DESCRIPTION OF COURSES

International Master degree PM3F | **Fall semester**

Code		Code
ST 9	Food Engineering & Food Science - Basics	FS1
ST10-1	Food safety and quality management - Basics	FS2
ST10-2	Product innovation and food safety management 2	FS3
ST11	Advanced tools and methodologies for food characterisation	FS4
ST12	Innovative food processing	FS5
ST13	Energy and sustainability	FS6
ST14	Advanced process control	FS7
LV3	International communication and leadership for engineers	FS15

Specific to Fall semester

	Baking technology	FS8
	Baking process	FS9
	Food freezing and thawing	FS10
	Fruit juice technology	FS11
	Innovation and creativity: design thinking at the service of engineers	FS12
	Data science - basics and explorarion	FS13
	Data science - explain and predict	FS14

Food Engineering & Food Science - basics				Number of hours	Objectives
Public concerned					Developing a food product based on the diversity of ingredients available today and on the understanding of their functional properties related to transformation processes: - Understanding the manufacture of various types of ingredients regarding their food sector - Understanding the implementation of ingredients related to their functional properties - Ingredients selection according to the manufacturing process and the target characteristics of the final product, including their role in the food structure, stabilization and organoleptic specificities. - Development of food products within formulation constraints (i.e. Clean label) - Evaluation of the food product properties (texture, stability, colour, nutritional characteristics…)
Pm3F	English Fall Semester		Lectures	22	
			tutorials	8	
			Lab	12	
			project		
Code			ECTS : 3		
ST 9	FS 1				

Contents

Grasp the uses of different types of ingredients in relation to their manufacturing processes: diversity of ingredients available on the market and their quality (protein, fibres, lipid ingredients and additives)

Manufacture and handling of dry ingredients: characterization of powders properties (flow behaviour, rehydration,

Non-thermal stabilization process and consequences on food properties

Behaviour of food products as a function of temperature

Tutorials: formulation of a Clean label product, nutritional calculation ...

Food safety and quality management - basics				Number of hours	Objectives
Public concerned					To get the students the fundamental elements of Food Safety Management (Pre-requisite programs, HACCP…) and an overview of Risk Analysis with its three interconnected pillars: risk assessment, risk management and risk communication. Lectures and Tutorials will be illustrated by case-studies related to food industry.
Pm3F	English Fall Semester		Lectures	16	
			tutorials	6	
			Lab		
			project		
Code			ECTS : 1.5		
ST 10-1	FS 2				

Contents

Understanding the Standards
Elements of a Management System
certification and accreditation
Practice through case studies

Food safety management and communication : 6 hours (lectures)

Food safety management:
- Pre-requisite programs, best practice, product and process controls
- Sampling, validation, verification
- Relevance of finished product testing; illustrations with various examples

Communication:
- Risk perception, risk communication,
- Communication adapted to various stakeholders: authorities, customers, consumers

Quantitative risk assessment : 6 hours (lectures) - 6 hours (tutorials)

Introduction to probability, uncertainty and risk assessment modelling:
- probability distributions illustrated through examples
- uncertainty and variability
- risk assessment modelling approach

Chemical risk assessment:
- Exposure assessment,
- Dose-Response model
- Practice through case studies

Microbiological risk assessment:
- Exposure assessment: inactivation, partitioning, growth
- CCP/ process criteria to meet an FSO (risk-based management)
- Practice through case studies

<table>
<tr><td colspan="4">Product Innovation & Food Safety Management 2</td><td>Number of hours vs public concerned</td><td>Objectives</td></tr>
<tr><td colspan="3">Public concerned</td><td></td><td></td><td rowspan="6">Be able to determine the shelf life of food products with regard to their microbiological safety and to anticipate the impact of new trends in the food industry such as reformulation aiming to improve nutritional quality or the evolution of processing methods</td></tr>
<tr><td rowspan="4">Pm3F</td><td rowspan="4">English Fall Semester</td><td rowspan="4">SEQUOIA</td><td>Lectures</td><td>13 - 13 - 8</td></tr>
<tr><td>tutorials</td><td>8</td></tr>
<tr><td>Lab</td><td>4</td></tr>
<tr><td>project</td><td></td></tr>
<tr><td colspan="3">Code</td><td rowspan="2" colspan="2">ECTS : 1.5</td></tr>
<tr><td>ST 10-2</td><td>FS 3</td><td></td></tr>
<tr><td colspan="6">Contents
Trends in industry and food safety impacts
Microbial hazards along the food chain
Predictive microbiology
Methods of food stabilisation
Shelf life determination</td></tr>
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Advanced tools and methodologies for food characterization

