Undergraduate Engineering Summer School

FLoW

Grand Industrial Challenges in France

May 21st – June 14th 2024

PROVISIONAL COURSES

CONTENT

1 ECTS = 15 - 20 hours of workload completed by the student (lectures, labs, projects, personal work…) / 2 European Credits (ECTS) are equivalent to American Credit

SCIENTIFIC COURSES
60 h – 4 ECTS

FEAT – FOOD, WINE & WATER

Introduction to Food Processing

Wine & Beer Technology

Water Science & technology

This track offers about 60 hours of lectures and projects related to some challenges in the fields of food and water sciences. First sessions will present the major unit operation in food processing systems and how to master them to improve sustainability. The second sessions will give a synthetic presentation of the most fermented beverage iconic of the South of France: beer and wine, from harvest to winemaking and aroma. The last sessions will focus on conventional and innovative technologies for water treatment, waste management and on ecological systems and biodiversity preservation. During these 4 weeks you will be interacting with researchers experts in various fields of food and water and discovering the activities developed in the South of France. Lecturers are members of two major engineering schools of Montpellier: Polytech Montpellier and Institut Agro ofMontpellier. The provisional syllabus of the track is detailed below. It includes some references that might support you during the school or guide your way for a more thorough exploration of the covered material.

INTRODUCTION TO FOOD ENGINEERING (IFE)
(10,5h lectures + 6h practical works)

1. ANALYZING AND DESIGNING MAJOR UNIT OPERATIONS N FOOD PROCESSING SYSTEMS :

Introduction to food industry, food engineering, engineering basics, impacts on chemistry. Energy sources, energy balances / Psychrometrics, thermodynamics / Heat transfer / Preservation Drying, dehydration / Thermal processing / Fluid flow / Extrusion processing / Examples, exercises

2. PRACTICAL WORKS :

Those practical classes (6h) take place in a food processing pilot plant and are based on some of the major unit operation in food processing such as canning, production line, pasteurization, concentration and drying. Over these classes, students work on semi industrial pilots and practice their knowledge on fFood processing in situations close to those of industrial production. Each topic consists of a learning phase (start and conduct of pilots), followed by a phase of autonomy (choice of parameters, number of trials, optimization). Organizational aspects, metrology and internal communication are the strengths of this practical training as well as scientific and technical aspects. Industrial fluid consumption (steam, water, compressed air / vacuum, electricity) are integrated into the process and followed with a sustainable development approach.

Assessment: Written exam, multiple-choice questions, calculation questions, short questions

Reference sources:

- *Heldman, D. R., Lund, D. B. 2007. Handbook of Food Engineering, 2nd ed. CRC Press.*
- *Singh, R. P., Heldman, D. R. 2014. Introduction to Food Engineering, 5th edition. Elsevier.*
- *Valantas, K. J., Rotstein, E., Singh, R. P. 1997. Handbook of Food Engineering Practice. CRC Press.*
- *Singh, R. P. Explore Food Engineering : http://www.rpaulsingh.com*

WINE & BEER TECHNOLOGY (WBTECH)
(9h lectures + 12h practical works)

1. WINE TECHNOLOGY : A SYNTHETIC PRESENTATION OF ONE OF THE MOST CONSUMED FERMENTED BEVERAGE

Wine technology

Lecture: Understanding wine technology from harvest to winemaking. Selection of grape variety, "terroir", vineyard management and quality of wine. Process of white, red, sweet and sparkling wine-making, fermentations, aging.

Wine aroma, sensory analysis and market

Lecture: Aroma compounds in wines (how they are formed during winemaking and wine aging) and sensory evaluation of wines (methodology and explanation of wine sensory attributes). Presentation of the Mediterranean wines (category, food matching, history, market).

