Algerian Democratic and People's Republic

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Ministry of Higher Education and Scientific Research

National Educational Committee for the Science and Technology sector

HARMONIZATION
TRAINING OFFER
ACADEMIC MASTER

Update
2021-2022

Domain	Sector	Speciality
Aeronautical Science and Technology		*Aeronautical propulsion*

Algerian Democratic and People's Republic

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2021-2022

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I – Master's identity card

Access conditions

(Indicate the bachelor's degree specializations that can provide access to the Master's degree)

Sector	Harmonized Master	Licenses providing access at the master's level	Ranking according to compatibility of the license	Coefficient affected to the licence
Aeronautics	Aeronautical Propulsion	Aeronautics	**1**	**1.00**
		Energy	**2**	**0.80**
		Construction	**3**	**0.70**
		Physical	**3**	**0.70**
		Other licenses in the ST domain	**5**	**0.60**

II – Half-yearly organization sheets for the specialty courses

Semester 1:

Teaching unit-training	Materials / Titled	Credits	Coefficient	VHH Neckrs	VHH TD	VHH TP	VHS (15 weeks)	Additional Work in Consultation tion (15 weeks)	Evaluation mode-luation CC	Exa-men
Fundamental EU Code: UEF 1.1.1 Credits: 10 Coefficients: 5	Advanced Fluid Mechanics	6	3	3h00	1h30		67h30	82h30	40%	60%
	Turbomachines 1	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 1.1.2 Credits: 8 Coefficients: 4	Heat and mass transfer1	4	2	1h30	1h30		45h00	55h00	40%	60%
	Applied thermodynamics	4	2	1h30	1h30		45h00	55h00	40%	60%
EU Methodology gic Code: UEM 1.1 Credits: 9 Coefficients: 5	Advanced Fluid Mechanics Practical Work	2	1			1h30	37h30	37h30	40%	60%
	Practical work on heat and mass transfer	2	1			1:30 a.m.	to 10:30 p.m.	27h30	100%	
	Applied Thermodynamics Practical Work	2	1			1:30 a.m.	to 10:30 p.m.	27h30	100%	
	Aircraft design	3	2	1h30		1:00 a.m.	- 10:30 p.m.	27h30	100%	
EU Discovery Code: UED 1.1 Credits: 2 Coefficients: 2	***Basket of choice 1***	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
	Basket of choice 2	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Transversal EU Code: UET 1.1 Credits: 1 Coefficients: 1	Technical English and Terminology	1	1	1h30			10:30 p.m.	2:30 a.m.		100%
Total semester 1		**30**	**17**	**1:30 p.m.**	**6:00 a.m.**	**5:30 a.m.**	**375:00**	**375:00**		

Semester 2:

Teaching unit-ment	Materials	Credits	Coefficient	VHH			VHS (15 weeks)	Additional Work in Consultation tion (15 weeks)	Evaluation mode-luation	
	Titled			Neck rs	TD TP				CC	Exa-men
Fundamental EU Code: UEF 1.2.1 Credits: 10 Coefficients: 5	Finite volume method	6	3 3h00 1h30				67h30	82h30 40% 60%		
	Turbomachines 2	4 2 1h30 1h30					45h00	55h00 40% 60%		
Fundamental EU Code: UEF 1.2.2 Credits: 8 Coefficients: 4	Heat and mass transfer 2	4 2 1h30 1h30					45h00	55h00 40% 60%		
	In-depth aerodynamics	4 2 1h30 1h30					45h00	55h00 40% 60%		
EU Methodology gic Code: UEM 1.2 Credits: 9 Coefficients: 5	Practical work Finite volume method	2	1			1:00 a.m. 37:30 p.m.		37h30 100%		
	TP Turbomachines 2	2	1			1:30 a.m. to 10:30 p.m.		27h30 100%		
	Advanced Aerodynamics Practical Work	2	1			1:30 a.m. to 10:30 p.m.		27h30 100%		
	Regulation and control	3	2 1h30			1:00 a.m. - 10:30 p.m.		27h30 40% 60%		
EU Discovery Code: UED 1.2 Credits: 2 Coefficients: 2	***Basket of choice 1***	1	1 1h30				10:30 p.m.	2:30 a.m.		100%
	Basket of choice 2	1	1 1h30				10:30 p.m.	2:30 a.m.		100%
Transversal EU Code: UET 1.2 Credits: 1 Coefficients: 1	Compliance with standards and rules of ethics and integrity	1	1 1h30				10:30 p.m.	2:30 a.m.		100%
Total semester 2		**30 17 1:30 p.m. 6:00 a.m. 5:30 a.m. 375:00 375:00**								

Semester 3:

Teaching unit-ment	Materials: Titled	Credits	Coefficient	VHH: Course	VHH: TD	VHH: TP	VHS (15 weeks)	Work Complementary (15 weeks)	Assessment method: CC	Assessment method: Exam
Fundamental EU Code: UEF 1.3.1 Credits: 10 Coefficients: 5	Gas dynamics	6	3	3:00 a.m. to 1:30 a.m.			67h30 82h30 40% 60%			
	Digital Aerodynamics	4	2	1h30 1h30			45h00 55h00 40% 60%			
Fundamental EU Code: UEF 1.3.2 Credits: 8 Coefficients: 4	Aeroacoustics and turbulence	4	2	1h30 1h30			45h00 55h00 40% 60%			
	Combustion	4	2	1h30 1h30			45h00 55h00 40% 60%			
Methodological EU Code: UEM 1.3 Credits: 9 Coefficients: 5	Digital Aerodynamics TP	2	1			1h30 37h30 37h30 100%				
	TP Combustion	2	1			1h30 22h30 27h30 100%				
	Gas dynamics practical work	2	1			1h30 22h30 27h30 100%				
	Optimization	3	2	1h30		1:00 a.m. 10:30 p.m. 12:30 p.m. 40% 60%				
EU Discovery Code: UED 1.3 Credits: 2 Coefficients: 2	***Basket of choice 1***	1	1	1h30			10:30 p.m. - 2:30 a.m.			100%
	Basket of choice 2	1	1	1h30			10:30 p.m. - 2:30 a.m.			100%
Transversal EU Code: UET 1.3 Credits: 1 Coefficients: 1	Documentary research and dissertation design	1	1	1h30			10:30 p.m. - 2:30 a.m.			100%
Total semester 3		**30 17 1:30 p.m. 6:00 a.m. 5:30 a.m. 375:00 375:00**								

EU Discovery (S1, S2 and S3) of your choice

1. Materials of aeronautical structures
2. Non-destructive testing
3. Signal processing
4. Flight control and dynamics
5. Aircraft Fuels and Pollution
6. Programming for scientific computing
7. Compressible and supersonic flows
8. Finite element method *9. Orbit mechanics*
10. Airport management and security
11. Applied mathematics
12. Rocket Engines and Electric Propulsion
13. Hydraulic, Pneumatic and Electrical Systems for Aeronautics
14. Automation of Hydraulic, Pneumatic and Electrical Systems for Aeronautics tick
15. Helicopter
16. Aeroelasticity
17. Parametric analysis of the engine cycle
18. Dynamic analysis of rotors
19. Project management
20. Design of a micro aerial vehicle (MAV)
21. Others (to be defined by the training team according to local and/or regional priorities) nales)

Semester 4

Internship in a company leading to a dissertation and a defense.

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

This table is given for information purposes only.

Evaluation of the End of Master's Cycle Project

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

III - Detailed program by subject for semester S1

Semester: 1

Teaching unit: UEF 1.1.1

Subject: Advanced Fluid Mechanics

VHS: 67 h30 (Lecture: 3h00, Tutorial: 1h30)

Credits: 6

Coefficient: 3

Teaching Objectives: This course aims to give students a deeper insight into fluid mechanics, both by elucidating the fundamental principles of macroscopic physics in order to state the Navier-Stokes equation. In this UEF, the Cauchy tensors for stress and the constitutive law are introduced via the model of a Newtonian fluid in equilibrium in the gravitational field. To encourage general curiosity and in order to solve concrete problems, some general notions of advanced fluid mechanics such as the boundary layer, flows in pipes, dimensional analysis, introduction to turbulence are then introduced in a qualitative manner.

Recommended prior knowledge:

Basic concepts of fluid mechanics, mathematics and thermodynamics.

Content of the subject:

Chapter 1: Dynamics of viscous fluids **(5 weeks)**

1. Velocity and acceleration fields: - Local acceleration, Convective acceleration
2. Description and origin of forces in a fluid: - Volume forces, Surface forces, Linear forces (surface tension)
   - Constraints on a fluid particle
3. Momentum conservation equation
4. Equation of motion for Newtonian fluids (Navier Stockes) :
   - Limiting cases of viscosity: Euler equations, Stokes flow
   - Typical boundary conditions in fluid flows
   - Some simple solutions of the Navier Stockes equation

Chapter 2: Dimensional Analysis and Similarity **(2 weeks)**

1. Purpose of dimensional analysis
2. Principle of dimensional homogeneity
3. Vaschy-Buckingham Theorem (Pi Theorem)
4. Common dimensionless numbers in MDF and physical meaning:
   - Reynolds, Euler, Froude, Mach...
5. Different forms of similarity: - Geometric similarity - Kinematic similarity
   - Dynamic similarity
6. Application to models

Chapter 3: Boundary Layers **(3 weeks)**

1. Boundary layer on a flat plate:
   - Boundary layer thickness

- Displacement thickness
- Thickness of the momentum 2.

Boundary layer equation:

- Blasius solutions, Wall shear, Friction drag

3. Von Karman integral equation
4. Boundary layer stability and transition to turbulence
5. Effects of a pressure gradient: - Influence of acceleration or deceleration - Detachment of the boundary layer

Chapter 4: Introduction to turbulent flows : 1. Fluctuations in the velocity vector. **(3 weeks)**

2. Average movement.
3. Modeling of turbulence.
4. Turbulence models.

Chapter 5: Experimental Methods in Fluid Mechanics 1. Hot Wire Anemometer **(2 weeks)**

2. Laser Doppler Velocimetry 3. Particle Image Velocimetry

Assessment method:

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

Bibliographic references:

1- Inge L. Ryhming, Fluid Dynamics, Polytechnic and University Press Romands.

2- P. Chassaing, Turbulence in fluid mechanics, CEPADUES– Editions

3- R. Comolet, Experimental fluid mechanics, Volume II, dynamics of real fluids, turbomachines, Editions Masson, 1982.

4- TC Papanastasiou, GC Georgiou and AN Alexandrou, Viscous fluid flow, CRC Press LLC, 2000.

5- Adil Ridha, Course in Real Fluid Dynamics, M1 Mathematics and applications: Mechanics specialty, 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.

9- H. Tennekes and JL Lumeley, A first course in turbulence, The MIT Press 1972 10- Cengel YA & Cimbala JM "Fluid Mechanics: Fundamentals and Applications" McGraw-Hill 2004.

11- Kundu RK & Cohen IM “Fluid Mechanics” Academic Press 2002.

12- White FM “Fluid Mechanics” McGraw-Hill 2011.

Semester: 1

Teaching unit: UEF 1.1.2

Subject: Turbomachinery 1

VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4

Coefficient: 2

Teaching objectives

This course is an introduction to the operating principles, performance and design of turbomachinery.

The course first reviews the essential concepts of fluid dynamics and thermodynamics. Concepts relevant to all turbomachinery are then introduced. Axial turbines and compressors are studied in depth, including their kinematics, performance, and design.

At the end of this course, students will be expected to:

- Understand the operating principles of turbines and pumps/compressors.
- Be able to perform characteristic and performance analyses for a variety of machines.

- Be able to carry out basic design studies.
- Understand the basic operating principles of centrifugal machines, propellers, hydraulic turbines and wind turbines.

Recommended prior knowledge:

It is recommended to master: Thermodynamics, Fluid Mechanics.

Content of the material:

Chapter 1: Review of essential concepts of fluid mechanics and thermodynamics **(2 weeks)** mic

- Conservation laws: mass, momentum, energy
- Dimensional analysis
- Compressible flow

Chapter 2: Introduction to turbomachinery

- Definitions of machines
- Angular momentum
- Euler equation for turbomachines
- Speed triangles
- Yields and losses

Chapter 3: Two-dimensional floor

- Geometry and analysis of the flow field
- Compressor stages
- Turbine stages

Chapter 4: Centrifugal Machines

- Cinematics
- Centrifugal pumps and compressors
- Diffusers
- Radial turbines

Assessment method:

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

Bibliographic references :

1. *Erik Dick. Fundamentals of Turbomachines-Springer Netherlands (2015)*
2. *SL Dixon and CA Hall. Fluid Mechanics and thermodynamics -Seventh edition Elsevier (2014)*
3. *RK Bansal. A Text Book of Fluid Mechanics and Hydraulic Machines. laxmi posts (2005)*
4. *Lucien Vivier. Steam and Gas Turbines. Albin Michel Edition. Paris 1965*

Semester: 1

Teaching unit: UEF 1.2.1

Subject: Heat and mass transfer1

VHS: 45h30 (Lecture: 1h30, Tutorial: 1h30)

Credits: 4

Coefficient: 2

Teaching Objectives The objective of this UEF is to lead students towards an understanding of physical phenomena while exposing the specific laws governing heat and mass transfer, to enable them to estimate the different heat and mass flows and to identify the analogy between the heat equation and that of diffusion. Establish their links to the behavior of thermal systems and arrive at a practical appreciation of the physical origins of transfers through concrete examples.