Public concerned				
Pm3F	English Fall Semester	PEPS	Lectures	26
			tutorials	4
			Lab	6
			project	
Code			ECTS : 4	
ST 11	FS 4			

Number of hours

Objectives

To characterize both solid and liquid foods using mechanical and thermal analysis techniques.
To know the basic principles needed to select and operate mechanical and thermal analysis instruments, design experiments and interpret the data.
To be aware of advanced electronic technologies to assess physical characteristics of foods.
To characterize both solid and liquid foods using mechanical and thermal analysis techniques.
To know the basic principles needed to select and operate mechanical and thermal analysis instruments, design experiments and interpret the data.
To be aware of advanced electronic technologies to assess physical characteristics of foods.

Prerequisites

Basic knowledge on physical and organoleptic properties of foods
Thermodynamics / Mass and energy balances
Foundations in mathematics

Contents

Mechanical properties

Principles of flow behavior and deformation of food systems. Measurement of viscosity and viscoelastic properties. Modeling behavior with Maxwell and Kelvin-Voigt models.

Thermal properties

Thermal conductivity, specific heat, enthalpy, glass transition measurement, differential scanning calorimetry.

Texture of foods

Assessment of mechanical properties by large deformation scale methods. Texture profile analysis and correlation with sensorial tests. Texture–structure relationships.

Non-destructive methods to assess physical characteristics of foods

Spectrophotometry, X-rays Micro-tomography, Magnetic Resonance Imaging

Innovative Food Processing

Public concerned				Number of hours vs public concerned
Pm3F	English Fall Semester	PEPS	Lectures	40 - 40 - 18
			tutorials	12 - 10 - 6
			Lab / Project	30 - 20 - 16
Code			ECTS : 7	
ST 12	FS 5			

Objectives

Designing and implementing innovative processes in food industries requires a high level based on many engineering skills. This module relies on several teaching units focusing on both technological and modeling aspects which are helpful to design efficient and innovative food processing units. The main objectives could be summarized as follows:
- Understanding and setting up a modeling approach dedicated to food engineering problems,
- choosing the best technology to ensure optimal processing of food products,
- dimensioning of a food processing unit by taking into account a scale-up approach and various constraints,
- improving the global efficiency of processing from an optimization based methodology,
- implementing newly designed processes.

Prerequisites

Applied thermodynamic (first and second principles),
Heat transfer (conduction/convection/radiation phenomenon
Mass transfer (Fick's first and second laws based on diffusion and convection),
Heat and mass balances
Unit operations of chemical engineering
Mathematical basis on ordinary and partial differential equations

Contents

Process simulation

Introduction to thermodynamic models (2h lecture)
Practical work on demo stations (10h lab): How to model a unit operation? Which thermodynamic model and database to choose? (examples based on food engineering problems such as evaporation, concentration, cooling, drying, ...)
Process simulation software: PROSIM ®

Modeling / Optimization

Introduction to numerical modeling and optimization
Equations based modeling for food engineering problems
Optimization (implementation of optimization algorithms, i.e. Nelder Mead Simplex, Levenberg Marquardt, constraint optimization, ...)
Multiphysics Modelling

Innovative processes

High Pressure - Electrotechnologies - microwave - extrusion - Supercritical extraction CO2 - Electro Hydro Dynamics

Energy & Sustainability				Number of hours	Objectives
Public concerned					To understand the issues of the cold chain. To know how primary energy is consumed in different food industry areas. To know ready-market and under development technologiesallowing to save money. To understand how does a refrigeration system run and to be aware of relative international regulations. To know how to estimate the energy consumption of a process. To be able to propose a technological solution for a food process according to the objectives of the company, taking into account opportunities and constraints. To be able to pre-design the system. To know the different indicators allowing to characterize the energy performance of an equipment. To understand the issues of the cold chain. To know how primary energy is consumed in different food industry areas. To know ready-market and under development technologiesallowing to save money. To understand how does a refrigeration system run and to be aware of relative international regulations. To know how to estimate the energy consumption of a process. To be able to propose a technological solution for a food process according to the objectives of the company, taking into account opportunities and constraints. To be able to pre-design the system. To know the different indicators allowing to characterize the energy performance of an equipment.
Pm3F	English Fall Semester	PEPS	Lectures	30 - 30 - 8	
			tutorials	26 - 26 - 0	
			Lab	4 - 4 - 0	
			project		
Code			ECTS : 5		
ST 13	FS 6				

Contents

Thermodynamics: reminder on energy balance of components and/or equipments under steady-state and dynamic conditions. Heat loads estimation for a storage cold room and chilling/freezing processes. A project on a complete energy audit of a food industry equipment: minimum energy requirement, distribution of energy consumptions,…

Refrigeration systems: reminder on 1-stage vapor-compression system (energy and mass balances, p-h and T-s diagrams), multi-stage and cascade vapor-compression systems, alternative refrigeration systems (sorption, Peltier, acoustic, magnetic,…), international regulations on refrigerants, heat pump specificities,…

Advantages of thermal energy storage in food industry & precautions to consider.

