

E.C.T.S. DEPARTMENTAL COORDINATOR

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CHARACTERIZATION OF THE CHEMICAL ENGINEERING COURSES

Executive President: Jorge da Silva Mariano

Commission Vice-President: Luís Miguel Moura Neves de Castro

Voter: Elisa Maria Mendes de Vasconcelos Raposo Lapa

Scientific President: Maria Nazaré Coelho Pinheiro

Commission Vice-Presidente: Luís Miguel Moura Neves de Castro

Pedagogic Teacher's body representant: Acácio Fernando da Silva João

Commission Assistent's body representant: Maria João Anunciação Moreira

Students, Teachers and Staff:	Students	Bachelor degree	161
		Graduation degree	48
	Teachers	Professors	21
		Assistants	3
		Instructors	2
	Staff	Technicians	2
		Administratives	1
		Cleaning Staff	2
2004/05			

Facilities: Central Building

BASEMENT	Instrumental Analysis Laboratory
	Materials Laboratory
	Offices
LEVEL 0	Executive Commission
	Scientific Commission
	Practice of Technology Laboratory
	Calculus Laboratory
	Project Design Room
LEVEL 1	Organic Chemistry Laboratory
	Complements of Instrumental Analysis Laboratory
	Offices
LEVEL 2	Thermodynamics Laboratory
	Lecture Halls
	Audiovisual Room
	Offices

Building A

BASEMENT	Warehouse
LEVEL 1	Control Laboratory
	Meeting Room
	Classrooms
	Offices
LEVEL 2	Lecture Hall
LEVEL 3	Classroom
	Offices

Building B

BASEMENT	Analytical Chemistry Laboratory
	Biochemistry Laboratory
	Offices
LEVEL 1	Chromatography Laboratory
	Offices

Objective: The Chemical Engineering course taught at Instituto Superior de Engenharia de Coimbra aims to produce bachelors and graduates in Chemical Engineering with expertise and scientific ability enough to pursue a career in industrial or service organizations, to provide the industry with services on process development and consulting areas, and develop relevant scientific research in the area.

Mission: The mission of the Chemical Engineering course of the Instituto Superior de

Engenharia de Coimbra is intimately connected with the specific objectives of the Chemical Engineering nowadays, focusing in four strategic lines:

1. To provide the students with an extensive basis of knowledge, aiming to prepare engineers able to achieve prominent technical and management positions in industry and service organisations, and simultaneously able to adapt to the concerns of technological and environmental requirements of the industry of the 21st. century;
2. To develop research in Chemical Engineering in order to improve the knowledge on engineering sciences, and the role of teachers and students at industrial level, particularly at regional scale, as innovation agents and trouble shooters;
3. To promote the integration of young graduates in the industry;
4. To contribute to the economic and social development and increase the quality of life of the Country.

Strategy:

Chemical Engineering speciality involves diverse kinds of knowledge, from molecular synthesis to optimization and process control of industrial units, thus requiring different types of approach depending on the scenario. To account for the multidisciplinary and multiscale characteristics of the area, the structure of the course stands on a basis of integrated knowledge that encompasses a large set of topics ranging from Organic and Analytical Chemistry to Process Design and Optimization of production units and products. On the other hand, industrial competitiveness requires the Engineering professionals to have knowledge on complementary areas aiming to adequately manage the resources available such as Energy, Ecological, Social, and Human resources. Taking into account these concerns, the Department of Chemical Engineering (DCE) provides the students with knowledge on additional topics focused on the Human Resources Management, Quality Management, Environmental Management and Economy beyond the technical subjects that form the core of Chemical Engineering speciality. The implementation of such a policy aims at providing the students with specific skills on Chemical Engineering topics and additional knowledge on the so called horizontal areas.

Employability: Inquiries to former-students enabled to characterise the employability of the

Chemical Engineering graduates. The main activities are: teachers of the secondary education (17.5 %), consultants in the quality area (15.2 %), in laboratories of quality control (14.8 %), in commercial and sales areas (9.4 %), in production engineering (7.4 %), as teachers of high level education institutions (6.1 %), in management (4.8 %), in environmental area (4.3 %), in administrative sector (4.0 %), and in research and development (3.6 %), beyond other activities with smaller weight in employment. This dispersion of graduates by fields of activity strengthens the flexibility and adaptation ability of engineers produced by DCE, and brings positive feedback to the choice for the large spectrum of topics covered along the course.

Structure: The changes introduced in the Basis Law of the Portuguese Educative System in July 1997 led to the creation of two-stage based degree courses at Instituto Superior de Engenharia de Coimbra, among which was the Chemical Engineering graduation. This structure, implemented in 1999, includes a first cycle with the duration of six semesters, that confers the bachelor degree, and the second cycle, comprising four additional semesters, that confers the graduation degree in Chemical Engineering. The strategy then followed in building the structure of the 1st. cycle was mainly focused in providing the students with a wide but deep formation in Basic Sciences, such as Mathematics, Physics and Chemistry; with the ability to analyze and project simple process units, and the ability to use laboratorial methods devoted to chemical analysis. The specificity of this curricular structure relatively to competitors at regional scale is the focus put on experimental learning, which was implemented by including an extensive amount of courses of practical nature in the curricular program.

The curricular structure of the course is in agreement with homologous courses at national and international scale. It is also in agreement with policies defined by national and international organizations focused on the accreditation and integration of high-level education courses in what concerns to the weights of each one of the different areas of formation (Basic Sciences, Engineering Sciences, Speciality Sciences and Complementary Sciences) in curricular program. Basic Sciences (BASC) are commonly defined as the subjects of basic scientific formation, Engineering Sciences (ENGC) are subjects based on applications of Basic Sciences, Speciality Sciences (SPEC) are areas of formation focused on the application of

knowledge to the resolution of real problems of the speciality, and Complementary Sciences (COMC) are topics that complement the scientific line of the speciality. The weight of each of these formation areas was evaluated on the basis of European Credit Transfer System (ECTS).

Area	ECTS (%)
Basic Sciences	21.7
Engineering Sciences	18.7
Speciality Sciences	46.8
Complementary Sciences	12.8

Access:

The candidates to Bachelor degree or graduation in Chemical Engineering at Instituto Superior de Engenharia de Coimbra is required to successfully complete the secondary studies, the submission to national examinations in the subjects of Chemistry and Mathematics or Physics and Mathematics, minimum classifications of 95/200 points in each of these examinations, and candidacy classification of 100/200 points¹.

The Chemical Engineering course at Instituto Superior de Engenharia de Coimbra gives regional preference to the candidates of the districts of Aveiro, Castelo Branco, Coimbra, Guarda, Leiria and Viseu (25% of the *numerus clausus*). It also gives ability preference to the candidates with previous formation in Technological Chemistry (420), Technological Chemistry/Laboratory Analysis (541), Technological Chemistry/Manufacture Technician (542), Technological Chemistry/Laboratory Technician/Chemical Analyst (421), Technological Chemistry/Production Technician (306), Quality Control Technician (437), Environmental Technician (041), Chemical Technician (042), Biotechnology Technical (169), Chemistry (167) and Group 1/Chemistry (815) (20% of the *numerus clausus*).

**Teaching
Methods and
Assessment:**

The teaching method adopted by CED is oral exposition of the subjects in theoretical classes, supervised problem solving in tutorial classes. Moreover, individual capacity of experimentation and experimental fundamentals are improved in laboratorial classes. The assessment is mainly based on closed book examinations. Approval is given when the student achieves 10/20 points. The grading may be different from the examination classification, particularly when involves other assessment components, such as laboratorial

¹ The candidacy classification is calculated by weighting 65% the average of the classification of secondary studies and 35 % the classification in national examinations.

information. In some cases the students are not submitted to examination and the assessment is achieved through individual and/or group projects. In this case, the students are examined, during the semester/year, by written reports and its oral presentation and discussion.



INSTITUTO SUPERIOR DE ENGENHARIA DE COIMBRA

Plan of Study

Code	Subject	Hours/Week				ECTS
		Lecture	Tutorial	Laboratory	Total	
1st Year – 1st Semester						
41101	Mathematics	2	3		5	(*)
41102	Physics	2	2		4	(*)
41103	Fundamentals of Physics and Chemistry	3		3	6	(*)
41104	Organic Chemistry I	2			2	3.5
41105	Analytical Chemistry	3		3	6	5.5
41106	Introduction to Computers	2	3		5	4.5
1st Year – 2nd Semester						
41101	Mathematics	2	3		5	12.0
41102	Physics	2	2		4	9.0
41103	Fundamentals of Physics and Chemistry	3		3	6	12.0
41201	Organic Chemistry II	2		3	5	6.5
41202	Industrial Drawing			3	3	3.0
41203	Numerical Methods	2	2		4	4.0
2nd Year – 1st Semester						
42101	Instrumental Analysis I	3		3	6	7.5
42102	Thermodynamics I	3	2		5	6.0
42103	Statistical Methods	2	2		4	4.0
42104	Fluid Mechanics	2	3		5	5.0
42105	Introduction to Chemical Processes	2	4		6	7.5
2nd Year – 2nd Semester						
42201	Instrumental Analysis II	1		3	4	4.5
42202	Thermodynamics II	3		3	6	6.0
42203	Utilities and Industrial Equipment	3	2		5	5.5
42204	Unit Operations I	2	2		4	4.0
42206	Heat and Mass Transfer	2	2		4	5.0
42205	Instrumentation and Control	3	2		5	5.0
3rd Year – 1st Semester						
43101	Practice of Technology			4	4	(*)
43102	R&D in Chemical Engineering			4	4	(*)
43104	Unit Operations II	3	3		6	7.0
43103	Materials	3	1	2	6	7.0
43105	Economy and Management	2	2		4	4.5
3rd Year – 2nd Semester						
43101	Practice of Technology			4	4	13.0
43102	R&D in Chemical Engineering			4	4	10.0
43201	Unit Operations III	3	3		6	6.5
43202	Chemical Reactors I	2	4		6	6.5
43203	Management and Planning I	2	2		4	5.5

4th Year – 1st Semester

44101	Complements of Mathematics	2	2		4	4.5
44102	Complements of Heat and Mass Transfer	2	2		4	5.0
44103	Biochemistry and Macromolecules	2		3	5	5.0
44104	Practice of Chemical Technology I			4	4	5.5
44105	Applied Thermodynamics	2	2		4	4.5
44106	Numerical Methods and Modeling	2	2		4	5.5

4th Year – 2nd Semester

44201	Chemical Reactors II	2	2		4	4.5
44202	Complements of Instrumental Analysis	2		3	5	6.0
44205	Practice of Chemical Technology II			4	4	8.0
44203	Process Control	2	2		4	7.0
44204	Unit Operations IV	2	3		5	4.5

5th Year – 1st Semester

45101	Design Project			5	5	(*)
45102	Seminar			5	5	(*)
45103	Optimization and Quality Strategies	2	3		5	7.0
45201	Environmental Management	2	2		4	5.0
(**)	Elective I	2	2		4	4.0

5th Year – 2nd Semester

45101	Design Project			5	5	22.0
45102	Seminar			5	5	13.0
45104	Management and Planning II	2	2		4	5.0
(**)	Elective II	2	2		4	4.0

(*) – Credits of annual subject summed at the end of the 2nd Semester.