Recommended prior knowledge:

To follow this course effectively, it is preferable to have basic knowledge of thermodynamics, fluid mechanics as well as basic mathematics.

Content of the material:

Chapter 1: General information on heat transfers **(2 weeks)**

1. Modes of heat transfer 2. Fundamental laws of heat transfer: - Fourier's law, Newton's law, Stefan-Boltzmann law
3. Energy Balance: Energy Conservation Equation

Chapter 2: Heat Conduction

1. Generalized Fourier's law 2. Thermal conductivity, thermal diffusivity 3. Heat diffusion equation: Cartesian, cylindrical and spherical coordinates
4. Initial and boundary conditions: Dirichlet, Neumann, mixed…

Chapter 3: Conduction in steady and transient conditions

1. Stationary one-dimensional conduction:
   - Simple and composite wall
   - Thermal resistance
   - Electrical analogy
   - Contact resistance
   - Fin theory
2. Stationary 2D and 3D conduction:
   - Form factor concept
   - Numerical methods (finite differences)
3. Conduction in transient regime:
   - Medium with negligible internal thermal resistance
   - Semi-infinite medium

Chapter 4: General information on mass transfer

1. Fick's Law
2. Definition of molecular diffusion
3. Concept of matter flow density
4. Definition of mass and molar average velocities

Assessment method:

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

Bibliographic references :

1. *Heat transfer, Ana-Maria BIANCHI, Yves FAUTRELLE, Jacqueline ETAY, University Agency of the Francophonie, Polytechnic and University Presses French-speaking Switzerland (2004).*
2. *Introduction to thermal transfers, Jean-Luc Battaglia, Andrzej Kusiak, Jean Ro-dolphe Puiggali, Dunod, Paris (2010).*
3. *Heat Transfer: A Practical Approach, Yunus A. Cengel, Mcgraw-Hill; 2nd Edition, (2002).*
4. *Sparrow EM, Cess RD Radiation heat transfer, Mac Graw Hill, 1978.*
5. *Franck P. Incropera, David P. De. Witt. Fundamentals of Heat and Mass Transfer, Ed John Wiley & Son 1990.*
6. *Jean-François Saccadura. Introduction to thermal transfers, Ed. Lavoisier, Paris 1993.*
7. *Hans Dieter Baehr · Karl Stephan. Heat and Mass Transfer.*
8. *Jean Taine and Jean-Pierre Petit. Heat transfers., ed. Dunod, Paris 1995*
9. *André B. De Vriendt. The Transmission of Heat. vol. 1, volume 1: Generalities. The con-duction, ed. Gaëtan Morin, 1982.*
10. *Taine J., Petit J.-P. Heat transfers, course and basic data, Dunod, 1995.*
11. *Whitaker S. Fundamental principles of heat transfer, Robert E. Krieger Publishing Com-Company Inc., 1983.*
12. *Wong HY Heat transfer for engineers, Longman, 1977.*

Semester: 1
Teaching unit: UEF 1.2.2
Subject: Applied thermodynamics
VHS: 45h30 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Knowledge and thermodynamic analysis of new cold generation processes: in particular from renewable energies: (absorption and ejector cycle) and the various configurations as well as the analysis of the various operating units such as the absorber, the regenerator.

Recommended prior knowledge: (Basic concepts:
Thermodynamics, turbomachines, heat and mass transfer, fluid mechanics).

Content of the material:

1. Generalities and fundamental principles **(2 weeks)**

- Thermodynamics and energy. - The states and equilibrium of a system. - The zeroth principle of thermodynamics. - The first and second principles of thermodynamics.

2. Gas-powered cycles **(3 weeks)**

-Carnot cycle.-Otto cycle. - Diesel cycle. - Stirling and Ericsson cycle. - Brayton cycle.

3. Steam power cycles (3 weeks)

Carnot steam cycle. - Ideal Rankine cycle. - Reheating cycle. - Regeneration cycle. - Cogeneration cycle.

4. Refrigeration cycles **(3 weeks)**

- Refrigerating machines. - Reverse Carnot cycle, Refrigerants, heat pumps, innovative compression refrigeration systems, gas refrigeration cycles.

5. Thermodynamic relationships and gas mixtures (3 weeks)

- An overview of partial derivatives and their relationships, Maxwell's relationship, Clapeyron's equation, Some general relationships of thermodynamics, Joule-Thompson coefficient, variations of enthalpy, internal energy and entropy of real gases, Composition of a gas mixture, PVT behavior of mixtures, thermodynamic variables of mixtures of real gases.

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Assessment method:

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

Bibliographic references:

1. *YA Cengel, MA Boles. "Thermodynamics: A Pragmatic Approach." McGRAW-HILL.*
2. *JC Sisi, "Principles of Thermodynamics," McGRAW-HILL, EDITORS.*
3. *J. Vidal, "Thermodynamics: Application to chemical engineering and the petroleum industry", TECHNIP Edition.*
4. *J. Vidal, "Thermodynamics: Application to chemical engineering and the petroleum industry", TECHNIP Edition.*
5. *A. Lallemand, "Exercises and problems in thermodynamics, from principles to applications to machines", TECHNOSUP, Ellipses.*
6. *A. Lallemand, "Refrigeration machines and heat pumps, from theory to practice, Course and corrected problems", TECHNOSUP, Ellipses.*
7. *W. Alexandre, "Macroscopic thermodynamics. For the use of students in the sciences of the engineer.*

Semester: 1
Teaching unit: UEM 1.1
Subject: Advanced Fluid Mechanics Practical Work VHS:
10:30 p.m. (Practical Work: 1:30 p.m.)
Credits: 2
Coefficient: 1

Teaching Objectives: The
Advanced Fluid Mechanics Practical Module plays a fundamental and active role in enabling students to acquire cognitive understanding and empirical information in the field of fluid mechanics. This module is carried out in the form of a series of experiments that serve to help our students better understand the fluid mechanics they have done theoretically during the past semester and consolidate the theoretical knowledge acquired in the fluid mechanics course.

Recommended prior knowledge: Fluid mechanics and thermodynamics courses.

Content of the material: According to existing material

TP N°1: Flow meters in loaded flows (The venturi & the diaphragm);
TP N°2: Flow through an orifice;
TP N°3: Experience of the impact of a water jet on different obstacles;
TP N°4: Reynolds experiment: laminar and turbulent flows;
TP N°5: Flow around an obstacle;
TP No. 6: Measurements of singular pressure losses in a pipe and speed profiles.
Other practical work to be offered depending on the material available.

Assessment method:
Continuous assessment: *100%.*

Bibliographic references :

1. *Books and handouts available in educational and research laboratories* (Thermal *Lab* , ***MDF*** *Lab* , ***Aerodynamics*** *Lab , Departmental Research Lab) and departmental 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: UEM 1.2

Subject: Practical work Heat and mass transfer

VHS: 10:00 p.m. (TP: 1h30)

Credits: 2

Coefficient: 1

Teaching objectives :

Practically illustrate the transfer of heat and mass, Measurements and exploitation of the results-
states.

Recommended prior knowledge:

(It is recommended to master heat transfer, Mathematical tools: derivation, differentiation, plane geometry).

Content of the material: according to existing material

Practical **work No. 1:** Thermal conduction (study of conduction along a simple bar, a composite bar, study of the thermal conductivity of an insulator, study of radial conduction).

TP N°2: Thermal convection (determination of the heat transfer coefficient in natural convection and forced convection as well as the influence of the exchange surface on the h: use of the rectangular, cylindrical fin).

TP No. 3: Thermal radiation (Stefann Boltzman law, inverse square law, Lambert's Cisi-nus law, etc.)

TP No. 4: Heat exchanger: determining the performance of a concentric exchanger in co-current and counter-current circulation

TP No. 5: Cooling tower: Heat and mass transfer.

Other practical work to be offered depending on the material available.

Assessment method:

Continuous assessment: *100%.*

Bibliographic references :

5. Franck P. Incropera, David P. De. Witt "Fundamentals of Heat and Mass Transfer", Ed John Wiley & Son 1990.

6. Jean-François Saccadura "Introduction to thermal transfers", Ed. Lavoisier, Paris 1993.

*7. Books and handouts available in educational and research laboratories (Thermal Lab , **MDF** Lab , **Aerodynamics** Lab , Departmental Research Lab) and departmental libraries. 8. http://www.tecquipment.com/Thermodynamics/Heat_Transfer.aspx?page=1*

9. http://www.deltalab-smt.com/teaching-energetics/heat-exchanges

10. Websites.

Semester: 1

Teaching unit: UEM 1.3

Subject: Applied Thermodynamics Practical Work

VHS: 10:00 p.m. (TP: 1h30)

Credits: 2

Coefficient: 1

Teaching objectives:

Carry out different physical thermodynamics experiments: Application of thermodynamics.

Recommended prior knowledge: (Thermodynamics course).

Content of the material: according to existing material

TP No. 1: Determination of coefficient of performance in:

- A heat pump, water-air
- A refrigeration machine (water-water, air-air)

TP No. 2: Determination of the coefficient of performance for different refrigerants (R134a and R22)

Other practical work to be offered depending on the material available.

Assessment method:

Continuous assessment: *100%.*

Bibliographic references:

1. *http://www.tecquipment.com/Thermodynamics.aspx*
2. *http://www.deltalab-smt.com/teaching-energetics/thermodynamics*
3. *YA Cengel, MA Boles. "Thermodynamics: A Pragmatic Approach." McGRAW-HILL.*
4. *D. Richon, "Elements of experimental thermodynamics", Ecole des Mines de Paris*
5. *A. Lallemand, "Exercises and problems of thermodynamics, from principles to applications to machines", TECHNOSUP, Ellipses.*
6. *A. Lallemand, "Refrigeration machines and heat pumps, from theory to practice, Course and corrected problems", TECHNOSUP, Ellipses.*
7. *Books and handouts available in the educational laboratories (Thermal Laboratory, MDF Laboratory, Motor Laboratory) and departmental libraries and*
8. *Websites and others.*

Semester: 1
Teaching unit: UEM 1.4
Subject: Aircraft Design
VHS: 37h30 (Lecture: 1h30, Practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

The aircraft design specific to the Aeronautical Propulsion Master aims to train students to master the 3D CAD software SOLIDWORKS or CATIA.

The parts of the training:

- Advanced part modeling teaches students how to use multibody solids, loft and sweep features, and the most advanced SolidWorks features for defining complex shapes.

- Advanced surface modeling training teaches students how to use surface features to create complex parts.

Recommended prior knowledge:

Knowledge acquired from the Aircraft CAD module, basic SOLIDWORKS or CATIA

Content of the material:

1. Understanding Surfaces (2 weeks)

Extruded surface, flat surface, restricting a surface, stitched surface.

2. Introduction to surface management (2 weeks)

Surface with revolution, swept surface, radiated surface, Extended surface.

3. Advanced Surface Modeling Techniques (3 weeks)

Ruled surfaces, Smoothing surfaces.

4. Sketching with splines (4 weeks)

Spline and Spline Tools, Evaluating Curvature Fields, Control Polygon, Spline Handles Analyzing Geometry, Curvature, Zebra Stripes, Style Spline, Adjusting Spline

5. 3D design of an aircraft (4 weeks)

Application of different modeling techniques in order to design a complete aircraft or an element (blade, hull, wing, fuselage, wheel, etc.)

Practical work part:

Under SolidWorks or other CAD software

Application of different modeling techniques in order to design a complete aircraft or an element (blade, hull, wing, fuselage, wheel, etc.)

Assessment method:

Continuous assessment: 40%, Exam: 60%

Bibliographic references:

1. *Official SolidWorks software website (see Help)*
2. *Official website of CATIA software (see Help)*
3. http://perso.univ-lemans.fr/~fcalvay/projetsmnrv/model_crash_abaqus.htm

Semester: 1

Teaching unit: UED 1.1 Subject: Subject 1 of your choice

VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1

Coefficient: 1

Content of the material:

See the basket of choices: The choice of subject for this semester is left to the discretion of the teaching team

Assessment method:

Review: *100%.*

Semester: 1

Teaching unit: UED 1.2 Subject: Subject 2 of your choice

VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1

Coefficient: 1

Content of the material:

See the basket of choices: The choice of subject for this semester is left to the discretion of the teaching team

Assessment method:

Review: *100%.*

Semester: 1

Teaching unit: UET 1.1

Subject: Technical English and Terminology

VHS: 10:30 p.m. (Class: 1.5 hours)

Credits: 1

Coefficient: 1

Teaching objectives:

Introduce the student to technical vocabulary. Strengthen their knowledge of the language. Help them understand and summarize a technical document. Enable them to understand a conversation in English held in a scientific setting.

