materials and molecules
  The band structure of metals, semiconductors and insulators: the origin of the color of metals, color produced by electronic transitions from transition metal impurities, by point defects and by charge transfer in insulators, color of semiconductors with energy gaps in the visible , allochromatism and idiochromatism. Origin of color in organic molecules.

- Physical origin of structural colors
  Colors due to interference and diffraction, Rayleigh and Mie diffusion, anisotropy, polarization, colors produced by dispersion. Relationship between the visual appearance of a material and optical constants: opalescence, iridescence, metallic appearance, transparency, glaze. Hints of holography. Methods and approaches to induce coloration in materials: colors in nature (colors in biology, gems and atmospheric phenomena), pigments, dyes, glass and plastic colorations, color filters and film deposition.

- Physics of vision
  Photophysics of the vision process, scotopic and photopic vision, notes on comparative animal vision, colorimetry.

Prerequisites

Student requirements match the topics listed in the “Orienteering for Future Students and Admission Procedures”, available on the e-learning platform.

Teaching form

The lectures will be frontal (videorecorded and made available on the course's e-learning platform). The course also includes simulations of the main aspects covered in lectures and hand-on experiments on color measurement techniques. Participation in the latter activities is strongly recommended, but the activities can also be followed remotely and in asynchronous mode.

42h In-person lesson

Textbook and teaching resource

- The Physics and Chemistry of Color: The Fifteen Causes of Color by Kurt Nassau. ISBN: 978-0-471-39106-7
- Other resources from books, teacher's slides and scintific articles will be made available on the e-learning

platform.

Semester

First semester.

Assessment method

Oral examination, which involves a series of questions designed to assess the student's understanding and ability to apply course concepts to color appearence and measurement, physical mechanisms involved in the production and vision of colors.
Below are the grading ranges out of 30:

18-21

- Basic Knowledge: Minimal understanding of the topics covered. Ability to remember and repeat simple concepts.
- Analytical Skills: Limited ability to analyze problems and propose solutions.
- Communication: Ability to express ideas simply, with some difficulty and errors. Acceptable but not always clear communication.

21-24

- Basic Knowledge: Good understanding of the topics covered. Ability to apply learned concepts.
- Analytical Skills: Ability to identify problems and propose appropriate solutions. Good level of critical thinking.
- Communication: Ability to express ideas clearly and coherently, with some minor errors. Good oral communication.

24-27

- Basic Knowledge: Excellent understanding and mastery of the topics covered. Ability to connect different concepts.
- Analytical Skills: High ability to analyze complex problems and propose effective solutions. Excellent level of critical thinking.
- Communication: Ability to express ideas very clearly and coherently, with very few errors and appropriate language. Excellent oral communication.

27-30

- Basic Knowledge: Outstanding and in-depth understanding of the topics covered. Ability to innovate and create original connections.
- Analytical Skills: Extraordinary ability to analyze complex problems and propose innovative and original solutions. Highly developed critical thinking.
- Communication: Ability to express ideas extremely clearly, coherently, and persuasively. Excellent oral communication.

Office hours

Available at least two days a week, by appointment via email.

Sustainable Development Goals