Code (**)	Elective Subjects	Semester
45107	Anthropogenic Pollution	1
45204	Energy and Environment	2
45203	Granular Material Characterization	2

Course:	Chemical Engineering		
Subject:	Mathematics		Code: 41101
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>1</u>	Semester:	<u>A</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>3</u>	Lab.	ECTS:	<u>12.0</u>
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Aims	To provide the students with the basics on calculus and linear algebra required along the graduation.
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Syllabus	Complements of Differential Calculus. Integral Calculus. Notions of Calculus in R_2 . Differential Equations. Matrices and Linear Equations Systems. Vector Calculus. Eigenvectors and Eigenvalues.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	<ul style="list-style-type: none"> - Swokowski, Earl W., "Cálculo com geometria analítica", São Paulo: McGraw-Hill, 1983 - Grossman, Stanley I., "Calculus", 5^a ed., New York: Saunders College Publishing, 1992 - Azenha, A., Jerónimo, M. A., "Elementos de cálculo diferencial e integral em R e R_n", Lisboa: McGraw-Hill, 1995 - Saraiva, M. A., Silva, M. A., "Primitivação", 3^a ed., Porto: ASA, 1997
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Assessment	<ol style="list-style-type: none"> 1. Closed book examination. Two mid-term tests (T1 and T2), with the final classification (CF) being equal to the weighted sum between the classification in both tests, $CF = 0.50T1 + 0.50T2$. 2. End of academic year closed book examination, comprising all the subjects lectured, with classification CE. In this case, $CF = CE$.
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Course:	Chemical Engineering		Code: 41102
Subject:	Physics		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>1</u>	Semester:	<u>A</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>2</u>	Lab.	ECTS:	<u>09.0</u>
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Aims	To provide the students with basic knowledge on physics, particularly required for students grasping of subsequent subjects.
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Syllabus	Unit systems. Kinematics. Particle and particle systems dynamics. Hydrostatics. Hydrodynamics and viscosity. Electrostatic field. Electric field. Condensers. Continuous current. Magnetic field. Electromagnetic field.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving. Laboratorial classes.
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Readings	Lecture notes. Tutorial problems. Solved problems, available at the Web.
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Bibliography	<ul style="list-style-type: none"> - Tipler, Paul A., "Física", vol. 1 e 2, 4ª ed., Rio de Janeiro: Livros Técnicos e Científicos, 2000 - Beer, F. P., Johnston, E. R., "Mecânica Vectorial para Engenheiros", vol. 1, 6ª ed, McGraw-Hill, 1998 - Halliday, D., Resnick, R., "Física", Rio de Janeiro: Livros Técnicos e Científicos, 1981 - Sears, F., Zamansky, M., Young, H., "Física", vol. 1 e 2, Rio de Janeiro: Livros Técnicos e Científicos, 1991 - Alonso, M., Finn, A., "Física", Madrid: Addison-Wesley Iberoamericana, 1999
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Assessment	<p>1. Closed book examination. Two mid-term tests (T1 and T2), with the final classification (CF) being equal to the weighted sum between the classification in both tests and classification in laboratorial component (CL), $CF = 0.20CL + 0.80(0.50T1 + 0.50T2)$.</p> <p>2. End of academic year closed book examination, comprising all the subjects lectured, with classification CE. In this case, $CF = 0.20CL + 0.80CE$.</p>
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Course:	Chemical Engineering		Code: 41103
Subject:	Fundamentals of Physics and Chemistry		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>1</u>	Semester:	<u>A</u>	Hours/Week:	Lect. 3	Tutorial	Lab. 3	ECTS:	<u>12.0</u>
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Aims	To supply an introduction to physical phenomena involved in chemistry. To show the relevance of atomic and molecular structures in physical and chemical properties of materials. To provide the students with experience on volumetric titration and ability in recognizing the importance of stoichiometry, kinetics and thermodynamics of chemical reactions involved.
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Syllabus	Atomic spectroscopy and Bohr's model of mono electronic atom. Old Quantum theory. Fundamentals of Wave Mechanics (Quantum Mechanics). Applications of the Wave Mechanics to systems and processes with physical and chemical interest. Electronic structure of single and multielectronic atoms.
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Teaching Method	Lecture sessions: Oral exposition. Laboratory sessions: Laboratorial classes. Each laboratorial experiment is preceded by the discussion of objectives and execution procedure.
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Readings	Lecture notes. Experimental procedures.
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Bibliography	<ul style="list-style-type: none"> - Eisberg, R. M., "Fundamentals of Modern Physics", New York: John Wiley & Sons, 1961 - Herzberg, G., "Atomic Spectra and Atomic Structure", New York: Dover, 1944 - Douglas, B. E., McDaniel, D. H., Alexander, J. J., "Concepts and Models of Inorganic Chemistry", New York: John Wiley & Sons, 1983 - Levine, I. N., "Physical Chemistry", New York: McGraw-Hill, 1995 - Mahan, B. H., Meyers, R. J., "University Chemistry", Menlo Park: Benjamin, 1987
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Assessment	<p>1. Closed book examination. Two mid-term tests (T1 and T2), with the final classification (CF) being equal to the weighted sum between the two tests and the classification in the laboratorial component (CL), $CF = 0.25CL + 0.75(0.50T1 + 0.50T2)$.</p> <p>2. End of academic year closed book examination, comprising all the subjects lectured, with classification CE. In this case, $CF = 0.25CL + 0.75CE$.</p>
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Course:	Chemical Engineering		
Subject:	Organic Chemistry I		Code: 41104
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>1</u>	Semester:	<u>1</u>	Hours/Week:	Lect. 2	Tutorial	Lab.	ECTS:	<u>03.5</u>
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Aims	To provide the students with the basics on the area of Organic Chemistry, and present synthesis strategies and analysis methods with relevance in Chemical Engineering and Applied Chemistry.
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Syllabus	Alkanes. Alkenes. Alkynes. Cyclical aliphatic hydrocarbons. Dienes and polymers. Aromatic hydrocarbons and aromatic electrophilic substitution. Alkylbenzene, alkenylbenzene and alkynylbenzene. Halides alkyls. Alcohols. Ethers.
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Teaching Method	Lecture sessions: Oral exposition.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	- Loudon, G. M., "Organic Chemistry", 3 ^a ed., Redwood: Addison-Wesley, 1995 - Morrison, R., Boyd, R., "Química Orgânica", 13 ^a ed., Lisboa: Fundação Calouste Gulbenkian, 1996 - Streitwieser, A. Jr., Hatchcock, C. H., "Introduction to Organic Chemistry", New York: Collier McMillian, 1976
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Analytical Chemistry		Code: 41105
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>1</u>	Semester:	<u>1</u>	Hours/Week:	Lect. 3	Tutorial	Lab. 3	ECTS:	<u>05.5</u>
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Aims	To introduce the students into the basics of Analytical Chemistry, focusing the study on the application of methods in Chemical Engineering and Applied Chemistry areas.
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Syllabus	Acid-base equilibrium. Precipitation based titrations. Complex formation based titrations. Introduction to redox equilibrium. Introduction to electrochemistry. Theory of redox titrations. Applications of redox titrations. Gravimetric analysis.
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Teaching Method	Lecture sessions: Oral exposition. Laboratory sessions: Laboratorial classes. Each laboratorial experiment is preceded by a theoretical explanation.
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Readings	Lecture notes. Tutorial problems. Experimental procedures.
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Bibliography	- Skoog, D., West, D., Holler, F., "Fundamentals of Analytical Chemistry", 7 ^a ed., Saunder College Publishing, 1997 - Mendhas, R., Denney, J., Barnes, M., Vogel, A., "Análise Química Quantitativa", 6 ^a ed., Livros Técnicos e Científicos, 1989 - Christian, G., "Analytical Chemistry", 5 ^a ed., John Wiley & Sons, 1994 - Harris, D., "Exploring Chemical Analysis", 2 ^a ed., W. H. Freeman and Company, 2001
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification in the laboratorial component (CL), $CF = 0.50CE + 0.50CL$.
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Course:	Chemical Engineering		
Subject:	Introduction to Computers		Code: 41106
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>1</u>	Semester:	<u>1</u>	Hours/Week:	Lect. 2	Tutorial 3	Lab.	ECTS:	<u>04.5</u>
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Aims	To provide the students with some concepts of computational systems operation and scientific programming languages, particularly FORTRAN 90. To guide the pupils in the use of available computational resources. To motivate them for the use of COMPAQ FORTRAN (FORTRAN 90) compiler aiming to solve problems with relevance in Chemical Engineering.
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Syllabus	Generalities. Van Neumann model. Basic components of computational systems. Hardware. Software. Interfaces. Internet. Tools of common use. Algorithms. Programming languages. Classification of programming languages. Basics of FORTRAN 90. Algorithm and program development.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes. Tutorial problems. Assignments.
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Bibliography	<ul style="list-style-type: none"> - Nakamura, S., "Applied Numerical Methods with software", New Jersey: Prentice Hall, 1991 - Tanenbaum, A. S., "Operating systems - Design and implementation", New Jersey: Prentice Hall, 1987 - Ellis, T. M. R., "FORTRAN 77 Programming", 2^a ed., London: Addison-Wesley Publishing Company, 1991 - Rosch, W. L., "Desvendando o hardware do PC", Vol. 1, 2^a ed., Rio de Janeiro: Editora Campus, 1991 - Stultz, R. A., "MS-DOS 6.2", São Paulo: Makron Books, 1994
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification from the assignments (CL), $CF = 0.50CE + 0.50CL$.
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Course:	Chemical Engineering		
Subject:	Organic Chemistry II		Code: 41201
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