Energy efficiency: pinch analysis methodology (flowsheet and data extraction, hot and cold composite curves, heat exchanger network), exergy analysis

Life Cycle Assessment for the eco-design of an equipment: methodology, impact on energy consumption and environment. Case study by using SimaPro 8

Advanced Process Control				Number of hours	Objectives
Public concerned					To be able to understand dynamics of linear and nonlinear systems, and to implement relevant control systems, including parameter and state estimations (observers).
Pm3F	English Fall Semester	BT 3	Lectures	8	
			tutorials	8	
			Lab	4	
			project	10 - 0 - 0	
Code			ECTS : 3		
ST 14	FS 7				

Contents

Reminders about linear transfer functions and controllers

State Space representation (linear and non linear)

Linear quadratic control - state feedback

Luenberger observer - Kalman Filter

Introduction to nonlinear control

Moving horizon state estimation

project using Matlab®

Baking Technology				Number of hours	Objectives
Public concerned					The global objective is to discover the baking technology with more emphasis on the impact of each ingredient on the final quality of the product. The application will be on bread
	English Fall Semester		Lectures	15	
			tutorials		
			Lab	4	
			project		
Code			ECTS : 1.5		
	FS 8				

Different lectures will be done , mostly related to the interactions between ingredients, formulation and process interactions. 4 major types of products will be considered, bread, cake, biscuits and dry cereal products such as rusk and crackers

A factory will be visited during the teaching session

The wheat flour and other flours

Improvers in bread baking

Enzymes, emulsifiers,

The texture of cereal products

Staling of bread

Baking powder

Case of cake products; recipes, processes; and strategy in sugar reduction

Case of biscuit products; recipes and strategy in sugar reduction

Case of salty cereal products, crackers and rusks processes

Baking Process				Number of hours	Objectives
Public concerned					The global objective is to discover the baking industry as a whole. Different processes for different products; the lectures will cover all stages of the process for preparation of different products such as bread and frozen croissant. A focus will be done on important steps that are often bottleneck in a the baking industry such as fermentation, baking and refrigeration after baking
	English Fall Semester		Lectures	9	
			tutorials		
			Lab	7	
			project		
Code			ECTS : 1.5		
	FS 9				

Contents

The baking industry – introduction from flour to different products

Dough mixing and lamination

Fermentation & Enzymes

Ovens and Baking technology

Cooling, freezing, storage

Tutorials fermentation, enzymes and baking powder

Food Freezing & Thawing				Number of hours	Objectives
Public concerned					The global objective is to discover the freezing and thawing processes, which are heavily used in the food industry. The impact of these processes on the quality of foods, as well as the evolution of quality during frozen storage will be outlined
	English Fall Semester		Lectures	13	
			tutorials		
			Lab	8	
			project		
Code			ECTS : 2		
	FS 10				

Contents

Food freezing; regulations and food quality

Freezing process – conventional & freezing time

Freezing process – innovations

Quality loss during storage

Frozen food structure ; image analysis

Food thawing; regulations and quality issues

Thawing processes – conventional & thawing time

Thawing processes – non conventional

Teaching Lab Food Freezing

Teaching Lab cryogenic freezing

Fruit Juice Technology				Number of hours	Objectives
Public concerned					The global objective is to discover the fruit juice technology with emphasis on the effect of each stage of the production on the physical properties and the final quality of the product. The process will be applied to apple juice.
	English Fall Semester		Lectures	2	
			tutorials	2	
			Lab	8	
			project		
Code			ECTS : 1		
	FS 11				

Contents

Fruit processing applied to apple juice

Physico-chemical measurements and thermal treatment

Apple juice production on pilot plant

Innovation & Creativity : Design thinking at the service of engineers			Number of hours	Objectives
Public concerned				Design thinking is a process initially used by designers to innovate from existing uses or to invent. It can be used to solve problems based on user needs and develops solutions for them (products, services, experiences, new form of management ...). This approach can thus be applied to very varied sectors (industry, teaching, hospitals...), from marketing to management through technology. This teaching unit should allow students to have a more global vision of innovation management through the application of design thinking to an innovation project.
	English Fall Semester		Lectures	2
			tutorials	20
			Lab	12
			project	8
Code			ECTS : 4	
	FS 12			