Assessment: Multiple-choice questions + Sensory methodology

Reference sources:

- *Understanding Wine Chemistry, Andrew L. Waterhouse Gavin L. Sacks David W. Jeffery, Wiley, 2016, doi 10.1002/9781118730720*
- *Handbook of Enology, Volume 1 The Microbiology of Wine and Vinifications 2nd Edition P. Ribéreau- Gayon, D. Dubourdieu, B. Donèche and A. Lonvaud, 2006 John Wiley & Sons.*
- *Handbook of Enology, Volume 2 The Chemistry of Wine, Stabilization and Treatments, 2nd Edition P. Ribéreau-Gayon, Y. Glories, A. Maujean and D. Dubourdieu, 2006 John Wiley & Sons.*
- *Wine Flavour Chemistry, Second edition, Jokie Bakker Ronald J. Clarke, 2012*
- *Wine science: principles and applications. Ronald S. Jackson. Third Edition, 2018, Elsevier.*
- *Wine tasting: A professionnal handbook. Ronald S. Jackson. Third Edition, 2018, Elsevier.*
- *Wine Grapes: A Complete Guide to 1,368 Vine Varieties. J. Robinson, 2012, Penguin books*
- *Terroir and Other Myths of Winegrowing, M. Mathews, 2016, University of California press*
- *The Science of Grapevines: Anatomy and Physiology, M. Keller, Third Edition, 2020, Elsevier*

2. BEER TECHNOLOGY

Beer Technology

Lecture: beer from history to trends in brewing technology and quality control.

Practical works
Rrtisanal manufacture of beer and sensory evaluation.

Assessment: multiple-choice questions

Reference sources:

Palmer, J. J. (2017). How to brew: everything you need to know to brew great beer every time. Brewers Publications.

WATER SCIENCE AND TECHNOLOGY (WST)
(22,5 h lecture + practical works + visit)

1. ASSURING CLEAR WATER

Lectures + small projects: Conventional and innovative technologies for water treatment and waste water management. Water contamination can be very diverse and can be harmful for both environment and human health. The content of this course willbe divided into three main parts. The first part will be dedicated to the presentation ofthe different type of water contaminants/pollution (anthropogenic or natural pollution) and how it can affect the ecosystem and human health. In a second part, the different water treatment techniques will be presented for both wastewater management and drinking water production. Finally, a presentation of innovative water technology based on membrane processes for specific applications will be details in the last part of this lecture.

Reference sources:

- Vigneswaran S. & Visvanathan C. 1995. Water treatment processes : Simple option. CRC Press Published - 224 Pages - ISBN 9780849382833

2. SUSTAINABLE AQUATIC ECOSYSTEMS

Lectures and small projects on the ecosystem ecological status and biodiversity preservation. This course aims at introducing ecological basic knowledge of a river system and aquatic organisms, and providing tools to evaluate the ecological status of rivers. Human impacts (such as dam construction) jeopardize ecosystem functioning and biological resources sustainability, and solutions for the ecological continuity restoration are presented.

Reference sources:

- *Schmutz S. & Sendzimir J. 2018. Riverine Ecosystem Management. Science for Governing Towards a Sustainable Future. Aquatic Ecology Series Vol 8. 562 pages*
- *Baudoin JM et al 2014. Assessing the passage of obstacles by fish. Concepts, design and application. Ed. Knowledge of action. 200p*
- *Molles M.C. Jr. 2005. Ecology: concepts and applications. Mc Grow Hill Ed. 3rd edition. 622p.*
- *Townsend C.R., Begon M. & Harper J.L.2003. Essentials of Ecology. Blackwell Publishing 2nd edition. 530p.*

Assessment: Multiple-choice questions, small-project

SUSTAINABLE ENERGY & MATERIALS

Energetic solutions in the south of France

Materials for sustainable development

Nanomaterials & Nanotechnologies

This track offers about 60 hours of lectures, labs and projects related to some challenges in the fields of materials: from miniaturization to energetical and environmental issues. You will learn how to select or develop a material for a specific application, taking into account its environmental impact and adapting the size to gain in efficiency, to bring new properties.... During these 4 weeks you will be interacting with researchers experts in various fields of materials and discovering the activities developed in the South of France. The provisional syllabus of the track is detailed below. It includes some references that might support you during the school or guide your way for a more thorough exploration of the covered material.