			Lect.	Tutorial	Lab.			
Year:	1	Semester:	2	Hours/Week:	2	3	ECTS:	06.5

Aims	To provide the students with knowledge regarding the synthesis of organic substances. To introduce the pupils into the laboratory techniques used in synthesis, purification and analysis of organic compounds with industrial interest. The laboratory classes intend to give the students the chance of test at lab scale topics of knowledge introduced in the courses of Organic Chemistry.
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Syllabus	Epoxies. Carboxylic acids. Functional derivatives of carboxylic acids. Sulphonic acids and derivatives. Amines. Diazo salts. Phenols. Aldehydes and ketones. Multi-ring aromatic compounds. Dicarboxylic acids.
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Teaching Method	Lecture sessions: Oral exposition. Laboratory sessions: Laboratorial classes.
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Readings	Lecture notes. Tutorial problems. Experimental procedures.
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Bibliography	<ul style="list-style-type: none"> - Streitwieser, A. Jr., Hatchcock, C. H., "Introduction to Organic Chemistry", New York: Collier McMillian, 1976 - Morrison, R., Boyd, R., "Química Orgânica", 13ª ed., Lisboa: Fundação Calouste Gulbenkian, 1996 - Allinger, N., "Química Orgânica", 2ª ed., Rio de Janeiro: Guanabara Dois, 1978 - Loudon, G. M., "Organic Chemistry", 3ª ed., Redwood: Addison Wesley, 1995 - Vogel, A., "Química Orgânica", Vol. 3, Rio de Janeiro: Livros Técnicos e Científicos, 1971
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification in the laboratorial component (CL), $CF = 0.75CE + 0.25CL$.
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Course:	Chemical Engineering		
Subject:	Industrial Drawing		Code: 41202
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>1</u>	Semester:	<u>2</u>	Hours/Week:	Lect.	Tutorial	Lab.	ECTS:	<u>03.0</u>
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Aims	To introduce the pupils into the interpretation of technical drawings. To provide the students with experience on the execution of fast sketches of technical models.
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Syllabus	Drawing material and its use. Basic norms of technical drawing. Orthogonal views. Cuts and sections. Quoting. Quick view drawing.
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Teaching Method	Laboratory sessions: Drawing projects produced from educational prints as models. Preceding each drawing an explanation is given by presenting similar cases.
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Readings	Lecture notes.
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Bibliography	<ul style="list-style-type: none"> - Cunha, Veiga da, "Desenho Técnico", 8ª ed., Lisboa: Fundação Calouste Gulbenkian, 1991 - Morais, Simões, "Desenho Técnico e Industrial", Porto Editora - Silva, Arlindo; Dias, João, Sousa, Luís, "Desenho Técnico Moderno", Lidel - Groutel, E., "Dessin Prespectif Industriel", Foucher Ed.
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Assessment	<ol style="list-style-type: none"> 1. Assignments developed during the semester. The final classification (CF) is the weighted sum of the classification obtained at each assignment. 2. End of semester closed book examination (CE). In this case the CF is equal to the classification in the exam, CF = CE.
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Course:	Chemical Engineering		Code: 41203
Subject:	Numerical Methods		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>1</u>	Semester:	<u>2</u>	Hours/Week:	Lect. 2	Tutorial 2	Lab.	ECTS:	<u>04.0</u>
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Aims	To provide the students with the general concepts regarding Numerical Methods and Numerical Analysis, particularly, necessary conditions, applicability and methods limitations. To stimulate the students to use packages and computational libraries for solving numerical problems with relevance in Chemical Engineering, such as Matlab, Mathematica, and Derive.
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Syllabus	Numerical errors. Polynomial interpolation. Solution of systems of nonlinear equations. Numerical integration. Numerical derivation.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving. Development of a project using MATLAB.
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Readings	Lecture notes. Tutorial problems. Notes - "Como usar o Matlab".
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Bibliography	<ul style="list-style-type: none"> - Burden, Richard L., Faires, J. Douglas, "Numerical Analysis"; Boston: PWS-KENT Publishing Company, 1993 - Chapra, S. C., C., Raymond P., "Numerical Methods for Engineers", New York: McGraw-Hill, 1989 - Conte, S. D., Boor, C., "Elementary Numerical Analysis", McGraw-Hill, 1981 - Faires, J. Douglas, B., Richard, "Numerical Methods", Pacific Grove: ITP, 1998 - Ruggiero, Márcia A. Gomes, Lopes, Vera Lúcia da Rocha, "Cálculo Numérico, Aspectos Teóricos e Computacionais", São Paulo: McGraw-Hill, 1988
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Assessment	<ol style="list-style-type: none"> 1. Development of an assignment (CL) and end of semester closed book examination (CT). The final classification (CF) is the weighted sum between CL and CT as follows: $CF = 0.25CL + 0.75CT$. 2. End of semester closed book examination (CE). The final classification (CF) is equal to the classification obtained in the exam, $CF = CE$.
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Course:	Chemical Engineering		
Subject:	Instrumental Analysis I		Code: 42101
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>2</u>	Semester:	<u>1</u>	Hours/Week:	Lect. 3	Tutorial	Lab. 3	ECTS:	<u>07.5</u>
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Aims	To provide the pupils with basic theoretical knowledge and experimental training on chemical analysis techniques, particularly Molecular Spectroscopy (UV, Vis and IR), Atomic Absorption and Emission, Potentiometry and Conductimetry.
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Syllabus	Electromagnetic radiation and interaction of radiation with matter. Introduction to absorption spectroscopy. UV and Vis spectroscopy. Molecular absorption. Infra-red radiation absorption. Conductimetry. Atomic absorption spectroscopy. Flame emission spectroscopy. Introduction to electrochemistry. Potentiometry based methods.
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Teaching Method	Lecture sessions: Oral exposition. Laboratory sessions: Laboratorial classes.
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Readings	Lecture notes. Experimental procedures.
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Bibliography	<ul style="list-style-type: none"> - Gonçalves, M^a de Lurdes, "Métodos Instrumentais para Análise de Soluções", Lisboa: Fundação Calouste Gulbenkian, 2001 - Skoog, D. A., Leary, J. J., "Principles of Instrumental Analysis", 4^a ed., Saunders College Publishing, 1992 - Robison, J. W., "Undergraduate Instrumental Analysis", 5^a ed., M. Dekker, 1995 - Rubinson, K. A.; Rubinson, J. F., "Contemporary Instrumental Analysis", 1^a ed., Prentice Hall, 2000 - Settle, F. A., "Handbook of Instrumental Techniques for Analytical Chemistry", Editor, 1997
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification in the laboratorial component (CL), $CF = 0.50CE + 0.50CL$.
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Course:	Chemical Engineering		
Subject:	Thermodynamics I		Code: 42102
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>2</u>	Semester:	<u>1</u>	Hours/Week:	Lect. 3	Tutorial 2	Lab.	ECTS:	<u>06.0</u>
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Aims	To provide the students with the principles and basic laws of Thermodynamics, its applicability and the tools to establish relations between diverse physical properties.
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Syllabus	Basic concepts of Thermodynamics. Pure substance properties. First law of Thermodynamics: applied to closed systems, and to control volumes. Second law of Thermodynamics. Entropy. Systems analysis based on the second law of Thermodynamics. Relations between thermodynamic properties.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	<ul style="list-style-type: none"> - Çengel, Yunus, Boles, M. A., "Thermodynamics: An Engineering Approach", 3^a ed., McGraw-Hill, 1994 - Moran, M. J., Shapiro, H. N., "Fundamentals of Engineering Thermodynamics", 3^a ed., New York: John Wiley & Sons, 1998 - Sonntag, R. E., Van Wylen, G. J., "Introduction to Thermodynamics Classical and Statistical", 3^a ed., New York: John Wiley & Sons, 1991 - Çengel, Yunus, "Introduction to Thermodynamics and Heat Transfer", New York: McGraw-Hill, 1997 - Smith, J. M., Van Ness, H. C., Abbot, M. M., "Introduction to Chemical Engineering Thermodynamics", 5^a ed., McGraw-Hill, 1996
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Statistical Methods		Code: 42103
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>2</u>	Semester:	<u>1</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>2</u>	Lab.	ECTS:	<u>04.0</u>
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Aims	To provide the students with the basics on the area of Probability and Statistics. To introduce techniques for the analysis of data with relevance for Chemical Engineering.
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Syllabus	Introduction. Statistical meaning and importance of statistical thinking. Data analysis. Introduction to probability. Random variables. Probability distributions - discrete and continuous cases. Sampling and sample distribution. Limit theorems. Statistical inference - moment's estimation, and hypothesis tests.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	<ul style="list-style-type: none"> - Guimarães, R. C., Cabral, J., "Estatística", Lisboa: McGraw-Hill, 1997 - Bhattacharyya, J., "Statistics, principles and methods", New York: John Wiley & Sons, 1992 - Montgomery D. C., Runger G.C., "Applied Statistics and Probability for Engineers", 2^a ed., New York: John Wiley & Sons, 1999 - Murteira, B., "Análise exploratória de dados", Lisboa: McGraw-Hill, 1993 - Murteira, B., "Probabilidades e Estatística", Lisboa: McGraw-Hill, 1990 - Reis, E. e outros, "Estatística Aplicada", vol. 1 e 2, Sílabo
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		Code: 42104
Subject:	Fluid Mechanics		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>2</u>	Semester:	<u>1</u>	Hours/Week:	Lect. 2	Tutorial 3	Lab.	ECTS:	<u>05.0</u>
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Aims	To provide the students with general concepts on Fluid Mechanics, giving particular relevance to its application in Chemical Engineering area. To introduce Fluid Mechanics in the context of Unit Operations.
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Syllabus	Introduction to Fluid Mechanics: fluids characterization, piping, application, units and dimensions, dimensional analysis, and model theory. Fluid Mechanics applied to Chemical Engineering. Bernoulli equation. Flow measurement principles. Pumping - power required, efficiency, generic types of fluid pumps, characteristic equations and curves, pumping through compressed air systems. Connections between Fluid Mechanics and Unit Operations. Flow of solid particles into liquids.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving. Study visits to speciality industries.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	- Costa, E., "Mecânica dos Fluidos", Porto Alegre: Ed. Globo, 1973 - Streeter, V., "Mecânica dos Fluidos", São Paulo: McGraw-Hill, 1974 - Boxer, G., "Fluid Mechanics", Basingstoke: MacMillan Press, 1988 - Widden, M., "Fluid Mechanics", Hampshire: MacMillan Press, 1996 - Rao, N., "Fluid Flow Machines", New Delhi: McGraw-Hill, 1986
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification in the laboratorial component (CL), $CF = 0.85CE + 0.15CL$.
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Course:	Chemical Engineering		Code: 42105
Subject:	Introduction to Chemical Processes		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>2</u>	Semester:	<u>1</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>4</u>	Lab.	ECTS:	<u>07.5</u>
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Aims	To introduce the students into industrial processes calculations. To provide the students with a systematic approach to apply in the solution of problems concerned to industrial processes. The basic steps of the approach developed are: to identify and define the problem; to establish relations between degrees of freedom based on the analysis of process data; to solve the yielding system of equations and analyze problem solution.
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Syllabus	Unit systems. Representation of compositions of mixtures and solutions. Chemical reactions. The ideal gas law. Ideal gas behaviour. Chemical analysis of gaseous substances. Pressure. Pressure units. Temperature. Temperature units. Standard pressure and temperature conditions. Density and volumetric mass. Mass balances. Energy. Types of energy. Energy equations and enthalpy balances. Heat capacities of gas, solid, liquid substances, and solutions. Latent heats: of fusion, state transition, and vaporization. Air-water systems. Psychrometric chart. Wet and dry temperature, dew point, molar and relative moist. Heat of reaction. Thermodynamic laws. Heats of formation, solution and atomization of chemical species. Enthalpy-concentration diagrams. Saturated solution-vapour equilibrium. Enthalpy balances for adiabatic and nonadiabatic systems.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Tutorial problems.
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Bibliography	<ul style="list-style-type: none"> - Hougen, O. A., Watson, K. M., Ragatz, R. A., "Chemical Process Principles: Material and Energy Balances", New York: John Wiley & Sons, 1954 - Felder, R. M., Rousseau, R. W., "Elementary Principles of Chemical Processes", 3^a ed., New York: John Wiley & Sons, 2000 - Henley, E. J., Rosen, E. M., "Material and Energy Balances Computations", New York: John Wiley & Sons, 1969 - Schmidt, A. X., List, H. L., "Material and Energy Balances", New York: Prentice Hall, 1962 - Schlesinger, M. E., "Mass and Energy Balances in Materials Engineering", New Jersey: Prentice Hall, 1995
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Instrumental Analysis II		Code: 42201
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>2</u>	Semester:	<u>2</u>	Hours/Week:	Lect. 1	Tutorial	Lab. 3	ECTS:	<u>04.5</u>
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Aims	To present the principles and instrumentation of separation based methods used for analysis of chemical species. To provide the students with experience regarding the use of chromatographic techniques such as GLC and HPLC.
Syllabus	Chemical separations. Generalities. Methods of separation involving change of phase. Methods of separation involving extraction. Chromatographic separations.
Teaching Method	Lecture sessions: Oral exposition. Laboratory sessions: Laboratorial classes. Each laboratorial experiment is preceded by the discussion of its objectives and methodology.
Readings	Lecture notes. Experimental procedures.
Bibliography	<ul style="list-style-type: none"> - Peters, D. G., Hayes, J. M., Hieftje, G. M., "Chemical Separations and Measurements", W. B. Saunders, 1974 - Skoog, D. A., Leary, J. J., "Principles of Instrumental Analysis", 4^a ed., Saunders College Publishing, 1992 - McNair, H. M., Miller, J. M., "Basic Gas Chromatography", John Wiley & Sons, 1998 - Lough, W. J., Wainer, I. W., "High Performance Liquid Chromatography", 1^a ed., Chapman and Hall, 1996
Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification in the laboratorial component (CL), $CF = 0.50CE + 0.50CL$.