Contents

1) Presentation of the innovation process by using the design thinking and of the innovation project

2) Generation and development of new ideas

3) Transcription of idea(s) in realization steps

4) Present the result of your thinking in a creative way, to convince potential users

5) Technical and practical development of the idea

6) Evaluation of your product or concept (technical analysis, sensory analysis, survey, fe

Data science - basics and exploration

Number of hours	Objectives

Public concerned				
	English Fall Semester	EuReCa	Lectures	6
			tutorials	22
			Lab	
			project	4
Code			ECTS : 3	
	FS 13			

Contents

Introduction to Statistics with R

We begin by introducing the R language with some basic elements. Then, we define the nature of data issued from various collections (experiments, surveys, sensors ….). Finally, we show some useful data manipulation tools.

Discover the R language with some basic programing concepts;

Understand the Nature of data and their collection;

Experiment useful data manipulation functions.

Get insight into the data

This part is devoted to univariate and bivariate statistics to summarize one variable and investigate the relationship between two variables. We show how graphical displays together with numerical outputs can provide synthetic results.

Summarize one / two variable(s) with descriptive statistics ;

Present summaries with Tabular and graphical displays.

Synthesize the data into an easy and understandable form

This part covers the main multivariate analysis techniques to deal with several variables. Principal Component Analysis aims at transforming a large number of correlated variables into a few uncorrelated principal components. Clustering aims at partitioning objects into a small number of groups that are as homogenous as possible.

Synthesize the data using Principal Component Analysis and Display the data onto a map;

Partition the data into groups using Clustering techniques and Characterize the groups thus formed.

Methods will be illustrated on various case studies. Beyond direct applications in food areas, this course is the first step to grasping the use of statistics in a scientific context. A special attention is paid to a balance between (1) Methodological aspects, (2) Practical applications and (3) Communication aspects with the interpretation of the results.

In order to provide safe, nutritious, healthy and palatable products, food industries collect large amounts of data related to process, quality, research and development, consumer insights etc. This leads food practitioners from various areas to perform data analysis on a daily basis. Furthermore, data analysis is becoming increasingly sophisticated requiring statistical and computer science technical skills, which fit under the umbrella of Data Science.
The aim of this course is to provide the very first operating level:
To learn application of basic statistics and data visualization in food industries;
To become familiar with R, the language of reference for statistical computing and graphics;
To get insight into the data and provide synthetic results;
To learn multivariate statistical methods for data exploration purpose.
Technical skills
Application of data analysis methods to summarize and visualize data
Use of the R language for data processing and analysis
Interpretation of statistical results and communication

Data science - explain and predict				Number of hours	Objectives
Public concerned					To go further in Data Science, the aim of this second course is to provide advanced techniques for the analysis of specific data encountered in chemometrics (Omics, spectral, imaging ...) and to conduct a multivariate data analysis. Emphasis will be given on supervised methods where the aim is to explain or predict one or several response variables. In the scope of chemometrics, the data flood generated by modern analytical techniques requires dedicated analysis techniques, which can handle a great number of variables, often highly correlated together. Among these techniques, a focus will be done on the Partial Least Squares Regression, the chemometrics Swiss knife, to explain a set of response variables with highly correlated variables.
	English Fall Semester	EuReCa	Lectures	9	
			tutorials	6	
			Lab		
			project	4	
Code			ECTS : 2		
	FS 14				

Contents

Introduction to Chemometrics

We begin by introducing Chemometrics and depicting the nature of data ranging from Omics, spectral data and imaging. Then we give an overview of the main data analysis techniques in chemometrics with a particular focus on supervised techniques.

Explain one or several variables with the Partial Least Squares (PLS) regression

This part is devoted to the presentation of PLS regression. We present how PLS regression operates a mixed stategy between Principal Component Analysis and Multiple Regression in order to provide simultaneously interpretable models and graphical displays. We present the main R stream programming to process data with PLS

Process hyperspectral images by chemometrics

This part covers the main stream to process hyperspectral images by applying PCA and clustering

Methods will be illustrated on various case studies involving analytical data. A special attention is paid to a balance between (1) Methodological aspects, (2) Practical applications in the R language and (3) Decision and validation models.

Evaluation will be done on the basis of a project related to a case study.