الجمهورية الجزائرية الديمقراطية الشعبية

People's Democratic Republic of Algeria

وزارة التعليم العالي والبحث العلمي

Ministry of Higher Education

and Scientific Research

TRAINING OFFER

ACADEMIC MASTERS

NATIONAL PROGRAM

2016 - 2017

Field	Branch	Speciality
Sciences and Technologies	***Mechanical engineering***	***Energetics***

I – Half-yearly course organization sheets specialty

Semester 1

Teaching unit	Matter	Credit	Coefficient	C	Tutorials	PW	Volume (hour)
Fundamental Unit	Advanced Fluid Mechanics	6	3	3h00	1h30		67h30
	Thermal machines	4	2	1h30	1h30		45h00
	Advanced heat and mass transfer	4	2	1h30	1h30		45h00
	Advanced numerical methods	4	2	1h30	1h30		45h00
Methodological unit	Instrumentation and measurements	4	2	1h30		1h30	45h00
	PW Numerical Methods	2	1			1h30	22h30
	PW Thermal machines	2	1			1h30	22h30
	PW Fluid Mechanics	1	1			1h00	15h00
Discovery unit	Optionel subject	1	1	1h30			22h30
	Optionel subject	1	1	1h30			22h30
Transversale Unit	Technical English and terminology	1	1	1h30			22h30

Semester 2

Teaching unit	Matter	Credit	Coefficient	Courses	Tutorials	PW	Volume (hour)
Fundamental Unit	Combustion	4	2	1h30	1h30		45h00
	Gas dynamics	4	2	1h30	1h30		45h00
	Thermal drying	2	1	1h30			22h30
	Heating and air conditioning	4	2	1h30	1h30		45h00
	Advanced turbomachinery	4	2	1h30	1h30		45h00
Methodological unit	Finite volume methods	4	2	1h30	1h30		45h00
	PW Turbomachinery	4	2	1h30		1h30	45h00
	Control and regulation	3	2	1h30		1h00	37h30
Discovery unit	Optionel subject	2	1			1h30	22h30
	Optionel subject	3	2	1h30		1h00	37h30
Transversale Unit	Ethics, deontology and intellectual property	1	1	1h30			22h30

Semester 3

Teaching unit	Matter	Credit	Coefficient	C	Tutorials	PW	Volume (hour)
Fundamental Unit	Advanced internal combustion engines	6	3	3h00	1h30		67h30
	Cryogenics	4	2	1h30	1h30		45h00
	Propulsion mechanics	4	2	1h30	1h30		45h00
	Heat exchangers	4	2	1h30	1h30		45h00
Methodological unit	CFDs and software	4	2	1h30		1h30	45h00
	Optimization	3	2	1h30		1h00	37h30
	PW Heat exchangers	2	1			1h30	22h30
Discovery unit	Optionel subject	1	1	1h30			22h30
	Optionel subject	1	1	1h30			22h30
Transversale Unit	Documentary research and master's thesis design	1	1	1h30			22h30

Discovery Unit (S1, S2 and S3)

1- Energy transport and storage

2- Applied electronics

3- Applied electrical engineering

4- Energy audit

5- Renewable energies

6- Maintenance and Industrial Safety

7- Hygiene and safety

8- Aeronautics

9- Transportation

10- Reliability

11- quality management

12- Collaborative design

13- Theory of solving innovation problems "TRIZ Method"

14- Hydraulic and pneumatic systems and devices

15- Other...

Semester 4

Internship in a company sanctioned by a thesis and a defense.

	SHV	Coeff	Crédits
Personal Work	550	09	18
Internship in a company	100	04	06
Seminars	50	02	03
Other (Supervision)	50	02	03
Total Semester 4	750	17	30

II - Detailed program by subject of semester S1

Semester: 1
Teaching Unit: UEF 1.1.2
Subject: Advanced Fluid Mechanics
Total teaching hours: 45h (Class: 01h30, tutorials: 01h30)
Credits: 4

Objectives of the course:

To acquire the necessary knowledge of fluid mechanics, such as the main conservation laws, in order to adapt them to the concerns of experimenters and engineers/designers: calculation and dimensioning of structures, components and distribution networks of renewable energy systems. Complementary technical knowledge in applied fluid mechanics for hydraulic networks.

Recommended prerequisites:

Basic knowledge of fluid mechanics.

Develop expertise in the field of analytical and numerical methods in order to understand and use advanced concepts in fluid mechanics.

Analytical and numerical problem-solving work (with the help of commercial software) is used to better understand the theoretical material. Synthesis project.

Course content:

Chapter 1: Review of fluid statics (cases of reservoirs and storage tanks) (1 week)

Chapter 2: Concept of fluid dynamics (review of equations without proof) (1 week)

Chapter 3: Primary and secondary fluid flow regimes (2 weeks)

Chapter 4: Application of conservation laws (mass, momentum, and energy) to these regimes (case of typical problems) (3 weeks)

Chapter 5: Flow in pipes (introduction to Fanno and Reiley flows) (3 weeks)

Chapter 6: Calculation of distribution networks and operating points of a thermodynamic system (3 weeks)

Chapter 8: Hydrodynamic lubrication (2 weeks)

Assessment method:

Continuous control: 40%; Exam: 60%.

Bibliography:

1. Thermohydraulique multiphasique, document de cours, G. BERTHOUD, ENSPG – France, 1993.

2. Boiling condensation and gas –liquid flow, P. B. WHALLEY, Oxford, 1987.

3. Multiphase Flow Dynamics, Kaviany, Maasoud, 1- Fundamentals.

4. Multiphase Flow Dynamics, Kaviany, M., 2- Thermal and Mechanical Interactions.

Semester 1
Course unit: FTU 1.1.1
Course Title : Thermal Machines
SHV: 45 hours (class: 01h30, tutorial: 01h30)
Credits: 4
coefficient: 2

Teaching objectives:

This teaching contributes to the acquisition of essential knowledge for energy master students. Students will obtain the fundamentals to understand and analyze the operation of different types of thermal machines.

Recommended prior knowledge:

Thermodynamics

Content of the Course:

Chapter 1: Reminder of technical thermodynamics (2 weeks)

- Notions of state variables, equations of state of ideal gases
- First law of thermodynamics
- Second law of thermodynamics

Chapter 2: Machines with receiver cycles (3 weeks)

- Compressors (reciprocating compressors: single-stage and multi-stage compression, efficiency)
- Refrigeration machines
- Heat pump

Chapter 3: Ideal Cycles of Internal Combustion Engines (2 weeks)

- Spark ignition cycle
- Diesel Cycle
- mixte Cycle

Chapter 4: Gas Turbine and Jet Engine (3 weeks))

- - Basic cycle,
- - Other cycles,,
- - Performance criteria and efficiencies

Chapter 5: Steam Turbine (3 weeks))

- Rankine cycle without and with overheating
- Hirn Cycle
- - Racking cycles

Chapter 6: Other types of engines (2 weeks)

- Stirling engines

- Ericsson engines
- Air compressed engines

Assessment method::

Continuous Control: 40%, Exam: 60%.

