CE 51300 Lighting in Buildings
Sem. 2, Lecture 2, Lab 1, Cr. 3.
Restriction: Graduate or senior level undergraduate standing
Prerequisites: CE 41300 Building Envelope Design and Thermal Loads or graduate standing

Description: This course focuses on the design of illumination systems in buildings (electric and natural lighting) in order to achieve energy-efficiency and visual comfort. The first part of the course includes analytical lighting calculation techniques, visual perception, radiative transfer, lamp characteristics, electric lighting system design and control for calculation of required indoor illuminance levels. The second part of the course covers daylighting (natural lighting) systems, including state-of-the-art daylighting prediction models as well as design and control of such devices and advanced metrics. The course also has a lab section, in which the students learn how to work with lighting and daylighting tools and build their own computational transient lighting models in open programming languages, in order to design illumination systems and predict electricity consumption and potential energy savings.

Level: Graduate or senior undergraduate Level

Course instructor: Athanasios Tzempelikos

Course outline:
Lighting metrics, calculations and measurements - Nature of light and sight; Basic photometric quantities; Lighting terms and metrics**;** Inverse square law**;** Luminance equations**;** Lambertian surfaces and diffusion**;** Sky luminance**;** Measuring luminous flux**;** General square law in 3D**;** Zonal lumens for light sources (2 weeks)
Illuminance from non-point sources - Strip, tube and rectangular sources**;** General flux transfer theory (1 week)
Vision and color, radiant energy and light - Spectral sensitivity**;** Luminous efficacy**;** Vision factors**;** Contrast and brightness, spectral power density**;** Emissivity and selective radiators**;** Luminescence and incandescence**;** Relating lumens and watts**;** Color temperature (1 week)
Lamps – Incandescent, tungsten-halogen, fluorescent and CF lamps: properties, construction, types, characteristics, life and losses, efficiency; Ballasts**;** Circuits and starting methods**;** Mercury, metal halide and high-pressure sodium lamps (1 week)
Luminaires and controls for interior lighting - Criteria**;** Luminaire characteristics and classifications, luminance and optics –glare criteria**;** Photometric reports**;** Visual comfort and glare indices; Lighting control functions and types; Control circuit types**;** (2 weeks)
Interior lighting design: average and detailed illuminance calculations- Illuminance selection**;** Basic lumen method; Non-rectangular spaces; Detailed Flux transfer; Luminous exitance and relationships**;** Configuration factors**;** Form/view factors and properties**;** One-bounce flux transfer analysis**;** Multiple-bounce analysis, radiosity method and detailed illuminance calculations (2 weeks)
Daylighting prediction models- Basic daylighting models (CIE and ASHRAE sky models)**;** Solar geometry and model similarities; The Perez all weather sky model**;** Weather data and detailed model formulation (2 weeks)

Windows and optics - Optical properties as fundamental variables**;** Angle dependency**;** Basic ray tracing for optical properties**;** Selective glazings and coatings for daylighting (1 week)
Daylighting metrics and shading - Daylight factors**;** Illuminance histograms**;** Useful illuminances**;** Daylight autonomy**;** Energy savings from daylighting; Shading devices: types, properties and controls (1 week)
Lighting and daylighting research projects and applications (2 weeks)

<u>Lab sessions:</u>
Introduction to lighting software (1 week)
Ecotect software (3 weeks)
Comfen software (2 weeks)
Daysim, Radiance and other software (1 week)
Other software (2 weeks)
Programming and building computational models for lighting calculations (3 weeks)
Experimental measurements in Bowen labs (2 weeks)