ENERGETIC SOLUTIONS IN THE SOUTH OF FRANCE (ES)
(18h lectures + 6h practical works & visit)

This course aims at presenting three different energetic solutions developed in the south of France. The context and energetical issues will be introduced

followed as well as the concept of energy and its emergence throughout history, some recalls of the main principles…
Then different energy conversions will be developed through the eyes of material engineers.

The first topic is about the materials involved in the nuclear reactor , the requirement for these materials and the radiation damages occurring in materials (1). Finally, explaining the security issues, materials for transport, recycling and storage of nuclear wastes will be presented.

The second topic is related to batteries (2): How does it work? What are the main electrical features of a battery depending on the couple used, e.g. Lead/acid, Li-ion, Fuel Cells? What is the link between the "inside" functioning and the "outside" (black box) performances? and finally what are the main industrial development of batteries in the framework of the sustainable energy "revolution" imposed by the climate change.
Other solutions for energy storage will be evoked, commonly named 'electro-fuels', based on either Hydrogen (best candidate but suffers up to now from some drawbacks such as its storage capacity and safety) or Ammonia (NH3), showing some advantages on hydrogen.

The third part will be dedicated to solar photovoltaic and thermal power starting with the principle of the thermodynamic conversion of concentrated solar energy. The challenges related to thermal storage, and night power release will also be discussed. We will present
the Different commercial solar thermal power plants in the world and the vision for the future… In order to better understand the Photovoltaic solution, Photovoltaic effect will be explained, the interest for concentrated photovoltaic solution will be detailed. Finally, we
will evoke the photovoltaic energy distribution within the French electricity grid and the management of PV power plant.

Welding is present in all industrial infrastructures, and particularly in Energy and Materials plants. This course will give an introduction on welding science and technologies. (3)

Assessment: Multiple-choice questions

Reference sources:

- *(1) An Introduction to Nuclear Materials: Fundamentals and Applications by K. Linga Murty, Indrajit Charit, Publisher: Wiley-VCH; 1 edition (January 29, 2013)*
- *(2) Electrochemical Energy Storage (Anglais) Broché – 3 mars 2015 by Jean-Marie Tarasco, Patrice Simon , ISTE Ltd. (3 mars 2015)*
- *(3) Welding Level 1 Trainee Guide, 3e, Paperback by NCEER*

MATERIALS FOR SUSTAINABLE DEVELOPMENT (MFSD)
(10,5h lectures + 6h practical works & projects)

The objective of this course is to give an introduction to engineering methodology for Eco design (concept, norms and practical tools). The industrial LCA SIMAPRO2 software will be used for practical lessons and project.
Materials for sustainable development: context and history.

Life cycle assessment method: life cycle and Emission/Extraction inventory Life cycle assessment method: Impact factor calculation
LCA practical lessons: Inventory, Environmental Impact and Case study LCA project

Assessment: Multiple-choice questions

Reference sources:

- *"Environmental Life Cycle Assessment" 1st Edition, Olivier Jolliet et al. CRC Press (2015) - 302 Pages, ISBN 9781439887660 - CAT# K14053*
- *https://www.pre-sustainability.com/download/SimaPro8IntroductionToLCA.pdf*

NANOMATERIALS AND NANOTECHNOLOGIES (NANO)
(10,5h lectures + 9h practical works & project)

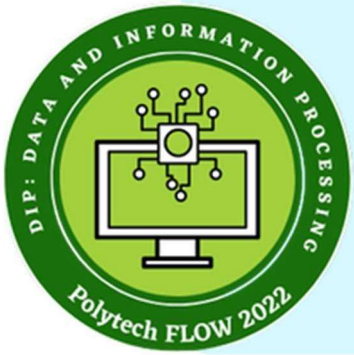
New properties and tools, innovation and social issues
Lectures will be dedicated to the presentation of the synthesis methods, the structure and the electronic and optical properties of nanomaterials. A special emphasis will be made on carbon nanostructures (graphene, carbon nanotubes, fullerenes), metallic nanoparticles and porous silica nanomaterials. The norms and rules, as well as the issues of toxicity and sustainability will also be discussed. The main characterization techniques of nanomaterials will be presented, and illustrated through practical problems. Among these, scanning and transmission

electron microscopy, atomic force microscopy, scanning ion microscopy, focused ion beam, electron diffraction, GISAXS and reflectometry will be introduced. The goal of these lessons is to provide students with a set of characterization tools with a comprehensive description of their relevance and limits regarding the addressed problem.

