UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2019/2020
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)	BRUCATO VALERIO MARIA BARTOLO — Professore Ordinario — Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	9
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**BRUCATO VALERIO MARIA BARTOLO** Tuesday 14:00 15:00 Studio del docente, Viale delle Scienze, Edificio 6, Stanza 3019, Palermo Wednesday 14:00 15:00 Studio del docente, Viale delle Scienze, Edificio 6, Stanza 3019, Palermo Thursday 14:00 15:00 Studio del docente, Viale delle Scienze, Edificio 6, Stanza 3019, Palermo

DOCENTE: Prof. VALERIO MARIA BARTOLO BRUCATO

PREREQUISITES	Basic knowledge on: algebra, functions of one or more variable, infinitesimal calculus, mechanics, chemistry.
LEARNING OUTCOMES	Knowledge and understanding - After the course the student will become conscious of equilibrium thermodynamics, problems related to transport phenomena and simple fluid dynamic relationships. He will be able to do simple hydrostatic calculations, transfer coefficients evaluation and apply mass, energy and momentum balance equations to equipment and 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. 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 Acceptable 6-7 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 aim to train the students towards professional biomedical engineering. expertise on applied research on equipment and biomedical process design. Necessary fundamentals to face problems related to the management and development of equipment and biomedical processes.
TEACHING METHODS	Lectures, practical class.
SUGGESTED BIBLIOGRAPHY	J.M. Smith, H.C. Van Ness, Introduction to chemical engineering thermodynamics, McGraw-Hill international, ISBN: 978-0071247085 Bird R.B., Stewart W.E., Lightfoot E.N., Fenomeni di trasporto, Casa Editrice Ambrosiana, Milano (1970), ISBN: 978-8808080622 R. Mauri – Fenomeni di trasporto. – Pisa University Press; 3 edizione (9 luglio 2014), ISBN: 978-8867413522

SYLLABUS

Hrs	Frontal teaching
3	Course introduction. Unit of measure and dimensions; dimensional consistency; 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 ideal gas law Temperature scale, extensive and intensive quantities, closed and open system, thermodynamical state and state variables.

SYLLABUS

Hrs	Frontal teaching
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. Volumetric thermal expansion coefficient and volumetric pressure expansion coefficient.
3	First law of thermodynamics, closed systems formulation, internal energy, enthalpy. isothermal, constant volume and constant pressure transformations, specific heat and ideal gas definition.
3	Thermophysics: Phase transition and enthalpy change for pure substances. Energy balance on closed systems.
4	Reversible transformations, equilibrium and second law of thermodynamics. Entropy definition, mathematical second law of thermodynamics formulation. Helmholtz and Gibbs free energy definition and properties.
4	Main relationships between thermodynamic potentials, ideal gas expression. 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.
4	Gibbs free energy expression for variable composition systems. Partial pressure definition. Mixing entropy and 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.
3	Non ideal variable composition systems, partial molar properties, component fugacity of a component in real mixtures, activity. Reference state, Henry law, phase rule. 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.
3	Fluid dynamics; Newton law of viscosity. Non Newtonian fluids. Laminar pipe flow; Reynolds experience; flow regime; pipe friction factor, Reynolds number and correlations.
3	Stress due to fluid motion around submerged objects; terminal velocity. Heat transfer: conduction and Fourier law and , units. Conduction in a slab and in cylindrical geometry.
3	Heat transfer: conduction and Fourier law, units. Conduction in a slab and in cylindrical geometry. Radiant heat transfer
3	Forced and natural convection. Combination of heat transfer resistances in series in a slab and in cylindrical geometry. Open systems energy balance. Temperature distribution along a heated or cooled pipe. Bernoulli equation.
3	Buckingham theorem. Nusselt and Prandtl numbers. Convective heat transfer correlations. Lumped parameters transient heat exchange.
3	Mass transfer, Fick's law. Mass transfer coefficients, Chilton-Colburn analogy, Sherwood and Schmidt numbers, series combination of mass transfer resistances.

Hrs	Practice
27	Practical class for calculation on the course topics.