People's Democratic Republic of Algeria

Ministry of Higher Education and Scientific Research

National Pedagogical Committee for the Science and Technology sector

ACADEMIC MASTER'S HARMONIZE

National Programme

Updated 2025

Field	Discipline	Speciality
Science And Technologies	***Mechanical Engineering***	***Energy***

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مواءمة

برنامج وطني

تحيين2025

Field	Discipline	Speciality
Science And Technologies	***Mechanical Engineering***	***Energy***

I–Master's Program Fact Sheet

Access conditions

(Indicate the Bachelor's degree specializations that can grant access to the Master's program)

Sector	harmonized master	Licenses granting access at the master's	Ranking based on license compatibility	Coefficient assigned to the license
Mechanical Engineering	**Energy**	Energy	**1**	**1.00**
		Aeronautics	**2**	**0.80**
		Mechanical engineering	**2**	**0.80**
		Process Engineering	**3**	**0.70**
		Other ST licenses	**4**	**0.60**

II – Semester course organization sheets of the specialty

Semester 1

Teaching unit	Subjects / Titled	Credits	Coefficient	Weekly hours: Course	Weekly hours: Tutorial	Weekly hours: Practical	Semester Hours (15 weeks)	Additional Work Consultation (15 weeks)	Evaluation method: Continuous Assessment	Evaluation method: Exam
Fundamental EU Code: UEF 1.1.1 Credits: 8 Coefficients: 4	Advanced Fluid Mechanics	4	2	1h30m	1h30m		45h00	55h00	40%	60%
	Thermal machines	4	2	1h30m	1h30m		45h00	55h00	40%	60%
Fundamental EU Code: UEF 1.1.2 Credits: 10 Coefficients: 5	In-depth heat and mass transfer	6	3	3h00	1h30m		67h30	82h30	40%	60%
	Advanced numerical methods	4	2	1h30m	1h30m		45h00	55h00	40%	60%
Methodological Unit Code: UEM 1.1 Credits: 11 Coefficients: 7	Instrumentation and measurements	4	2	1h30m		1h30m	45h00	55h00	40%	60%
	Numerical Methods Lab	2	1			1h30m	10h30m	27h30	100%	
	Thermal machinery practical work	2	1			1h30m	10h30m	27h30	100%	
	TP MDF	1	1			1h30m	3h00	10:00	100%	
	Advanced Python Programming	2	2	1h30m		1h30m	45h00	55h00	40%	60%
EU Discovery Code: UED 1.1 Credits: 1 Coefficients: 1	Elective subject	1	1	1h30m			10h30m	02h30		100%
Total semester 1		**30**	**17**	**12:00**	**6:00**	**7:30**	**382h30**			

Semester 2

Teaching unit	Subjects / Titled	Credits	Coefficient	Weekly hours: Course	Weekly hours: Tutorial	Weekly hours: Practical	Semester Hours (15 weeks)	Additional Work Consultation (15 weeks)	Evaluation method: Continuous Assessment	Evaluation method: Exam
Fundamental EU Code: UEF 1.2.1 Credits: 10 Coefficients: 5	Combustion	4	2	1h30m	1h30m		45h00	55h00	40%	60%
	Gas dynamics	4	2	1h30m	1h30m		45h00	55h00	40%	60%
	Thermal Drying	2	1	1h30m	1h30m		10h30m	27h30		100%
Fundamental EU Code: UEF 1.2.2 Credits: 8 Coefficients: 4	Heating and air conditioning	4	2	1h30m	1h30m		45h00		40%	60%
	Advanced Turbomachinery	4	2	1h30m	1h30m		45h00	55h00	40%	60%
Methodological Unit Code: UEM 1.2 Credits: 9 Coefficients: 5	Finite volume methods	6	3	1h30m		3:00	67h30	h30	40%	60%
	Servomechanisms and Regulation	3	2	1h30m		1h30m	37h30	37h30	40%	60%
EU Transversal Code: UET 1.2 Credits: 3 Coefficients: 3	Adherence to ethical standards and rules of integrity	1	1	1h30m			10h30m	02h30		100%
	Elements of Applied AI	2	2	1h30m	1 hour 30 minutes		45h00	5h00	40%	60%
Total semester 2		**30**	**17**	**1:30 PM**	**6:00**	**6:00**	**382h30**			

Semester 3

Teaching unit	Subjects	Credits	Coefficient	Weekly hours			Semester Hours (15 weeks)	Additional Work Consultation (15 weeks)	Evaluation method	
	Titled			**Course**	**Tutorial**	**Practical**			**Continuous Assessment**	**Exam**
Fundamental EU Code: UEF 2.1.1 Credits: 8 Coefficients: 4	Advanced Internal Combustion Engines	4	2	1h30m	1h30m		45h00	55h00	40%	60%
	Cryogenics	4	2	1h30m	1h30m		45h00	55h00	40%	60%
Fundamental EU Code: UEF 2.1.2 Credits: 10 Coefficients: 5	Propulsion mechanics	6	3	1h30m	1h30m		67h30	82h30	40%	60%
	Heat exchangers	4	2	1h30m	1h30m		45h00	55h00	40%	60%
Methodological Unit Code: UEM 2.1 Credits: 9 Coefficients: 5	CFDs and software	4	2			3h00	45h00	55h00	100%	
	Optimization	3	2	1h30m		1h30m	37h30	37h30	40%	60%
	TP Heat Exchangers	2	1	1h30m		1h30m	10h30	27h30	100%	
EU Transversal Code: UET 2.1 Credits: 3 Coefficients: 3	Reserve engineering	2	2	1h30m	1 hour 30 minutes Workshop		45h00	5h00	40%	60%
	Documentary research and dissertation design	1	1	1h30m			10:30 PM	2h30		100%
Total semester 3		**30**	**17**	**12:00**	**6:00**	**7:30**	**382h30**			

Discovery Unit (Semes 1, 2 and 3)

1- *Energy transport and storage*
2- *Applied Electronics*
3- *Applied Electrotechnics*
4- *Energy audit*
5- *Renewable energies*
6- *Maintenance andIndustrial safety*
7- *Hygiene and safety*
8- *Aeronautics*
9- *Transportation*
10- *Reliability*
11- *quality management*
12- *Collaborative Design*
13- *Theory for solving innovation problems: the "TRIZ Method"*
14- *Hydraulic and pneumatic systems and devices*

Semester 4

This semester is dedicated to the completion of the final master's project. It is carried out in a company or in a research laboratory (university or research center). It culminates in a dissertation and an oral defense.

	VHS	Coeff	Credits
Personal Work	550	09	18
Company internshipor in a laboratory	100	04	06
Seminars	50	02	03
Other (Framework)	50	02	03
Total Semester 4	750	17	30

This table is provided for informational purposes only.

Evaluation of the Master's Final Year Project

- Scientific value (Jury's assessment) /6
- Dissertation Writing (Jury Assessment) /4
- Presentation and answering questions (Jury's assessment) /4
- Supervisor's assessment /3
- Presentation of the internship report (Jury's assessment) /3

III - Detailed program by subject for semester S1

Semester 1
Teaching Unit: UEF 1.1.1
Subject: Advanced Fluid Mechanics
VHS: 45 h00 (course: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:
The aim of this course is to develop the student's foundational knowledge. The energy specialization is closely linked to the phenomenology of viscous and turbulent flows observed in energy systems; understanding and analyzing these flows is essential. A thorough understanding of the physical and mathematical laws and models governing these often complex flows is fundamental to the specialization and provides the necessary solid foundation for research.

Recommended prior knowledge:

Fundamentals of Fluid Mechanics, Fundamentals of Mathematics.

Content of the material:
Chapter 1: Introduction **(1 week)**
Fundamental principles and theorems of fluid statics and kinematics. Concept of potential flows.

Chapter 2: Dynamics of viscous flows **(6 weeks)**
Viscous fluids. Description of viscous friction. Strain rate and stress tensors and their relationship. Navier-Stokes equation. Applications to laminar flows (Poiseuille, Couette).

Chapter 3 Applications of the Navier-Stokes equations **(2 weeks)**
Limiting cases of viscosity. Low Reynolds number flow: Hydrodynamic lubrication, long movement of a sphere, long movement of a cylinder.

Chapter 4 Laminar boundary layers **(6 weeks)**
Equations of linear linear motion (LLM). Characteristic parameters of LLM (displacement and momentum thicknesses, shape factor). Exact solutions of LLM (case of a flat plate). Von-Karman integral equation. Analysis of LLM using the Karman-Pohlhausen method. Stability of LLM.

Chapter 5 Concepts of turbulent flows **(1 week)**
Fluctuations in the velocity vector. Mean motion. Turbulence modeling. Turbulence models.

Evaluation method:
Continuous Control:40%,Exam :60%.

Bibliographical references:

1- *Inge L. Ryhming, Fluid Dynamics, Presses Polytechniques et Universitaires Romandes.*
2- *P. Chassaing, Turbulence in Fluid Mechanics, CEPADUES– Editions*
3- *R. Comolet, Experimental Fluid Mechanics, Volume II, Dynamics of Real Fluids, Turbomachinery, Masson Editions, 1982.*
4- *TC Papanastasiou, GC Georgiou and AN Alexandrou, Viscous fluid flow, CRC Press LLC, 2000.*

5- *Adil Ridha, Course on Dynamics of Real Fluids, M1 Mathematics and Applications: Mechanics specialization, University of Caen, 2009.*
6- *RW Fox, AT Mc Donald and PJ Pritchard, Introduction to fluid mechanics, sixth edition, Wiley and sons editor, 2003*
7- *Hermann Schlichting, Boundary layer theory, McGraw Hill book Company.*
8- *WP Graebel, Advanced fluid mechanics, Academic Press 2007.*

Semester 1
Teaching unit: UEF 1.1.1
Subject: Thermal machines
VHS: 45 hours (course: 1h30, tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:
This course contributes to the acquisition of essential knowledge for Master's students in energy. Students will gain the fundamentals to understand and analyze the operation of different types of thermal machines.

Recommended prior knowledge:
Thermodynamics

Content of the material:

Chapter 1: Review of Technical Thermodynamics (2 weeks)
- Concepts of state variables, equations of state for ideal gases
- First law of thermodynamics
- Second law of thermodynamics

Chapter 2: Receiver Cycle Machines (3 weeks)
- Compressors (reciprocating compressors: single-stage and multi-stage compression, efficiencies)
- Refrigeration machines
- Heat pump

Chapter 3: Ideal Cycles of Internal Combustion Engines (2 weeks)
- Spark-ignition cycle
- Diesel Cycle
- Mixed cycle

Chapter 4: Gas Turbine and Turbojet (3 weeks)
- Basic cycle,
- Other cycles,
- Performance criteria and returns

Chapter 5:Steam turbine (3 weeks)
- Rankine cycle without and with overheating
- Hirn's Cycle
- Draw-off cycles

Chapter 6:Other types of engines (2 weeks)
- Stirling engines
- Ericsson motor
- Compressed air engine

Evaluation method:
Continuous control:40%,Exam :60%.

Bibliographical references:

1. *Technical Thermodynamics, volumes 1, 2 and 3, Maurice Bailly- Bordas Paris – Montreal 1971.*
2. *Thermal machines,EmilianKoller, technical and engineering collection Dunod, 2005.*
3. *Thermodynamics of fluid systems and thermal machines: Principles, models and applications, FOHR Jean-Paul, Lavoisier 2010.*

Semester 1
Teaching unit: UEF1.1.2
Subject: In-depth heat and mass transfer
VHS: 67h00 (course: 3h00, Tutorial: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

- Master the basic concepts of the three modes of heat transfer;
- Knowing how to write a balance sheet and construct a basic model.

Recommended prior knowledge:

- Training in mathematics and physics or mechanics;
- Knowledge of applied thermodynamics.

Content of the material:

Chapter 1: Thermal Conduction (4 weeks)

1. Two-dimensional heat conduction in steady state, Analytical methods, Method of separation of variables, Conduction shape factor. Graphical method, Numerical methods (finite differences).
2. Heat conduction in transient regime: Lumped Capacitance Model (LCM Method), Domain of validity.
   One-dimensional transient solutions: Use Fourier analysis and Laplace transform.