Bibliographic references:

1. *Thermodynamique technique, volumes 1,2 et 3, Maurice Bailly- Bordas Paris –Montréal 1971.*
2. *Machines thermiques, EmilianKoller, collection technique et ingénierie Dunod, 2005*
3. *Thermodynamique des systèmes fluides et des machines thermiques :Principes, modèles etapplications, FOHR Jean-Paul, Lavoisier 2010*

Semester: 1
Teaching unit: FTU 1.1.2
Subject: Advanced heat and mass transfer
SHV: 45h00 (Course: 1h30, T: 01h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Master the basic notions of the three modes of heat transfer
Know how to write a balance sheet and build an elementary model

Recommended prior knowledge:

Mathematics and physics or mechanics background
Knowledge of applied thermodynamics

Subject content:

Chapter 1: Conduction (4 weeks)
• Fourier's law and generalized Fourier's law, tensor of thermal conductivities, thermal conductivities, thermal diffusivities and effusivities.
• Conduction equation (CE), linear boundary conditions and examples of non-linear conditions.
• One-dimensional transient solutions: Use Fourier analysis and Laplace transformation.
• The longitudinal and transverse fins, show the establishment of the equations in the two cases.
• Propose some solutions
• Employment opportunity and optimization.
• The most common profiles (rectangular, trapezoidal).
Chapter 2: Radiant Heat Transfer (5 weeks)
• Laws and definitions in radiative transfer. Planck's law, Kirchhoff's law, Bouguer's formula.
• Radiative properties of surfaces. Exchanges between surfaces separated by a transparent medium.
• Beer's law. Radiative properties of gases (MST). Radiative properties of particles. Establishment of the radiative transfer equation (ERT).
• Some approximate solutions of the simplified ERT
Chapter 3: Convection (3 weeks)
• Reminders of dimensional analysis, usefulness of dimensionless numbers.
• Mechanical and thermal boundary layers, integral methods.
• Convection equations, modeling of a convection problem.
• Solutions to some convection problems. Forced convection in a cylinder. Natural convection on a flat vertical plate and in a rectangular cavity.
Chapter 4: Heat transfers during phase changes (2 weeks)
• Condensation on a vertical flat plate and on a horizontal cylinder, Nusselt film theory. Practical use of correlations.

• Boiling of pure substances, main parameters involved in boiling. Evaluation of transfer rates in this mode and inherent errors.

Chapter 5: Mass Transfer **(1 week)**

• Diffusion equation, Fick's law
• Simultaneous heat and mass transfer
• Mass diffusion mechanism
• Convective diffusion

Assessment method:

Continuous Control: 40%, Exam: 60%.

Semester : 1
Teaching unit: FTU 1.1.2
Matter : Advanced numerical methods
SHV: 45h (Lesson: 1h30, tutorials: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives :

Learn new numerical techniques to solve the different equations appearing in energetics (fluid mechanics, thermal, ...). The emphasis will be put on the solution of differential equations and partial differential

Recommended prior knowledge :

The course of Fluid Mechanics (L3)

Mathematics

Numerical methods (licence)

Matter content :

Chapter 1: 1st order equations, Taylor series development, Euler's method and error propagation, Runge-Kutta methods and error assessment, ODE systems, multi-step methods, prediction-correction method. EDO systems, multi-step methods, prediction-correction method. Application to boundary layer equations of forced and natural flow and convection on flat plates. **(3 weeks)**

Chapter 2: Finite Difference Methods, Presentation of the method. Resolution of a 2D conduction problem, stationary, representing an elliptic equation. direct and iterative solution of the obtained system. Multi-step methods and Douglas-Rachford stationnarization techniques, convergence optimization. **(3 weeks)**

Chapter 3: Parabolic equations: Case of unsteady conduction (or mass diffusion) 1D: Pure explicit schemes, pure implicit schemes and Crank-Nicholson schemes. 2D case: Two time level methods, ADE, Peaceman-Racheford ADI **(2 weeks)**

Chapter 4: Hyperbolic equations: Method of characteristics. Burger's equation, sound waves in a fluid **(2 weeks)**

Chapter 5: Study of the errors resulting from these types of schemes: Consistency, stability, convergence, dissipation and dispersion **(2 weeks)**

Chapter 6: Finite volume method: Advantages and disadvantages compared with finite differences method. Application to fluid mechanics (SIMPLE, SIMPLER, SIMPLEQ, QUICK, TEAMKE algorithms for turbulent). How to choose ? **(3 weeks)**

Evaluation mode :

Continuous assessment: 40%; Exam: 60%.

References:

1. F. Jedrzejewski, Introduction aux méthodes numériques, Deuxième édition, Springer- Verlag, France, Paris 2005.
2. W. H. Press, S. Teukolsky, W. T. Vetterling, B. P. Flannery, Numerical recipes in Fortran, Cambridge University press, 1995.
3. B. Carnahan, H. A. Luther and J. O. Wilkes, Applied numerical methods, R. Kriegerpublisher, 1990.
4. F. S. Acton, Numerical methods that work, The mathematical association of America, 1990.
5. Joe D. Hoffman, Numerical Methods for Engineers and Scientists 2nd Edition, Marcel Dekker, editor, 2001.
6. N. Boumahrat et Gourdin, Méthodes numériques, OPU, 1980.
7. J. D. Faires and R. L. Burden, Numerical methods, Brooks Cole 3rd edition, 2002
8. Oliver Aberth, Introduction to Precise Numerical Methods, Elsevier editor, 2007.
9. Rao V. Dukkipati, Numerical methods, Publishing for one world, 2010
10. M. N. Ozisik, "Finite Difference Methods in Heat Transfer"; Mechanical and Aerospace Engineering Department North Carolina State University
11. H.K. Versteeg et W. Malalasekera, An introduction to computational fluid dynamics. The Finite volume method, Longman scientific & technical, London, 1995.
12. Zienkiewic, Numerical methods in heat transfer, Mc Graw Hill editor, 1988.
13. J. C. Tannehill, D. A. Anderson and R. H. Plercher, Computational Fluid Mechanics and Heat Transfert, second edition, Taylor and Francis editor, 1997.
14. H. Lomax,T. H. Pulliam and David W. Zingg, Fundamentals of Computational FluidDynamics, 1999

Semester: 1
Course unit: MTU 1.1
Subject: Instrumentation and measurements
SHV: 45h (class: 01h30, T : 01h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The student will learn the principles of Instrumentation and Regulation (Metrology Process control, Physical quantities, passive, active, integrated sensor, Characteristics, Transmitter and standards and Block diagram.