Course:	Chemical Engineering		
Subject:	Thermodynamics II		Code: 42202
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>2</u>	Semester:	<u>2</u>	Hours/Week:	Lect. 3	Tutorial	Lab. 3	ECTS:	<u>06.0</u>
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Aims	To provide the students with theoretical knowledge on Thermodynamics of mixtures and phase equilibrium. To provide the students with relevant laboratorial experience and integrate it into the theoretical basics introduced.
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Syllabus	Mixtures and solutions. Systems with variable composition. Solutions. Real gas behaviour. Ideal solutions. Ideal diluted solutions. Non-ideal solutions. Phase equilibrium. Phase rule. Phase equilibrium in single component systems. Phase equilibrium in multi-component systems.
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Teaching Method	Lecture sessions: Oral exposition. Laboratory sessions: Laboratorial classes. Along the experiments the students must solve typical problems on the subjects covered and demonstrated.
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Readings	Lecture notes. Tutorial problems. Experimental procedures.
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Bibliography	<ul style="list-style-type: none"> - Levine, Ira N., "Physical Chemistry", 4^a ed., New York: McGraw-Hill, 1995 - Atkins, P. W., "Physical Chemistry", 6^a ed., Oxford: Oxford University Press, 1998 - Smith, J. M., Van Ness, H. C., Abbot, M. M., "Introduction to Chemical Engineering Thermodynamics", 5^a ed., McGraw-Hill, 1996 - Azevedo, E. Gomes, "Termodinâmica Aplicada", 2^a ed., Lisboa: Escolar Editora, 2000 - Guémez, J., Fiolhais, C., Fiolhais, M., "Fundamentos de Termodinâmica do Equilíbrio", Lisboa: Fundação Calouste Gulbenkian, 1998
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification in the laboratorial component (CL), $CF = 0.50CE + 0.50CL$.
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Course:	Chemical Engineering		Code: 42203
Subject:	Utilities and Industrial Equipment		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>2</u>	Semester:	<u>2</u>	Hours/Week:	Lect. 3	Tutorial 2	Lab.	ECTS:	<u>05.5</u>
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Aims	To provide the students with the basics to characterize, design and select equipment and structures involved in the production, treatment and distribution of utilities with relevance in chemical industry.
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Syllabus	Industrial water. Fuels and combustion. Thermal boilers and fluids. Refrigeration and cooling. Compressed air and vacuum pressure equipment. Electrical services.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes.
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Bibliography	<ul style="list-style-type: none"> - Betz Laboratories Inc., "Industrial Water Conditioning", 9^a ed., Betz Laboratories Inc, 1991 - Juanico, F. M., "Instalações Industriais", Cascais: Principia, 1998 - Juanico, F. M., "Geradores de Calor", Porto: ECEMEI, 1992 - Torreira, R. P., "Fluidos Térmicos", São Paulo: Hemus ed. - Bessonov, L., "Electricidade Aplicada para Engenheiros", Porto: Lopes da Silva Editora, 1976
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Unit Operations I		Code: 42204
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>2</u>	Semester:	<u>2</u>	Hours/Week:	Lect. 2	Tutorial 2	Lab.	ECTS:	<u>04.0</u>
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Aims	To provide the students with the basic knowledge on simple Unit Operations.
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Syllabus	The Unit Operations in Chemical Engineering - basic concepts and examples. Centrifugation and equipment. Solid particles classification. Sedimentation and thickening equipment. Gravimetric sedimentation. Agitation and mixture. Fluid flow across porous materials. Filtration. Fluidity of solid particles. Solid particles classification based on drying methods. Solid milling.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving. Study visits to industrial installations in order to promote students integration of theoretical topics covered with industrial relevance.
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Readings	Lecture notes. Tutorial problems. Assignments.
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Bibliography	- Coulson, J., "Chemical Engineering", Vol. 1 e 2, 3 ^a ed., New York: Pergamon Press, 1980 - Alves, L., "Tecnologia Química", Lisboa: Fundação Calouste Gulbenkian, 1991 - Smith, J., Harriot, P., "Unit operations of Chemical Engineering", 5 ^a ed., Singapore: McGraw-Hill, 1993 - Foust, A., "Principles of Unit Operations", 18 ^a ed., New York: John Wiley & Sons, 1960 - Brown, J., "Unit Operations", New York: John Wiley & Sons, 1972
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification from the assignments (CL), $CF = 0.85CE + 0.15CL$.
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Course:	Chemical Engineering		
Subject:	Heat and Mass Transfer		Code: 42206
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	2	Semester:	2	Hours/Week:	Lect. 2	Tutorial 2	Lab.	ECTS:	05.0
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Aims	To provide the students with basic understanding on the mechanisms of mass and heat transfer under a mathematically and physically based view. To establish steady state macroscopic and microscopic balances of mass and energy for diverse geometries and bodies. To provide the students with knowledge regarding the mass transfer of a solute between phases, and film resistances. To stimulate the use of the concepts introduced in the design of simple equipment. To develop the ability of solving problems involving heat and mass transfer.
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Syllabus	Heat transfer: Introduction. One-dimensional steady state conduction. Heat exchangers. Correlations to estimate heat transfer coefficients. Mass transfer: Introduction. Mass diffusion: Fick's law. Interfacial mass transfer. Diffusion in a moving medium.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	- Çengel, Yunus, "Heat Transfer - A Practical Approach", 2 ^a ed, McGraw-Hill, 2003 - Incropera, F. P., DeWitt, D. P., "Fundamentals of Heat and Mass Transfer", 5 ^a ed., John Wiley & Sons, 2001 - Welty, J. R., Wicks, C. E., Wilson, R. E., "Fundamentals of Momentum, Heat and Mass Transfer", 4 ^a ed., John Wiley & Sons, 2001 - Holman, J. P., "Heat Transfer", 9 ^a ed., McGraw-Hill, 2002
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Control and Instrumentation		Code: 42205
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>2</u>	Semester:	<u>2</u>	Hours/Week:	Lect. 3	Tutorial 2	Lab.	ECTS:	<u>05.0</u>
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Aims	To provide the students with a general understanding of the characteristics of process control in Chemical Engineering. To provide the students with knowledge regarding controller tuning techniques.
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Syllabus	Generalities. Introduction. Definitions of Process Control. Classes of instruments. Signal acquisition. Measurement standards. Measurement of pressure, temperature, flow, level, weight, speed, volumic mass, and moist. Transmitters. Pneumatic transmitters. Controllers. Controllers requiring not energy. Electric and hydraulic controllers. Control valves. Types of valves. Tuning of control loops. Open loop transient dynamics. Ziegler-Nichols tuning method.
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Teaching Method	Lecture sessions: Oral exposition Tutorial sessions: Problem solving. When possible oral exposition is completed by laboratorial experimentation and demonstration.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	<ul style="list-style-type: none"> - Curtis, J., "Controlo de Processos: Tecnologia da Instrumentação", Fundação Calouste Gulbenkian, 1990 - Considine, D., "Process Instruments and Controls Handbook", McGraw-Hill Book Company - Holzbock, W. G., "Instrumentos para Medicion y Control", Compañía Editorial Continental, 1964 - Foust, A. S., "Principles of Unit Operations", 18^a ed., New York: John Wiley & Sons, 1960 - Lipták, B. G., "Process Measurement and Analysis", 3^a ed., CRC Press, 1999
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Practice of Technology		Code: 43101
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>3</u>	Semester:	<u>A</u>	Hours/Week:	Lect.	Tutorial	Lab.	ECTS:	<u>13.0</u>
							4		