Chapter 2: Heat Convection (5 weeks)

1. Natural convection:
   Natural convection on a vertical flat plate. Physical mechanisms, boundary layer equations in laminar flow, similarity study, transition to turbulent flow. Natural convection in a rectangular cavity.
2. Forced convection:
   Hydrodynamic and thermal boundary layers, Integral methods. Convection equations, Modeling a convection problem.
   Solutions to some convection problems. Forced convection in a cylinder.
3. Heat transfer during phase changes:
   Boiling of pure substances. Main physical quantities involved in boiling. Boiling in a vessel and convective boiling. Boiling regimes. Evaluation of the heat transfer coefficient and inherent errors.
   Types of condensation. Condensation in droplets and film condensation. Film condensation on a vertical flat plate and on a horizontal cylinder, Nusselt's theory. Liquid film flow regimes. Practical application of correlations.

Chapter 3: Heat Transfer by Radiation (3 weeks)

1. Beer's Law. Radiative properties of gases (Semi-Transparent Media STM). Radiative properties of particles. Establishment of the Radiative Transfer Equation (RTE).
2. Some approximate solutions to the simplified ETR.

Chapter 4: Mass Transfer (3 weeks)

1. Mass transfer by diffusion: Mechanisms of mass diffusion. Composition of the mixture. Fick's law, Mass diffusivity.

2. Convective mass transfer: Mass boundary layer. Convective mass flux. Dimensionless numbers and thicknesses of boundary layers (mass, hydrodynamic, thermal). Conjugate heat and mass transfer.

Evaluation method:
Continuous control:40%,Exam :60%.

Bibliographical references:

1. *HS Carslaw, Introduction to the mathematical theory of the conduction of heat in solids, Mc Millan and Co ed., 1921, 2nd edition.*
2. *HS Carslaw and JC Jaeger, Conduction of heat in solids, 2nd edition, Clarendon press ed., 1959.*
3. *Latif Jiji, Heat Conduction, Jaico Publishing House, 2003.*
4. *Ozisik, M.N., 1980, Conduction Heat Transfer, John Wiley and Sons, New York.*
5. *Gebhart, Heat transfer, McGraw Hill editor, 1971*

A. *B. De Vriendt, The transmission of heat, Volume 2, Introduction to thermal radiation, Gaetan Morin, 1983.*

6. *Bejan, AD Kraus, Heat transfer handbook, John Wiley Editor, 2003.*
7. *Vedat S. Arpaci, Conduction Heat transfer, 1966 by Addison-Wesley publishing.*
8. *R. Ghez, A Primer of Diffusion, John Wiley and Sons Editor, 1988, 2nd edition.*
9. *Chandrasekhar, radiative transfer, Dover publication, 1960.*
10. *MF Modest, Radiative heat transfer, Academic Press, 3rd edition, 2012*
11. *M. Quinn Brewster, Thermal radiative transfer and properties, Wiley Inter-science Publication, 1992*
12. *Hottel, H. C, and A. F. Sarofim, Radiative Transfer, McGraw-Hill, New York, 1967*
13. *R. Siegel and JR Howell, Thermal Radiation Heat Transfer, 5th Edition, Ed. Taylor and Francis, 2010.*
14. *M. NecatiOsizik, Radiative transfer and interactions with conduction and convection, Ed. J. Wiley and Sons*
15. *RB Bird, WE Stewart, EN Lightfoot, Transport phenomena, Wiley editor, 1960.*
16. *Rjucsh K. Kundu, IM Cohen, Fluid Mechanics, 2nd Edition, Academic Press, 2002.*
17. *DP Kesseler and RA Greenkorn, Momentum, Heat, and Mass transfer: Fundamentals, M. Dekker, 1999.*
18. *Kreith, F.; Boehm, RF et al., Heat and Mass Transfer, Mechanical Engineering Handbook Ed. Frank Kreith, CRC Press LLC, 1999.*
19. *HD Baehr and K. Stephan, Heat and Mass transfer, 2nd revised edition, Springer Verlag editor, 2006.*
20. Yunus A. Çengel, Afshin J. Ghajar:Heat and Mass Transfer, Fundamentals and Applications, McGraw-Hill, 2015.
21. Frank P. Incropera, David P. Dewitt, Theodore L. Bergman, Adrienne S. Lavine: fundamentals of heat and mass transfer, John Wiley and Sons, 2006.

Semester 1
Teaching unit: UEF 1.1.2
Subject: Advanced numerical methods
VHS: 45 hours (course: 1h30, tutorial: 1h30)
Credits: 4
Semester 2

Teaching objectives:
Learn new numerical techniques to solve the various equations arising in energy (fluid mechanics, heat transfer, etc.). Emphasis will be placed on solving differential and partial differential equations.

Recommended prior knowledge:
It is recommended to master numerical, mathematical analysis (PDE).

Content of the material:
Chapter 1: **Concepts of partial differential equations** **(1 week)**
Concepts of modeling. Classification of PDEs. Linear and nonlinear PDEs. Different types of boundary conditions.

Chapter 2: **Analytical methods** **(2 weeks)**
Principle of superposition. Method of separation of variables. Application to the diffusion equation with Dirichlet condition, to the Laplace equation in Cartesian coordinates and to the wave equation.

Chapter 3 Finite difference methods **(6 weeks)**
Introduction to numerical methods. Principle of the MDF. Discretization schemes. Stability, consistency, and convergence. Discretization methods (explicit, implicit, Crank-Nicholson). Application to the diffusion equation. Matrix formulation. Boundary conditions of the second type. Nonlinear equations. Multidimensional problems.

Chapter 4 Laplace's equation **(5 weeks)**
5-point formulation. Variable Dirichlet conditions. Solution methods. Neumann condition. Poisson equation. 9-point formation. Non-rectangular domain. Nonlinear equations and three-dimensional problems.

Chapter 5 Wave equation **(1 week)**
Discretization and stability. Different discretization schemes (Euler, Upwind, Lax, Leapfrog). Solution methods.

Evaluation method:
Continuous Control:40%,Exam :60%.

Bibliographical references:

1. *F. Jedrzejewski, Introduction to Numerical Methods, Second Edition, Springer-Verlag, France, Paris 2005.*
2. *WH Press, S. Teukolsky, WT Vetterling, BP Flannery, Numerical recipes in FORTRAN, Cambridge University press, 1995.*
3. *B. Carnahan, HA Luther and JO Wilkes, Applied numerical methods, R. Kriegerpublisher, 1990.*
4. *FS 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 and Gourdin, Numerical Methods, OPU, 1980.*
7. *JD Faires and RL 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. *MN Ozisik, "Finite Difference Methods in Heat Transfer"; Mechanical and Aerospace Engineering Department North Carolina State University*
11. *HK Versteeget W. Malalasekera, An introduction to computational fluid dynamics. The Finite volume method, Longman scientific & technical, London, 1995.*
12. *Zienkiewic, Numerical methods in heat transfer, McGraw Hill editor, 1988.*
13. *JC Tannehill, DA Anderson and RH Plercher, Computational Fluid Mechanics and Heat Transfer, second edition, Taylor and Francis editor, 1997.*
14. *H. Lomax, TH Pulliam and David W. Zingg, Fundamentals of Computational FluidDynamics, 1999*
15. *SV Patankar, Numerical heat transfer and fluid flow, McGrawHill, Hemisphere, Washington, DC, 1980.*
16. *HK Versteeget W. Malalasekera, An introduction to computational fluid dynamics. The Finite volume method, Longman scientific & technical, London, 1995.*

Semester 1
Teaching Unit: UEM 1.1
Subject: Instrumentation and measurements
VHS: 45h (course: 1h30, practical: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The student will learn the principles of Instrumentation and Regulation (Metrology, Process Control, Physical Quantities, Passive, Active, Integrated Sensors, Characteristics, Transmitter and Standards and Functional Diagram).
Practical exercises (depending on the technical capabilities of the institution)

Recommended prior knowledge:

General mechanics, electricity,Basic elements of electronics.

Content of the material:

Chapter 1: Introduction **(1 week)**

Chapter 2 Methods and techniques of measurement in thermal engineering **(4 weeks)**
- Temperature measurement
- Pressure measurement
- Flow measurement

Chapter 3 Calibration **(3 weeks)**
- Calibration of a thermocouple
- Calibration of a pressure sensor
- Calibration of a flow meter

Chapter 4 Data processing **(3 weeks)**
- Concept of a random variable
- Data acquisition system
- Calculation of errors and uncertainties
- Descriptive statistics

Chapter 5: Introduction to experimental designs **(4 weeks)**
- Terminology
- Study of a case (Complete Factorial Plan)

Evaluation method:

Continuous control:40%,Exam :60%.

Bibliographical 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. RJ Goldstein, "Fluid Mechanics Measurements", 1983.

Semester 1
Teaching Unit: UEM 1.1
Subject: TPM digital methods
VHS: 10h30 (practical: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:
The student will acquire the necessary skills to numerically model physical phenomena in the field of energy. The modeling is based on numerical discretization methods aimed at a better understanding of fluid flow phenomena coupled with heat and mass transfer.

Recommended prior knowledge:
Numerical methods course, numerical analysis, programming.

Content of the material:

1. **Analytical resolution** **(3 weeks)**
   - 1D Heat Equation
   - 2D Laplace Equation
2. **Numerical solution of the Poisson equation** **(4 weeks)**
   - Explicit diagram
   - Implicit scheme
   - Crank-Nicholson scheme
3. **Numerical solution of the Laplace equation** **(4 weeks)**
   - Dirichlet Conditions
   - Neumann conditions
4. **Numerical solution of the wave propagation equation** **(4 weeks)**

Evaluation method:
Continuous Control: 100%.

Bibliographical references:

1. *John D. Anderson, JR. Computational Fluid Dynamics the Basics With Applications, (1995).*
2. *T.CebeciJ.RShao F. Kafyeke E. Laurendeau. Computational Fluid Dynamics for Engineers. (2000).*
3. *Suhas V Patankar. Numerical Heat Transfer and Fluid Flow. (1980).*
4. *Ferziger&Peric. Computational Methods for Fluid Dynamics.*
5. *Randall J. Leveque. Finite Volume Methods for Hyperbolic Problems,*
6. *E.Toro. Riemann solvers and numerical methods for fluid dynamics, Springer, Berlin (1999).*
7. *https://www-n.oca.eu/pichon/IDRIS_Fortran_cours.pdf*
8. *http://www.idris.fr/formations/mpi/*
9. *Fluent 5.4.8 Copyright 1999 Fluent Inc.*

Semester 1
Teaching Unit: UEM 1.1
Subject: practical thermal machine
VHS: 10h30 (practical: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:
Students will acquire the fundamentals to understand and practically analyze the operation of different types of heat engines.

Recommended prior knowledge:
MDF, thermodynamics, heat engines.

Content of the material: depending on the existing equipment.

1. Hydraulic turbines and pumps;
2. Steam turbine and thermal power plant;
3. Gas turbine and turboshaft engines;
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.

Evaluation method:
Continuous Control: 100%.

Bibliographical references:

Semester 1
Teaching Unit: UEM 1.1
Subject: TP MDF
VHS: 3h00 (practical: 1h00)
Credits: 1
Coefficient: 1

Teaching objectives:

The Fluid Mechanics Practical Module plays a fundamental and active role in enabling students to acquire cognitive understanding and empirical knowledge in the field of fluid mechanics. This module is conducted as a series of experiments designed to help students better understand the fluid mechanics concepts they have studied theoretically during the previous semester and to consolidate the theoretical knowledge acquired in the fluid mechanics course.

Recommended prior knowledge:

Course in fluid mechanics and thermodynamics.

Content of the material:depending on the existing equipment

To practically illustrate the knowledge acquired in the Fluid Mechanics course.

Practical Exercise No. 1: Flow meters in pressurized flows (The venturi & the diaphragm);
Practical Exercise No. 2: Flow through an orifice;
Practical Exercise No. 3: Experimenting with the impact of a water jet on different obstacles;
Practical Exercise No. 4: Reynolds experiment: laminar and turbulent flows;
Practical Exercise No. 5: Flow around an obstacle;
Practical Exercise No. 6: Measurements of singular pressure losses in a pipe and velocity profiles.
Other practical exercises to be proposed depending on the available equipment.

Evaluation method:

Continuous Control: 100%.