Practical work (according to the technical capacities of the establishment)

Recommended prior knowledge:

General mechanics, electricity, basic elements of electronics.

Material content:

Chapter 1: Introduction (1 weeks)

Chapter 2: Different types of measurements (3 weeks)

2.1 Measurements of acoustic and vibration quantities

2.2 Measurement of hydraulic and pneumatic quantities

- 2.3 Measurements of mechanical quantities
- 2.4 Measurement of thermal quantities
- 2.5 Measurement of dimensional quantities
- 2.6 Measurement of electrical quantities
- 2.7 Measurement of optical quantities
- 2.8 Measurement of volume, mass, time

Chapter 3: Nondestructive testing (1 weeks)

Chapter 4: Organization, methods and measurement techniques (2 weeks)

Chapter 5: Calibration (1 weeks)

Chapter 6: Signal processing (3 weeks)

Chapter 7: Data Processing (2 weeks)

Chapter 8: Introduction to Design of Experiments (2 weeks)

Assessment method:

Continuous Control: 40%, Review: 60%.

Bibliographic references:

1. “Physical measurements and instrumentation: Statistical and spectral analysis of measurements, sensors”, Barchiesi, Dominique, Paris, Ellipse, 2003.

2. “Sensors in industrial instrumentation”, Asch, Georges, Paris, Dunod, 1999.

3. R.J. Goldstein, “Fluid Mechanics Measurements”, 1983.

Semester : 1
Teaching unit: MTU 1.1
Matter : PW numerical methods
SHV: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives :

The student will have the necessary competences to numerically model the physical phenomena in the field of energy. The modeling is based on numerical discretization methods for a better understanding the fluid flow phenomena coupled with heat and mass transfer

Recommended prior knowledge :

Fluid mechanics, thermodynamics and numerical methods.

Matter content :

Programming of PDE solution methods using MATLAB or Fortran

- Diffusion and radiation problems
- Convection-diffusion problems
- Flow field calculation
- Other Applications in the domain of energy systems

Evaluation mode :

Continuous assessment: 100%.

Semester 1
Teaching unit: MTU 1.1.1
Subject : Practical work Thermal machines
SHV: 45 hours (practical work: 01h30)
Credits: 2
coefficient: 1

Teaching objectives:

Students will obtain the fundamentals to practically understand and analyze the operation of different types of thermal machines.

Recommended prior knowledge:

Fluid mechanics, thermodynamics, thermal machines.

Content of the subject: according to the existing material

1. Turbines and hydraulic pumps
2. Steam turbine and thermal power plant
3. Gas turbine and turboshafts
4. External combustion engines: Stirling engine
5. Internal combustion engines
6. heat pump
7. Refrigeration machines
8. Single-phase heat exchangers
9. Steam generators
10. exergy analysis

Assessment method:
Continuous Control: 100%.

Semester: 1
Teaching unit: MTU 1.1
Subject: Practical work Fluid dynamics
SHV: 15h00 (PW: 01h00)
Credits: 1
Coefficient: 1

Teaching objectives:

Study of head losses in laminar and turbulent regimes, identification of the transition Reynolds number, demonstration of a singular loss. Comparison of the loss laws obtained with those of the bibliography. Descriptions of the main hydraulic components: valves, flowmeters, pumps. Awareness of regulation. Global energy balance and network performance calculation.

Recommended prior knowledge:

Fluid dynamics, thermodynamic numerical methods.

Content of the subject: according to the existing material
Practically illustrate the knowledge acquired in the Fluid Mechanics course.

1. Flow measurement
2. viscosity
3. Center Of Thrust Study
4. Static Fluids
5. flow around an obstacle
6. Pulse of a jet
7. Pressure drops and velocity profiles
8. Study of the influence of the pressure field on a hydrodynamic bearing
9. Effect of the inclination of a plane pad on the pressure distribution

Assessment method:
Continuous Control: 100%.

Semester: 1
Teaching unit: TTU 1.1
Subject: Technical English and Terminology
SHV: 22h30 (course: 01h30)
Credits: 1
Coefficient: 1

Teaching objectives :

Introduce the student to technical vocabulary. Strengthen his knowledge of the language. Help him to understand and synthesize a technical document. Allow him to understand an English conversation held in a scientific setting.

Recommended prerequisites:

Basic vocabulary and grammar in English

Content of the subject:

- Written comprehension: Reading and analysis of texts related to the specialty.

- Oral comprehension: Using authentic scientific extension video documents, note taking, summary and presentation of the document.

- Oral expression: Presentation of a scientific or technical subject, development and exchange of oral messages (ideas and data), Telephone communication, Gestural expression.

- Written expression: Extraction of ideas from a scientific document, Writing a scientific message, Exchange of information in writing, CV writing, letters of applications for internships or jobs.

Recommendation: It is strongly recommended that the Subject Matter Lead present and explain at the end of each session (maximum) a dozen technical words of the specialty in all three languages (if possible) English, French and Arabic.

Evaluation method:

Examination: 100%.

III - Detailed program by subject of semester S2

Semester: 2
Teaching unit: FTU 1.2.1
Matter 2: Combustion
SHV: 45h00. (C: 1h30 ; T : 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Introducing students to the field of combustion, the student will learn to calculate the properties of gas mixtures, the calorific values of hydrocarbons as well as the adiabatic temperature of the flames. Also, notions of chemical equilibrium, chemical kinetics and the different types of flames will be taught.

.

Recommended prior knowledge:

Thermodynamics (first law and enthalpy, second law and entropy)

Content of matter:

Chapter 1: Reminders and Fundamentals of Combustion (3 weeks)

1.1 Types of fuels and combustibles: solid, liquid and gaseous, physical and chemical properties, octane number, cetane number.