Aims	To consolidate theoretical concepts previously acquired by enabling the students to learn from laboratorial experimentation. To develop the ability of students in planning experiments, analyze and criticize the results, and finally in elaborating a report.
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Syllabus	Flow measurement. Fluids flow from a tank. Moody diagram validation. Sedimentation. Filtration. Heat exchanger operation. Agitation and mixture. Milling. Fluid pumping. Draining across porous beds and fluidization. Estimate of mass diffusion coefficients. Automatic control of level, pressure and flow variables.
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Teaching Method	Laboratory: All the students, obligatorily, must perform 12 experiments and elaborate a report on each one of the laboratorial works, which is then discussed. In the end of the academic year, each group of students presents publicly one of the experiments conducted.
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Readings	Experimental procedures.
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Bibliography	<ul style="list-style-type: none"> - Bird, R. B., Stewart, W. E., Lightfoot, E. N., "Transport Phenomena", John Wiley & Sons, 1960 - Coulson, J. M., Richardson, J. F., "Tecnologia Química", Vol.1 e 2, 3ª ed., Fundação Calouste Gulbenkian, 1980 - Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., Andersen, L. B., "Princípios das Operações Unitárias", Livros Técnicos e Científicos, 1982. - McCabe, W. L., Smith, J. C., Harriote, P., "Unit Operations of Chemical Engineering", 5ª ed., McGraw-Hill, 1993 - Perry, R. H., Green, D. W., Maloney, J. O., "Perry's Chemical Engineers' Handbook", 6ª ed., McGraw-Hill, 1984
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Assessment	The final classification (CF) is the weighted sum of the grade obtained in each report.
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Course:	Chemical Engineering		Code: 43102
Subject:	R&D in Chemical Engineering		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>3</u>	Semester:	<u>A</u>	Hours/Week:	Lect. Tutorial Lab.	ECTS:	<u>10.0</u>

Aims	To provide the students with experience and knowledge regarding the development of research projects with relevance in the area of Chemical Engineering and, simultaneously, to introduce them into the industrial environment.
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Syllabus	<p>Development of a report in the Chemical Engineering area. Bibliographic review and referencing.</p> <p>Examples of projects developed by students:</p> <ul style="list-style-type: none"> - "Biogás - Aproveitamento de Resíduos Sólidos Orgânicos" - "Estabilidade de Soluções Industriais de Hipoclorito de Sódio" - "Caracterização e Tratamento de uma Solução Residual de Óxido de Crómio da Fábrica Renault – C.A.C.I.A."
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Teaching Method	Adjusted to each project.
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Readings	Adjusted to each project.
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Bibliography	Adjusted to each project.
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Assessment	The final classification (CF) results from the appraisal of the R&D work developed during the academic year.
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Course:	Chemical Engineering		
Subject:	Unit Operations II		Code: 43104
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>3</u>	Semester:	<u>1</u>	Hours/Week:	Lect. 3	Tutorial 3	Lab.	ECTS:	<u>07.0</u>
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Aims	To teach subjects, of the chemical technology field that the student may find in their professional life.
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Syllabus	Separation of binary mixtures. Mass transfer based operations involving continuous contact. Phase equilibrium. One stage equilibrium calculations. Study of stage-based operations. Counter-current stage based operations involving reflux. Simplified methods for the calculation of equilibrium stages. Simplified method for dynamic distillation calculation. Design of equipment involving discontinuous contact, such as decanters and columns.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	- Foust, A. S., Wenzel, L. A., Clump, C. W., Maus, L., Anderson, L. B., "Principles of Unit Operations", John Wiley & Sons, 1980
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Assessment	<p>The student can chose between the two available systems:</p> <ol style="list-style-type: none"> 1. Closed book mid-term tests during the semester, group works and assignments (CL), and end of semester closed book examination (CE). The CF is the weighted sum between CE (minimum of 7.5 out of 20 points) and CL. $CF = 0.60CE + 0.40CL$. 2. End of semester closed book examination. The final classification (CF) matches the exam classification (CE), $CF = CE$.
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Course:	Chemical Engineering		
Subject:	Materials		Code: 43103
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>3</u>	Semester:	<u>1</u>	Hours/Week:	Lect. 3	Tutorial 1	Lab. 2	ECTS:	<u>07.0</u>
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Aims	To provide the students with understanding regarding the structure, chemical properties, advantages, technological properties and applicability of metallic, plastic, ceramic and composite materials. To provide the students with the theoretical basis on the deterioration of materials caused by chemical attack. Metal corrosion.
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Syllabus	Introduction to the Material Engineering Science. Tests and materials properties. Atomic arrangement. Phase diagrams. Metal, ferrous and non-ferrous materials. Polymeric materials. Ceramic materials. Composite materials. Corrosion.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving. Laboratory sessions: Laboratorial classes.
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Readings	Lecture notes. Tutorial problems. Experimental procedures.
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Bibliography	<ul style="list-style-type: none"> - Smith, W. F., "Princípios de Ciência e Engenharia dos Materiais", McGraw-Hill, 1998 - Lima, A. V., Castro, A. G., "Ciência e Tecnologia dos Materiais", Universidade de Trás-os-Montes, 1988 - Crawford, R. J., "Plastics Engineering", Butterworth Heinemann, 1998 - Ferreira, J. M. G. C., "Tecnologia da Fundição", Lisboa: Fundação Calouste Gulbenkian, 1999 - Fontana, M., Greene, N., "Corrosion Engineering", McGraw-Hill, 1967
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained at the written exam (CE) and the classification in the laboratorial component (CL), $CF = 0.85CE + 0.15CL$.
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Course:	Chemical Engineering		Code: 43105
Subject:	Economy and Management		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>3</u>	Semester:	<u>1</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>2</u>	Lab.	ECTS:	<u>04.5</u>
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Aims	To provide the students with information on the economic system. To stimulate students to grasp how private companies operate at financial and economical level. To provide students with knowledge enough to interpret organization accounts. To introduce the students on the role of inflation-rate and value depreciation. The importance of depreciation in evaluating investment projects - methods. To provide the students with generic information on the State accounts and to stimulate the interpretation of the money flows. To briefly introduce International Economy - old paradigms, post 2 nd World War paradigms and recent paradigms.
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Syllabus	Microeconomics. Macroeconomics. Economical Engineering. Industrial company accounts (economic viability studies). Introduction to International economy and markets.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	- Samuelson, P., Nordhaus, W., "Economia", 16 ^a ed. Lisboa: McGraw-Hill, 1999 - Relatório do Banco de Portugal - Oliveira, José Alberto Nascimento, "Engenharia Financeira" - Marchal, M. O. P, "Éléments d'Économie Contemporaine", Paris: Cujas, 1982
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Unit Operations III		Code: 43201
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>3</u>	Semester:	<u>2</u>	Hours/Week:	Lect. 3	Tutorial 3	Lab.	ECTS:	<u>06.5</u>
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Aims	To provide the students with additional concepts on mass and heat transfer in the context of separation based unit operations. To improve the students ability to solve design problems with relation to the unit operations presented.
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Syllabus	<p>Continuous gas - liquid separation processes: continuous humidification processes, absorption in packed towers (concentrated and diluted mixtures).</p> <p>Drying of process materials: equilibrium moisture content of materials; rate of drying curves; calculation methods for constant-rate and falling-rate drying periods.</p> <p>Evaporation: types of evaporation equipment and operation methods; overall heat-transfer coefficient in evaporators; calculation methods for single and multiple-effect evaporators.</p>
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Teaching Method	<p>Lecture sessions: Oral exposition.</p> <p>Tutorial sessions: Problem solving.</p>
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Readings	<p>Lecture notes.</p> <p>Tutorial problems.</p>
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Bibliography	<p>- Geankoplis, C. J., "Transport Processes and Separation Process Principles (includes Unit Operations)", 4^a ed., Prentice Hall, 2003</p> <p>- McCabe, Smith, Harriott, "Unit Operations of Chemical Engineering", 6^a ed., McGraw-Hill, 2001</p> <p>- Treybal, R. E., "Mass Transfer Operations", 3^a ed., McGraw-Hill, 1980</p>
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Chemical Reactors I		Code: 43202
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>3</u>	Semester:	<u>2</u>	Hours/Week:	Lect. 2	Tutorial 4	Lab.	ECTS:	<u>06.5</u>
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Aims	To provide the pupils with the basic concepts on Chemical Kinetics and ideal reactors design operating isothermally and non isothermally for processing single reactions.
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Syllabus	Introduction to the study of Reaction Engineering. Interpretation of the results of discontinuous reactor operation. Design of discontinuous reactor for simple reactions. Most important types of reactor, basic areas of application and characteristics. Design equations. Reactors involving recycle. Introduction to reactor project for multiple reactions. Enthalpy influence on project design of non-isothermic reactors. Temperature and pressure effects.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	<ul style="list-style-type: none"> - Levenspiel, Octave, "Chemical Reaction Engineering", 3^a ed., New York: John Wiley & Sons, 1999 - Levenspiel, Octave, "The Chemical Reactor Omnibook", Oregon: OSU Book Stores, 1984 - Froment, Bischoff, "Chemical Reactor Analysis and Design", 2^a ed., New York: John Wiley & Sons, 1990 - Smith, J. M., "Chemical Engineering Kinetics and Reactor Design", New York: McGraw-Hill, 1981 - Fogler, H. Scott, "Elements of Chemical Reaction Engineering", 3^a ed., New Jersey: Prentice Hall, 1999
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		Code: 43203
Subject:	Management and Planning I		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>3</u>	Semester:	<u>2</u>	Hours/Week:	Lect. 2	Tutorial 2	Lab.	ECTS:	<u>05.5</u>
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Aims	To provide the students with the basic knowledge on management and an actual view of its main features. To focus the study in operation management with adequate tools in the areas of project and stock management.
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Syllabus	Organization strategy. Product focused strategic planning. Competitive priorities. Quality management (introduction). Process design. New technologies of production. Forecasting techniques. Provision function. Production planning. Project planning. Decision Support Techniques (Simplex Method).
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	- Krajewski, L. J., Ritzman, L. P., "Operations Management: Strategy and Analysis", 4 ^a ed., Addison-Wesley, 1996 - Curtis, A., Pillet, M., Martin, C., "Gestão da Produção", 3 ^a ed., Lisboa: Lidel, 1994
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Complements of Mathematics		Code: 44101
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>4</u>	Semester:	<u>1</u>	Hours/Week:	Lect. 2	Tutorial 2	Lab.	ECTS:	<u>04.5</u>
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Aims	To provide the students with complementary knowledge on Mathematical Analysis aiming to improve their ability to handle specific problems with relevance in Chemical Engineering.
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Syllabus	Differential calculus in R_n . Multiple-dimension integration. Laplace transforms. Complements of statistical inference and hypothesis tests. Variance analysis.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Tutorial problems.
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Bibliography	<ul style="list-style-type: none"> - Azenha, A., Jerónimo, M. A., "Elementos de Cálculo Diferencial e Integral em R e em R_n", Lisboa: McGraw-Hill, 1995 - Guimarães, R. C., Cabral, J., "Estatística", Lisboa: McGraw-Hill, 1997 - Croft, A., "Engineering Mathematics", Wokingham: Addison-Wesley, 1992 - Lapin, L. L., "Probability and Statistics for Modern Engineering", 2^a ed., Boston: PWS-Kent, 1990 - Ross, S. L., "Differential Equations", 3^a ed., New York: John Wiley & Sons, 1984
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), $CF = CE$.
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Course:	Chemical Engineering		Code: 44102
Subject:	Complements of Heat and Mass Transfer		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>4</u>	Semester:	<u>1</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>2</u>	Lab.	ECTS:	<u>05.0</u>
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Aims	To provide the students with additional knowledge regarding physical and mathematical description of the mechanisms involved in mass and heat transfer. To improve the ability to derive dynamic macroscopic and microscopic balances for mass and energy in diverse geometries. To apply numerical methods for solving heat conduction problems. To develop the ability of students in solving problems involving simultaneous heat and mass transport phenomena.
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Syllabus	Heat transfer: Introduction. Steady state conduction and convection. The general heat conduction equation. Transient heat conduction. Numerical methods in heat conduction problems. Mass transfer: Introduction. Steady state mass diffusion and convection. The mass diffusion equation. Transient mass diffusion.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	- Çengel, Yunus, "Heat Transfer - A Practical Approach", 2 ^a ed, McGraw-Hill, 2003 - Incropera, F. P.; DeWitt, D. P., "Fundamentals of Heat and Mass Transfer", 5 ^a ed., John Wiley & Sons, 2001 - Welty, J. R., Wicks, C. E.; Wilson, R. E., "Fundamentals of Momentum, Heat and Mass Transfer", 4 ^a ed., John Wiley & Sons, 2001 - Holman, J. P., "Heat Transfer", 9 ^a ed., McGraw-Hill, 2002
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		Code: 44103
Subject:	Biochemistry and Macromolecules		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>4</u>	Semester:	<u>1</u>	Hours/Week:	Lect. <u>2</u>	Tutorial	Lab. <u>3</u>	ECTS:	<u>05.0</u>
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Aims	To provide students with complementary knowledge on Organic Chemistry aiming to improve their skills to use it in areas such as Polymers Engineering and Biotechnology.
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Syllabus	Biochemistry - Amino acids. Peptides. Proteins. Enzymes. Macro-molecules - Polymers classification. Types of bonding in polymeric materials. Bonding force. Bonding and temperature importance. Solvent importance on bonding force. Stereoisomerism in vinyl polymers. Crystallinity and amorphous polymers. Polymerization mechanisms. Polymerization methods. Determination of the molecular weight of polymers. Industrial importance of polymers. Commercially important polymers. Natural polymers. Polymers and environment.
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Teaching Method	Lecture sessions: Oral exposition. Laboratory sessions: Laboratorial classes.
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Readings	Lecture notes. Experimental procedures.
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Bibliography	- Stryer, Lubert, "Biochemistry", 4 ^a ed., New York: W. H. Freeman and Company, 1995 - Allcock, H. R., Lampe, F. W., "Contemporary Polymer Chemistry", Englewood Cliffs: Prentice Hall, 1990 - Rosen, S. L., "Fundamental Principles of Polymeric Materials", 2 ^a ed., New York: John Wiley & Sons, 1993 - Lehninger, A. L., "Bioquímica", Vol. 1, Edgard Blucher Lda., 1976
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification in the laboratorial component (CL), $CF = 0.75CE + 0.25CL$.
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Course:	Chemical Engineering		Code: 44104
Subject:	Practice of Chemical Engineering I		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>4</u>	Semester:	<u>1</u>	Hours/Week:	Lect. Tutorial Lab.	ECTS:	<u>05.5</u>