Recommended prior knowledge:

Basic English Vocabulary and Grammar

Content of the material:

- Written comprehension: Reading and analysis of texts relating to the aeronautical specialty.
- Oral comprehension: Based on authentic popular science video documents, note-taking, summary and presentation of the document.
- Oral expression: Presentation of a scientific or technical subject, development and exchange of oral messages (ideas and data), Telephone communication, Gestural expression.
- Written expression: Extracting ideas from a scientific document, Writing a scientific message, Exchanging information in writing, writing CVs, letters of application for internships or jobs.

Recommendation :

The subject manager is strongly recommended to present and explain at the end of each session (at most) around ten technical words of the specialty in the three languages (if possible) English, French and Arabic.

Assessment method:

Review: *100%.*

Bibliographic references:

1. PT Danison, Practical guide to writing in English: usages and rules, practical advice, Editions d'Organisation 2007
2. A.Chamberlain, R. Steele, Practical Guide to Communication: English, Didier 1992
3. R. Ernst, Dictionary of Applied Technology and Sciences: French-English, Dunod 2002.
4. J. Comfort, S. Hick, and A. Savage, Basic Technical English, Oxford University Press, 1980
5. EH Glendinning and N. Glendinning, Oxford English for Electrical and Mechanical Engineering, Oxford University Press 1995
6. TN Huckin, and AL Olsen, Technical writing and professional communication for nonnative speakers of English, McGraw-Hill 1991 7. J. Orasanu, Reading Comprehension from Research to Practice, Erlbaum Associates 1986

IV - Detailed program by subject for semester S2

Semester: 2

Teaching unit: UEF 2.1.1
Subject: Finite volume method

VHS: 67 h30 (Lecture: 3h00, Tutorial: 1h30)
Credits: 6

Coefficient: 3

Teaching objectives:

-Master the discretization of EDPs using the finite volume method.
- Solve discretized equations using calculation algorithms (SIMPE, SIMPLER, etc.)
-Allow students to develop finite volume calculation codes.

Recommended prior knowledge: Numerical analysis, differential equations, computer tools.

Content of the subject:

Chapter 1: General information on computational fluid dynamics (CFD). **(1 week)**
Chapter 2: The finite volume method for diffusion problems. **(2 weeks)**
Chapter 3: The finite volume method for convection-diffusion problems. **(3 weeks)**
Chapter 4: Solution algorithms (SIMPLE, SIMPLER, PISO). **(3 weeks)**
Chapter 5: Solution of discretized algebraic equations. **(2 weeks)**
Chapter 6: The finite volume method for transient flows. **(2 weeks)**
Chapter 7 : The Volume Method for Convection-Diffusion Problems (method ÿ-ÿ). **(2 weeks)**

Assessment method:

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

Bibliographic references:

1. *HK Versteeg, W. Malasasekera, "Introduction to ComputationalFluid Dynamics: The finite volume method (2nd Edition)", Pearson, Prentice Hall, 2007.*
2. *SV Patankar, "Numerical Heat Transfer and Fluid Flow", Hemisphere, Washington, DC, 1980.*
3. *F. Jedrzejewski, Introduction to Numerical Methods, Second edition, Springer-Verlag, France, Paris 2005.*
4. *WH Press, S. Teukolsky, WT Vetterling, BP Flannery, Numerical recipes in Fortran, Cambridge University press, 1995.*
5. *B. Carnahan, HA Luther and JO Wilkes, Applied numerical methods, R. Kriegerpublisher, 1990.*
6. *FS Acton, Numerical methods that work, The mathematical association of America, 1990.*
7. *Joe D. Hoffman, Numerical Methods for Engineers and Scientists 2nd Edition, Marcel Dekker, editor, 2001.*
8. *N. Boumahrat and Gourdin, Numerical Methods, OPU, 1980.*
9. *JD Faires and RL Burden, Numerical methods, Brooks Cole 3rd edition, 2002*
10. *Oliver Aberth, Introduction to Precise Numerical Methods, Elsevier editor, 2007.*
11. *Rao V. Dukkipati, Numerical methods, Publishing for one world, 2010.*

Semester: 2

Teaching unit: UEF 2.1.2
Subject: Turbomachines 2

VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4

Coefficient: 2

Teaching objectives

The course aims to provide fundamental knowledge on the design and industrial application of turbomachinery.

This involves developing an overview of applied thermodynamics and aerodynamics, as well as applying this knowledge in several technological fields.

The objectives are:

- Explain how turbomachinery is applied in various fields of power generation such as gas turbine and combined cycle power plants, wind and hydroelectric power plants, wind and hydroelectric engineering.

- Formulate design criteria for turbomachines for a range of applications.
- Carry out the preliminary design of a range of turbomachines.
- Be able to apply commercial tools to define a more detailed design of turbomachinery.

Recommended prior knowledge:

It is recommended to master: Thermodynamics, Fluid Mechanics, turbo-machinery course 1 acquired in “S1”.

Content of the material:

Chapter 1: Axial Turbines

Introduction, Single-stage velocity triangle, single-stage impulse, multi-stage impulse, reaction stages, blade-to-gas velocity ratio, losses and efficiencies, Efficiency curves.

Chapter 2: Radial Turbine Elements of the radial turbine stage, speed triangles of a stage, HS diagram, Losses in a stage, characteristics and efficiency.

Chapter 3: Axial Compressors

Introduction. Geometry and operating principle, single-stage velocity triangles, HS diagram. Flow through a row of blades, stage losses and efficiency, supersonic and transonic stages, supersonic and transonic stages Characteristics and efficiency - Stalling and surge

Chapter 4: Centrifugal Compressors

Introduction and different parts of centrifugal compressor, working principles.
HS diagram. Nature of the flow in the wheel, slip factor, diffuser, Volute, characteristics, efficiencies and losses in a centrifugal compressor.

Chapter 5: Three-dimensional effects in turbines and compressors
- Radial balance
- Three-dimensional flow characteristics and loss mechanisms - Design elements

Assessment method:

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

Bibliographic references :

1. *Erik Dick. Fundamentals of Turbomachines-Springer Netherlands (2015)*
2. *SL Dixon and CA Hall. Fluid Mechanics and thermodynamics -Seventh edition Elsevier (2014)*
3. *RK Bansal. A Text Book of Fluid Mechanics and Hydraulic Machines. laxmi posts (2005)*
4. *Lucien Vivier. Steam and Gas Turbines. Albin Michel Edition. Paris 1965*

Semester: 2

Teaching unit: UEF 2.2.1 Subject: Heat and mass transfer 2 VHS: 45h30 (Lecture: 1h30, TD: 1h30)

Credits: 4

Coefficient: 2

Teaching objectives This UEF aims to complete the body of knowledge in heat and mass transfer in the first semester by focusing on i) Heat and mass transfer by convection, ii) Heat transfer by radiation.

Recommended prior knowledge: Basic notions of fluid mechanics and applied mathematics as well as knowledge of heat and mass transfer 1 acquired in S1 are essential.

Content of the material:

Chapter 1: Heat and Mass Transfer by Convection 1. Convective Boundary Layer:
Dynamic, Thermal and Mass Boundary Layer 2. Local and Average Convective Heat Transfer Coefficient:
Heat Transfer, Mass Transfer
mass
3. Laminar and turbulent flow 4. Types of
convection: Forced, Natural and Mixed 5. Common dimensionless
numbers and physical meaning: - Reynolds, Prandtl, Schmidt, Nusselt,
Sherwood, Grashof, Rayleigh, Lewis...
6. Correlations for calculating heat and mass transfer: - Internal and external forced
convection - Internal and external natural
convection

Chapter 2: Heat Transfer by Radiation
1. Electromagnetic spectrum 2.
Thermal radiation 3. Classification
of bodies subjected to radiation: - Transparent, opaque and semi-
transparent bodies 4. Black body radiation: - Planck's law,
Wien's law, Stefan-Boltzman's law -
Energy emitted in a range of wavelengths - Radiation energy
intensity - Irradiation

5. Radiative properties: -
Transmission, Reflection and Absorption - Kirchhof's
law - Gray body 6.
Radiative
exchanges between surfaces:
- Form factor: Reciprocity, Crossed chord method, Formulas and abacuses
- Exchanges between two black surfaces
- Exchanges between two gray surfaces

Assessment method:

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

Bibliographic references :

1. *Heat transfer, Ana-Maria BIANCHI, Yves FAUTRELLE, Jacqueline ETAY, University Agency of the Francophonie, Polytechnic and University Presses French-speaking Switzerland (2004).*
2. *Introduction to thermal transfers, Jean-Luc Battaglia, Andrzej Kusiak, Jean Ro-dolphe Puiggali, Dunod, Paris (2010).*
3. *Heat Transfer: A Practical Approach, Yunus A. Cengel, Mcgraw-Hill; 2nd Edition, (2002).*
4. *Sparrow EM, Cess RD Radiation heat transfer, Mac Graw Hill, 1978.*
5. *Franck P. Incropera, David P. De. Witt. Fundamentals of Heat and Mass Transfer, Ed John Wiley & Son 1990.*
6. *Jean-François Saccadura. Introduction to thermal transfers, Ed. Lavoisier, Paris 1993.*
7. *Hans Dieter Baehr · Karl Stephan. Heat and Mass Transfer.*
8. *Jean Taine and Jean-Pierre Petit. Heat transfers., ed. Dunod, Paris 1995*
9. *André B. De Vriendt. The Transmission of Heat. vol. 1, volume 1: Generalities. The con- duction, ed. Gaëtan Morin, 1982.*
10. *Taine J., Petit J.-P. Heat transfers, course and basic data, Dunod, 1995.*
11. *Whitaker S. Fundamental principles of heat transfer, Robert E. Krieger Publishing Com- Company Inc., 1983.*
12. *Wong HY Heat transfer for engineers, Longman, 1977.*

Semester: 2

Teaching unit: UEF 2.2.2

Subject: Advanced Aerodynamics

VHS: 45h30 (Lecture: 1h30, Tutorial: 1h30)

Credits: 4

Coefficient: 2

Teaching Objectives: The
objective of this UEF is to study advanced aspects of fluid mechanics and aerodynamics. This subject aims to deepen students' knowledge of complex aerodynamic phenomena, such as subsonic airfoils in two dimensions and the finite wing in three dimensions, boundary layer phenomena, lift, drag, aerodynamic design and aeronautical propulsion.

Recommended prior knowledge:

Basic knowledge of aerodynamics, fluid mechanics and applied mathematics is essential.

Content of the material:

Chapter 1: Reminders and basic concepts

1.1 The statics of the atmosphere
1.2 Navier-Stokes equations 1.3
Similarity theory 1.4 Boundary
layer 1.5 Viscous drag

1.6 Nomenclature of profiles and aerodynamic parameters
1.7 Nomenclature of wings and aerodynamic parameters
1.8 Evolution of wings during the interwar period
1.9 Elliptical wings

Chapter 2: Dynamics of incompressible flows without viscous effect

2.1 Euler and Bernoulli equations
2.2 Circulation and vorticity
2.3 Kelvin's Theorem and Irrotational Flow
2.4 Current Function and Speed Potential
2.5 Potential Flow and Laplace Equation
2.6 Elementary potential flows
2.7 Conformal Transformation – Zhukovsky Theory
2.8 Source Panel Method

CHAPTER 3: Theory of skeletal (thin) profiles

3.1 Fundamental equation of thin profile theory
3.2 Symmetrical thin profiles
3.3 Thin cambered profiles

Machine Translated by Google

3.4 Shock waves

3.5 Lift coefficients and the zero-lift angle of incidence for a symmetrical thin profile and a cambered profile.

3.6 High lift and CL control, trapping (suction and blowing)

3.7 Thick profiles (supercritical wing) - Vorticity panel method

3.8 Evolutionary wings

3.9 Variable geometry wings (Swing Wing)

3.1O Digital Applications

CHAPTER 4: The Plane Wing of Finite Span

4.1 Wingtip Effects

4.2 Vortex system of a wing 4.3 Prandtl's lifting line theory - Elliptical distribution

4.4 General Distribution

4.5 Digital Applications

CHAPTER 5: Real flow around a wing

5.1 Consideration of a real viscous fluid

5.2 Study of detachment (detachment of the boundary layer)

5.3 Evolution of boundary layer detachment on a thin profile

5.4 Evolution of the boundary layer on a thick profile

5.5 Study of stall on profile with a high-lift device (flap or slat)

5.6 Effect of aspect ratio on max CL for three-dimensional wings

Assessment method:

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

Bibliographic references :

1. *John D. Anderson, Fundamentals of aerodynamics, McGraw-Hill, New York, 1991.*
2. *Arnold M. Kuethe, Chuen-Yen Chow, Foundations of aerodynamics: bases of aerodynamics design, Wiley, New York, 1998.*
3. *John J. Bertin, Michael L. Smith, Aerodynamics for engineers, Prentice Hall Englewood Cliffs, NJ, 1989.*
4. *Paraschivoiu.I. , "Subsonic Aerodynamics," Editions de l'École Polytechnique de Montréal. Canada. 1998.*
5. *Lo Houghton, PW Carpenter: Aerodynamics for Engineering Students fifth edition.1993.*
6. *Fluid mechanics and aerodynamics. Gline grosso-1998 .London.*
7. *J.LUNEAU A.BONNET: Theory of fluid dynamics.CEPADUES-EDI-TIONS.1992.*

Semester: 2

Teaching unit: UEM 2.1
Subject: Practical work Finite volume method

VHS: 10:30 p.m. (TP: 1:30 p.m.)
Credits: 2

Coefficient: 1

Teaching objectives:

Allows the student to:

- Master the discretization of EDPs using the finite volume method.
- Solve discretized equations using calculation algorithms (SIMPE, SIMPLER, etc.)
- Allow students to develop finite volume calculation codes.