Bibliographical references:

1. *Existing books and handouts at the teaching and research laboratories (Thermal Laboratory, MDF Laboratory, Aerodynamics Laboratory, Department Research Laboratory) and department libraries.*
2. *http://www.tecquipment.com/Thermodynamics/Heat_Transfer.aspx?page=1*
3. *http://www.deltalab-smt.com/teaching-energetics/heat-exchanges*
4. *Websites.*

Semester 1
Teaching Unit: UED 1.1
Subject: Elective subject
VHS: 10h30 (course: 1 h 30)
Credits: 1
Coefficient: 1

Semester: S1
Teaching Unit: UET 1.1.1
Subject: Advanced Python Programming
VHS: 45h00 (course 1h30, Practical 1h30)
Credits: 2
Coefficient: 2

Objectives of the subject:
Skills targeted:
- Use of computer tools for the acquisition, processing, production and dissemination of information
- Skills in Python and project management,
- Skills in automation and data visualization.

Goals :
- To deepen mastery of the Python language and introduce students to the basics of data analysis and artificial intelligence.
- Acquire a solid foundation in computer science.
- Learn to program in Python, Excel
- Mastering task automation
- Mastering project management software

Materials needed:
- A computer with Python installed,
- Python libraries: NumPy, Pandas, Scikit-learn, Matplotlib, os.listdir, os.path.exists, os.mkdir, os.rmdir, Matplotlib, Seaborn, Plitly, Request, Beautiful Soup, Tkinter, PyQT, …
- Tensorflow, PyTorch.

Prerequisites: Python programming.

Content of the material:
Chapter 1: Reminderson programming in Python (2 weeks)
1. Introduction: Basic computer concepts and digital tools, installation of Python.
2. Introduction to the concept of an operating system: Roles, types (Linux, Windows, etc.), priority management,
3. Introduction to computer networks (Principles, IP address, DNS, internet, etc.)
4. Basic programming: Interactive mode and script mode, Variables, data types, operators. Conditional structures and loops (if, for, while).
5. Essential functions and elements: Predefined functions and function creation. Standard modules (math, random). Strings, lists, basic database manipulation.
6. Files, Lists, Tuples, Dictionaries,
7. Exercises:
    - Python learning exercises
    - Exercises using the libraries seen in the course (Math, Random, NumPy, Pandas,…)
    - …

Chapter 2: Programming and Automation (4 weeks)

1. Principles of Task Automation
    - Python libraries for automation:
        - ✓ Pandas and NumPy.
        - ✓ Os, shutil: file and folder manipulation
        - ✓ Openpyxl or pandas: working with Excel or CSV files
    - Definitions and examples of automation (sending emails, etc.)
2. File manipulation with Python:
    - Use the libraries to:
        - ✓ Browse a folder (os.listdir)
        - ✓ Check for the existence of a file or folder (os.path.exists)
        - ✓ Create or delete folders (os.mkdir, os.rmdir)
        - ✓ Visualizing data: Matplotlib, Seaborn, Plitly
        - ✓ Request to interact with Application Programming Interfaces (APIs)
        - ✓ Beautiful Soup for Data Scraping
        - ✓ Tkinter, PyQt for visualizing graphical data
    - Copying or moving files with shutil…
    - Simple search, sorting and report generation.
    - Serialization and Deserialization (Using the pickle module).
    - Object serialization and processing of large files (streaming).
    - …
3. **Exercises**:
    - Using openpyxl and pandas to read, modify, and write Excel or CSV files for:
        - ✓ Create automatic reports
        - ✓ Automatically extract data
        - ✓ …
    - Scriptwriting for:
        - ✓ processing text files (searching, sorting)
        - ✓ automate technical calculations
        - ✓ manage simple reports (PDF, Excel)
        - ✓ …
    - Sorting, search, and insertion sort algorithms
    - Implement a search function in a list.
    - File operation
    - Secure browsing (simple network setup, password management)
    - …

Chapter 3: Advanced Excel Learning (2 weeks)

1. Principles of macros and creating a simple macro,
2. Pivot tables,
3. Histograms,
4. Bar charts,
5. Spider,
6. Etc.
7. **Exercises**Excel…

Chapter 4: Learning GanttProject (2 weeks)

1. Introductionto project management:
    - What is a project?
    - What are the challenges of managing a project?
    - GanttProject Interface
2. THEtasks(creation, modification, organization)
3. Managementtime (project start or end dates)
4. Managementresources

5. **Exercises**on Gantt Project

Chapter 5:Advanced Object-Oriented Programming (3 weeks)

1. Code organization:
   - Custom functions, settings, return value.
   - ModuTHE,importsand packages.
2. Structurescomplex data:
   - Lists,tuplesand dictionaries: creation, modification, deletion, browsing.
3. Fundamental concepts ofProgrammingobject-oriented (OOP):
   - Classes, objects, attributes, and methods.
   - Public, private and protected attributes.
4. Special methods:
   - **init**, str, repr, len.
5. Advanced concepts:
   - Encapsulation, abstraction, inheritance, polymorphism.
   - Advanced heritage, decorators, design patterns, metaclasses.
6. **Exercises**

Chapter 6:Introduction to Data for AI (2 weeks)

1. Introduction to common datasets in AI:
   - Iris, MNIST, CIFAR-10, Boston Housing, ImageNet.
2. Data preprocessingfor Machine Learning:
   - Data cleaning, normalization, encoding, and separation.
   - Cross-validation.
3. Feature Engineering techniques:
   - Selection, feature creation, dimensioning.
4. Essential Librariesfor the development of AI models:
   - scikit-learn, TensorFlow, Keras, PyTorch
5. **Exercises**

Practical exercises:

TP 01:Mastering the basics of Python programming

(Control structures, types, loops, simple functions)

1. Initiation
2. Read and process text files
3. Manage simple reports (PDF, Excel)

TP 02:

Develop specifications for a mini task automation project using Python, consisting of automatically identifying and sending reports via email using Python:

1. Loading data from a file (e.g., experimental measurements),
2. Perform simple statistical analyses on the data (mean, standard deviation with interpretation),
3. Generate a graph,
4. Sending the result using Python.

TP 03:

1. Excel programming of the dashboard seen in class
2. Creating automated Excel spreadsheets
3. Simple macros,
4. Conditional formulas,
5. Research V.

TP 04:

Organizing a meeting using Ganttproject

1. Create a new project:
    - Project name: "Meeting…"
    - Start date: Date and time of the meeting
    - Estimated duration: total meeting time
2. Task definition
    - Agenda items (each agenda item becomes a task)
    - Subtasks: If a point is compound, then create the corresponding subtasks.
    - Initial and final tasks (e.g., "Welcoming participants", "closing the meeting")
3. Definition of resources:
    - Participants (each participant is a resource)
    - Equipment (computer, data projector…)
4. Estimated durations:
    - Duration of each item: time required for each item on the agenda
    - Transition time from one point to another
5. Creating the Gantt chart:
    - View the agenda
    - Identify the key points
6. Track progress in real time (Gantt chart projection)

TP 05: Advanced structures and code organization

(Custom functions, dictionaries, modules, and modular organization)

TP 06: Advanced Object-Oriented Programming in Python

(Encapsulation, inheritance, special methods, simple design patterns)

Lab 07: File Manipulation and Data Analysis

(Reading/writing files, word processing, introduction to Pandas and NumPy)

Lab 08: Data preparation and processing for artificial intelligence

(Loading AI datasets, cleaning, transformation, feature selection)

Final Project

Title : Analysis and visualization of a dataset + simple predictive model

Skills used: Data reading, OOP, advanced structures, Pandas, Scikit-learn. (Oral presentation + written report).

Evaluation method:

Exam 60%, CC=40%

Bibliography

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[2] . C. Paroissin, (2021): Data science practice with R: arranging, visualizing, analyzing and presenting data. Paris: Ellipses, DL 2021.

[3] . S.Balech and C.Benavent: NLP text minig V4.0, (Paris Dauphine – 12/2019): link:https://www.researchgate.net/publication/337744581_NLP_text_mining_V40_-_une_introduction_-_cours_programme_doctoral

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[5] . Ramalho, L.. Fluent Python. "O'Reilly Media, Inc.", 2022;

[6] . Swinnen, G. Learning to program with Python 3. Editions Eyrolles, 2012;

[7] . Matthes, E. Python crash course: A hands-on, project-based introduction to programming. no starch press, 2019

[8] . Cyrille, H. (2018). Learning to Program with Python 3. Eyrolles, 6th edition. ISBN: 978-2212675214

[9] . Daniel, I. (2024). Learning to code in Python, I read

[10] . Nicolas, B. (2024). Python, from complete beginner to object-oriented programming: Course and solved exercises, 3rd edition, Ellipses

[11] . Ludivine, C. (2024). Selenium: Master your functional tests with Python, Eni

Online resources:

- Official Python documentation:docs.python.org
- Python exercises on Codecademy:codecademy.com/learn/learn-python-3
- W3Schools Python Tutorial: w3schools.com/python/

IV - Detailed program by subject for semester S2

Semester 2
Teaching Unit: UEF 1.2.1
Subject: Combustion
VHS: 45 h (course: 1h 30, tutorials: 1h 30 hours)
Credits: 4
Coefficient: 2

Teaching objectives:

This course introduces students to the field of combustion. Students will learn to calculate the properties of gas mixtures, the calorific values of hydrocarbons, and the adiabatic temperature of flames. Concepts of chemical equilibrium, chemical kinetics, and the different types of flames will also be taught.

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Recommended prior knowledge:

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

Contents of the material:

Chapter 1: Review and fundamental concepts of combustion (3 weeks)

1.1 Types offuels and combustibles: solids, liquids and gases, physical and chemical properties, octane rating, cetane rating.
1.2 Enthalpy of reaction and sensible enthalpies.
1.3 Gas mixtures, stoichiometry, richness and excess air coefficient.
1.4 Combustion reactions.
1.5 Calorific value: Calculation of LHV and HHV.

Chapter 2: Thermochemistry (3 weeks)

2.1 Adiabatic temperature of theflame at constant volume and constant pressure.
2.3 Calculation of the temperature of a combustion chamber.
2.4 Equilibrium constants and reaction rates.
2.5 Combustion kinetics.

Chapter 3: Equations of Reactive Flows(2 weeks)

3.1 Conservation of mass, momentum, energy and chemical species.
3.3 Chemical and thermal production terms.

Chapter 4: Laminar flames for premixing and diffusion (3 weeks)

4.1 Definition of premix flames and application examples.
4.2 Structure and speed of premixed flames.
4.3 Theory and kinetics of laminar premixed flames.
4.5 Definition of diffusion flames and application examples.
4.6 Structure of diffusion flames.
4.7 Mathematical formulation for laminar flames.

Chapter 5: Turbulent Flames (4 weeks)

6.1 Autoignition and propagation.
6.2 Turbulent premix flames.
6.3 Some premixed combustion models.
6.4 Turbulent diffusion flames.
6.5 Some models of non-premixed combustion.
6.6 Combustion regimes and diagrams of turbulent combustion.

Evaluation method:

Continuous control:40%,Exam :60%.

Bibliographical 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: UEF 1.2.1
Subject: Gas dynamics
VHS: 45 hours (course: 1h 30, tutorials: 1h 30)
Credits: 4
Coefficient: 2

Teaching objectives:

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

Recommended prior knowledge:

Thermodynamics and fluid mechanics.

Content of the material:

Chapter 1: Introduction to Gas Dynamics (1 week)

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

Chapter 2: Isentropic 1D Flow in a Variable Cross-Section Duct (5 weeks)

1. Basic equations (continuity, momentum, energy).
2. General laws of isentropic flow: generating state and critical state.
3. 1D flow in a pipe of variable cross-section 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 Shockwaves

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

II. Oblique Shock Waves

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

Chapter 4:Prandtl-Meyer relaxation (2 weeks)

Chapter 5: Non-Isentropic 1D Flow in a Conduit with Constant Cross-Section ((3 weeks)

I. Adiabatic flow with friction: Fanno flow

1. Analysis of Fanno flow and basic equations.
2. Variation of flow characteristics as a function of Mach number.
3. Coefficient of friction and change in entropy.
4. Shock wave in the Fanno flow.

II. Frictionless flow with heat exchange: Rayleigh flow

1. Analysis of Rayleigh flow and basic equations.
2. Variation of flow characteristics as a function of Mach number.
3. Change in entropy.

III. Flow with friction and heat exchange

Evaluation method:

Continuous control:40%,**Exam :**60%.