Assessment: Multiple-choice questions

Reference sources:

- *Nanomaterials: An Introduction to Synthesis, Properties and Applications, 2nd edition, Dieter Vollath, Wiley-VCH (2013)*
- *Nanomaterials and Nanochemistry, C. Bréchignac, P. Houdy, M. Lahmani ed, Springer (2006)*
- *Nanomaterials Chemistry: Recent Developments and New Directions by C. N. R. Rao, Achim Muller, Anthony K. Cheetham, Wiley-VCH, 1 edition (July, 2007)*
- *The Physics and Chemistry of Nanosolids by Frank J. Owens, Charles P. Poole, Jr. Wiley-Blackwell (mai 2008)*
- *Nanomaterials, Commission for the Investigation of Health Hazards of Chemical Compounds in the Work Area, DFG Report, Wiley VCH (2013)*



DATA & INFORMATION PROCESSING

Programmable Digital Electronics

Opperating & Programming Computers

Big Data Management & Analysis

This track offers 60 hours of lectures and labs around the transformation of measures from our environment to signal, then to data and finally to the analysis of data by most sophisticated methods. First sessions will concentrate on signal (acquisition, filter, processing) then on systems to handle the information digitally (electronic cards, operating systems, programs on computers) or transmit it to the Internet. On a wider scope, information becomes data, and you will discover the basics of Data Science: innovative ways of storing data, mining data to extract meanings or intentions by machine learning and artificial intelligence methods.

Lecturers are members of Université Montpellier or of the Montpellier antenna of IBM corp.
The syllabus of the track is detailed below. It includes some references that might support you during the school or guide your way for a more thorough exploration of the covered material.

Assessment: Short reports

PROGRAMMABLE DIGITAL ELECTRONICS (PDE)
(13,5h lectures + 3h project & visit)

1. DIGITAL FILTERS

Keywords: Digital filters: Finite Impulse Response (FIR) and Infinite Response (IIR) Filters, Digital filter simulation with Matlab.

Filtering is one of the most widely used functions of digital signal processing. Filtering enables to remove undesired frequencies from the signals of interest (for instance remove the DC offsets and high frequency noise from the electronic components of the sensors used for signal acquisition). The aim of this lab is to handle analysis simulation of digital filters (i.e. display the frequency response according to the filter definition, study the filter stability through zero-pole representation in the complex plane) as well as the main synthesis functions (i.e. compute the adequate coefficients for digital filters according to a given response description) using Matlab. A brief introduction on the digitization of analog (i.e. physical) signals will be presented.

Reference sources:

- *Wanhammar Lars, Saramäki Tapio, "Digital Filters using MATLAB" (Springer, 1st ed., 2020), ISBN 978-3- 030-24063-9*

2. INTRODUCTION TO PROGRAMMABLE DIGITAL ELECTRONICS

In this lab you will concentrate on the way signals can be acquired from physical measurements by sensors. In return, devices rely on light, sound or motor actuators to act on their environment. We'll study the particular case of LEDs (which are easy to simulate, remember we deliver this year remote learning sessions). Then you will discover the world of programmable digital electronics

through the programming of an Arduino board in order to control actuators and receive input from sensors.

Reference sources:

- *Brian Evans "Beginning Arduino Programming: Writing Code for the Most Popular Microcontroller Board in the World" (APress, 1st ed., 2011)*

3. FINITE STATE MACHINES

In this lab you will concentrate on the way signals can be acquired from physical measurements by sensors. In return, devices rely on light, sound or motor actuators to act on their environment. We'll study the particular case of LEDs (which are easy to simulate, remember we deliver this year remote learning sessions). Then you will discover the world of programmable digital electronics through the programming of an Arduino board in order to control actuators and receive input from sensors.