1.2 Enthalpy of reaction and sensitive enthalpies

1.3 Gas mixtures, stoichiometry, richness and excess air coefficient

1.4 Combustion reactions

1.5 Calorific value: Calculation of LCV and HCV

Chapter 2: Thermochemistry (3 weeks)

2.1 Adiabatic flame temperature at constant volume and constant pressure

2.3 Calculating the temperature of a combustion chamber

2.4 Equilibrium constants and reaction rates

2.5 Combustion kinetics

Chapter 3: Reactive flow equations (2 weeks)

3.1 Conservation of mass, momentum, energy and chemical species

3.3 Chemical and thermal production terms

Chapter 4: Premixing and Diffusion Laminar Flames (3 weeks)

4.1 Definition of premix flames and examples of application

4.2 Structure and velocity of premixed flames

4.3 Theory and kinetics of premixed laminar flames

4.5 Definition of diffusion flames and examples of application

4.6 Structure of diffusion flames

4.7 Mathematical formulation for laminar flames

Chapter 5: Effects of Combustion on the Environment (2 weeks)

5.1 Role of combustion sources in air pollution

5.2 Nitrogen oxides: types, formation, thermal NO, early NO, NO from fuel, calculation of production rate

5.3 Carbon oxides: CO, CO_2

5.4 Unburnt hydrocarbons and soot

5.5 Polycyclic Aromatic Hydrocarbons

5.6 Some methods of controlling and reducing pollutants

Chapter 6: Turbulent Flames (2 weeks)

6.1 Self-ignition and propagation

6.2 Turbulent premix flames

6.3 Some models of premixed combustion

6.4 Turbulent diffusion flames

6.5 Some non-premixed combustion models

6.6 Combustion regimes and turbulent combustion diagrams

Evaluation mode:

Continuous Control: 40%, Exam: 60%.

Bibliographic references:

1. *Stephen Turns, An Introduction to Combustion: Concepts and Applications 3rd Edition ISBN-13: 978-0073380193*
2. *Kenneth Kuan-yunKuo, Principles of Combustion 2nd Edition ISBN-13: 978-0471046899*
3. *Warnatz J, Maas U, Dibble RW. Combustion. 3rd ed. Springer Berlin Heidelberg New York; 2006.*
4. *El Mahallawi F, El Din Habik S, Fundamentals and Technology of combustion, Elsevier 2002, ISBN- 0-08-044 108-8*

Semester: 2
Teaching unit: FTU 1.2.1
Matter 2: Gas dynamics
SHV: 45h00. (C: 1h30 ; T : 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Gas dynamics is a very vast field whose theoretical objective is the study of compressible flows at high speeds. These types of flows are most often encountered in the practical field of the aeronautical and space industry. This module deals only with the one-dimensional approach of compressible flows of ideal gases

Recommended prior knowledge:

Thermodynamics and fluid mechanics

Content of matter:

Chapter 1: Introduction to Gasodynamics (1 week)

1. Thermodynamic concepts and relationships
2. Isentropic relations of an ideal gas
3. Compressibility and propagation of sound waves
4. General expression of the speed of sound
5. Mach number and Mach waves
6. Subsonic, transonic, supersonic and hypersonic flows

Chapter 2: 1D Isentropic Flow in Variable Section Conduit (5 weeks)

1. Basic equations (continuity, momentum, energy)
2. General laws of isentropic flow: generating state and critical state
3. 1D flow in a variable section pipe and Hugoniot's theorem
4. Study of a flow in a nozzle: convergent and convergent-divergent
5. Overview of subsonic and supersonic diffusers

Chapter 3: Shockwaves (4 weeks)

I- Normal Shock Waves

1. Basic equations (continuity, momentum, energy) and Prandtl relation
2. Relations of the normal shock wave as a function of the Mach number
3. Borderline cases: weak shock waves, strong shock waves
4. The mobile normal shock wave
5. Pitot tube in supersonic

II. Oblique Shock Waves

1. Concept on oblique shock waves
2. Basic equations and Prandtl relation
3. Reflection of oblique waves

Chapter 4: 1D Non-Isentropic Flow in Constant Section Conduit (5 weeks)

I. Adiabatic flow with friction: Fanno flow
1. Fanno flow analysis and basic equations
2. Variation of flow characteristics as a function of Mach number
3. Coefficient of friction and variation of entropy
4. Shock wave in the Fanno flow
II. Flow without friction and with heat exchange: Rayleigh flow
1. Rayleigh flow analysis and basic equations
2. Variation of flow characteristics as a function of Mach number
3. Variation of entropy
III. Flow with friction and with heat exchange
Isothermal flow with friction

Evaluation mode:

Continuous Control: 40%, Exam: 60%.

Semester: 2
Course Unit: FTU 1.2.1
Material: Thermal drying
VHS: 10h30 (class: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

The purpose of the course is to present the theoretical principles of thermal drying, including mechanisms, mass and heat transfer equations, drying curves and diagrams of humid air. The techniques of thermal drying are linked to thermodynamic laws and to the principles of mass and heat transfer, which allows the student to apply his prerequisite knowledge to solve drying problems in the various sectors: agro-food, textiles, papers, building materials,…

Recommended prior knowledge:

Thermodynamics, Mass and Heat Transfer

Subject content:

Chapter 1: Reminders on moist air: Absolute humidity, relative humidity, dry bulb temperature, wet bulb temperature, dew point, enthalpy, mixing of moist air, diagram of moist air **(2 weeks)**

Chapter 2: Drying Theory: Drying Terminology, Mechanisms Occurring During Drying **(3 weeks**)

Chapter 3: Calculation principles for dryers: Method of determining the calculation parameters, Calculation and dimensioning of a conveyor belt dryer, Calculation and dimensioning of a pneumatic dryer, Calculation of a rotary dryer, Calculation of a fluidized bed **(5 weeks)**

Chapter 4: Drying apparatus and processes: Drying of solid products, Drying of pasty products, Drying of liquid products, Definition of a dryer, Auxiliary devices necessary for the operation of a dryer **(5 weeks)**

Assessment method: Exam: 100%.

Bibliographic references:

1. *Mujumdar A. S., Handbook of industrial drying, Marcel Dekker, New-York, 1987.*

2. *Nadeau J.-P., Puiggali J.-R., Séchage: des processus physiques aux procédés industriels, 307p., Tec et Doc, Paris, 1995.*
3. *Catherine BONAZZI, Jean-Jacques BIMBENET, Séchage des produits alimentaires-Principes, Techniques de l'ingénieur, f3000 , 2003*
4. *Catherine BONAZZI, Jean-Jacques BIMBENET, Séchage des produits alimentaires-Appareils et applications, Techniques de l'ingénieur, f3002, 2008*
5. *Jean VASSEUR , Séchage industriel: principes et calcul d'appareils- Autres modes de séchage que l'air chaud, partie 1, Techniques de l'ingénieur, Techniques de l'ingénieur, j2453, 2011*
6. *Jean VASSEUR , Séchage industriel : principes et calcul d'appareils- Séchage convectif par air chaud (partie 2), Techniques de l'ingénieur, j2452, 2010*
7. *André CHARREAU, Roland CAVAILLÉ , Séchage. Théorie et calculs, Techniques de l'ingénieur, j2480, 1995*

Semester: 2
Course Unit: UEF 1.2.2
Subject: Heating and air conditioning
VHS: 45h (class: 01h30, tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:
The content of this subject gives students the notions and tools necessary for the dimensioning of heating and air conditioning installations.