Bibliographical references:

1- *Patrick Chassaing. Fluid Mechanics, 3rd edition, Cépaduès, Toulouse, 2010. André Lallemand. One-dimensional flow of compressible fluids, Engineering Techniques, Energy Engineering, B-8-165.*
2- *FM White. Fluid Mechanics, 5th edition, McGraw-Hill, New York, 2003.*
3- *RW Fox and AT McDonald. Introduction to Fluid Mechanics, 5th edition, New York: Wiley, 1999.*
4- *JD Anderson. Modern Compressible Flow with Historical Perspective, 3rd edition, New York: McGraw-Hill, 2003.*
5- *H. Liepmann and A. Roshko. Elements of Gas Dynamics, Dover Publications, Mineola, NY, 2001.*
6- *Genick Bar–Meir, Fundamentals of Compressible Fluid Mechanics, Minneapolis, MN 55414-2411, 2009.*
7- *Robert d. Zucker, Oscar Biblarz, Fundamentals Of Gas Dynamics, JOHN WILEY & SONS, 2002.*
8- *Patrick Oosthuizen, William Carrascallen, Compressible Fluid Flow, McGraw-Hill, 1997.*
9- *Klaus Hoffmann, Computational Fluid Dynamics, Volume II, EES, 4th edition, 2000.*

Semester 2
Teaching unit: UEF 1.2.1
Subject: Thermal drying
VHS: 10h30 (course: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:
The aim of this course is to present the theoretical principles of thermal drying, including mechanisms, mass and heat transfer equations, drying curves, and psychrometric charts. Thermal drying techniques are linked to thermodynamic laws and the principles of mass and heat transfer, enabling students to apply their prior knowledge to solve drying problems in various sectors: food processing, textiles, paper, construction materials, etc.

Recommended prior knowledge:
Thermodynamics, Mass and Heat Transfer

Content of the material:

Chapter 1 Reminders about humid air **(2 weeks)**
Absolute humidity, relative humidity, dry-bulb temperature, wet-bulb temperature, dew point, enthalpy, moist air mixing, psychrometric chart.

Chapter 2 Drying theory **(3 weeks)**
Drying terminology, Mechanisms involved during drying.

Chapter 3 Principles for calculating dryers **(5 weeks)**
Method of determining 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 dryer.

Chapter 4 Drying Equipment and Processes **(5 weeks)**
Drying of solid products, Drying of pasty products, Drying of liquid products, Definition of a dryer, Ancillary devices necessary for the operation of a dryer.

Evaluation method:
Exam :100%.

Bibliographical references:

1. *Mujumdar AS, Handbook of industrial drying, Marcel Dekker, New York, 1987.*
2. *Nadeau J.-P., Puiggali J.-R., Drying: from physical processes to industrial processes, 307p., Tec et Doc, Paris, 1995.*
3. *Catherine BONAZZI, Jean-Jacques BIMBENET, Drying of food products - Principles, Techniques de l'ingénieur, f3000, 2003.*
4. *Catherine BONAZZI, Jean-Jacques BIMBENET, Drying of food products - Equipment and applications, Techniques de l'ingénieur, f3002, 2008.*
5. *Jean VASSEUR, Industrial drying: principles and calculation of equipment - Other drying methods than hot air, part 1, Techniques de l'ingénieur, Techniques de l'ingénieur, j2453, 2011.*
6. *Jean VASSEUR, Industrial drying: principles and calculation of equipment - Convective drying by hot air (part 2), Techniques de l'ingénieur, j2452, 2010.*

7. *André CHARREAU, Roland CAVAILLÉ, Drying. Theory and calculations, Techniques de l'ingénieur, j2480, 1995.*

Semester 2
Teaching unit: UEF 1.2.2
Subject: Heating and air conditioning
VHS: 45h (course: 1h30, tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:
The content of this subject provides students with the necessary concepts and tools for sizing heating and air conditioning systems.

Recommended prior knowledge:
Thermodynamics, heat transfer, fluid mechanics.

Content of the material:

Chapter 1. Review of thermodynamics and heat transfer (1 week)
- General concepts of thermodynamics
- Modes of heat transfer

Chapter 2: Building Thermal Performance (2 weeks)
- Algerian Thermal Regulations (DTR documents)
- Heating requirements
- Thermal insulation

Chapter 3: General Principles of Heating (5 weeks)
- Calculation of heat loss
- Heat production
- Distribution and broadcasting

Chapter 4: General Principles of Air Conditioning (5 weeks)
- Calculation of heat gains
- Air conditioning systems and distribution networks
- Humid air and hx diagram
- Cold production

Chapter 5: System Regulation (1 week)

Chapter 6: Renewable Energy Equipment (1 week)

Evaluation method:
Continuous control:40%,Exam :60%.

Bibliographical references:
1. Treatise on heating and air conditioning, H. Rietschel and W. Raiss, Dunod 1993.
2. Practical heating, J. Bossard and J. Hrabovsky, Dunod 2014.

Semester 2
Teaching Unit: UEF 1.2.2
Subject: Advanced Turbo machinery
VHS: 45 hours (course: 1h 30, tutorials: 1h 30)
Credits: 4
Coefficient: 2

Teaching objectives:
To describe, starting from basic concepts (of turbomachinery and fluid mechanics), the methods of design, analysis and construction of turbomachinery to enable students tounderstanding the flows that develop in turbomachinery and to develop basic elements for the design and selection of these machines.

Recommended prior knowledge:
Thermodynamics, heat transfer, fluid mechanics, turbomachinery.

Content of the material:

Chapter 1. **(3 weeks)**
Review of turbomachinery, classification, the concept of similarity, dimensionless numbers and velocity triangles, Euler's equation for turbomachinery

Chapter 2.Aerodynamics of blade grids **(3 weeks)**
2.1 Aerodynamic forces (lift and drag)
2.2 Correlations for the design of blade grids (strength, deviation, deflection,...)

Chapter 32D flow in turbomachinery **(4 weeks)**
3.1 Simplified radial equilibrium equation
3.2 Actuator Disk Theory
3.3 Blade-to-blade flow
3.4 Boundary layers and the concept of transition

Chapter 4.3D Flow in Turbomachinery **(3 weeks)**
4.1 Governing equations
4.2 CFD for turbomachinery (applications and limitations)
4.3 Unsteady Flow and Stator-Rotor Interaction
4.4 Cooling of turbomachinery
4.5 Losses in turbomachinery (profile losses, due to secondary flows, clearance losses, etc.
4.6Measurement techniques in turbomachinery

Chapter 5 Construction of turbomachinery **(2 weeks)**
5.1 Turbomachine components: bearings, couplings, gearboxes, lubrication and sealing systems
5.2 Construction of steam turbines: nozzles, blades, single-stage efficiency, casing and diaphragm, rotor, material, balancing, valves and steam inlet valves, speed control
5.3 Gas turbines: compressor, combustion chamber, turbine, fuels
5.4 Compressors: centrifugal, axial, reciprocating, use.

Evaluation method:
Continuous control:40%,Exam :60%.

Bibliographical references:

1. *SLDixonFluid Mechanics, Thermodynamics of Turbomachinery, 5th ed., Elsevier Butterworth.*
2. *Heineman, 2005.*
3. *HIH Saravanamuttoo, GFCRogers, H. Cohen, and PV 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. *JC Han, S. Dutta, S. Ekkad, Gas Turbine Heat Transfer And Cooling Technology, Taylor & Francis 2000.*

Semester 2
Teaching Unit: UEM 1.2
Matter : Finite volume method
VHS: 45h00 (Subject: 1h30, practical: 3h00)
Credits: 6
Coefficient: 3

Teaching objectives:
Learn numerical techniques to solve the various governing equations of fluid mechanics and heat transfer. Emphasis will be placed on solving conservation equations. This course also enables students to develop the ability to understand and program the finite volume method for fluid flow phenomena coupled with heat and mass transfer, and to effectively use CFD software, which is essential for solving industrial problems.

Recommended prior knowledge:
It is recommended to master numerical, mathematical analysis (PDE).

Content of the material:
Chapter 1: Generalities on Computational Fluid Dynamics (CFD) **(1 week)**

Chapter 2: Storage instructions (2 weeks)
- Mass conservation equation.
- Equation for the conservation of momentum.

Chapter 3: Finite volume method for diffusion problems **(6 weeks)**
1- One-dimensional diffusion problem
   - 1D diffusion equation.
   - 1D diffusion equation with source term.
2- two-dimensional diffusion problem
   - 2D stationary diffusion equation without source term.
   - 2D steady-state diffusion equation with source term.
3- Two-dimensional diffusion problem.

Chapter 4: Finite volume method for convection-diffusion problems
(6 weeks)
1- Stationary 1D convection-diffusion equation
   - Centered diagram
   - Upwind diagram
   - Exponential scheme
   - Hybrid Scheme
   - Power Law Scheme
2- Unsteady 1D diffusion equation
   - Explicit diagram
   - Implicit scheme
   - Crank-Nicholson scheme

Organization of practical work:
1- **Digital resolution by the MVF of broadcasting problems**.
   - One-dimensional diffusion problem.
   - Two-dimensional diffusion problem.

2- **Numerical resolution of convection-diffusion problems using MVF.**
- Stationary 1D convection-diffusion equation: Centered scheme, Upwind scheme, Exponential scheme, Hybrid scheme, Power Law scheme.
- Unsteady 1D diffusion equation: Explicit scheme, Implicit scheme, Crank-Nicholson scheme.

Evaluation method:

Continuous control:40%,Exam :60%.

Bibliographical references:

1. HK Versteeg, W. Malasasekera, "Introduction to ComputationalFluid Dynamics: The finite volume method (2nd Edition)", Pearson, Prentice Hall, 2007.
2. *S.V.Patankar, "Numerical Heat Transfer and Fluid Flow", Hemisphere, Washington, DC, 1980*.

Semester 2
Teaching Unit: UEM 1.2
Subject: TP Turbo machine
VHS: 10h30 (practical: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:
To put into practice the basic concepts (of turbomachinery and fluid mechanics), the methods of design, analysis and construction of turbomachinery to enable studentsunderstanding the flows that develop in turbomachinery and to develop basic elements for the design and selection of these machines.

Recommended prior knowledge:
Turbomachinery course

Content of the material:
Do some practical work on turbomachinery depending on the equipment available, using simulation software.

Evaluation method:
Continuous control: 100%.

Bibliographical references:

Semester 2
Teaching Unit: UEM 1.2
Subject: Servomechanisms and regulation
VHS: 37h30 (course: 1h30, Practical: 1h30)
Credits: 3
Coefficient: 2

Teaching objectives:
The aim is to teach students the basic principles of a control system by continuously measuring the difference between the actual value of the variable to be controlled and the desired setpoint value, and calculating the appropriate control to apply to one (or more)actuator(s) so as to reduce this gap as quickly as possible.

Recommended prior knowledge:
Digital methods, computer science, electricity…

Content of the material:

Chapter 1: Introduction to Control Systems (2 weeks)
Concepts of analog control systems. Structure diagram.
Representation of a control system. Functional diagram of a closed-loop system. open-loop and closed-loop control. transfer function. transfer function of elementary systems. exercises

Chapter 2: Performance of a linear control system (2 weeks)
Concept of operating regime, Performance evaluation of a closed-loop system, static and dynamic accuracy, study of some elementary systems, Performance, Exercises.

Chapter 3: Analysis of linear control systems (2 weeks)
Frequency responses and Bode plots, Nyquist plot: Frequency response of a low-frequency system, Black-Nichols diagram, Exercises

Chapter 4: Stability of Linear Control Systems (3 weeks)
Methods for studying stability, Routh-Hurwitz method (algebraic criterion), Geometric stability criteria, Exercises

Chapter 5: Correction of Linear Control Systems (3 weeks)
Concepts of correction for linear servo systems, themain controllers, P, PI, PIDPID controller tuning, Exercises

Chapter 6: Adaptive Learning Systems (3 weeks)
Concepts of adaptive systems, different learning mechanisms, exercises

Evaluation method:
Continuous control:40%,Exam :60%.