Reference sources:

- *https://www.allaboutcircuits.com/textbook/digital/chpt-11/finite-state-machines/*
- *Modeling Software with Finite State Machines: A Practical Approach*

OPERATING AND PROGRAMMING COMPUTERS (OPC)
(16,5h lectures + 9h practical works & project)

1. OPERATING SYSTEMS

We will first shortly introduce the roles of operating systems to manage information and resources in a computer. We will then focus on the case of Unix systems, investigating how this system manages users, files, processes and on the powerful command line commands. Then a lab will invite you to practice commands on such a system. Activities will be guided thanks to a remote learning system. You will also be introduced to file sharing between distant computers and to issuing commands on a remote computer.

Assessment: lab exercises & project

Reference sources: - Operating System Concepts, 9th Edition, Wiley & Sons, by A. Silberschatz, P.B. Galvin, G. Gagne, 2012.

2. PYTHON PROGRAMMING

A lecture will focus on the main programming concepts and present the way they can be phrased in the Python language. Python is recognized as one of the top programming languages and one with the easiest learning curve. It is used for numerous applications from interfacing with sensors to programming games, analyzing data, and even programming web apps. A lab will then allow you to manipulate various data structures in Python.

Assessment: project

Reference sources:

- *Python Crash Course, E. Matthes, No Starch Press, 2016*
- *Web tutorial: https://docs.python.org/3/tutorial/index.html*

3. INTRODUCTION TO THE INTERNET OF THINGS

The Internet of Things (IoT) is considered as the third Internet revolution and is mainly about physical objects and devices communicating data on the Internet. The accumulated data helps people or programs to remotely monitor places (homes, crop
fields, highways, product lines…), objects (cars, dispensers, transit…) and to raise alerts.
In this you will apply your freshly acquired python skills to interact with sensors and actuators connected to raspberry PIs. We will then concentrate on communicating data from a computer to the internet, through http or dedicated protocols and try different platforms that collect and publish IoT data. The goal here is to become familiar with systems extracting data from their environment and communicating it for analysis by high-level methods.

Assessment: project

4. PROGRAMMING THE WEB

Keywords : Client-Server application, http protocol, data storing, javascript, node- express

You will study and practice the main protocol to exchange data on the web, architectures of web apps remotely accessible from browsers. Your attention will go both to client-side and server-side code, mainly focusing on the Javascript language. You will also explore ways to store information on the web to be able to access from anywhere on earth where the internet is available.

Assessment: project

5. TEAM PROJECT

You will apply skills related to this module on a practical team-project.

BIG DATA MANAGEMENT AND ANALYZING (BDMA)
(15h lectures + 3h practical works & project)

1. SIMULATING DATA

Keywords: simulation, multi-agent system, strategies, key performance indicators, block programming.

Many studies are conducted from a modeling of our environment or of human interactions. Most often models are first tested on simulated data and when validated, they're applied to real data. This lab presents a very simple way of leading simulations on human day-to-day interactions. We will then apply simulations to evaluate several competing strategies to circumvent the spreading of the COVID virus.

Assessment: Short survey of the lab

2. BASICS OF SQL AND NOSQL DATABASES

Keywords: Databases, Sql, Nosql, Big Data, Data Storage.

This Lab introduces the main concepts and a broad view of databases and modern big data storage solutions. Through a lecture we introduce the basis of the relational database model and SQL query language. Next, we show the evolution of data management solutions based on different needs: web, social networks, big data, clouds, etc. Then we provide more details of a Nosql document based storage solution, MongoDB, that can be useful in many applications. Practical exercises are proposed to experiment both SQL over a relational database and MongoDB.

Assessment: Short survey of the lab

3. EXPLORING GRAPH DATABASES

Keywords: Graph Databases, Graph Processing Engine, Graph Storage Engine, Pattern Matching.

Graph databases are useful for a lot of use cases where links between data matter. Let's follow the graph together for a journey in the world of fraud detection,recommendation, impact analysis, social networks, and see how we can make data processing and analysis through pattern matching to solve this issues. Through a lecture, we introduce the basis of NoSQL graph databases, then a lab lets you explore the main concepts and a broad view of NoSQL graph databases and related issues.