Aims	To provide the students with the chance to operate at lab scale equipment replicating Unit Operations with relevance in Chemical Engineering and improve the knowledge regarding the controller tuning. To develop the ability of the pupils in planning experiments, as well as to analyze and criticize the results.
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Syllabus	Drying in a tray drier. Gas-liquid absorption. Automatic control at bench scale kits. Continuous and discontinuous reactor operation.
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Teaching Method	Laboratory sessions: All the students, obligatorily, carry out 4 lab works and elaborate a report on each one, which later discussed. In the end of the semester, each group presents publicly one of the works.
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Readings	Experimental procedures.
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Bibliography	<ul style="list-style-type: none"> - McCabe, W. L., Smith, J. C., Harriot, P., "Unit Operations of Chemical Engineering", 5^a ed., McGraw-Hill, 1993 - Coulson, J. M., Richardson, J. F., "Tecnologia Química", Vol. 2 e 6, Lisboa: Fundação Calouste Gulbenkian - Perry, R. H., Green, D., "Perry's Chemical Engineers Handbook", 6^a ed., McGraw-Hill, 1984 - Curtis, D. J., "Controlo de Processos", 3^a ed., Lisboa: Fundação Calouste Gulbenkian, 1988 - Treybal, R. E., "Mass Transfer Operations", 3^a ed., McGraw-Hill, 1980
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Assessment	The final classification (CF) is the weighted sum of the grade obtained in each report.
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Course:	Chemical Engineering		
Subject:	Applied Thermodynamics		Code: 44105
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>4</u>	Semester:	<u>1</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>2</u>	Lab.	ECTS:	<u>04.5</u>
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Aims	To provide the students with complementary knowledge on Chemical Thermodynamics.
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Syllabus	Thermal cycles. Carnot's cycle. Gas thermal machines. Steam thermal machines. Combined gas-steam cycles. Estimation methods for thermodynamic properties. P-V-T relations for gas and liquids. Mixture volumetric properties. Estimate of vapour pressure and vaporization enthalpy for pure liquids. Phase equilibrium estimation in multicomponent systems.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	<ul style="list-style-type: none"> - Çengel, Yunus, Boles, M. A., "Thermodynamics: An Engineering Approach", 3^a ed., McGraw-Hill, 1994 - Moran, M. J., Shapiro, H. N., "Fundamentals of Engineering Thermodynamics", 3^a ed., New York: John Wiley & Sons, 1998 - Sonntag, R. E., Van Wylen, G. J., "Introduction to Thermodynamics Classical and Statistical", 3^a ed., New York: John Wiley & Sons, 1991 - Çengel, Yunus, "Introduction to Thermodynamics and Heat Transfer", New York: McGraw-Hill, 1997 - Smith, J. M., Van Ness, H. C., Abbot, M. M., "Introduction to Chemical Engineering Thermodynamics", 5^a ed., McGraw-Hill, 1996
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		Code: 44106
Subject:	Numerical Methods and Modeling		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>4</u>	Semester:	<u>1</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>2</u>	Lab.	ECTS:	<u>05.5</u>
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Aims	To provide the students with the ability to mathematically represent a typical system with relevance in the area of Chemical Engineering, and choose and implement numerical algorithms capable of solving the model derived. To apply theoretical concepts in classroom, by using computational platforms, packages and libraries for solving numerical problems arisen.
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Syllabus	Numerical methods. Numerical integration. Numerical differentiation. Numerical solution of Ordinary Differential Equations. Numerical solution of Partial Differential Equations. Modeling. Types of models. Constitutive physics. Macroscopic and microscopic balances of mass, moment and energy. Systems analysis. State Space Theory. Model linearization. Numerical solution of state space models in continuous and discrete spaces.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Assignments. Tutorial problems.
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Bibliography	<ul style="list-style-type: none"> - Atkinson, K. E., "An Introduction to Numerical Analysis", 2^a ed., Singapore: John Willey & Sons, 1989 - Bequette, B. W., "Process Dynamics - Modeling, Analysis and Simulation", Upper Saddle River - New Jersey: Prentice Hall PTR, 1998 - Biran, A., Breiner, M., "Matlab 5 for Engineers", Dorchester: Addison-Wesley, 1999 - Bird, R. B., Stewart, W. E., Lightfoot, E. N., "Transport Phenomena", New York: John Willey & Sons, 1960 - Cutlip, M. B., Shacham, M., "Problem solving in Chemical Engineering with Numerical Methods", Upper Saddle River, New Jersey: Prentice Hall PTR, 1999 - Duarte, B. P. M., "Apontamentos de Computação Aplicada à Engenharia Química", Edição do autor, Coimbra: ISEC, 2003
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Chemical Reactors II		Code: 44201
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>4</u>	Semester:	<u>2</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>2</u>	Lab.	ECTS:	<u>04.5</u>
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Aims	To physically describe the absorption phenomena involved in catalytic reactors. To provide the students with knowledge regarding the role of absorption isothermals and kinetic models in developing kinetic expressions based on the controlling step of multi step processes. To analyze the causes for catalyst deactivation and strategies to reduce the importance of the problem. To compare the main types of catalytic reactors and project design methods.
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Syllabus	Catalysis. Adsorption. Catalysts properties. Selectivity. Heterogeneous catalytic reaction kinetics. Diffusion and reaction within a catalyst. Catalysts deactivation. Heterogeneous catalytic reactors.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes.
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Bibliography	<ul style="list-style-type: none"> - Levenspiel, Octave, "Chemical Reaction Engineering", 3^a ed., New York: John Wiley & Sons, 1999 - Levenspiel, Octave, "The Chemical Reactor Omnibook", Oregon: OSU Book Stores, 1993 - Figueiredo, J. L., Ramôa Ribeiro, F., "Catálise Heterogénea", Lisboa: Fundação Calouste Gulbenkian, 1989 - Nunes dos Santos, A. M., "Reactores Químicos", Lisboa: Fundação Calouste Gulbenkian, 1990 - Smith, J. M., "Chemical Engineering Kinetics", New York: McGraw-Hill, 1981
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Complements of Instrumental Analysis		Code: 44202
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	4	Semester:	2	Hours/Week:	Lect. 2	Tutorial	Lab. 3	ECTS:	06.0
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Aims	To improve the students understanding of the theoretical basis standing chromatographic separation. To present the foundations of molecular spectroscopy based methods used in analytical determination. To provide the students with laboratorial experience in instrumental analytical chemistry. To demonstrate the versatility of analytical chromatography methods and specificity of other analytical techniques.
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Syllabus	Chemical separations - an analytical based perspective. Methods of separation involving extraction. Practical aspects. Chromatography - fundamentals and concepts, instrumentation and its use in instrumental chemical analysis. Chromatographic separations. Instrumentation in chromatography. Analytical chromatography.
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Teaching Method	Lecture sessions: Oral exposition Laboratory sessions: Laboratorial classes.
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Readings	Lecture notes. Experimental procedures.
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Bibliography	<ul style="list-style-type: none"> - Peters, D. G., Hayes, J. M., Hieftje, G. M., "Chemical Separations and Measurements", W. B. Saunders, 1974 - McNair, H. M., Miller, J. M., "Basic Gas Chromatography", John Wiley & Sons, 1998 - Lough, W. J., Wainer, I. W., "High Performance Liquid Chromatography", Chapman and Hall, 1996 - Skoog, D. A., Leary, J. J., "Principles of Instrumental Analysis", 4^a ed., Saunders College Publishing, 1992 - Giddings, J. C., "Dynamics of Chromatography - Part I, Principles and Theory", Marcel Dekker, 1965
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification in the laboratorial component (CL), $CF = 0.50CE + 0.50CL$.
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Course:	Chemical Engineering		
Subject:	Practice of Chemical Engineering II		Code: 44205
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