Recommended prior knowledge:
Thermodynamics, heat transfer, fluid mechanics

Material content:

Chapter 1. Reminder of thermodynamics and heat transfer **(1 week)**
- General notions of thermodynamics
- Heat transfer modes

Chapter 2: Thermal building **(2 weeks)**
- Algerian thermal regulations (DTR documents)
- Thermal needs
-Thermal insulation

Chapter 3: General principles of heating **(5 weeks)**
- Calculation of heat losses
- Heat generation
- Distribution and issuance

Chapter 4: General principles in air conditioning **(5 weeks)**
- Calculation of thermal inputs
- Air conditioning systems and distribution networks
- Humid air and h-x diagram
- Cold production

Chapter 5: System Control **(1 week)**
Chapter 6: Renewable Energy Equipment **(1 week)**

Assessment method: Continuous Assessment: 40%, Examination: 60%.

Bibliographic references:

1. Treatise on heating and air conditioning, H. Rietschel and W. Raiss, Dunod 1993
2. Heating practice, J. Bossard and J. Hrabovsky, Dunod 2014

Semester: 2
Teaching unit: FTU 1.2.2
Subject: Advanced Turbomachinery
Lecture hours: 45 (Class: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching Objectives:

To describe, based on the basic concepts of turbomachinery and fluid mechanics, the methods of design, analysis, and construction of turbomachinery to enable students to understand the flows that occur in turbomachinery and to develop basic elements for the design and selection of these machines.

Recommended Prerequisites:

Thermodynamics, Heat Transfer, Fluid Mechanics, Turbomachinery

Subject Contents:

Chapter 1. Overview of Turbomachinery, Classification, Similarity Concept, Dimensionless Numbers, and Velocity Triangles, Euler's Turbomachinery Equation (3 weeks)

Chapter 2. Aerodynamics of Blade Rows (3 weeks)

2.1 Aerodynamic Forces (Lift and Drag)

2.2 Correlations for the Design of Blade Rows (Solidity, Deflection, Deviation, etc.)

Chapter 3. 2D Flow in Turbomachinery (4 weeks)

3.1 Simplified Radial Equilibrium Equation

3.2 Theory of Actuator Disks

3.3 Blade-to-Blade Flow

3.4 Boundary Layers and Notion of Transition

Chapter 4. 3D Flow in Turbomachinery (3 weeks)

4.1 Governing Equations

4.2 CFD for Turbomachinery (Applications and Limits)

4.3 Unsteady Flow and Stator-Rotor Interaction

4.4 Cooling of Turbomachinery

4.5 Losses in Turbomachinery (Profile, Secondary Flow, Clearance, etc.)

4.6 Measurement Techniques in Turbomachinery

Chapter 5. Turbomachinery Construction (2 weeks)

5.1 Components of Turbomachinery: Bearings, Couplings, Gearboxes, Lubrication and Sealing Systems

5.2 Steam Turbine Construction: Nozzles, Blades, Stage Efficiency, Casing and Diaphragm, Rotor, Material, Balancing, Steam Admission Valves and Governors

5.3 Gas Turbines: Compressor, Combustion Chamber, Turbine, Fuels

5.4 Compressors: Centrifugal, Axial, Reciprocating, and Applications.

Mode of Assessment:

Continuous Control: 40%, Exam: 60%.

Bibliographic references:

1. S. L.DixonFluid Mechanics, Thermodynamics of Turbomachinery, 5th ed., Elsevier Butterworth-

2. Heineman, 2005.

3. H.I.H. Saravanamuttoo, G.F.C.Rogers, H. Cohen, and P.V. Straznicky, Gas Turbine Theory, 6th ed.,

4. Pearson Education, London, 2008.

5. B. Lakshminarayana, Fluid Dynamics and Heat Transfer of Turbomachinery, Wiley, New York, 1996.

6. J.C Han, S. Dutta, S. Ekkad, Gas Turbine Heat Transfer And Cooling Technology, Taylor & Francis 2000

Semester: 2
Teaching unit: MTU 1.2
Subject: Finite volume method
SHV: 45h00 (course: 01h30, PW : 01h30)
Credits: 4
Coefficient : 2

Teaching objectives:

- Master the discretization of PDEs by the finite volume method.

- Solve the equations discretized by calculation algorithms (SIMPE, SIMPLER…)

-Allow students to develop calculation codes in finite volumes.

Recommended prior knowledge:

In-depth numerical methods

Subject content :

Chapter 1: General information on computational fluid dynamics (CFD). **(1 week)**

Chapter 2: The finite volume method for diffusion problems. **(2 weeks)**

Chapter 3: The finite volume method for convection-diffusion problems. **(3 weeks)**

Chapter 4: Solution algorithms (SIMPLE, SIMPLER, PISO). **(3 weeks)**

Chapter 5: Solution of discrete algebraic equations. **(2 weeks)**

Chapter 6: The finite volume method for transient flows. **(2 weeks)**

Chapter 7: The volume method for convection-diffusion problems (ε-ω method). **(2 weeks)**

Assessment method:
Continuous assessment: 40%; Exam: 60%.

Semester : 2
Teaching unit: MTU 1.2
Matter : PW Turbomachine
SHV: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives :

Put into practice the basic notions (of turbomachines and fluid mechanics) the methods of design, analysis and construction of turbomachines to allow students to understand the flows that are established in turbomachines and to develop elements of basis for the design and selection of these machines.

Recommended prior knowledge :

Turbomachinery course.

Matter content :

Do some practical work on turbomachines depending on the available equipment, use of simulation software.

Evaluation mode :

Continuous assessment: 100%

Semester : 2
Teaching unit: MTU 1.2
Matter : Servo-control and regulation
SHV: 45h (Lesson: 1h30, PW: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives :

The objective is provide to students the basic principles of a servo-control system and measure, permanently, the gap between the real value of the quantity to be controlled and the set value to be reached, and to calculate the appropriate command to be applied to one (or several) actuator(s) in order to reduce this gap as quickly as possible.

Recommended prior knowledge :

Numerical methods, informatics, electricity....

Matter content :

Chapter 1: Study of the principles of linear controlled or servo-controlled systems (temperature control, climatization control, production lines control, etc.) **(2 weeks)**

Chapter 2: Systems Analysis: **(2 weeks)**

Chapter 3: Dynamic characteristics of a system **(2 weeks)**

Chapter 4: Open-loop and closed-loop control **(3 weeks)**

Chapter 5: Basic system of regulation s (PID,...) **(3 weeks)**

Chapter 6: Adaptive systems by learning **(3 weeks)**

Evaluation mode :

Continuous assessment: 40%; Exam: 60%.