Recommended prior knowledge: Numerical analysis, differential equations, computer tools, programming languages.

Content of the subject:

TP 1: Matlab commands and functions.

TP 2: Python commands and functions.

TP 3: Programming in Matlab/Python of the finite volume method to solve diffusion problems.

- One-dimensional diffusion problem
- Two-dimensional diffusion problem

TP 4 : Programming in Matlab/Python of the finite volume method to solve convection-diffusion problems.

- Stationary 1D convection-diffusion equation: Centered scheme, Off-center scheme (Up-wind), Exponential scheme, Hybrid scheme, Power Law scheme
- Unsteady 1D diffusion equation: Explicit scheme, Implicit scheme, scheme of Crank-Nicholson

TP5 : Programming in Matlab Matlab/Python of the finite volume method to resolve transient flows.

Assessment method:

Continuous Assessment: 100%

Bibliographic references :

1. HK Versteeg, W. Malasasekera, "Introduction to Computational Fluid 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 2.2

Subject: Turbomachinery VHS practical

work: 10 p.m. (practical work: 1.5 hours)

Credits: 2

Coefficient: 1

Teaching objectives

The Turbomachinery Practical Work plays a fundamental and active role in enabling aeronautics students to acquire cognitive understanding and empirical information in the aeronautical field. This module is carried out in the form of a series of experiments that serve to help our students better understand the turbomachinery course that they have done theoretically during the two semesters.

The program of this module includes basic experiments on turbomachines for which our aerodynamics laboratory has the facilities.

Recommended prior knowledge:

It is recommended to master the turbomachinery course.

Content of the material: according to the available material

Plan some experiences related to turbomachines according to the available means.

TP N°1: Study of the characteristics of a centrifugal fan:

- Performance of a centrifugal fan
- Variation of fan performance as a function of speed
- Variation of fan performance depending on the wheel type
- Dimensionless performance curves
- Determination of the specific fan speed

TP N°2: Study of the characteristics of an axial fan :

- The pressure variation in the fan, power received by the fan and efficiency as a function of the non-dimensional flow rate

TP N°3: Study of the characteristics of hydraulic centrifugal pumps :

- The system allows the study of the characteristics of two centrifugal pumps mounted in series or in parallel.

TP No. 4: Pelton turbine:

- The system allows the study and characterization of the operation of a Pelton turbine

TP No. 5: Steam turbine:

Machine Translated by Google

- action steam turbine
- reaction steam turbine

Assessment method:

Continuous assessment: *100%.*

Bibliographic references :

1. http://www.tecquipment.com/#
2. http://www.deltalab-smt.com/teaching-mechanical-engineering/fluid-mechanics-aerodynamics/aerodynamics/subsonic-suction-wind-tunnel-ea600
3. Books and handouts available in the educational and research laboratories (Thermal *Laboratory , **MDF** Laboratory , **Aerodynamics** Laboratory , Departmental Research Laboratory) and departmental libraries.*
4. *Websites.*

Semester: 2

Teaching unit: UEM 2.3

Subject: Advanced Aerodynamics Practical Work

VHS: 10:30 p.m. (TP: 1:30 p.m.)

Credits: 2

Coefficient: 1

Teaching Objectives : The "Advanced Aerodynamics Practical Work" Module plays a fundamental and active role in enabling aeronautics students to acquire cognitive understanding and empirical information in the aeronautical field. This module is carried out in the form of a series of experiments that serve to help our students better understand the aerodynamics they have done theoretically during the past semester as well as familiarize themselves with the related devices and machines.

Recommended prior knowledge: depending on the material available
It is recommended to master applied fluid mechanics, aerodynamics, and flight mechanics.

Content of the material:

TP No. 1: Measuring the lift and drag of an airplane wing

We propose to determine the characteristics of a NACA aircraft wing profile (drag, lift and finesse) in a subsonic wind tunnel:

- Measurement of pressure distribution on the intrados and extrados of an aircraft wing profile.
- Measurement of lift, drag and moment with an aerodynamic balance with three components on different aircraft wing profiles as a function of the incidence.
- Comparison of NACA aircraft wing profiles of different symmetrical and cam- brés, with and without shutter.
- Study of the phenomenon of stall and finesse of the aircraft wing.
- Effect of Reynolds number on maximum lift.

TP N°2: Vortex wake

- In an aerodynamic wind tunnel, the wake production regions caused by flow depressions around an aircraft wing profile and a cylinder at different Reynolds numbers are studied.

- Visualizations by smoke generator will make it possible to establish the relationship between the size of the air wake pocket and the drag coefficient.

TP No. 3: Laminar and turbulent boundary layer

Velocity profiles will be recorded in a boundary layer developing on a flat plate (smooth and rough) placed in a wind tunnel:

- The laminar and turbulent regimes will be studied successively. The different characteristic thicknesses of the boundary layer will be compared with the theoretical thicknesses deduced from the Blasius and Prandtl approaches.

- Study of the effect of pressure gradient on the aerodynamic development of a boundary layer.

TP No. 4: Drag of aerodynamic bodies

We are interested in the origin of aerodynamic drag for different types of aerodynamic bodies placed in a subsonic wind tunnel, we measure the pressure around the profile to estimate the forces on the body. We look at how these quantities evolve through modifications of the geometry of the body.

Assessment method:

Continuous assessment : *100%.*

Bibliographic references :

1. *http://www.tecquipment.com/#*
2. *http://www.deltalab-smt.com/teaching-mechanical-engineering/fluid-mechanics-aerodynamics/aerodynamics/subsonic-suction-wind-tunnel-ea600*
3. *Technical manual and teaching notes for the experimental wind tunnel*
4. *Books and handouts available in the educational laboratories (MDF Laboratory, Aerodynamics Laboratory) and departmental libraries.*

Semester: 2

Teaching unit: UEM 2.4

Subject: Regulation and control

VHS: 37h30 (Lecture: 1h30, Practical work: 1h00)

Credits: 3

Coefficient: 2

Teaching objectives

Introduction to control theory through learning the concepts: *('system', 'control', 'static'* and *'transient'* characteristics of the response of a dynamic system, etc.).

A control loop is a control scheme which, in the presence of disturbances, tends to maintain a certain relationship (reduced error) between the instantaneous response (output) of a system, and the 'setpoint' (reference input) by comparing these two signals, and using the difference as a means of control. In this context, the student acquires skills *in the analysis* and *synthesis* (design) of control systems.

Recommended prior knowledge

Basic Mathematics: Differential and Integral Calculus, Complex Analysis

Content of the subject:

Course :

Chapter 1: Introduction to servo systems. **(1 week)**

Chapter 2: Laplace Transform. **(2 weeks)**

Chapter 3: Modeling of systems and Transfer Function. **(2 weeks)**

Chapter 4: 1st and 2nd Order Systems , Synthesis Specifications (Stability, Speed, Precision). **(2 weeks)**

Chapter 5: Stability Analysis (Routh criterion, etc.), **(1 week)**

Chapter 6: Error analysis, precision of servo systems. **(1 week)**

Chapter 7: Summary of correctors: P, PI, PID. **(4 weeks)**

Chapter 8: Overview of methods: Bode, Nyquist; locus of roots; … **(2 weeks)**

Organization of practical work:

TP1: Upgrade for the exploitation of Matlab toolboxes

Toolbox / Matlab, control and Simulink …: *scope, source, comparator, step, pure delay, transfer function, disturbance,* measurement *noise* , etc.

TP2: Determination of the transfer function of a system and plotting of the time and frequency responses in open loop and closed loop.

Using the commands : *tf, Ident, Step, Impulse, ,…*etc

TP3: Temporal analysis of LTI systems

First and second order and higher order and notion of dominant poles under Matlab and Simu-link.

Modeling and identification of an RLC electrical circuit by a first/second order model (random excitation by a voltage generator and measurement of the output voltage by a voltmeter).

TP3: Stability and precision of servo-controlled systems

TP4: Adjustment of a first-order system by a P and PI regulator (synthesis of a phase advance corrector, frequency response method, etc.).

TP5: Frequency analysis of systems

Bode, Nyquist, Locus of roots under Matlab and Simulink.

Using the commands : *Lsim, Ltiview, Bode, Nyquist*

Use the *RLTOOL* command to synthesize the controller that stabilizes the transfer function.

TP6: Depending on the means available : Analysis and adjustment of real analog loop systems in the laboratory

Position and speed control, temperature control, flow and level.

Assessment method

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

Reference

1. *KATSUHIKO OGATA, Modern Control Engineering, Prentice-HALL, (1st ed. 1970) and/ or (5th ed. 2010)*
2. *Automation course Volume 2, Analog control regulation and control, Jean-Louis Ferrier, Maurice Rivoire, Eyrolles*
3. *Automatic: regulations and controls, by Thierry Hans and Pierre Guyénot, June 20, 2014.*
4. *Automation exercises, volume 2: Servo control, regulation, analog control*
5. *by Maurice Rivoire and Jean-Louis Ferrier, Eyrolles*
6. *Continuous controls and regulations. Volume 2, Analysis and synthesis, problems with resolutions, by Collectif and Elisabeth Boillot, January 1, 2002*
7. *Industrial regulation, Modeling tools, methods and control architectures, Work directed by: Emmanuel Godoy, Collection: Technique and Engineering, Dunod/ L'Usine Nouvelle, 2014 - 2nd edition - 552 pages, EAN13: 9782100717941*

Semester: 2

Teaching unit: UED 2.1 Subject: Subject 1 of your choice

VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1

Coefficient: 1

Content of the material:

See the basket of choices: The choice of subject for this semester is left to the discretion of the teaching team

Assessment method:

Review: *100%.*

Semester: 2

Teaching unit: UED 2.2
Subject: Subject 2 of your choice

VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1

Coefficient: 1

Content of the material:

See the basket of choices: The choice of subject for this semester is left to the discretion of the teaching team

Assessment method:

Review: *100%.*

Semester: 2

Teaching unit: UET 2.1

Subject: Compliance with standards and rules of ethics and integrity

VHS: 10:30 p.m. (Class: 1.5 hours)

Credits: 1

Coefficient: 1

Teaching objectives:

To raise student awareness of the ethical principles and rules that govern life at university and in the workplace. To raise awareness of the need to respect and value intellectual property. To explain the risks of moral evils 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 subject:

A. Compliance with rules of ethics and integrity

1. **Reminder of the MESRS Ethics and Professional Conduct Charter:** Integrity and honesty. Academic freedom. Mutual respect. Demand for scientific truth, Objectivity and critical thinking. Equity. Rights and obligations of the student, the teacher, the administrative and technical staff, **2. Honest and responsible research**

- Respect for the principles of ethics in teaching and research
- Responsibilities in teamwork: Professional equality of treatment. Conduct against discrimination. The pursuit of the general interest. Inappropriate conduct in the context of collective work - 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 involuntary plagiarism, detection of plagiarism, sanctions against plagiarists, etc.). Falsification and fabrication of data.

3. Ethics and professional conduct in the world of work:

Legal confidentiality in business. Corporate loyalty. Corporate responsibility. Conflicts of interest. Integrity (corruption in the workplace, its forms, consequences, methods of combating it, and sanctions against it).

B- Intellectual property

1. **Fundamentals of intellectual property** 1- Industrial property. Literary and artistic property.
   2- Rules for citing references (books, scientific articles, communications at a conference, theses, dissertations, etc.)

2. Copyright

- **Copyright in the digital environment**

  Introduction. Database copyright, software copyright. Specific case of free software.

- **Copyright in the Internet and e-commerce**

Domain name law. Intellectual property on the internet. E-commerce website law. Intellectual property and social networks.

• **Patent**

Definition. Rights in a patent. Usefulness of a patent. Patentability. Patent applications in Algeria and around the world.

3. Protection and enhancement of intellectual property

How to protect intellectual property. Rights violations and legal tools. Valuing intellectual property. Protecting intellectual property in Algeria.

