ENVIRONMENTAL ENGINEERING PHYSICS

Degree in: Sustainable Building Engineering
6 CFU (60 hours)
a.y. 2023-2024

1. THERMODYNAMICS

a. Zero principle
   Thermodynamic quantities. Thermodynamic systems. Adiabatic and diathermal walls. Zero principle of thermodynamics. Empirical temperature idea. Thermometric properties. Thermometric scales
b. First principle
   Heat. mechanic work. first principle of thermodynamics for closed systems. Total energy. Internal energy. Enthalpy. First principle for open systems.
c. Second principle
   Formulation of Kelvin Planck. Formulation of Clausius. Equivalence of the two formulations. Mention about Caratheodory formulation and axiomatic formulation of thermodynamics. Clausius closed integral. Entropy. Entropic sources. Theory of the increase of entropy.
d. Thermodynamic potentials
   Helmotz free energy. Gibbs potential. Kelvin equations.
e. Properties of materials
   Thermal expansion. Adiabatic and isothermal compressibility. Specific heat
f. Ideal gases
   Virial expansion. Hypothesis of ideal gas. Transformations for ideal gases: reversible and irreversible adiabatic, isothermal, isobaric, isochoric, isenthalpic. Properties of ideals gases.
g. Thermodynamic diagrams
   P-v; *P-T*; *P-v-T*, *T-s*; *h-s*; *P-h*. Transformations for real substances.
h. Thermodynamic cycles
   Open system cycles for gases Joule cycle. Open system cycles for vapours: Rankin and Hirn Cycles, refrigeration cycle.
i. Air and steam mixtures
   Definition of quantities for humid air: total humidity, relative humidity, enthalpy. Construction of the Mollier diagram of the humid air and of psychrometric (ASRAE) diagram. Transformations of humid air: refrigerating and heating at constant total humidity, adiabatic saturation and cooling with moisture separation, mixing of two flows. Design of air thermal plants: winter case and summer case.

2. HEAT TRANSFER

a. Basics of heat transfer
   Heat transfer mechanisms. Fourier law of conduction and definition of thermal conductivity. Newton law of convection. Basic concepts of radiation.
b. Conduction
   Methods of measuring thermal conductivity. General equation of conduction. Boundary conditions. Solutions for steady state problems: infinite slab and infinite cylinder without

and with heat generation, composite layers, global conduction heat transfer coefficient. Lumped parameter problems, without and with heat generation. Distributed parameters problems.

c. Convection
   Buckingham theorem and determination of dimensionless number for convection. Forced convection external to surfaces. Forced convection in closed spaces. Natural convection. Convection with phase change: condensation and boiling.
d. Radiation
   Spectrum of electromagnetic radiation. Definition of radiation quantities: exitance, radiance, irradiation, radiant intensity. Lambert law. Basic laws of radiation: Planck, Stephan Boltzmann, Wien. Properties of surfaces: absorbance, reflectance, transmittance, emissivity. Kirchhoff law of radiation. Black body model. Grey body model. Heat transfer by radiation between two black surfaces: radiation configuration factors. Heat transfer among grey surfaces: radiosity, electrical analogy. Radiation with a partially absorbing medium: law of Bourough Beer.
e. Heat exchangers
   Theory of heat exchangers: classification, tube in tube heat exchangers in counter flow and parallel flow configuration. Size problem and rate problem criteria for designing heat exchangers. Dimensionless numbers. ΔT_{ml} , ε-NTU and ψ-P methods.

3. ACOUSTICS

a. Introduction,
b. Fundamental of earing:
   Anatomy of the ear, disorders of the ear, hearing evaluation
c. Human response to sound:
   Loudness, noisiness, annoyance, pitch, masking
d. Noise metrics and regulations:
   Weighting networks, loudness and annoyance ratings for steady noises, speech interference, non-steady noise, statistical descriptors, hearing damage risk,
e. Physics of sound:
   Acoustic variables, sound waves, speed of sound, wave equation (plane, spherical), source directionality
f. Units and levels:
   Levels and decibels, combining decibel levels, relations between L_p, L_w, and L_I, source directionality,
g. Instrumentation for noise measurements:
   Purposes of measurements, sound level meters, microphones, frequency analysis, FFT analysis, combination of two or more frequency bands, white noise and pink noise
h. Acoustics of rooms and enclosures:
   Sound fields in a room, sound absorption, experimental determination of absorption, normal incidence coefficient α_n, Sabine absorption coefficient α_{sabine}, room averaged coefficient $\alpha_{average}$, sound decay and reverberation time, relating reverberation time to room dimensions and materials, effect of mounting.