UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2016/2017
BACHELOR'S DEGREE (BSC)	CHEMICAL ENGINEERING
SUBJECT	ELEMENTS OF CHEMICAL ENGINEERING
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50297-Ingegneria chimica
CODE	05761
SCIENTIFIC SECTOR(S)	ING-IND/24
HEAD PROFESSOR(S)	BRUCATO VALERIO MARIA BARTOLO — Professore Ordinario — Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	12
INDIVIDUAL STUDY (Hrs)	192
COURSE ACTIVITY (Hrs)	108
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	2° 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	Consolidated knowledge on: algebra, functions of one or more variable, infinitesimal calculus, mechanics, chemistry, phase equilibrium and state diagrams.
LEARNING OUTCOMES	knowledge and understanding - After the course the student will become conscious of problems related to transport phenomena and will became familiar with mass, energy and momentum balance equations as well as related transport constitutive models. Furthermore he will be able in calculating and/or evaluating friction factors and heat and mass transfer coefficients. Basic knowledge of radiant heat transfer will be provided. - The student will be able to select and use the needed and appropriate relationships for chemical engineering processes. making judgements - The student will be able to autonomous evaluate transport phenomena relationships applicability, results reliability and confidence, boundary conditions to apply to transport phenomena problems. Skills in application knowledge and understanding - learning of new and more complex approach to problems involving the course topics will be easier as fundamentals and logic approach scheme to face problems are current contents of the course. communication skills - The student will acquire the skill of state and tranfer problems related to course topics by the use of the appropriate scheme mathematics and terminology. Learning skills - By the acquired knowledge on transport phenomena the student will own the fundamental approach of balance equations, both macroscopic and microscopic, to complex problems; - furthermore he will know the difference between qualitative and quantitative approach to chemical engineering design of units and reactors.
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-thematiccoherence 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 on fundamentals and application of transport phenomena knowledge for professional work as well as applied research on chemical engineering unit and process design.
TEACHING METHODS	Lectures + practical class.

SUGGESTED BIBLIOGRAPHY	Bird, R. Byron, Stewart, Warren E., Lightfoot, Edwin N., Transport Phenomena - revised 2nd Edition, Wiley (2007), ISBN: 978-0470115398 R. Mauri – Fenomeni di trasporto. – Pisa University Press; 3 edizione (9 luglio 2014), ISBN: 978-8867413522

SYLLABUS

Hrs	Frontal teaching
25	Stress, stress tensor definition, newtonian fluids definition, viscosity dependence on temperature and pressure. Balance principle, conservative quantities balance, total mass balance. Momentum balance and boundary conditions. Steady state differential mass balance on systems with velocity depending on one coordinate (inclined plane laminar flow, pipe laminar flow, slit flow). Stokes law. Laminar vs turbulent flow, Reynolds number, turbulent flow properties. Dimensional analysis and Buckingham theorem, friction factor definition, relationship between friction factor and Reynolds number, pipe pressure loss, drag force and falling submerged objects terminal velocity calculation. Momentum macroscopic balance, energy dissipation and mechanical energy balance (Bernoulli equation), concentrated and distributed mechanical energy loss; macroscopic balance examples. Microscopic momentum balance.
24	Heat flow, Fourier law, thermal conductivity dependence on temperature and pressure, Prandtl number. Heat balance and boundary conditions, steady heat flow trough flat slab and composite flat slabs, heat exchange coefficient, series composition of thermal resistances in flat geometry; steady heat flow trough a cylindrical walls and composite cylindrical walls, heat exchange coefficient, series composition of thermal resistances in cylindrical walls. Haet conduction with generation (electrical Joule effect, viscous dissipation, chemical reaction); heat transfer in laminar pipe flow; cooling fin, natural convection. Transient heat conduction: energy differential balance, solutions with fixed wall temperature and wall heat exchange coefficient, dimensional analysis of the problem, different regimes and Biot number. Dimensional analysis of heat transport by Buckingham theorem, dimensional correlations for heat transfer coefficient, Coburn analogy. Macroscopic energy balance equation and applications. Microscopic energy Balance. Radiant heat transfer: opaque body, absorbance coefficient and emissivity, grey bodies, Stefan Boltzmann law, Lambert law, view factors.
23	Mass flow, Fick's law, dependence of diffusivity on temperature and pressure, Schmidt number; Mass balance and boundary conditions. Equimolar diffusion and stagnant component diffusion, mass transfer coefficients; diffusion with surface chemical reaction. Transient solid diffusion, analogy with transient solid heat transfer. Penetration theory, instantaneous and averaged mass transfer coefficient, limitation for the solution applicability. Mass transfer coefficient dimensional analysis by Buckingham theorem, adimensional heat and mass transfer numbers analogy. Interface mass transfer conditions, phase equilibrium, series combination of mass transfer resistances. Macroscopic mass balance, simultaneous heat and mass transfer. Microscopic mass balance.

Hrs	Practice
13	Hydrostatic forces on flat submerged surfaces, curved surfaces and buoyancy calculations. Pressure loss and flow rate in laminar pipe flow and for free surface inclined plane flow calculations. Tangenziale stress in pipes and submerged objects calculations. Bernoulli equation for hydraulic circuit calculations. Terminal velocity determination of falling objects calculations.
12	Steady heat conduction calculations, with and without generation, in solids with different geometries. Heat exchange coefficients calculations. Steady macroscopic energy balance application to open and closed systems. Lumped and distributed parameters heat transient calculations.
11	Steady diffusion in different geometries calculations. Mass transfer coefficient calculations. Open and closed systems macroscopic mass balance applications. Lumped and distributed parameters transient mass transfer calculations.