ANEXO I

Escuela Técnica Superior de Ingeniería

GENERAL SPECIFICATIONS

COURSE 24/25

Subject Data

Name:
Operaciones Básicas de Ingeniería Química II

English name:
Unit Operations of Chemical Engineering II

Code:	**Type:**
606210216	Compulsory

Hours:

	Total	**In class**	**Out class**
Time distribution	150	60	90

ECTS:

Standard group	**Small groups**			
	Classroom	**Lab**	**Practices**	**Computer classroom**
4.14				1.86

Departments:	**Knowledge areas:**
Chemical Engineering, Physical Chemistry and Materials Science	Chemical Engineering
Year:	**Semester**
3°	2°

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TEACHING STAFF

Name:	E-mail:	Telephone
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Others Data (Tutoring, schedule...)

ETSI building, ETP033 (floor -1)

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SPECIFIC INFORMATION OF THE COURSE

1. Contents description:

1.1 In English:

Separation operations involving mass transfer between phases will be studied: distillation, steady state and batch rectification, gas absorption, and liquid-liquid and solid-liquid extractions. They will be further classified into equilibrium-staged and continuous contact processes.

1.2 In Spanish:

Se estudian operaciones de separación que implican la transferencia de materia entre fases (destilación, rectificación en estado estacionario y por lotes, absorción de gases, extracción líquido-líquido y extracción sólido-líquido) y se hace la distinción entre procesos que se producen por etapas de equilibrio y aquéllos que se llevan a cabo por contacto continuo.

2. Background:

2.1 Situation within the Degree:

This course addresses mass transfer separation operations; thus, previously gained knowledge on mass and enthalpy balances, fluid mechanics, heat transmission and phase equilibrium are applied.

2.2 Recommendations

For the course contents to be properly understood, students must have previous knowledge on mass and enthalpy balances, estimation of equilibrium data, phase diagrams and fluid dynamics on packed beds. Moreover, students should be familiar with the use of advanced engineering calculation software.

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3. Objectives (as result of teaching, or skills or abilities and knowledge):

To provide students with knowledge on how to analyze, select, design, calculate and optimize industrial chemical processes based on heat and mass transfer, and controlled by phase equilibrium.

4. Skills to be acquired

4.1 Specific Skills:

E01: knowledge on mass and enthalpy balances, biotechnology, mass transfer, separation operations, chemical reaction engineering, reactors design, raw materials and energy resources valorization and transformation.

4.2 General, Basic or Transversal Skills:

CB2: students are expected to develop professionalism in their study field
CB5: students are expected to develop self-learning capability with a view to their further postgraduate studies
G01: Solving problem
G02: Making decisions
G04: Putting theoretical knowledge into practice
G09: Creativity
CT2: Analysis capability
CT4: ICT competences

5. Training Activities and Teaching Methods

5.1 Training Activities:

- Theoretical contents lectures.
- Solving problem seminars.
- Computer aided case studies workshops.
- Teacher-guided assignments.

5.2 Teaching Methods::

- Master class.
- Computer aided case studies, in small groups.
- Problem solving.
- Assessments and exams.

5.3 Development and Justification:

1. Master class, which will address theoretical contents and will promote acquisition of competences E01 and G04. It may be supported by the app Quizizz (gamification).
2. Problem solving: this methodology will be used to put the theoretical contents into practice through the resolution of numerical problems. These seminars are related to competences E01, G01, G04, G09 and CT2. The problems will be solved with **MS Excel** (built-in functions and macros). For certain exercises, **Mathcad Prime** may be also considered.
3. Computer aided case studies, in small groups: the process design simulator **Aspen Plus** will be used to analyze the effect of process variables through specific case studies on distillation, rectification, absorption and extraction. Teaching will be assisted with the use of own-creation **video-tutorials**. These workshops will be aimed to the acquisition of competences E01, G01, G02, G04, G09, CB2, CB5, CT2 and CT4. Virtual activity with overseas Universities may be also considered **(COIL)**.
4. Assessments and exams, in couple or individually, on the computer workshops or on problem solving exercises; they address competences E01, G01, G02, G04, G09, CB2, CB5, CT2 and CT4.