			Lect.	Tutorial	Lab.		
Year:	4	Semester:	2	Hours/Week:	4	ECTS:	08.0

Aims	To provide the student with the chance to operate at lab scale equipment replicating Unit Operations with relevance in Chemical Engineering. To improve the pupils ability in planning experiments, as well as to analyze and criticize the results.
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Syllabus	Distillation of an azeotropic binary mixture. Evaporation. Solid-liquid extraction. Humidification.
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Teaching Method	Laboratory sessions: All the students, obligatorily, carry out 4 lab works and elaborate a report on each one, which later discussed. In the end of the semester, each group presents publicly one of the works.
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Readings	Experimental procedures.
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Bibliography	<ul style="list-style-type: none"> - McCabe, W. L., Smith, J. C., Harriot, P., "Unit Operations of Chemical Engineering", 5^a ed., McGraw-Hill, 1993 - Coulson, J. M., Richardson, J. F., "Tecnologia Química", Vol. 2 e 6, Lisboa: Fundação Calouste Gulbenkian - Perry, R. H., Green, D., "Perry's Chemical Engineers Handbook", 6^a ed., McGraw-Hill, 1984 - Stanford, W., Hill, G. B., "Cooling Towers - Principles and Practice - A Practical Guide to Cooling Towers, Selection and Operation", 2^a ed., Carter Industrial Products, 1972 - Treybal, R. E., "Mass Transfer Operations", 3^a ed., McGraw-Hill, 1980
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Assessment	The final classification (CF) is the weighted sum of the grade obtained in each report.
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Course:	Chemical Engineering		
Subject:	Process Control		Code: 44203
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>4</u>	Semester:	<u>2</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>2</u>	Lab.	ECTS:	<u>07.0</u>
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Aims	To provide the students with the skills enough to be able to synthesize a control system for a typical chemical processes. To set a synthesis methodology based on sequence of steps involving process modelling, system analysis, structure characterization and controller tuning. To apply theoretical knowledge introduced to solve problems with computational platforms by using packages and libraries.
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Syllabus	Systems analysis. First order systems. Second order systems. High order systems. Model parameterization based on the dynamic response. Transfer functions. Matrices of transfer functions. Feedback control. Elements of the feedback control structure. Open loop dynamic response. Closed loop dynamic response. Controller synthesis. Stability analysis. Controller tuning. Frequency response. Model parameterization based on frequency response. Feedforward, ratio and cascade control structures. Stability analysis. Process control of complex dynamic processes. Compensators. Internal Model Control.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Tutorial problems.
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Bibliography	<ul style="list-style-type: none"> - Bequette, B. W., "Process Dynamics - Modeling, Analysis and Simulation", Upper Saddle River - New Jersey: Prentice Hall PTR, 1998 - Duarte, B., "Apontamentos de Controlo de Processos Químicos", Edição do autor, Coimbra: ISEC, 2001 - Ogunnaike, B. A., Harmon Ray, W., "Process Dynamics, Modeling and Control", New York: Oxford University Press, 1994 - Seborg, D. E., Edgar, T. F., Mellichamp, D. A., "Process Dynamics and Control", New York: John Willey & Sons, 1989 - Sell, N. J., "Process Control Fundamentals for the Pulp and Paper Industry", Atlanta: TAPPI Press, 1995
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Unit Operations IV		Code: 44204
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>4</u>	Semester:	<u>2</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>3</u>	Lab.	ECTS:	<u>04.5</u>
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Aims	To provide the students with additional topics on Unit Operations, particularly on the use of computational techniques and algorithms for calculating separation units.
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Syllabus	Processes of separation of multicomponent mixtures: Variable counting and calculations based on balances for equilibrium stage unit. Calculation based on approach methods. Calculation based on rigorous methods. Algorithms devoted to solve separation problems. Reactive absorption and distillation. Methods of separation for transient state units. Design of columns.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes.
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Bibliography	- Seader, J. D., Henley, E. J., "Separation Process Principles", John Wiley & Sons, 1998 - Foust, A. S., Wenzel, L. A., Clump, M., "Principles of Unit Operations", John Wiley & Sons, 1980
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Assessment	End of semester closed book examination. The final classification (CF) is the classification obtained in the written exam (CE), CF = CE.
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Course:	Chemical Engineering		
Subject:	Design Project		Code: 45101
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

			Lect.	Tutorial	Lab.		
Year:	5	Semester:	A	Hours/Week:	5	ECTS:	22.0

Aims	To develop the project design of a chemical production unit. To improve technical decision ability. To stimulate written and oral presentation of technical work.
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Syllabus	Bibliographical review of R&D related with the production unit. Market analysis. Process selection. Material and enthalpy balances. Project design of the production unit. Instrumentation and control. Layout. Analysis of the environmental impact of the unit. Economic analysis.
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Teaching Method	Laboratory sessions: Initially, the student attends to several presentations of interest matters. In a posterior phase, the students develop the ante-project. During the academic year, each group of students elaborates three progress reports, which contribute to their grading.
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Readings	Adjusted to each project.
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Bibliography	<ul style="list-style-type: none"> - Himmelblau, D., "Basic Principles and Calculations in Chemical Engineering", 6^a ed., Englewood Cliffs - New Jersey: Prentice-Hall, Inc., 1996 - Coulson, J. M. e Richardson, J. F., "Tecnologia Química", Vol.6, Lisboa: Fundação Calouste Gulbenkian, 1989 - Seader, J. D., Henley, E. J., "Separation Process Principles", New York: John Wiley & Sons, Inc., 1998 - Marlin, T. E., "Process Control - Designing Processes and Control Systems for Dynamic Performance", 2^a ed., New York: McGraw-Hill, 2000 - Metcalf & Eddy, "Wastewater Engineering, Treatment, Disposal and Reuse", 4^a ed., New York: McGraw-Hill, 2003
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Assessment	The final classification (CF) depends on the analysis of the work developed during the academic year, the appraisal of the written ante-project and oral presentation.
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Course:	Chemical Engineering		
Subject:	Seminar		Code: 45102
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

			Lect.	Tutorial	Lab.		
Year:	5	Semester:	A	Hours/Week:	5	ECTS:	13.0

Aims	To provide the students with complementary knowledge on subjects included not in the course. To introduce the students into the industrial environment. To provide the student with useful techniques on bibliographic review. To improve the ability of developing group work. To improve the students skills in oral communication with the help of audiovisual equipment.
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Syllabus	Industrial Safety - a 12 hours course involving assessment. Human Resources Management - a 12 hours course involving assessment. Industrial Property and Licensing - a 12 hours course involving assessment. Oral and Written Communication - a 25 hours duration course involving assessment. Communication techniques. Visits to industrial units. Seminars organized with potential employers aiming to characterize an industrial sector. Elaboration of a monography devoted to a scientific or industrial topic in which the use of written communication techniques introduced and bibliography referencing is tested. Use of databases for information management.
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Teaching Method	Laboratory sessions: Guided individual work. Personal and group initiative is stimulated.
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Readings	Adjusted to each work.
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Bibliography	<ul style="list-style-type: none"> - Moreira, C. A., Azevedo, A. G., "Metodologia Científica" - Osborn, S.; Motley, M. T., "Improving Communication" - Almeida, F. N., "Psicologia para Gestores", Lisboa: McGraw-Hill, 1995 - Canavarro, J. M. P., "Teorias e Paradigmas Organizacionais", Coimbra: Quarteto ed., 2000 - Luthans, F., "Organizational behaviour", New York: McGraw-Hill, 1998 - Miguel, A. S. S. R., "Manual de Higiene e Segurança do Trabalho", 5ª ed., Porto: Porto Editora, 2000
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Assessment	Final tests of the modules of Interpersonal Relations (RI), Hygiene and Security at Work (HST) and Communication (Com); appraisal of R&D written work (Mon) and it's oral exposition (EO). Globally the final classification (CF) is: $CF = 0.125RI + 0.125HST + 0.05Com + 0.60Mon + 0.10EO$.
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Course:	Chemical Engineering		Code: 45103
Subject:	Optimization and Quality Strategies		Elective <input type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>5</u>	Semester:	<u>1</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>3</u>	Lab.	ECTS:	<u>07.0</u>
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Aims	To provide the students with a set of tools for implementing a Quality System encompassed into a continuous improvement and innovation strategic policy. To exploit optimization in managing resources such as energy and labour force. To introduce the students into the problem of scheduling of batch units operations and labour force.
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Syllabus	Optimization. Basic concepts of optimization. Application of optimization methodologies to three problem types: batch process sequencing; design of batch units; heat integration. Algorithmic (programming) and heuristic formulations. The pinch method for heat network synthesis. Applied statistics. Basic concepts of applied statistics. Probability. Forecasting based on time series analysis. Quality. The Quality paradigm evolution. The role of Quality. The agents involved. Quality functions: quality control, quality management and quality guarantee. Quality tools. Statistical Process Control. Control charts. Experiments planning. Standards. Certification. Strategy and quality policy. Organizational structure of the enterprise and influence on Quality function. Benchmarking. Product design techniques. QFD. Innovation. Innovation and creativity tools.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving in computer platforms.
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Readings	Tutorial problems. Assignments.
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Bibliography	<ul style="list-style-type: none"> - Bank, J., "Qualidade Total - Manual de Gestão", 2ª ed., Portugal: Edições CETOP, 1998 - Biegler, L. T., Grossmann, I. E., Westerberg, A. W., "Systematic Methods of Chemical Process Design", New Jersey: Prentice Hall PTR, 1997 - Box, G. E. P., Jenkins, G. M., Reinsel, G. C., "Time Series Analysis - Forecasting and Control", 3ª ed., New Jersey: Prentice Hall, 1994 - Chase, R. B., Aquilano, N. J., Jacobs, F. R., "Production and Operations Management - Manufacturing and Services", 8ª ed., New York: McGraw-Hill, 1998 - Duarte, B. P. M., "Apontamentos de Optimização e Estratégias de Qualidade", Edição do autor, Coimbra: ISEC, 2002
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the examination (CE) and the classification in the homework (CL), $CF = 0.50CE + 0.50CL$.
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Course:	Chemical Engineering		
Subject:	Environmental Management		Code: 45201
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>5</u>	Semester:	<u>1</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>2</u>	Lab.	ECTS:	<u>05.0</u>
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Aims	To provide the students with complementary knowledge on Environmental Management. To stimulate the students awareness for the need of manage industrial activity according to environmental concerns.
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Syllabus	Gas effluents and treatment methods. Liquid effluents and treatment methods. Solid residues, management and treatment methods.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving.
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Readings	Lecture notes.
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Bibliography	<ul style="list-style-type: none"> - Davis, Mackenzie L., Cornwell, David A., "Introduction to environmental engineering", New York: McGraw-Hill, 1991 - Straub, Conrad P., "Practical handbook of environmental control", Boca Raton: CRC Press, 1990 - Kiely, Gerard, "Environmental engineering", Massachusetts: McGraw-Hill, 1996 - Metcalf & Eddy, Inc., "Wastewater engineering, Treatment, disposal and reuse", New York: McGraw-Hill, 1991 - Direcção Geral do Ambiente, "Relatório do Estado do Ambiente 1999" Lisboa, 2000 - Hammer, M. J., Hammer, M. J. Jr., "Water and Wastewater Technology", Englewood Cliffs: Prentice Hall, 1996
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Assessment	<p>The student may chose between the two assessment systems:</p> <ol style="list-style-type: none"> 1. Closed book mid-term tests during the semester, group works and assignments (CL), and end of semester closed book examination (CE). The CF is the weighted sum between CE (minimum of 7.5 out of 20 points) and CL. $CF = 0.40CE + 0.60CL$. 2. End of semester closed book examination. The final classification (CF) matches the exam classification (CE), $CF = CE$.
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Course:	Chemical Engineering		
Subject:	Management and Planning II		Code: 45104
Teaching Language:	Portuguese	Compulsory <input checked="" type="checkbox"/>	Elective <input type="checkbox"/>
Pre-requisites:	None		

