UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2022/2023
BACHELOR'S DEGREE (BSC)	BIOMEDICAL ENGINEERING
SUBJECT	TRANSPORTATION PHENOMENA AND THERMAL DYNAMICS
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50297-Ingegneria chimica
CODE	18409
SCIENTIFIC SECTOR(S)	ING-IND/24
HEAD PROFESSOR(S)	CARFI' PAVIA FRANCESCO — Ricercatore a tempo determinato — Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	9
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**CARFI' PAVIA FRANCESCO** Thursday 15:00 18:00 Edificio 6 (ingresso EX Ingegneria Chimica), primo piano, Ufficio 1012 (corridoio vicino alla scala antincendio, prima porta a sinistra). Friday 10:00 13:00 Edificio 6 (ingresso EX Ingegneria Chimica), primo piano, Ufficio 1012 (corridoio vicino alla scala antincendio, prima porta a sinistra).

DOCENTE: Prof. FRANCESCO CARFI' PAVIA

PREREQUISITES	Basic knowledge on: algebra, functions of one or more variable, infinitesimal calculus, mechanics, chemistry
LEARNING OUTCOMES	Knowledge and understanding - At the end of the course the student will be conscious of equilibrium thermodynamics, problems related to transport phenomena and simple fluid dynamic relationships. He will be able to handle heat and mass transfer coefficients and apply mass, energy and momentum balance equations to biological system; Skills in application knowledge and understanding - The student will be able to select and use the needed and appropriate relationships for the project of biomedical equipment and processes as well as of biochemical systems. Making judgements - The student will be able to autonomous evaluate: relationships applicability to thermodynamics and transport problems, results reliability and confidence, boundary conditions to apply to transport phenomena problems; Communication skills - The student will acquire the skill of state and transfer problems related to course topics. He will be able to discuss problems involving thermodynamics and transport phenomena by the use of the appropriate scheme mathematics and terminology. Learning skills - By the acquired knowledge on thermodynamics and transport phenomena the student will own the fundamental approach of balance equations to complex problems; - Furthermore he will know the difference between qualitative and quantitative approach to equipment and biomedical process design
ASSESSMENT METHODS	The assessment will be based on class test + oral. The following score table will be applied: Indicator - Knowledge and competence of contents Descriptor and score range: Excellent 10 Autonomous and effective 8-9 Acceptable6-7 Fragmentary or partly superficial 4-5 Inadequate 0-3 Indicator - Applicative skill, precision, logical-thematic coherence Descriptor and score range: Excellent 10 Adequate 8-9 Acceptable also if partly driven 6-7 Limited 4-5 Inadequate 0-3 Indicator - Expression and terminology, reprocessing skills and multi-disciplinary connections Descriptor and score range: Excellent 10 Effective and well-structured 8-9 Generally satisfactory 6-7 Hesitant and rough 4-5 Inadequate 0-3
EDUCATIONAL OBJECTIVES	The course aims at training students towards professional biomedical engineering. expertise on applied research on equipment and biomedical process design. Fundamentals knowledge needed to face problems related to the management and development of equipment and biomedical processes
TEACHING METHODS	Lectures, practical in classroom
SUGGESTED BIBLIOGRAPHY	R. Mauri – Fenomeni di trasporto. – Pisa University Press; 3 edizione (9 luglio 2014) - ISBN: 978-8867413522 P. Atkins J. de Paula J. Keeler - Chimica Fisica, 6 edizione, Zanichelli - ISBN: 9788808620521 Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera - Fundamentals of Heat and Mass Transfer, 7th Edition - John Wiley & Sons, Incorporated, 2011

- ISBN: 1118137256, 9781118137253

SYLLABUS

Hrs	Frontal teaching
2	Course introduction. Suggested books. Unit of measure and dimensions; unit conversion; fluids; density of fluids; pressure; stress and mechanical equilibrium
3	Balance principle. Mass balance. Transient mass balance
3	Work, Heat and Energy. Temperature and different Temperature scale, extensive and intensive quantities, closed and open system, thermodynamical state and state variables
3	Pure substances, blends, solutions. Volumetric properties of pure substances, P/T, P/V, PV/P diagrams. Critical point, State equation for pure substances; ideal gas state equation, Van der Waals equation, viral equation, compressibility factor.
3	First law of thermodynamics, closed systems formulation, internal energy, enthalpy. isothermal, constant volume and constant pressure transformations, specific heat and ideal gas definition
2	Thermophysics: Phase transition and enthalpy change for pure substances. Energy balance on closed systems
3	Reversible transformations, equilibrium and second law of thermodynamics. Cycles. Entropy definition, mathematical second law of thermodynamics formulation. Gibbs free energy definition and properties
3	Pure fluids thermodynamics properties, theorem of corresponding states. Pure phase equilibria, Clapeyron and Antoine equation. Fugacity definition for pure and constant composition systems, phase equilibrium by fugacity.
3	Ideal gas mixtures properties. Ideal solution and thermodynamics properties. Phase equilibrium for variable composition ideal solutions and Raoul's law, phase diagrams. Dew point, boiling point and phase composition of ideal liquid vapor equilibrium systems
2	Non ideal variable composition systems, partial molar properties, component fugacity of a component in real mixtures, activity. Reference state, Henry law, phase rule. Colligative properties and osmotic pressure
3	Steady state mass balance: examples. Continuum mechanics elements, stress definition; fluid definition; fluid density. Hydrostatic; pressure definition; static constant density fluid pressure distribution
4	Fluid dynamics; Newton law of viscosity; Non Newtonian fluids; pipe and channel flow; Bernoulli equation; Reynolds experience; flow regimes; pipe friction factor
4	Stress due motion around submerged objects; terminal velocity
4	Heat transfer; conduction convection and radiant heat transfer, units. Conduction heat transfer; Conduction in flat and cylindrical geometry
4	Energy balance. Open systems energy balance. Temperature distribution along a heated or cooled pipe
4	Series heat transfer resistance combination, forced convection. Conduction and convection in cylindrical objects
4	Mass transfer, Fick's law. Mass transfer coefficient, Chilton-Colburn analogy, series combination of mass transfer resistances

Hrs	Practice
27	Practical class for calculation on the course topics