Assessment: Short quiz at the end of the session

Reference sources:

- *Graph Databases, 2nd Edition, Ian Robinson, Jim Webber, Emil Eifrem, O'Reilly Ed.*

4. DATA MINING

This course presents the main methods of data mining from the computer science perspective: supervised and unsupervised algorithms such as decision trees, naive Bayes, k-nearest neighbours, k-means,… and pattern mining (frequent item-sets,

association rules, sequential patterns). The course also focuses on evaluation methods

(confusion matrix, quality measures). You will explore several datasets and methods through a hands-on lab.

Assessment: Short survey of the lab

5. CLOUD, IOT & AI PROTOTYPING

Discover a cloud computing platform (IBM Cloud) and measure the interest proposed by this large catalog of services around the Internet of Things (IoT), Artificial Intelligence (IA) and data management, and quickly develop IoT solutions, with data collection and augmentation using AI services (natural language processing, computer vision, etc.). A lab will then allow you to build an IoT data processing chain through Node-Red. This block-based graphical coding interface will allow you to acquire, store, monitor and explore data without coding.

Assessment: Screenshots of the lab key steps

Reference sources: https://www.ibm.com/design/ai/basics/ml/
https://nodered.org/docs/tutorials/
https://developer.ibm.com/technologies/machine-learning/tutorials

6. QUANTUM COMPUTING

Quantum computing is the next generation programming paradigm. IBM is one of the few world- wide companies building quantum computers and making them freely available to programmers in search of challenges. During this session, the potential of quantum computing will be presented as well as basic ideas on how to program such computers.

TUTORED CROSS-DISCIPLINARY PROJECT ON SUSTAINABILITY 16 h – 1 ECTS

12h face to face + 4h individual work

This course consists of a tutored project on sustainable development in an international context. During the 4 weeks, you will work in small teams supervised by a professor. The objective of the project is to work in groups from different cultures and scientific disciplines in order to write the specifications of an innovative product/service responding to one of the 17 sustainable development issues established by the United Nations. During the 4 weeks, the projects will be conducted by alternating face-to-face learning sessions and non-face group work sessions. This project also covers an initiation to project management.

Assessment: Oral defence of the project

Reference source:

- *https://www.un.org/development/desa/disabilities/envision2030.html*

FRENCH LANGUAGE & CULTURE, INTERCULTURALITY
24 h – 1 ECTS

- **Presentation of France and immersion in the Occitanie Region (Regional economy, art of living in Occitanie)**
- **Basic French vocabulary (gastronomy and culture)**
- **Introductionto interculturality and to the cultural specificities of France**

This track of about 24 hours offers a presentation of France and an immersion in the Occitanie Region (Regional economy, Art of living in the South of France).

In small working groups you will learn the basic French vocabulary (gastronomy and culture). During these 4 weeks you will also benefit from an introduction to interculturality and the cultural specificities of France.

FRANCE AND OCCITANIE REGION

Geographical, economic and cultural presentation of France and Occitanie.

France: presentation of the richness and diversity of France from a geographical, social, cultural and culinary point of view.
Occitanie: presentation on the geographical and natural specifications. Focus on some key cities.

REGIONAL ECONOMY

Economic assets: work on the specificities of the Occitanie Region. Comparison between clichés and reality.
The South de France products: coastal specificities, agriculture, wine and food products of Occitanie.

ART OF LIVING IN OCCITANIE

Great traditions ofvarious festivals: work around drama, dance, music, Mediterranean cinema. Regional specialties: Provence markets, Camargue races, culinary specialties.

INTERCULTURALITY (3h FACE-TO-FACE)

The concepts of culture, cultural dimensions, intercultural relations, culture shock Specificities of the French culture and links with its History, Settlement, Geography

Assessment: Production of a personal video integrating the linguistic and cultural concepts presented and discussed.

Reference sources:

- *Meyer E. 2016. The Culture Map: Decoding How People Think, Lead, and Get Things Done Across Cultures. PublicAffairs. First Trade Paper Edition*
- *Goethe Institute. Lifeswap : https://vimeo.com/user20904244*

IF YOU HAVE ANY QUESTION PLEASE CONTACT

polytech-flow@montpellier.fr

https://www.polytech.umontpellier.fr/international/summer-school