Year:	<u>5</u>	Semester:	<u>2</u>	Hours/Week:	Lect. 2	Tutorial 2	Lab.	ECTS:	<u>05.0</u>
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Aims	To provide the students with knowledge regarding the basic tools to understand the needs of an industrial organization concerning capacity planning, management and control. To provide the students with a multi-level perspective of industrial management concerning competitiveness strategies, quality and efficiency criteria.
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Syllabus	Planning, scheduling and sequencing. Resource allocation. Industrial costs and capacity planning. Forecasting and industrial development. Project synthesis of batch production units involving the application of concepts introduced.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Problem solving. Capacity planning works involving Mass Balances, Design and Optimization.
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Readings	Lecture notes. Tutorial problems.
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Bibliography	<ul style="list-style-type: none"> - Krajewsky, L. J., Ritzman, L. P., "Operations Management", Addison Wesley, 1996 - Roldão, V. S., "Planeamento e Programação da Produção", Monitor - Projectos e Edições, Lda, 1995 - Chase, R. B., Aquilano, N., "Production and Operations Management", Irwin, 1989 - Hillier, F. S., Lieberman, G. J., "Introduction to Operations Research", McGraw-Hill - Ramalhete, M., Guerreiro, J., "Programação Linear", McGraw-Hill
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification in the homework (CL), $CF = 0.40CE + 0.60CL$.
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Course:	Chemical Engineering		
Subject:	Energy and Environment		Code: 45204
Teaching Language:	Portuguese	Compulsory <input type="checkbox"/>	Elective <input checked="" type="checkbox"/>
Pre-requisites:	None		

Year:	<u>5</u>	Semester:	<u>2</u>	Hours/Week:	Lect. <u>2</u>	Tutorial <u>2</u>	Lab.	ECTS:	<u>04.0</u>
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Aims	To improve the students awareness regarding the environmental problem arising from industrial operation. To provide the students with knowledge regarding the role and structure of Environment Management Systems, and introduce the basic foundations standing its implementation. To provide the students with an introduction on energy management at world scale, particularly focused on industrial activity.
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Syllabus	Introduction to environmental problems. Implementation of Environmental Management Systems. Environmental Management industrial programs. Energy. Limitations, rationalization measures and techniques.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: Simulation exercises on the implementation of industrial environmental management systems. Problem solving.
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Readings	Lecture notes. European Standards. Legislation.
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Bibliography	<ul style="list-style-type: none"> - Beaud, M., Beaud, C., Bouguerra, M., "Estado do Ambiente no Mundo", Edição dos autores, Lisboa: Instituto Piaget, 1995 - Brundtland, G. H., "O Nosso Futuro Comum", Trad. Deolinda Estudante e Rui Protássio, Lisboa: Meribérica/Liber, 1991 - Castilho A., Pires, A. R., Guerreiro, F. J. F., Alves P., Martins C., Gonçalo D., "Guia Interpretativo NP EN ISO 14001:1999", Apcer, 2001 - Clements, Richard B., "Complete Guide to ISO 14000", Prentice Hall, 1996 - Davis, Mackenzie L., Cornwell, David A., "Introduction to Environmental Engineering", New York: McGraw-Hill, 1991
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Assessment	<p>The student may chose between the two assessment systems:</p> <ol style="list-style-type: none"> 1. Closed book mid-term tests during the semester, group works and assignments (CL), and end of semester closed book examination (CE). The CF is the weighted sum between CE (minimum of 7.5 out of 20 points) and CL. $CF = 0.45CE + 0.55CL$. 2. End of semester closed book examination. The final classification (CF) matches the exam classification (CE), $CF = CE$.
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Course:	Chemical Engineering		
Subject:	Granular Materials Characterization		Code: 45203
Teaching Language:	Portuguese	Compulsory <input type="checkbox"/>	Elective <input checked="" type="checkbox"/>
Pre-requisites:	None		

Year:	<u>5</u>	Semester:	<u>2</u>	Hours/Week:	Lect. <u>2</u>	Tutorial	Lab. <u>2</u>	ECTS:	<u>04.0</u>
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Aims	To provide the students with the ability to identify physical properties of small particles such as the granulometry aiming to bridge such measurements with final product properties. To give the students a general view of available analytical techniques for physical characterization of granular materials.
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Syllabus	Particle characterization - size and shape. Sampling, sample dispersion, and statistical treatment of results. Size equivalent dimensions based on different measured properties. Analytical techniques for granular characterization. Particle sedimentation. Techniques based on the interaction between light and particles. Measurement of solids volume. Mercury porosimetry. Techniques based on gas-solid adsorption and absorption phenomena. Techniques based on optic microscopy.
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Teaching Method	Lecture sessions: Oral exposition. Laboratory sessions: Laboratorial classes. Development of a monographic assignment.
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Readings	Lecture notes.
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Bibliography	<ul style="list-style-type: none"> - Allen, T., "Particle Size Measurement - Powder Sampling and Particle Size Measurement", Vol. 1, "Particle Size Measurement - Surface Area and Pore Size Determinations", Vol. 2; 5^a ed., Netherlands: Kluwer Academic Publishers, 1999 - Gregg, S. J., Sing, K. S. W., "Adsorption, Surface Area and Porosity", 2^a ed., London: Academic Press Inc., 1991 - Webb, P. A., Orr, C., "Analytical Methods in Fine Particle Technology", Norcross: Micromeritics Instrument Corporation, 1997 - Rasteiro, M. G., "Caracterização de Materiais Granulares 1^a parte - Distribuições Granulométricas - Cadernos de Engenharia Química", nº 2, DEQ, Coimbra: FCTUC, 1993 - Ferreira, P. J., "Caracterização de Materiais Granulares 2^a parte - Forma das Partículas - Cadernos de Engenharia Química", nº 3, DEQ, Coimbra: FCTUC, 1995
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification in the laboratorial component (CL), $CF = 0.15CE + 0.85CL$.
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Course:	Chemical Engineering		Code: 45107
Subject:	Anthropogenic Pollution		Elective <input checked="" type="checkbox"/>
Teaching Language:	Portuguese	Compulsory <input type="checkbox"/>	
Pre-requisites:	None		

Year:	<u>5</u>	Semester:	<u>1</u>	Hours/Week:	Lect. 2	Tutorial 2	Lab.	ECTS:	<u>04.0</u>
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Aims	To provide the students with the awareness on the importance of environmental management and influence of the human based pollution in ecosystems.
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Syllabus	Introduction: definitions and sources of environmental pollution. Introduction on toxicology. Air and anthropogenic pollution. Water and anthropogenic pollution. Thermal anthropogenic pollution. Solid residues. Chemically based pollution and plagues. Medicament pollution. Radioactivity. Sound pollution.
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Teaching Method	Lecture sessions: Oral exposition. Tutorial sessions: R&D support. Study visits to RWTS and WTS. R&D assignment.
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Readings	Lecture notes.
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Bibliography	<ul style="list-style-type: none"> - Casarett, D., "Toxicologia", 5ª ed., Amadora: McGraw-Hill, 2001 - Lima, L., "Tratamento e Biorremediação", 3ª ed., São Paulo: Hemus, 1995 - Imhoff, K., "Manual de Tratamento de Águas Residuais", São Paulo: Edgard Blucher, 1998 - Sewell, G., "Administração e Controle da Qualidade Ambiental", São Paulo: E.P.U., 1978 - Lagrange, B., "Biométhane", Vol. 2, Aix en Provence: Edisud, 1980
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Assessment	End of semester closed book examination. The final classification (CF) is the weighted sum between the classification obtained in the written exam (CE) and the classification in the laboratorial component (CL), $CL = 0.35CT + 0.15CR$ (CT is the grade from the R&D and CR is the report grade), $CF = 0.50CE + 0.50CL$.
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