Bibliographical references:

1. *Automatic Control Course Volume 2, Servomechanisms, Regulation, Analog Control, Jean-Louis Ferrier, Maurice Rivoire, Eyrolles.*
2. *Automation: regulation and control systems, ofThierry Hansand Pierre GuyénotJune 20, 2014.*

3. *Automatic control exercises, volume 2: Servomechanisms, regulation, analog control.*
4. *ofMaurice RivoireAndJean-Louis FerrierEyrolles.*
5. *Continuous Servomechanisms and Regulations. Volume 2, Analysis and Synthesis, Problems with Solutions, by Collective andElisabeth Boillot,January 1, 2002.*
6. *Industrial regulation, Modeling tools, control methods and architectures, Edited by:Emmanuel Godoy, Collection:Technology and Engineering, Dunod/L'Usine Nouvelle, 2014 - 2nd edition - 552 pages, EAN13: 9782100717941.*
7. *Le Gallo, O. Automatic Control of Mechanical Systems. Dunod. (2009).*
8. "Automatic Linear Current 1A ISMIN".
9. "Electronics Volume 2: Linear, Communication and Filtering Closed-Loop Systems: Course and Exercises", François Manneville, Jacques Esquieu, Ed. Dunod.
10. "Automatic Control: Control of Linear Systems", Philippe de Larminat, Ed. Hermes.

Semester 2
Teaching Unit: UET 1.2
Subject: Adherence to ethical standards and rules of integrity
VHS: 10h30 (course: 1 h30)
Credit: 1
Coefficient: 1

Teaching objectives:

To raise students' awareness of ethical principles and the rules governing life at university and in the workplace. To educate them about respecting and valuing intellectual property. To explain the risks of moral failings such as corruption and how to combat them, and to alert them to the ethical issues raised by new technologies and sustainable development.

Recommended prior knowledge:

Ethics and professional conduct (the foundations)

Content of the material:

A. Respect for the rulesof ethics and integrity,

1. **Reminder of the MESRS Charter of Ethics and Professional Conduct:**Integrity and honesty. Academic freedom. Mutual respect. Demand for scientific truth, objectivity and critical thinking. Fairness.Rights andobligationsof the student,of the teacher, administrative and technical staff,

2. Ethical and responsible research

- Respect for ethical principles in teaching and research
- Responsibilities in teamwork: Equal professional treatment. Conduct against discrimination. Pursuit of the common good. Inappropriate conduct in the context of teamwork
- Adopting responsible conduct and combating abuses: 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.

3. Ethics and professional conduct in the workplace:

Legal confidentiality in business. Loyalty to the company. Responsibility within the company. Conflicts of interest. Integrity (corruption in the workplace, its forms, its consequences, methods of combating it and sanctions against corruption)

B- Intellectual Property

I- Fundamentals of Intellectual Property

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

II- Copyright

1. **Copyright in the digital environment**
Introduction. Copyrightdatabases, software copyright. Specific case of free software.
2. **Copyright in the internet and e-commerce**
Domain name law. Intellectual property on the internet. E-commerce website law. Intellectual property and social networks.
3. **Patent**
Definition. Rightsin a patent. Usefulness of a patent. ThePatentability. Patent applicationin Algeria and around the world.

III- Protection and enhancement of intellectual property

How to protect intellectual property. Rights infringement and legal tools. VIntellectual property valorization. Intellectual property protectionin Algeria.

C. Ethics, sustainable development and new technologies

Link between ethics and sustainable development, energy efficiency, bioethics and new technologies (artificial intelligence, scientific progress,Humanoids, robots, drones,

Evaluation method:

Exam: 100%

Bibliographical references:

1. Charter of university ethics and professional conduct, https://www.mesrs.dz/documents/12221/26200/Charte+fran ais+d f.pdf/50d6de61-aabd-4829-84b3-8302b790bdce
2. Decree No. 933 of July 28, 2016 establishing the rules relating to the prevention and fight against plagiarism
3. E. Prairat, On teaching ethics. Paris, PUF, 2009.
4. Racine L., Legault GA, Bégin, L., Ethics and Engineering, Montreal, McGraw Hill, 1991.
5. Siroux, D., Deontology: Dictionary of ethics and moral philosophy, Paris, Quadrige, 2004, p. 474-477.
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7. Didier Ch., Thinking about the ethics of engineers, Presses Universitaires de France, 2008.
8. Gavarini L. and Ottavi D., Editorial. On professional ethics in training and research, Research and training, 52 | 2006, 5-11.
9. Caré C., Morality, ethics, deontology. Administration and education, 2nd quarter 2002, no. 94.
10. Jacquet-Francillon, François. Concept: Professional Ethics. Le Télémaque, May 2000, no. 17
11. Carr, D. Professionalism and Ethics in Teaching. New York, NY Routledge. 2000.
12. Galloux, JC, Industrial Property Law. Dalloz 2003.
13. Wagret F. and JM., Patents, Trademarks and Industrial Property. PUF 2001
14. Dekermadec, Y., Innovating through patents: a revolution with the internet. Insep 1999
15. AEUTBM. The engineer at the heart of innovation. University of Technology of Belfort-Montbéliard
16. http://www.app.asso.fr/
17. http://ressources.univ-rennes2.fr/propriete-intellectuelle/cours-2-54.html
18. Fanny Rinck and Léda Mansour, "Literacy in the Digital Age: Copy-Paste Among Students," Grenoble 3 University and Paris Nanterre University, Nanterre, France
19. The ABCs of Copyright, United Nations Educational, Scientific and Cultural Organization (UNESCO)
20. Alain Bensoussan white paper – Open science in a digital republic, CNRS Scientific and Technical Information Directorate
21. Copyright in the cultural industries. - Cheltenham: E. Elgar, 2002. - XXII-263 p.
22. Similarity detection software: a solution to electronic plagiarism? Report of the Working Group on Electronic Plagiarism presented to the Subcommittee on Pedagogy and ICT of the CREPUQ
23. Emanuela Chiriac, Monique Filiatrault and André Régimbald. "Student's Guide: Intellectual Integrity, Plagiarism, Cheating and Fraud... Avoiding Them and, Above All, How to Properly Cite Your Sources" 2014
24. University of Montreal publication. "Strategies for preventing plagiarism," Integrity, Fraud and Plagiarism, 2010
25. Pierrick Malissard "Intellectual Property "Origin and Evolution" 2010.
26. The website of the World Intellectual Property Organizationwww.wipo.int.

Semester: S2
Teaching Unit: 1.2.1
Matter : Elements of applied artificial intelligence
VHS: 45h00 (Lecture 1h30, Practical 1h30)
Credits: 2
Coefficient: 2

Skills targeted:

- Identifying the opportunities of artificial intelligence in engineering sciences
- Understanding the ethical implications of AI and best practices for its use.
- Ability to use AI techniques in problem-solving

Goals :

- Mastery of AI algorithms
- An introduction to the fundamental concepts, tools, and applications of modern artificial intelligence, with an emphasis on hands-on practice with Python and its libraries.
- To deepen one's knowledge of the Python language,
- Understanding AI approaches to problem-solving,

Prerequisites:

Advanced Python Programming

Materials needed:

- A computer with Python installed,
- Python libraries: NumPy, Pandas, Scikit-learn, Matplotlib, os.listdir, os.path.exists, os.mkdir, os.rmdir, Matplotlib, Seaborn, Plitly, Request, Beautiful Soup, Tkinter, PyQT, …
- TensorFlow, PyTorch, …

Content of the material:

Chapter 1:Introduction to Artificial Intelligence (AI) (1 week)

1. Definitions and fields of application of AI.
2. Historical evolution of AI.
3. Introduction to the major areas:
   - Machine Learning
   - Deep Learning**)**

Chapter 2:Basic Mathematics for AI (1 week)

1. **Linear Algebra**: vectors, matrices, products, norms.
2. **Probability & Statistics**:
   - Variables, expectation, variance.
   - Common distributions: normal, binomial, uniform.
3. **Simple linear regression**:
   - Formulation, cost, optimization.
   - Implementation using Scikit-learn.
4. **Exercises:**
   - Matrix manipulation using the NumPy library (Python)
   - Exercise on linear regression (using a Python library such as Scikit-learn, for example)
   - Explaining the Matplotlib library (Python)
   - …

Chapter 3: Machine Learning (3 weeks)

1. Key concepts: Data, Models, features, labels, generalization.
2. Phases of a learning pipeline: training, validation, testing.
3. Types of learning:

- Supervised
- Nosupervised
- Byreinforcement (overview)

4. **Exercises:**
   - To delve deeper into the concepts covered in the course
   - …

Chapter 4: Supervised Classification (3 weeks)

1. Simple classification model training principle:
2. Models and algorithms:
   - SVM (Support Vector Machine)
   - Decision trees
3. Performance evaluation:
   - Confusion matrix, precision, recall, F1-score.
5. **Exercises:**
   - Explain how to use Scikit-learn?
   - Comparison of several models on a dataset
   - …

Chapter 5:Unsupervised learning

1. The concept of clustering.
2. Algorithms:
   - **K-means**
   - DBSCAN(Density-Based Spatial Clustering of Applications with Noise)
3. 2D visualization and interpretation of results.
4. **Exercises:**
   - Explain how to use a clustering algorithm on a dataset
   - Explain how to visualize the clusters.
   - …

Chapter 6:Neural networks

1. Neural network architecture:
   - Perception,
   - Layers and hidden layers, weight, bias.
   - Functionactivation:ReLU, Sigmoid, Softmax, ….
   - Application exercises
2. Introduction to Deep Learning:
   - Concept of deep layers.
   - Introduction to Convolutional Neural Networks (CNNs)
3. **Exercises:**
   - Explaining TensorFlow and PyTorch
   - Analyze a text dataset and predict sentiment
   - …

Chapter 7: Mini project (supervised personal work outside of class):

Creation of a complete classification or clustering model, including preprocessing, training, and visualization; choose and process one project from start to finish (to be distributed at the beginning of the semester):

- Handwritten character recognition
- Natural disaster prediction
- Develop a chatbot capable of answering a company's frequently asked questions in a natural way.

- Develop a system capable of distinguishing normal machine sounds from those indicating an anomaly (defective bearing, excessive vibration, etc.)
- Develop a system (mini AI) capable of analyzing the sentiments expressed in social media posts about a product, brand or event.
- …

Practical exercises:

TP 01: Initialization

TP 02:

- Implementing a simple regression with Scikit-learn visualization with Matplotlib (For example)
- Visualize the results with Matplotlib
- …

TP 03:

- Machine learning pipeline and data separation
- To delve deeper into the concepts seen during the course

TP 04:

- Using Scikit-learn to train a simple classification model
- …….

TP 05:

- Implementing a clustering algorithm on a dataset
- Visualize the clusters **Unsupervised clustering (K-means, DBSCAN).**
- …

TP 06:

- Build a simple neural network with TensorFlow, PyTorch, or Keras
- Build a simple CNN to classify images (example: MINIST dataset)
- …

Evaluation method:

Exam 60%, CC=40%

Bibliography:

- Ganascia, J. Gabriel (2024): AI explained to humans. Paris, France - Edition le Seuil.

- Anglais, Lise, Dilhac, Antione, Dratwa, Jim et al. (2023): Ethics at the heart of AI. Quebec Obvia.

- J. Robert (2024): Natural Language Processing (NLP): Definition and Principles – Data Science. Link:https://datascientest.com/introduction-au-nlp-natural-language-processing

- What is natural language processing? Link:https://aws.amazon.com/fr/what-is/nlp/

- M. Journe: Elements of Discrete Mathematics – Ellipses

- F. Challet: Deep Learning with Python – Eyrolles

- H. Bersini (2024): Artificial intelligence in practice with Python – Eyrolles

- B. Prieur (2024): Natural Language Processing with Python – Eyrolles

- V. Mathivet (2024): Implementation in Python with Scikit-learn – Eyrolles

- G. Dubertret (2023): Introduction to Cryptography with Python – Eyrolles

- S. Chazallet (2023): Python 3 – The Fundamentals of the Language - Eyrolles

- H. Belhadef, I. Djemal: NLP Method – Course at the University of Msila - Algeria

V - Detailed program by subject for semester S3

Semester: 3
Teaching unit: UEF 2.1.1
Subject: Deep internal combustion engine
VHS: 45 hours (course: 1h 30, Tutorials: 1h 30)
Credits: 4
Coefficient: 2

Teaching objectives:

- Understand the physical and chemical processes occurring during combustion and transfer in internal combustion engines. Understand the reaction of a given engine when one of its parameters is changed, using modeling.