C. Ethics, sustainable development and new technologies

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

Assessment method:

Exam: *100%.*

Bibliographic 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. Order No. 933 of July 28, 2016 establishing the rules relating to the prevention and fight against plagiarism
3. The ABCs of Copyright, United Nations Educational, Scientific and Cultural Organization (UNESCO)
4. E. Prairat, On teaching ethics. Paris, PUF, 2009.
5. Racine L., Legault GA, Bégin, L., Ethics and engineering, Montreal, McGraw Hill, 1991.
6. Siroux, D., Deontology: Dictionary of Ethics and Moral Philosophy, Paris, Quadrige, 2004, p. 474-477.
7. Medina Y., Ethics, what will change in the company, Editions d'Organisation, 2003.
8. Didier Ch., Thinking about the ethics of engineers, Presses Universitaires de France, 2008.
9. Gavarini L. and Ottavi D., Editorial. of professional ethics in training and research, Research and training, 52 | 2006, 5-11.
10. Caré C., Morality, ethics, deontology. Administration and education, 2nd quarter 2002, no. 94.
11. Jacquet-Francillon, François. Concept: professional ethics. Le télémaque, May 2000, no. 17
12. Carr, D. Professionalism and Ethics in Teaching. New York, NY Routledge. 2000.
13. Galloux, JC, Industrial Property Law. Dalloz 2003.
14. Wagret F. and JM., Patents, trademarks and industrial property. PUF 2001
15. Dekermadec, Y., Innovating through patents: a revolution with the internet. Insep 1999
16. AEUTBM. The engineer at the heart of innovation. Belfort-Montbéliard University of Technology
17. Fanny Rinck and Léda Mansour, Literacy in the Digital Age: Copy and Paste among Students, Grenoble 3 University and Paris-Ouest Nanterre La Défense University, Nanterre, France
18. Didier DUGUEST IEMN, Citing your sources, IAE Nantes 2008
19. Similarity detection software: a solution to electronic plagiarism? Report of the Working Group on Electronic Plagiarism presented to the CRE-PUQ Subcommittee on Pedagogy and ICT
20. Emanuela Chiriac, Monique Filiatrault and André Régimbald, Student Guide: Intellectual Integrity Plagiat, cheating and fraud… avoiding them and, above all, how to cite your sources correctly, 2014.
21. Publication of the University of Montreal, Strategies for the prevention of plagiarism, Integrity, fraud and plagiat, 2010.
22. Pierrick Malissard, Intellectual Property: Origin and Evolution, 2010.
23. The website of the World Intellectual Property Organization www.wipo.int
24. http://www.app.asso.fr/

V - Detailed program by subject for semester S3

Semester: 3

Teaching unit: UEF 3.1.1

Subject: Gas dynamics

VHS: 67 h30 (Lecture: 3h00, Tutorial: 1h30)

Credits: 6

Coefficient: 3

Teaching objectives:

The Gas Dynamics course is a challenging one, as many different relationships are involved, and problems can be solved in a variety of ways. Gas dynamics is a very broad field that focuses on the theoretical and study of compressible flows at high speeds. These types of flows are most often encountered in the practical field of the aeronautics and space industry. This module only deals with the one-dimensional approach to compressible flows of ideal gases.

Recommended prior knowledge:

Basic knowledge of thermodynamics (ideal gas), fluid mechanics and mathematics is essential.

Content of the subject:

Chapter 1: Introduction to Gas Dynamics **(1 week)**

1. Thermodynamic concepts and relationships
2. Ideal gas relations
3. Compressibility

Chapter 2: One-Dimensional Compressible Flow **(2 weeks)**

1. Basic equations (continuity, momentum, energy)
2. General expression for the speed of sound
3. Mach number and Mach waves
4. General laws of isentropic flow: generating state and critical state
5. pv and Ts diagrams

Chapter 3: Shockwaves **(4 weeks)**

I- Normal Shock Waves

1. Basic equations (continuity, momentum, energy) and Prandtl's relation
2. Relationship of normal shock wave as a function of Mach number
3. Limiting cases: weak shock waves, strong shock waves 4.

PV and Ts diagrams

5. The normal moving shock wave
6. Practical considerations

II. Oblique Shock Waves

1. Concept on oblique shock waves
2. Basic equations and Prandtl's relationship
3. Reflection of oblique waves
4. Practical considerations

Chapter 4: One-Dimensional Flow with Heat Exchange - Rayleigh Flow

(3 weeks)

1. Rayleigh flow analysis and basic equations 2. Variation of flow characteristics with Mach number 3. Entropy variation 4. Shock wave in Rayleigh flow
5. pv and Ts diagrams

Chapter 5: One-Dimensional Adiabatic Flow with Friction - Fanno Flow

(3 weeks)

1. Analysis of Fanno flow and basic equations 2. Variation of flow characteristics as a function of Mach number 3. Friction coefficient and entropy variation 4. Shock wave in Fanno flow

5. pv and Ts diagrams

Chapter 6: Quasi-one-dimensional compressible flow **(3 weeks)**

1. Basic equations (continuity, momentum, energy)
2. Variation of flow characteristics as a function of section and Mach number 3. Study of a flow in a nozzle: convergent and convergent-divergent 4. Overview of subsonic and supersonic diffusers 5. Interaction between nozzle, Fanno and Rayleigh

Assessment method:

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

Bibliographic references:

1- Patrick Chassaing. Fluid Mechanics, 3rd edition, Cépaduès, Toulouse, 2010.
2- André Lallemand. One-dimensional flow of compressible fluids, Engineering techniques Energy engineering, B- 8- 165
3-FM White. Fluid Mechanics, 5th edition, McGraw-Hill, New York, 2003.
4- RW Fox and AT McDonald. Introduction to Fluid Mechanics, 5th edition, New York: Wiley, 1999.
5-JD Anderson. Modern Compressible Flow with Historical Perspective, 3rd edition, New York: McGraw-Hill, 2003.
6- H. Liepmann and A. Roshko. Elements of Gas Dynamics, Dover Publications, Mineola, NY, 2001.
7- Genick Bar–Meir, Fundamentals of Compressible Fluid Mechanics, Minneapolis, MN 55414-2411, 2009
8- Robert d. Zucker, Oscar Biblarz, Fundamentals Of Gas Dynamics, JOHN WILEY & SONS, 2002
9- Patrick Oosthuizen, William Carrascallen, Compressible Fluid Flow, McGraw-Hill, 1997 10- Klaus Hoffmann, Computational Fluid Dynamics, Volume II, EES, 4th edition, 2000 11- Cambel, AB, Jennings, BH, Gas Dynamics, McGraw-Hill, New York, 1958.
12- John, JEA, Gas Dynamics, 2nd ed., Prentice Hall, Upper Saddle River, NJ, 1997.
13- Shapiro, AH, The Dynamics and Thermodynamics of Compressible Fluid Flow, Vol. I, John Wiley & Sons, New York, 1953.
14- Thompson, PA, Compressible Fluid Dynamics, McGraw-Hill, New York, 1972.
15- Owczarek, JA, Fundamentals of Gas Dynamics, International Textbook Co., Scranton, PA, 1964.

Semester: 3

Teaching unit: UEF 3.1.2

Subject: Digital Aerodynamics

VHS: 45h00 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4

Coefficient: 2

Teaching objectives:

(This course aims to familiarize the student with basic methods applied in computational fluid mechanics (CFD), namely the different discretization methods and the algorithms most commonly used in numerical simulation applied to aerodynamics.
This course also introduced the student to developing codes for numerical resolution of incompressible or compressible Navier-Stokes equations as well as the use of commercial codes in this field.

Recommended prior knowledge:

(Basic knowledge of numerical methods and fluid mechanics).

Content of the material:

Chapter 1: - **(2 weeks)**

Reminder of conservation equations in fluid mechanics.
- The different types of partial differential equations (PDE) and classification: hyperbolic, parabolic, elliptical.
- Systems of equations. Method of characteristics for hyperbolic PDEs.

Chapter 2: **(5 weeks)** -

Principle of the finite difference method.
- Numerical discretization of PDEs in ODE systems. Consistency, stability, convergence. Explicit and implicit schemas.
- Diffusion model equation: explicit and implicit schemes
- Linear convection model equation: explicit and implicit schemes, centered and decentered differences.
- Treatment of boundary conditions.

Chapter 3: - **(5 weeks)**

Nonlinear convection model equation (Burgers) and numerical capture of discontinuities overnight stays.
- Linear and non-linear convection-diffusion model equation (Burgers with diffusion).
- Hyperbolic systems in conservative form: Euler equations for compressible flows, discontinuities, jump conditions, explicit and implicit schemes. Numerical schemes for scalar equations: explicit schemes of Euler, Lax-Wendroff, Mac-Cormak, Godunov, etc. Implicit schemes with linearization of the convective term.

Chapter 4: (3 weeks)
- Finite differences for structured mesh with transformation from physical space to the computing space.

Assessment method:

Continuous assessment: *40% ;* Exam: *60%.*

Bibliographic references:

1. *Computational Fluid Dynamics The Basics With Applications. John D. Anderson, J.R. (1995).*
2. *Computational Fluid Dynamics Volume 1. 2& 3, Klaus A. Hoffmann, Steve T. Chiang. Fourthedition (2000).*
3. *Computational Fluid Dynamics for Engineers. T.CebeciJ.RShao F. Kafyeke E. Laurendeau (2000).*
4. *Numerical Heat Transfer and Fluid Flow. Suhas V Patankar (1980).*
5. *Computational Methods for Fluid Dynamics, Ferziger&Peric.*
6. *Finite Volume Methods for Hyperbolic Problems, Randall J. Leveque.*
7. *High Resolution Methods for Incompressible and Low Speed Flows, Drikakis & Rider.*
8. *E. Godlewski, PA Raviart, Hyperbolic systems of conservation laws , Mathematics and Ap- Collection plications de la SMAI, Ellipses, Paris (1991).*
9. *E. Godlewski, PA Raviart, Numerical approximation of hyperbolic systems of conservation laws , Springer, New York (1996).*
10. *E. Toro, Riemann solvers and numerical methods for fluid dynamics, Springer, Berlin (1999).*
11. *R. LeVeque, Finite volume methods for hyperbolic problems, Cambridge University Press (2002).*
12. *B. Després, F. Dubois, Hyperbolic systems of conservation laws. Application to the dynamics of Editions of the Ecole Polytechnique (2005). gas,*
13. *C. Dafermos, Hyperbolic Conservation Laws in Continuum Physics, Springer, Berlin (2005).*

Semester: 3

Teaching unit: UEF 3.2.1

Subject: Aeroacoustics and turbulence

VHS: 45h30 (Lecture: 1h30, Tutorial: 1h30)

Credits: 4

Coefficient: 2

Teaching objectives This
course is devoted to the fundamentals of aeroacoustics, the science of noise of aerodynamic origin in order to reduce noise pollution and improve passenger comfort.
Examples of these nuisances include the turbulence of a free jet or its interaction with a surface, wing profile, helicopter rotor blades, compressor or turbine wheels, cavity which would need to be modelled to quantify and optimise them.

Recommended prior knowledge

Advanced fluid mechanics, linear algebra, signal processing.

Content of the subject:

1. Introduction to turbulence - Introduction, orders of magnitude, physical description. - Statistical approach: averaged Navier-Stokes equations. - Vortex dynamics.

(4 weeks)

2. Introduction to Acoustics **3.**
Equations and Resolution of Linear Acoustics.
4. Sound intensity and sound levels.
5. Basic equations of Aeroacoustics (Nonlinear Acoustics)
6. Some examples on aerodynamic noise.
7. Passive and active noise control.
8. Acoustic certification ICAO noise regulations

Assessment method:

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

Bibliographic references :

1. *Dowling, AP & Fowcs Williams, JE, 1983, Sound and sources of sound, John Wiley & Sounds.*
2. *Jensen, FB, Kuperman, WA, Porter, MB & Schmidt, H., 1994, Computational ocean acoustics, AIP Press, New York.*
3. *Crighton, DG, Dowling, AP, Ffowcs Williams, JE, Heckl, M. & Leppington, FG, 1992, Modern methods in analytical acoustics, Springer-Verlag, London.*
4. *Goldstein, ME , 1976, Aeroacoustics, McGraw-Hill.*
5. *D. Crighton, A. Dowling, J. Fowcs Williams, M. Heckel & F. Leppington, Modern methods in analytical acoustics, Springer Verlag, 1994*
6. *MS Howe, Acoustics of fluid-structure interactions, Cambridge University Press, 1998*

7. *WK Blake, Mechanics of flow-induced sound and vibration (vol. 1 & 2), Academic Press, 2017 (2nd ed.)*
8. *S. Clegg & W. Devenport, Aeroacoustics of low Mach number flows, Academic Press, 2017*
9. *Howe, MS, 1998, Acoustics of fluid-structure interactions, Cambridge University Press, Cambridge.*

Semester: 3

Teaching unit: UEF 3.2.2
Material: Combustion

VHS: 45h30 (Lecture: 1h30, Tutorial: 1h30)
Credits: 4

Coefficient: 2

Teaching Objectives:

Combustion and flames are very useful technical operations in many industrial systems. The purpose of combustion is to produce thermal energy.
To master these combustion processes, students need to understand certain basic elements based on physical and chemical knowledge. Indeed, combustion and flames are gas flows in which heat and mass exchanges, as well as chemical or physical reactions, occur. All knowledge of fluid mechanics is useful for the study of flames.