References:

1. Cours d'automatique Tome 2, Asservissement régulation commande analogique, Jean-Louis Ferrier, Maurice Rivoire, Eyrolles

2. Automatique : régulations et asservissements, de Thierry Hans et Pierre Guyénot, 20 juin 2014.

3. Exercices d'automatique, tome 2 : Asservissement, régulation, commande analogique

4. de Maurice Rivoire et Jean-Louis Ferrier, Eyrolles

5. Asservissements et régulations continus. Volume 2, Analyse et synthèse, problèmes avec résolutions, de Collectif et Elisabeth Boillot, 1 janvier 2002

6. Régulation industrielle, Outils de modélisation, méthodes et architectures de commande, Ouvrage dirigé par : Emmanuel Godoy, Collection: Technique et Ingénierie, Dunod/L'Usine Nouvelle, 2014 - 2ème édition - 552 pages , EAN13 : 9782100717941

Semester: 2
Teaching unit: TTU 1.2
Subject: Ethics, deontology and intellectual property
SHV: 22h30 (course: 01h30)
Credits: 1
Coefficient : 1

Teaching objectives:

Develop student awareness of ethical principles. Introduce them to the rules that govern life at the university (their rights and obligations vis-à-vis the university community) and in the world of work. Make them aware of the respect and valuation of intellectual property. Explain to them the risks of moral evils such as corruption and how to combat them.

Recommended prior knowledge:

None

Subject content :

A- Ethics and deontology

I. Notions of Ethics and Deontology (3 weeks)

1. Introduction
   1. Definitions: Morality, ethics, deontology
   2. Distinction between ethics and deontology
2. Charter of ethics and professional conduct of the MHESR: Integrity and honesty. Academic freedom. Mutual respect. Requirement of scientific truth, objectivity and critical thinking. Equity. Rights and obligations of the student, teacher, administrative and technical staff.

3. Ethics and deontology in the world of work
   Legal confidentiality in business. Loyalty to the company. Responsibility within the company, Conflicts of interest. Integrity (corruption in work, its forms, its consequences, methods of fighting and sanctions against corruption)

II. Integrity and responsible research (3 weeks)

1. Respect for the principles of ethics in teaching and research
2. Responsibilities in teamwork: Professional equality of treatment. Conduct against discrimination. The search for the general interest. Inappropriate conduct in the context of collective work
3. Adopting responsible conduct and combating excesses: Adopting responsible conduct in research. Scientific fraud. Conduct against fraud. Plagiarism (definition of plagiarism, different forms of plagiarism, procedures to avoid unintentional plagiarism, detection of plagiarism, sanctions against plagiarists, etc.). Falsification and fabrication of data.

B- Intellectual property

I- Fundamentals of intellectual property (1 week)

1- Industrial property. Literary and artistic property
2- Rules for citing references (books, scientific articles, conference papers, theses, dissertations, etc.)

II- Copyright (5 weeks)

1. Copyright in the digital environment
Introduction. Database copyright, software copyright. Specific case of free software.

2. Copyright in the internet and electronic commerce
Domain name rights. Intellectual property on the internet. Law of the e-commerce site. Intellectual property and social networks.

3. Patent
Definition. Rights in a patent. Usefulness of a patent. Patentability. Patent application in Algeria and worldwide.

4. Trademarks, designs and models
Definition. Trademark Law. Design law. Denomination of origin. The secret. Counterfeit.

5. Geographical Indication Law
Definitions. Protection of Geographical Indications in Algeria. International Treaties on Geographical Indications.

III- Protection and enhancement of intellectual property (3 weeks)
How to protect intellectual property. Violation of rights and legal tool. Valuation of intellectual property. Protection of intellectual property in Algeria.

Assessment method:
Examination: 100%

IV - Detailed program by subject of semester S3

Semester: 3
Teaching unit: FTU 2.1.1
Matter : Advanced internal combustion engine
SHV: 67h30. (C: 3h00 ; T : 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

- Understand the physical and chemical processes taking place during combustion and transfer in internal combustion engines. Understand the reaction of a given engine when changing one of its parameters using modeling.
- Build a model of an internal combustion engine. Optimize the sizing and settings of an engine under efficiency, power and polluting emissions constraints using an engine model.

Recommended prior knowledge:

Thermodynamics and mathematics of L1 and L2.

Content of matter:

Chapter 01: New Techniques and Improved Engine Performance (2 weeks)

1-1 Undersizing
1-2 Variable distribution
1-3 Variable Compression Rate
1-4 Miller-Atkinson cycle
1-5 Stratified charge
1-6 HCCI concept
1-7 PCCI concept

Chapter 02: Gasoline Injection Techniques (2 weeks)

2-2 K-jetronic system
2-3 D-jetronic system
2-4 L-jetronic system

Chapter 03: Modeling combustion in engines (4 weeks)

3-1 Model an area
3-2 Two-zone model
3-3 Multi-zone model

Chapter 04: Formation of pollutants (2 weeks)

4-1 Carbon Monoxide
4-2 Unburned hydrocarbons
4-3 Formation of aromatics
4-4 Soot formation
4-5 Formation of NOx

Chapter 05: Supercharging of ICEs by turbocharger (2 weeks)

5-1 Maps (turbine, compressor, motor) and functional characteristics
5-2 Engine - turbocharger adaptation

Evaluation mode:

Continuous control: 40%; Exam: 60%.

Bibliographic references:

1. Heywood, J.B. Internal Combustion Engine Fundamentals. New York, NY, McGraw-Hill. Inc. 1983.

2. Ramos, J.I. Internal Combustion Engine Modeling. Hemisphere Publishing Corporation.

1989. P. 326-332.

3. Merker, G.P. et al Simulating of Combustion and pollutant formation for engine development. Springer, 2004.

4. Lakshminarayanan P. A, Aghav, Y.V. Modelling diesel combustion. Springer 2010.

5. Gestion moteur Essence et diesel "Diagnostique et réparation T1, T2 et T3. Editions ETAI

2007.

6. Parois A. Suralimentation des moteurs de véhicules par turbocompresseur.

7. Delanette M. Technique de l'automobile. editions techniques et normalisation. 1996.

Semester: 3
Teaching unit: FTU 2.1.1
Subject: Cryogenics
Total Hours: 45h (lectures: 01h30, tutorials: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Understand the operation of gas liquefaction processes;
Know how to calculate the energy balances and performance of the different liquefaction processes used;
Know how to determine the operating parameters of cryogenic fluids."