- Build an internal combustion engine model. Optimize the sizing and settings of an engine under constraints of efficiency, power, and pollutant emissions using an engine model**.**

Recommended prior knowledge:
Thermodynamics and mathematics of L1 and L2.

Contents of the material:

Chapter 01 New techniques and improved engine efficiency (2 weeks)
1-1 Undersizing.
1-2 Variable distribution.
1-3 Variable compression ratio.
1-4 Miller-Atkinson Cycle.
1-5 Layered load.
1-6 HCCI Concept.
1-7 PCCI Concept.

Chapter 02 Gasoline injection techniques **(2 weeks)**
2-1 Electronic engine management and diagnostics.
2-2 K-jetronic system.
2-3 D-jetronic system.
2-4 L-jetronic system.

Chapter 3 Modeling combustion in engines **(4 weeks)**
3-1 Model one zone.
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 Formation of soot.
4-5 NOx Formation.

Chapter 05: Turbocharging of the MCIs **(2 weeks)**
5-1 Mapping (turbine, compressor, motor) and functional characteristics.
5-2 Engine – turbocharger adaptation.

Evaluation method:
Continuous control: 40%; Examination: 60%.

Bibliographical references:

1. Heywood, JB Internal Combustion Engine Fundamentals. New York, NY, McGraw-Hill.Inc. 1983.
2. Ramos, JI Internal Combustion Engine Modeling. Hemisphere Publishing Corporation. 1989. P. 326-332.
3. Merker, GP et al Simulating of Combustion and pollutant formation for engine-development. Springer, 2004.
4. Lakshminarayanan P. A, Aghav, YV Modeling diesel combustion.Springer 2010.
5. Petrol and diesel engine management "Diagnostics and repair T1, T2 and T3. ETAI Editions 2007.
6. Walls A. Supercharging of vehicle engines by turbocharger.
7. Delanette M. Automotive Technology. Technical and Standardization Editions. 1996.

Semester: 3
Teaching unit: UEF 2.1.1
Subject: Cryogenics
VHS: 45h (course: 1h30, tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

- Understanding how gas liquefaction processes work;
- Knowing how to calculate the energy balances and performance of the different processes used in liquefaction;
- Knowing how to determine the working parameters of cryogenic fluids.

Recommended prior knowledge:
Thermodynamics; Energy conversion; Fluid mechanics.

Content of the material:

CHAPTER 1: REVIEW OF THE MAIN PROCESSES FOR OBTAINING LOW TEMPERATURES **(2 weeks)**

1.1 Joule-Thomson expansion, isentropic expansion, escape process...
1.2 Concept of inversion temperature of a gas.
1.3 Inversion curve of a gas (diagram (T, P)).
1.4 Isenthalpic constriction coefficient.
1.5 Isentropic constriction coefficient.

CHAPTER 2:LIQUEFACTION PROCESSESGAS **(4 weeks)**

2.1 General information on gas liquefaction
2.1.1 Importance and use of liquefied gases.
2.1.2 History of experiments on gases.

2.2 Liquefaction by Joule-Thomson expansion
2.2.1 Linde process.
2.2.2 Linde process with pre-cooling of the working gas.
2.2.3 Linde double-strangle process.

CHAPTER 3 CRYOGENIC CYCLES WITH GAS EXPANSION IN EXPANSION REGULATORS **(2 weeks)**

3.1 Expansion of gases in the expansion valves to the initial temperature level (at the compressor outlet).
3.2 Connection of the expansion valve at the intermediate temperature level.
3.3 Connection of the expansion valve at the lower temperature level (evaporator outlet).

CHAPTER 4 COMBINED CRYOGENIC CYCLES **(2 weeks)**

4.1 Combination of isenthalpic and isentropic relaxation on the same process.
4.2 Advantages of the combined cycle.

CHAPTER 5: STUDY OF INDUSTRIAL GAS LIQUEFACTION FACILITIES

(4 weeks)

5.1 Nitrogen and oxygen liquefaction facilities.
5.2 Natural gas (LNG) liquefaction processes.
5.3 Hydrogen Liquefaction.
5.4 Liquefaction of Helium.

Evaluation method:
Continuous control: 40%; Examination: 60%.

Bibliographical references:

1. Pierre Petit: Separation and liquefaction of gases. Engineering Techniques. J3600;
2. Olivier Perrot: Course on refrigeration machines. IUT of Saint Omer Dunkerque. Department of Thermal Engineering and Energy. 2010 – 2011.
3. CRYOGENIC ENGINEERING Second Edition Revised and Expanded Thomas M. Flynn CRYOCO, Inc. Louisville, Colorado, USA2005.

Semester: 3
Teaching unit: UEF 2.1.2
Subject: Propulsion mechanics
VHS: 67h30 (course: 3h00, Tutorials: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

The course is essentially intended to familiarize the student with the construction elements, operation and energy calculation of thermal propulsion turbomachines (gas turbine, turbojet, rocket engine).

Recommended prior knowledge

The basic concepts of thermodynamics and gas dynamics.

Content of the material:

Chapter 1: Propulsion principle.

1. Airplanes.
2. The principles.
   - 1.1. Principle of lift (How does an airplane fly?)
   - 1.2. Propulsion Principle (How does an airplane move?)

Chapter 2: Principles and performance of jet engines.

1. The push.
2. Forms of energy in a jet engine.
3. The powers.
4. Yields.

Chapter 3: Gas turbine.

1. Structural elements of a gas turbine.
2. Operating principle.
3. Energy calculation of a gas turbine.

Chapter 4: Aviation engine (Turbojets).

1. Operating principle of the turbojet engine.
2. The structural elements of the turbojet engine.
3. The different types of turbojet engines.
4. Analysis and calculation of a single-flow turbojet engine.

Chapter 5: Rocket engine.

1. Thrust and operating principle.
2. Starters and Motors.
3. Descriptive parameters of an engine.
4. The fundamental relationships.

Evaluation method:

Continuous control: 40%; Examination: 60%.

Bibliographical references:

1. Klaus Hünecke, Jet engines: fundamentals of theory, design, and operation, Zenith Imprint, 1997, 241 p.
2. Jean-Claude Thevenin, The turbojet engine, engine of jet aircraft, Aeronautical and Astronautical Association. France, 2004, 46 p.
3. Albin Bolcs. Thermal Turbomachinery (volumes 1 and 2), Lausanne 1993.
4. S.Candel. Fluid Mechanics Volume 3 (Exercises), Dunod 1995.
5. George p. Sutton, 0scar Biblarz, Rocket Propulsion Elements, JOHN WILEY & SONS, 2001.

Half: 3
Teaching unit: UEF 2.1.2
Subject: Heat exchangers
VHS: 45h (course: 1h30, tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:
Mastering the calculation of heat exchangers in steady and variable regimes.

Recommended prior knowledge:
Heat transfer, thermodynamics, mechanical engineering.

Content of the material:

Chapter 1:
1. General information on heat exchangers.
2. Construction types and fluid flow configuration.

Chapter 2: Element of thermal calculation
1. Overall heat transfer coefficient in a heat exchanger.
2. Fouling factor.
3. Analysis of a heat exchanger.

Chapter 3: Thermal calculation methods for heat exchangers
1. DTLM method.
2. ε-NUT method.

Chapter 4: Thermal calculation of heat exchangers in non-steady-state operating conditions
1. Storage type heat exchanger.
2. Regenerator type heat exchanger.

Evaluation method:
Continuous control:40%,Exam :60%.

Bibliographical references:

1. C. Bougriou, Calculations and technology of heat exchangers, Office des Publications Universitaires, 2010.
2. DQ Kern,Heat transfer process.McGraw-Hill: New York, 1984.
3. AP Frass,andM.N. Ozisik, Heat exchangers design, John Wiley, 1965.
4. V. Afgan, and EU Shlunder,Heat exchangers; Design and theory,McGraw-Hill: New York, 1974.
5. JG Vollier, Collier,Convective boiling and condensation heat transfer.McGraw-Hill: New York, 1981.
6. J.Padet, Thermal heat exchangers.Global calculation methods with 11 solved problemsElsevier, 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: UEM 2.1
Subject: CFD and software
VHS: 45h (practical: 03h00)
Credits: 4
Coefficient: 2

Teaching objectives:

This course provides the necessary foundation for the development and use of Computational Fluid Dynamics (CFD) codes. These foundations are now absolutely essential for Master's students in Mechanical Engineering (Energy option) to understand and optimize industrial facilities, where flows coupled with heat and mass transfer play a crucial role. Indeed, the curriculum must be designed so that students can understand the main characteristics of numerical methods, use a commercial code, and analyze and interpret the results. Furthermore, emphasis must be placed on modeling different laminar and turbulent flow regimes. The ANSYS/Fluent software, chosen for all numerical exercises in the program, is currently the most widely used commercial software worldwide.

Recommended prior knowledge:
MDF, Thermodynamics.

Content of the material:

1. Presentation in the computing room of the ANSYS/Fluent software and the tree view mode for solving, as well as the usual commands.

TP: Getting started with the software through an example of simulating Rayleigh-Taylor instabilities.

2. Representation of turbulent flows. Concept of closure. Reynolds tensor. Simulation of turbulence – RANS (k/epsilon) models.

TP: Flow around an obstacle (cylinder or sphere) of the Von Carman type.

3. Solving Navier-Stokes equations and SIMPLE algorithms – Purely convective transfer.

TP:natural convection in a differentially heated confined cavity.

4. Solving Navier-Stokes equations and SIMPLE algorithms - Conductive-convective transfers.

TP: Numerical simulation of a double-tube counter-current heat exchanger.

5. Solving Navier-Stokes equations and SIMPLE algorithms - Coupled convecto-diffusive transfers.

TP: Simulation of the diffusion of a chemical species in laminar flow.

6. Structured and unstructured meshes and basics of the finite volume method.

TP: Numerical simulation of the phase change (solidification or melting) in 2D of a pure substance.

Evaluation method:
Continuous Control:100%,

Bibliographical references:

1. User guide for: Gambit, Mesh, Fluent, CFX, Origin and Tecplot.
2. For practical exercises: see ANSYS (Fluent or CFX).

Example:
https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules

Semester: 3
Teaching Unit: UEM 2.1
Subject: Optimization
VHS: 37h30 (course: 1h30, practical: 1h00)
Credits: 3
Coefficient: 2

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

Recommended prior knowledge:
Basic mathematical concepts. Linear algebra.Matrix algebra.

Content of the material:

Chapter I: Linear optimization **(3 weeks)**
- General formulation of a linear program
- Examples of linear programs (Production problem, Mixing problem, Cutting problem, Transportation problem)
- Solving the problem using the Simplex method:
  - Basic principles and 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.
- Conditions required for a minimum.
- Sufficient conditions for a minimum.
- Local methods.
- Unidimensional search methods.
- Gradient methods.
- Methods of conjugate directions.
- Newton's method.
- Quasi-Newton methods.

Chapter III: Nonlinear optimization with constraints **(4 weeks)**
- Lagrange multipliers.
- Karush-Kuhn-Tucker conditions.
- Penalty method.
- Sequential quadratic programming.

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

Organization of practical work: it is preferable that the practical exercises be direct applications in the field of mechanical engineering.

TP 1: presentation of the reference optimization functions in Matlab.

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

Evaluation method:
Continuous control:40%,Exam :60%.

Bibliographical references:

1. *E. Aarts & J. Korst, Simulated annealing and Boltzmann machines: A stochastic approach to combinatorial optimization and neural computing. John Wiley & Sons, New York, 1997.*
2. *D. Bertsekas, Nonlinear programming. Athena Scientific, Belmont, MA, 1999.*
3. *M. Bierlaire, Introduction to Differentiable Optimization. Presses polytechniques et universitaires romandes, Lausanne, 2006.*
4. *F. Bonnans, Continuous Optimization: Course and Solved Problems. Dunod, Paris, 2006.*
5. *F. Bonnans, JC Gilbert, C. Lemaréchal and C. Sagastizàbal, Numerical Optimization: Theoretical and Practical Aspects. Springer, Berlin, 1997.*
6. *PG Ciarlet, Introduction to Numerical Matrix Analysis and Optimization. Masson, Paris, 1994.*
7. *E. Chong and S. Zak, An introduction to optimization. John Wiley & Sons, New York, 1995.*
8. *Y. Colette and P. Siarry, Multi-objective Optimization. Eyrolles, Paris, 2002.*
9. *JC Culioli, Introduction to optimization. Ellipses, Paris, 1994.*
10. *J. Dennis & R. Schnabel, Numerical methods for unconstrained optimization and nonlinear equations. Prentice Hall, Englewood Cliffs, NJ, 1983.*
11. *R. Fletcher, Practical methods of optimization. John Wiley & Sons, New York, 1987.*
12. *P. Gill, W. Murray, & M. Wright, Practical optimization. Academic Press, New York, 1987.*

Semester: 3
Teaching Unit: UEM 2.1
Subject: practical Heat Exchangers
VHS: 10h30 (practical: 1h30)
Credits: 2
Coefficient: 1

Teaching objectives:
Apply the knowledge acquired during the lectures and tutorials on Heat Exchangers to several types of heat exchangers. Verify the results of manual calculations and those from the test bench.