The student will learn to calculate the properties of gas mixtures, the calorific values of different fuels, adiabatic flame temperatures, etc. Notions on chemical equilibrium, chemical kinetics and the different types of flames will be provided.

.

Recommended prior knowledge:

Technical and in-depth thermodynamics, fluid mechanics, heat and mass transfer.

Content of the material:

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

1.1 Types of fuels and combustibles: solid, liquid and gaseous, physical and chemical properties, octane number, cetane number.
1.2 Reaction enthalpy and sensible enthalpies.
1.3 Gas mixtures, stoichiometry, richness and excess air coefficient.
1.4 Combustion reactions.
1.5 Calorific value: Calculation of PCI and PCS

Chapter 2: Thermochemistry (3 weeks)

2.1 Adiabatic flame temperature at constant volume and constant pressure.
2.3 Calculation of the temperature of a combustion chamber.
2.4 Equilibrium constants and rates of reactions.
2.5 Kinetics of combustion.

Chapter 3: Reactive Flow Equations (2 weeks)

3.1 Conservation of mass, momentum, energy and chemical species

3.3 Chemical and thermal production terms.

Chapter 4: Laminar Premix and Diffusion Flames 4.1 Definition of **(3 weeks)**
Premix Flames and Application Examples.
4.2 Structure and speed of premix 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: Effects of combustion on the environment 5.1 **(2 weeks)**
Role of combustion sources in air pollution
5.2 Nitrogen oxides: types, formation, thermal NO, early NO, fuel-derived NO, production rate calculation
5.3 Carbon oxides: CO, CO2
5.4 Unburned hydrocarbons and soot
5.5 Polycyclic Aromatic Hydrocarbons
5.6 Some methods of controlling and reducing pollutants

Chapter 6: Turbulent Flames 6.1 **(2 weeks)**
Autoignition and Propagation
6.2 Turbulent premix flames
6.3 Some models of premixed combustion
6.4 Turbulent diffusion flames
6.5 Some models of non-premixed combustion
6.6 Combustion regimes and diagrams of turbulent combustion

Assessment method:

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

Bibliographic references:

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

Semester: 3

Teaching unit: UEM 3.1

Subject: Digital Aerodynamics Practical Work

VHS: 10:30 p.m. (TP: 1:30 p.m.)

Credits: 2

Coefficient: 1

Teaching objectives:

The student will have the skills necessary to numerically solve physical phenomena in the field of aeronautics. The resolution is based on numerical discretization methods with a view to a better understanding of fluid flow phenomena coupled with heat and mass transfers.

Recommended prior knowledge:

Course in numerical aerodynamics, numerical analysis, programming.

Content of the subject:

1. Analytical resolution **(2 weeks)**

- 1D heat equation
- 2D Laplace equation **2.**

Numerical resolution of Poisson's equation **(4 weeks)**

- Explicit diagram
- Implicit schema
- Crank-Nicholson diagram

3. Numerical resolution of the Laplace equation **(4 weeks)**

- Dirichlet conditions
- Neumann conditions

4. Numerical resolution of the model equation (Burgers) **(5 weeks)**

- Nonlinear convection model equation (Burgers) and numerical capture of discontinuities.
- Linear and nonlinear convection-diffusion model equation (Burgers with broadcast).

Assessment method:

Continuous assessment: *100%.*

Bibliographic references:

1. *John D. Anderson, JR. Computational Fluid Dynamics The Basics With Applications. (1995).*
2. *T.Cebeci J.RShao F. Kafyeke E. Laurendeau. Computational Fluid Dynamics for Engi-neers. (2000).*
3. *Suhas V Patankar. Numerical Heat Transfer and Fluid Flow. (1980).*

Machine Translated by Google

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.
10. http://www.tecplot.com/products/tecplot-360/
11. http://www.originlab.com/

Semester: 3

Teaching unit: UEM 3.2

Subject: Practical work Combustion

VHS: 10:00 p.m. (TP: 1h30)

Credits: 2

Coefficient: 1

Teaching objectives:

This practical work will allow you to master the operating principle of a low-pressure boiler intended for the tertiary sector. Boilers or furnaces are devices allowing the continuous transfer of thermal energy to a heat transfer fluid (generally water or dry steam). The objective of this practical work is twofold: to understand the combustion mechanism between a fuel and the oxidant, then to be able to establish an energy balance and decide on the thermal efficiency. Also, the student will be able to familiarize himself with the specific instrumentation for combustion control while observing the complex mechanism of combustion.

Recommended prior knowledge:

It is recommended to master the concepts of technical thermodynamics, combustion courses and fluid mechanics.

Content of the subject:

TP No. 1: Burner test bench

1. Determination of the performance of a low pressure boiler;
2. Visualization and description of flames;
3. Analysis of polluting emissions from combustion;
4. Methods of recovering sensible energies lost in the atmosphere.

TP No. 2: Test bench of an internal combustion engine

Determination of the performance of a spark-ignition engine using a test bench containing: a **Honda GX140 type engine,** a TD115 hydraulic dynamometer ,
and a **TD114** measuring unit. The measured parameters are:

1. Exhaust gas temperature;
2. Fuel consumption time;
3. The torque exerted by the dynamometer on the engine;
4. The engine rotation speed;
5. Intake air flow as well as richness and excess air.

Assessment method:

Continuous assessment: *100%*

Bibliographic references:

5. *http:// www.tecquipment.com/ #*
6. *http:// www.deltalab-smt.com/ teaching-mechanical-engineering/ fluid-mechanics-ae-rodynamics/ aerodynamics/ subsonic-suction-wind-tunnel-ea600*
7. *Books and handouts available in the educational laboratories (MDF Laboratory, Motor Laboratory) and departmental libraries 8. Websites and others.*

Semester: 3

Teaching unit: UEM 3.3

Subject: Practical work on gas dynamics

VHS: 10:00 p.m. (TP: 1h30)

Credits: 2

Coefficient: 1

Teaching objectives

The Gas Dynamics Practical Module plays a fundamental and active role in enabling aeronautics students to acquire cognitive understanding and empirical information in the aeronautical field. This module is carried out in the form of a series of experiments that serve to help our students better understand the gas dynamics they have done theoretically during the past semester as well as familiarize themselves with the related devices and machines.

The program of this module includes the basic experiments of gas dynamics our aerodynamics laboratory has the facilities.

Recommended prior knowledge:

It is recommended to master the course of gas dynamics, thermodynamics.

Content of the material:

Plan some experiments related to gas dynamics according to the means available:

TP No. 1: Experimentation of flows in constant section pipes.

TP N°2: Experimentation of compressible flows in pipes and pressure losses: singular and linear.

TP No. 3: Experimentation of compressible flows through orifices.

TP No. 4: Study of nozzle performance.

TP No. 5: Experimentation of pressure distribution in the nozzles.

Assessment method:

Continuous assessment: *100%.*

Bibliographic references :

1. *Erik Dick. Fundamentals of Turbomachines-Springer Netherlands (2015)*
2. *RK Bansal. A Text Book of Fluid Mechanics and Hydraulic Machines. laxmi posts (2005)*
3. *Lucien Vivier. Steam and Gas Turbines. Albin Michel Edition. Paris 1965*
4. *http://www.tecquipment.com/#*
5. *http://www.deltalab-smt.com/teaching-mechanical-engineering/fluid-mechanics-aerodynamics/aerodynamics/subsonic-suction-wind-tunnel-ea600*

Semester: 3

Teaching unit: UEM 3.4

Subject: Optimization

VHS: 37h30 (Lecture: 1h30, Practical work: 1h00)

Credits: 3

Coefficient: 2

Teaching objectives:

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

Recommended prior knowledge: Basic notions of mathematics, linear algebra, matrix algebra.

Content of the subject:

Chapter I: Mathematical reminders **(2 weeks)**

1. Positivity, Convexity, Minimum 2. Gradient and Hessian
3. Necessary conditions for a minimum 4. Sufficient conditions for a minimum **Chapter II:** Linear optimization

1. General formulation of a linear program **(3 weeks)**

2. Examples of linear programs (Production problem, Mixing problem, Cutting problem, Transportation problem)
3. Solving the problem using the Simplex method:
   - Basics and basic solutions of linear programs
   - The simplex algorithm
   - Initialization of the simplex algorithm (the two-phase method).

Chapter III: Unconstrained Nonlinear Optimization 4. Local Methods 5. One-Dimensional Search Methods **(5 weeks)**

6. Gradient methods 7. Conjugate direction methods 8. Newton's method

9. Quasi-Newton methods

Chapter IV: Nonlinear optimization with constraints **(5 weeks)**

10. Lagrange Multipliers
11. Karush-Kuhn-Tucker conditions 12. Projected gradient method
13. Projected Newton method (for bound constraints)
14. Penalty Method 15. Sequential Quadratic Programming

Organization of practical work :

it is preferable that the practical work be direct applications in spatiality:

TP 1: Introduction to Matlab and presentation of the reference optimization functions; Presentation of the optimtool optimization tool in Matlab; Definition and plotting of the curves of some test functions in optimization

TP 2: Solving a linear optimization problem without constraints; Solving a linear optimization problem with constraints

TP 3: Nonlinear minimization without constraints; Nonlinear minimization without con- gradient, Hessian and other constraints

TP 4: Nonlinear minimization with equality constraints; Nonlinear minimization with inequality constraints; Minimization with equality and inequality constraints, Sequential quadratic programming

TP 5 : Using the optimtool tool or other tool to solve a problem nonlinear optimization with constraints

Assessment method:

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

Bibliographic 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. Polytechnic Press and French-speaking academics, Lausanne, 2006.*
4. *F. Bonnans, Continuous Optimization: Course and Corrected 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, Multiobjective 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: UED 3.1 Subject: Subject 1 of your choice

VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1

Coefficient: 1

Content of the material:

See the basket of choices: The choice of subject for this semester is left to the discretion of the teaching team

Assessment method:

Review: *100%.*

Semester: 3

Teaching unit: UED 3.2
Subject: Subject 2 of your choice

VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1

Coefficient: 1

Content of the material:

See the basket of choices: The choice of subject for this semester is left to the discretion of the teaching team

Assessment method:

Review: *100%.*

Semester: 3

Teaching unit: UET 3.1

Subject: Documentary research and dissertation design

VHS: 10:30 p.m. (Class: 1.5 hours)

Credits: 1

Coefficient: 1

Teaching objectives :

To give students the tools they need to research useful information and use it more effectively in their final year project. To help them navigate the various stages of writing a scientific document. To demonstrate the importance of communication and to teach them how to present their work 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 subject
- Gather basic information (acquisition of specialized vocabulary, meaning-cation of terms, linguistic definition)
- The information sought
- Take stock of your knowledge in the field

Chapter I-2: Selecting information sources - Type of documents **(2 Weeks)**

(Books, Theses, Dissertations, Periodical articles, Conference proceedings, Audiovisual documents, etc.)

- Type of resources (Libraries, Internet, etc.)
- Evaluate the quality and relevance of information sources

Chapter I-3: Locating documents **(01 Week)**

- Research techniques
- Search operators

Chapter I-4: Processing information **(2 Weeks)**

- Work organization
- The starting questions
- Summary of the documents selected
- Links between different parties
- Final plan of the documentary research

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

- Systems for presenting a bibliography (The Harvard system, The Vancouver system, The mixed system, etc.)
- Presentation of documents.
- Citation of sources

Part II: Memory Design

Chapter II-1: Plan and stages of the report **(2 Weeks)**

- Identify and delimit the subject (Summary)
- Problems and objectives of the thesis
- Other useful sections (Acknowledgments, Table of abbreviations, etc.)
- The introduction *(Writing the introduction last)*
- State of the specialized literature
- Formulation of hypotheses
- Methodology
- Results
- Discussion
- Recommendations
- Conclusion and perspectives
- The table of contents
- The bibliography
- The annexes

Chapter II-2: Writing Techniques and Standards - **(2 Weeks)**

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 of understanding and expression.
- Save, secure, archive your data.

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

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

How to present a poster
- How to present an oral communication.
- Defense of a dissertation

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

(Formulas, sentences, illustrations, graphs, data, statistics, etc.)
- The quote
- The paraphrase
- Indicate the complete bibliographic reference

Assessment method:

Exam: 100%

Bibliographic 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. *A. Mallender Tanner, ABC of technical writing: user guides, instructions, online help, Dunod, 2002.*
4. *M. Greuter, How to write your dissertation 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. *M. Beaud, the art of the thesis, Editions Casbah, 1999.*
7. *M. Beaud, the art of the thesis, La découverte, 2003.*
8. *M. Kalika, Master's thesis, Dunod, 2005.*

IV-Basket of choices

Detailed programs for some subjects

For the *Discovery EU* (S1, S2, S3)

Semester: 1, 2, 3

Teaching unit: UED 1.1

Material: Aerodynamic structure materials

VHS: 10:30 p.m. (1.5 hour lesson)

Credits: 1

Coefficient: 1

Teaching objectives:

This course, dedicated to the materials of aeronautical structures, is intended for Master LMD students specializing in Aeronautical Structures, Mechanical Engineering. It focuses on industrial materials, often innovative in nature, different from structural materials (metals and composites), used not only for their mechanical resistance properties, but also for their ability to fulfill a specific function.