Recommended prior knowledge:
- Thermodynamics
- Energy conversion
- Fluid mechanics

Content of the subject:

Chapter 1: Review of the main processes for obtaining low temperatures (2 weeks)

1.1 Joule-Thomson expansion, Isentropic expansion, exhaust process ...
1.2 Concept of gas inversion temperature
1.3 Gas inversion curve (graph of (T, P))
1.4 Isenthalpic throttling coefficient
1.5 Isentropic throttling coefficient

Chapter 2: Gas Liquefaction Processes (4 weeks)

2.1 General information about gas liquefaction
2.1.1 Importance and use of liquefied gases
2.1.2 Historical experiments on gases
2.2 Liquefaction by Joule-Thomson expansion
2.2.1 Linde process
2.2.2 Linde process with prior cooling of the working gas
2.2.3 Linde process with double throttling

Chapter 3: Cryogenic cycles with gas expansion in expanders (2 weeks)

3.1 Gas expansion in expanders at the initial temperature level (at the compressor outlet)
3.2 Connection of the expander at the intermediate temperature level
3.3 Connection of the expander at the lower temperature level (evaporator outlet)

Chapter 4: Combined Cryogenic Cycles (2 weeks)

4.1 Combination of isenthalpic and isentropic expansion in the same process
4.2 Advantages of the combined cycle

Chapter 5: Study of Industrial Gas Liquefaction Facilities (4 weeks)

5.1 Liquefaction facilities for nitrogen and oxygen
5.2 Liquefaction processes for natural gas (LNG)
5.3 Liquefaction of hydrogen
5.4 Liquefaction of helium

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Bibliographic references

1. Pierre Petit : Séparation et liquéfaction des gaz. Technique de l’ingénieur. J3600 ;

2. Olivier Perrot : Cours des machines frigorifiques. I.U.T. de Saint Omer Dunkerque. Département Génie thermique et énergie. 2010 – 2011.

3. Cryogenic Engineering Second Edition Revised And Expanded Thomas M. Flynn Cryoco, Inc. Louisville, Colorado, U.S.A.2005.

Semester: 3
Teaching unit: FTU 2.1.2
Subject: Propulsion mechanics
Total Hours: 45h (lectures: 01h30, tutorials: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:
The main purpose of the course is to familiarize the student with the constructive elements, the operation and the energy calculation of thermal propulsion turbomachines (gas turbine, turbojet, rocket engine).

Recommended prior knowledge:

basic notions of thermodynamics and gas dynamics

Content of the subject:

Chapter 1 Propulsion principle

1 Planes

2 Principles

2.1 Principle of lift (How does an airplane fly?)

2.2 Principle of propulsion (How does an airplane move?)

Chapter 2 Principles and performance of jet engines

1 The thrust

2 Forms of energy in a jet engine

3 Powers

4 Yields

Chapter 3 Gas Turbine

1 Construction elements of a gas turbine

2 Principle of operation

3 Energy calculation of a gas turbine

Chapter 4 Aircraft Engine (Turbojet Engines)

1 Principle of operation of the turbojet engine

2 The constructive elements of the turbojet engine

3 The different types of the turbojet engine

4 Analysis and calculation of a single-flow turbojet

Chapter 5 Rocket Engine

1. Thrust and working principle
2. Launchers and Engines
3. Descriptive parameters of a motor
4. Basic relationships

Assessment method:

Continuous assessment: 40%; Exam: 60%.

Semester: 3
Teaching unit: FTU 2.1.2
Matter : Heat exchangers
SHV: 45h. (C: 1h30 ; T : 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Master the calculation of heat exchangers in permanent and variable regimes.

Recommended prior knowledge:

Heat transfers, thermodynamics, mechanical construction

Content of matter:

Introduction.

Chapter 1. Classification of Heat Exchangers.

Chapter 2. Methods of thermal calculation of heat exchangers

Chapter 3. Coefficient of convective exchange without phase change in exchangers heat.

Chapter 4. Coefficient of convective exchange in transfer with phase change.

Chapter 5. Global exchange coefficient and global conductance of an exchanger

Chapter 6. Performance and calculation of heat exchangers.

Chapter 7. Technology of heat exchangers.

Chapter 8. Optimization and Energy Integration of Heat Flows in Networks exchangers.

Evaluation mode:

Continuous Control: 40%, Exam: 60%.

Bibliographic references:

1. C. Bougriou, Calculs et technologie des échangeurs, Office des Publications Universitaires, 2010.
2. D.Q. Kern,Process heat transfer. McGraw-Hill : New York, 1984.
3. A.P. Frass, et M.N. Ozisik, Heat exchangers design, John Wiley, 1965.
4. V. Afgan, et E.U. Shlunder, Heat exchangers; Design and theory, McGraw-Hill: New York, 1974.
5. J.G. Vollier, Collier, Convective boiling and condensation heat transfer. McGraw-Hill: New York, 1981.
6. J. Padet, Echangeurs de chaleurs thermiques. . Méthodes globales de calcul avec 11

Problèmes résolus. Elsevier, 1994.
7. A. Bejan, Heat transfer, New-York.Wiley, 2003.
8. F. Incropera, Fundamentals of heat and mass transfer,7th edition New-York.Wiley,2011.

Semester: 3
Teaching unit: MTU 2.1
Matter : CFDs and software
SHV: 45h. (C: 1h30 ; T : 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The purpose of this subject is to familiarize the student with calculation and post-processing techniques and software. In a first chapter a general description of the problem is made based on the notions already acquired. From the second chapter each session will begin with a course of 1h or 1h30 which will introduce the concepts which will be identified. The second chapter introduces the post-processing software which is essential in the visualization of the results of calculations, in this chapter the results calculated beforehand can be used for learning. The third chapter introduces Ansys' Gambit and Mesh meshers. The student must learn the techniques of tracing the different geometries as well as the generation of the different types of meshes. The remaining chapters introduce the different types of flows encountered in practice, namely: external, internal and reactive, other types of flows can be addressed.

Recommended prior knowledge:

Fluid mechanics, Thermodynamics

Content of matter:

Chapter I: Reminders on the methods of finite differences and finite volumes **(1 week)**

1. Discrete form of the transport equation of the generalized variable.
2. Numerical schemes and pressure processing algorithms (Implicit, SIMPLE, PISO, etc.).
3. Treatment of source terms.
4. Resolution by scanning.
5. General flowchart of a program for solving transport equations.

Chapter 2: Post-processing software (integrated in the code or not) **(2 weeks)**

1. Curve and field plotter software: Origin, Tecplot, etc.
2. Applications on curve tracers.
3. Field plotter applications.

Chapter 3: Mesh Generators **(2 weeks)**

1. The Gambit mesher: Plotting the geometry, mesh and boundary conditions.
2. The Ansys mesh generator: Tracing of geometry, mesh and boundary conditions.
3. Treatment of the mesh close to the walls: Case of laminar and turbulent flows.

Chapter 4: External flows (Resolution by Computer code: Fluent, CFX...) **(3 weeks)**

1. Definitions and cases of application.
2. Flow over a flat plate (boundary layer).
3. Flow around a dawn.
4. Flow around a cylinder (stationary and unsteady).

Chapter 5: Internal flows (Resolution by calculation code) **(3 weeks)**

1. Definitions and cases of application.
2. Flow in a pipe.
3. Convection in a pipe: Laminar (Nusselt's problem) and turbulent.
4. Compressible flow in a convergent-divergent nozzle.

Chapter 6: Reactive flows (Resolution by Fluent, CFX....) **(4 weeks)**

1. Definitions and cases of application in the field of combustion.
2. Turbulent free-jet diffusion flames (Methane-air, hydrogen-air, etc.).
3. Turbulent co-flow diffusion flames in a combustion chamber (Methane-air, hydrogen-air, etc.).
4. Flames of premixes.

Assessment method: Continuous assessment: 40%; Exam: 60%.

Semester: 3
Teaching unit: MTU 2.1
Subject: Optimization
SHV: 37h30 (course: 01h30, PW:1h)
Credits: 3
Coefficient: 2

Teaching objectives:
Become familiar with operational research models. Learn to formulate and solve optimization problems and master the appropriate techniques and algorithms.

Recommended prior knowledge:
Basic notions of mathematics. Linear algebra. Matrix algebra.

Subject content :

Chapter I: Linear Optimization **(3 weeks)**
- General formulation of a linear program
- Examples of linear programs (Production problem, Mixing problem, Cutting problem, Transport problem)
- Resolution of the problem by the Simplex method:
  - Basics and basic solutions of linear programs
  - The simplex algorithm
  - Initialization of the simplex algorithm (the two-phase method).

Chapter II: Non-linear optimization without constraints **(5 weeks)**
- Positivity, Convexity, Minimum
- Gradient and Hessian
- Necessary conditions for a minimum
- Sufficient conditions for a minimum
- Local methods
- One-dimensional research methods
- Gradient methods
- Methods of conjugate directions
- Newton's method
- Quasi-Newton methods

Chapter III: Non-linear optimization with constraints **(4 weeks)**
- Lagrange multipliers
- Karush-Kuhn-Tucker terms
- Penalty method
- Sequential quadratic programming

Chapter IV: Stochastic optimization methods **(3 weeks)**
- The genetic algorithm
- The particle swarm method

Organization of the practicals: it is preferable that the practicals are direct applications in the field of mechanical construction.

Practical work 1: presentation of optimization reference functions in Matlab
Practical work 2: Presentation of the optimization tool optimtool in matlab
Practical work 3: Definition and plotting of the curves of some test functions in optimization
Practical work 4: Solving a linear optimization problem without constraints
Practical work 5: Solving a linear optimization problem with constraints
Practical work 6: Nonlinear minimization without constraints
Practical work 7: Nonlinear minimization without constraints with gradient and Hessian
Practical work 8: Nonlinear minimization with equality constraints
Practical work 9: Nonlinear minimization with inequality constraints
Practical work 10: Minimization with equality and inequality constraints
Practical work 11: Use of the optimtool or other tool to solve a nonlinear optimization problem with constraints
Practical work 12: Minimization with constraints using the GA function

Assessment method: Continuous assessment: 40%; Exam: 60%.

Semester: 3
Teaching unit: MTU 2.1
Matter : PW Heat exchangers
SHV: 22h30. (PW : 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:

Apply the knowledge acquired during the course and tutorials of the subject Heat exchangers on some types of exchangers. Verification of the results of the manual calculation and that of the test bench

Recommended prior knowledge:

Mastery of the knowledge acquired during the course, mastery of the computer tool

Content of matter:

Familiarity with the equipment available in the laboratory

TP 1. Twin-tube heat exchangers

TP 2. Tubular heat exchanger

TP 3. Plate heat exchanger

TP 4. Introduction to commercial software

Evaluation mode:

Continuous Control: 100%.

Bibliographic references:

Brochures available at the laboratory level.

Semester: 3
Teaching unit: TTU 1.3
Matter : Documentary research and master's thesis design
SHV: 22h30. (C : 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

Give the student the necessary tools to find useful information to better use it in his graduation project. Help him through the different steps leading to the writing of a scientific document. Make him aware of the importance of communication and teach him to present the work carried out in a rigorous and educational manner.

Recommended prior knowledge:

Writing methodology, Presentation methodology.

Content of matter:

Part I-: Documentary research:

Chapter I-1: Definition of the subject (02 Weeks)

- Subject title
- List of keywords concerning the subject
- Gather basic information (acquisition of specialized vocabulary, meaning of terms, linguistic definition)
- The information sought
- Take stock of your knowledge in the field

Chapter I-2: Selecting sources of information (02 weeks)

- Type of documents (Books, Theses, Dissertations, Periodical articles, Conference proceedings, Audiovisual documents, etc.)
- Type of resources (Libraries, Internet…)
- Assess the quality and relevance of information sources

Chapter I-3: Locating documents (01 Week)

- Research techniques
- Search operators

Chapter I-4: Processing information **(02 weeks)**

-Work organization

- The starting questions

- Summary of selected documents

- Links between different parties

- Final plan of the documentary research

Chapter I-5: Presentation of the bibliography **(01 Week)**

- The systems for presenting a bibliography (The Harvard system, The Vancouver system, The mixed system, etc.)

- Presentation of documents.

- Citation of sources

Part II: Thesis Design

Chapter II-1: Dissertation plan and stages **(02 weeks)**

- Identify and delimit the subject (Summary)

- Issues and objectives of the dissertation

- The other useful sections (Acknowledgements, Table of abbreviations, etc.)

- The introduction (Writing the introduction last)

- State of the specialized literature

- Formulation of hypotheses

-Methodology

-Results

-Discussion

- Recommendations

-Conclusion and perspectives

-Table of contents

-The bibliography

-Annexes

Chapter II- 2: Writing techniques and standards **(02 weeks)**

-Formatting. Numbering of chapters, figures and tables.

-Cover Page

- Typography and punctuation

-Writing. Scientific language: style, grammar, syntax.

- Spelling. Improved general linguistic competence in terms of comprehension and expression.

- Save, secure, archive your data.

Chapter II-3: Workshop: Critical study of a manuscript **(01 week)**

Chapter II-4: Oral presentations and defenses **(01 Week)**

- How to present a Poster

- How to present an oral communication.

- Defense of a dissertation

Chapter II-5: How to avoid plagiarism? **(01 Week)**

(Formulas, sentences, illustrations, graphs, data, statistics,...)

-The quote

- The paraphrase

- Indicate the complete bibliographic reference

Evaluation mode:

Continuous Control: 100%.