Recommended prior knowledge:
Mastery of the knowledge acquired during the course, mastery of computer tools.

Content of the material:

Familiarization with the equipment available in the laboratory.

TP 1. Twin-pipe heat exchangers.
TP 2. Tubular heat exchanger.
TP 3. Plate heat exchanger.
TP 4. Introduction to commercial software.

Evaluation method:
Exam**:**100%.

Bibliographical references:
Brochures are available at the laboratory.

Semester 3
Teaching Unit: UET 2.1
Subject 1: Reverse Engineering
VHS: 45 hours (course: 1 h 30 and Workshop: 1 hour 30 minutes)
Credits: 2
Coefficient: 2

Teaching objectives:

- Understanding the principles and objectives of Reverse Engineering (RE) in the field of science and technology (ST),
- To become familiar with the tools and methods of RE in the relevant specialty.
- To understand the value and ethics of RE principles in the design, manufacturing, and quality assurance of products,
- Encouraging critical thinking, technical curiosity, reasoned reverse engineering, and innovation,
- Learn to analyze, document and model an existing system without initial documentation.

Skills targeted

- Decompose and analyze an existing system,
- To faithfully reproduce a technical diagram or 3D model from an existing product,
- Apply diagnostic and simulation tools,
- Working in a group on an exploratory project,
- Identify the legal limits of reverse engineering

Adaptability to specializations within the field of Science and Technology:

- All specialties within the ST field are affected, according to
- Examples of tasks: Digital technical documentation, technology watch results, technical project management, collaboration on plans, report analysis, understanding of industrial processes, production data monitoring, reporting techniques, prototyping, testing)

Prerequisites:

–Fundamental knowledge in the specialty.

Contents of the material:

1. Introduction to Reverse Engineering

- History, legal and ethical issues of the RE,
- Definitions and fields of application: Approaches (hardware, software, processes…)
- Areas of expertise: maintenance, remanufacturing, cybersecurity, competitive intelligence

2. General Methodology

- Analysis of a “black box” system
- Functional decomposition
- Block diagrams, input/output diagrams, energy or information flow diagrams

3. Hardware Reverse Engineering

- Electronic boards: visual inspection, component identification
- Tools used: multimeter, oscilloscope, logic analyzer
- Electrical diagram recognition,
- Reconstructing schematics using KiCad / Proteus

4. Reverse engineering software

- Static analysis of binaries (e.g., .exe, .hex, .bin)
- Decompilation, disassembly (introduction to Ghidra, IDA Free, or Hopper)
- Behavior observation: sniffing, monitoring (e.g. Wireshark)
- Microcontroller cases: flash memory reading, firmware extraction

5. Mechanical Reverse Engineering

- 3D scanning: scanning, manual measurements
- Reproduction of CAD models from existing parts
- Software used: SolidWorks, Fusion360

6. Security and intrusion detection

- Reverse engineering in cybersecurity: malware detection, vulnerabilities
- Software signing, protections against RE (obfuscation, encryption)

7. Real-world case studies

- Analysis of an obsolete or unknown product (mouse, power supply, Bluetooth module, etc.)
- Example of reverse engineering of a mechanical part or simple system (fan, housing)

Examples of practical work (based on the 4 Geniuses)

- **Electrical Engineering:**

- Reverse engineering an electronic module without a schematic
- Example: Bluetooth module, time-delay relay
- Objectives: to identify the function, to draw the diagram, to propose an improved variant.
- Identification of components (ICs, transistors, resistors, etc.).
- Tools used: multimeter, oscilloscope, logic analyzer.
- Reading and extracting firmware from a microcontroller.
- Introduction to the detection of electronic counterfeits.

- **Mechanical Engineering :**

- Reverse engineering a simple mechanism
- Examples: hand pump, torque wrench, mini press...
- Mechanical dismantling of a system (pump, gear, cylinder…).
- Measurements and reconstruction of plans or 3D models with CAD software (SolidWorks, Fusion360).
- Identification of materials and manufacturing methods.
- Functional simulation based on the recreated model.

- **Civil Engineering:**

- Analysis of existing structures without plans (walls, slabs, structures…).
- Examples: metal staircase, window sill, formwork)
- Study and reverse engineering of an existing structural element
- Identification of materials, assemblies and constraints.
- Modeling of the structure using Revit, AutoCAD or SketchUp.
- Study of the rehabilitation or reproduction of old structural elements.

- **Process Engineering:**
- Reverse engineering of a laboratory module
- Examples: simple instruments, distillation, filtration, heat exchanger, reactor…
- Analysis of existing industrial systems (distillation column, heat exchanger, reactor…).
- Reconstruction of PFD and PID diagrams from the observation of an installation.
- Identification of sensors, actuators, control devices.
- Study of mass/energy flow in a process.

Evaluation method:

- practical techniques
- Mini reverse engineering project (report + presentation)
- Final exam (multiple-choice questions + case study)

- Exam: 60% Practical work: 40%

Bibliographical references:

- Reverse Engineering for Beginners – Dennis Yurichev (free online)
- The IDA Pro Book – Chris Eagle (software)
- Practical Reverse Engineering – Bruce Dang
- Documentation:
  - https://ghidra-sre.org
  - https://www.kicad.org
  - https://www.autodesk.com/products/fusion-360

Semester: 3
Teaching Unit: UET 2.1
Subject 1: Documentary research and dissertation design
VHS: 10h30 (course: 1 hour 30 minutes)
Credits: 1
Coefficient: 1

Teaching objectives:
To give the student the necessary tools to search for useful information in order to better utilize it in their final year project.Help him through the various stages involved in writing a scientific document. Inform himthe importance of communication and himlearn to present the work done in a rigorous and educational manner.

Recommended prior knowledge:
Writing methodology, Presentation methodology.

Content of the material:

Part I: Documentary Research:

Chapter I-1: Definition of the subject (2 Weeks)
- Subject title.
- List of keywords related to the topic.
- Gather basic information (acquisition of specialized vocabulary,meaning of terms, linguistic definition).
- The information sought.
- To take stock of one's knowledge in the field.

Chapter I-2:Selecting information sources (2 Weeks)
- Document type (Lbooks, theses, dissertations, journal articles, conference proceedings, audiovisual documents…).
- Type of resources (Libraries, Internet…).
- Evaluate the quality and relevance of information sources.

Chapter I-3:Locate the documents (1 Week)
- Research techniques.
- Search operators.

Chapter I-4: Processing information (2 Weeks)
- Work organization.
- The initial questions.
- Summary of the selected documents.
- Links between different parts.
- Final plan for the literature search.

Chapter I-5: Presentation of the bibliography (1 Week)
- Bibliography presentation systems (The Harvard system, The Vancouver system, The mixed system…).
- Presentation of the documents.
- Citation of sources.

Part II: Memory Design

Chapter II-1Dissertation Plan and Stages **(2 Weeks)**

- Define and delimit the subject (Summary).
- Problem statement and objectives of the thesis.
- Other useful sections (Acknowledgments, Table of abbreviations…).
- The introduction (The writing of*the introduction last).*
- State of the specialized literature.
- Formulation of hypotheses.
- Methodology.
- Results.
- Discussion.
- Recommendations.
- Conclusion and perspectives.
- The table of contents.
- The bibliography.
- The appendices.

Chapter II- 2Writing techniques and standards **(2 Weeks)**

- The formatting.Numbering of chapters, figures and tables.
- The cover page.
- Typography and punctuation.
- Writing. Scientific language: style, grammar, syntax.
- Spelling.Improvement of general language skills in terms of comprehension and expression.
- Back up, secure, archive your data.

Chapter II-3:Workshop : Critical study of a manuscript **(1 Week)**

Chapter II-4Oral presentations and defenses **(1 Week)**

- How to present a poster.
- How to present an oral communication.
- Dissertation defense.

Chapter II-5: How to Avoid Plagiarism? **(1 Week)**

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

- The quote.
- The paraphrase.
- Provide the complete bibliographic reference.

Evaluation method:

Exam: 100%

Bibliographical references:

1. *M. Griselin et al., Guide to Written Communication, 2nd edition, Dunod, 1999.*
2. *JL Lebrun, Practical guide to scientific writing: how to write for the international scientific reader, Les Ulis, EDP Sciences, 2007.*
3. *HAS.Mallender Tanner, ABC of technical writing: user manuals, instructions for use, online help, Dunod, 2002.*
4. *Mr. Greuter, Writing your thesis or internship report well, L'Etudiant, 2007.*

5. *M. Boeglin, Reading and Writing at University: From the Chaos of Ideas to Structured Text. L'Etudiant, 2005.*
6. *Mr. Beaud, The Art of the Thesis, Casbah Editions, 1999.*
7. *Mr. Beaud, The Art of the Thesis, La Découverte, 2003.*
8. *Mr. Kalika, Master's thesis, Dunod, 2005.*

Suggestions for some discovery topics

Semester: x
Teaching Unit: UED xx
Subject: energy transport and storage
VHS: 10h30 (course: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:

Recommended prior knowledge:

Content of the material:

Chapter 1 Different forms of energy.

Chapter 2 Energy management: production, transformation, transport and storage.

Chapter 3 Energy transport.
- 3.1 Transport of fuels.
- 3.2 Transport of electrical energy.
- 3.3 Transport of hydraulic energy.
- 3.4 Transport of thermal energy.

Chapter 4 Energy storage.
- 4.1 Interest.
- 4.2 Energy efficiency of an energy storage system.
- 4.3 Forms of energy storage.
  - 4.3.1 Mechanical storage: potential and kinetic (pumping, compressed air, flywheels, etc.).
  - 4.3.2 Electrochemical and electrostatic storage: batteries and accumulators.
  - 4.3.3 Chemical storage: hydrogen and methane
  - 4.3.4 Thermal and thermochemical storage: sensible heat, latent heat, energy by sorption.
  - 4.3.5 New storage technologies.
- 4.4 Energy storage cost.

Evaluation method:
Exam: 100%.

Bibliographical references:

Semester: x
Teaching Unit: UED xx
Subject: Energy Audit
VHS: 10h30 (course: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:
To present the tools for conducting an energy audit and to enable students to acquire the necessary knowledge to carry out energy audits in different sectors of activity.

Recommended prior knowledge:

Thermodynamics, heat transfer, heat engines.

Content of the material:

Chapter 1. General Information on Energy **(2 weeks)**
- Types and sources of energy
- Energy transport
- Algerian Energy Pricing System (electricity and thermal)
- Algerian legislation and the obligation of energy audits

Chapter 2: Energy Audit **(4 weeks)**
- Industrial sector
- Tertiary sector
- Building sector

Chapter 3: Energy Audit Methodology **(4 weeks)**
- Preliminary Audit
- Detailed audit
- Recommendations for energy-saving solutions
- Costing of solutions and return time
- Drafting the audit report

Chapter 4: Implementation of an energy management system **(2 weeks)**
- The ISO 50001 standard

Chapter 5: Case Study **(3 weeks)**

Evaluation method:
Exam: 100%.

Bibliographical references:

1. Energy audit, PA Bernard, 1995.
2. Technical guide to energy auditing, K. Moncef and M. Dominique, 2016.
3. Material and energy balances, G. Henda, 2012.
4. www.aprue.org.dz

Semester: x
Teaching Unit: UED xx
Subject: Renewable energy
VHS: 10h30 (course: 1 h 30)
Credits: 1
Coefficient: 1

Teaching objectives:
Have general knowledge about renewable energies.

Recommended prior knowledge:
Heat transfer, MDF, thermodynamics.