Recommended prior knowledge:

This course requires basic knowledge of matrix calculation, elasticity, fracture mechanics, resistance of materials and aeronautical structures.

Content of the subject:

Chapter 01: Materials for aeronautical and space structures 1.1 Objective and scope of application 1.2 Constituent elements of an aircraft **(2 weeks)**

1.3. Main properties of the constituents 1.4. Functionality of the constituent elements

1.5. Characterization of classical materials
1.6. Characterization of advanced materials

Chapter 02: Anisotropy of Materials 2.1. Anisotropic Materials **(3 weeks)**

2.2. Symmetry Planes and Behavior.

2.3. Orthotropic materials

2.4. Transverse isotropy

2.5. Isotropic materials

Chapter 03: Main common materials 3.1. Wood and derivatives **(3 weeks)**

3.2. Metals and alloys

3.3. Organic materials
3.4. Mineral materials

3.5. Mechanical behavior of materials
3.6. Elasticity and Plasticity

3.7. Resistance and damage 3.8. Aeronautical applications

3.9. New aluminum alloys and solutions for aeronautical structures

Chapter 04: Composite materials and sandwiches 4.1. General information **(4 weeks)**

4.2. Composite materials
4.3. Multi-material materials
4.4. Sandwich panels
4.5. Smart materials and adaptronics
4.6. Nanomaterials
4.7. Mechanical behavior and rupture

Chapter 05: Selection of materials 5.1. **(3 weeks)**

Usage properties
5.2. Material-function suitability
5.3. Material-Process Suitability
5.4. Additive manufacturing
5.5. Multi-criteria selection
5.6. Choice between aluminum alloy and organic composites
5.7. Strengthening and repair of damaged structures

Assessment method:

100% exam

References:

1. Kittel C., "Solid State Physics", Dunod, 1998.
2. Boch P., "Ceramic materials and processes", Hermès Science Publications, 2001.
3. Haussonne J.-M. et al., "Ceramics and glass, Principles and production techniques", Treatise on Materials, vol. 16, Presses Polytechniques et Universitaires Romandes, 2005.
4. Cornet A. and Deville JP, "Physics and Engineering of Surfaces", Monograph of Materio-logy, EDP Sciences, 1998
5. Gourgues-Lorenzon AF and Naze L., Materials for the engineer, behavior, damage and fatigue failure 2008.
6. Jefferson Andrew, J. Arumugam, V., Saravanakumar, K., Dhakal, HN and Santulli, C., 2015. Compression after impact strength of repaired GFRP composite laminates under repeated impact loading. Composite Structures, 133:911-920.
7. Aggelopoulos, ES, Righiniotis, TD and Chryssanthopoulos, MK, 2014. Composite patch repair of steel plates with fatigue cracks growing in the thickness direction. Composite Structures, 108:729-735.

Semester: 1, 2, 3
Teaching unit: UED 1.3
Subject: Non-destructive testing
VHS: 10:00 p.m. (lesson: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives: The objective is to teach the student a set of methods for characterizing the state of integrity of structures or materials, without degrading them, either during production, during use, or during maintenance. We speak of non-destructive testing (NDT) or non-destructive examinations1.

Recommended prior knowledge:
Processes for obtaining parts, welding

Content of the subject:

Chapter 1: Introduction

1. Presentation: definition; NDT and maintenance; defects encountered (development defects; manufacturing or assembly defects; operating defects)
2. Common methods: visual inspection; penetrant testing; magnetic particle testing; radio-graphy; eddy currents; ultrasound.
3. Areas of application: nuclear power plants ; steel cables ; tanks.

Chapter 2: Basic Principles

1. Visual examination
2. Generalization of the principle to different techniques.

Chapter 3: Sweating

1. Principles of the method *2.*
Physicochemical properties involved: definition of the parameters; physical laws involved; the bleeding mechanism.
3. Different types of products used: penetrants; emulsifiers; developers.
4. Operating technique adapted to different products.
5. Selection of products according to requirements.
6. Control methods. Documents for controlling a part 7. Standards.
Advantages and disadvantages

Chapter 4 - Magnetic Resonance Imaging

1. General principle: introduction; principle.
2. Basic notions of magnetism and electromagnetism.
3. Principle of the method: excitation; disturbance; revelation; …; defects detect-labels.
4. Implementation of the method: preparation of the parts; choice of the current form; …
5. Interpretation of results: representative spectra; conservation of results; examples; …
6. Advantages and disadvantages. Standards.

Chapter 5 - Eddy Currents

1. Introduction
2. Physical principles: electromagnetic induction; Faraday's law; inductance of a solenoid; concept of impedance; series association of a resistance and an inductance; generation of currents.
3. Fault detection: simplified principle of instrumentation; principle of detection; …
4. Equipment.
5. The different examinations: external examinations of tubes; internal examinations of tubes; …
6. Advantages, disadvantages, limits of the method: defects highlighted; controls of ferromagnetic materials; advantages and disadvantages; other applications; standards.

Chapter 6 - Ultrasonic testing

1. Introduction
2. Physical principles: matter; defects in solids; vibrations; sounds and ultra-sounds; …
3. The production of ultrasound: the piezoelectric phenomenon; acoustic intensity; ….
4. Ultrasonic testing techniques.
5. Performance: fault detection; fault location and characterization; ….
6. Equipment.
7. Advantages, disadvantages, limits of the method: advantages and disadvantages; normalization.

Chapter 7 - Acoustic Emission

1. Principle.
2. Advantages, disadvantages, limits of the method: field of application; main application sectors; advantages and disadvantages.

Chapter 8 - X-ray

1. Principle.
2. Physical principles: sources of radiation; electromagnetic spectrum of the light ; …
3. Performance, limits of the method

Semester: 1, 2, 3
Teaching unit: UED 1.4
Subject title : Signal processing.
VHS: 10:30 p.m. (lesson: 1.5 hours)
Credits: 1
Coefficients: 1

Teaching objectives:

(Knowing how to study signals and process them, which will allow us to study vibrations in engines).

Recommended prior knowledge:

(It is recommended to master mathematical tools: derivation, differentiation, basics of electronics).

Content of the subject:

1. Introduction to signal processing **(5 weeks)**

1. Signal types: analog, digital, random, noise...
2. Representations of a signal: temporal, complex, frequency, spectral, etc.
3. Energy, power, correlation, convolution...
4. Principle of an information transmission system...
5. Principle of a data acquisition and processing chain...
6. Principle of a digitization chain...

2. Spectral analysis: Fourier series, Fourier transform, distribution (5 se-Maines)

1. Sampling, quantization, Shannon's theorem...
2. Laplace transform, Z transform...
3. Digital Fourier Transform: TFD, FFT ...
4. Analog filtering: passive, active...
5. Digital filtering: FIR, IIR ...

Depending on the means (time, lab, etc.):

Practical work on active filters with operational amplifiers **(2 weeks)**

Practical work on digital filters (with Matlab or other...) **(2 weeks)**

Assessment method:

Exam: ***100%***

Bibliographic references :

1. *BEKKA Rais El Hadi OPU Fundamentals of Signal Processing.*
2. *BELLOULATA Kamel OPU Introduction to digital signal processing in Matlab.*
3. *GAZIN JF Sescosem Active filters.*
4. *BEAUFILS & RAMI Sybex Digital filtering.*

5. https:// moodle.insa-rouen.fr/ course/
6. http:// www.rennes.supelec.fr/ ren/ perso/ ghiet/ TDS/
7. https:// openclassrooms.com/ courses/ bases-de-traitement-du-signal
8. Bellanger M. Dunod, Digital Signal Processing.
9. Picinbono B. Dunod, Theory of signals and systems.
10. Cottet F. Dunod Signal processing and data acquisition....

Semester: 3

Teaching unit: UED 1.5

Subject: Flight Control and Dynamics

VHS: 10:30 p.m. (Class: 1.5 hours)

Credits: 1

Coefficient: 1

Teaching objectives:

This course contributes to the acquisition of essential knowledge for aeronautical master's students. Students will obtain the necessary solid foundations on the one hand, performance, stability and control characteristics of an aircraft and on the other hand, its different flight phases throughout the aircraft's specific mission during takeoff, climb, cruise, descent and landing.

Recommended prior knowledge:

The basics of flight mechanics and aerodynamics.

Content of the subject:

Chapter 1: Introduction and Generalities on Flight Mechanics

- Definition of aerodynamic forces using Newton's second law (rap-
  pels)
- Definition of propulsive and mass forces (reminders)
- Reminders of the different roll, pitch and yaw axes
- Development of mathematical expressions for forces, moments
  aerodynamics, lift, drag and thrust over the entire aircraft in the equilibrium state as well as the kinematics equations.
- The various consecutive rotations of the rigid aircraft in flight and the various re-
  fathers.
- Reminders of the different moments applied to the aircraft in flight
- Steady-state and disturbed-state flights
- Application exercises **(3 weeks)**

Chapter 2: The different phases of flight and their equations

- Straight and level flight
- Uniform straight climb flight
- Uniform straight descent flight
- Gliding
- The symmetrical level turn
- Load factor
- Takeoff and landing
- Application exercises **(3 weeks)**

Chapter 3: Trajectory Control

- Roll control
- Reverse lace
- Pitch control

Machine Translated by Google

- Induced yaw and roll control (3 weeks)

Chapter 4: Aircraft polar and the different high-lift devices

- Definition of the polar of a wing or an airplane
- Eiffel-style fleece
- Polar speeds
- The finesse of the airplane wing
- High and low lift devices
- Study of stalling
- Application exercises (3 weeks)

Chapter 5: Static stability of an aircraft

- **Longitudinal static stability**
- Centering of the aircraft (position of the center of gravity relative to the focus)
- Movement around the pitch axis
- **Transverse static stability**
- Rotations around the roll and yaw axes
- Dihedral effects
- Arrow effects
- Effect of drift (3 weeks)

Assessment method:

Exam: ***100%.***

Bibliographic references:

1. *McCormick. BW, Aerodynamics, aeronautics and flight mechanics, 2nd ed., Wiley, New York, 1995.*
2. *JL Boiffier. The Dynamics of flight: The equations. Wiley, 1998.*
3. *John Anderson. Introduction to flight. McGraw-Hill, 1978, 1985, 1989*
4. *Roskam, J.: Methods for estimating stability and control derivatives of conventional subsonic airplanes Lawrence, Kansas, 66044, 1971.*
5. *Aerodynamics and mechanics of flight. BIA. 2016.*
6. *“Airplane Pilot’s Manual – Visual Flight”, SFACT Editions CEPADUES*

Semester: 1, 2, 3

Teaching unit: UED 1.6

Subject title : Aircraft Fuels and Pollution

VHS: 10:30 p.m. (lesson: 1.5 hours)

Credits: 1

Coefficients: 1

Teaching objectives

The content of this course, intended for Master's students in aeronautical technology, complements the other contents of the training of this course, allows students to complete their knowledge in the aeronautical field by having an overview of the different fuels used in propulsion and particularly in aeronautics. In addition, an environmental aspect has been included to make students aware of the pollution problems caused by these fuels which are current with projections towards the future (new engines and new fuels.

Recommended prior knowledge

(No prerequisites are required to understand the content of this module).

Content of the subject:

1. Fuels - Shooting **(3 weeks)**

- The essences
  - Physical properties. - Chemical & thermal. - Definition of octane numbers. - Types of gasoline and their formulation. - Finishing additives. - Aviation gasolines,
- Diesel
  - Physical, chemical & thermal properties.
  - the cetane index
  - Diesel formulation. - Additional diesel treatments.

2. Jet Fuel Physical, Chemical & Thermal Properties **(3 weeks)**

- Combustion mode. - Required characteristics. - Jet fuel formulation.

3. Heavy fuels **(2 weeks)**

4. Fuels and environmental protection **(4 weeks)**

- Desulfurization of fuels.
- Relationships between fuel characteristics and pollutant emissions.
- Fuels and the greenhouse effect.
- Fuels and the formation of tropospheric ozone.
- Research into new low-polluting fuels: Liquefied petroleum gas, - Natural gas "Aquazole", - Biofuels

5. 'Emissions and Pollution Control Systems' Standards. **(3 weeks)**

Assessment method:

100% exam

Bibliographic references :

1. *WG Dukek,* Aviation and Other Gas Turbine Fuels, *Wiley-VCH Verlag GmbH & Co, coll. Kirk-Othmer Encyclopedia of Chemical Technology, 1992.*
2. *GJ* Bishop,Aviation Turbine Fuels, *Wiley-VCH Verlag GmbH & Co, coll. Ullmann's Encyclopedia of Industrial Chemistry,2000.*
3. *Jean-Luc Goudet,* Biofuel for aircraft takes off, *on 4. "Biofuels take off", Air et Cosmos, No. 2155, January 16, 2009*
5. *Paul Kuentzmann (ONERA), "Alternative aviation fuels: A solution for sustainable development?", in* ***La Lettre AAAF*** *Côte d'Azur, no. 172 January 2009*

6. *J,C, Guibert, Fuels and Engines 7. , Ed Technip, Automobiles and engine pollution, Ipp publications, Ed technip.*
8. http://www.futura-sciences.com , *Futura-Sciences, November 2012* UOP and , Honeywell's PetroChina Produce Green Jet Fuel for China's First Biofuel Flightsur *UOP.com*

Semester: 1, 2, 3
Teaching unit: UED 1.7
Subject: Compressible and supersonic flows
VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1
Coefficient: 1

Teaching objectives :

(The course is devoted to flows where compressibility phenomena are no longer negligible. The study will be carried out for non-viscous fluids and is based on the careful use of balance equations (mass, momentum, energy and entropy)

The transition from a global balance sheet to a local writing allows, in the event of the presence of discontinuity surfaces in the domain, to clearly identify the jump relationships which re-link the thermomechanical quantities on either side of the discontinuity locations.