6. Detailed Contents

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BLOCK I: Introduction to mass transfer separation operations

CHAPTER 1. GENERAL CONCEPTS

1. Introduction
2. Operations. Description and equilibrium data
   - 2.1. Distillation and rectification (fractional distillation)
   - 2.2. Absorption/stripping
   - 2.3. Liquid-liquid extraction
   - 2.4. Leaching (solid-liquid extraction)

CHAPTER 2. CONTACT TYPES AND FLUID DYNAMICS

1. Equilibrium staged columns
   - 1.1. Description
   - 1.2. Diameter calculation
   - 1.3. Efficiency concept
2. Packed columns
   - 2.1. Description
   - 2.2. Diameter calculation

CHAPTER 3. EQUILIBRIUM DISTILLATION. DIFFERENTIAL DISTILLATION

1. Equilibrium or "flash" distillation
2. Differential or "open" distillation

BLOCK II: Equilibrium staged separations

CHAPTER 4. PONCHON-SAVARIT BASED METHODS

1. Application to binary rectification
2. Application to leaching
   - 2.1. Single stage
   - 2.2. Crosscurrent flow
   - 2.3. Countercurrent flow

CHAPTER 5. McCABE-THIELE BASED METHODS

1. Application to binary rectification
   - 1.1. Continuous rectification
   - 1.2. Batch rectification
2. Application to absorption
3. Application to L-L extraction (immiscible liquids)

CHAPTER 6. TRIANGULAR DIAGRAM METHODS

1. Application to L-L extraction
   - 1.1. Single stage
   - 1.2. Crosscurrent flow
   - 1.3. Countercurrent flow
2. Application to leaching

BLOCK III: Continuous contact (rate based) separations

CHAPTER 7. TRANSFER UNIT BASED METHOD

1. Introduction
2. Mass transfer coefficients. Concept and estimation
3. Packed column height calculation
   - 3.1. Application to binary rectification
   - 3.2. Application to absorption

7. Bibliography

7.1 Basic Bibliography:

PROBLEMAS DE INGENIERÍA QUÍMICA: OPERACIONES BÁSICAS. TOMOS I y II
J. Ocon, G. Tojo. Ediciones Aguilar, Madrid, 1966
EQUILIBRIUM STAGED SEPARATIONS
P.C. Wankat. Prentice Hall, New Jersey, 1988
OPERACIONES DE TRANSFERENCIA DE MASA (2nd ED.)
R.E. Treybal. McGraw-Hill, México D.F., 1991
OPERACIONES DE SEPARACIÓN EN INGENIERÍA QUÍMICA. MÉTODOS DE CÁLCULO
P.J. Martínez de la Cuesta, E. Rus Martínez. Prentice Hall, Madrid, 2004
PRINCIPLES OF CHEMICAL SEPARATIONS WITH ENVIRONMENTAL APPLICATIONS
R.D. Noble, P.A. Terry. CUP, Cambridge, 2004
SEPARATION PROCESS PRINCIPLES (2nd ED.)
J.D. Seader, E.J. Henley. John Wiley & Sons, New York, 2006
MASS TRANSFER AND SEPARATION PROCESSES. PRINCIPLES AND APPLICATIONS (2nd ED.)
D. Basmadjian. CRC Press, Boca Raton, 2007
PRINCIPLES AND MODERN APPLICATIONS OF MASS TRANSFER OPERATIONS (2nd ED.)
J. Benitez. John Wiley & Sons, New Jersey, 2009
MASS TRANSFER OPERATIONS FOR THE PRACTICING ENGINEER
L. Theodore, F. Ricci. John Wiley & Sons, New Jersey, 2010
MASS TRANSFER CONCEPTS
K. Asokan. CRC Press, Boca Raton, 2011
SEPARATION PROCESS ENGINEERING: INCLUDES MASS TRANSFER ANALYSIS (4th ED.)
P.C. Wankat. Prentice Hall, Boston, 2017
MASS TRANSFER II (16th ED.)
K.A. Gavhane. Nirali Prakashan, Pune, 2017
PROBLEMAS RESUELTOS DE OPERACIONES DE SEPARACIÓN
F.J. Montes. Paraninfo Universidad, Madrid, 2019

7.2 Additional Bibliography:

HANDBOOK OF SEPARATION TECHNIQUES FOR CHEMICAL ENGINEERS
P.A. Schweitzer. McGraw-Hill, New York, 1997
CHEMICAL ENGINEERING, VOL. 2, PARTICLE TECNOLOGY AND SEPARATION PROCESSES (5th ED.)
J.F. Richardson, J.H. Harker. Butterworth-Heinemann, Oxford, 2002
TRANSPORT PROCESSES AND SEPARATION PROCESS PRINCIPLES (INCLUDES UNIT OPERATIONS) (4th ED.)
C.J. Geankoplis. Prentice Hall, New Jersey, 2003
ASPEN PLUS V8.0. GETTING STARTED BUILDING AND RUNNING A PROCESS MODEL
Aspen Technology Inc., Burlington, 2012
DISTILLATION DESIGN AND CONTROL USING ASPEN SIMULATION (2nd ED.)
W.L. Luyben. Wiley, New Jersey, 2013
DISTILLATION: EQUIPMENT AND PROCESSES
A. Gorak, Z. Olujic. Elsevier, Amsterdam, 2014
DISTILLATION: FUNDAMENTALS AND PRINCIPLES
A. Gorak, E. Sorensen. Elsevier, Amsterdam, 2014
TUTORIAL DE ASPEN PLUS. INTRODUCCIÓN Y MODELOS SIMPLES DE OPERACIONES UNITARIAS
F. Espínola. Universidad de Jaén, Jaén, 2015
USING ASPEN PLUS IN THERMODYNAMICS INSTRUCTION: A STEP-BY-STEP GUIDE
S.I. Sandler. Wiley: AICHE, New Jersey, 2015
ASPEN PLUS: CHEMICAL ENGINEERING APPLICATIONS
Kamal I.M. Al–Malah. Wiley, New Jersey, 2017
CHEMICAL PROCESS DESIGN AND SIMULATION: ASPEN PLUS AND ASPEN HYSYS APPLICATIONS
J. Haydary. Wiley: AICHE, New Jersey, 2019

8. Systems and Assessment Criteria

8.1 System for Assessment:

- Theory/Problems Exam
- Practical assignment
- Individual student monitoring

8.2 Assessment Criteria and Marks:

8.2.1 Examinations Convocatory I

1. Theory/Problems Exam (70 %): competences E01, G01, G04 and CT2 will be assessed through **a final exam** (date officially assigned by ETSI) which will be composed of 3-4 numerical problems on the Theory/Problems lectures. The student will have to solve the exam using a **MS Excel** spreadsheet.
2. Practical assignment (20 %): competences E01, CB2, CB5, G01, G02 G04, G09, CT2 and CT4 will be evaluated through an **Aspen Plus assignment,** in couples, which will deal with the computer sessions contents (10 %). The students will be also asked to prepare a **video-report**, in English language (10 %).
3. Individual student monitoring (10 %): The students will be asked to complete an **online multiple choice test** (10-20 questions) on the Aspen Plus simulations.

Please, do NOTE that:

- **100 % attendance to computer sessions is compulsory**.
- A minimum overall mark of 5 over 10 is required to pass.
- If a minimum mark of 4 over 10 is not attained in part 1, parts 2 and 3 will not be considered. Likewise, parts 2 and 3 will not be considered if their marks are lower than part 1's. In both cases, part 1 will represent 100 %.
- Students are free to opt for maintaining part 2 and/or 3 marks forever (as long as they reach a minimum mark of 5 over 10) or repeating them the following academic course.
- Mobile phones are forbidden in class, computer sessions and exams.

8.2.2 Examinations Convocatory II

1. Theory/Problems Exam (70 %): competences E01, G01, G04 and CT2 will be assessed through **a final exam** (date officially assigned by ETSI) which will be composed of 3-4 numerical problems on the Theory/Problems lectures. The student will have to solve the exam using a **MS Excel** spreadsheet.
2. Practical assignment (20 %): Convocatory I (June) grades will be applied.
3. Individual student monitoring (10 %): Convocatory I (June) grades will be applied.

Please, do NOTE that:

- **100 % attendance to computer sessions is compulsory**.
- A minimum overall mark of 5 over 10 is required to pass.
- If a minimum mark of 4 over 10 is not attained in part 1, parts 2 and 3 will not be considered. Likewise, parts 2 and 3 will not be considered if their marks are lower than part 1's. In both cases, part 1 will represent 100 %.
- Students are free to opt for maintaining part 2 and/or 3 marks forever (as long as they reach a minimum mark of 5 over 10) or repeating them the following academic course.

Mobile phones are forbidden in class, computer sessions and exams.

8.2.3 Examinations Convocatory III

1. Theory/Problems Exam (70 %): competences E01, G01, G04 and CT2 will be assessed through **a final exam** (date officially assigned by ETSI) which will be composed of 3-4 numerical problems on the Theory/Problems lectures. The student will have to solve the exam using a **MS Excel** spreadsheet.
2. Practical assignment (20 %): Convocatory I (June) grades will be applied.
3. Individual student monitoring (10 %): Convocatory I (June) grades will be applied.

Please, do NOTE that:

- **100 % attendance to computer sessions is compulsory**.
- A minimum overall mark of 5 over 10 is required to pass.
- If a minimum mark of 4 over 10 is not attained in part 1, parts 2 and 3 will not be considered. Likewise, parts 2 and 3 will not be considered if their marks are lower than part 1's. In both cases, part 1 will represent 100 %.
- Students are free to opt for maintaining part 2 and/or 3 marks forever (as long as they reach a minimum mark of 5 over 10) or repeating them the following academic course.

Mobile phones are forbidden in class, computer sessions and exams.

8.2.4 Extraordinary Convocatory

1. Theory/Problems Exam (70 %): competences E01, G01, G04 and CT2 will be assessed through **a final exam** (date officially assigned by ETSI) which will be composed of 3-4 numerical problems on the Theory/Problems lectures. The student will have to solve the exam using a **MS Excel** spreadsheet.
2. Practical assignment (20 %): Convocatory I (June) grades will be applied.
3. Individual student monitoring (10 %): Convocatory I (June) grades will be applied.

Please, do NOTE that:

- **100 % attendance to computer sessions is compulsory**.
- A minimum overall mark of 5 over 10 is required to pass.
- If a minimum mark of 4 over 10 is not attained in part 1, parts 2 and 3 will not be considered. Likewise, parts 2 and 3 will not be considered if their marks are lower than part 1's. In both cases, part 1 will represent 100 %.
- Students are free to opt for maintaining part 2 and/or 3 marks forever (as long as they reach a minimum mark of 5 over 10) or repeating them the following academic course.

Mobile phones are forbidden in class, computer sessions and exams.

8.3 Single Final Evaluation:

Theory/Problems Exam (100 %): competences E01, G01, G04 and CT2 will be assessed through **a final exam** (date officially assigned by ETSI) which will be composed of 3-4 numerical problems on the Theory/Problems lectures. The student will have to solve the exam using a **MS Excel** spreadsheet.