Content of the material:

Chapter 1. GENERAL INFORMATION (1 week)
Definitions and vocabulary: renewable energies, sustainable development, renewable energies in Algeria.

Chapter 2. Wind Energy (2 weeks)
II.1. Wind and its characteristics.
II.2. The different types of wind turbines.
II.3Main components.
II.4. Geometric Profiles.
II.5. Operating parameters, Betz limit.
II.6. Uses.

Chapter 3. SOLAR ENERGY (Solar Project) (6 weeks)
Definitions: The solar resource
III.1. Solar energy system.
III.2. Data relating to the sun and solar radiation, calculation of solar coordinates.
III.3. Concepts of time, TSV, TSM, TU, TL.
III.5. Components and models for calculating solar radiation.
III.6. Thermal conversion of solar energy.
III.7. Photovoltaic conversion of solar energy.

Chapter 4. HYDRAULIC ENERGY (1 week)
IV.1. Definitions, the water cycle in nature.
IV.2. Operating principle.
IV.3. Types of dams, types of turbines used, types of power plants.
Chapter 5GEOTHERMAL ENERGY **(2 weeks)**
V.1. Definitions, principle of the technology.
V.2. Different types of geothermal deposits.
V.3. Uses.

Chapter 6. BIOMASS ENERGY (2 weeks)
VI.1. Definitions and origins.
VI.2. Constituents of biomass.
VI.3.Valuationthermochemical.
VI.4.Valuationchemical.

VI.5.Valuationbiological.

Evaluation method:

Exam: 100%.

Bibliographical references:

1. M. Capderou: Solar Atlas of Algeria, University Publishing Office, Algiers 1988.
2. JM. Chasseriaux: Thermal Conversion of Solar Radiation AFME 1984.
3. Y. Jannot: “Solar Thermal Engineering”, Course and Exercises. October 2003.
4. R. Bernard, G. Menguy, M. Schwartz: Solar Radiation, Thermal Conversion and Application. Technique et Documentation 1998.
5. P.DE BRICHAMBAUT: Solar Radiation and Natural Radiative Exchanges, Gauthier-Villars 1983.
6. J. Dsssautel: Heliothermic Sensors, EDISUD 1979.
7. J. Taine, JPPetit: Thermal Transfers, Mechanics of Anisothermal Fluids, Bodas 1989.
8. Guide to Renewable Energies in Algeria, (MEM, DER, 2002).
9. S. Bragard: Solar Water Heaters, From Study to Implementation of Sustainable Development Projects. Energy 2030 Agency SA
10. Daguenet Michel, “Solar Dryers: Theory and Practice” Unesco-1985.
11. CharreauA, Cavaille R. “Drying: Theory and Calculations”, Technique De L'ingénieur J2480.
12. HAS. A. Sfeir and G. Guarracino, "Solar Systems Engineering: Application to Housing", Technique & Documentation - 1981.
13. M. Villoz, A. Labouret, 'Photovoltaic Solar Energy' The Professional's Manual.
14. JADuffieAnd WA Beckman: “Solar Energy Thermal Processes”, Wiley-Interscience, New York (1974).
15. P. Chouard, H. Michel and MF Simon, "Thermal Balance of a Solar House", Collection of the Directorate of Studies and Research EDF, Eyrolles Edition-1977.
16. JF Sacadura: “Initiation to Thermal Transfers”, Technique Et Documentation, Paris 1978.
17. W.HAS. Beckman, SA Klein and JA Duffie, “Solar Heating Design By The F-Cart Method” Edition Jhon Willey – New York 1977.
18. DuffieJa, Beckman WA, “Solar Engineeringof Thermal Processes”, John Wiley & Sons Inc, New York, -1980.
19. A.Labouret, G.Cumunel, JPBraun, B.Faraggi: Solar Cells, French Technical and Scientific Edition, Dunod Paris 2001.
20. REspic, "A Simple Formula for Estimating Energy Savings Provided by a Solar Water Heater." Promoclim Energie, Thermal Studies and... Volume 10 E, No. 4 - October 1979.
21. MDagaev, V. Demine, I. Klimishin and V. Charugin, "Astronomy", MIR Edition Moscow. -1986, Translation by Valentin Polonski).
22. McadamsW. H, “Transmission of Heat. », ÉditionDunod, -2nd Edition, -1961Kays W. M & Crawford M. E, “Convective Heat and Mass Transfer”, Mc Graw Hill Series in Mechanical Engineering.
23. Abdelkrim Haddad, “Thermal Transfers”, Dar-El-Djazairia -2001.
24. M. Carlier, “General and Applied Hydraulics”, Collection of the Directorate of Studies and Research of Electricity of France – Volume 14, Eyrolles Edition.
25. Jean Lemale. "Geothermal Energy". Le Moniteur. © Dunod, Paris 2009. ISBN 978-2-10-052879-0.
26. Regulatory Technical Document, ''Thermal Regulations for Residential Buildings - Rules for Calculating Heat Losses'', DTR C3-2', Booklet 1. CNERIB, Algiers, 1998.

Semester: x
Teaching Unit: UED xx
Subject: Maintenance of energy installations
VHS: 10h30 (course: 1 h 30)
Credits: 1
Coefficient: 1

Teaching objectives:

To know the basics of industrial maintenance, as well as the failures of energy installations and their solutions.

Recommended prior knowledge:

Knowledge of energy installations;
Know the statistical laws (normal, exponential).

Content of the material:

1. Introduction to maintenance.
2. Definition of the main concepts of maintenance.
3. Mathematical methods and tools for implementing maintenance actions.
4. Methodological tools for behavior analysis.
5. Software tools for maintenance (computer-aided maintenance management).
6. TPM (total productive maintenance).
7. Maintenance of some energy installations (compressor, heat pump, condenser, etc.).

Evaluation method:

Exam: 100%.

Bibliographical references:

1. Frédéric Tomala. Maintenance course. Systems management department. Higher Engineering Studies;
2. François Manchy, Jean Pierre Vernier: Maintenance: methods and organizations. 3rd edition DUNOD;
3. F. Castellazi, D. Cogniel, Y. Gangloff: Memotech industrial maintenance. ELeducalivre Edition.

Semester: x
Teaching Unit: UED xx
course: Electronic
VHS: 10h30 (course: 1 h 30)
Credits: 1
Coefficient: 1

Teaching objectives:

Recommended prior knowledge:

Content of the material:

Chapter 1 Preliminary concepts - Review

Chapter 2 Sinusoidal steady state

Chapter 3 The diode and its applications

Chapter 4 The bipolar transistor and its applications

Chapter 5 The linear integrated circuit and its applications

Evaluation method:
Exam: 100%.

Semester: x
Teaching Unit: UED xx
Subject: Electrotechnics
VHS: 10h30 (course: 1 h 30)
Credits: 1
Coefficient: 1

Teaching objectives:

Recommended prior knowledge:

Content of the material:

Chapter 1 Three-phase systems.

Chapter 2 The transformer.

Chapter 3 Direct current machines.

Chapter 4 Synchronous machines.

Chapter 5 Asynchronous machines.

Evaluation method:
Exam: 100%.

Semester: x
Teaching Unit: UED xx
Subject: Hydraulic and Pneumatic Systems
VHS: 10h30 (course 1h 30)
Credits: 1
Coefficient: 1

Teaching objectives:

The program's objective is to provide students with a set of essential knowledge necessary for a physical understanding of hydraulic and pneumatic systems. This begins with the description of the various components (cylinders, distributors, valves, etc.) and progresses to the creation of hydraulic or pneumatic diagrams.

Recommended prior knowledge:

Knowledge of fluid mechanics, machine components and laws of physics.

Content of the material:

Chapter 1: Introduction and background **(2 weeks)**

- Hydraulic fluids: Mineral oils, synthetic oils and their characteristics.
- Calculation of pressure losses.
- Air and oil filtration.
- Air and oil filters: Types and choices.

Chapter 2: Hydraulic pumps, compressors and motors **(6 weeks)**

- Pumps: Types, construction and selection of axial piston pumps, radial piston pumps, vane pumps, gear pumps, screw pumps.
- Elements for calculating pumps.
- Compressors: Types, construction and selection of compressors.
- Elements for calculating compressors.
- Hydraulic motors: Axial piston motors, radial piston motors, gear motors, vane motors, slow cam and roller motors.
- Calculation elements for hydraulic motors.
- Single-acting cylinders, double-acting cylinders, double-rod double-acting cylinders, telescopic cylinders, rotary cylinders.
- Calculation of the cylinders.

Chapter 3: Other organs used in the
Hydraulic and pneumatic circuits **((3 weeks)**

- Distributors: Types, construction, selection and ordering (direct, indirect).
- Pressure limiters: Types, construction, selection and control (direct, indirect).
- Flow restrictors: Types, construction, selection and control (direct, indirect).
- Accumulators and reservoirs: Types, calculation and selection.
- Pipes: Materials, dimensions.
- Sensors: force, speed, position, temperature, etc.

Chapter 4: Practical Examples: **(4 weeks)**

- Establishment of hydraulic and pneumatic diagrams.
- Calculation of hydraulic and pneumatic circuits.

Evaluation method:

Exam: 100%.

Bibliographical references:

1. *Jacques Faisandier, Hydraulic and Pneumatic Mechanisms, Collection:Technology and Engineering, Dunod/L'Usine Nouvelle, 2013.*
2. *José RoldanViloria, Aide-mémoire: Industrial Hydraulics, L'Usine Nouvelle - Dunod.*
3. *R.-C. Weber, Safety of pneumatic systems, Festo Edition, 2012.*
4. *Simon Moreno,Edmond PeulotPneumatics in automated production systems, Publisher(s):Casteilla, 2001.*

Semester :x
Teaching Unit UED xx
Subject: Industrial Maintenance
VHS: 10h30 (course: 1 h 30)
Credits: 1
Coefficient: 1

Teaching objectives:

- To plan, estimate, direct or carry out the installation, commissioning, troubleshooting, modification and repair of devices, tools and machines;
- Design, implement and manage preventive maintenance methods and processes;
- Organize and carry out the modification or improvement of production machines and systems;

Recommended prior knowledge:
Basic concepts in industrial maintenance.

Content of the material:

Chapter 1 General Information and Definitions on Industrial Maintenance **(2 weeks)**
Introduction - Importance of maintenance in the company - Objectives of maintenance in the company - Maintenance policies in the company.

Chapter 2:Maintenance organization **(1 week)**
The role of maintenance within the overall structure - Internal maintenance organization -Human resources -Material resources

Chapter 3:Maintenance methods and techniques **(2 weeks)**
Generalities – Maintenance methods (corrective; preventive; systematic and conditional preventive) – Maintenance operations – Related maintenance activities.

Chapter 4:Availability and FMD concepts **(4 weeks)**
Reliability – Maintainability – Availability – FMEA concepts – Costs and analysis of an FMEA policy – Failure Mode, Effects and Criticality Analysis (FMEA)

Chapter 5:Machine file and technical documentation **(1 week)**
Purpose of the documentation - Machine file.

Chapter 6:Maintenance costs **(3 weeks)**
Cost composition - Cost analysis and ABC method - Optimal preventive maintenance - Example of MTBF calculation - Optimization of replacement using the probability model - Choice between maintenance and replacement - Economic life - Equipment decommissioning.

Chapter 7: CMMS **(2 weeks)**

Evaluation method:
Exam: 100%.

Bibliographical references:

1- *Jean-Claude FrancastelMaintenance Engineering: From the design to the operation of an asset, Publisher(s):Dunod,The New Factory, Collection :Technology and Engineering - Industrial Management, 2009.*
2- *François Castellazzi,Yves Gangloff,Denis CognielIndustrial Maintenance: Maintenance of industrial equipment, Publisher: Cateilla, 2006.*
3- *Pascal Denis,Pierre Boyé,André Bianciotto, Guide to industrial maintenance, Editions: Delagrave, 2008.*
4- *Serge Tourneur, Corrective maintenance in electrical equipment and installations: Troubleshooting and measurement, Editions: Cateilla, 2007.*
5- *Jean-Marie Auberville, Industrial Maintenance From Basic Maintenance to Safety Optimization, Editions: Ellipse.*
6- *Sylvie Gaudeau, Hassan Houraji, Jean-Claude Morin, Julien Rey, Industrial Equipment Maintenance. Volume 1: From Component to System. Publisher: Hachette.*