Acoustic approximation, one-dimensional flows, continuous or not, shocks (straight, oblique) will be discussed).

Recommended prior knowledge:

(It is recommended to master aerodynamics, fluid mechanics, and the basics of thermodynamics).

Content of the material:

1. Compressible flows, balance laws **2.** Linear acoustics, speed of sound **(3 weeks)**

3. Unidirectional compressible flows: The Laval nozzle **(4 weeks)**

4. Unsteady unidirectional compressible flows: the method of characterization-ticks.

5. Piston problems.

6. Unidirectional compressible flows: the straight shock. **(4 weeks)**

7. Unidirectional compressible flows: the straight shock 'The shock tube.'

8. Stationary compressible flows: the oblique shock

9. Prandtl Meyer's relaxation.

10. Thin profiles **(4 weeks)**

11. Thin profile applications

Assessment method:

Exam: ***100%.***

Bibliographic references :

1. *A. SELLIER, Introduction to compressible flows and heterogeneous fluids", Les Editions de l'Ecole Polytechnique, (2001).*
2. *A. SELLIER, Compressible Aerodynamics", Photocopy of the Ecole Polytechnique, (2004).*
3. *Anderson, McGraw Hill, Hypersonic and High Temperature Gas Dynamics, (1989)*
4. *Courant R. and Fiedrichs, KO, Supersonic Flow and Shock Waves, (1948). Macmillan, New York.*
5. *NA Cumpsty. Compressor Aerodynamics. Krieger Publishing Company, (2004.)*
6. *JD Anderson, McGraw Hill, Modern Compressible Flow. (2003).*

Semester: 1, 2, 3

Teaching unit: UED 1.8

Subject: Finite element methods

VHS: 10:30 p.m. (Class: 1.5 hours)

Credits: 1

Coefficient: 1

Teaching Objectives The finite element method is one of the recent methods applied in the static and dynamic analysis of discrete and continuous bodies of aircraft internal structures and space structures. The stresses in each element and the deformations at each node as well as the forces in all directions can be determined and compared to the elastic limit of each element in order to avoid their rupture and plastic deformation.

The bar, beam, rectangular, triangular and thetrahedral elements will be analyzed and their stiffness matrix will be determined.

Recommended prior knowledge

The basic knowledge required to be able to follow this course are the following modules: RDM, Mechanical Vibration and Continuous Media Mechanics, etc.

Content of the subject:

Chapter 1: General Introduction - The Finite Element Method and its Applications **(02 weeks)**
- The different finite element methods

Chapter 2: Stiffness matrix **(3 weeks)**
- Determination of the stiffness matrix of bar, beam, plate and other elements
- Analysis of triangular elements and types of deformation (two-dimensional)
- Analysis of the tetrahedron element (three-dimensional)

Chapter 3: Dynamic analysis of bodies **(04 weeks)**
- Dynamic analysis of discrete and continuous bodies using the finite element method
- Determination of the mass and damping matrix
- Castigliano's theorem and potential deformation energies

Chapter 4: Free and forced vibration **(4 weeks)**
- Free and forced vibration by finite elements: 1, 2 and/or several degrees of freedom
- Application to continuous bodies and discrete structures (bar elements, beams and continuous elements)

Chapter 5: Applications **(02 weeks)**
- Application to internal structures of aircraft and space structures: structures in lattices, internal structures in aircraft wings

Assessment method:

100% exam.

Bibliographic references:

1- Finite element methods, Brahim Necib (UFMC1- 2012 handout)
2- Analysis of structures by finite elements, JFimbert, Edition: Cepadues

3- Modeling of structures by finite elements, JL.Batoz, Edition: Hermes
4- Structural mechanics using the finite element method, Ph.Trompette, Edition: Masson
5- Finite element methods for thin shell problems M.Bernadou, Edition: Masson
6- Finite element method, T.Gmur, Edition: Romandes
7- the calculation of structures by finite elements, H.Debaecker, Edition: Hermes
8- Finite Elements, Volume 1, Zienckewiz, Edition: BH
9- Understanding Finite Elements (Principles, Formulation and Corrected Exercises), Jean-Louis Batoz and Gouri Dhatt. Modeling of Structures by Finite Elements Volume 1,2.
10- Introduction to the Finite Element Method Lenneth Rocky, Roy Evans, William Grffiths and David Nethercit

11- Finite Element Methods HTYang
12- Finite element modeling For stress analysis, Robert D. Cook
13- Finite element analysis, McGRAW-HILL. George R. Buchanan. Shaum's outlines series. 14- Structural analysis RCCoates, MGCoutie, FKKong. Second edition.

Semester: 1, 2, 3
Teaching unit: UED 1.9 Subject:
Orbit mechanics VHS: 22:30
(Course: 1:30)
Credits: 1
Coefficient: 1

Teaching Objectives: The
objective of this module is to introduce the student to space mechanics, orbital mechanics, astronomy and the mechanics of movements in space. Orbital mechanics is particularly linked to celestial mechanics , which aims to predict the trajectories of space objects such as rockets or spacecraft , including orbital maneuvers, orbital plane changes and interplanetary transfers.

Note: This module is a discovery unit. It can be replaced by another discovery unit module depending on the department's choice...

Recommended prior knowledge: The knowledge
required to follow this course is the following modules: Air operations, Air traffic and control, etc.

Content of the material:

- Introduction to orbital mechanics - History of
the universe and basic laws of orbits.
- Lunar theory and interpretation of orbits - Equation
of trajectories: Elliptical Trajectory, Circular Trajectory, Para- Trajectory
bolic, Hyperbolic Trajectory
- Determination of trajectories from observations
  - History
  - Coordinate system, Coordinate transformation
  - Fundamental elements of a trajectory
  - Low, medium and high altitude trajectories based on a radar observer
  - Determination of the time factor
- Basic orbit maneuvers
  - Determination of near-Earth satellite paths
  - Effect of latitude and disturbances
- Celestial Mechanics and Gravitation of Celestial Bodies
- Orbits: definitions, calculation and speeds
- Earth orbits and satellite orbits
- Mechanical energy of satellites

Assessment method:

100% exam

Bibliographic references:

Semester: 1, 2, 3

Teaching unit: UED 1.10

Subject: Airport management and security

VHS: 10:30 p.m. (lesson: 1 hour 30 minutes)

Credits: 1

Coefficient: 1

Teaching objectives

(To enable students to know the security policy and standards on security and risk management).

Recommended prior knowledge

(No prerequisites are required to understand the content of this module.).

Content of the subject:

Chapter 1: Security Policy and Organization **(2 weeks)**

- Management commitment and responsibility.
- Responsibilities of staff.
- Safety supervision.
- Appointment of staff assigned to functions related to the SMS.
- SMS implementation plan.
- Coordination of emergency response planning.

Chapter 2: Risk Management - Hazard Identification Process. **(2 weeks)**

- Risk assessment and mitigation process.

Chapter 3: Security Level Assurance - Monitoring and Measuring Security Performance. **(2 weeks)**

- Change management.
- Continuous improvement of the SMS.

Chapter 4: Safety Culture **(3 weeks)**

- Training and awareness. - Internal communication on security.
- Exchanges on security matters between PN training organizations and authorities.

Chapter 5: State Responsibilities in Security Management **(3 weeks)**

- National Safety Program. - Acceptable Level of Safety Performance.
- Security supervision

Chapter 6: Safety Management System - International General Aviation - Aeroplanes. **(3 weeks)**

- Collection of security data.
- Analysis of security data.
- Data protection on security.
- Exchange of security information

Assessment method:

Exam: ***100%.***

Bibliographic references :

1. *Order of 20 May 2011 relating to the implementation of safety management systems for pilot training organizations and associated instruction 2. ICAO Guide published under reference no. 9859/ AN 460, entitled "Safety Management Manual" rite*
3. *http:// www.icao.int/ anb/ safetymanagement/ DOC_9859_FULL_EN.pdf.*
4. *ICAO Safety Management Systems (SMS) Course*
5. *http:// www.icao.int/ anb/ safetymanagement/ training/ training.html*
6. *ICAO - Safety Management – Standards: http:// www2.icao.int/ en/ ism/ Pages/ Standards.aspx*
7. *Instruction of 20 May 2011 taken in application of the decree of 20 May 2011 relating to the implementation of safety management systems for pilot training organisations.*
8. *Law No. 2011-020 of February 27, 2011 relating to the Civil Aviation Code and its implementing texts-tions relating to security management (National Security Program)*
9. *Annexes 1, 6, 8, 11, 13 and 14 to the Convention on International Civil Aviation, signed in Chi-Cago on December 7, 1944.*
10. *enna.dz | National Air Navigation Establishment*
11. *Safety Management System (SMS)*

Semester: 1, 2, 3

Teaching unit: UED 1.11

Subject: Rocket engines and electric propulsion

VHS: 10:30 p.m. (lesson: 1 hour 30 minutes)

Credits: 1

Coefficient: 1

Teaching objectives

(To allow students on this course to gain an expert's insight into the field of space propulsion, which is different in more than one way from the aeronautical propulsion they studied in their undergraduate degree. A significant role has been given to fuels, which are also different from aviation fuels).

Recommended prior knowledge

(Knowledge of thermodynamics and fluid mechanics will facilitate understanding, particularly thermodynamics).

Content of the subject:

Introduction

1. Rocket engines **(3 weeks)**

- Liquid propellant rockets
  - Chemical propulsion modes
  - The main components of a liquid propellant rocket engine
  - SSME engines
- Solid propelgol rockets

2. Definition and calculation of performance • **(3 weeks)**

Thrust and specific impulse

- Acceleration of a rocket
- Performance of a rocket engine

3. Thermochemistry of the combustion chamber **4.** Flow with **(2 weeks)**

chemical reaction in the nozzle • Flow at chemical equilibrium **(3 weeks)**

- frozen flow.

5. Choice of propellants. **(1 week)**

6. Other types of rocket engines. **(1 week)**

Assessment method:

Exam: ***100%.***

Bibliographic references :

1. Theory and Applications of Thermodynamics, by Michael M. Abbott , Schaum series, editions Mc Graw Hill

2. Mechanics and thermodynamics of propulsion, by Philip Hill, Wesley editions

3. Reactors - Rockets: solid propellants, by J. Dardare, ENSAE editions 4. Principles of combustion, by Kenneth K. Kuo, John Wiley editions

Semester: 3

Teaching unit: UED 1.12
Material: Aeroelasticity

VHS: 10:30 p.m. (Class: 1.5 hours)
Credits: 1

Coefficient: 1

Teaching objectives:

The objective of aeroelasticity is to provide the student with the study of the effect of aerodynamic forces on the elastic flexibility of aircraft in static and dynamic states: the effectiveness of their control under the effect of lift – convergence and divergence. The static and dynamic elastic analysis of continuous bodies will be considered. Then an application to the dynamic analysis of aircraft wings using numerical methods, the k-method or pk method will be considered.

Recommended prior knowledge:

The knowledge required to be able to follow this course are the following courses: Aerodynamics, Continuous Media Mechanics, RDM, Aeronautical Structures, etc.

Content of the material:

Chapter 1: Presentations of the different forces applied to aircraft
(In static and dynamic state) **(02 weeks)**

Chapter 2: General theory of elasticity of continuous bodies (4 weeks)
- One-, two- and three-dimensional linear elasticity in static and dynamic states
- Generalized Hooke's Law and Energy Function in Three Dimensions
- Isotropic, anisotropic media and Lamné's elasticity constants
- Plane elasticity, plane stress and plane strain

Chapter 3: Airy function in coordinates and energy theorem **(04 weeks)**
- Airy function in cylindrical, polar and cylindrical coordinates
- Application to elasto-static problems in plates
- Application to elasto-static problems in cylindrical bodies
- Static and dynamic aeroelasticity

Chapter 4: Dynamic analysis of continuous bodies *using numerical methods* **(03 weeks)**
- *K-method and PK method*
- Applications to the flexibility of aircraft wings
- Effect of lift, drag and speeds
- Effect of damping on the aircraft structure

Chapter 5: Aeroelastic studies of flutter **(02 weeks)**

Assessment method:

Exam: ***100%.***

Bibliographic references: